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Plastic and Reconstructive Surgery of Burns

An Atlas of New Techniques and Strategies

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Preface

For I neither received it from man, nor was I taught it,
but I received it through a revelation of Jesus Christ.
(*Galatians 1:12*)

In the early 1970s, the first ever 55-bed inpatient Department of Plastic and Reconstructive Surgery opened in the A. V. Vishnevsky Institute of Surgery at the Russian Academy of Science in Moscow, Russia. Being a main referral burn center in Russia, we had an opportunity to operate on thousands of burn patients and we came to the conclusion that more research was needed to develop more effective surgical techniques, especially for severely burned patients. Over the years, we studied the anatomical features of patients with burn complications and developed multiple advanced surgical methods to treat scar deformities of skin and soft tissues, especially postburn contractures of joints and other body areas.

With divine help and revelations from the Creator, the anatomical structure of scar contractures was successfully studied, which led to the development of new methods for the surgical treatment of burns that significantly improved outcomes for the surgical rehabilitation of burned patients.

Some of the most significant results of this research include:

- A direct anatomical cause of contractures was established: for most patients, it is a scar surface deficit of a trapezoid shape. This determines the trapezoid shape of the flap necessary to compensate for the surface deficit.
- Research of the anatomy of the contractures led to a new classification of all contractures: *Edge*, *medial,* and *total* contractures, independent of their location and severity.
- Based on the anatomical research, a more effective trapezoid-flap plasty surgical method was developed, which yields superior results for edge- and medial-type contractures (85% of all the contractures seen in clinical settings).
- New methods of surgical treatments of face and neck deformities were developed due to the identification of axial blood supply to the skin of the neck. Various surgical techniques using split cervico-thoracic flaps were offered for the reconstruction of burned face tissue and contractures of the neck with great results.
- Very important work was done in restoring function of the burned hand (syndactyly, finger contractures, tendinopathies, and arthropathies due to burns). Use of trapezoid-flap plasty for contractures along with mechanical traction devices and tendon transplantation can return function to many disabled patients.
- An effective new method for the reconstruction of the shape, position, and skin of the burned breast was developed.
- We developed a new treatment method for severe adduction contractures of the shoulders based on the use of axillary island skin or scar tissue in the form of a subcutaneous pedicle flap in combination with skin transplantation.
- Sural flap with proximal base was developed and helped resolve the problem with ulcers and skin defects in the Achilles tendon area.

We invite you to expand your knowledge and learn new approaches to burn treatment based on a three-dimensional understanding of tissue deficit and excess. Our extensive experience demonstrated that most contractures can be successfully and completely eliminated without re-contracture as long as the surface/tissue deficit is fully compensated. The first two chapters explain the anatomy of contracture surface deficit and classification based on the location of the scar fold and tissue surplus in relation to joint surfaces. Understanding these principles will enable surgeons to apply recommended surgical techniques to a variety of burn contractures regardless of location and severity.

Many of the surgical procedures described in this atlas provide detailed planning, marking, and step-by-step surgical details, supported by pictures, schemes, and illustrations. We challenge you to step out of the comfort zone of triangular flaps and try your first Y-shaped radial incision to see an additional 30% release of the contracture and the appearance of a trapezoid wound requiring a trapezoid flap. Once you perform your first successful trapezoid-flap plasty, there will be no going back to triangular flaps for most contractures encountered in your practice.

The authors wish success to all surgeons using surgical techniques presented in this atlas. We want to see better outcomes and happy, thankful patients filled with gratitude to God and to the surgeons who offered them help.

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1 Postburn Scar Contracture: Formation, Anatomy and Classification

Introduction

Despite significant achievements in burns treatment, the number of scar contractures is high [1]. Among three burn consequences—scar deformity, contracture, and tissue defect—contractures most often lead to disability. Therefore, efficient treatment of scar contractures is of primary importance in the surgical rehabilitation of burned patients. Treating burn scar contractures remains a challenging problem for reconstructive surgeons, and no definitive conclusions have been reached about the effectiveness of different techniques [2].

"According to the World Health Organization (WHO) burns are a huge global health problem resulting in death and devastation to those who survive large burns as they are faced with significant functional limitations that prevent purposeful and productive living" [3]. For many years, the classic approach to contracture treatment used triangular local-flap techniques and skin transplantation. Existing anatomical contracture names or classifications (linear, wide, wide linear, web straight linear, narrow, long, quadratic, cordlike) do not characterize the contracture anatomy that is the basis for successful surgical treatment. The techniques based on skin grafting and triangular flaps have known disadvantages; therefore, rehabilitation of burned patients with contractures is far from perfect. Our observations show that the absence of progress in scar contracture treatment with local triangular flaps is caused mainly by insufficient study of contracture formation, contracture anatomy, scar surface deficit (contracture cause), and the lack of anatomical classification of scar contractures. Our classification, based on the anatomy of thousands of clinical observations, divides all scar contractures into three types: edge, medial, and total [4, 5].

Functional Zones of Joint Surfaces

In the plane of surgical treatment, a joint's surface is divided into flexion (*F*) and extension (*E*) surfaces; the boundary among them passes along the joint rotation axis level ("+" symbol) (Figs. 1.1, 1.2, 1.3, 1.4, 1.5, and 1.6). The flexion surface (*F*) of large joints (axilla, elbow, knee, ankle, and first interdigital space) has a curvature of nearly 90°, which divides it into two parts: flexion lateral (*FL*) and flexion medial (*FM*). The dividing line passes along the edges of joint fossa, ankle anterior surface, and first web space fossa or between the flexion lateral and medial surfaces. The flexion lateral surface of the large joints (one or both joint sides) spreads from the edge of the joint fossa to the joint rotation axis level. The scars, forming the edge commissural contractures (syndactyly, microstomia), spread from the fold crest on the dorsal and palmar hand to the metacarpophalangeal joints or from the cheek to the normal level of the mouth orifice angle location. Medial flexion surface covers the fossa of large joint, interdigital fossa, ankle anterior, and neck anterior and lateral surfaces.

All flexion rounded surfaces of the small (interphalangeal) joints, neck, trunk, and perineum are considered as one flexion/adduction surface. Scars located on joint flexion surfaces (lateral and medial) cause the corresponding flexion contracture: edge or medial. Scars located on the joint extension surface (beyond joint rotation axis level), do not participate in the flexion contracture formation. The flexion surfaces of the small (interphalangeal) joints, neck, lateral trunk, and perineum are considered as one flexion medial surface. Scars located on joint flexion lateral surfaces cause "edge" contracture. Contracted scars covering flexion medial surfaces form "medial" contracture. Scars that stretch through flexion lateral (FL) and flexion medial (FL) surfaces cause "total" contracture. And scars located on the joint extension(E)

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surface (beyond joint rotation axis level) do not contribute to flexion contracture formation. Scars covering the joint flexion lateral or medial surface and causing contractures are strongly connected to undamaged neighboring surfaces—flexion and extension surfaces.

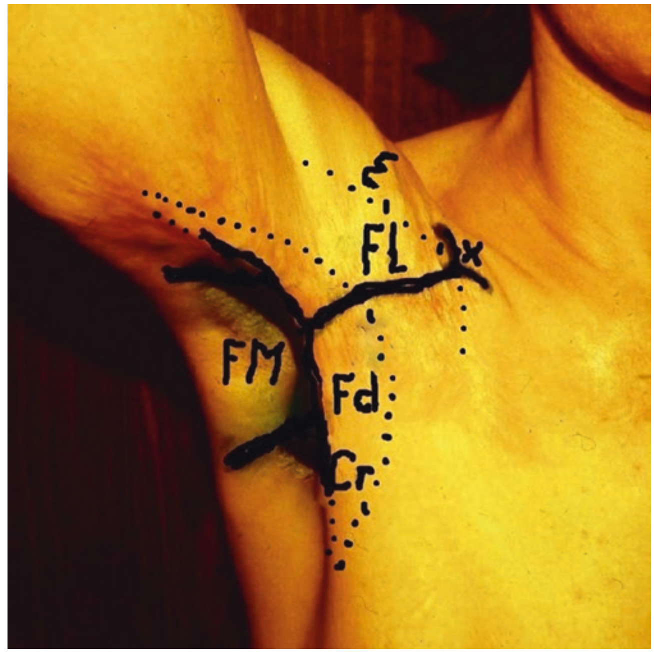

Fig. 1.1 Functional zones of big joint surface and shoulder edge contracture. *E* extension surface above the shoulder joint rotation axis ("+"); *F* joint flexion surface, which is divided by surface curvature into flexion lateral (*FL*) and flexion medial (*FM*); the flexion lateral surface is scars, the medial flexion surface (joint fossa) is healthy skin; scars formed the fold (*Fd*) along the edge of joint fossa; the crest of the fold (*Cr*) is the edge of scars; Y-line—the distance from the fold's crest to the joint rotation axis or joint FL surface

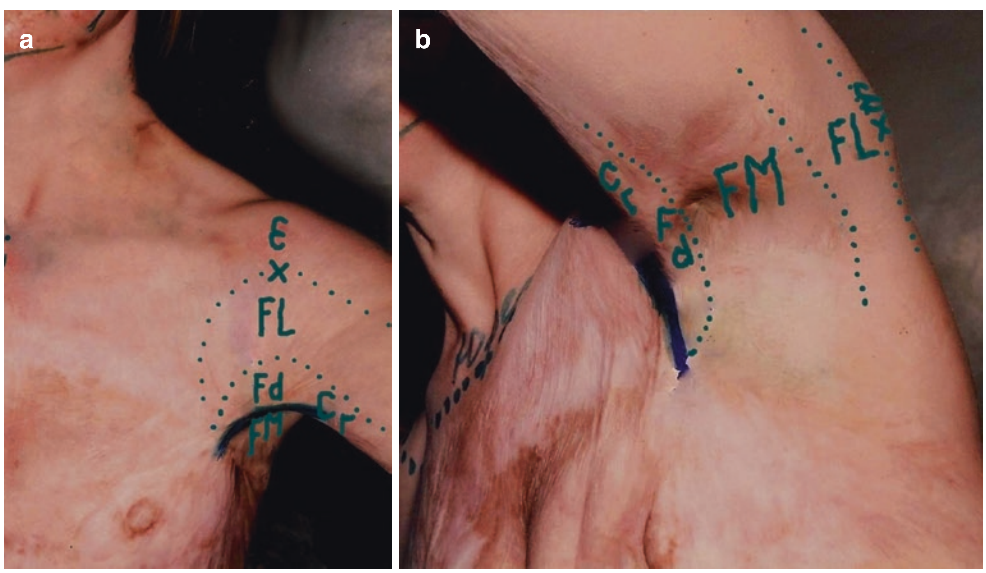

Fig. 1.2 Edge joint flexion contracture formation. (**a**) Scars on the joint anterior lateral flexion surface and neighbor zones spread downward (distally), involving healthy skin of flexion medial surface (*FM*) and form the fold (*Fd*) located along anterior joint fossa edge, among the flexion lateral and flexion medial surface. (**b**) The flexion medial surface of the joint is undamaged (*FM*); therefore, the fold's sheets have a different quality: the lateral surface comprises scars and is the cause of the contracture; the medial sheet and the flexion medial surface are healthy skin (*FM*). The scar has a surface deficit in length from the fold crest to the joint rotation axis ("+") and is the cause of the contracture, and both sheets have a surface surplus; the fold sheets are used for scar surface deficit compensation and contracture elimination

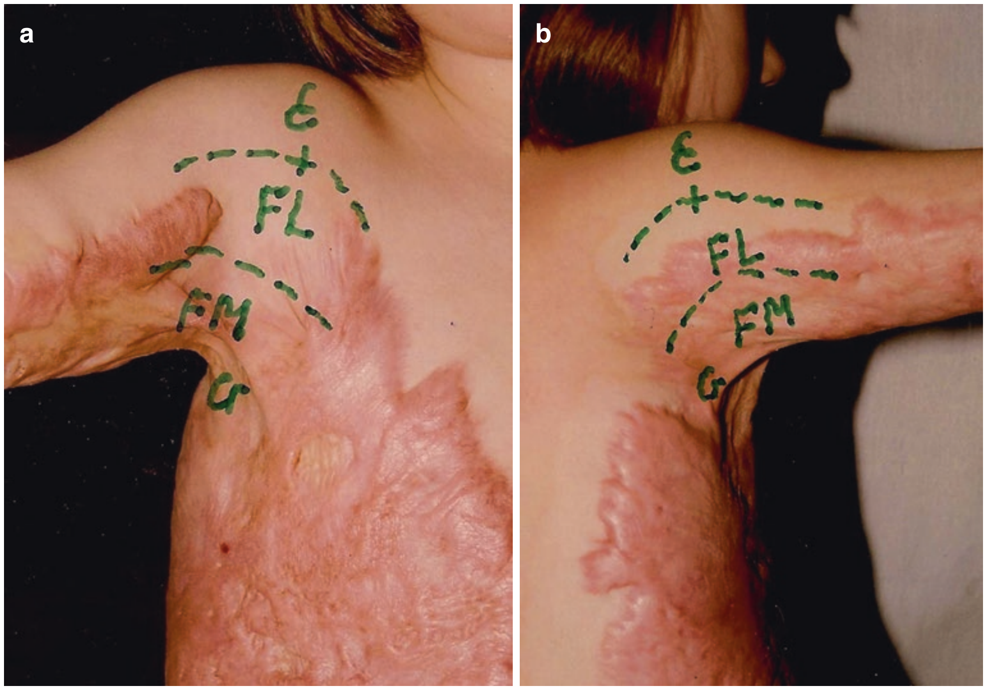

Fig. 1.3 Joint medial flexion/adduction contracture formation. (**a**, **b**) Shoulder joint medial adduction contracture, anterior and posterior view; scars covered flexion medial surface (*FM*), displaced down (distally) and forming a fold that approached the shoulder to chest wall (scar surface deficit in length) and caused the joint contracture; flexion lateral surface (*FL*) and extended surface (*E*) does not participate in contracture formation. The fold crest lies along fossa medial line; therefore, both fold sheets are scars, have a surface deficit in length (contracture cause) and surface surplus in width (from flexion lateral surface [fossa's edges] to the fold crest [*Cr*]), which allows contracture treatment with local flaps

Fig. 1.4 Total shoulder joint flexion/adduction contracture formation. Contracted scars covered the shoulder joint's flexion lateral and flexion medial surfaces and connected the shoulder with the chest wall

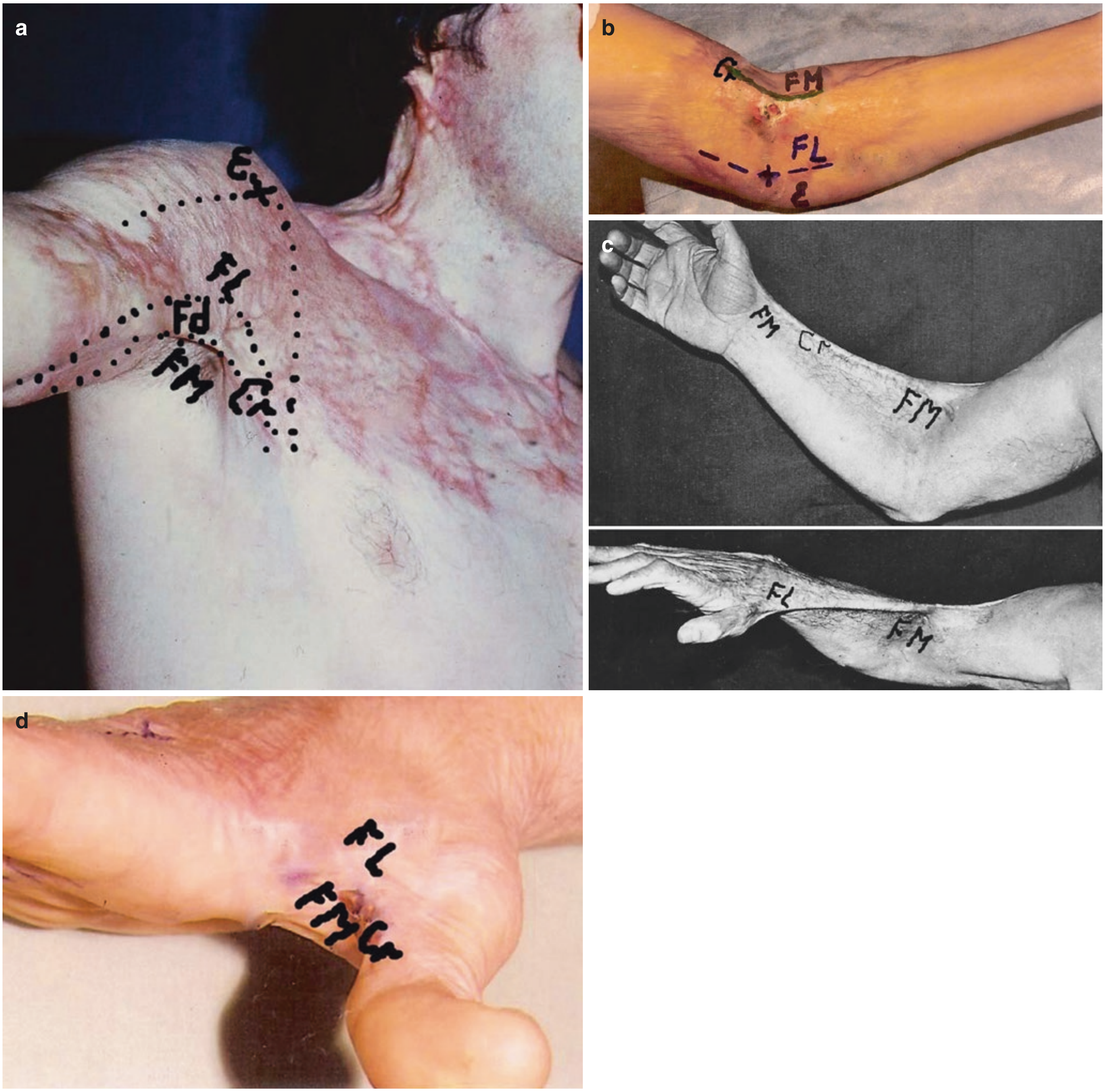

Fig. 1.5 (**a**) Edge shoulder adduction contracture: joint functional zones and anatomy. (**b**) Elbow edge flexion scar contracture. (**c**) Wrist and elbow edge scar flexion scar contractures. (**d**) First web space edge adduction contracture. (**e**) Dorsal syndactyly-interdigital edge commissural scar contractures. (**f**) Inguinal edge contracture. (**g**) Edge knee contracture. (**h**) Edge ankle flexion contracture. (**i**) Lateral neck edge contracture. (**j**) Scar microstomia anatomy

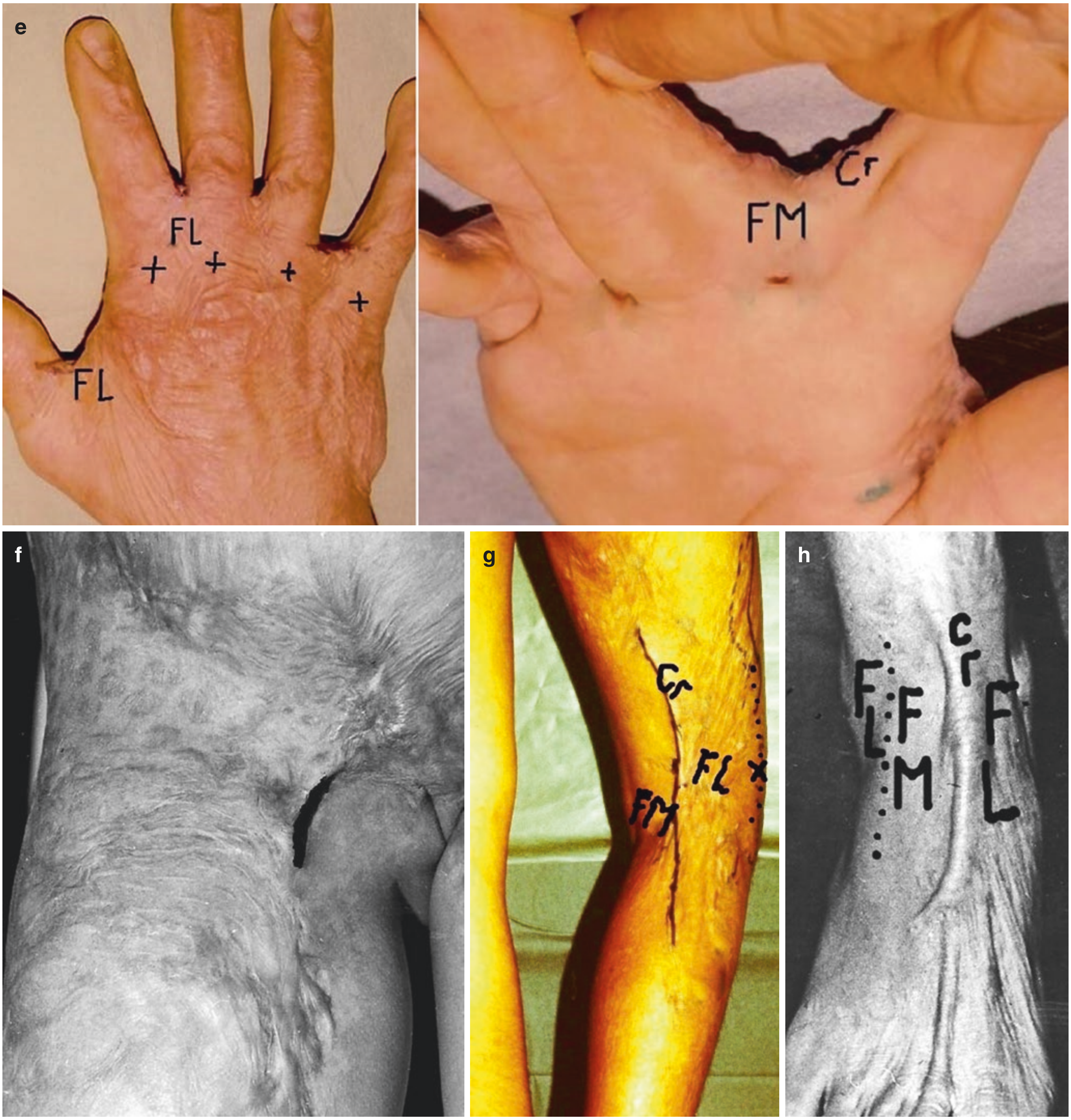

Fig. 1.5 (continued)

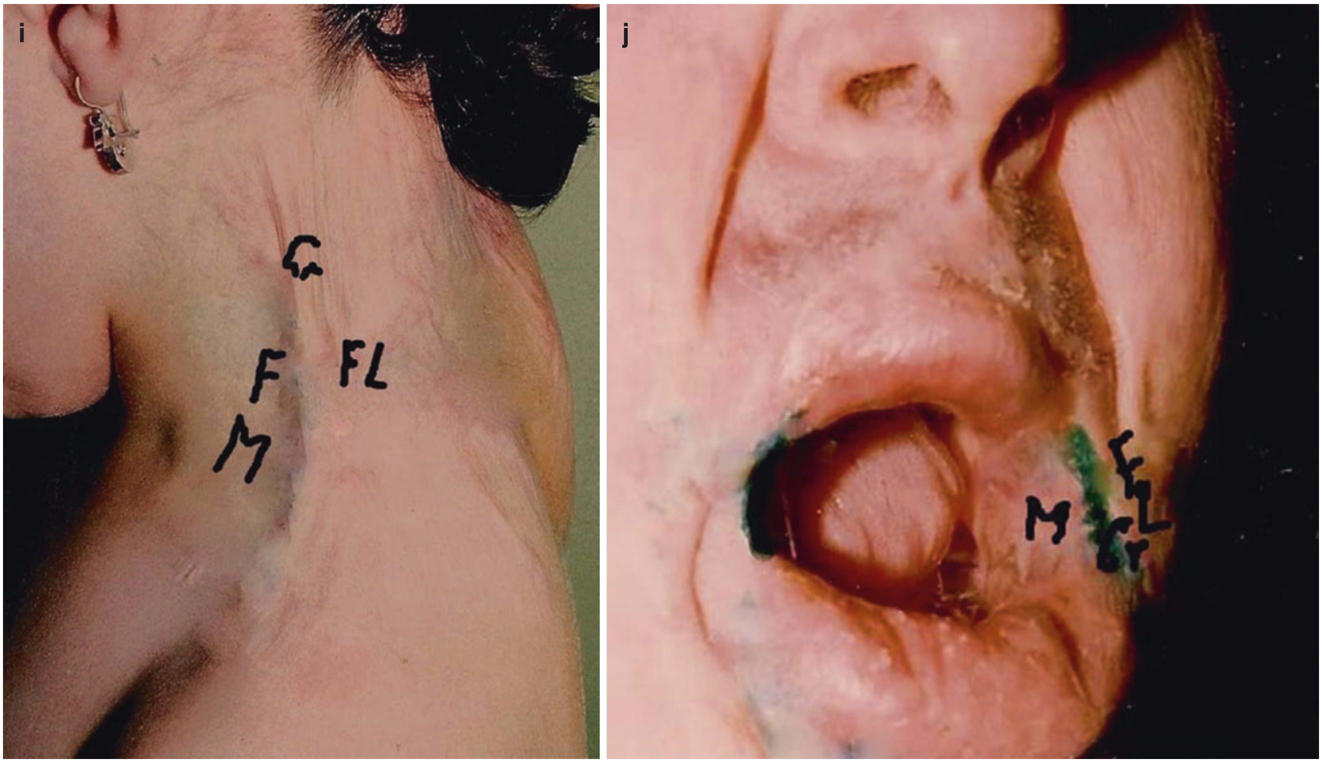

Fig. 1.5 (continued)

Edge Contracture Formation

Burns and scars that cover a joint's flexion lateral surface (*FL*) spread on lateral surfaces of anatomical segments, forming the joint and lateral commissural surface (dorsal and palmar hand and cheek). During wound healing, scars' connective tissue contracts and spreads distally, approaching the neighboring segment (Fig. 1.2). Growing distally, scars involve the healthy skin of the flexion medial surface. As a result, *the crescent fold is formed along the joint fossa's edge* or among the joint's flexion lateral and flexion medial surfaces. After burns to the neck's posterior surface, the fold is formed along the lateral neck; cheek burns are complicated by the fold formation in the oral angle. Scar protrusion increases with time, drawing-in neighboring healthy skin. The resulting crescent fold consists of two sheets of different quality: the lateral sheet is scars, and the medial sheet is healthy skin; scars spread in the direction of the undamaged joint's fossa or flexion medial surface and commissural fossa. Thus, the varied qualities of the fold's sheets are a most important anatomical and clinical feature of edge contracture. The crest of the fold is the scar's edge. Contracted scars located on the flexion lateral (*FL*) surface and the scars of the lateral fold's sheet (continuation scars of FL surface) have a surface deficit in length, which causes contracture, but both sheets are new anatomical structures and have skin and scar surface surplus, allowing contracture elimination with local tissues.

Medial Contracture Formation

Burns of the large joints' fossa or flexion medial surface (*FM*), ankle anterior surface, finger flexion surfaces, commissural fossa, lateral neck and truncal surfaces, and perineum are complicated with growth-contracted scars, which approach the neighboring segment of joints and commissure and cause medial contracture (Fig. 1.3). Attempts to keep the joint extended elevate scars above the flexion medial surface of the joint and neighboring segments, forming a fold. Maximal scar protrusion or crest of the fold passes along the central line of the flexion medial surface of big joints; the lateral neck surface (Fig. 1.3b); the finger flexion surface (Fig. 1.5e); and the lateral truncal surface (Fig. 1.5i). Since scar tension is maximal in the center of the medial flexion zone, both sheets of the fold are scars and are of equal quality. Scar sheets have a surface deficit in length, which causes a contracture, and scar surplus in width, which allows contracture elimination with local flaps. Flexion lateral surface (*FL*) of the large joint can be undamaged or covered with scars that do not participate in the contracture formation. All flexion surfaces of small joints (Fig. 1.5e) and the lateral surface of the trunk (Fig. 1.5i) are totally covered with contracted scars, which are elevated above the finger flexion surface and lateral trunk. As a result, the fold is formed, both sheets of which are scars in which there is a scar surface deficit in length, which causes contracture and a scar surface surplus in width, which allows contracture release with local flaps alone or in combination with skin transplants.

Total Contracture Formation

The scar contracture formation shows that there are only three ways in which scar contractures can develop (Fig. 1.4). These ways are defined by the scars' locations, by the presence or absence of the fold, by the location of the fold on the flexion surface, and by the quality of the fold's sheets. The scar surface surplus in the fold's sheets allows contracture treatment with local tissue. Deep and vast burns injuring the joint's flexion (and extension) surfaces result in scar formation, tightly surrounding the joint without a fold. A severe scar surface deficit forms a total contracture, excluding any possibility of a local-flap technique application.

Edge Postburn Scar Contracture Anatomy and Clinical Signs

Edge contractures (Fig. 1.4) make up 60% of the total number of contractures (authors' statistics). They are caused by:

(a) Burns and scars covering the flexion lateral surface (*FL*) of the large joints from the fold crest to the joint rotation axis, commissure, posterior neck, dorsal or palmar hand, or lateral surface of ankle joint.
(b) Contracted scars form a crescent fold along the joint fossa's edge, ankle anterior, and lateral neck surface and commissural edge.
(c) The fold consists of the two different quality sheets; scars are lateral sheet (according to joint fossa or joint's flexion medial surface), commissure, neck posterior surface, or ankle anterior surface. The medial sheet and neighboring surface of the joint's fossa, and the surfaces of anterior and lateral neck and inner commissure, remain undamaged.
(d) The crest of the fold is the edge of scars.

These four anatomical features determined the name for this type: *Edge*. The medial sheet and adjacent joint fossa, the ankle and neck anterior surface, the inner commissural angle and cheek, are healthy skin, and serve as donor sites. A fold's length and its protrusion differ from case to case, depending on the contracture's location and severity, and can cause the contracture of neighboring joints. Only the scar sheet causes contracture and neighboring contracted scars in which there is a surface deficit in length. In both sheets, there is a scar surface surplus in width sufficient for scar surface deficit compensation without skin grafts, pedicle, and free flaps.

Similar Anatomy of Edge Scar Contractures of the Joints, Commissures, Neck, and Inguinal

For common signs of functional zones and anatomy of edge contractures, see Fig. 1.5. Definition of symbol and abbreviations:

E—Joint extension surface

"+"—Joint rotation axis

FL—Flexion lateral surface and lateral sheet of the fold (FD, Fd, Fold) are scars and edge contracture causes

FM—Flexion medial surface (fossa) and medial fold sheet (Fd) are healthy skin

FD, Fd—Fold is surface surplus, the lateral sheet is scars, part of flexion lateral surface; medial sheet of the fold and fossa are healthy skin (donor site)

Cr—Crest of the fold, the edge of the scar.

Anatomical Features and Clinical Signs of Medial Scar Contractures of the Joints, Commissures, Neck, Trunk, and Perineum

Medial contracture makes up 25% of the total number of contractures (Fig. 1.6). Medial contractures, independent of their location and severity, have specific anatomical features and clinical signs:

(a) Contractures are caused by burns and contracted scars, covering the joint fossa or flexion medial surface (*FM*) of large joints, or joint flexion surface of the interphalangeal joints, anterior ankle, perineum, inner surfaces of commissure, anterior and lateral neck, and lateral truncal surfaces.
(b) Contracted scars form *the crescent fold located along the medial line of the joint's fossa* or medial line of the joint flexion surface, ankle anterior surface, perineum, lateral truncal and neck surfaces, nose anterior surface, and inner commissural surface.
(c) Both sheets of the fold are scars and spread from the fold's crest to the joint fossa's edges (large joints), the joint rotation axis level of small joints, and commissural edges. These three anatomical features determine the name for this type: *Medial*.

The fold is a new anatomical structure, and scar surface surplus is useful for contracture elimination with local flaps. Both scar sheets of the fold have a surface deficiency in length, which causes contracture, and surface surplus in width, which allows contracture treatment with local flaps per se or in combination with skin transplants. The fold can be small and short or may spread on the neighboring areas and joints.

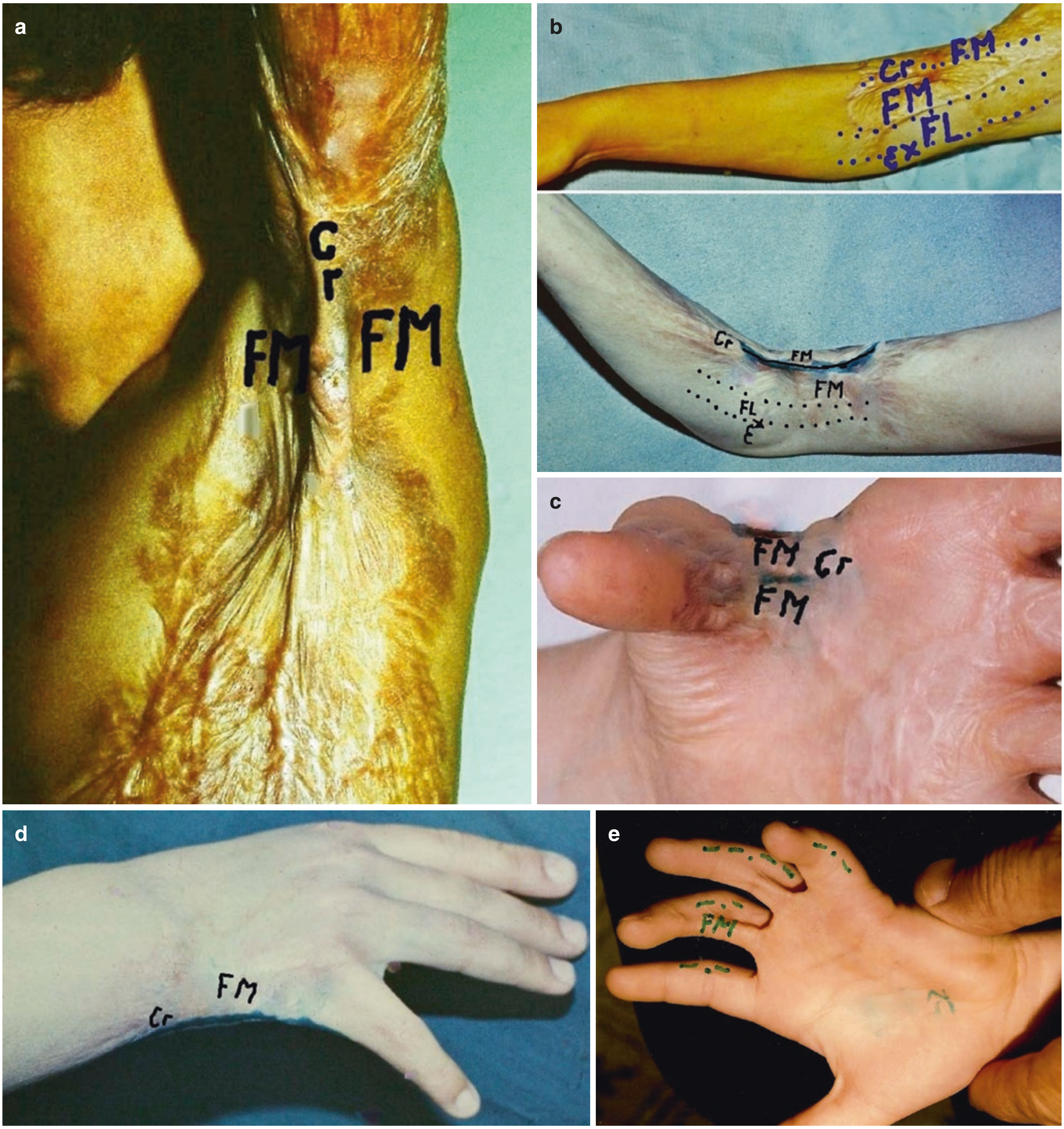

Fig. 1.6 Anatomy of medial scar flexion/adduction contractures are characterized by: (1) Scars cover the joint FM-flexion medial surface. (2) The crescent fold, which is located along the medial line of the joint's fossa, or medial line of joint flexion surface, the medial line of the ankle anterior surface, perineum, and inner commissural surface. (3) Both sheets of the fold are scarred and spread from the fold's crest to the edges of the large joint fossa, the joint rotation axis level of small joints, or where the scar's contraction disappears. Scars and sheets of the fold cover neck anterior and lateral surfaces, trunk, and perineum. (**a**) Shoulder medial adduction scar contracture. (**b**) Elbow medial scar flexion contracture (two cases). (**c**) First web space medial adduction scar contracture. (**d**) Wrist medial scar deviation/flexion contracture. (**e**) Fingers medial flexion contractures. (**f**) Knee medial scar flexion contracture. (**g**) Ankle medial scar flexion contracture. (**h**) Neck lateral medial scar contracture. (**i**) Lateral truncal medial scar contracture. (**j**) Perineum medial scar adduction contracture

Fig. 1.6 (continued)

Similar Total Contracture Anatomy of Different Location

After deep extensive burns, scars tightly surround the joint, or obliterate commissures and perineum, creating a severe scar surface deficit without a fold, which does not allow contracture treatment with local tissue (Fig. 1.7). These anatomical criteria characterized contracture as *total* (15% of total number). Because of severe tension and traumatization during joint extension, scars are converted to pathologic (solid, rough, thick), and are prone to necrosis and ulceration. Along with the scar contracture, deep burns could injure the articular structures, making the contracture more severe and treatment more complex. Severe scar surface deficit excludes the use of local-flap techniques; it can be compensated for and contracture treated with skin grafts, scar quadrangular subcutaneous pedicle flap (see Chap. 22), or regional pedicle or free flaps.

Fig. 1.7 (**a–c**) Total shoulder, elbow, and wrist scar contractures. (**d**) First web space total scar adduction contracture. (**e**) Total interdigital scar contractures. (**f**) Knee total scar contracture. (**g**) Ankle total scar contracture. (**h**) Total perineum scar contracture (obliteration)

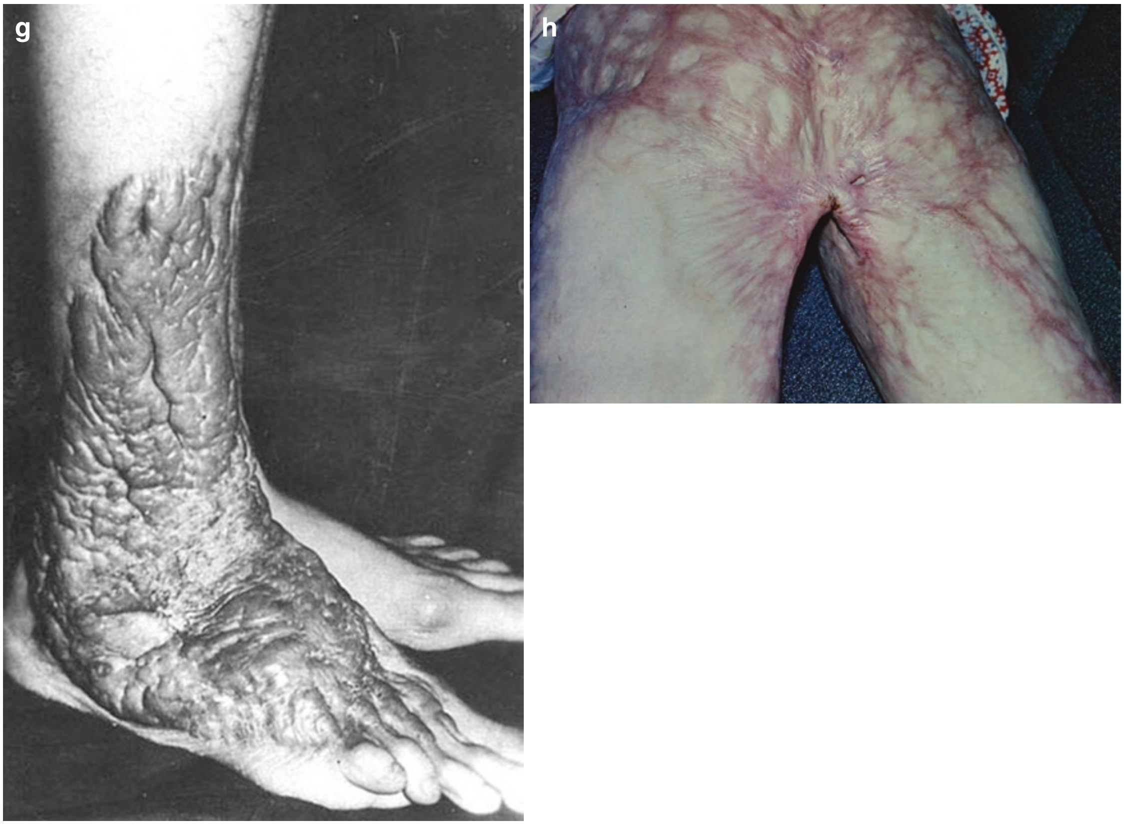

Fig. 1.7 (continued)

Conclusion

The flexion surface of large joints is divided into flexion lateral (*FL*) and flexion medial (*FM*); the flexion surface of the small joints, perineum, and trunk are all classified as medial. In all cases, contracted scars covering the flexion lateral surface form an anatomically specific contracture type: *Edge*. Contracted scars covering the flexion medial surface form *medial* contracture. Scars located on the joint extension surface (beyond joint rotation axis level) do not participate in the flexion contracture formation. The tissue of flexion lateral (FL) and joint extension (E) surfaces, and both joint's flexion surfaces (FL and FM) are tightly connected between themselves.

Our three-type classification system includes all specific anatomical features and clinical signs.

Scars that are located on all joint flexion surfaces, or circularly, create a total contracture. Every contracture type has specific anatomical features and clinical signs, regardless of location and severity, and these are the basis for diagnosis, operation planning, and choice of technique.

The fold's presence and surface surplus in the fold's sheets allows the edge and medial contractures to release with local flaps that compensate for scar sheet surface deficits in length (contracture cause).

Inadequate anatomical studies and the absence of an anatomical classification have impeded the development of anatomical-based surgical techniques for treating postburn scar contractures. Therefore, Z-plasty and Y-V plasty, based on the use of triangular pointed flaps, are considered to be basic local-flap techniques, and are used despite their shortcomings and disadvantages. Multiple existing modifications and combinations have been proposed that confirm that the anatomy of scar contractures is as still inadequately studied.

The understanding of postburn scar contracture anatomy, including the scar surface deficit, is the first and main step toward successful surgical rehabilitation.

The rationale behind the choice of surgical technique and estimation of its efficacy in treatment is based on the use of a commonly accepted anatomical classification.

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2 Deficit of Postburn Scar Surface is Contracture Cause and Basis for Adequate Reconstructive Techniques Development and Choice

Introduction

Of the three outcomes of burns—scar deformity, contracture, and tissue defect—contractures most often lead to disability. Therefore, the efficacious treatment of scar contractures is of the greatest importance in the surgical rehabilitation of burned patients. Complete contracture removal significantly improves the appearance of the contracted region. Over many years, scar contracture treatment has conformed with classic methods, especially concerning local-flap techniques. Triangular-flap techniques—Z-plasty and Y-V plasty and their modifications and combinations—continue to serve as the basis for scar contracture treatment. The techniques based on triangular flaps have known disadvantages, and results of rehabilitation of burned patients with contractures are far from perfect. The development of new techniques is needed (*see* Chap. 1). Therefore, complex regional flaps are used in adults and children. According to our research [1], the main cause of the slow progress in scar contracture treatment with local tissues is insufficient study of (a) contracture anatomy, (b) contracture cause (scar surface deficit), and (c) anatomical classification of scar contractures.

Postburn Scar Contracture Anatomy

In the plane of surgical treatment, the joint's surface should be divided on *flexion* (*F*) and *extension* (*E*); the boundary between flexion and extension passes along the joint rotation axis level (Fig. 4.1). The flexion surface of large joints (axilla, elbow, and knee), ankle, and first web space is divided into two areas: *flexion lateral* (*FL*) and *flexion medial* (*FM*). The lateral surfaces of the large joints are spread from the edge of the joint fossa to the joint rotation axis level; the flexion medial surface includes the joint's fossa and ankle anterior surface; and the scars, forming the commissural contractures, spread from the fold crest on the dorsal and palmar hand or cheek. All flexion surfaces of the small (interphalangeal) joints, neck, lateral trunk, and perineum are considered as one flexion medial surface. Scars located on the joint flexion lateral surface cause *edge* contracture (Fig. 2.1), contracted scars covering the flexion medial surface form *medial* contracture (Fig. 2.1), and scars located on the joint extension surface (beyond the joint rotation axis level) do not participate in the flexion contracture formation. Scars covering the joint flexion or the flexion and extension surfaces are tightly connected and form *total* contracture.

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Edge Scar Contracture Anatomy (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9)

Burns and scars that are located on *the lateral joint's FL and lateral commissural surface* form the fold that the contracture causes. The fold is located along the edge of the large joint, commissural fossa, and ankle anterior surface; the *crest of the fold* (*Cr*) is the scar's edge. In the fold, only the lateral sheet is a scar, and a continuation of scars covers the FL surface. The scars covering the joint FL surface and the lateral scar sheet of the fold have a surface deficit in length that causes contracture. Both sheets have surface surplus of scar and skin. The medial sheet is a continuation of healthy skin of the FM surface or the joint fossa and are excellent donor sites, allowing contracture elimination with local tissue. Thus, four signs characterize an edge contracture:

(a) Contracture is caused by scars covering the joint FL surface.
(b) Scars growing distally form the fold located along the edge of the joint fossa.
(c) The lateral sheet in the fold is scar tissue; the medial sheet is healthy skin.
(d) The crest of the fold is the edge of the scar.

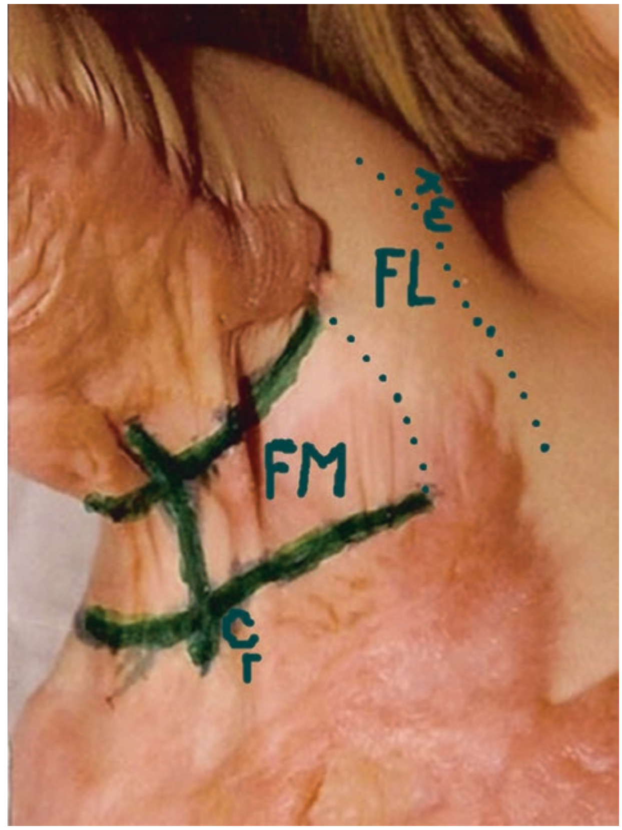

Fig. 2.2 Anatomy and joint surfaces of medial contractures (right shoulder) and clinical signs. Scars cover a *FM* joint's flexion medial surface or joint's shoulder fossa; scars form the fold that covers all fossa, has surface surplus in width and surface deficit in length, which causes the contracture. Clinical signs: scars cover the joint flexion medial surface (*FM*); *Cr* the crest of the fold passes along the middle axillary line; *FL* the flexion lateral surfaces are healthy skin and does not participate in contracture formation; *E* extension surface; "+" joint rotation axis

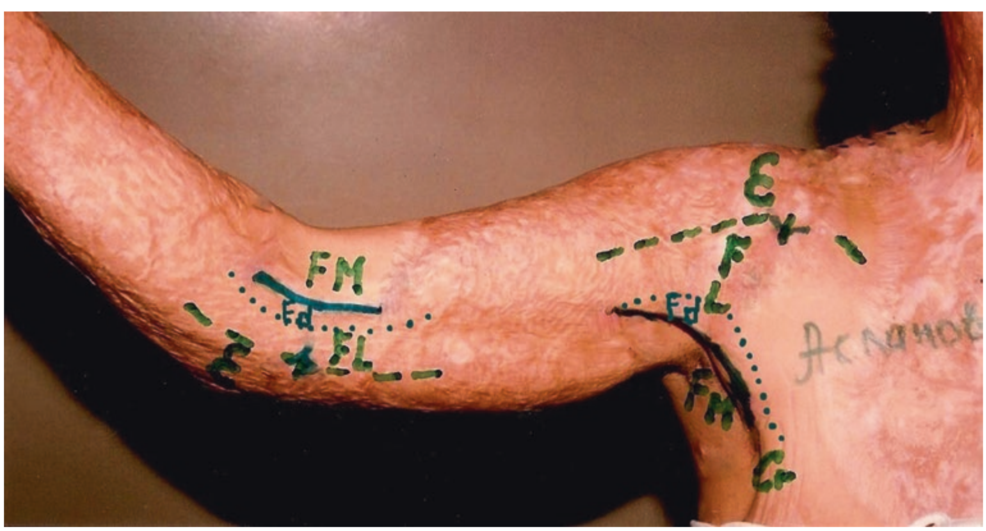

Fig. 2.1 Anatomic features and functional zones of joints of edge contractures (shoulder and elbow). Functional zones: *E* extension surface; "+" joint rotation axis; *FL* flexion lateral surface is scar; *Fd* fold is continuation of scars of FL surface; therefore, lateral sheet of the fold is scar; *FM* the flexion medial surface is fossa; the medial fold sheet is part of the fossa and healthy skin; fold sheets are surface surplus of scars and healthy skin; *Cr* the crest of the fold is the edge of scar. Clinical signs of shoulder and elbow edge flexion contractures; (**a**) scars cover a *FL* flexion lateral surface and form a fold (*Fd*); (**b**) the fold is located along the joint fossa's edge; (**c**) different fold sheets' quality: the lateral sheet is scar and part of the flexion lateral surface; the medial fold's sheet and joint fossa (*FM*) are healthy skin and the donor site; (**d**) *Cr* the crest of the fold is the edge of scar. Sheets of the fold in conjunction with the fossa's tissue are sufficient for contracture elimination

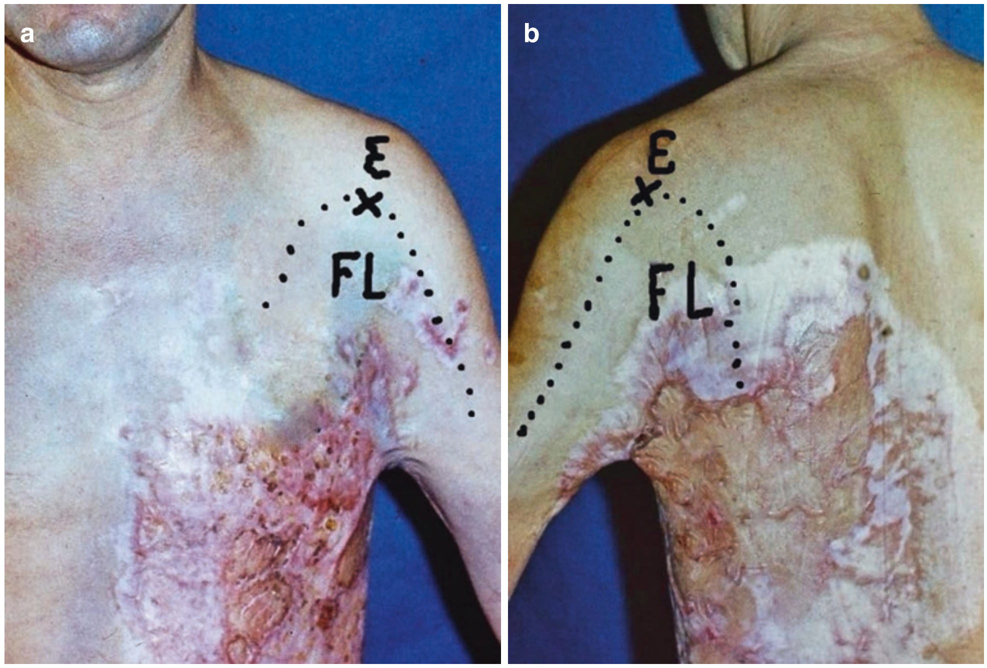

Fig. 2.3 Anatomy of total scar contracture: (**a**, **b**) Anterior and posterior view. Scars tightly surround the joint on three sides, covering and obliterating the axillary fossa; the shoulder fused with the chest wall and formed the total contracture; no fold, no scar surface surplus; therefore, severe scar surface deficit forms total scar adduction contracture and excludes reconstruction with local tissues

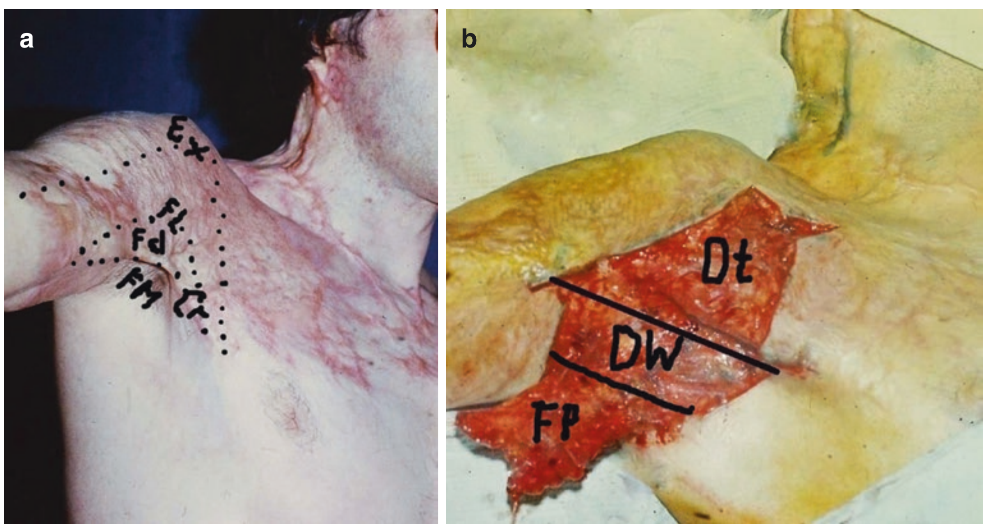

Fig. 2.4 Edge shoulder anterior adduction contracture caused by trapeze-shaped scar surface deficit. (**a**) Shoulder edge contracture anatomy: *E* joint extension surface; "+" joint rotation axis; *FL* flexion lateral surface; *Fd* fold (lateral sheet) is continuation of FL surface; *Cr* crest of the fold; *FM* flexion medial surface, or axillary fossa, is healthy skin; (**b**) scar surface deficit determination: contracted scars (the flexion lateral surface [*FL*] and the scar fold sheet [*Fd*] are dissected from the fold crest [*Cr*] to the joint rotation axis [+] with a Y-shaped incision); wound (*Dt* scar surface deficit) accepted trapezoid form (upper of strip); length of wound end along joint rotation axis level is nearly 6 cm; mobilized axillary adipose-cutaneous trapezoid flap (*Fp*), donor wound (*DW*) in axillary fossa. Operation details can be found in Chap. 16

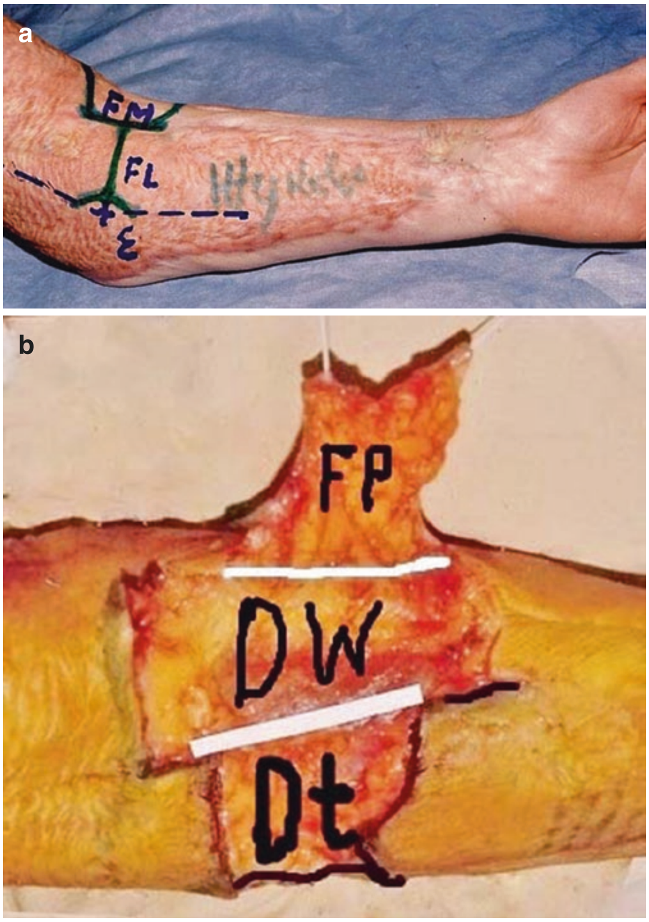

Fig. 2.5 Edge elbow flexion contracture caused by scar surface deficit of scars covering the joint flexion lateral surface (*FL*) and scars of the fold. (**a**) Contracture anatomy: *FM* surface (fossa and fold); *FL* flexion lateral surface from fold crest to the joint rotation axis ("+"); *E* joint extension surface; lines of the trapezoid flap in fossa and Y-line for scar dissection; (**b**) after scar dissection and flap mobilization: *Dt* trapezoid scar surface deficit of scars on FL surface, end equals 6 cm (contracture cause); *Fp* the trapezoid flap is mobilized from cubital fossa; *DW* donor wound (see Chap. 23)

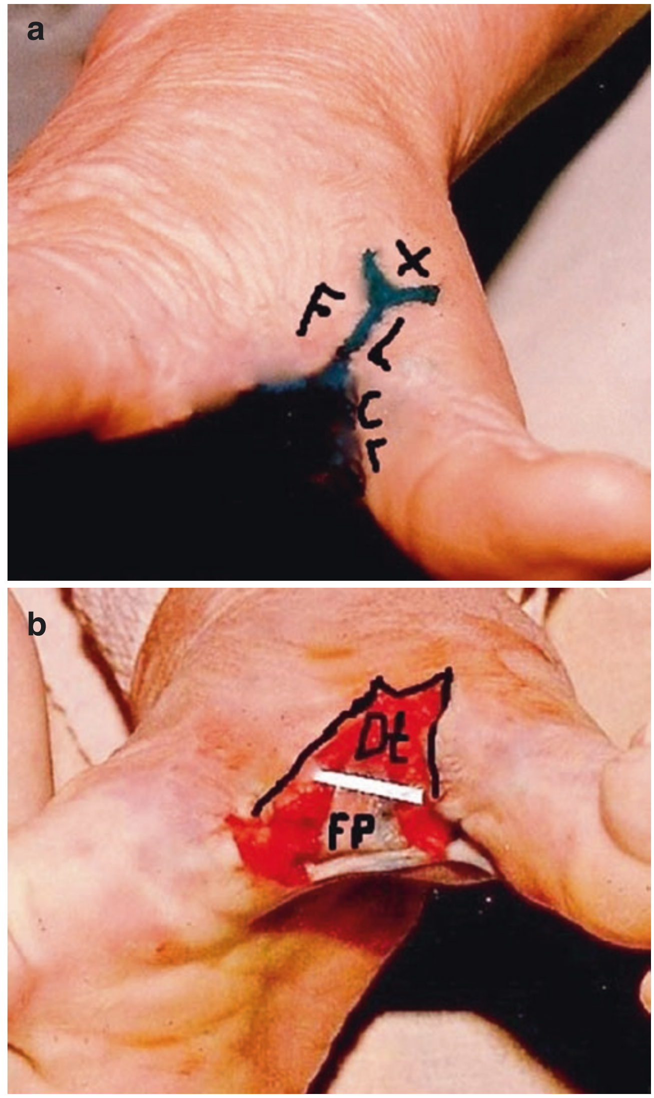

Fig. 2.6 Edge first web space adduction contracture caused by trapeze-shaped scar surface deficit (*Dt*). (**a**) Pre-operative view; *FL* the fold's lateral scar sheet; *Cr* crest of the fold; Y-line for scar dissection; (**b**) contracted scar sheet of the fold dissected with a Y-incision; a trapezoid wound (Dt-M-trapezoid scar surface deficit) appeared (above strip), end of M-wound (surface deficit) equals 2.5 cm; trapezoid flap (*Fp*) elevated from fossa. Operation details can be found in Chap. 27

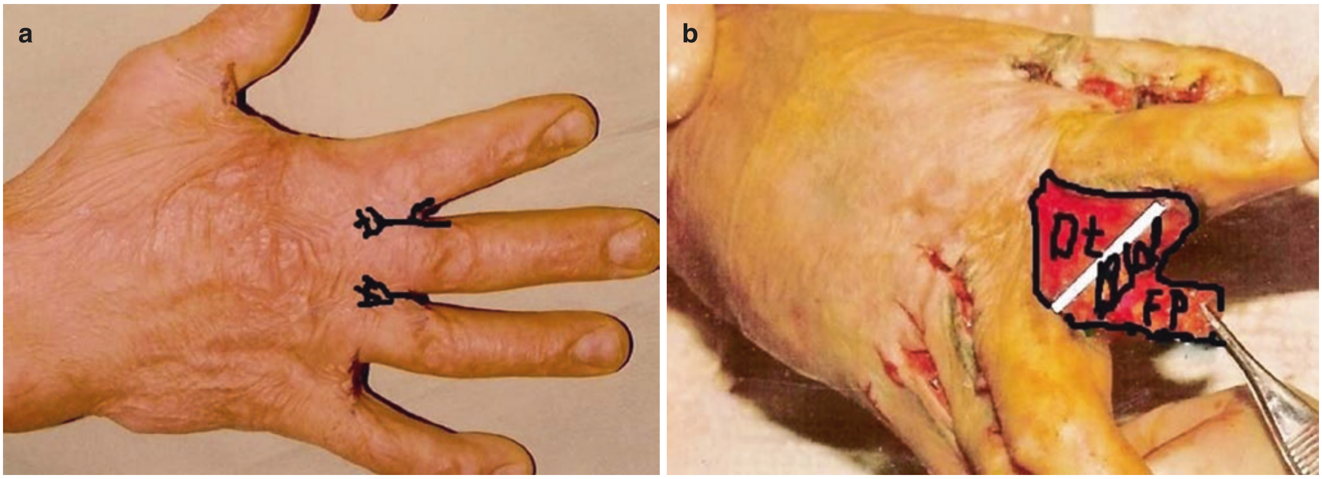

Fig. 2.7 Dorsal interdigital adduction contractures caused by scars of the dorsal hand having surface deficit. (**a**) Scars of the hand dorsum, growing distally, form the fold between proximal phalanges. The dorsal fold's sheet is scar and participates in syndactyly formation, Y-line for contracture release and cause definition; (**b**) after scar dissection with a Y-incision and contracture elimination, a trapezoid wound appeared or *Dt* trapezoid scar surface deficit from the fold's crest to the metacarpal bone heads, *DW* donor wound; adequate flap (*Fp*) elevated in interdigital fossa (see Chap. 28)

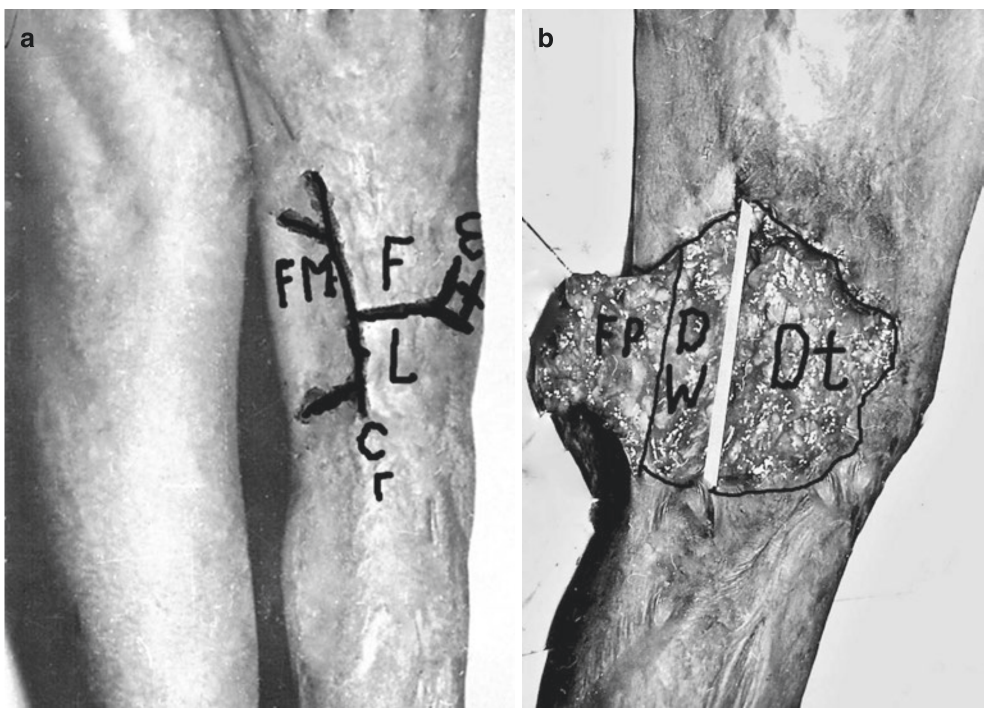

Fig. 2.8 Scar surface deficit—cause of knee edge flexion contracture. (**a**) Contracture anatomy: *FL* scars on the joint flexion lateral surface and the lateral sheet of the fold caused contracture; *FM* the flexion medial surface or popliteal fossa is healthy skin; *Cr* crest of the lateral fold sheet; *E* joint extension surface; "+" joint rotation axis; borders of the flap in popliteal fossa or FM surface; Y-line for contracted scar dissection from the fold crest to the joint rotation axis; (**b**) contracture released: *Dt* large wound or trapezoid scar surface deficit or contracture cause; *FP* popliteal trapezoid flap mobilized; *DW* donor wound. Operation details can be found in Chap. 33

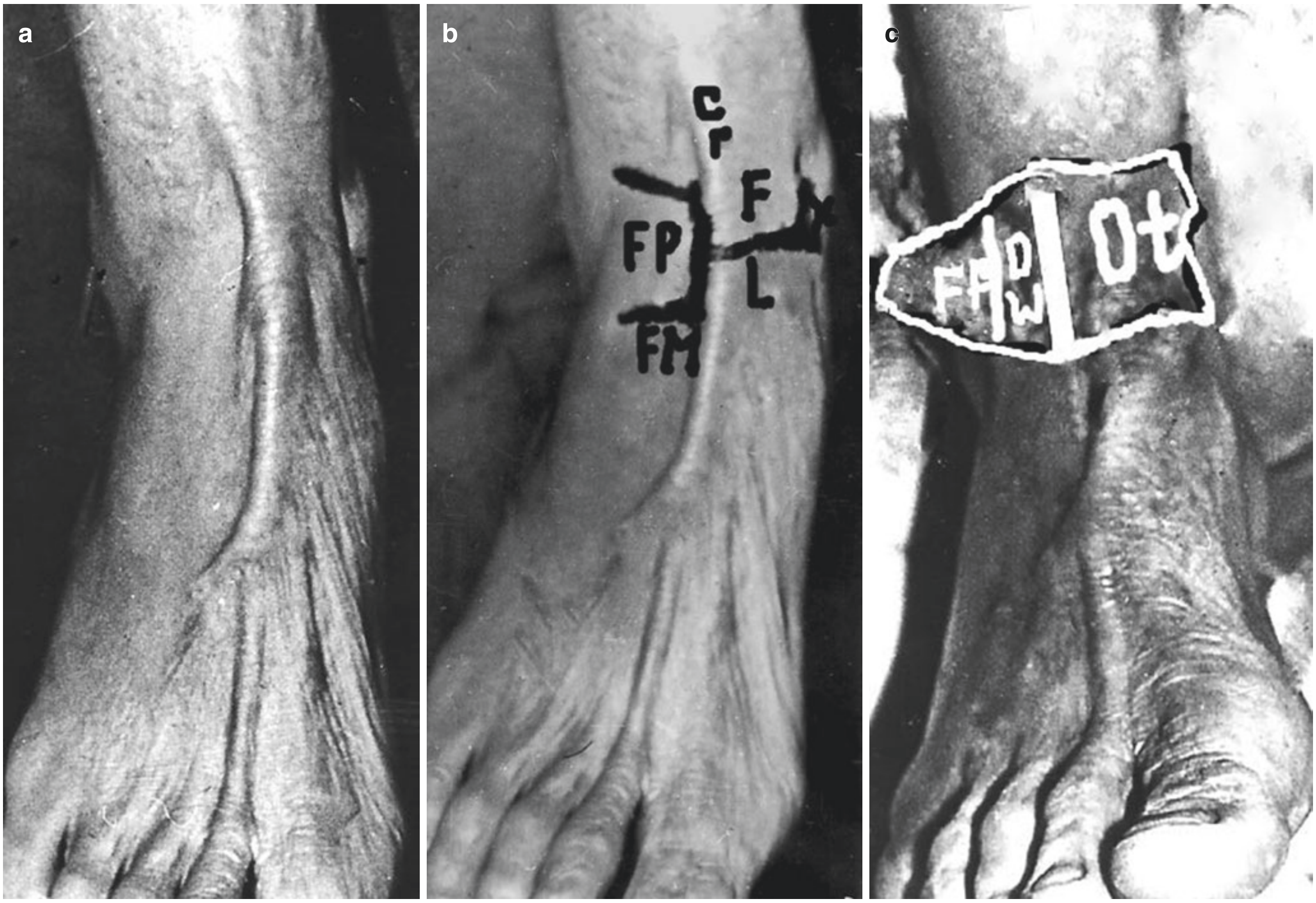

Fig. 2.9 Ankle edge contracture caused by scars of the joint FL surface and the lateral scar sheet of the fold. (**a**, **b**) Anatomy: *FL* scars of the ankle lateral surface forming the fold and causing the contracture; *FM* healthy ankle anterior surface and donor site; *Cr* the crest of the fold is the edge of scar; planning: Y-line for scar incision and two lines, trapezoid flap borders; (**c**) the wound appeared (right from the strip), which is scar surface deficit (*Dt*), real contracture cause, the wound has a trapezoid form, and the matching flap is mobilized (*FP* flap, *DW* donor wound) for scar surface deficit compensation and contracture elimination. Operation details can be found in Chap. 36

Anatomy of Medial Scar Contracture (Figs. 2.2 and 2.6)

Scars covering the *FM* surface (fossa of large joints), ankle anterior surface, finger flexion surface, commissural fossa, first web space, perineum, neck anterior and lateral surface, nose, and lateral trunk, form the fold. Scars of the FM surface and both sheets of the fold have surface deficit in length causing the *medial contracture*. The fold passes along the medial line of the joint's flexion medial surface, commissural, and first web space fossa, perineum, lateral trunk, dorsum nose, and anterior and lateral surfaces of the neck. Both sheets of the fold are scars, and have a length surface deficit and scar surface surplus, the surface of which is enough for contracture elimination with local flaps. The lateral flexion surface of the large joint can be undamaged or covered with scars that do not participate in contracture formation. The scars located on the flexion medial surface of large joints, commissural fossa, perineum, nose, neck anterior and lateral surfaces, and lateral trunk, which form the fold in which both fold sheets are scars, create *the medial contracture type*.

Three signs characterize the medial contracture:

(a) Contracture is caused by scars covering the joint flexion medial (FM) surface and first web space fossa, fingers' flexion surface, perineum, lateral trunk, dorsum nose, and anterior and lateral surfaces of the neck
(b) Scars form the fold that passes along the middle line of the zone covered by scars
(c) Both sheets of the fold are scars

Total Contracture Anatomy (Fig. 2.3)

Deep and vast burns that injure the joint's flexion and extension surfaces result in scar formation. The scars tightly surround the joints, without a fold. There is severe scar surface deficit, which excludes any possibility of using a local-flap technique; large wounds are covered with skin grafts, regional pedicle, and free flaps.

Scar Surface Deficit as the Real Cause of Contracture

The diagnosis of "scar contracture"—including knowing the contracture type, the contracture severity, and the scar's location and its spreading—does not explain the surgical anatomy and cause of the contracture. As the cause is scar surface deficit, the main focus of reconstruction (planning and technique choice) is knowing the form and size of the scar surface deficit and its location in relation to the contracted joint.

Exploration of Scar Surface Deficit in Relation to Contracture Cause and Local Flaps and Anatomical Local-Flap Technique Substantiation Allowing Complete Scar Contracture Elimination (Fig. 2.4)

Reconstruction with classic local techniques for scar contracture treatment (Z-plasty and Y-V plasty and their modifications and combinations) is performed with straight (lineal) incisions of contracted scars at different angles. As a rule, a triangular wound appears, which is covered with triangular-pointed flaps (transposition and advancement). The purpose of the plasty method is to draw on the operating field before contracture release using a straight line, and the operation is accomplished with straight incisions. In the case of Z-plasty, a central line passes along the fold's crest, and the next two lines, at 60° to the first one (not perpendicular). With Y-V plasty, triangular symmetrical figures (flaps) are placed on each fold's sheet, beside the fold crest.

When planning the Z-plasty and Y-V plasty techniques, the scar surface deficit (its location, form, and size) as the cause of contracture is not taken into account.

In the case of *edge* joint contracture, the first incision along the fold crest separates the contracted scar (FL) from healthy skin on the FM surface; the other edge of the scar stays tightly connected to the normal skin of the extension (E) surface. Since contracted scars are tightly connected to the tissue of the extension surface (E), the lineal (straight) radial incisions of contracted scars from the fold's crest to the joint's rotation axis form, as a rule, a triangular wound. Divergence of the triangular wound is incomplete and does not reach the joint rotation axis, and contracture release is thus not full.

In the case of a joint *medial* contracture, the first incision along the fold's crest separates the scar sheets. The second radial incision of sheets from the fold's crest to the fossa edges (to FL surfaces) forms a triangular wound in every sheet. At the apex of the triangular wound scars cannot diverge since they are connected to FL surface, creating an impression that contracture or surface deficit is absent. But in fact, surface deficit is present through all of the FM surface of contracture. Therefore, to separate FM from FL and completely diverge the wound - Y-incision is used at the edge of the FL surface. When Y-incision is used, wound surface takes trapezoid shape and requires trapeze flap for closure. Incomplete wound edge divergence causes incomplete contracture release. Therefore, after covering the wound with a triangular flap, contracture elimination is incomplete.

In other words, dissection of contracted scars with lineal incisions causes, as a rule, a triangular wound with a pointed end that does not reflect the real scar surface deficiency form (Fig. 2.2) since the neighboring tissues of the joint's extension surface (Fig. 2.1) are tightly connected to the scar of the flexion surface. Because the wound has a triangular form and the wound edges do not diverge enough, the contracture is not fully released. After dissection of contracted scars with a lineal incision, the wound that appears generally takes on the triangular pointed form in all cases of edge and medial scar contractures.

These observations led to the conclusion that scar surface deficit is not triangular, and that at the joint rotation axis, it is still present and is not equal to zero (in cases of edge and medial contractures). Therefore, it has become clear that for complete contracture release without incision prolongation on the neighboring joint extension zone, it is necessary (in cases of edge contractures) to separate the contracted scars of the lateral flexion surface from: (1) the healthy skin along the fold's crest; and (2) the scars of extension surface along the joint rotation axis (Figs. 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9). In the case of medial contractures, the contracted scars of the flexion medial surface should be separated from the scars on the lateral flexion surface (Figs. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20). This can be achieved with a T-shaped scar incision along the joint rotation axis (level contracture) and the edge of the joint fossa (medial contracture). The Y-shaped incision is more effective. After the Y-shaped incision, the end of the wound accepts an M-form that allows the wider scar edges divergence by transforming the M-figure into a straight line. Therefore, the incision of contracted scars in all cases must be in a Y shape. Before the joint rotation axis (edge contracture) and edge of joint fossa (medial contracture), the incision is split at 45° and lengthened along the joint rotation axis level or fossa edge to fully release the contracture. The use of Y-shaped incisions for contracted scar dissection leads to trapezoid wound formation. The formation of the trapeze-shaped wound reflects the scar surface deficit form, size, and location (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9). Therefore, the trapezoid flap is needed for wound covering. Trapeze-flap plasty allows for the complete use of the scar surface surplus and edge and medial contracture elimination with local tissues (Fig. 2.20) in most contractures.

Consequently, the use of Y-shaped incisions for contracted scar dissection leads to the formation of a trapezoid wound and demonstrates that straight (lineal) incisions of contracted scars should not take place.

To cover a trapezoid wound, the trapezoid flap is needed, and trapeze-flap plasty is necessary for scar surface surplus and neighboring healthy skin use, and to complete the wound resurfacing and edge and medial contracture elimination. In cases of total contracture, the scars' dissections do not have a specific form as incisions are aimed at complete contracture release. Because the surface deficit of the scar sheet of the fold causes contracture, determining the location, size, and form is considered the first step in contracture treatment. Scar surface deficit causing contracture occupies the joint flexion lateral surface to the joint rotation axis level, posterior neck, dorsal hand, and cheek (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9). The size and form of the surface deficit is estimated as follows: the scar sheet is separated from the healthy skin with an incision along the fold crest; then, the contracted scars on the flexion lateral (*FL*) surface are separated from the scars of the joint extension (*E*) surface with a 45° Y-shaped perpendicular incision from the fold's crest to the joint's rotation axis, malleoli, or full contraction release if contracture is cervical or commissural (microstomia and syndactyly). After joint and neck extension, finger abduction, and mouth orifice opening, as a rule, the trapeze-shaped wound is formed, reflecting the scar surface deficit form, size, and location (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9). The scar sheet surface deficit (wound) in length is maximal at the fold's crest and spreads, subsiding to the joint rotation axis, neck, hand, and cheek surface. The trapezoid form of scar surface deficit (the wound) is preserved (not triangular), independent of contracture location and severity. Consequently, the trapezoid flap (not triangular) is needed for wound covering and scar-deficit compensation. The optimal donor site for adequate (trapezoid) flap construction is a healthy medial fold's sheet and adjacent undamaged area: joint and commissural fossa, ankle and neck anterior surface. Maximal use of the local (sheets of the fold) and neighboring tissue (flexion medial surface of large joints, anterior surface of ankle and neck and commissural fossa, serving as donor sites) and adequate contracture elimination is achieved with trapeze-flap plasty (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9).

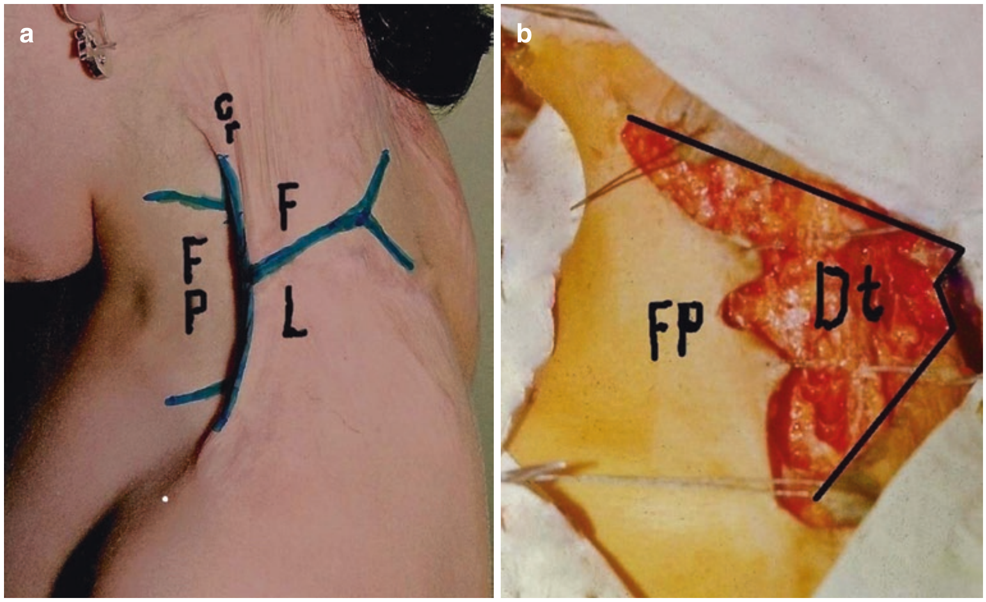

Fig. 2.10 Lateral edge neck contracture caused by trapezoid scar surface deficit. (**a**) Anatomy before operation: scars on posterior surface of the neck, fold on lateral neck, *Cr* crest of the fold; the posterior fold's sheet is scar; the medial sheet and anterior neck are healthy skin; planning of operation: line along the fold's crest for separation of scars from healthy skin, *FL* scars on flexion lateral surface causing contracture; Y-line for contracture release; *FP* two lines on the neck anterior surface are borders of trapezoid flap; (**b**) after scar dissection with a Y-shaped incision: *Dt* trapezoid wound appeared, or trapezoid scar surface deficit—real contracture cause; the end of the trapezoid wound is nearly 7 cm in length. Operation details can be found in Chap. 12

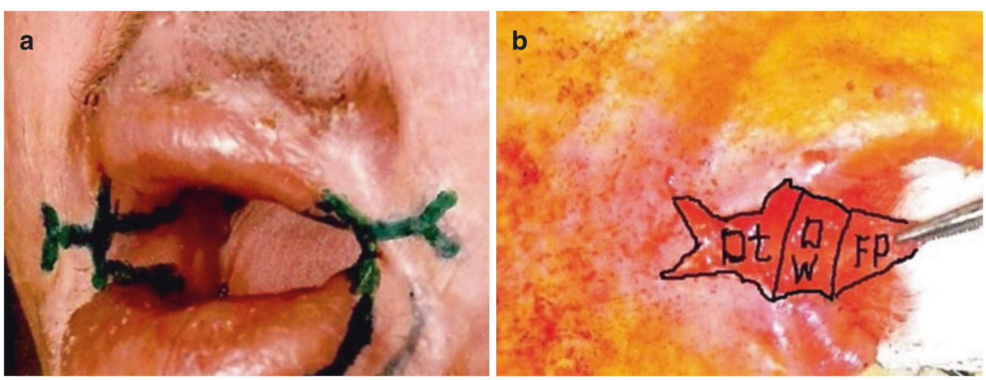

Fig. 2.11 Microstomia caused by trapezoid surface deficit in the lateral scar sheet of the fold. (**a**) Anatomy: microstomia caused by scars covered the cheek and formed the fold in the mouth angles; the lateral fold's sheet is scar, the medial sheet is healthy mucosa. Planning: Y-line incision for contracture release; a line along the fold's crest—sheet separation; two-line trapezoid mucosal flap: scars of the cheek caused a fold in commissural angle; planning of operation; (**b**) after dissection, the fold's scar sheet with a Y-shaped incision and flap mobilization: *Dt* trapezoid wound or scar surface deficit or contracture cause; *DW* donor wound; *FP* trapezoid flap. Operation details can be found in Chap. 4

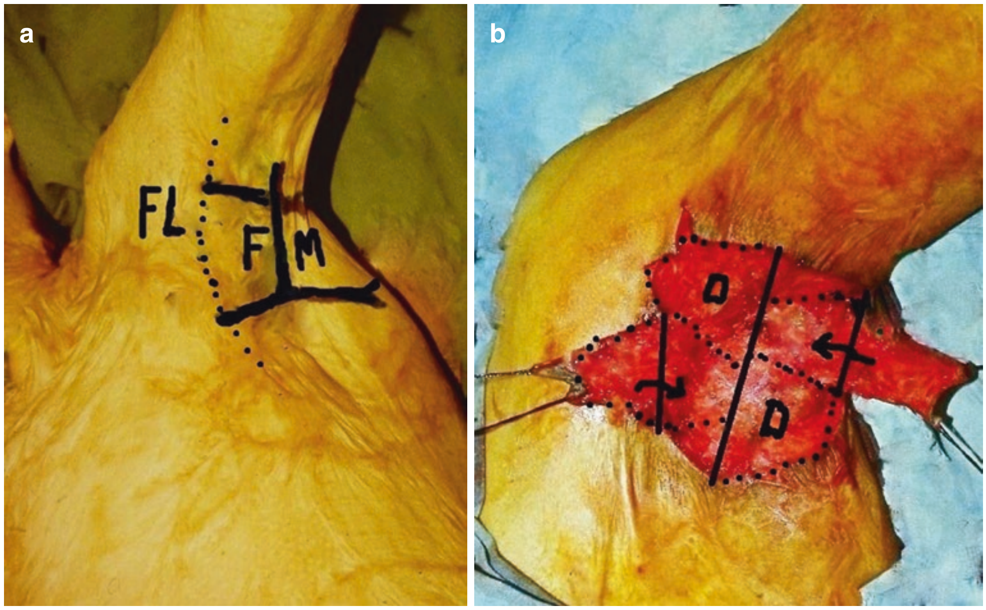

Fig. 2.12 Medial axillary adduction contracture caused by trapezoid scar surface deficit in length of both scar sheets of the fold and scars of the flexion medial surface (*FM*). (**a**) Anatomy: scar covered the axillary fossa or FM surface; scars formed a fold, both sheets of which are scars; two axillary trapezoid flaps planned in FM (fossa) surface; *FL* flexion lateral surface; (**b**) two flaps mobilized and contracture released; a large wound appeared, consisting of *Dt* scar surface deficit trapezoid form and *DW* donor wound, which is smaller than *Dt*; the flaps' surface is enough for deficit compensation and contracture elimination (Chap. 21)

Fig. 2.13 Elbow medial scar contracture caused by trapezoid scar surface deficit scars of flexion medial surface (*FM*). (**a**) Contracture anatomy: scars covered the joint FM (flexion medial) surface; scars formed a crescent fold, the *Cr* crest of which passes along the middle line of cubital fossa; the sheets of the fold are scars; three pairs of trapezoid flaps are marked; (**b**) scars of FM surface were dissected by radial Y-incisions, and trapezoid wounds appeared or *Dt* scar surface deficit—real contracture cause; and *FP* trapezoid adipose-scar flaps; (**c**) counter transposed flaps compensate surface scar deficit and contracture elimination

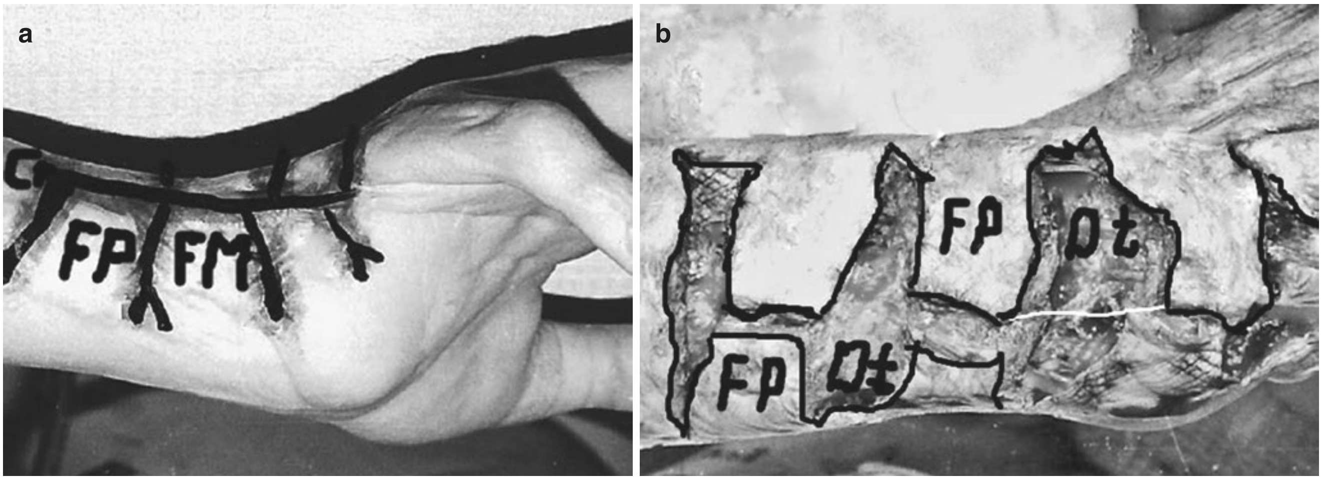

Fig. 2.14 Medial wrist contracture (ulnar hand deviation) caused by scar's trapezoid deficit of fold's sheets and scars on ulnar wrist surface. (**a**) Anatomy: scars covered *FM* flexion medial (ulnar) surface of the wrist and formed semilunar fold, both sheets of which are scars; planning of three pairs of trapezoid flaps with radial Y-incisions; (**b**) scars dissected, appeared: *Dt* trapezoid wounds or scar surface deficit (real contracture cause) and *FP* trapezoid flaps between the trapezoid Dt; flaps are used for scar surface deficit compensation (Chap. 26)

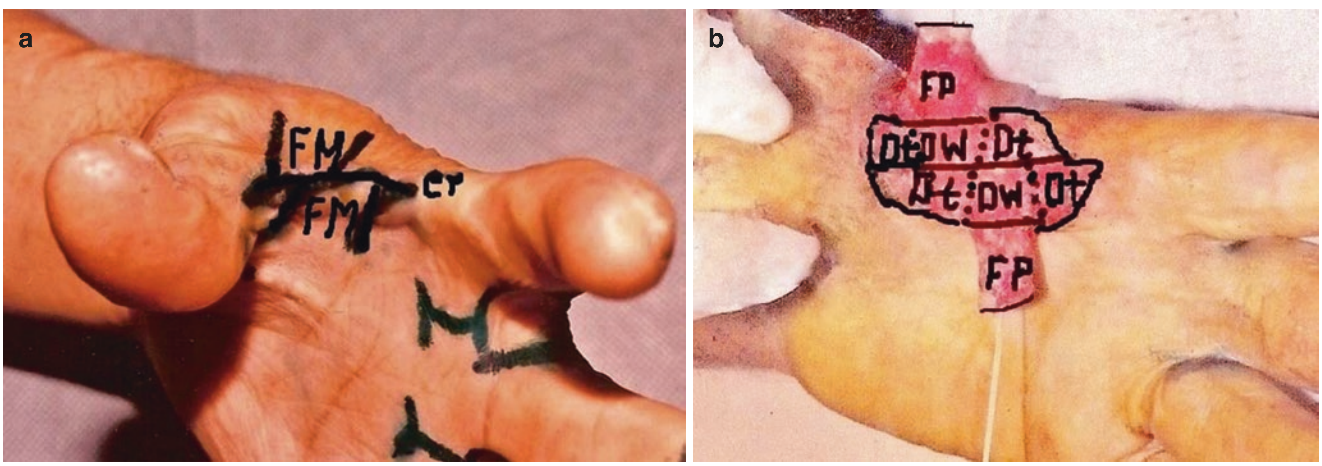

Fig. 2.15 Medial adduction contracture of first web space is caused with scars trapezoid surface deficit of both fold's sheets in length (between proximal phalange and second metacarpal bone). (**a**) Anatomy of medial contracture of first web space: Scar fold filled out web space and adducted first finger. Both sheets of the fold are scars, hawing surface deficit in length (along the fold's crest) and surface surplus in width (from the fold base to the crest); two trapezoid flaps marked. (**b**) Flaps (FP) mobilized and contracture released. Big wound appearing consisted from donor one (DW) and scar surface deficit (Dt) (beside medial line) trapezoid form (Chapter 27)

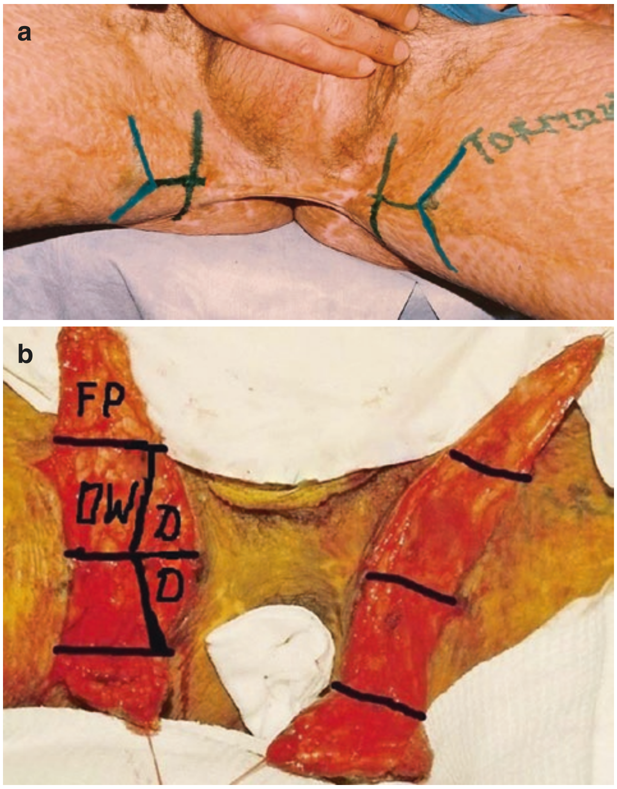

Fig. 2.16 Medial perineal contracture caused by scars, which formed transverse fold; both sheets of fold are scars and have trapezoid surface deficit in length (contracture cause). (**a**) Pre-operative view, planning two pairs of scar trapezoid flaps marked by Y-lines; (**b**) flaps mobilized with Y-incisions beside perineal raphe; two trapezoid wounds (one in every sheet) appeared with common basement (middle strip). Wound anatomy: *FP* flap mobilized; *DW* donor wound; *D* deficit of scar sheets, causing contracture. Operation details can be found in Chap. 31

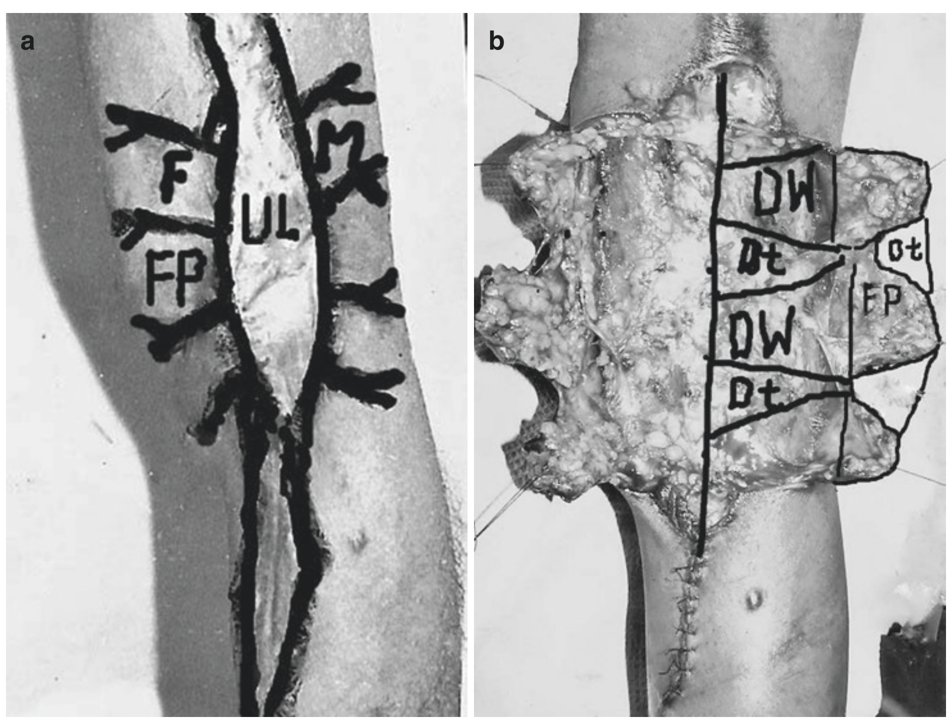

Fig. 2.17 Knee medial flexion contracture caused by scars covering the joint flexion medial surface (*FM*). (**a**) Scars formed a fold along medial flexion surface line, *UL* ulcer on fold's crest; both sheets of the fold are scars; planning of three pairs of trapezoid flaps *FP*; (**b**) after radial Y-shaped incisions and mobilization of flaps to edges of popliteal fossa, trapezoid flaps and *Dt* scar surface deficit appeared (part of wound): scar surface deficit (form and size) is among mobilized flaps (*Dt*). Operation details can be found in Chap. 33

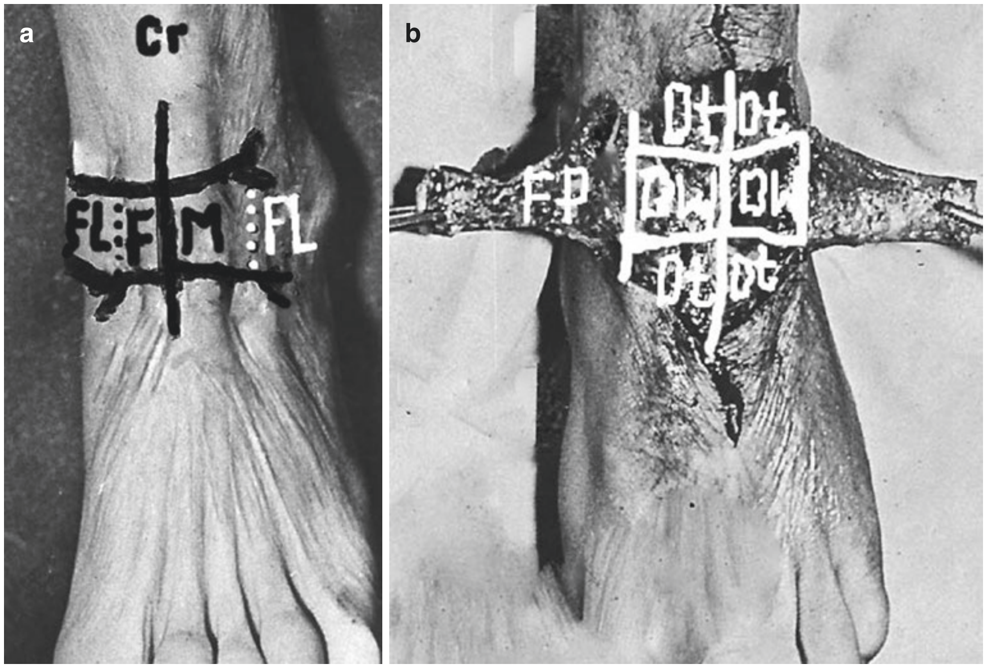

Fig. 2.18 Ankle medial dorsiflexion contracture caused by surface deficit of scars covering the joint flexion medial (*FM*) surface. (**a**) Contracted scars of FM surface or ankle anterior surface formed the semilunar fold, both sheets of which are scars and have surface deficit in length (contracture cause); *Cr* crest of the fold. Planning of two trapezoid flaps by radial Y-lines; *FL* ankle flexion lateral surfaces; (**b**) after radial Y-incisions and trapezoid flaps mobilization, a large wound appeared, consisting of two parts according to each fold's sheet (divided line along fold's Cr); every wound part consists of *Dt* surface deficit and *DW* donor wound; the flaps and the *Dt* scar deficit has trapezoid form. Common Dt surface is equal to the wound's surface minus both flaps' surfaces. Operation details can be found in Chap. 36

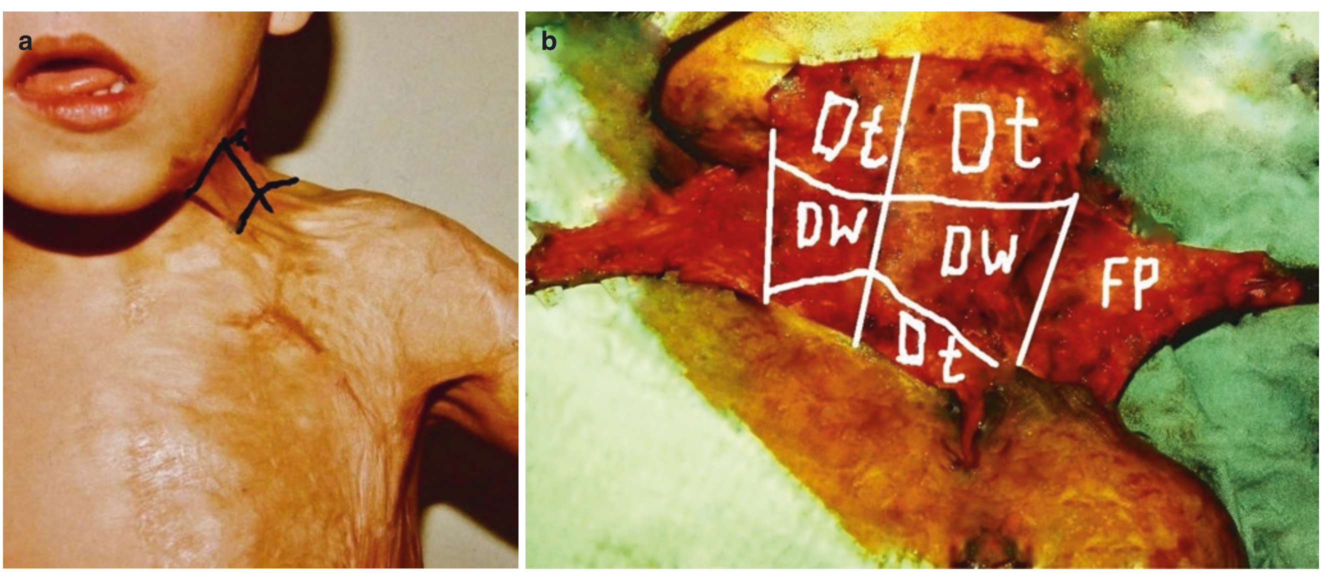

Fig. 2.19 Medial lateral neck contracture caused by scar tissue located on the lateral cervical surface and formed a fold; in the fold's sheet there is a trapezoid scar surface deficit in length, causing contracture. (**a**) Contracture anatomy: scars formed a fold, both sheets of which are scars; two trapezoid adipose-scar flaps are marked; (**b**) after flap mobilization and contracture release, two trapezoid wounds appeared with common basement (medial strip), for one flap anteriorly and posteriorly of the neck. *Dt* surface deficit; *DW* donor wound; *FP* flap; Dt and DW surfaces are nearly equal in size and have trapezoid form. Therefore, *Dt* scar surface deficit of contracted scars is real contracture cause. Operation details can be found in Chap. 12

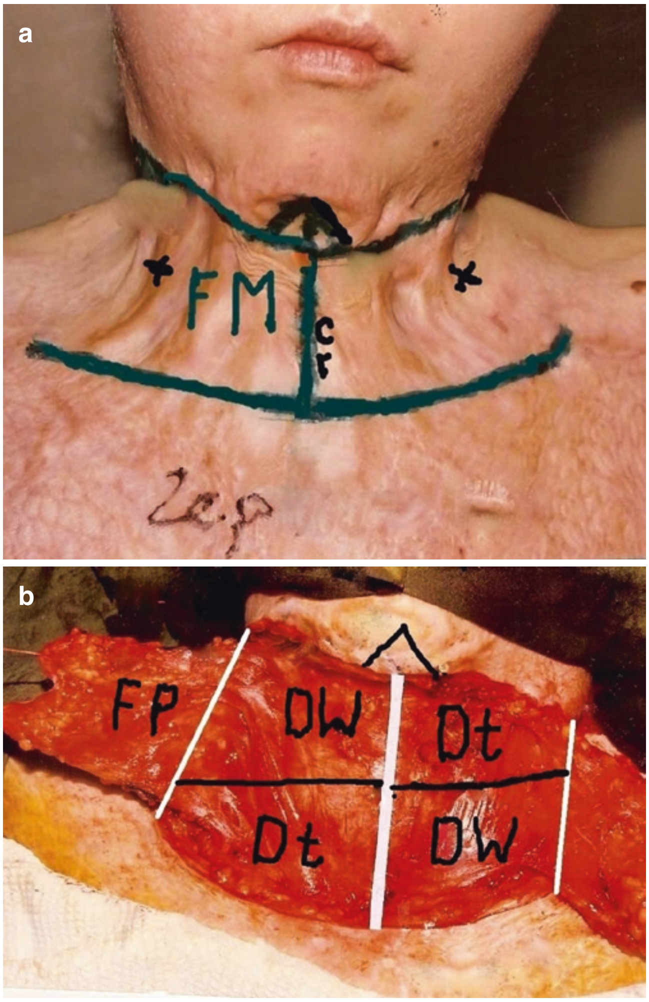

Fig. 2.20 Medial neck anterior contracture is caused by surface deficit of scars covering anterior and bilateral neck surfaces. (**a**) Anatomy: scars formed a fold; *Cr* the crest of the fold passes along the middle line of neck anterior surface; *FM* each scar sheet covers half of the anterior-lateral neck surface; "+"—exit of perforator vessels furnishing neck anterior surface. Pre-operative view, planning of two trapezoid flaps; (**b**) incisions up to the neck muscles and mobilization of two scar-fascial trapezoid *FP* flaps (one on every side of the neck); a large wound appeared, consisting of two trapezoid wounds (between strips), each of which is *DW* donor wound and *Dt* scar surface deficit. Scar surface deficit, causing contracture, equals the wound surface of both flaps minus the flaps' surface. Flaps compensated scar surface deficit and contracture was eliminated (see Chap. 13)

Scar Surface Deficit Causing Edge Scar Contractures

Edge contractures are characterized by four anatomical features (clinical signs):

(a) Contractures are caused by scars covering the joint flexion lateral surface and forming the fold located along the large joint fossa: shoulder, elbow, and knee (Figs. 2.1, 2.2, and 2.3); edge of the ankle anterior surface (Fig. 2.4); first web space (Fig. 2.5); commissural edge of the mouth orifice (Fig. 2.6); interdigital commissure (Fig. 2.7); and neck anterior and lateral surfaces (Figs. 2.8 and 2.9).

(b) The scars of the FL surface, growing distally, form the fold passing along the joint fossa edge and the edge of the commissural fossa.

(c) The lateral fold sheet is scar tissue, and the medial sheet and adjacent area are healthy skin (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9); the lateral scar sheet has a surface deficit in length (contracture cause), and both sheets have surface surplus in width allowing contracture treatment with local flaps (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9).

(d) The fold's crest is the edge of the scar (Figs. 2.1, 2.2, 2.3, 2.4, 2.5, 2.6, 2.7, 2.8, and 2.9).

Scar Surface Deficit Causing Medial Scar Contracture

Medial scar flexion contractures are characterized and caused by:

(a) Scars covering the flexion medial surface of large joints: axillary, elbow, wrist, knee, and ankle (Figs. 2.10, 2.11, 2.12, 2.13, and 2.14); first web space (Fig. 2.15); flexion surface of interphalangeal joints (Fig. 2.16); nose, anterior and lateral neck (Figs. 2.17 and 2.18); perineum (Fig. 2.19); and lateral truncal surface (Fig. 2.20).
(b) Scars forming a fold located along the medial line of the joint flexion surface, nose, anterior and lateral neck, lateral trunk, and perineum (Figs. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20).
(c) The sheets of both folds are scars and have surface deficit in the length, causing contracture, and scar surface surplus, allowing the contracture elimination with local flaps (Figs. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20).

The form and size of the scar sheet surface deficit is estimated as follows: The fold's sheets are separated with an incision along the fold crest; scar sheets covering scars of the flexion medial surface (*FM*) are dissected with a perpendicular Y-shaped radial incision, which is divided at 45° to the joint fossa edges or flexion lateral surface (*FL*) (large joints), the joint rotation axis of small joints, and full contracture release on cheek, neck, perineum, and lateral trunk.

The size and form of the scar surface deficit of medial contracture of the perineum, first web space commissure and wrist, and anterior and lateral neck and trunk, are estimated with the same method: The fold's sheets are separated with an incision along the fold crest. The contracture is completely released with a radial cross-cut Y-shaped incision. The wound (scar surface deficit) and the flap (semilunar fold) accept, as a rule, the trapezoid form, independent of the number of cross-cut Y-incisions (Figs. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20). Both sheets, in all their extensions, including the subcutaneous fat layer, are converted into adipose-scar flaps with radial Y-incisions; regardless of the number of incisions, wounds (scar surface deficit) and flaps accept the trapezoid form. As wounds and flaps have a trapezoid form, the counter-transposition of which allows the scar surface deficit compensation, wound covering and full contracture elimination are achieved with a single procedure (Figs. 2.10, 2.11, 2.12, 2.13, 2.14, 2.15, 2.16, 2.17, 2.18, 2.19, and 2.20).

Uniformity (trapezoid) of scar surface deficiency or wounds, appearing after edge and medial contracture release (contracture cause), makes adequate flap planning (semilunar fold) and reconstruction implementation understandable, simple, safe, and easy.

Scar Surface Deficit of Total Scar Contracture

Scar surface deficit of total scar contracture becomes obvious after contracted scar dissection at the joint rotation axis projection; the appearing wound has a different size and form, the resurfacing of which requires a skin graft, regional pedicle, or free flaps (Fig. 2.21).

After extensive burns, rough hypertrophic scars often grow. Large skin surfaces deformed by scars are combined with scar contracture and injury of donor sites. Vast scar deformity excludes any type of local and regional flap-plasty (Fig. 2.22). Rough hypertrophic ulcerous and pathologic scars undergo excision after their maturation and wound resurfacing with skin transplants (Chap. 40).

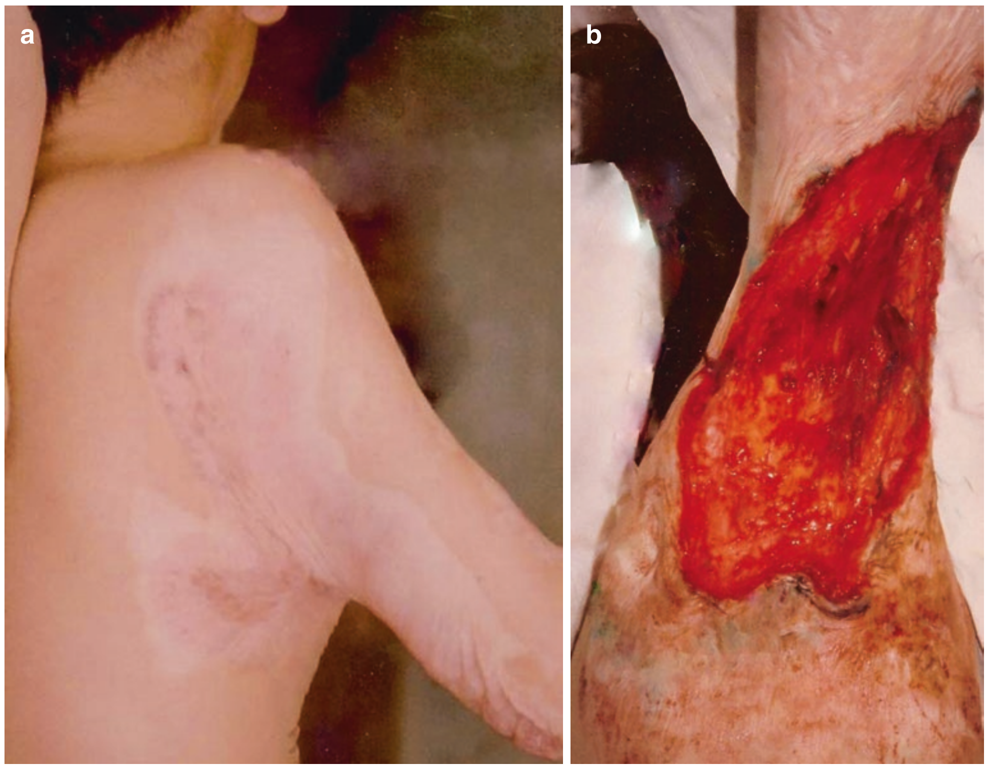

Fig. 2.21 Total shoulder adduction contracture is characterized by vast scars, tightly surrounding shoulder flexion (abduction) surface circularly, absence of a fold (surface surplus) and severe scar surface deficit. (**a**) Total shoulder adduction contracture; (**b**) after contracted scars dissection, large wound appeared, reflecting severe scar surface deficit, which does not have a specific form

Fig. 2.22 Total wrist flexion contracture development after deep burns and skin grafting, after which a fold or scar surface surplus has not formed. (**a**) Severe flexion wrist contracture, no fold, and scar surface surplus; (**b**) contracted scars incised and excised, a large wound appeared without specific form

Conclusion

The joint rotation axis divides a joint's surface on flexion and extension (*F* and *E*); curvature of a large joint's flexion surface (*F*) is along the joint fossa edge on flexion lateral (*FL*) and flexion medial (*FM*). Contracted scars are tightly connected when not contracted. For complete contracture release and free divergence of the wound's edges, scars that are contracted should be separated from those that are not contracted. This is achieved by dissecting contracted scars with a Y-shaped incision; after full contracture release and joint extension, the trapezoid, not triangular, wound appears. This means that at the joint rotation axis level (edge contractures) and the edge of the joint's fossa (medial contracture), the scar contraction does not equal zero, but has a linear size. As the scar surface deficit (contracture cause) has a trapezoid form, adequate contracture elimination can be achieved with similar (trapezoid) flaps. Trapeze-flap plasty allows for the effective use of the fold sheets surface surplus and neighboring tissue to achieve full edge and medial contracture elimination (85% of the total number). Trapeze-shaped scar surface deficit (contracture cause) indicates that local triangular flaps do not match the scar surface deficit, and the further use of Z-plasty and Y-V plasty is anatomically unsubstantiated.

Insufficient anatomical study and absence of anatomical classification has not allowed for development of anatomically-based surgical techniques for the treatment of scar contractures. Therefore, Z-plasty and Y-V plasty, based on triangular pointed flaps, are basic local-flap techniques that are used despite their imperfection and disadvantages. Conventional Z-plasty, for example, frequently leads to varying degrees of necrosis of the tips of the transposed flaps.

The data in the literature show that the most serious disadvantage of Y-V plasty is the restricted displacement of the immobilized flaps. After exploring the rehabilitation level of burned patients, Klein [2] concluded that it is apparent that one should expect an evolution in surgical techniques and technologies that can improve the function and appearance of people with burn injuries.

It is impossible to justify the choice of surgical techniques and estimate their efficacy without the use of a commonly accepted anatomical classification; therefore, the understanding of postburn scar contracture anatomy, including the scar surface deficit, is the first and main step towards surgical rehabilitation and the success of scar contracture treatment.

References

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3 Single-Stage Upper Lip and Philtrum Reconstruction in Burned Patients

Introduction

The upper lip is an important functional and esthetic feature and it has a defining role in the concept of modern beauty. Therefore, the upper lip, including all three of its subunits (philtrum and two laterals), should be reconstructed with a single-stage procedure. Such a technique, as the literature shows, has not yet been developed. Our new technique of total upper lip restoration with philtrum reconstruction is based on creating philtrum columns by preserving thicker and more rigid strips of scar tissue over the intended location of the philtrum and excising the rest of the scar of the upper lip. A single-flap skin graft covers all of the upper lip and the space between philtrum columns. A dedicated tied-over compression dressing allows creation of an anatomical depression between philtrum columns, restoring proper anatomy of the upper lip.

Anatomical Features of Burned Upper Lip and Philtrum

Facial burns cause multiple forms of damage. Total upper lip and philtrum injury is one of them. Several esthetic units are involved. The existing methods of reconstructive operations on the upper lip and philtrum were developed to eliminate small upper lip defects. The deformed-by-scars contracted upper lip is narrowed, shortened, and everted (ectropion), and the philtrum is replaced by scars. The scar excision and skin-grafting techniques that are currently being applied to treat the postburn upper lip do not restore the philtrum (Fig. 3.1b, c).

As a result, the lip receives a rounded smoothed shape, which distorts the appearance of the face and results in a major esthetic defect. The secondary re-creation of the philtrum dimple, using a composite skin-cartilage graft from an ear, slightly improves the contour of the lip. McCauley and Killyon [1] reported: "Reconstruction (of the upper lip) without a presence of a philtrum is more difficult. Unfortunately, most of our literature on reconstruction of the philtrum comes from correction of secondary cleft lip deformities… However, major losses of the philtrum require more innovative technique…" (p. 323–4).

Based on our assessment of thickness and elasticity of scars removed from the upper lip, we decided to use scars for philtrum column restoration. Further experience allowed development of a new method for rebuilding the upper lip with philtrum [2, 3]. In this chapter we describe a new, effective, single-stage method of upper lip and philtrum restoration.

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Fig. 3.1 Anatomy of postburn face deformity, including upper lip and philtrum, before and after skin grafting. Patient 1: (**a**) Before surgery: total postburn face and neck deformity, the lip eversion (ectropion), no philtrum. (**b**) 10 months after scar excision and skin grafting without philtrum rebuilt: smoothed upper lip. Patient 2: (**c**) Follow-up result after upper lip scar excision and skin grafting: smoothed, rounded, but abnormal-looking upper lip. (**d**) Columns formed from scars and skin transplant, remaining scars excised; upper lip covered with skin transplant, compression in philtrum groove made with tie-over dressing

Fig. 3.2 Philtrum restoration and upper lip reconstruction with local scars and skin grafting. (**a**) Before surgery, planning: column location, scar boundaries to be excised; (**b**) scars excised laterally and between columns, the epithelium removed from scar strips (columns); two expanders inserted in submandibular regions for future total face reconstruction; (**c**) upper lip covered with split skin transplant, the compression bolster placed in the groove between the ridges and fixed with tie-over dressing; (**d**) 7 days after surgery: columns and groove are visible. (**e**) 2 weeks after reconstruction; skin transplant is stable, philtrum and upper lip restored

Surgical Technique of Upper Lip and Philtrum Restoration

The surgery is performed only when the scars are mature (Fig. 3.2). The positioning of the ridges and the boundaries of scars to be excised are outlined (Fig. 3.2a, b). The width of the scar strips, which will later serve as the tops (crests) of the philtrum's ridges, need to be around 4 mm. Incisions on the lateral and medial sides of the marked ridges are directed at a 45° angle away from the ridge. Scars, lateral to the ridges and between them, are excised, allowing the remaining scar strips to stand out as ridges. Epithelium is then removed from the scar ridges and the lip is covered with a continuous split skin transplant.

After the skin graft is sutured in place, the two U-shaped sutures are led through the skin transplant through both ridges and under the groove's soft tissues. Gauze bolster is prepared in accordance with the length of the groove between the ridges. It is then placed in the groove and tied-over by previously inserted U-shaped sutures. This dressing generates proper compression to allow proper attachment of the graft and formation of the anatomical shape of the philtrum groove. The tie-over dressing for both sides of the upper lip and the philtrum are carried out separately. The dressings are replaced for the upper lip in 5 days, and for the philtrum in 7 days (Fig. 3.2d).

In most cases, restoration of the upper lip and philtrum is part of a much larger facial reconstruction. For example, reconstruction of the nose may be performed simultaneously (Fig. 3.3).

Fig. 3.3 Results of the philtrum, lip, and nose reconstruction. (**a**, **b**) Before surgery: severe deformity of the upper lip, nose, and philtrum destruction; (**c**, **d**) 2 months after reconstruction: scars have been excised and the wound covered with skin transplants; the restored philtrum adorns the upper lip and the whole face

When the upper lip and philtrum are part of a larger lower facial deformity, reconstruction is accomplished with an ascending neck flap (Fig. 3.4) or skin transplants (Fig. 3.5). Philtrum restoration is a very important part of the reconstruction of a deformed perioral region (Fig. 3.5).

In case of total face deformity, the philtrum and upper lip restoration are performed as a part of total face reconstruction (Fig. 3.6).

Fig. 3.4 Simultaneous elimination of multiple face deformities with upper lip and philtrum restoration. (**a**) Before surgery: multiple face deformities (absence of the philtrum, severe contracture of the lips, nose, cheeks, and chin deformity; (**b**) planning: bilateral partial cheek, chin, nose, and upper lip scar excision and philtrum restoration; (**c**, **d**) 6 months after philtrum restoration and partial face reconstruction

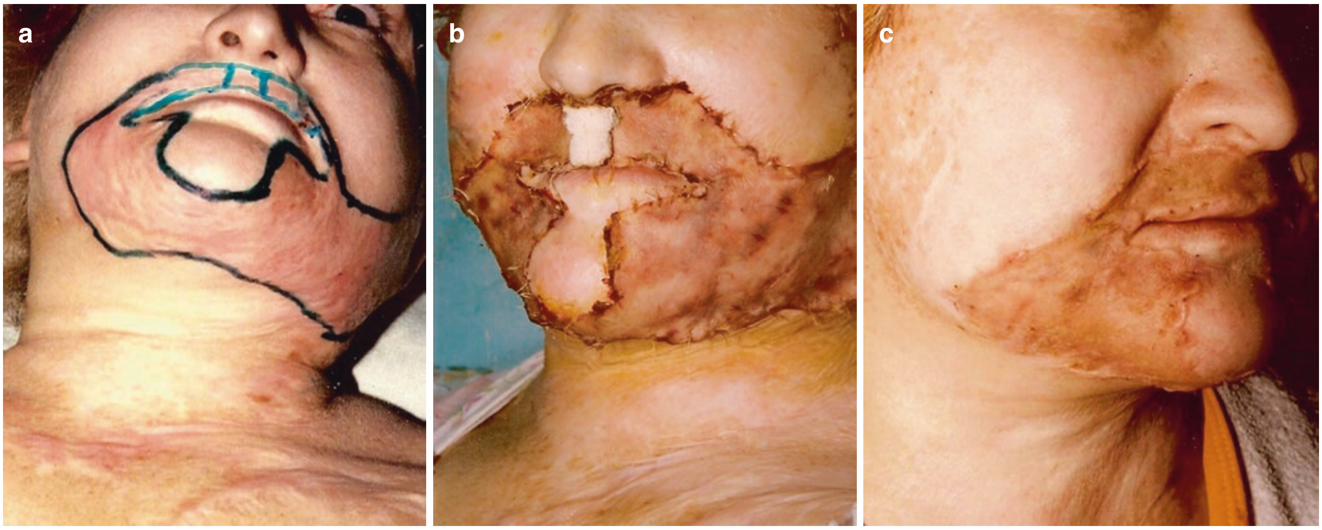

Fig. 3.5 Result of philtrum, upper lip, and perioral region reconstruction. (**a**) Philtrum absent, planning; (**b**) 7 days after surgery; (**c**) 2 months after reconstruction

Fig. 3.6 Results of face reconstruction with skin transplants, including upper lip and philtrum. (**a**) Pre-surgery view, planning; (**b**) 7 months after face reconstruction, including lips and philtrum

Conclusion

This technique carries a very low risk of complications. The use of this method allows for the achievement of normal esthetic characteristics and shape of the upper lip as well as the philtrum. The skin transplant is usually well grafted, preserving both the crests of the ridges and the groove of the philtrum. The ridges and the groove become clearly visible. The ridges maintain their height and length, since mature scars did not thin out or dissolve. The depth of the groove may become shallower over time, yet it remained visible at long-term follow-up. The upper lip contours and shape were within normal limits. The transplant acquired the properties of healthy skin without shrinking or lip contracture (ectropion) recurrence. No special pressure garment was used. Columns from scars, covered with skin transplant, do not dissolve, and the effect appears to be stable. Long-term follow-up results were good, and patient satisfaction was high. This simple technique solved the problem of restoration of shape and surface of a burned upper lip and philtrum without significant technical difficulties or complications.

Suggested Readings

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4 Postburn Microstomia: Anatomy and Elimination with Trapeze-Flap Plasty

Introduction

After facial burns, the commissural mucosa remains undamaged and scars form on the external surface of the mouth corners where the scar fold forms, narrowing the oral orifice and causing microstomia. The lips grow together, and the angles become obliterated. A small oral opening restricts oral intake, routine oral hygiene, dental procedures, and intubation in case of surgery. According to most authors, the scar tissue must be removed from the commissural angle; the wounds are closed with Y-V plasty or with the use of mucosal flap variations. Scars located in the corner of the mouth orifice have a trapezoid surface deficit and their removal increases the defect.

Therefore, we developed a method that consists of contracture release by scar dissection with a Y-incision up to the normal size of the orifice. After opening the mouth, a trapezoid wound appeared (scar surface deficit), and this was covered with a trapezoid mucosal flap.

Anatomy

The fold that causes microstomia (oral commissure contracture) consists of two sheets: the *lateral* sheet (or external sheet in the case of the mouth cavity) consisting of scars, and the *medial* sheet, which is healthy mucosa (Fig. 4.1). Usually, the lips' vermilion borders are injured and replaced by pale scars; the vermilion borders become smoothed. This is a typical edge contracture according to our classification. It is caused by the surface deficit of the lateral scar sheet and the scars of the oral commissure zone. The crest of the fold is the edge of the scars. The size and shape of the scar deficit that causes contracture can be determined in the following way: The fold's sheets are divided with an incision along the crest of the fold, then the scar sheet is dissected with a Y-shaped incision to the normal commissural level; the oral orifice is opened manually. A Y-shaped incision allows divergence of the scar edges, and complete contracture release and microstomia elimination, *without* going off the normal oral angle level. The incision can be extended for a complete contracture release. In case of incomplete contracture release, the rough scar borders are separated from the *orbicular oris* muscle. As a rule, the trapeze-shaped wound that is formed matches the size and form of the scar-surface deficit (Fig. 4.2b). There is no scar surface surplus at the oral angle. The bottom of the wound consists of a mucosal medial sheet and *orbicularis oris* muscle. The medial (internal) fold's sheet and the neighboring mucosa can be used for covering the wound and restoring the commissure. Consequently, the oral angle restoration, or commissural contracture release, or microstomia elimination, should consist of the dissection (not excision) of the contracted scars with a Y-shaped incision and wound coverage with the mucosal trapezoid flap (Fig. 4.2).

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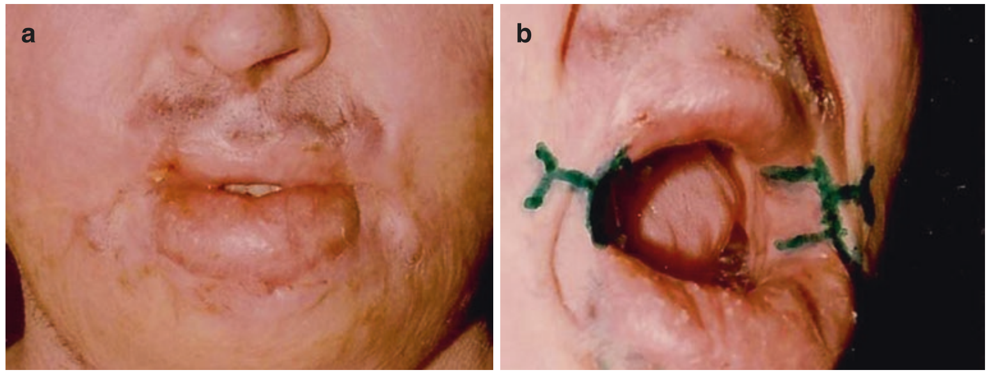

Fig. 4.1 Anatomy of postburn scar microstomia. (**a**) Severe oral orifice constriction; (**b**) microstomia caused by scars located on the cheek, which form a crescent-shaped fold; the external sheet of the fold is scar, the internal sheet is mucosal tissue. Surgery planned: one-flap trapeze-flap plasty

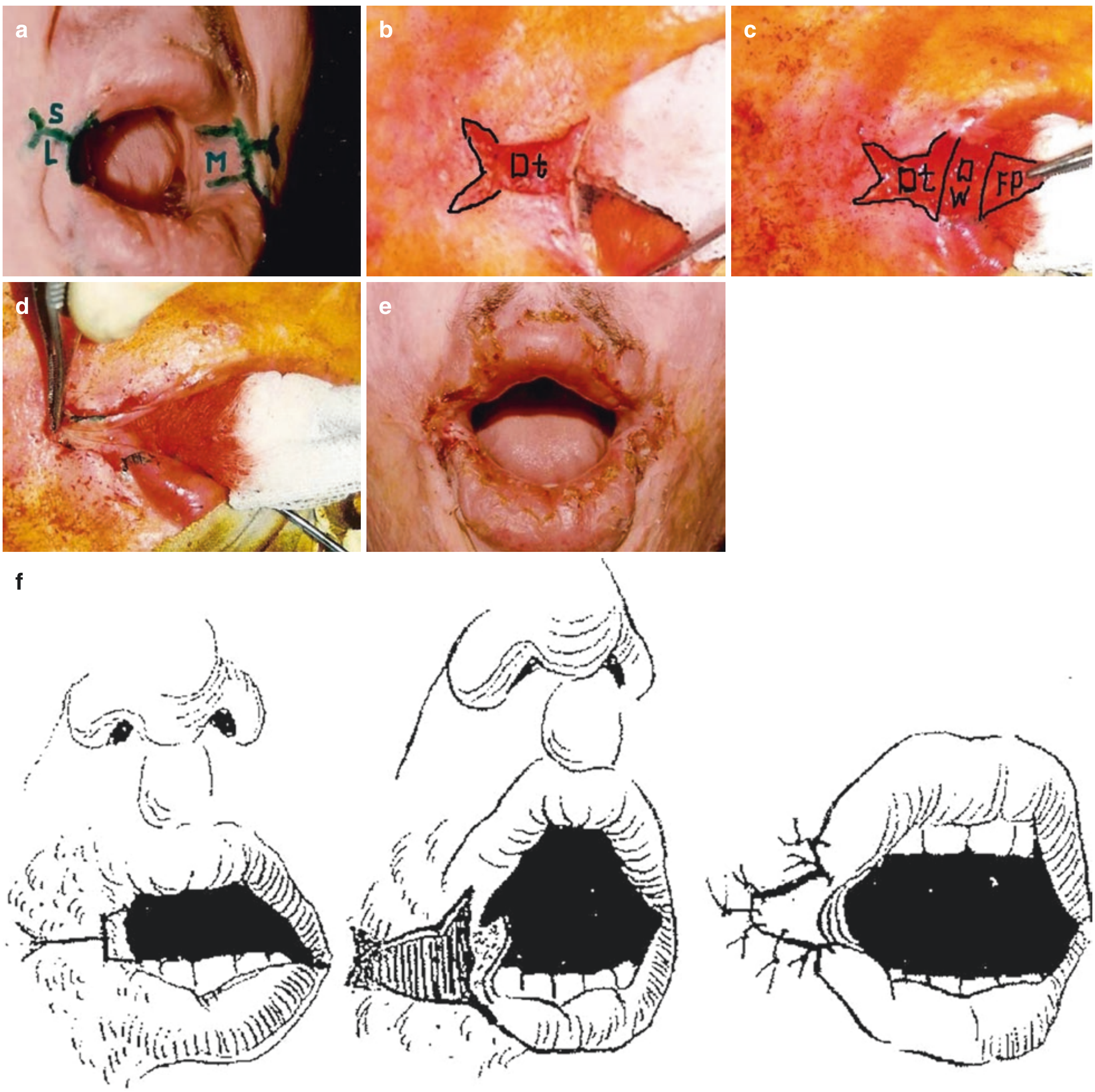

Fig. 4.2 Microstomia release and oral angle restoration with trapeze-flap plasty. (**a**) Pre-surgery, severe microstomia, anatomy; *SL* scar lateral fold's sheet; *M* mucosa; planning: lines: fold's sheets division along the fold crest, *Y* line of scar dissection, two lines on mucosa and medial fold's sheet—flaps borders; (**b**, **c**) after scar dissection and contracture release: wound (*Dt*) scar surface deficit accepts a trapezoid form; trapezoid flap (*FP*) mobilized; (*DW*) donor wound; (**d**) flap advanced on the wound; (**e**) 10 days after operation: microstomia eliminated, oral commissures restored; (**f**) scheme of trapeze-flap plasty

Surgical Technique

The oral angle contractures are of the edge type and are caused only by the lateral scar sheet of the fold (Fig. 4.1). Because the scar surface deficit has a trapezoid shape, the reconstruction is accomplished by dissecting scars and covering wounds with a trapezoid flap prepared from the medial fold's sheet and neighboring mucosa.

The surgical plan consists of drawing several lines: (1) along the fold's crest; (2) Y-shaped (slight upward direction) line of the scar's incision to the normal commissural level (vertical mid-pupillary line); and (3) lines outlining a trapeze-shaped flap on the mucosa (Fig. 4.2a). Drawing these lines allows one to estimate the size of the wound and the required flap size. The flap is designed to be larger than the wound surface by approximately 30–40%.

At first, the fold sheets are separated (scars from mucosa) with an incision made along the fold's crest; then, the scars are dissected and the contracture is released with the perpendicular Y-shaped incision. The Y-shaped end of the incision helps additional scar divergence and full contracture release. As a rule, a trapeze-shaped wound is formed (Fig. 4.2b). The scar's border is separated from the *orbicularis oris* muscle. If the scars are thick, the inner scar layer is removed, leaving a scar that is 2–3 mm thick. Then, the trapezoid flap is mobilized from the medial sheet (oral mucous membrane) (Fig. 4.2c). After adequate oral opening is achieved, the trapezoid flap is sutured in place, covering the oral commissure and the trapezoid-shaped wound that formed after Y-dissection of the scar contracture of the lateral mouth corner.

Conclusion

Good outcomes were achieved using trapeze-flap plasty (Fig. 4.3), even in cases when microstomia elimination was performed very soon after burns and when the scars were not yet mature, frequently as the first step of facial reconstruction. No flap loss or other postoperative complications occurred due to widespread mucosal blood circulation. After healing, the mucosal flaps gradually became vermilion borders; when the mouth was closed, no mucosa was visible. The functional follow-up results were good if contractures were released completely during surgery; cosmetic results were good, as the vermillion border levelled with the scars. In children, the mucosal flap continued to grow, preventing recurrence of microstomia. Oral commissure restoration, along with perioral area resurfacing, provides a significant improvement in the appearance of the face.

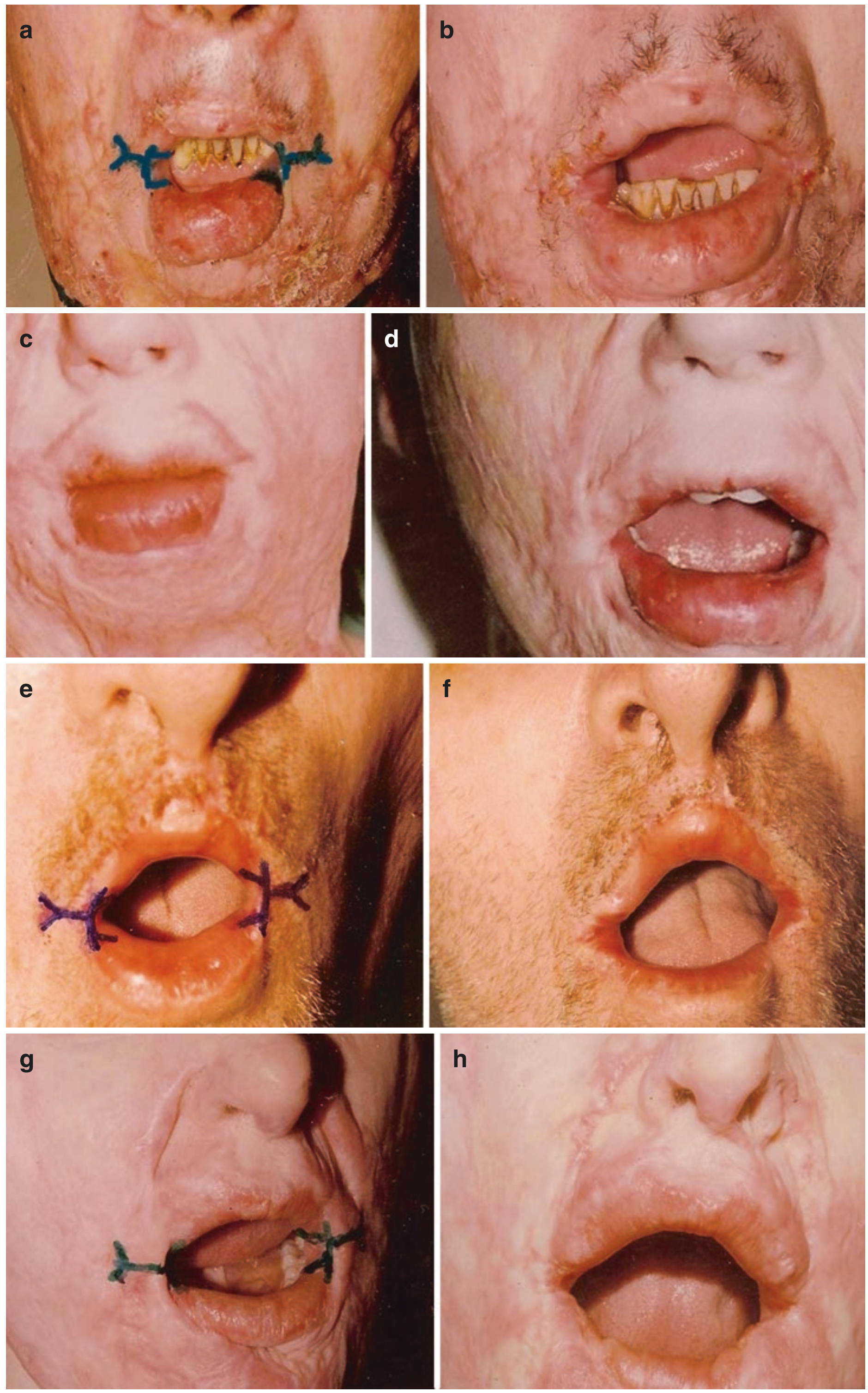

Fig. 4.3 Follow-up results of microstomia release with trapeze-flap plasty in four patients. (**a**, **c**, **e**, and **g)** Pre-surgery; (**b**, **d**, **e**, and **h**) follow-up results

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5 Elimination of Postburn Dorsal Nasal Contracture

Introduction

Because of its anatomical location and forward protrusion, the nose incurs more severe burns, especially the alae and dorsum. The nose is shortened, its tip is pulled up, the nasofrontal angle (nasion) is smoothed, and the epicanthus/fold appears at the medial corners of the eyes. Scars in children are especially traumatic because of the restriction of nose growth over time. Therefore, the nose contracture should be released early, before reconstruction of the rest of the face. A wide scar in the glabella allows for the nasofrontal angle and medial canthus of eye to be reconstructed with local flaps; the preferred technique is trapeze-flap plasty.

Contracture Anatomy

Nasal contracture is caused by scars that spread over the nose bridge, nasion, canthal area of the eyes, and glabella region of the forehead. As a result of the vertical contracture of the scars, the nasal dorsum becomes wider, scar folds form over the medial corners of the eyes (epicanthus), the nasofrontal angle disappears, and the nasal tip is pulled up (Fig. 5.1a, b). Because of scar protrusion, the scar surface surplus is formed in the zone of the nasofrontal angle (nasion) in the intercanthal region. This allows contracture to be eliminated using local tissues only. Therefore, nasal contractures are of the medial type, according to our classification, and are best treated with plasty using opposing adipose-scar trapezoid flaps.

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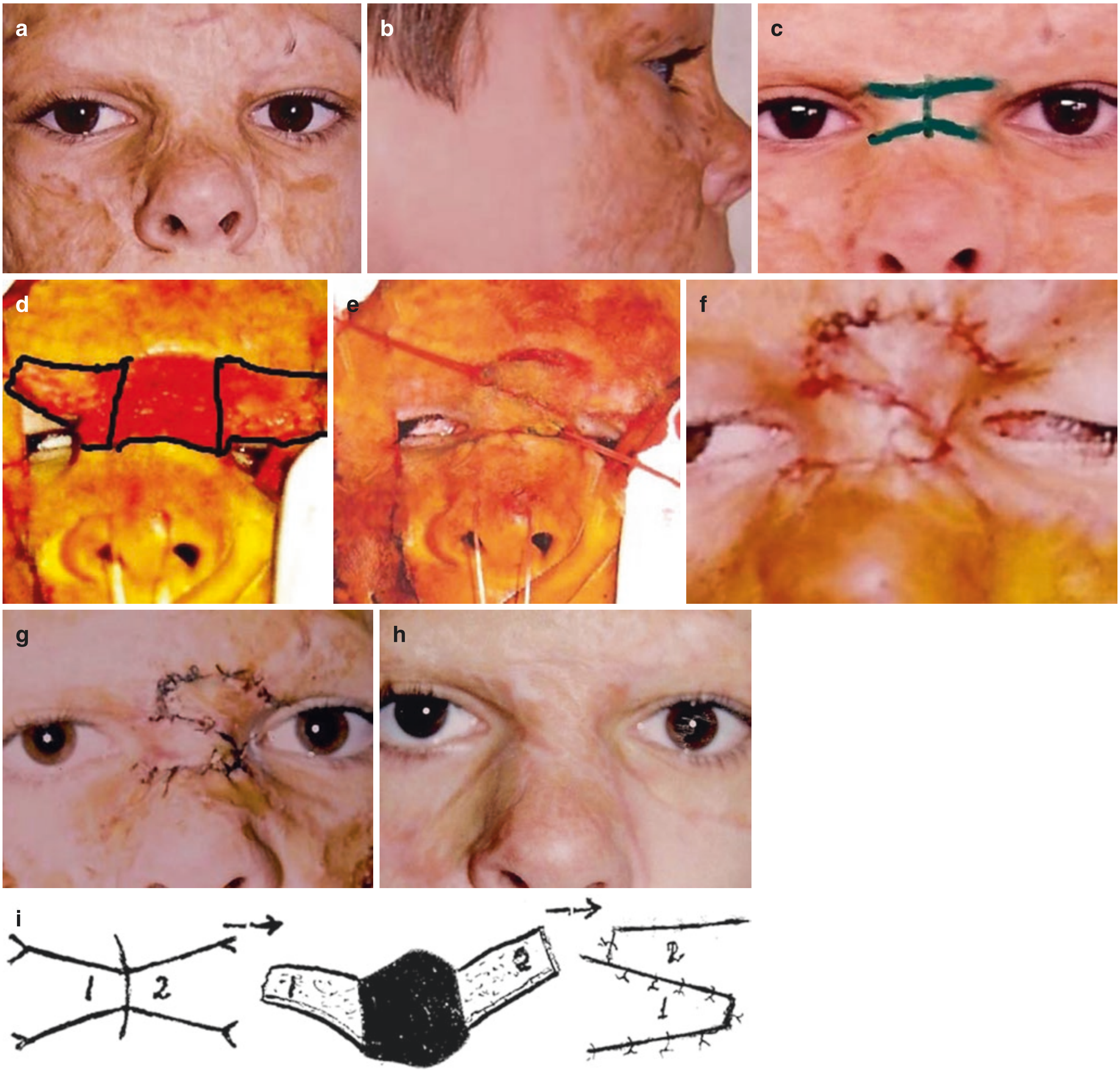

Fig. 5.1 Nasal contracture released with trapeze-flap plasty. (**a**) Preoperative view: face deformed with scars including the forehead, nose, and medial part of cheeks; nasal contracture, nasofrontal angle smoothed, wide; epicanthus formed bilaterally; (**b**) nose shortened, nose tip elevated; (**c**) trapeze-flap plasty planning: opposing flaps in nasofrontal angle zone, apex of the trapeze flap is at midline, base at medial canthus; (**d**) trapezoid adipose-cutaneous flaps mobilized and transposed towards one another; (**e**) transposed flaps sutured in place; (**f**) end of operation; (**g**) 7 days after reconstruction: flaps are viable, nose elongated by 1.5 cm, epicanthus eliminated, nasofrontal angle restored; (**h**) 2 years after reconstruction: normal nasal development, no nose contracture or deformity recurrence; (**i**) trapeze-flap plasty (scheme)

Surgical Technique

Reconstruction is aimed at the release of the nasal dorsum contracture, elimination of the epicanthus, restoration of nasofrontal angle depth, and thinner nasal dorsum (Fig. 5.1c–f). Two trapezoid flaps are marked in the nasofrontal angle (Fig. 5.1c). The suture is applied through the nasal tip for traction (Fig. 5.1d). The tips of the flaps correspond to the nasal dorsum medial line and are approximately 1 cm in width; the bases of the flaps are located at the level of the inner corner of the eye and are approximately 1.5 cm wide. The flaps are mobilized with a full subcutaneous fat layer until the contracture is completely released and the epicanthus is eliminated (Fig. 5.1d). By applying traction via suture and elevating scars on the contracted nasal dorsum, the contracture is released, and the nose elongated. As a result, the nasal dorsum wound becomes narrower, the nose longer, and the nasal tip reaches the appropriate level. Then, the flaps are transposed towards one another with moderate tension, so that the apex of one flap reaches the base of the opposite flap (Fig. 5.1e, f). The flaps are sutured to each other and to the wound borders. Results are shown in Figs. 5.1g, h and 5.3. Simultaneously, other anatomical facial units may be reconstructed. The scheme of the operation is shown in Fig. 5.1i. Trapeze-flap plasty is successfully used in cases of severe nasal deformity in patients of any age, including young children (Figs. 5.2 and 5.3).

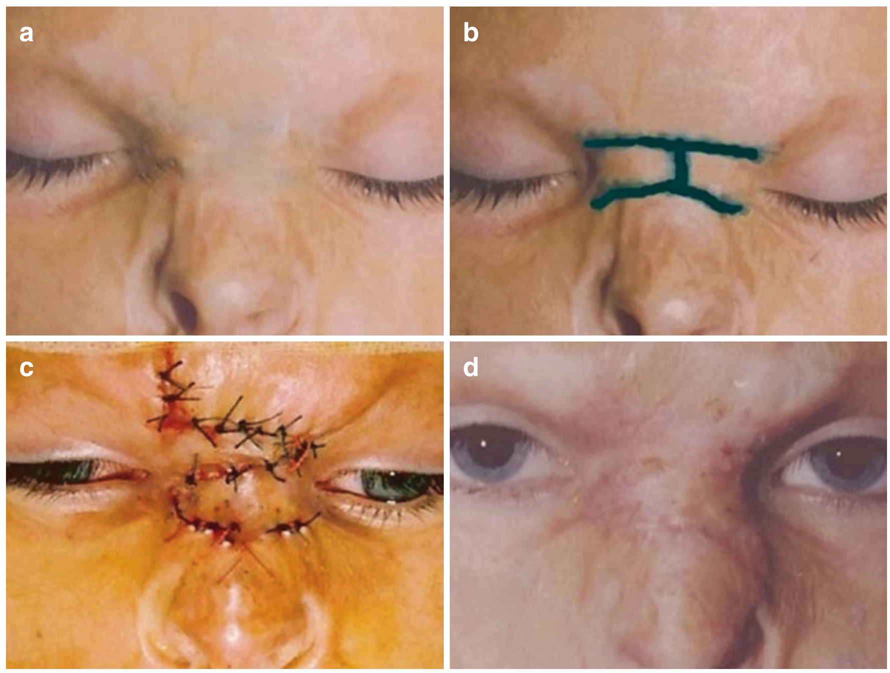

Fig. 5.2 Postburn nasal contracture release with trapeze-flap plasty. (**a**) Pre-surgery: nasal contracture and deformity, medial epicanthus, nasofrontal angle smoothed, wide; (**b**) trapeze-flap plasty planning; (**c**) end of operation: adipose scar trapezoid flaps counter-transposed; (**d**) 2 months after reconstruction: flaps alive, nose elongated, epicanthus eliminated, and nasofrontal angle restored

Fig. 5.3 Follow-up result after full face reconstruction, including nasal contracture release: nose contracture eliminated, nasofrontal angle restored

Conclusion

As a result of trapezoid adipose-scar flap transposition, the plasty zone and the nose itself are elongated by 1.3–1.8 cm (average of 1.5 cm). Epicanthus (scar fold over the medial corner of the eye) disappears; nasofrontal angle depth and nasal bridge shape are restored. The flaps have a steady blood circulation and do not undergo rotation; therefore, no flap loss or other postoperative complications occur. Follow-up results are good; long-term follow-up did not reveal any flap shrinkage, re-contracture of the nasal dorsum, or epicanthus recurrence. The nasofrontal angle (nasion) retains its normal depth; the nasal dorsum preserves normal width and contours. Operational scars and flap borders become barely visible. Nasal contracture elimination, elongation of the nose, nasal dorsum and nasofrontal angle restoration, and elimination of epicanthus significantly improve facial appeal.

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6 Split Ascending Neck Flap in Burned Face Resurfacing

Introduction

Postburn face and neck deformities, contractures, and large nevi are very traumatic cosmetic defects for patients and present serious problems for surgeons. Much attention is therefore paid to the development of the most effective reconstructive techniques. The problem is especially pressing in cases of total or extensive deformities (more than half of the cheek plus neck damage). The skin of the neck matches the skin of the cheeks better than any other transplant, but its displacement is restricted by platysma. Axial vessels are frequently injured during mobilization of the cervical flaps, leading to tissue necrosis. We overcame these obstacles by locating and preserving the vascular bundle of the skin of the anterior neck surface. Tissue expansion may be used to make neck flaps larger; however, a high rate of complications restricts extensive use of expanders. Various flaps are moved or rotated from neighboring and distant regions, and free tissue transfer has been used. However, differences in skin quality is a serious cosmetic disadvantage of these flaps.

Anatomy and Variants of the Split Ascending Neck Flap

The flap's name, *split ascending neck flap*, was proposed by Dr. Joel Feldman, a well-known plastic surgeon, who was a reviewer of the original article published in 1993 [1]. The flap has axial circulation and consists of healthy skin of the anterior surface of the neck with a thin layer of fat; platysma remains in place and is not disrupted. The critical goal of this technique is to preserve axial circulation of the flap. This area of the skin is supplied by a *superficial cervical artery perforator* that exits behind the middle portion of *sternocleidomastoid muscle*. Axial vessels originate from that anatomical point and must be spared and remain in situ (Figs. 6.1 and 6.2, symbol "+"). Axial circulation of the cervical skin, preserved during the flap mobilization, allows:

(a) Mobilization of a thin neck flap (without platysma, i.e.,"split" flap);
(b) Transposition of the flap with tension;
(c) Prevention of postoperative complications caused by insufficient blood supply.

The usual cervical flap transposition on the cheek is about 4–6 cm (Fig. 6.2a, b). Displacement of the flap can be increased considerably when including in the flap (via mobilization) the anterior thoracic adipose-cutaneous layer, which is separated from the clavicles, sternum, and pectoral fascia down to the level of the second rib and anterior axillary edge (Figs. 6.2, 6.3, and 6.4). In this way, the cervico-thoracic flap is formed without thoracic skin incision. The thoracic flap segment is displaced up towards the neck, covering the donor wound.

It has been observed that the *cervical flap's* efficacy becomes significantly higher when the tissues of the periauricular area and lateral cervical surface are included in the cervical flap down to the perforator exit (symbol "+"

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Fig. 6.1 Axial blood supply of the neck skin, a distribution of flap branches of *a. cervicalis superficialis*. (**a**) Locating the exit point of the cutaneous branch of *a. cervicalis superficialis*; (**b**) distribution of cutaneous vessels of anterior neck skin (scheme); (**c**) cadaver dissection: exit of cutaneous branches and distribution in flap; additional perforants marked with white; on platysma—external jugular vein

in Figs. 6.2a, b and 6.4b, c). This extension of the flap makes it larger and more mobile; the upper flap's perimeter becomes longer. As a result, a *cervico-periauricular flap* is formed. The mobilized periauricular and lateral cervical segment of the flap includes skin, subcutaneous fat layer, and sternocleidomastoid fascia. When the thoracic tissue is included in flap mobilization, the *cervico-thoraco-periauricular flap* is formed. As a rule, we used the more extensive cervico-thoraco-periauricular flap for total or extensive cheek deformity resurfacing. For isolated upper-half cheek deformity elimination, thoracic tissue is not included in the flap formation. Here, the flap includes the lower cheek's skin with a thin subcutaneous fat layer along with the cervico-periauricular flap. As a result, the *cervico-facio-periauricular* flap is formed (see Chap. 7).

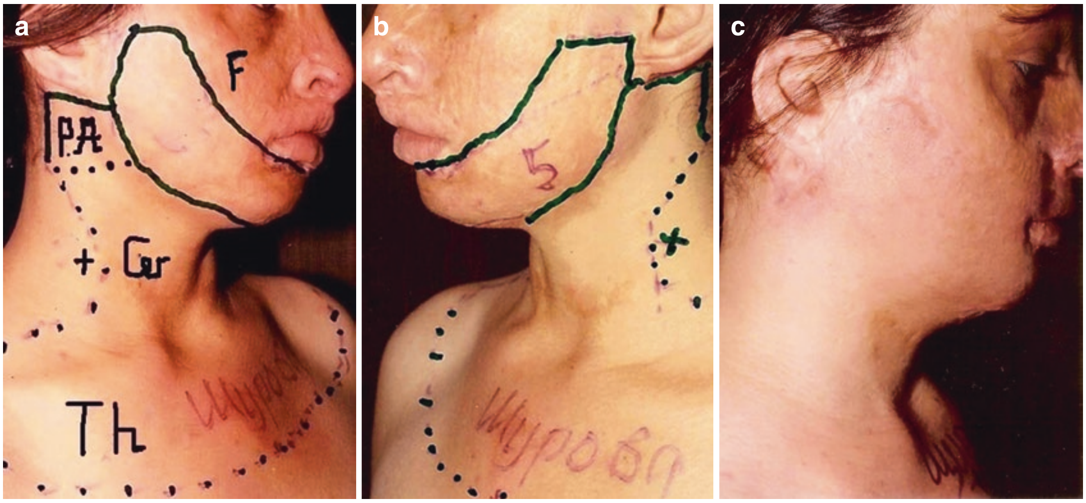

Fig. 6.2 Boundaries of split ascending neck flap. (**a**, **b**) Solid line—borders of scars excision; dotted line—borders of cervico-thoraco-periauricular flap mobilization right and left sides. *PA* periauricular facio-cutaneous flap; *Cer* cervical split adipose-cutaneous flap; *Th* thoracic adipose-cutaneous flaps (cervico-thoraco-periauricular flap); "+" exit location of the cutaneous branch of the superficial artery of the neck. (**c**) Split cervico-thoraco-periauricular flap was used for simultaneous resurfacing of wide face: cheeks and chin

Fig. 6.3 Split ascending neck flap mobilization and transposition on the face. (**a**) Planning cheek resurfacing: solid line—borders of scars excision; dotted line—cervico-thoraco-periauricular flap mobilization; "+"—perforators exit behind the middle part of sternocleidomastoid muscle; (**b**, **c**) the flap is elevated and distended by tight tamponing of the space under the flap with sterile gauze; scars excised; (**d**) flap transposed on the wound; (**e**) cheeks completely resurfaced (end of operation)

Fig. 6.4 Lower face resurfacing with split cervico-thoraco-periauricular ascending neck flap. (**a**–**c**) Before surgery, planning (dotted line—mobilization borders of cervico-thoraco-periauricular the flap; solid line—scar excision borders; "+" perforator exit; on right side, the periauricular segment included; (**d**) scars excised, split ascending neck flap mobilized and transposed on the lower face: flap is viable (5 days after surgery); (**e**, **f**) results (3 weeks after surgery): deformity of the lower face eliminated, face resurfaced with native skin with minimal operational scars; no donor site deformity

Axial Blood Supply of the Neck Skin

Our observations showed that subcutaneous muscle of the neck (platysma) prevents the stretching of the neck's skin-fat layer, and thus limits the possibility of its transfer to the face. Therefore, we began mobilizing the neck's skin using only the upper fatty layer above platysma, including only a thin layer of subcutaneous fat in the skin flap (i.e., splitting the fat layer). We left the subcutaneous muscle in situ. Therefore, the thin flap was given the name *split neck flap*.

The blood circulation of the anterior neck skin is supplied by two sources: (1) main (axial vessel) and (2) additional perforant arteries (Fig. 6.1b, c). The main source is the cutaneous branch of the *superficial artery of the neck (superficialis colli)*, which is one of four of the *thyrocervical trunk (truncus thireocervicalis)* that comes off the *subclavian artery*. The *superficial artery of the neck* has a diameter of 1.8–2.3 mm at its source and moves backward and outward along the front surface of the anterior *scalenus muscle*. It then crosses the *supraclavicular fossa* and reaches the edge of the *trapezoid muscle*, where it divides into multiple branches. The origin of the skin branches of the superficial neck artery (which is 1–1.2 mm in diameter and has a stem of 1–1.3 cm in length) as a rule is projected in the middle of the posterior edge of *sternocleidomastoid muscle* or up to 2 cm posteriorly. This corresponds to the area of crossing of the *external jugular vein* and *sternocleidomastoid muscle*. Then, the main stem of the skin branch of the *superficial artery* divides into two to three arteries of the second order, which then produces three to four branches, forming a strong net of the arterial anastomoses that spread over the entire skin surface of the anterior neck and connect with the similar vascular system of the opposite side. The adventitia of the wall of skin vessels is tightly connected to connective tissues of the reticulated skin layer and subcutaneous fat cellular tissue.

The additional source is made up of three to five perforant arteries, which are the skin branches of the *upper thyroid artery* and *facial artery* (the system of *exterior carotid artery*). The diameter of the perforant arteries does not exceed 0.2–0.3 mm; they perforate the platysma, branch inside the skin, and connect with the vascular system of the main source of blood circulation. The venous outflow is through the external jugular vein. These observations allowed us to determine the boundaries for mobilization on lateral surfaces and provided the safety of the mobilization toward the chest wall.

Common Principles of the Split Ascending Neck Flap Use

1. Planning (Fig. 6.3a): A solid line marks scars that will be excised and a neck flap incision 4 cm in length along the middle cervical line for flap splitting (Fig. 6.3b); dotted line: borders of flap mobilization.
2. Flap mobilization (Fig. 6.3b): Healthy skin is separated from scars, the periauricular flap is mobilized, *including* the fascia of the sternocleidomastoid muscle, and the donor wound is primarily closed. On the neck, the flap is separated from the platysma. On the chest wall, the adipose-cutaneous layer is separated from manubrium, clavicles, and *pectoralis major* fascia down to second ribs and the edge of axillary fossa. Then the neck flap is dissected 4 cm along the middle line.
3. The space under the flap is tightly packed with gauze during scar excision to control bleeding and flap-stretching (Fig. 6.3b, c).
4. The flap is transposed to the face with tension (Fig. 6.3d), and often the inner surface of the flap is sutured to the wound tissues over the face's solid structures; the inner layers of the flap and wound borders are closed with absorbable sutures.
5. Space under the flap on the neck is actively drained for 5 days. On the face, the flap is drained separately (Figs. 6.3e, 6.6g, and 6.7j); no immobilization is needed.

Using a Cervico-Thoraco-Periauricular Flap

(a) One-stage operation can restore the lower part of the face (Fig. 6.4a–f);
(b) Two-stage reconstruction can restore both cheeks in total (Fig. 6.5a–g);
(c) Two-stage reconstruction in conjunction with additional corrective surgeries can restore half of the facial skin and remove soft tissue defects (Fig. 6.6a–i);
(d) After the operation, transposed with tension on the face, the split neck flap preserves all natural properties and does not differ from facial skin (Fig. 6.7a–l).

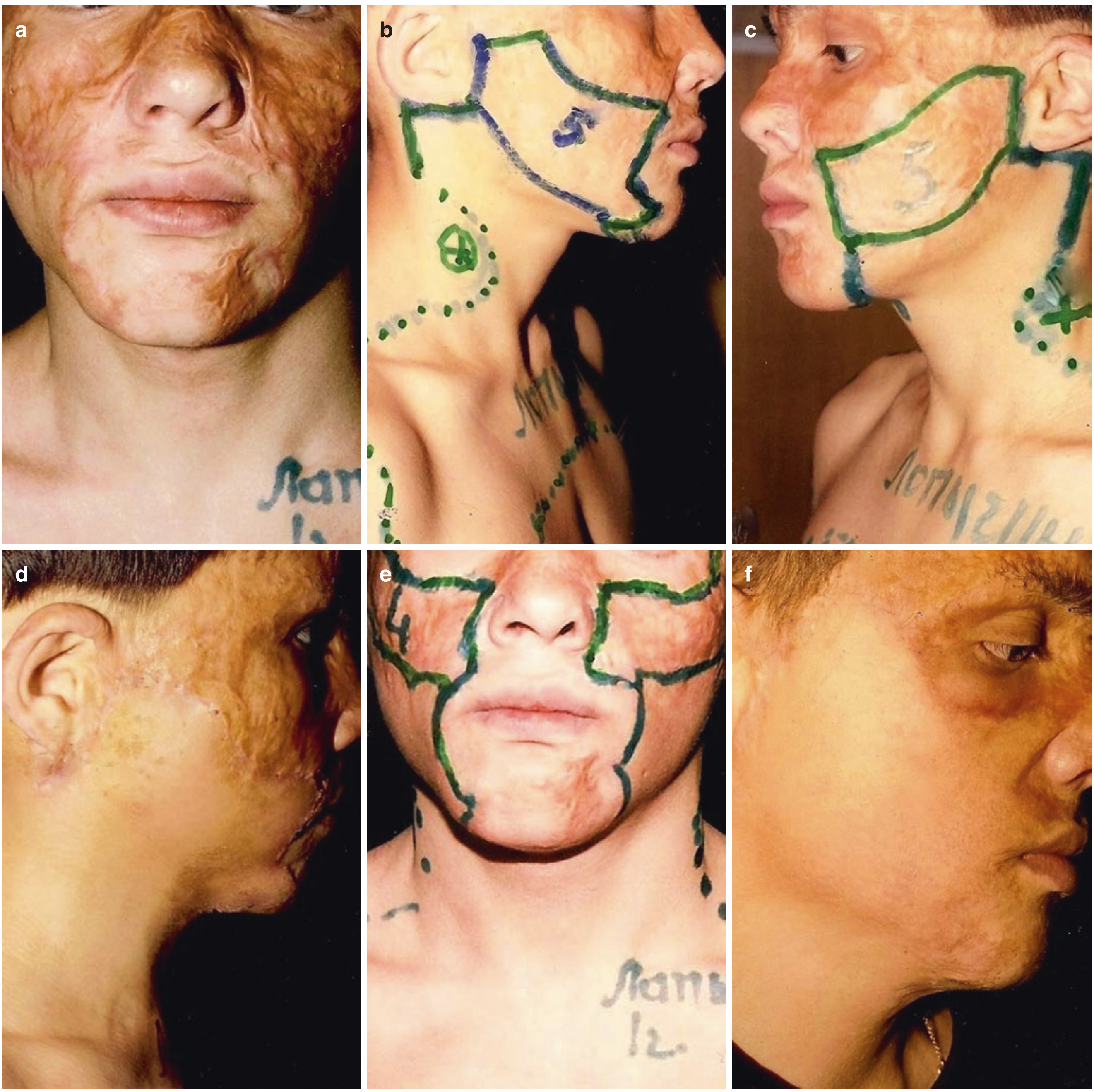

Fig. 6.5 Total resurfacing of both cheeks with two-stage transposition of split ascending neck flap. (**a**) Before operation; (**b**, **c**) first stage of reconstruction planning: solid lines—incisions for scars removal; dotted line—borders of flap mobilization; (**d**) result of the first stage of surgery; (**e**) planning of the second stage; (**f**, **g**) results: cheeks are totally restored with native neck skin; short line of operation scars; the donor site is not deformed, neck contours and cervico-mandibular angle are normal (1 year after surgery)

Fig. 6.5 (continued)

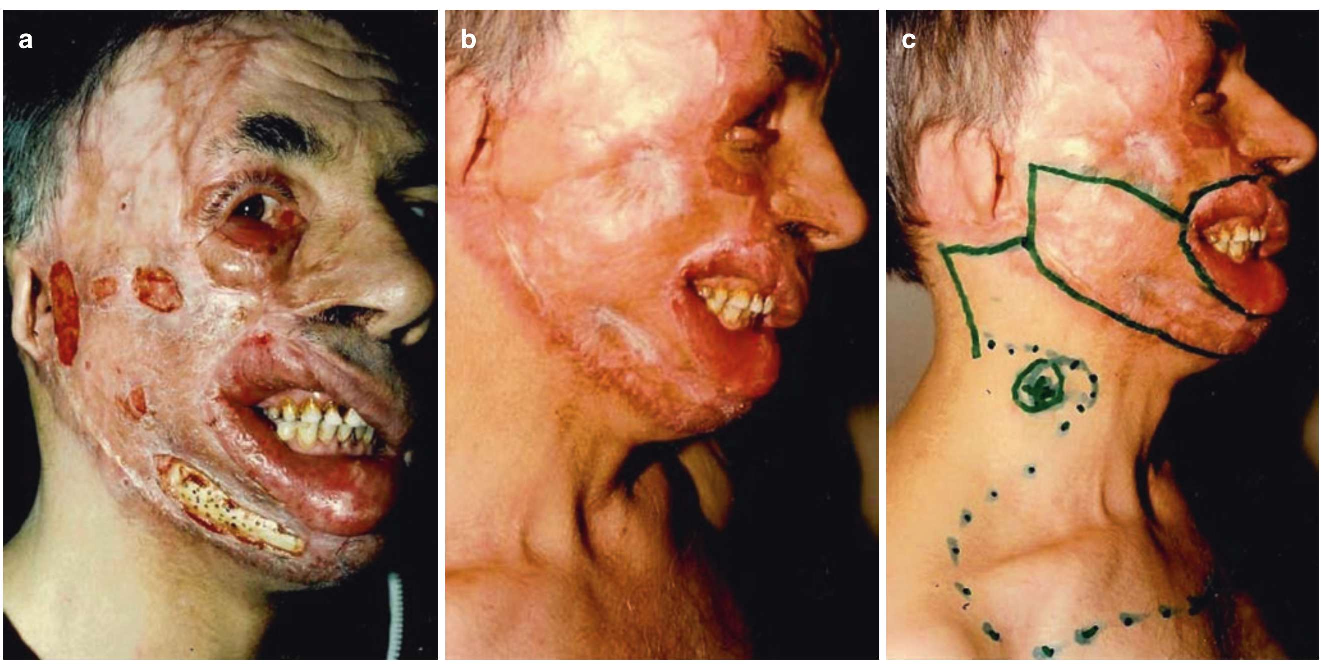

Fig. 6.6 Resurfacing of half the face (soft tissue defect and skin) with split ascending neck flap. (**a**) View after deep burns; (**b**) before the operation; (**c**) planning of the first step of face restoration: borders of scars excision and cervico-thoraco-periauricular flap; (**d**) results: 9 months after first-stage surgery; (**e**) planning the second-stage operation: borders of the cervico-thoraco-periauricular spit flap, borders of scar excision; (**f**) Inner layer of elevated previously transposed flap consists of a thin layer of connective tissue; (**g**) end of the operation; (**h**, **i**) final results

Fig. 6.6 (continued)

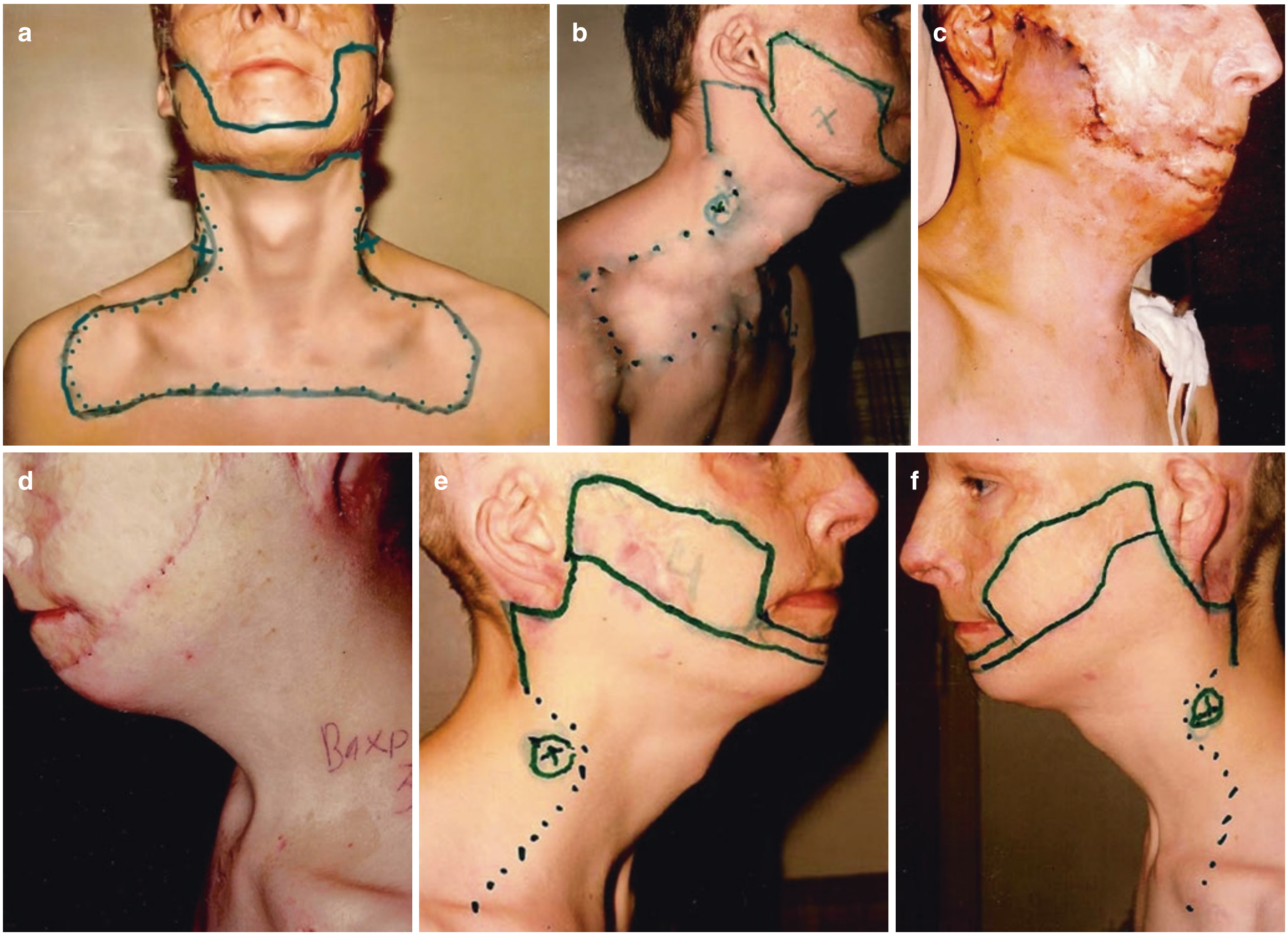

Fig. 6.7 Technique of two-stage resurfacing of both cheeks, submandibular region, and chin with thin cervico-thoraco-periauricular split ascending neck flap. (**a**, **b**) Pre-surgery, face deformed with scars; planning of operation: solid line—border of scars excision on the face; dotted line—borders of flap elevation; "+"—exit of perforators; (**c**, **d**) result of the first stage of the operation on the face; (**e**, **f**) planning the second-stage reconstruction; (**g**, **h**) flap elevated; (**i**, **j**) flap transposed on the cheeks and chin with tension; (**k**, **l**) results of the second stage

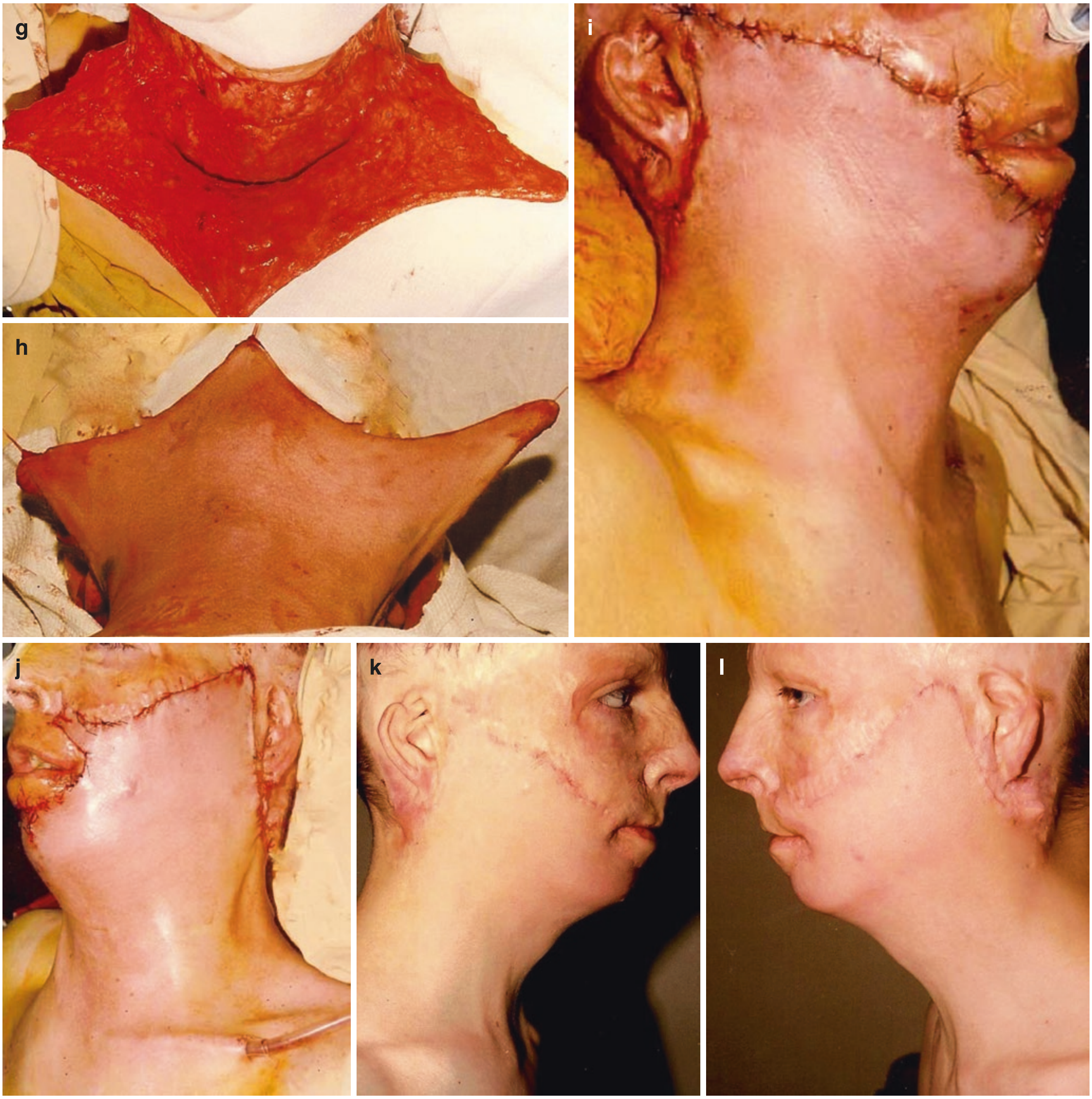

Fig. 6.7 (continued)

Lower Face One-Stage Resurfacing with Split Neck Flap

Using the cervico-thoraco-periauricular flap, one-stage reconstruction can restore the lower part of the face (Fig. 6.4a–f).

Two-Stage Total Cheek Resurfacing

Using a staged adipose-cutaneous cervico-thoraco-periauricular flap, half of the face can be resurfaced (skin and soft tissue defects) (Fig. 6.5a–g). The technique is based on the repeated use of the cervico-thoraco-periauricular flap, allowing simultaneous restoration of cheeks and chin.

Half-Face Resurfacing (Skin and Soft Tissue Defect)

Severe half-face tissue defects and deformity can be eliminated with two-stage cervico-thoraco-periauricular flap transposition (Fig. 6.6a–i).

Two-Stage Face Resurfacing with Split Ascending Neck Flap

For details of this technique and follow-up, see (Figs. 6.7, 6.8, and 6.9).

Fig. 6.8 Follow-up results of two-stage restoration of the face with split ascending neck flap. (**a**) Pre-surgery: severe face deformation with scars; (**b**–**d**) results 8 months after second-stage reconstruction with cervico-thoraco-periauricular flap

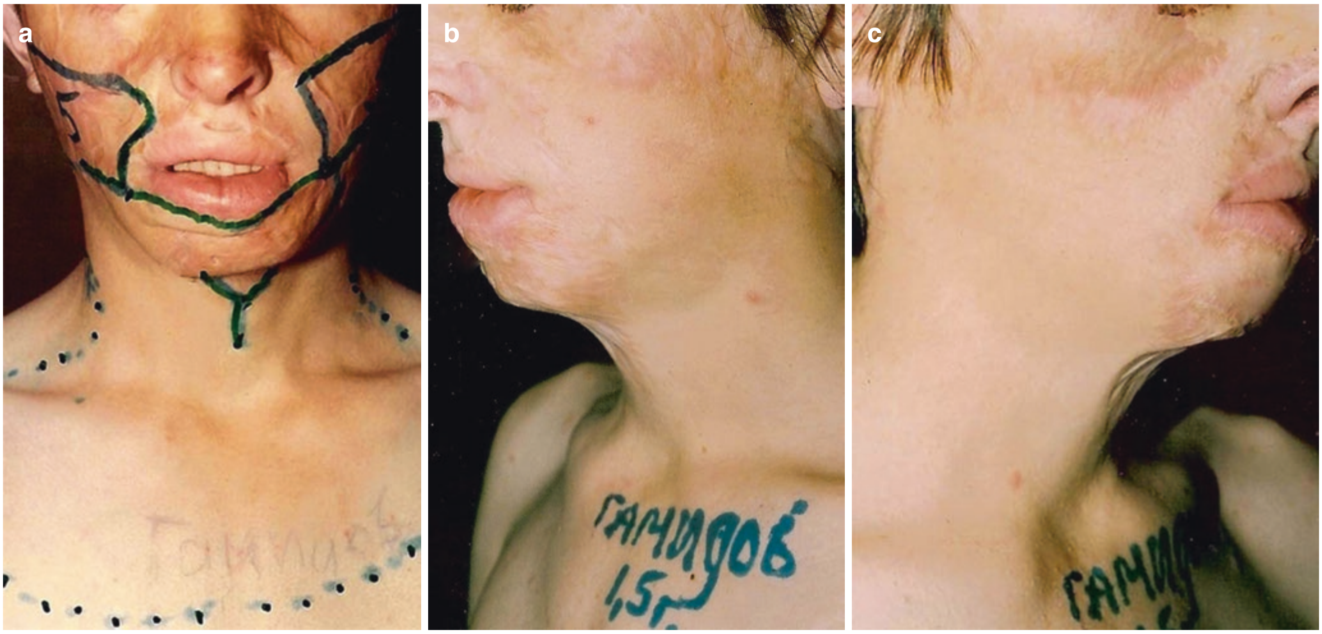

Fig. 6.9 Results of two-stage face and submandibular region resurfacing with split ascending neck flap. (**a**) Pre-surgery view, planning first-stage surgery; (**b**, **c**) 1 year and 6 months after reconstruction of submandibular region, cheeks, chin, and lower lip

Conclusion

Split ascending neck flap is optimal for burned face resurfacing. Flap's transposition on the face with tension can be used safely if vascular supply is preserved. Follow-up results of face resurfacing with a cervico-thoraco-periauricular flap are good. Neck skin matches the texture of face skin, preserves natural properties, and grows after surgery. Face contours are normal, without secondary deformities, and there is no soft tissue excess. The length of surgical scars is minimal. The donor site (neck and chest wall) does not have scars and looks normal (See Chapters 7 and 8).

Reference

1. Grishkevich VM, Ostrovsky NV. Postburn facial resurfacing with a split ascending neck flap. Plast Reconstr Surg. 1993;92:1385–92.

7 Burned Half-Cheek Resurfacing Techniques

Introduction

It is no secret that facial skin is different from skin from any other part of the body. A perfect graft should not only match the size and thickness of the recipient site, but also be compatible in texture, color, and softness. Neck skin has always been viewed as having the closest of all the desirable characteristics. It was used in cheek resurfacing for years but was limited by vascular complications and necrosis. Rotated and transposed flaps led to significant scarring of the donor site. We decided to develop a more standardized approach to treating partial cheek burns when repair can be carried out using mobilized local tissues. Our study of the vascular supply of the skin of the neck described in a previous chapter 6 enabled us to use cervical skin to the maximum potential without increasing the risk of vascular compromise and necrosis. These techniques, if used properly, carry a very low risk of flap necrosis while covering a significant portion of the cheek and minimizing surgical scarring.

The choice of surgical technique depends on the location of the scars on the cheek. While common principles of split ascending neck flaps remain true for all cheek reconstruction, differences in planning and staging of the surgery are worth mentioning. Here we present four types/forms of cheek deformity (lower, lateral, medial, and upper) and technical details of the surgeries specific for each type.

Split Ascending Neck Flaps Design and Specific Technical Features of Half-Cheek Resurfacing

The split ascending neck flap is used in several variants, depending on the size, the form of the scar's surface, and its location on the cheek. The flap consists of the basic neck split flap (without platysma) that includes the neck's anterior surface [1]. The area posterior to the center of the sternocleidomastoid muscle, where axial vessels originate, is spared (*superficial cervical artery* perforator exit) and is not mobilized or included in the flap (Fig. 7.1a, symbol "+"). These vessels, providing the anterior neck's skin with blood, make the cervical flap an axial type. Axial circulation of the neck skin allows flap undermining without platysma, with only a thin layer of fat (thus the name "split flap"), which makes the flap very thin. This axial circulation allows transposition of a cervical mobilized flap on the face with significant tension, without concern for tissue necrosis. Cervical flap advancement may be increased by a 4-cm incision along the vertical anterior mid-cervical line from the chin down, as seen in Fig. 7.1b.

The cervical flap transposition on the cheek is approximately 3–4 cm; however, the flap's displacement can be increased considerably when including in the flap a mobilized anterior thoracic adipose-cutaneous layer. Preparation of the thoracic extension of the split neck flap consists of separation from the clavicles, manubrium, and pectoral fascia down to the second ribs, and can laterally extend to the anterior edge of the axilla. Thus, a cervico-thoracic flap is formed without thoracic skin incision. The thoracic segment of the flap is displaced on the neck, covering the donor wound.

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It has been observed that the cervical flap's efficacy becomes significantly higher when the facio-cutaneous layer of the periauricular area and lateral cervical surface are included in the cervical flap down to the perforator exit (symbol "+"). This addition makes the cervical flap larger and more mobile, and the upper flap's perimeter becomes longer. As a result, a cervico-periauricular flap is formed.

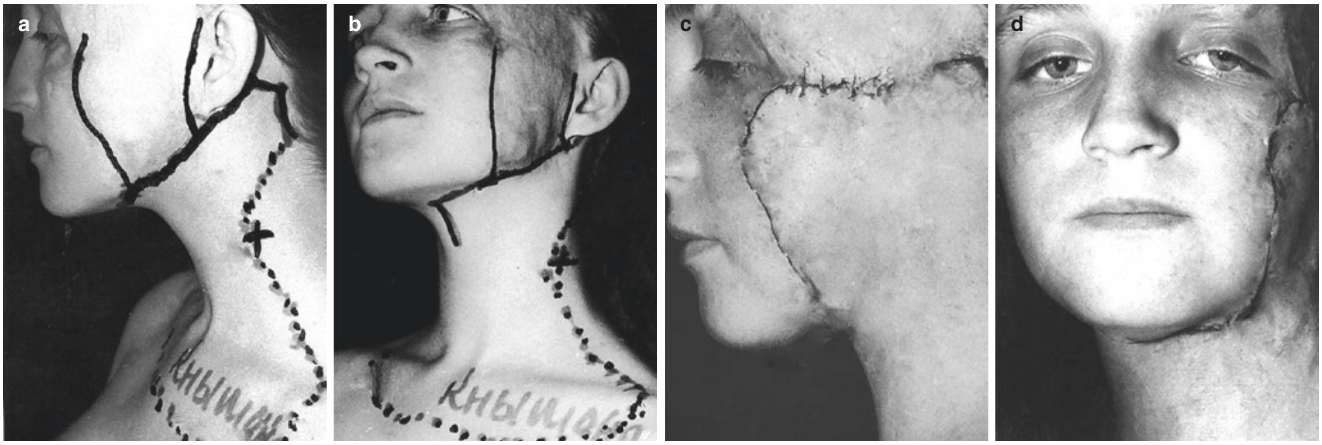

Fig. 7.1 Cervico-thoraco-periauricular flap design for *lateral half-cheek* resurfacing. (**a**, **b**) Lateral cheek deformity, planning: solid lines depict borders of scars to be excised and incisions in periauricular and submental areas flap preparation; dotted line depicts the boundaries of flap elevation (undermining); "+"—the site of perforator exit; (**c**, **d**) cervico-thoraco-periauricular flap resurfaced the cheek, flap alive; neck and cheek contours preserved (5 days after operation)

Lateral Cheek Resurfacing

Depending on the form of the scar's surface, two variants of cervico-thoraco-periauricular flaps are used: (1) an anterior neck flap prepared with skin incision along anterior mid-cervical line (Fig. 7.1a, b); and (2) a flap prepared without the neck's midline skin incision (Fig. 7.2). Planning and technical details are shown in Fig. 7.1a–d.

The mobilized periauricular and lateral cervical segment of the flap includes skin, fat layer, and sternocleidomastoid fascia. When thoracic tissue is included in the flap, the cervico-thoraco-periauricular flap is formed (Fig. 7.1a, b).

Lateral cheek resurfacing with a cervico-thoraco-periauricular flap without midline neck skin incision is shown in Fig. 7.2.

Fig. 7.2 Reconstruction of the *lateral cheek* without cervical midline incision. (**a**) Lateral cheek deformity, the chin not involved; surgery planning; (**b**) 3 weeks after operation, flap alive, deformity eliminated

Lower Cheek Resurfacing

Technical Details (Figs. 7.3 and 7.4)

Lower cheek deformities are eliminated using a cervico-thoraco-periauricular flap. Before surgery, the borders of scars to be removed and boundaries of flap mobilization are marked (Fig. 7.3a). The solid line marks the incisions to be made; the dotted line marks the boundaries of flap mobilization by undermining; the symbol "+" indicates *superficial cervical artery* perforator exit that needs to be preserved for viability of the flap. The flap includes the anterior neck surface; the thoracic segment reaches down to the second ribs and the anterior edge of axilla; and the periauricular segment includes retroauricular and lateral cervical regions. The first incision separates the cheek's healthy skin from scars and forms the periauricular segment and a flap angle in the submental region. Then, the periauricular segment is mobilized, including the sternocleidomastoid fascia for steady circulation. The donor wound in the periauricular region is primarily closed with the posterior neck's skin displacement forward and upward. Then, the cervical flap is mobilized with a thin fat layer without platysma.

Mobilization continues down to the upper chest wall, separating the adipose-cutaneous layer from clavicles, manubrium, and pectoral fascia down to the second ribs and axillary border. The superficial cervical artery perforator exit (symbol "+") remains in situ. The space under the flap is tightly tamponed with gauze for intra-operative skin distention and hemostasis while facial scars are being excised (Fig. 7.5b). After excision of the scars, the flap is transposed on the cheek with moderate tension, covering the wound up to 6 cm in width, from the ear to the oral commissure. The periauricular flap segment is placed anterior to the ear and sutured to the fascia and wound edges (Figs. 7.3a–c and 7.4a–c).

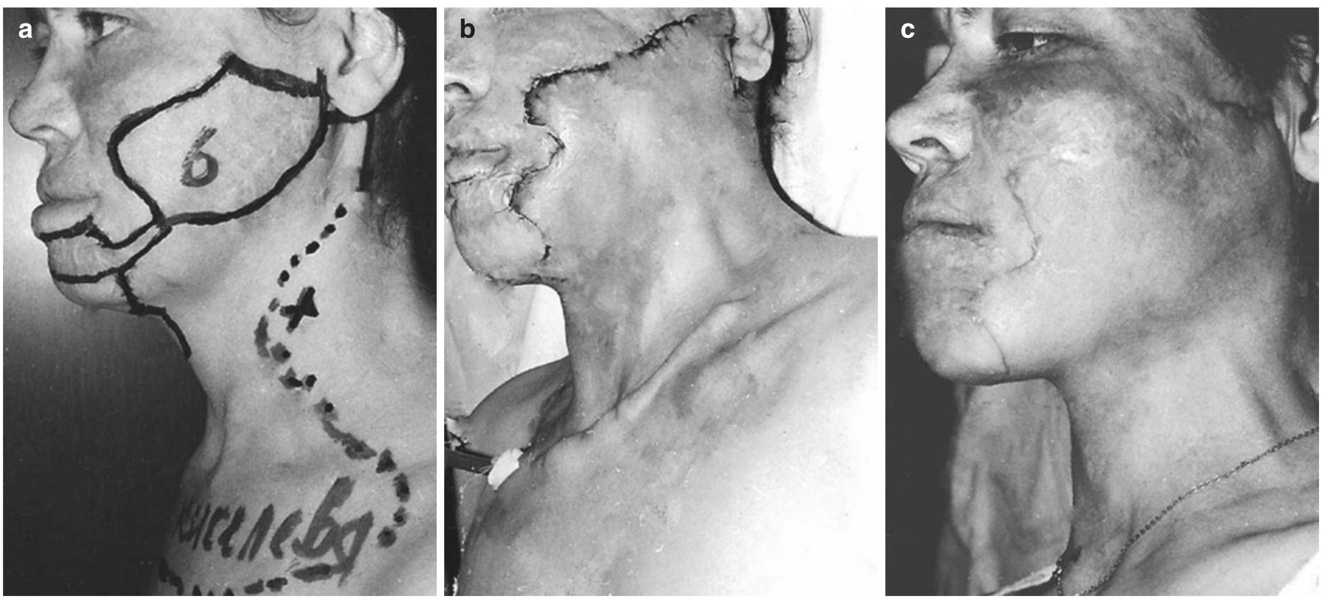

Fig. 7.3 *Lower cheek* resurfacing with cervico-thoraco-periauricular flap. (**a**) Planning: solid lines mark incisions around scars, the periauricular area, and submental angle; dotted lines outline boundaries of flap mobilization; (**b**) 5 days after surgery, the space under the flap drained; (**c**) 6 months after the operation: scars removed, cheek skin restored, donor site not injured, contours of the neck normal

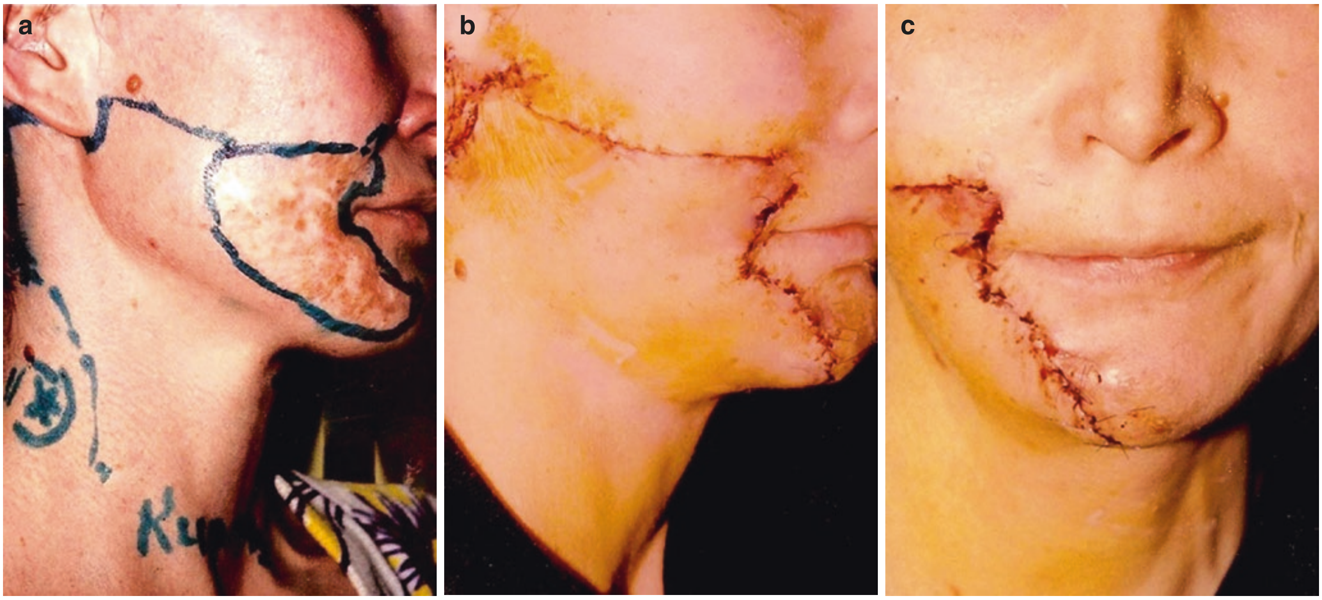

Fig. 7.4 *Lower-medial cheek* and chin resurfacing with cervico-thoraco-periauricular flap. (**a**) Scars covered the lower cheek and part of chin, deformed oral angle and nasolabial fold; (**b**, **c**) 7 days after reconstruction: the flap is alive, scars removed, the cheek restored with identical skin. The flap does not look like a patch, and normal contours of neck and mento-cervical angle are seen

Medial Cheek Resurfacing

The unique feature of resurfacing of isolated medial cheek scars is the presence of intact lateral cheek skin. This skin is healthy and is included in the flap. Reconstruction is performed with a regular cervico-facio-thoraco-periauricular flap (Figs. 7.5, 7.6, 7.7, and 7.8).

In cases of combined medial and upper cheek deformities, the residual healthy skin of the lower *and* lateral cheek with a thin fat layer is included in the flap, which forms a cervico-thoraco-facio-periauricular flap (see Fig. 7.4a). Tissue expansion of facial segment allows one to avoid inclusion of thoracic tissue; the flap in such cases is cervico-facio-periauricular (Fig. 7.7).

Fig. 7.5 *Medial cheek* and mouth angle resurfacing with cervico-facio-thoraco-periauricular flap. (**a**) Pre-operation, planning; (**b**) mobilized cervico-facio-periauricular flap expanded with gauze tampons; (**c**) flap transposed on the cheek; note placement of drains—cervical and under the flap (**d**) 12 days after operation, the flap is viable

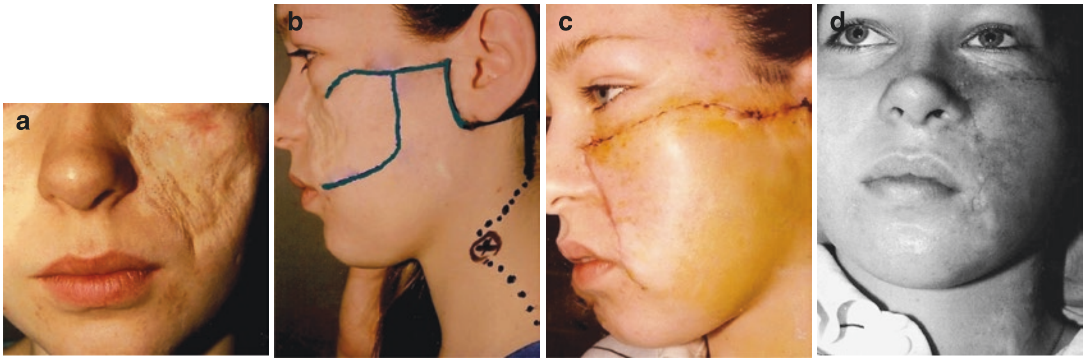

Fig. 7.6 *Upper-medial cheek* tissue defect elimination with cervico-facio-periauricular flap. (**a**) Before the operation, scars and soft tissue defect of left cheek; (**b**) planning the operation: solid line—incision, dotted line—boundaries of flap mobilization; (**c**, **d**) 1 week and 2 weeks after reconstruction with a cervico-facio-periauricular flap

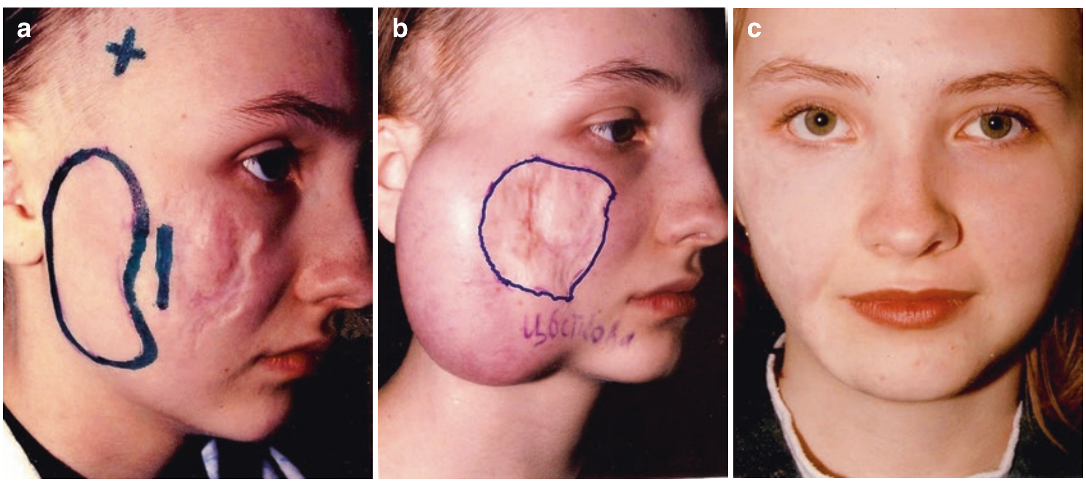

Fig. 7.7 *Medial soft tissue* defect of the right cheek elimination with the expanded cervico-facial flap prepared from the lateral cheek. (**a**) Pre-surgery view, planning of balloon insertion; (**b**) facial skin expanded; planning of operation; (**c**) 2 years after reconstruction

Fig. 7.8 Results of *medial cheek* (simultaneous chin, nose, upper lip, and philtrum restoration). (**a**) Pre-surgery, planning; (**b**) one-and-a-half years after reconstruction

Upper Cheek, Eyebrow, and Nose Resurfacing

The upper cheek is reconstructed with a cervico-facio-periauricular flap. First, the healthy lower cheek skin is expanded (Fig. 7.9a, b). After completion of expansion, cervical and periauricular flap segments are additionally mobilized and the flap is transposed on the upper cheek and sutured in place. It matches well to the surrounding healthy facial skin and contralateral cheek. Typically, the longer the period post-reconstruction, the better the results, to the point when the cheek appears normal and does not look like a patch of foreign skin. The tension on the flap and tissues of the face, neck, and chest wall gradually disappears as a result of tissue growth. Therefore, the cheek and neck contours look normal, and the neck and chest wall surfaces, as donor sites, are not damaged with operation scars. With skin growth and release of tension, no breast or nipple displacements are usually seen. The disfigured contours of the facial features, neck, and chest wall due to flap tension are only temporary.

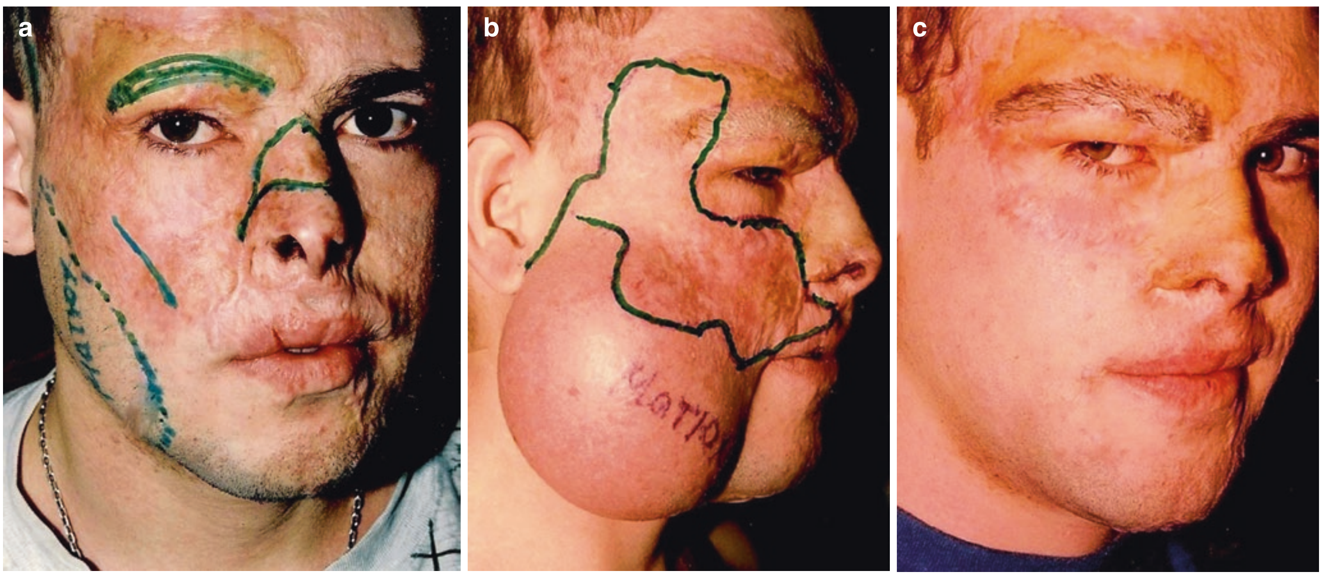

Fig. 7.9 *Upper cheek*, nose, and eyebrow reconstruction with a cervico-facio-periauricular expanded flap and a temporal pedicle flap. (**a**) Multiple facial deformities, planning of operations; (**b**) restored nose and eyebrow, expanded cervico-facial flap; planning cheek restoration; (**c**) results (2 years after surgery): cheek, temple, nose, and eyebrow restored

Conclusion

The split ascending neck flap in combination with neighboring tissue mobilization is optimal for burned half cheek resurfacing. No flap loss occurred. After we started including sternocleidomastoid fascia into the flap, no tissue necrosis occurred. As the flaps are thin, no soft tissue excess is observed. Operation scars are minimal and located only along one or two sides of the flap and are hardly visible, especially in the periauricular and submental regions. Skin organically flows from the neck onto the cheek without interruption, and never resembles a patch as in the case of many skin grafts done with other techniques. The tension of the flap and donor tissues of the neck and chest wall gradually disappear as a result of tissue growth; therefore, the cheek and neck contours are normal at long-term follow-up. The neck and chest wall surfaces, as donor sites, are not damaged by operation scars. With skin growth and release of tension, no long-term breast or nipple displacement was seen. The disfigured contours of the neck, face, and chest wall due to flap tension are only temporary.

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8 Total Cheek Resurfacing with Split Ascending Neck Flap

Introduction

As discussed in previous chapters, the skin of the neck is the best match for cheeks, but it is a limited resource, and its displacement is restricted. Every attempt should be made to resurface cheeks with neck skin. Tissue expansion is frequently used to make neck flaps larger; however, when used on the neck, it carries a high rate of complications due to soft-tissue compression. This limits the extensive use of expanders on the neck. Various flaps (pedicle, island, regular, and expanded) are transplanted from neighboring and distant regions, and free tissue transfer has been used. Differences in skin quality, however, are a serious cosmetic disadvantage of these flaps. We propose using a well-developed technique based on the split ascending neck flap [1], as described in this chapter.

First Stage of Bilateral and Unilateral Cheek Resurfacing with Split Ascending Neck Flap

Before surgery, the borders of scars to be excised and boundaries of the flap are marked. Solid lines mark the incisions, dotted lines mark boundaries of the flap mobilization, and the symbol "+" indicates the exit location of the superficial cervical artery perforator (Figs. 8.1b and 8.2b). For a detailed discussion of the significance of preserving this source of axial circulation of the neck flap, see Chap. 6. The flap includes skin of the anterior neck surface; the thoracic segment reaches down to the second ribs and anterior edge of the axillary fossa, and the periauricular region. Mapping for bilateral and single cheek resurfacing is shown in Figs. 8.1b and 8.2b. A line 4 cm in length is placed along the anterior medial neck line in the submandibular region (Fig. 8.1b).

The first incision separates the cheek scars from the healthy skin of the neck and forms the periauricular segment and flap angle in the submental region. Then, a periauricular segment (one or both) is mobilized down to the perforator exit. It is critical to include sternocleidomastoid fascia in this segment of the flap for steady circulation. The donor wound in the periauricular region is primarily closed by pulling skin of the back of neck forward and upward (Figs. 8.1c and 8.2c). Then, the cervical flap is mobilized, including skin and only the thin fat layer *without* platysma. The *superficial cervical artery* exit (symbol "+") stays in situ. Mobilization continues on the upper chest wall, separating the adipose-cutaneous layer from clavicles, manubrium, and pectoral fascia down to the second ribs and axillary fossa border. In the case of bilateral cheek resurfacing, the same steps are carried out symmetrically. The mobilized flap is transposed with tension on the cheek (or cheeks) for estimation of the scar surface area that can be resurfaced. Appropriate markings are made for scar excision.

Next, the space under the flap is tightly tamponed (packed) with gauze for intra-operative skin distension and hemostasis, while scar excision of the lower cheek is performed.

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Fig. 8.1 Total bilateral burned cheeks resurfacing with a cervico-thoraco-periauricular flap. (**a**) Before surgery (6-year-old boy): total face deformities with burn scars; (**b**) planning of operation: solid line indicates incisions: along the lower scar edge, anterior mid-cervical line (5 cm in length), periauricular flap contours, and scar borders on the cheeks for excision; symbol "+"—exit of superficial cervical artery perforators; dotted line indicates borders of flap mobilization; (**c**, **d**) transposed mobilized cervico-thoraco-peri-auricular flap restored lower and lateral cheek surfaces; neck donor wound covered with elevated thoracic segment of the flap; cervical wound drained with active drain; cheeks are drained separately; (**e**, **f**) the cervical flap on the cheeks expanded, planning of the second stage of the operation; (**g**, **h**) end of the operation; expanded cervico-periauricular flaps covered the cheeks; (**i**, **j**) result (5 years after operation): skin of the cheeks had been restored with well-matching neck skin; skin of the cervico-facial region is presented as one unit; contours of the face and neck are preserved. Skin of the face has preserved sensation and normal quality (color, thickness, elasticity). There has been no bulking, and no operation scars are present between the cheek and neck

Fig. 8.1 (continued)

After scar excision, the flap is transposed on the cheek (or cheeks) with moderate tension. The periauricular flap segment is placed in front of the ear and sutured to the temporal fascia. The upper flap border and its medial angle is sutured to underlying soft tissues for flap suspension. As a result of tension, the cervical part of the flap is displaced to the cheek, and the thoracic segment moves up on the neck, covering the donor wound. The skin edges are closed with two rows of sutures. To prevent scar widening due to significant tension of the flap, we use non-absorbable internal sutures. An active drain is placed under the flap on the neck for 5 days (Fig. 8.1c, d). The cheek is drained separately.

Fig. 8.2 Two-stage unilateral total cheek resurfacing with a cervico-thoraco-periauricular flap. (**a**) Hemifacial nevus, scars, lower lid grafted; (**b**) planning of the operation: solid line indicates scar excision, periauricular flap forming and forehead tissue expansion; "+"—perforator exit; dotted line indicates flap mobilization without skin incision; (**c**) the cervico-periauricular flap is mobilized, half of the cheek's surface restored, and the donor wound of the periauricular flap primarily closed; (**d**) stabilized cervico-periauricular flap is expanded on the face; temple region and eyebrow are corrected (**e**) 2 weeks after surgery: flap alive, mild vascular congestion, eyebrow narrowed, facial, and cervical contours preserved, mild lip swelling

Second Stage of Cheek Resurfacing with Expanded Split Ascending Neck Flap

Once the transposed tissues are stabilized and tension disappears—this period could last from 9 to 12 months—the expanders are implanted through an incision along the upper cheek surgical scar. The transposed cervical flap is elevated down to the edges of the mandible, dissecting friable fibers of connective tissues. The inner layer of the flap consists of scar (connective) tissue that looks like a sheet, stabilizing the blood circulation, reinforcing the flap's stability and tissue safety during balloon distension. Having achieved a sufficient increase in the surface area (Figs. 8.1e, f and 8.2d), reconstruction is accomplished: the flap is mobilized at the periphery for the flap's better displacement and facilitation of adaptation on the wound. Remaining scars of the upper and medial cheek are excised, and the wound is covered with the flap (Fig. 8.1g, h). The space under the flaps is drained. The edges of the flap are sutured to the temporal fascia and along the flap's edge to the underlying tissues. The lower eyelid can be temporarily sutured to the forehead to prevent ectropion. The result of the surgery: the total cheek is restored with well-matching skin and minimal surgical scarring (Figs. 8.1i, j and 8.2e).

Figure 8.2 illustrates a patient with a large deforming nevus of the left side of the face, showing results of nevus excision and total cheek resurfacing with a cervico-thoraco-periauricular flap.

The results of two-stage total cheek resurfacing in a girl with split ascending neck flap is shown in Fig. 8.3.

Fig. 8.3 Result of bilateral total burned cheeks resurfacing with a cervico-thoraco-periauricular flap and secondary cervico-periauricular flap expansion on the face. (**a**) Before the operation (7-year-old girl); total face deformities by burn scars; (**b**, **c**) cervico-thoraco-periauricular flap transposed on the cheeks; (**d**, **e**) both flaps expanded on the face; (**f**, **g**) results (7 years after reconstruction): cheeks restored completely; contours of the face and neck preserved, donor site undamaged

Fig. 8.3 (continued)

Two-Stage One-Cheek Resurfacing in Children

Our observations have shown that in children, two-staged face reconstruction is indicated, especially if the scar deforms half of the cheek, and more so if the scars involve the chin, lip, eyelids, or temple. Such an approach allows for avoidance of negative effects caused by pressure on the solid structures of the face. It also preserves jawline definition. Extended pressure by skin expanders can also cause deformation of the face in small children.

The goal of the first stage is to achieve as much resurfacing of the cheek as possible. The second stage of reconstruction is directed toward restoration of the chin, lips, lower eyelid, and temple. Restoration of these subunits can be successfully performed if the extended flap surface is sufficient to cover the areas without tension. In some cases, the flap is attached with sutures to underlying wound tissues to minimize tension on the edges of the wound. The surgical details are shown in Figs. 8.4, 8.5, and 8.6.

Fig. 8.4 Subtotal unilateral face resurfacing, injured by nevus and post-treatment keloid scars. Consecutive operative and balloon extension of a cervico-thoraco-periauricular flap. (**a**) Pre-surgery: subtotal right half face deformation with nevus and scars; (**b**) planning scar excision (solid line) and a facio-neck-periauricular-thoracic flap (dotted line) elevation; "+"—perforator exit; (**c**) result of the first stage of reconstruction; (**d**) planning of expander implantation; (**e**) expansion finished; (**f**) 7 days after second-stage surgery; (**g**) 1 year after face treatment using the new approach

Fig. 8.4 (continued)

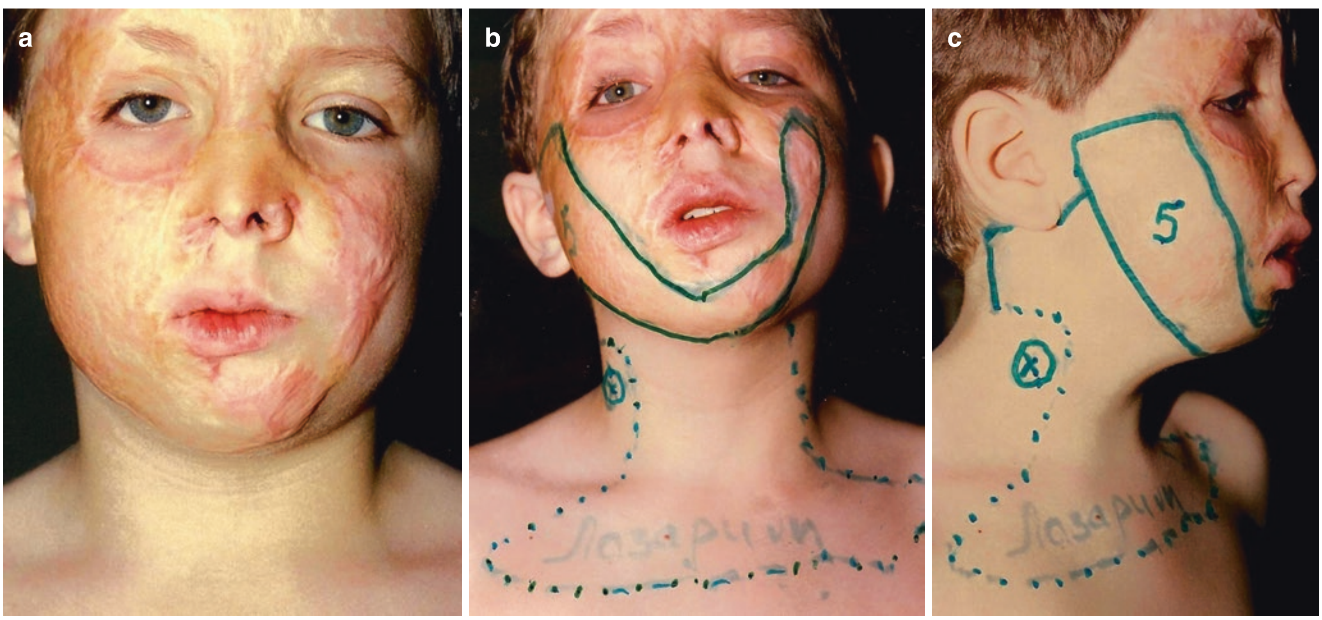

Fig. 8.5 Postburn half face resurfacing with consecutive operative and expander distension of split ascending neck flap. (**a**, **b**, **c**) Pre-surgery, planning: boundaries of scar excision and cervico-thoraco-periauricular flap elevation; (**d**, **e**) results of first stage of operation (9 days after surgery); (**f**) extended flap on the face; (**g**) 5 days after operation: half of face covered with flap; (**h**) 1 year after reconstruction

Fig. 8.5 (continued)

Fig. 8.6 Unilateral resurfacing of the face deformed by nevi and post-curative scars with a cervico-facio-periauricular flap, using consecutive operative and balloon extension. (**a**) Before surgery; (**b**) first stage planning; (**c**) result of first-stage surgery; (**d**) planning of expander insertion on the cheek and forehead; (**e**) tissue expansion finished; (**f**) end of operation with extended flaps; (**g**) 2 weeks after reconstruction

Conclusion

The first step of reconstruction, tissue expansion, and the final stage can be carried out successfully without flap loss or other serious complications. Scars on the cheeks are replaced with thin, pliable, well-matching skin flaps from the neck. Some swelling and venous congestion of the transposed tissues occurs, but circulation is usually restored in several weeks. Follow-up observations showed that neck skin on cheeks preserved its natural properties (color, texture, elasticity) and is a good match to surrounding facial skin, which is especially noticeable in cases of unilateral cheek reconstruction. No soft tissue excess is formed, and no debulking is needed. Operation scars are minimal in length and are located only along the upper and medial flap's borders. Due to lower tension on the scars after the second stage, overgrowth of scars or keloid formation is not commonly seen. The skin spreads smoothly from the neck on the cheeks and chin without interruption by scars, creating a normal appearance. The donor sites (neck and chest wall) remain undamaged, without tissue defects, skin grafts, or operative scars. The jawline and angle of the neck are usually preserved. No eyelid ectropion is observed with lower flap tension of second-stage surgery. Skin tension on the face, neck, and chest wall gradually disappears due to flap growth, which restores more defined cheek and neck contours over time. In children, the cervical skin on the cheeks grew proportionally to underlying tissues and surrounding healthy skin, allowing normal development of the face.

Reference

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9 Postburn Neck Scar Contracture Classification

Introduction

Being an open part of the body, the neck often suffers burns. Restricted head motion and apparent cosmetic defects are indications for reconstruction. Rehabilitation aims to release the contracture as part of skin surface restoration. The skin of the neck has specific characteristics that distinguish it from skin of other body areas. Therefore, after restoration, poorly matched grafted skin resembles patches, and this poses a difficult cosmetic challenge. In many cases, burns and scars damage only part of the anterior neck surface; in such cases, local healthy tissues can be used for reconstruction first. Types of neck scar contractures are based on scar location and the extent of neck surface involvement. The following classification system was developed after studying more than 250 patients [1, 2].

Neck Contractures: Anterior and Lateral Groups

To better understand the types of contractures on the neck and choices of surgeries for each deformity, we developed a detailed classification of neck contractures. First, we divided neck contractures into two types: anterior and lateral neck contractures. Each type is further subdivided into subtypes: anterior has six subtypes and lateral has two subtypes. Here we demonstrate all eight types of contractures commonly seen in neck burns.

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Anterior Neck Contractures

For the overall scheme of anterior neck contracture classification, see (Fig. 9.1).

1. *Medial neck contracture* is caused by a scar strip of 5–6 cm in width, spreading from the chin to the sternal manubrium (Fig. 9.2). The scar strip has a different form; the scars often cover the submandibular region and chest wall. In this type of contracture, the skin on the lateral cervical surfaces (donor sites) is healthy and is used for reconstruction (Chap. 10).
2. *Unilateral anterior neck contracture* is characterized by scars covering part or all of one side of the anterior neck surface (Fig. 9.3). Due to scar contraction, healthy skin can be displaced over a damaged neck side. Healthy skin of half the neck surface (donor site) is used for contracture release and skin restoration (Chap. 11).
3. *Medio-lateral unilateral neck contracture* includes the medial and lateral neck surface of one side (Fig. 9.4). The lateral surface of the opposite side of the neck is undamaged.
4. *Medio-lateral bilateral neck contracture* is caused by scars that cover all anterior neck surfaces and is also known as "total neck contracture" (Fig. 9.5). A lack of healthy skin calls for treatment with local scar-fascial, regional pedicle, or free flaps.
5. *Mentosternal contracture or fusion* (Fig. 9.6).
6. *Submental contracture* (Fig. 9.7).

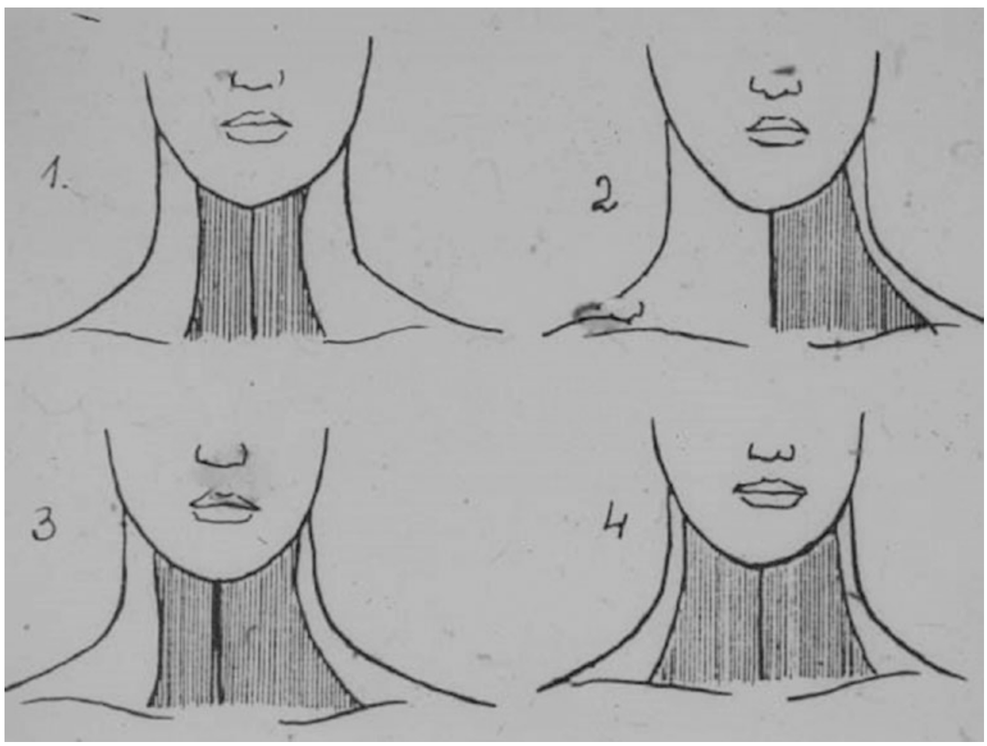

Fig. 9.1 Anterior neck scar contracture classification (scheme): 1—medial; 2—unilateral; 3—medio-unilateral; 4—medio-bilateral (total)

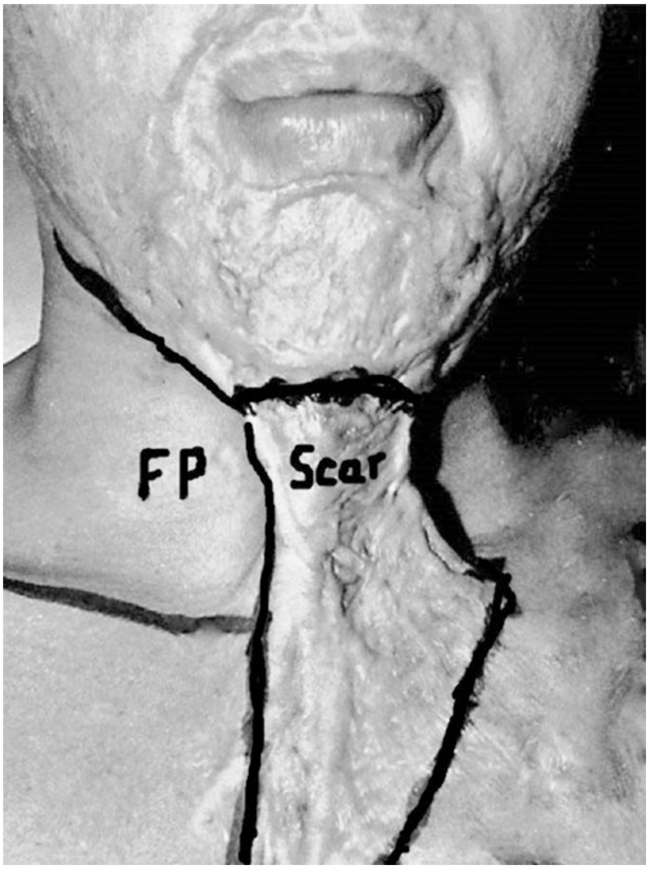

Fig. 9.2 Midline neck anterior scar contracture (medial type). *FP* flap

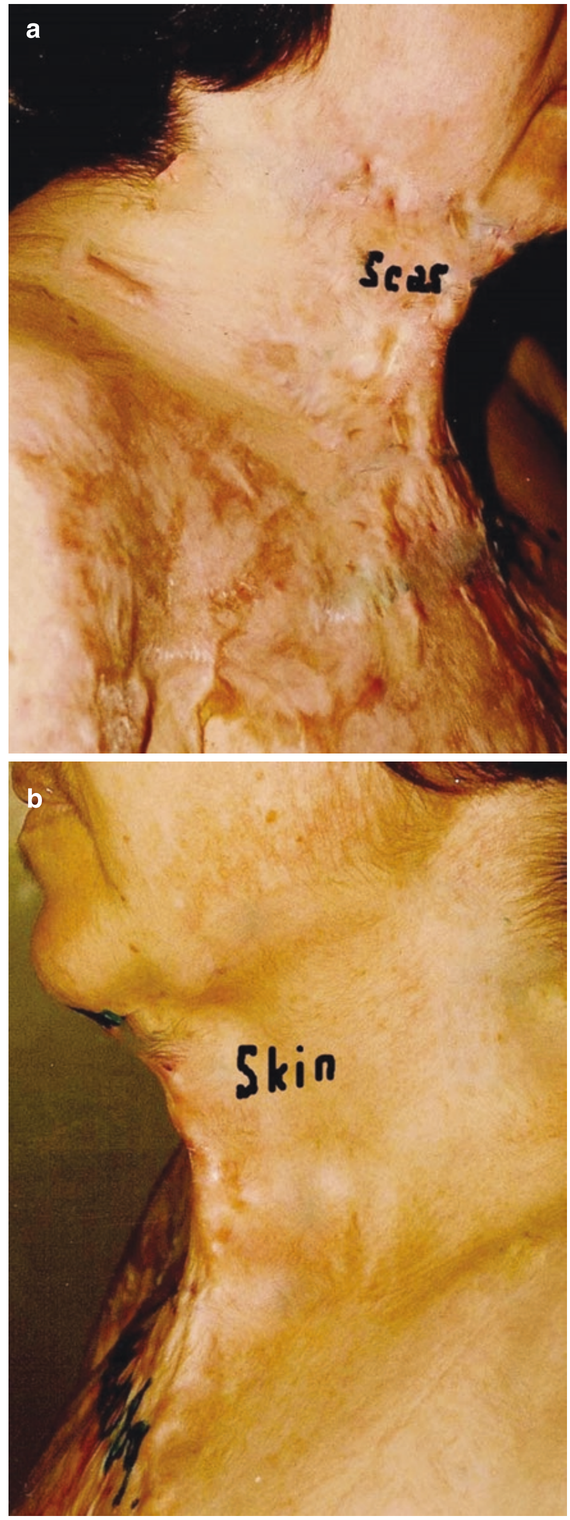

Fig. 9.3 Unilateral anterior neck scar contracture (edge type). (**a**) Scars on the right lateral surface of the neck; (**b**) the left side of the neck has healthy skin

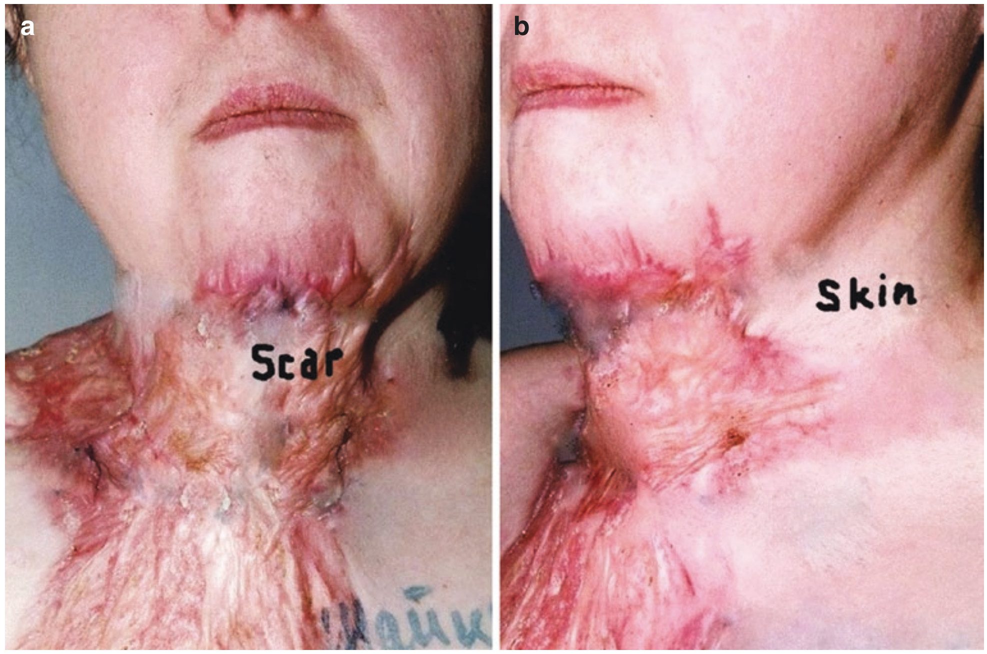

Fig. 9.4 Medio-lateral one-side anterior neck scar contracture (medial type). (**a**) Scars on the medial and right antero-lateral neck surfaces; (**b**) the left lateral neck surface has healthy skin

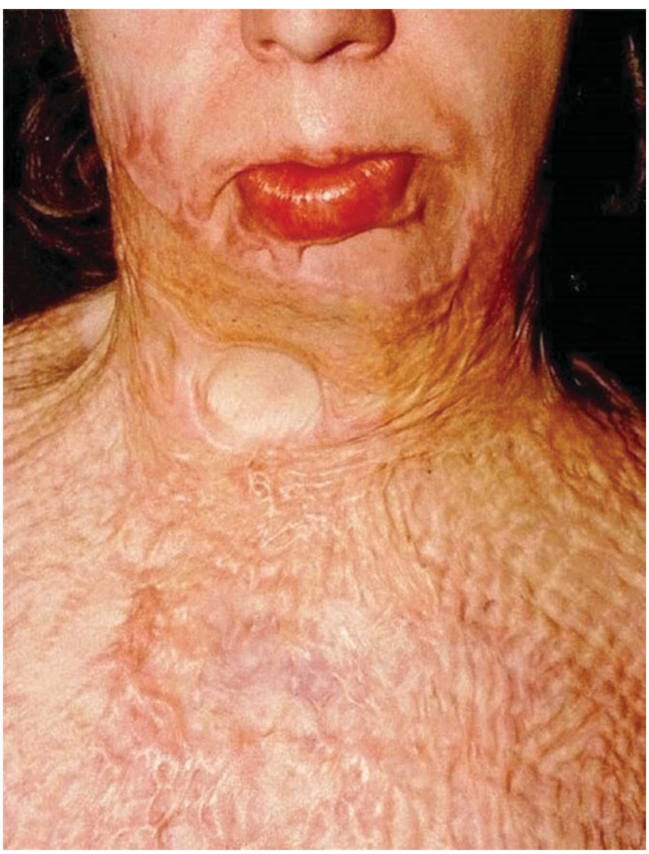

Fig. 9.5 Medio-lateral bilateral (total anterior) anterior neck contracture (medial type)

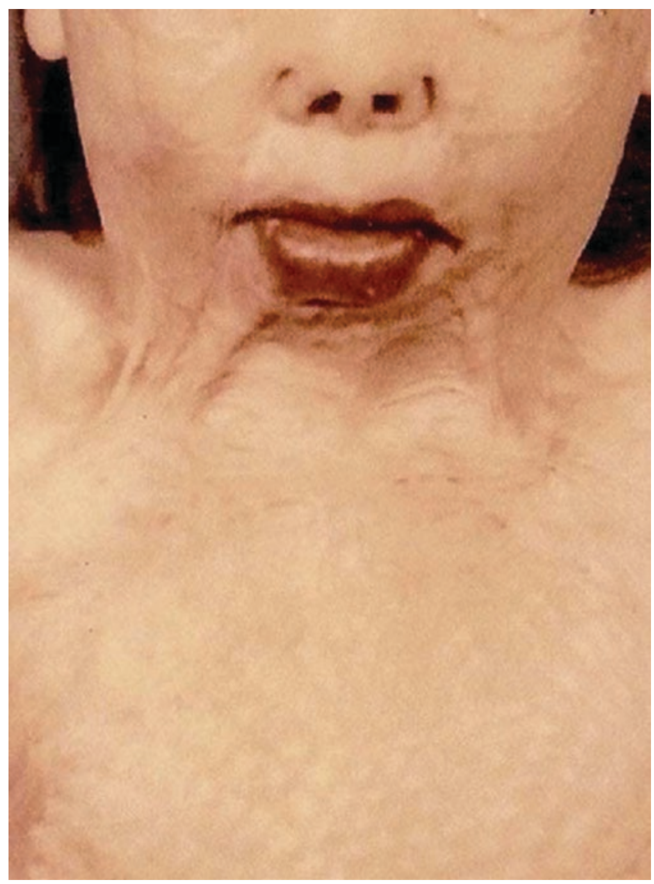

Fig. 9.6 Mentosternal contracture (fusion)

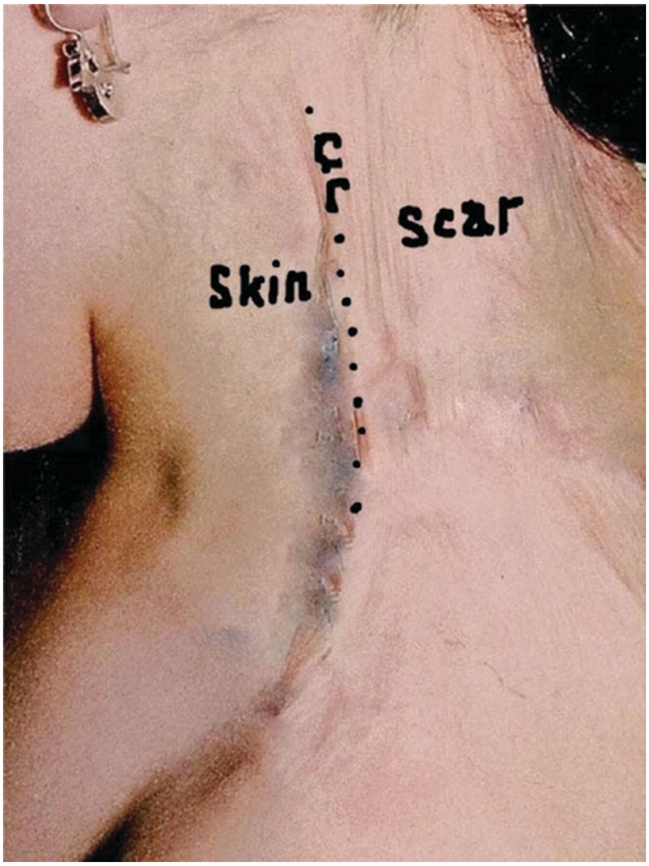

Fig. 9.7 Lateral edge neck scar contracture, scars covering the posterior surface of the neck. *Cr* crest

Lateral Neck Contractures

7. *Lateral edge neck contracture* is formed after burns of the posterior surface of the neck (Fig. 9.8 and Chap. 12).
8. *Lateral medial neck contracture* occurs after burns of the lateral surface of the neck (Fig. 9.9 and Chap. 12).

Fig. 9.8 Lateral medial neck scar contracture. Scars covered lateral neck surface; the fold formed along lateral neck surface; both sheets of the fold are scar tissue. *Cr* crest

Fig. 9.9 Submental deformity and contracture

Conclusion

This classification defines a skin-to-burn ratio, location, and surface size of the healthy skin and scars. Using these parameters, one can effectively choose an adequate surgical technique that will allow the most resourceful use of undamaged cervical skin. Knowledge of the axial blood supply of neck skin (Chap. 6) has significantly broadened the possibilities of treating neck contractures with undamaged local cervical and neighboring skin, and made the procedure more effective. Using special techniques of flap elevation, it is possible to restore and release midline and unilateral anterior contractures and the edge lateral neck contractures using healthy local tissue (see Chaps. 10 and 11). Recognition of specific types of neck contracture is easy (Fig. 9.1). The proposed classification plays an important role in choosing the proper technique and achieving good outcomes. It has opened up the possibilities for wider use of local tissues with minimal damage to the donor site, often avoiding skin grafting or reconstruction with pedicle and free flaps.

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10 Medial Neck and Submandibular Scar Contractures: Anatomy and Treatment

Introduction

Medial neck contracture is caused by scars that spread from the chin to the sternal manubrium and involve the submental and submandibular regions. The contractures can spread on the face and chest wall. The scars are often thick and rough and present a functional, as well as a severe cosmetic, defect. In terms of treatment, the most important task is to restore the surface with well-matched skin from the remaining neck skin on the lateral surfaces. Therefore, lateral neck skin undergoes expansion, even though the technique can be complicated by skin necrosis. After establishing that the anterolateral neck skin has axial blood supply, the medial contracture can be released with neck split flaps from the neck lateral surfaces. Stable blood circulation allows mobilization of healthy skin that does not damage axial vessels and transposition on the anterior neck with tension.

Anatomy of Midline Neck Contracture

In this group of patients, the contracture was caused by scars located along the medial line of the anterior surface of the neck (Fig. 10.1). Scars spread from the chin to the manubrium and can cover the lower face and chest wall (Fig. 10.2). The shape of the scars differs from case to case; they may be wider in the submental region and narrower closer to the manubrium, or vice versa (Figs. 10.3 and 10.4). The width of the scar strip is on average 5–7 cm. The scars protrude forward and often restrict head motion. The skin on the neck lateral surfaces remains healthy.

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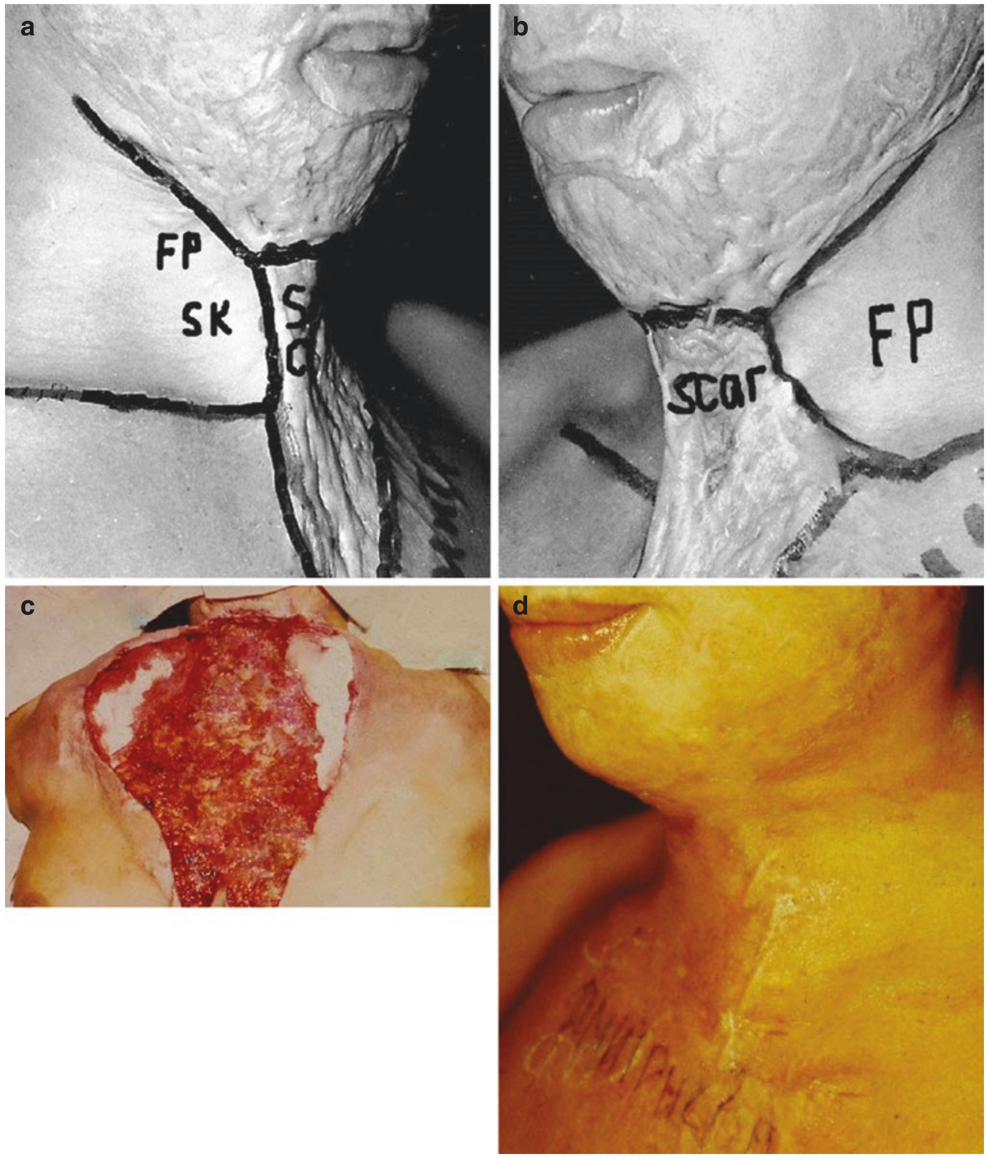

Fig. 10.1 Medial neck scar contracture anatomy and treatment with lateral cervical split flaps. (**a**, **b**) Protruded forward scar (*SCAR*) strip spreads from the chin to the middle neck region and covers the sternum zone. Lateral neck surfaces are undamaged; planning of operation: trapezoid flap (*FP*) on each neck side and borders of scar excision; (**c**) scar removed, neighboring adipose-cutaneous layer on the chest and split neck flaps on both sides of the wound elevated and extended with tight gauze tamponing of sub-flap space; (**d**) flaps counter-transposed, good functional and cosmetic outcomes

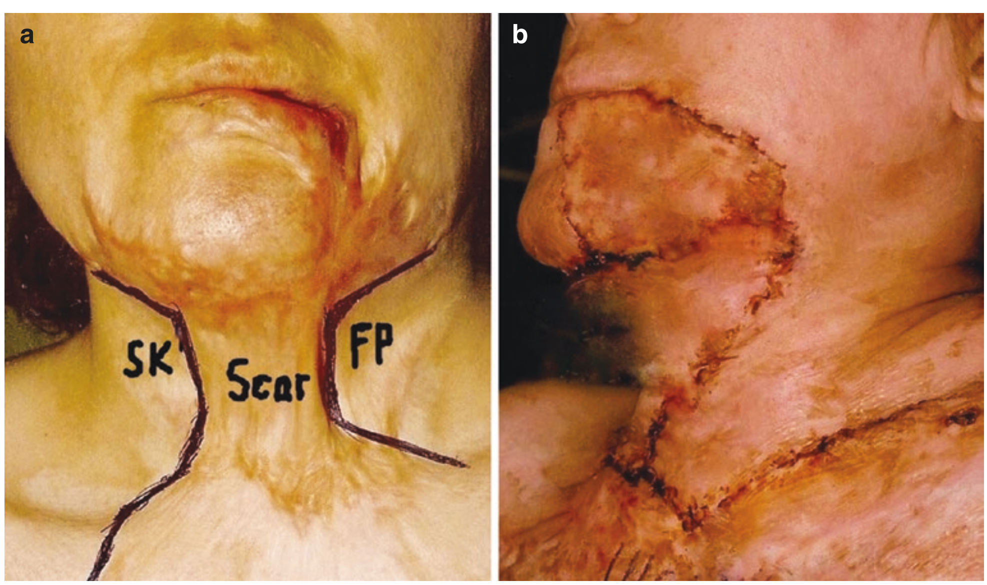

Fig. 10.2 Medial neck contracture treatment with lateral split neck trapezoid flaps. (**a**) Pre-surgery: Medial segment of the neck and submandibular region covered scars (*SCAR*); planning of two lateral split neck flaps (*FP*); (**b**) mobilized split neck flaps counter-transposed with tension, restored neck and submandibular region; left lower face scar deformity removed, wound skin grafted. Ten days after reconstruction, the flap and skin transplant are alive and contracture is eliminated

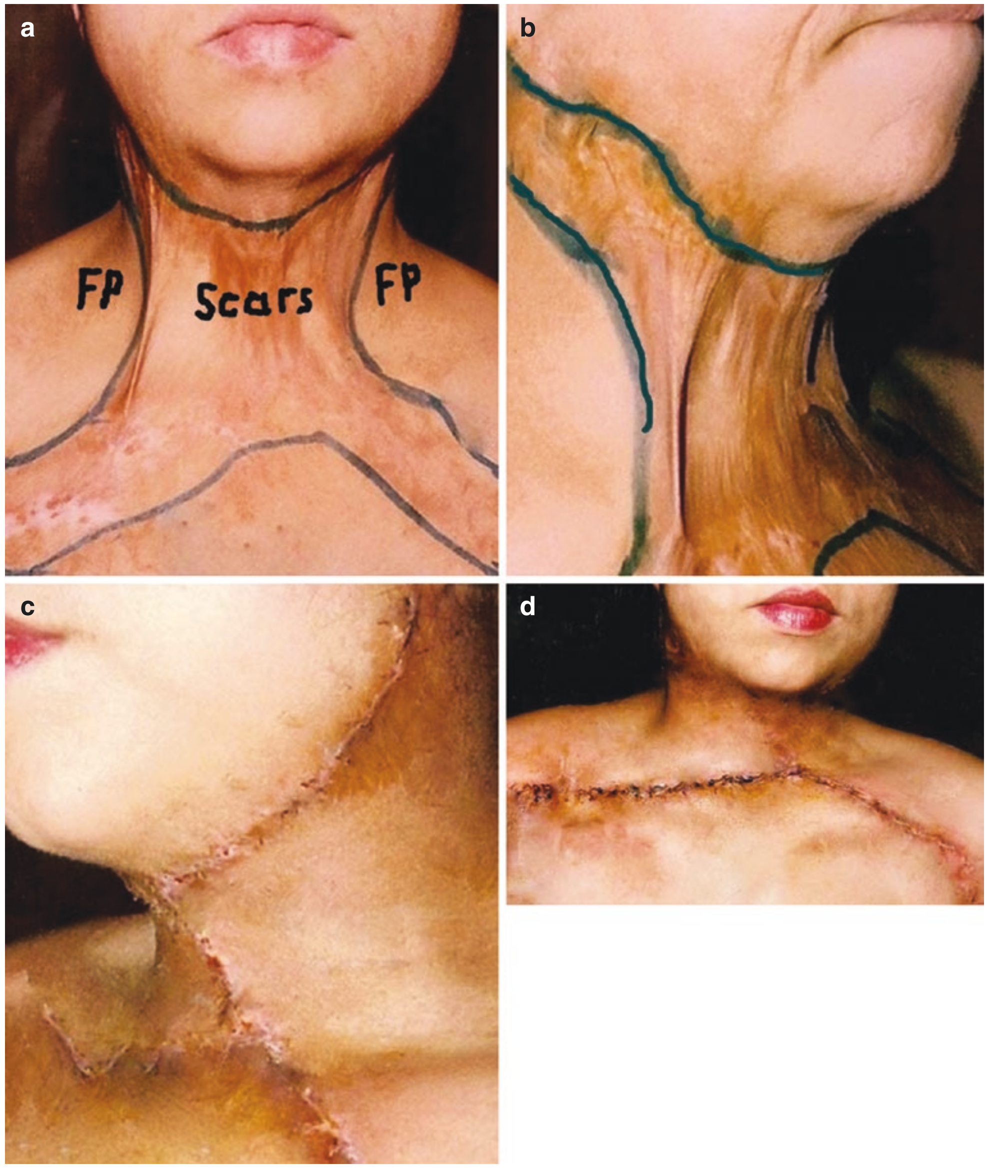

Fig. 10.3 Treatment of severe medial neck contracture: contracted scars took a butterfly shape. (**a**, **b**) Pre-surgery view, planning: boundary of scars (*SCARS*) for removal and flaps (*FP*) marked; (**c**, **d**) scars excised, contracture released, neighboring tissues elevated widely and displaced on the wound; neck and chest wall scar deformity and contracture eliminated, neck contours restored; flaps alive

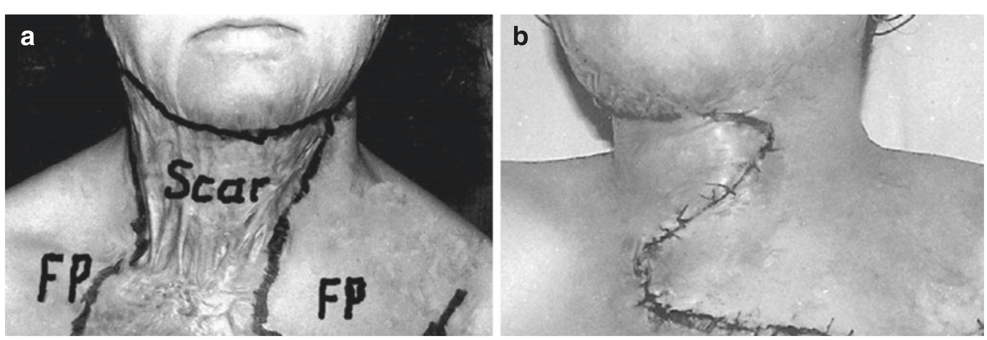

Fig. 10.4 Variant of medial neck, submandibular zone, and sternal contracture elimination and scar resurfacing with split cervico-thoracic trapezoid flaps. (**a**) Before surgery, planning of trapeze-flap plasty (*SCAR, FP*); (**b**) 10 days after reconstruction, the flaps are alive and contracture is eliminated

Contracture Treatment with Split Neck Flaps

In all cases, the aim of reconstruction is contracture elimination, scar excision, and skin restoration, with the neighboring healthy skin located laterally to the scars (Figs. 10.1 and 10.2). The edge of the scar to be removed and the borders of two neck split flaps are outlined. The exit of the perforators is marked; it should be located on the flap borders. See Chap. 6 for details of split neck flap mobilization. The scars are removed and the flaps are mobilized with a thin fat layer (split flap); platysma stays in situ. The space under the mobilized flap on the chest wall and neck can be extended with gauze tamponing (Fig. 10.1c). If the neck's split flaps are insufficient for wound covering, the thoracic adipose-cutaneous layer is involved (cervico-thoracic split flap); the flap is detached from the clavicles, manubrium, and pectoralis major muscle fascia (Figs. 10.1, 10.3, and 10.6). The mobilized flap on the chest wall and neck can be extended with gauze tamponing. If necessary, the trapezoid flaps are formed from the healthy skin by incising along the mento-cervical angle projection and upper clavicles (Fig. 10.2). The flaps are counter-transposed and placed on the wound, one above the other, with tension (Figs. 10.1, 10.2, and 10.4).

If a wound is large and the flap is transposed with severe tension, the inner flap's surface should be fixed with sutures to the fascia of the major pectoralis muscle and to the mandible (Figs. 10.3 and 10.5). The line of the flap's connection is passed oblique on the anterior neck surface; the location of upper and lower suture lines depends on the scar form and the borders of their excision. Simultaneously, the scars on the lower face and chest wall can be excised. The sub-flap's space is actively drained.

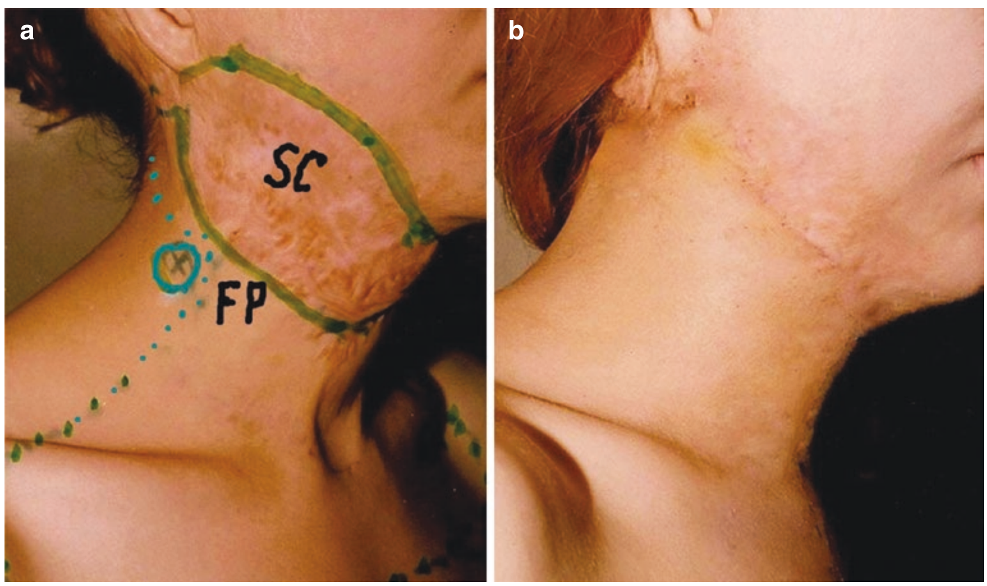

Fig. 10.5 Lateral submandibular contracture and deformity elimination by cervico-thoracic split ascending flap. (**a**) Pre-surgery marking of scars to be removed and boundaries of flap elevation; "+" perforator exit. (**b**) Follow-up result: deformity and contracture are eliminated

Submental/Submandibular Contracture and Atypical Neck Scar Deformities

Burns and scars often injure isolated regions of the neck (submental, submandibular, anterior, and lateral) or other zones. The scars look like an island of a different size and form, surrounded by the healthy skin (Figs. 10.5, 10.6, and 10.7). Usually, these scars present problems that are more cosmetic than functional. In all cases, local scars should be removed and the skin restored with split neck flap.

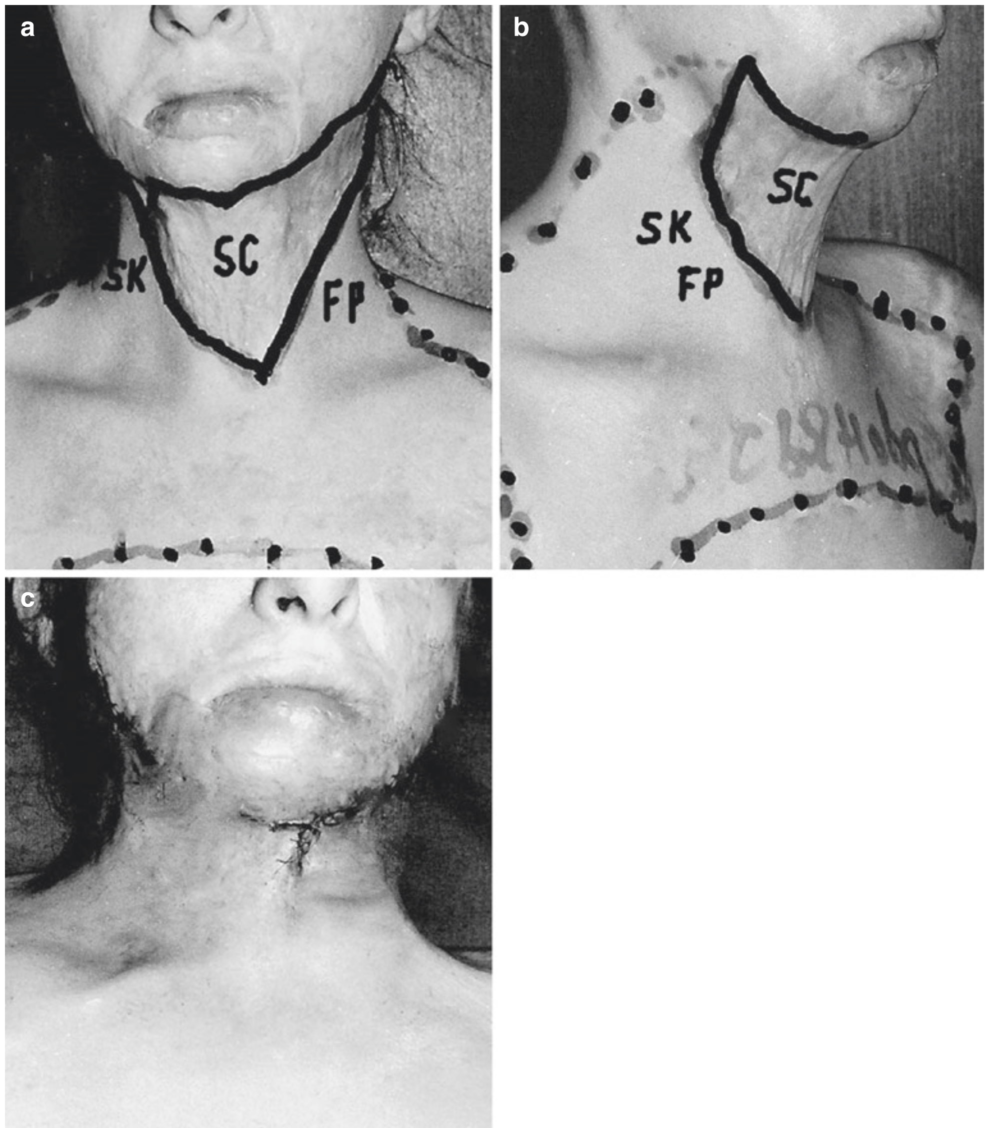

Fig. 10.6 Severe submandibular burn causing widespread contracted scars. (**a**, **b**) Pre-surgery view, planning: boundary of scars for removal and cervico-thoracic split flap elevation; (**c**) scars excised, contracture released, wound covered with a split ascending cervico-thoracic flap

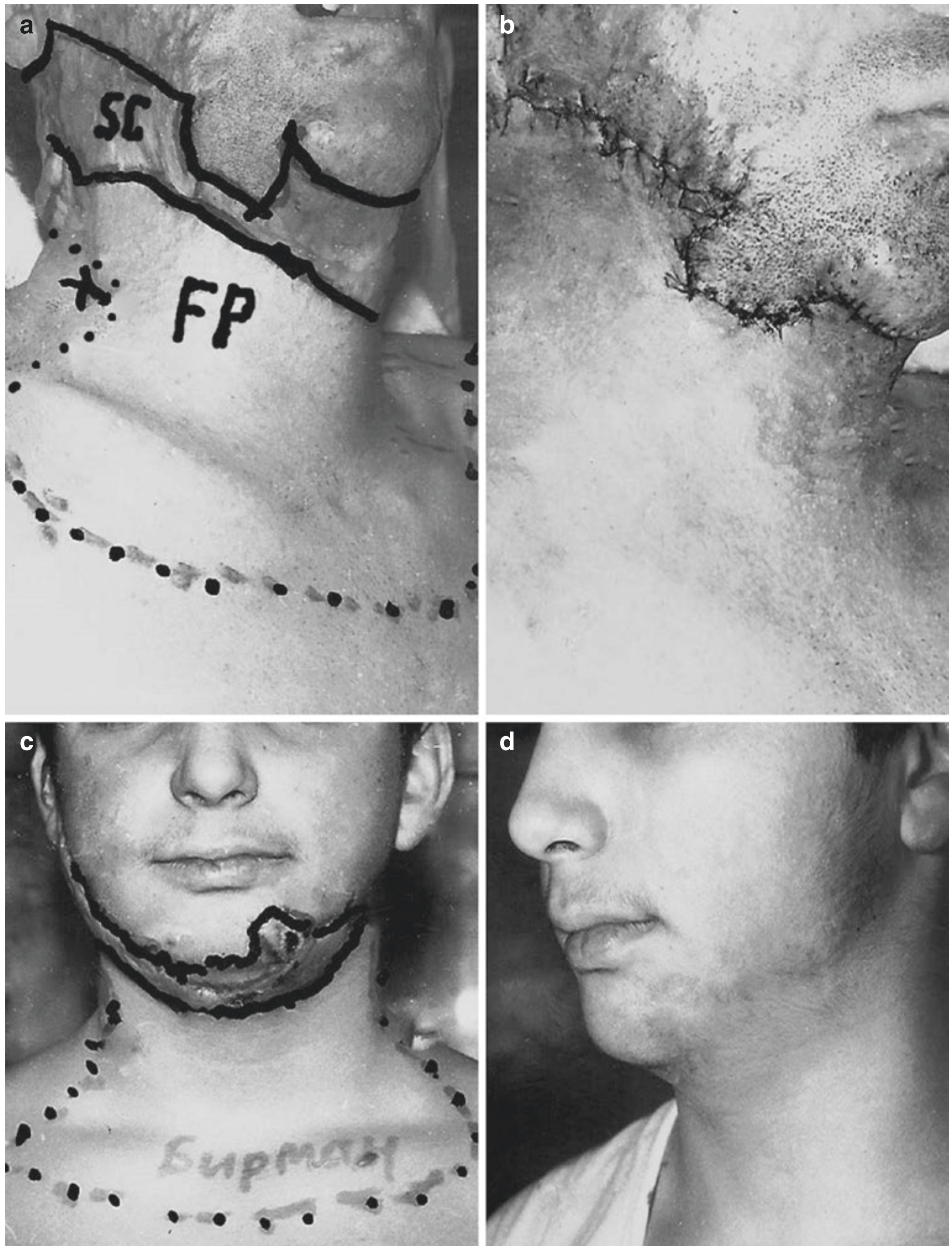

Fig. 10.7 Submandibular postburn deformity and contracture elimination with split ascending neck flap (two cases). (**a**, **c**) Pre-surgery, planning; (**b**, **d**) scars excised and wound covered with split ascending neck flaps; scar deformations removed

Conclusion

Reconstruction of the neck medial contracture with the split neck flaps, in most cases, yields good functional and cosmetic outcomes. Usually, the operation is one-staged. With time, skin tension disappears, and the contours of the operated area follow normal anatomical features.

Suggested Readings

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11 Unilateral Neck Scar Contracture and Deformity Elimination with Contralateral Split Neck Flap

Introduction

In this chapter, we focus on cases of neck burns and neck contractures in which only one side of the anterior neck is injured and the opposite side is largely preserved. Even though this is a very specific injury scenario, we found it to be very common among burn patients because the neck is an exposed area and because it is a natural reflex to turn the face away from a heat source, which leaves one side of the neck more exposed to injury.

While burns are healing, scars of one side of the neck become contracted, drawing surrounding skin toward the contractures. The scarred surface becomes smaller than the actual burned surface. Therefore, after scar excision, the wound opens up, becoming significantly larger than the scar surface.

Anatomy of Unilateral Neck Scar Contracture

The anterolateral width of the neck scars is from 5 cm in children to 8 cm in adults (Figs. 11.1 and 11.2). The scars descend to the corresponding half of the chest wall. The skin of the opposite anterolateral neck, posterior neck, and opposite half of the anterior chest wall remains undamaged. Scars that cover all of the anterior chest wall make neck reconstruction very challenging. In these cases, staged reconstruction of the chest and neck is needed. During healing of burns, the scar surface shrinks; the scarred surface becomes smaller than the real burned surface area (Fig. 11.1b), pulling healthy contralateral and back-of-neck skin toward the damaged area. Therefore, after the scar is released and excised, the wound becomes significantly larger than the scar surface marked for excision (Fig. 11.1d).

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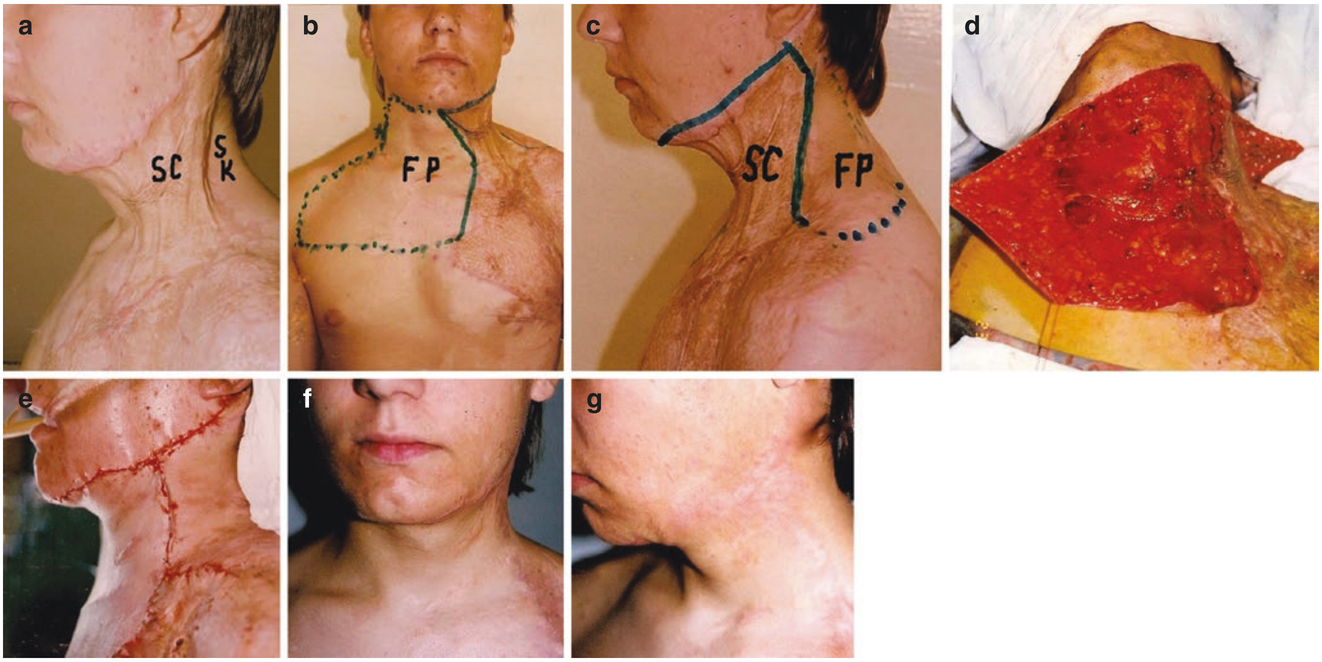

Fig. 11.1 Unilateral neck contracture anatomy and resurfacing with contralateral split cervico-thoracic flap. (**a**) Before operation: unilateral neck and chest wall deformity with contracture; (**b**, **c**) planning: solid line—incisions, dotted line—borders for flap mobilization, and symbol "+" is a perforator exit location; (**d**) whole neck split flap mobilized without platysma and incisions of healthy skin; (**e**) scars removed, wound covered with cervico-thoracic split flap; (**f**, **g**) 2 years after reconstruction, neck contracture and scar deformity eliminated

Fig. 11.2 Unilateral neck resurfacing with split cervico-thoracic flap with simultaneous chest wall deformity excision. (**a**) Pre-surgery: half of the anterior neck surface and submandibular region is covered with scars, causing contracture; scars on anterior chest wall; (**b**) planning, dotted line indicates the borders of large cervico-thoracic flap mobilization, solid line is border of scar excision; (**c**) 6 months after surgery

Reconstructive Technique [1]

The cervico-thoracic split flap boundaries (Figs. 11.1b and 11.2b) are marked on the undamaged side of the neck and chest wall (dotted line) and boundaries of the scars to be excised (solid line). The symbol "+" indicates the superficial cervical artery perforator exit (in the middle of the posterior edge of *sternocleidomastoid muscle*). Special care is necessary to protect this axial blood supply for the split flap to be viable. Healthy skin incisions are not planned.

First, the neck flap is mobilized from the incision along the scar border as outlined, with the thin subcutaneous fat layer, without platysma (split flap); the perforator exit place (posterior middle of *sternocleidomastoid muscle*) stays in situ (Fig. 11.1d; see also Fig. 11.6b). Then, the adipose-cutaneous chest wall flap is separated from the clavicle, manubrium, and pectoralis major muscle fascia down to the level of the second rib and axillary anterior fold on one or both sides, depending on the extent of the scar. The skin of the neck and chest wall is not incised. The under-flap cavity is tightly tamponed with gauze during neck scar excision to control bleeding and stretch the mobilized flap. Mobilized tissues are then transposed on the scarred neck surface with tension in order to determine the neck surface that can be covered by the flap.

After scar excision (nearly 6 cm in width, from mandibula to clavicle), the flap is advanced on the wound with significant tension covering the upper region of the neck first. Because of the tension created by the flap, the skin of the back of the neck is displaced forward, covering the donor site. The chest part of the flap is displaced upward to the neck, and non-mobilized tissues of the axilla and chest wall will also shift, covering the chest part of the donor site. As a result, the flap can advance significantly, resurfacing the neck surface (Fig. 11.1e). The lower cheek can be resurfaced (Fig. 11.3) and the chest wall scars excised simultaneously (Figs. 11.2 and 11.4). If chest skin is damaged, the flap's efficacy is restricted; therefore, scars that are only 5 cm in width are excised. The next reconstruction stage is undertaken 10–12 months later, after the tissue tension disappears due to skin growth. Boundaries of the repeat mobilization of

Fig. 11.3 Unilateral neck and low cheek resurfacing with split cervico-thoracic flap. (**a**) Before reconstruction; (**b**) planning; (**c**) 6 days after contracture elimination with a cervico-thoracic split flap

the adipose-cutaneous cervico-thoracic flap are somewhat wider as the skin's elasticity decreases. Additional scar excisions are not more than 4–5 cm wide. The flap is not fixed to the underlying tissue. The wound edges are closed with two rows of sutures (the inner row is non-absorbable) to prevent wound dehiscence. The under-flap space is actively drained. Neck splinting is not required.

Localization of scars on the neck and spreading on the face and chest wall differ from case to case. A specific reconstructive technique is used depending on the anatomy and size of the contracture. Some variants in pathology, methods, and results of their elimination with split neck flap are presented in Figs. 11.3, 11.4, 11.5, 11.6 and 11.7.

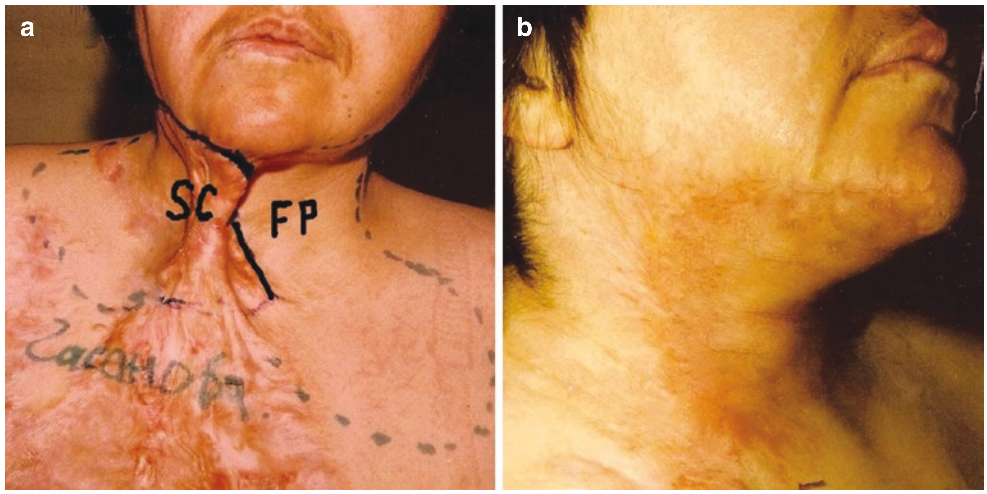

Fig. 11.4 Neck and chest wall reconstruction with a split cervico-thoracic flap. (**a**) Before operation, planning; (**b**) 4 weeks after surgery

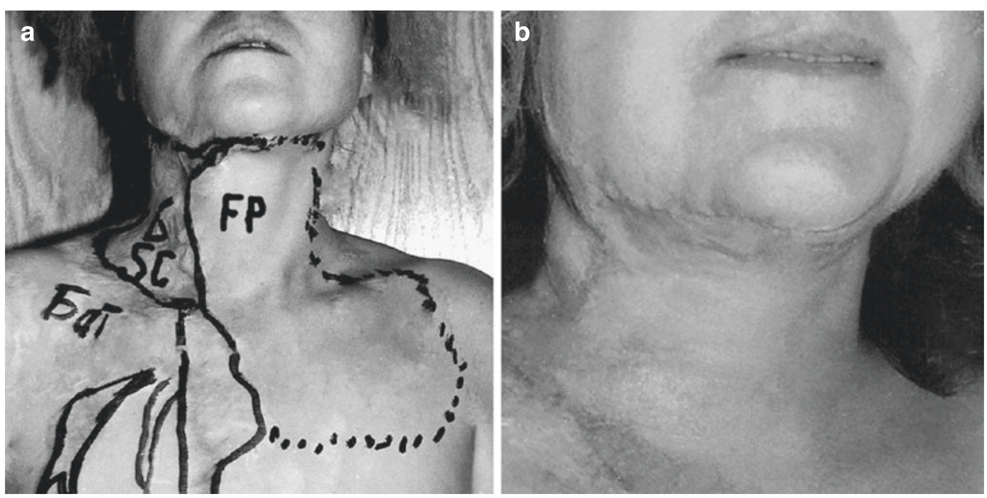

Fig. 11.5 Neck and chest wall reconstruction with a split cervico-thoracic flap. (**a**) Before surgery; planning the neck and chest wall reconstruction; (**b**) 2 weeks after surgery

Fig. 11.6 A variant of resurfacing half the neck anterior surface with contralateral split flap. (**a**) Pre-surgery view; the right side of the neck is covered with contracted scars; (**b**) scar excision; (**c**) end of operation: scars replaced with neck split flap

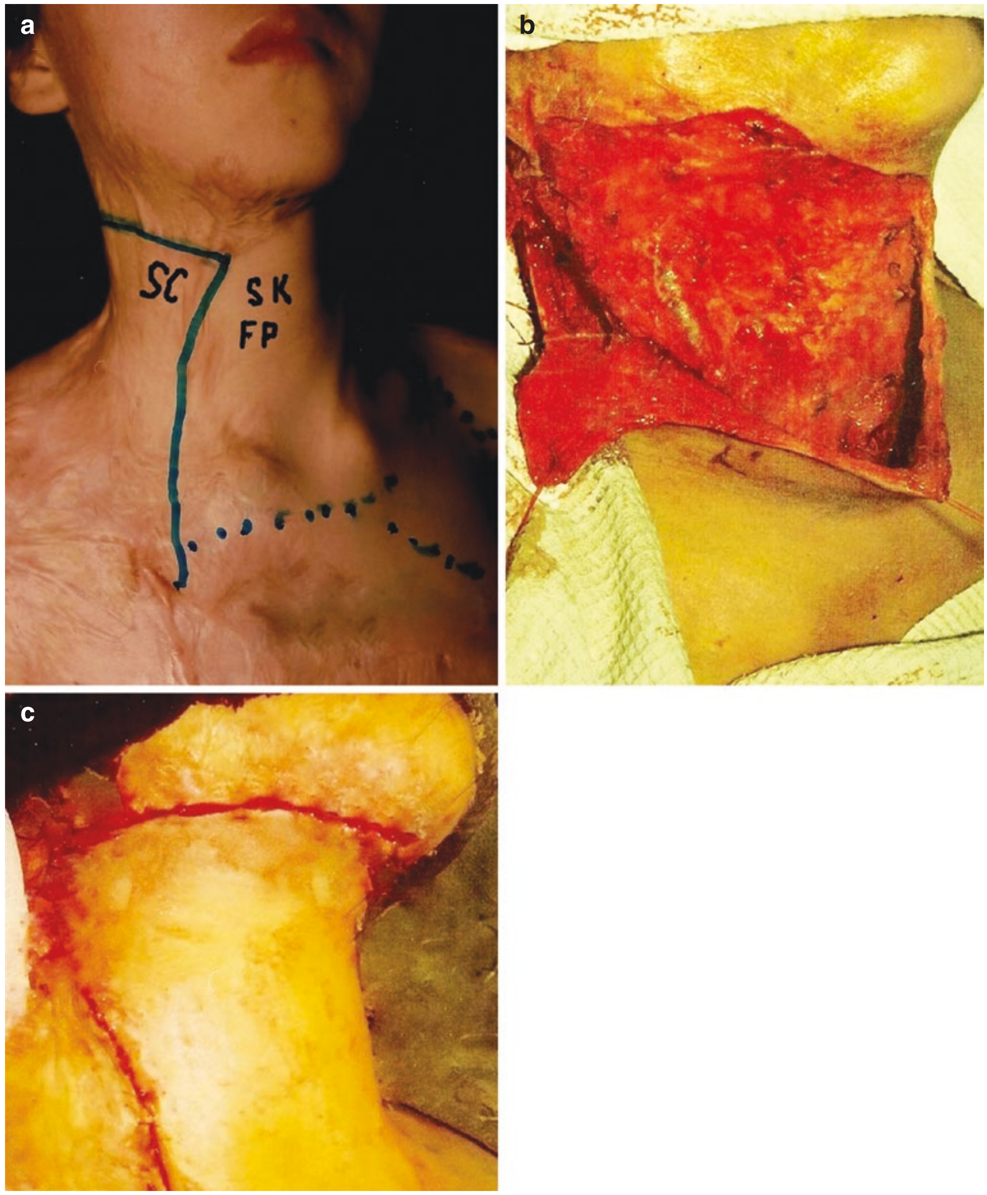

Fig. 11.7 Result of unilateral neck deformity and contracture elimination with a cervical split flap. (**a**, **b**) Pre-surgery view; (**c**) 3 weeks after reconstruction

Conclusion

Because of the flap transposition with tension, the adipose-cutaneous layer of the chest wall, axilla, shoulder joint, and the back of the neck are displaced on the donor wound (scar excision site). The soft tissues of the neck are squeezed, the neck becomes thinner, and the wound becomes narrower. With a single procedure, neck contractures are eliminated completely and the skin in the mandibular zone is restored. Chest wall scars are excised simultaneously with cervical reconstruction. No tissue failure or flap loss occurs if axial circulation of the neck flap is preserved. Mild flap microcirculation disorders (edema, venous stasis) gradually disappear over 2–4 weeks after surgery. Good cosmetic results are observed after single-stage reconstruction. No breast displacement is noticed at long-term follow up. A two-stage or three-stage reconstruction of the neck, using the same technique, yields good long-term results. Flap skin preserves its properties (elasticity, color, and texture) and continues to grow. The donor site remains undamaged; there are no operation scars on the anterior surface of the neck.

Reference

1. Grishkevich VM. Unilateral cervical burn scar deformity elimination with contralateral cervicothoracic flap. J Burn Care Res. 2012;33:e26–31.

12 Lateral Neck Contractures: Anatomy and Treatment

Introduction

Our observations of hundreds of burned patients showed that in lateral and posterior neck burns, contracture folds usually form along the lateral surface of the neck. Thick contracture cords severely restrict head motion and require surgical correction, especially in children. Both sheets of the contracture fold have a surface deficit in length (actual cause of contracture) and surface surplus in width. During release of the scar contracture, the surgical wound usually takes a trapezoidal form. The conclusion was drawn that scar surface surplus in width can be used to compensate for the scar surface deficit in length. Contracture elimination thus became possible using trapeze-flap plasty.

Lateral Neck "Edge" Contracture Anatomy

Edge neck contractures are typically caused by burns and scars located on the posterior neck surface (Figs. 12.1 and 12.2). Contracture is characterized by a crescent-shaped fold that forms along the medial line of the lateral neck surface (Fig. 12.1a, b). The fold spreads from head to shoulder and consists of two sheets with distinctive anatomical qualities: (1) the posterior sheet of the fold is scar (*S*), which covers the posterior neck surface; and (2) the anterior sheet of the fold is healthy skin (*H*), continuing to the uninjured skin of the anterior neck surface. The crest of the fold is the edge of the scar (thus the name of the deformity: *edge contracture*). Scars have a surface deficit in length, which causes the contracture, and both sheets—scar and skin—have surface surplus that allows contracture treatment with local flaps.

The scar surface deficit in length and surplus in fold's sheets must be determined since reconstruction is aimed to compensate the scar surface deficit with flaps of corresponding/matching form and size. The form and size of the scar surface deficit is estimated using the following steps: After planning the operation, the sheets are divided with an incision along the fold crest. Then the posterior (scar) sheet is dissected with a perpendicular Y-incision from the fold crest until complete contracture release. Incision ends with a Y-split at approximately 45° for easy scar edge divergence. After neck extension, the wound, as a rule, takes on a trapezoid form (Fig. 12.1c–f), reflecting the shape and size of the scar surface deficit (contracture cause). In other words, the cause of the contracture is scar surface deficit, which has a trapezoid shape. Scar surface deficit is maximal at the fold crest and gradually diminishes toward the posterior neck. This means that the form and size of the flap needed to cover the surface deficit to eliminate contracture must correspond to the deficit and thus have a trapezoid form (not triangular). In summary, the four anatomical features that characterize the contracture type we call edge contracture are (1) the scar location on the posterior surface of the neck; (2) the fold is formed along the lateral neck surface; (3) different qualities of the sheets of the fold; and (4) the edge of the scar is at the fold crest.

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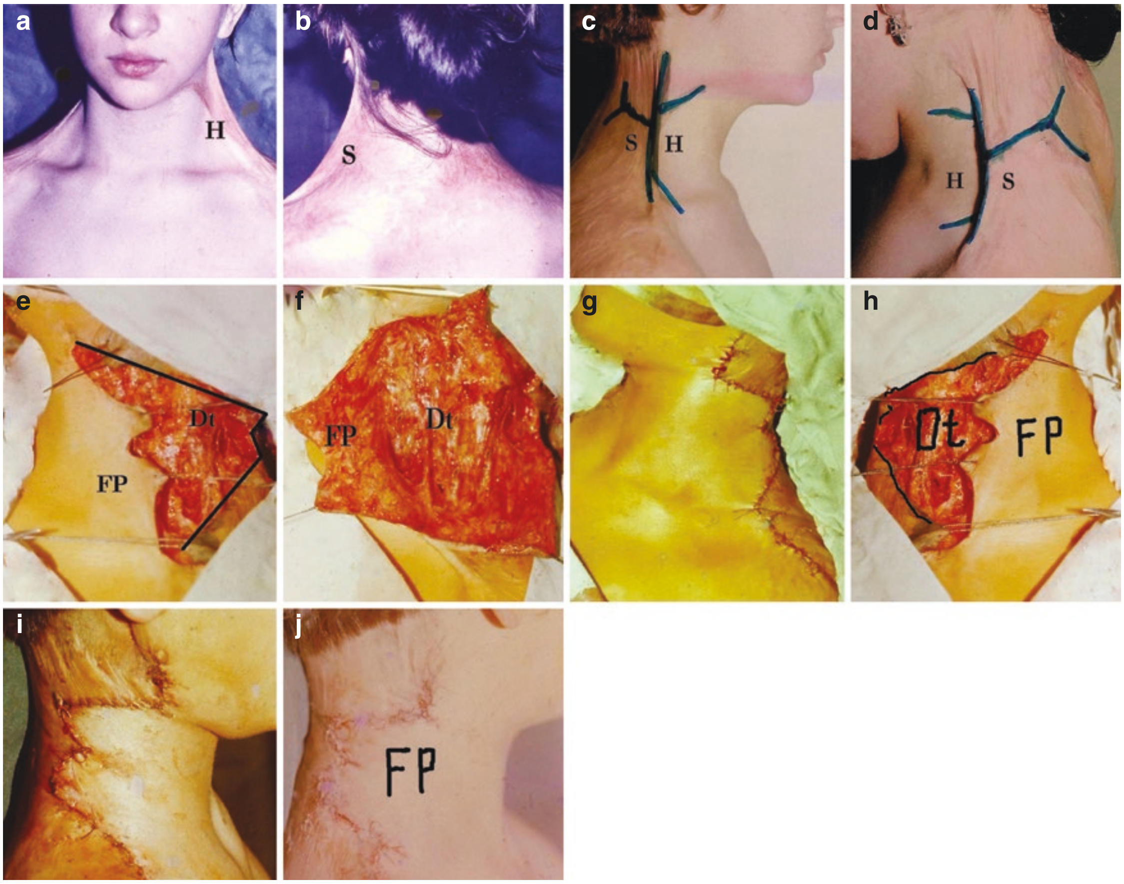

Fig. 12.1 Neck bilateral edge contracture anatomy and treatment with adipose-cutaneous flaps. (**a**, **b**) Bilateral edge contractures after posterior neck burns caused contracture folds in which the anterior sheet is healthy skin and the posterior sheet is scar and contracture cause; (**c**, **d**) planning of operation: on the anterior neck two trapezoid flaps are outlined, Y-shaped incisions for scar dissection; (**e**) after contracted scar dissection, trapezoid wound appeared (scar surface deficit); (**f**) adipose-cutaneous trapezoid flap mobilized; (**g**) end trapeze-flap plasty, contracture released; (**h**) right side of the neck reconstruction: scars dissected with Y-shaped incision, resulting trapezoid wound is scar surface deficit and contracture cause; (**i**, **j**) results: contracture totally eliminated, neck contours restored with excellent functional and cosmetic outcomes (7 days after surgery). *Dt* deficit, *FP* flap, *H* healthy skin, *S* scars

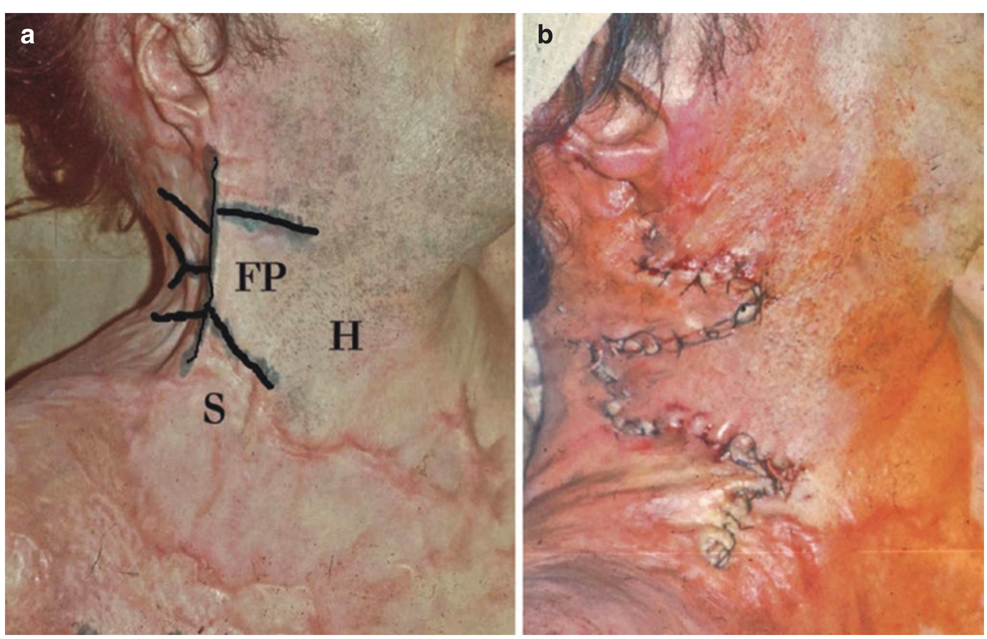

Fig. 12.2 Lateral neck edge contracture elimination with three trapezoid flaps. (**a**) Pre-surgery, planning: main flap planned from the healthy sheet of the fold (H) and the anterior surface of the neck; two adipose-scar flaps from the posterior (scar) sheet of the fold for donor wound covering; (**b**) end of operation; contracture totally released with counter-transposed trapezoid flaps. *S* scar, *H* healthy skin, *FP* flap

Lateral Neck "Edge" Contracture Treatment Technique

Edge Contracture Elimination with One Trapezoid Flap (Fig. 12.1a–j)

The presence of surface surplus in both sheets of the fold and healthy skin on the anterior neck surface allows contracture treatment with one local adipose-cutaneous trapezoid flap. The flap is prepared from the anterior (healthy) sheet of the fold and anterior surface of the neck. Planning of bilateral edge contracture elimination (Fig. 12.1c, d) consists of the following mapping: (1) line along the crest of the fold; (2) perpendicular line on the posterior (scar) sheet with Y-shaped end; and (3) two lines on anterior (healthy) sheet outlining the borders of the flap.

With the first incision along the fold crest, the sheets are separated. The following perpendicular Y-incision dissects the scar sheet contracted scars, and subcutaneous fat layer on the posterior neck surface. After full neck extension, as a rule, a trapezoid wound is formed (Fig. 12.1e, f). According to the wound shape and size, although wider by about 30%, the adipose-cutaneous trapezoid flap is mobilized from the anterior (healthy) sheet and the anterior neck surface (Fig. 12.1f). Only the superficial subcutaneous fat layer (without platysma) is included in the flap. The upper incision passes along the mentocervical angle; the lower incision passes above the clavicle. The end of the flap is about 6 cm wide, depending on the fold length, contracture type, and the patient's age. The length of the flap is about 6–8 cm. The end of the flap is cut 2 cm deep to match the M-shaped edge of the wound. The flap is transposed on the wound with tension and fixed to the wound borders. After that, contracture of the opposite side of the neck is released with the same technique (Fig. 12.1h–j). As a result of tension, the flap's base displaces toward the scars. The soft tissues of the neck are squeezed, and the mobilized skin of the anterior neck is displaced toward the injured cervical surface (posteriorly), covering the narrowed donor wound, compensating for the scar deficit, and eliminating contracture in full (Fig. 12.1g, j).

Reconstruction of Severe Edge Contracture with Three Trapezoid Flaps (Fig 12.2)

In extensive burns, scars on the chest wall may restrict neck tissue transposition and limit adipose-cutaneous flap mobilization. Insufficient surface of the anterior (healthy skin) trapezoid adipose-cutaneous flap is compensated by additional adipose-scar trapezoid flaps prepared from the posterior (scar) sheet of the fold (Fig. 12.2a, b). Such a severe scar surface deficit is compensated for with a three-flap trapeze-plasty. One (main) adipose-cutaneous flap is prepared from the healthy skin of the anterior surface; two other adipose-scar flaps are prepared from the posterior scar sheet of the fold for covering the donor wound on both sides of the main flap.

Lateral Neck "Medial" Contracture Anatomy

"Medial" neck contracture is caused by burns and scars located on the lateral cervical surface (Fig. 12.3a, b). The contracture is characterized by the presence of a crescent-shaped fold located along the medial line of the lateral surface of the neck on all its extent. Both sheets of the fold are scars (main feature of "medial" contracture) that spread on the neck anteriorly and posteriorly.

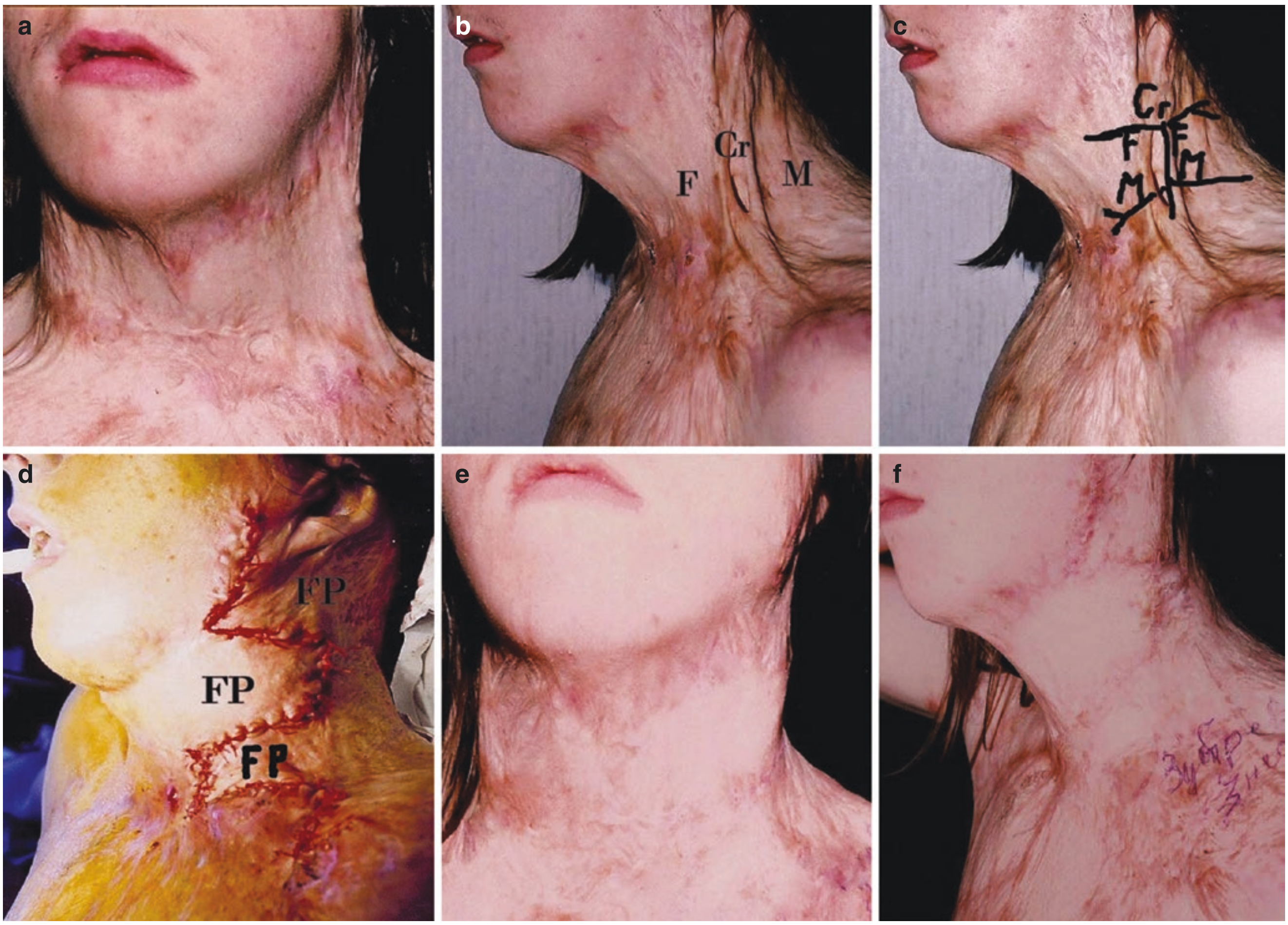

Fig. 12.3 Medial type scar contracture of lateral neck anatomy and treatment with trapeze-flap plasty. (**a**, **b**) Pre-operative view: contracture caused by the fold, in which both sheets are scars; (**c**) one pair of adipose scar trapezoid flaps planned; (**d**) adipose-scar flaps mobilized, counter-transposed, covered the wound; contracture released in full; (**e**, **f**) results (left side): contracture eliminated, neck contours restored, scar surface leveled (3 months after surgery). *FP* flap, *FM* flexion medial surface, *Cr* crest of the fold

Anatomy of Contracture Cause (Fig. 12.4a, b)

Both sheets of the scar fold have a surface deficit in length, causing contracture, and surface surplus in width, allowing contracture treatment by means of surface deficit compensation with local trapezoid flaps. The shape and size of the contracted scar surface deficit in length is estimated the following way. The fold sheets are divided with an incision along the fold crest; contracture is released by a perpendicular Y-shaped incision to the fold until contracture is fully released. After neck extension in the opposite direction, the wounds of both sheets, as a rule, take on a trapezoid form (Fig. 12.4b). This means that the cause of a "medial" type contracture of lateral neck is a scar surface deficit that has a trapezoid form. Consequently, adequate contracture treatment can be performed by means of surface deficit compensation with trapezoid flaps (not triangular).

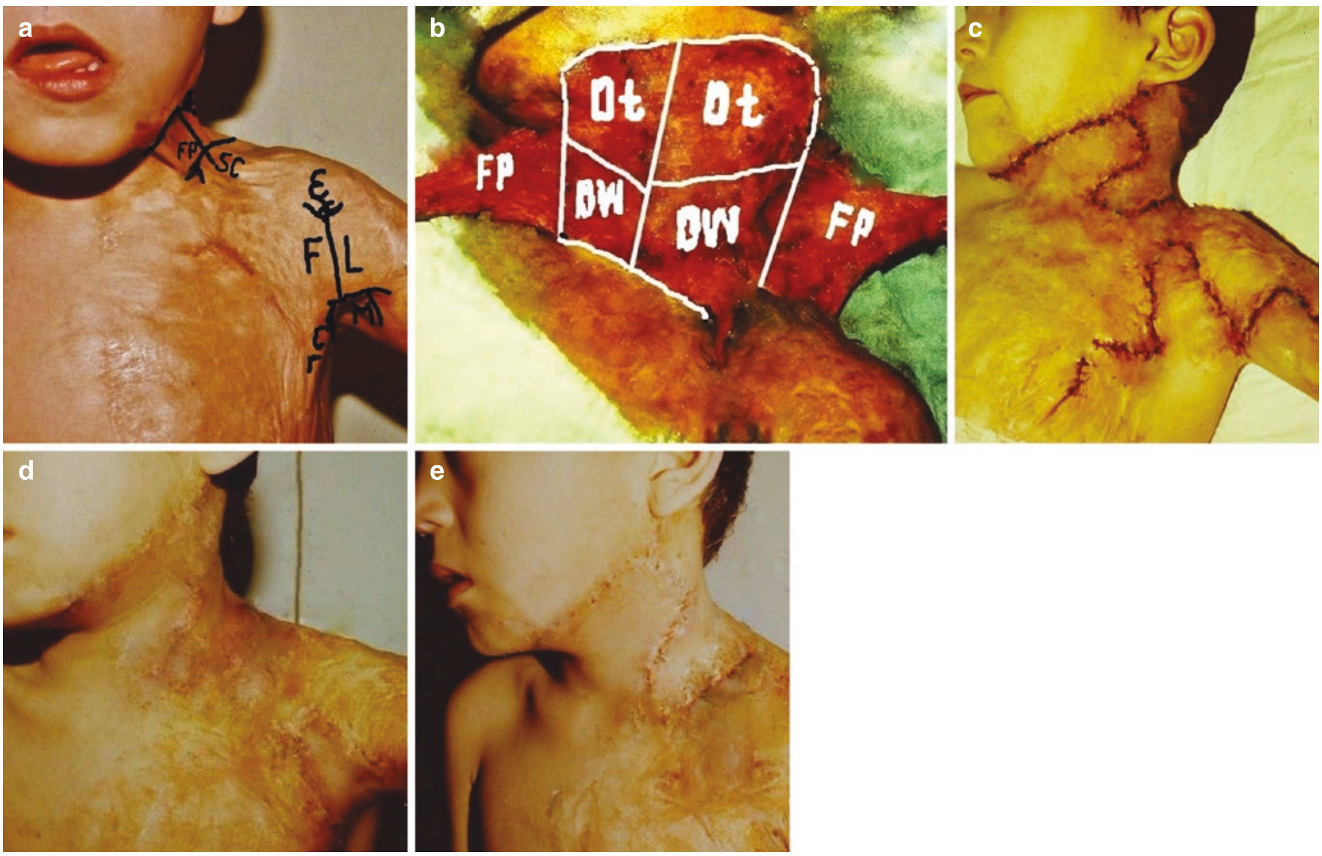

Fig. 12.4 Lateral neck "medial" type scar contracture anatomy and treatment in children using trapeze-flap plasty. (**a**) Pre-surgery: medial contracture of lateral neck surface caused by the scar fold; concomitant edge shoulder adduction contracture; planning: neck: *FP* trapezoid flaps planned; *SC* scars; shoulder: *FL* flexion lateral surface, scars; both sheets of the fold are scars; planning of medial neck and edge shoulder contractures elimination; (**b**) mobilized adipose-scar flap (*FP*), the wound between the middle and lateral strips consists of: scar surface deficit (*Dt*) of trapezoid form and *DW* donor wound; (**c**) 5 days after operation, counter-transposed flaps—neck contracture released; axillary trapezoid flap edge shoulder contracture eliminated; (**d**, **e**) 2 weeks after: medial neck and edge shoulder contractures eliminated

Treatment of medial contracture of lateral neck

Medial Contracture Treatment (Figs. 12.3, 12.4, and 12.5)

Planning consists of several mapping lines: one line along the crest of the scar fold and two radial lines that outline two trapezoid flaps in the central cervical zone. The radial lines, as a rule, form a trapezoid shape as the fold has a crescent form. The distance between radial lines (incisions) at the fold crest is about 5 cm depending on the patient's age, contracture severity, and the length of the fold. The flap's length depends on the fold's width and contracture severity. The fold is converted to the trapezoid figures with radial lines. After mapping, completed sheets are divided with an incision along the fold crest, and the pair of trapezoid flaps are mobilized, including the subcutaneous fat layer, which secures a steady blood circulation. The adipose-scar flaps are counter-transposed with tension covering the wound and elongating the lateral neck surface by more than 100%. The flap's free end reaches the base of the opposite flaps, and fully covers the wound. In this position, flaps are sutured together and to the wound's edge. Bilateral neck contractures can be reconstructed simultaneously using the same technique. Frequently, other contractures are eliminated simultaneously using trapeze-flap plasty (Figs. 12.4a and 12.5a).

Lateral neck contractures of the "medial" type are frequently observed in children; they may be combined with shoulder joint damage and anterior edge adduction contracture (Fig. 12.4a). Both contractures are eliminated simultaneously: the neck by one pair of adipose-scar trapezoid flaps (Fig. 12.4a–e); the shoulder contracture is released with an adipose-cutaneous trapezoid flap, mobilized in axillary fossa (Fig. 12.4a, c, d).

Vast burns to one side of the body cause different types of scar contractures; the "medial" type lateral neck contracture is combined with edge contractures of shoulder and elbow (Fig. 12.5a–d). Multiple contractures are eliminated in one stage using specific variants of trapeze-flap plasty for treatment of medial and edge contractures (Fig. 12.5a, d).

Fig. 12.5 Result of lateral neck "medial" contracture and "edge" shoulder contractures treatment with trapeze-flap plasty. (**a**) Before operation: severe lateral neck contracture and shoulder adduction and elbow flexion contractures; *FL* joint flexion lateral surface covered with scars, scars formed fold; *FM* fold on lateral neck surface; both sheets of the fold are scars; (**b**) planning: two opposite trapezoid flaps on the neck (and one trapezoid flap in axilla and elbow fossa, not shown); (**c**) neck contracture eliminated with one pair of trapezoid adipose-scar flaps; (**d**) edge shoulder contracture eliminated with one axillary adipose-cutaneous flap, elevated in axillary fossa. *S* scars, *CR* crest of the fold, *FM* scars, flexion medial surface. "+" joint rotation axis; *FD* fold, *FL* flexion lateral surface

Conclusion

Lateral neck scar flexion contracture is less common and anatomically different from anterior contracture. There are two forms (types) of lateral contractures: edge and medial. Both types are characterized by a fold formation along the central lateral cervical zone. In the fold sheets, there is surface surplus that allows contracture treatment and scar surface deficit (contracture cause) compensation, which has a trapezoid form. As the scar sheet surface deficiency has a trapezoid form (contracture cause), the optimal reconstructive anatomically substantiated technique for both types is based on trapezoid flaps (not triangular), yielding excellent functional and good cosmetic outcomes.

Suggested Reading

1. Grishkevich VM. Postburn neck lateral contractures: anatomy and treatment. A new approach. J Burn Care Res. 2015;36:e294–9.

13 Total Neck Anterior Scar Contracture: Anatomy and Treatment with Local Scar-Fascial Trapezoid Flaps

Introduction

One of the consequences of neck burns is neck scar deformity and contracture. Cervical contracture in children leads to functional impairment and has a profound psychological impact on the child; it inhibits mandibular growth, deforms the face, and creates kyphosis. Therefore, early surgical reconstruction is indicated. Skin grafting has a higher rate of contracture recurrence; in these cases, a flap seems to provide a durable solution. Despite the existence of multiple neck reconstruction methods, successful elimination of neck contracture remains a challenge for surgeons. A complete neck reconstruction aims to (1) eliminate the contracture and (2) restore the neck's skin using pedicle (expanded and not expanded) or free flaps.

There are cases, however, when it is simply impossible to complete both tasks simultaneously. For these patients, contracture elimination using local tissues seems to be a sufficient and satisfactory solution. Because triangular flap plasty methods do not allow for complete elimination of severe and moderate neck contractures, we propose reconstruction using scar-fascial trapezoid flaps. The flaps and reconstructive trapeze-flap technique are found to be reliable and successful; this procedure allows for the scar contracture release and neck contour restoration using local tissues [1, 2].

Anatomy of Postburn Total Neck Anterior Contracture

Besides causing disfigurement of the burned open body part, neck contractures have several anatomical features that predetermine the choice of plasty method (Fig. 13.1a–c). The length of the anterior neck surface is shortened, the mento-cervical angle is smoothed, and the scars protrude forward mostly in the middle neckline forming the fold. Therefore, the anterio-posterior neck distance becomes longer, the neck thicker, and the lateral neck surface, larger. The crest of the fold corresponds with the neck's middle line. Both fold sheets are scars that spread from the fold's crest to the lateral neck surfaces. In both fold sheets, there is a surface deficit in length that causes a contracture, and a surface surplus in width that allows for contracture elimination with local tissues. The anterior neck contracture is of the "medial" type and can be effectively eliminated with local trapezoid flaps. Skin with the subcutaneous fat layer of anterior and lateral neck surfaces was found to have an adequate axial blood supply through perforators of the superficial cervical artery (branch of subclavian artery, Fig. 13.2; see also Chap. 6). A perforator exit is located posteriorly to the middle of the sternocleidomastoid muscles (Fig. 13.1a, b; "+" symbol), as was reported from research on cadavers (Chap. 6). Therefore, healthy neck skin could be extensively mobilized without platysma. Deep burns of the neck can also damage the subcutaneous fat layer with perforators. In these cases, platysma, deep cervical fascia, and sternocleidomastoid muscle fascia are included in the flap, making the mobilization safe (scar-fascial trapezoid flap).

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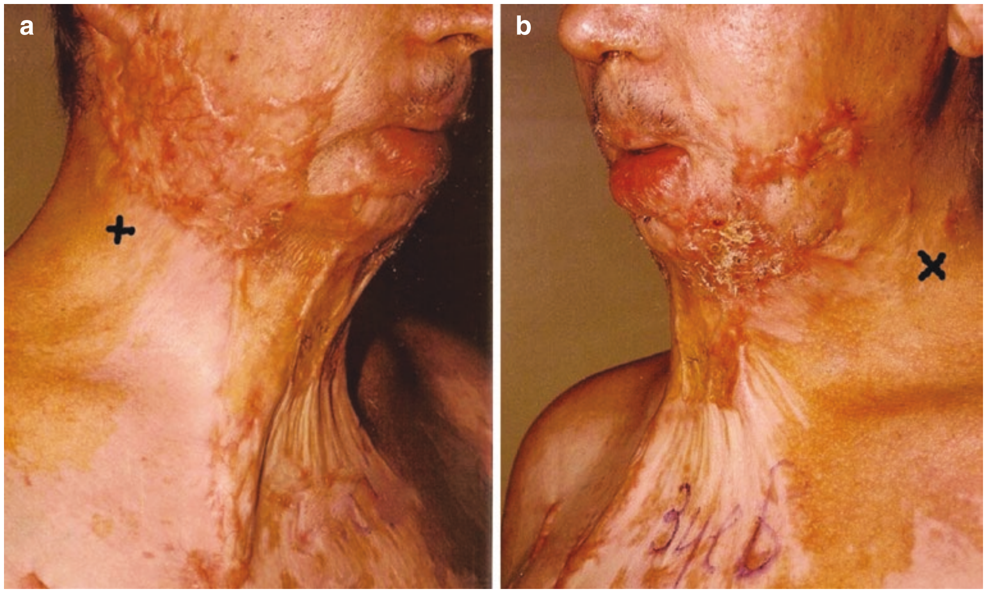

Fig. 13.1 Anatomy of neck anterior medial/total contracture and scar-fascial neck flap. (**a**, **b**) Vast scars cover the neck, face, and chest wall; smoothed mentocervical and mentosternal angles; scars protruded forward, forming the fold and making the neck anterio-posterior distance longer; the crest passes along the middle cervical line; Symbol "+" perforator exit. (**c**) Two scar-fascial trapezoid flaps mobilized; exposed sternocleidomastoid and neck muscles. Each flap includes half of the anterio-lateral neck surface: scars, fat layer, plathysma, and fascia, covering the neck and sternocleidomastoid muscles

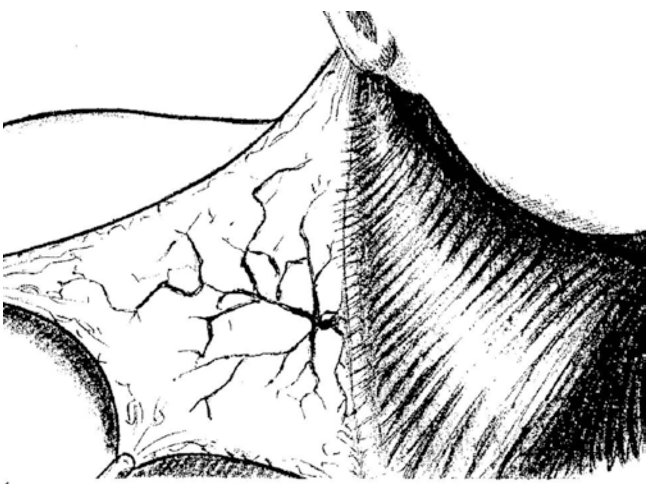

Fig. 13.2 Blood supplying the neck's adipose cutaneous layer with a perforator from the superficial cervical artery, the exit of which is behind of middle part of sternocleidomastoid flap (*see* Chap. 6)

Substantiation of the Scar-Fascial Flaps Use in Neck Moderate Anterior Contracture Treatment [1, 2]

The flap's base is located at the level of the middle of the sternocleidomastoid muscle and spreads from the mandibular angle to the clavicle middle point. As a rule, two trapeze-shaped figures (flaps) are outlined (Fig. 13.3a, b). The "+" symbol indicates the cervical superficial artery perforator exit. The flaps are mobilized from their top to their bases (Fig. 13.3c). The anterior jugular veins remain in situ. The deep fascia is separated from the neck muscles; the sternocleidomastoid muscles are separated from the fascial sheet on all their borders by incision of fascia along the anterior edge of muscle. Thus, the anterior sheet of fascia is included in the flap. Along the posterior edge of the sternocleidomastoid muscle, the fascia is not incised. Outside the mentioned muscles, the flaps were mobilized only above the clavicles in order to preserve the perforators. Consequently, the flaps include the scars, the fat layer, the platysma, and the deep cervical fascia (scar-fascial flap). After mobilization of trapezoid scar-fascial flaps, two trapezoid wounds appear on the neck beside the medial strip (Fig. 13.3c). The wound consists of: *Dt*–scar surface deficit beside the donor wound (*DW*). Scar surface deficit is located beside the *DW*; the surface deficit and donor wound have trapezoid form. The mobilized opposite flaps (*FP*) are transposed toward each other with tension, and the flap's end approaches the base of the opposite flap (Fig. 13.3d). The tension should not cause an increase of resistance to air movement in the endotracheal tube. The flaps are kept one above the other (Fig. 13.3c–f). Some scars of the triangular form in the submandibular zone are excised to shorten the wound perimeter.

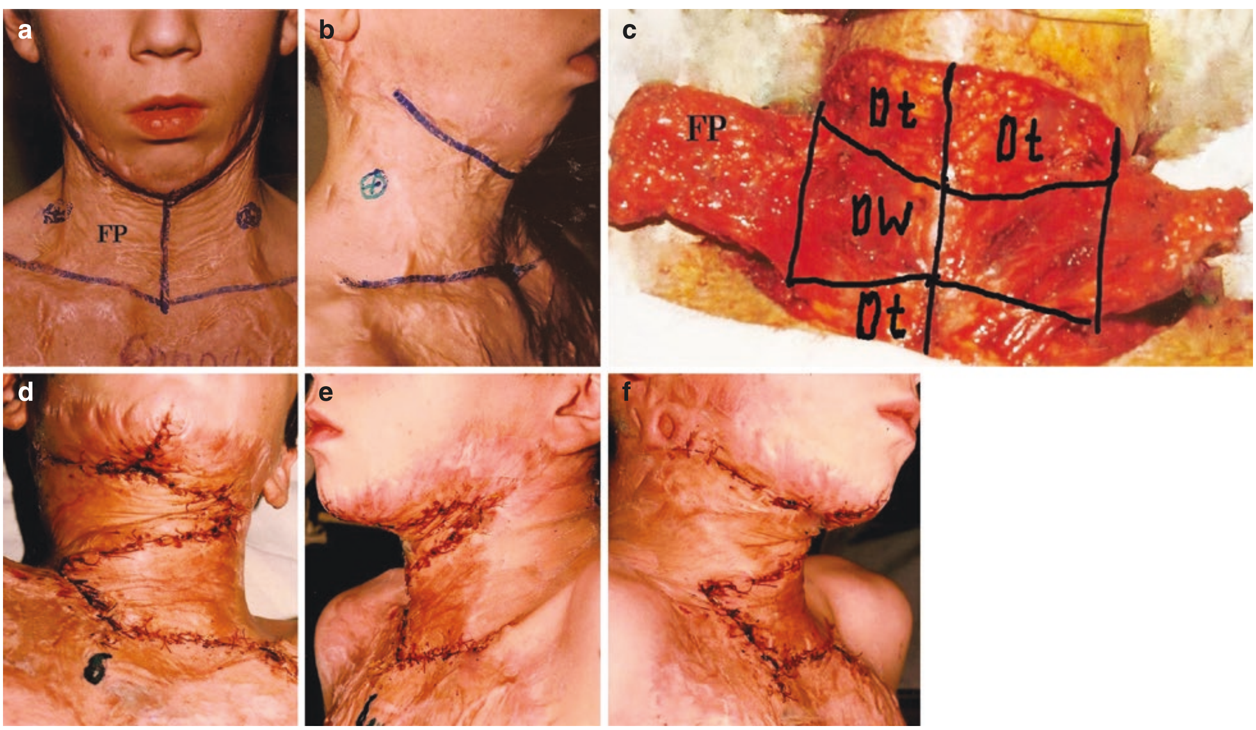

Fig. 13.3 Treatment of moderate neck anterior contracture with one pair of scar-fascial trapezoid flaps. (**a**, **b**) Before surgery, vast scars, smoothed neck angles, deformed mandibula; planning: *FP* two scar-fascial trapezoid flaps; "+" site of perforator exit; (**c**) scar-fascial trapezoid flaps mobilized, two trapezoid wounds appeared beside the medial strip: *Dt* scar surface deficit, *DW* donor wound, and *FP* flaps have trapezoid form; (**d**–**f**) contracture fully released and neck contours restored with counter-transposed flaps

Moderate-To-Severe (Total) Neck Medial Contracture Elimination

The signs of contracture are more severe: scars protrude forward and there is significant loss of mentocervical and mentosternal angles. Two trapezoid flaps are planned, one on each side of the neck (Fig. 13.4a, b). Reconstruction is performed in a manner similar to the previous case. After trapezoid scar-fascial flaps mobilization (Fig. 13.4b), the trapezoid wound appears on the neck (depicted with stripes). Counter-transposed flaps covered the wound, scar surface deficit compensated, and contracture was eliminated (Fig. 13.4c–f). Two years later, the neck skin was restored with expanded suprascapular flaps (Fig. 13.4g–i).

Fig. 13.4 Two-stage elimination of moderate-to-severe neck anterior (total) contracture with one pair of scar-fascial trapezoid flaps; first- and second-stage skin restoration with expanded scapular flaps. (**a**) Pre-operation view: the neck's anterior-lateral surfaces are covered with rough thick scars; planning: borders of one pair of trapezoid flaps marked (*FP*); *SC* scars; in submandibular triangular figure of scars to be removed; (**b**) scar-fascial trapezoid flap mobilized, a large wound appeared consisting of two trapezoid wounds reflecting trapezoid scar surface deficit (contracture cause) and trapezoid donor wound; neck muscles exposed; (**c**) flaps counter-transposed; (**d**) 5 days after the operation; flaps covered the wound, scar surface deficit is compensated, and contracture is eliminated; (**e**, **f**) result of first stage: contracture released, the neck contours restored, and scars stay in situ; (**g**–**i**) result of second stage operation (neck skin restoration) with expanded scapular flaps

Severe Neck Contracture Treatment: Variants of Wounds (Scar Surface Deficit) Covering the Submandibular Region and Over Clavicles and Manubrium

As seen in Figs. 13.5, 13.6, and 13.7, severe contracture is eliminated with a pair of the trapezoid flaps in combination with skin transplants. As mentosternal distance is greatly shortened (Fig. 13.5a), the width of the flap becomes shorter than in the previous variant. The planning (Fig. 13.5b, c) and mobilization (Fig. 13.5d, e) are the same as described in previously discussed cases. Counter-transposed flaps resurface the anterior cervical surface, but the small residual wound in the submandibular area or just above the sternum and clavicles, or in both these areas, remain uncovered by the flaps and are skin grafted (Fig. 13.5f, g). A full range of head motion and rotation are achieved (good functional results) (Fig. 13.5h, i). Stooped posture due to neck contractures disappears after neck contracture elimination (Fig. 13.5j, k).

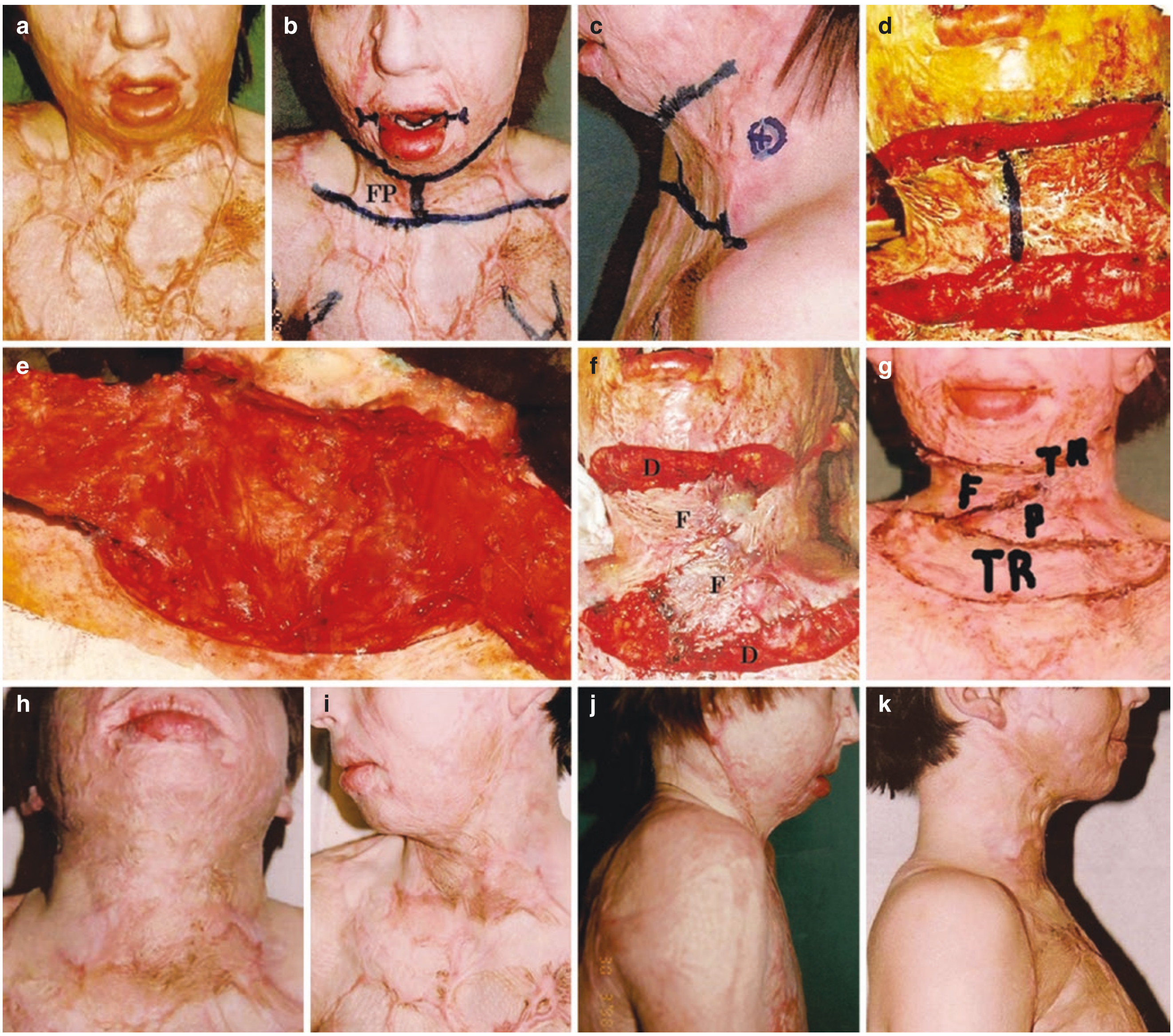

Fig. 13.5 Case 1: Severe neck anterior medial contracture elimination with scar-fascial trapezoid flaps and skin transplants. (**a**) Severe anterior neck contracture; (**b**, **c**) flaps planning; (**d**) first two incisions in mentosternal angle projection and over clavicles and manubrium; (**e**) scar-fascial trapezoid flaps are mobilized, which are narrower than usual; (**f**) flaps (*F*) counter transposed; wounds above and below the flaps are not covered, scar surface deficit (*D*) is larger than the flaps' surface; (**g**) *TR* wounds covered with skin transplants; *FP* flaps alive (2 weeks after surgery); (**h**, **i**) result of surgery: contracture released, function and contours of the neck restored, flap surface leveled; (**j**, **k**) stooping disappeared after surgery. Case 2: Total severe neck anterior contracture elimination with two-scar-fascial trapezoid flaps and two small wounds above clavicles, which were skin grafted. (**l**, **m**) Pre-surgery, planning; (**n**) scar fascial flaps mobilized; (**o**) counter-transposed flaps covered wound of neck, small wounds above clavicles; (**p**, **r**) *FP* neck anterior surface covered with flaps; *TR* small isolated wounds above clavicles were covered with skin transplants; 7 days after reconstruction, flaps and skin transplants are alive, contracture is eliminated, and the mentocervical angle is restored

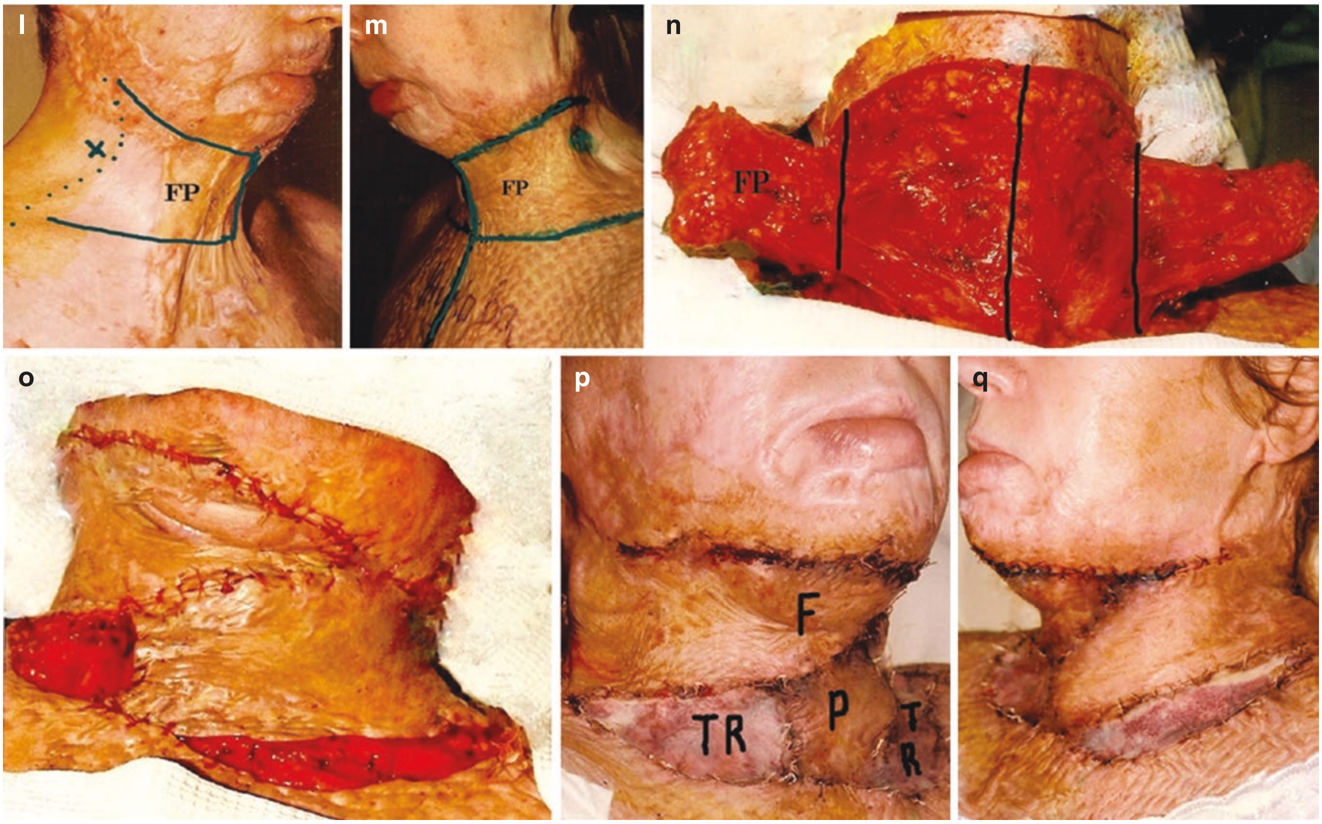

Fig. 13.5 (continued)

Fig. 13.6 Mentosternal fusion treatment with adipose-scar trapezoid flaps and skin grafts in children. (**a**) Pre-surgery view; (**b**, **c**) planning; (**d**) scar-fascial flaps, shorter and narrower than usual, mobilized on lateral surfaces of the neck; (**e**) 7 days after the operation: flaps covered the central zone of the neck anterior surface, wounds beside the counter-transposed flaps connected flaps covered with skin transplants; (**f**) result; (**g**) mild-to-moderate contracture developed 10 years later, planning of second stage operation; (**h**) adipose-scar trapezoid flaps mobilized and counter-transposed; (**i**, **j**) 1 year after reconstruction: contracture removed, neck contours restored, good common appearance

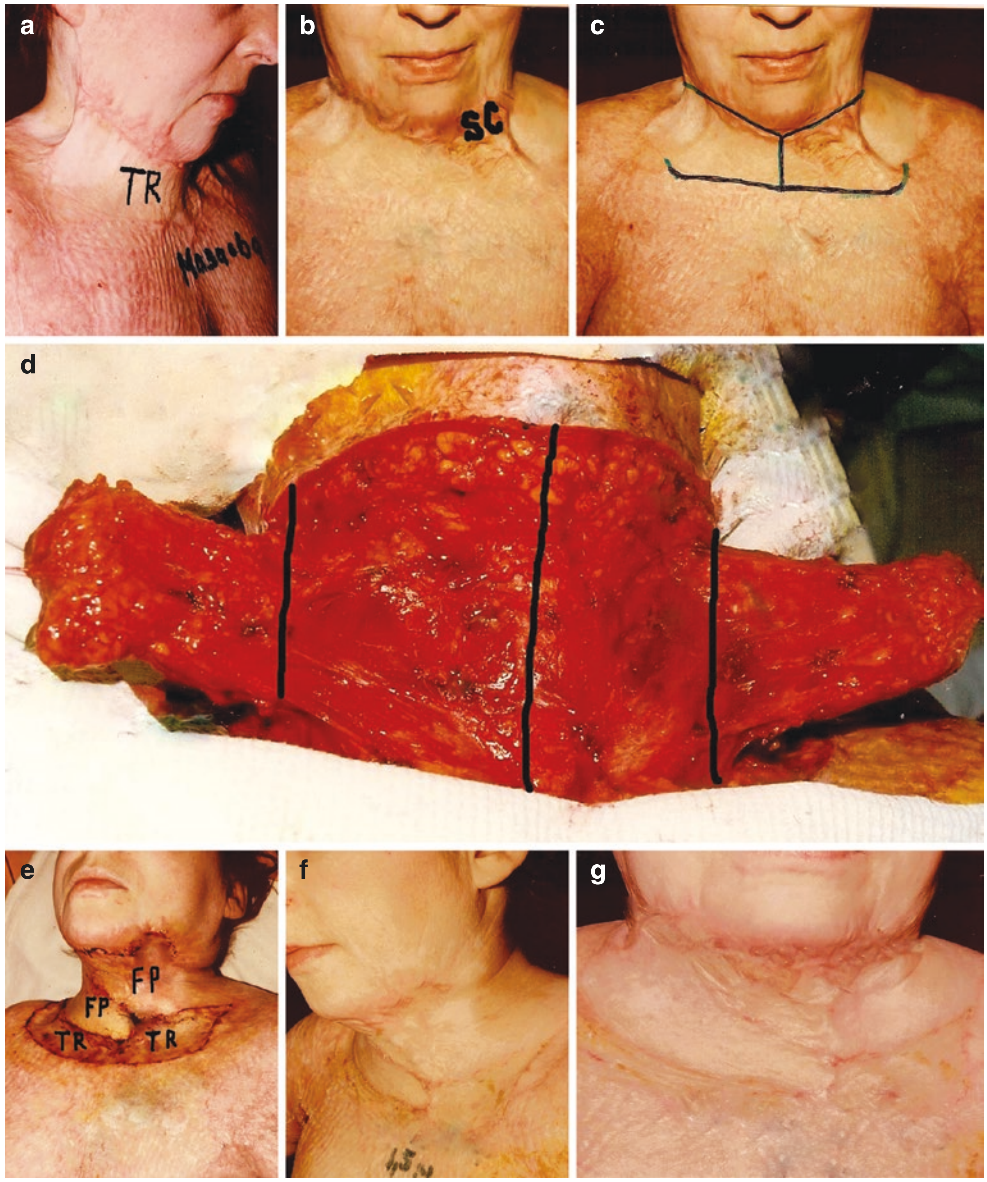

Fig. 13.7 Mentosternal fusion treated with two scar-fascial trapezoid flaps and skin transplant above clavicle and sternum. (**a**, **b**) Pre-surgery; view after burns skin grafting; *TR* skin transplant; *SC* scars; (**c**) planning operation with two flaps; (**d**) two scar-fascial flaps mobilized; (**e**) flaps (FP) covered the most part of the wound, starting from the submandibular area; clavicular zone of the wound was covered with skin transplant (*TR*); 13 days after surgery: flaps and transplant are alive, contracture is released, and the neck contours restored; (**f**, **g**) 2 months after operation; contracture is released and neck contours are restored significantly

Mentosternal Scar Fusion: Anatomy and Treatment

In cases of mentosternal scar fusion (Fig. 13.6, child; Fig. 13.7, adult), where the central part of neck surface is obliterated, trapezoid scar-fascial flaps are planned and mobilized on the lateral cervical surfaces (Fig. 13.6a–c). Treatment of mentosternal fusion with scar fascial trapezoid flaps is particularly effective in children. With transverse incision, the chin is separated from the manubrium; then, the flaps are elevated on the lateral neck surfaces using the usual procedure. Short flaps cover the central part of the wound. In the submandibular and supraclavicular regions, wounds are resurfaced with skin transplants (Fig. 13.6d, e) with good results (Fig. 13.6f). In children, the flap's surface becomes larger with time, but re-contracture can appear. This is removed with mobilization and counter-transposition of the same enlarged scar-fascial flaps prepared on all neck anterior surfaces (Fig. 13.6g–j). Scar-fascial flaps continue to grow, which allows complete contracture release without using skin transplants. The flap's growth is accompanied with changes in the flap scar surface, the quality of which improves common appearance.

In adults, at the first stage of the operation, scar-fascial flaps, harvested from the lateral cervical surfaces, can cover only the medial part of the neck anterior surface; wounds beside the flaps are skin grafted (Figs. 13.7a–g and 13.8). If the scars are immature and, therefore, contracture is not completely released because the scars continue to undergo contraction, the second stage of reconstruction is indicated 1 year later.

Chin-manubrium fusion should be released early, after the wound has healed (Fig. 13.8a–e). Adipose-scar trapezoid flaps, taken on both lateral surfaces of the neck, cover a central part of the neck anterior surface. The wounds beside the flaps are skin grafted (Fig. 13.9a–c). Since the scar is immature, flaps and skin grafts continue to shrink; therefore, a second, similar, operation is indicated after tissue maturation.

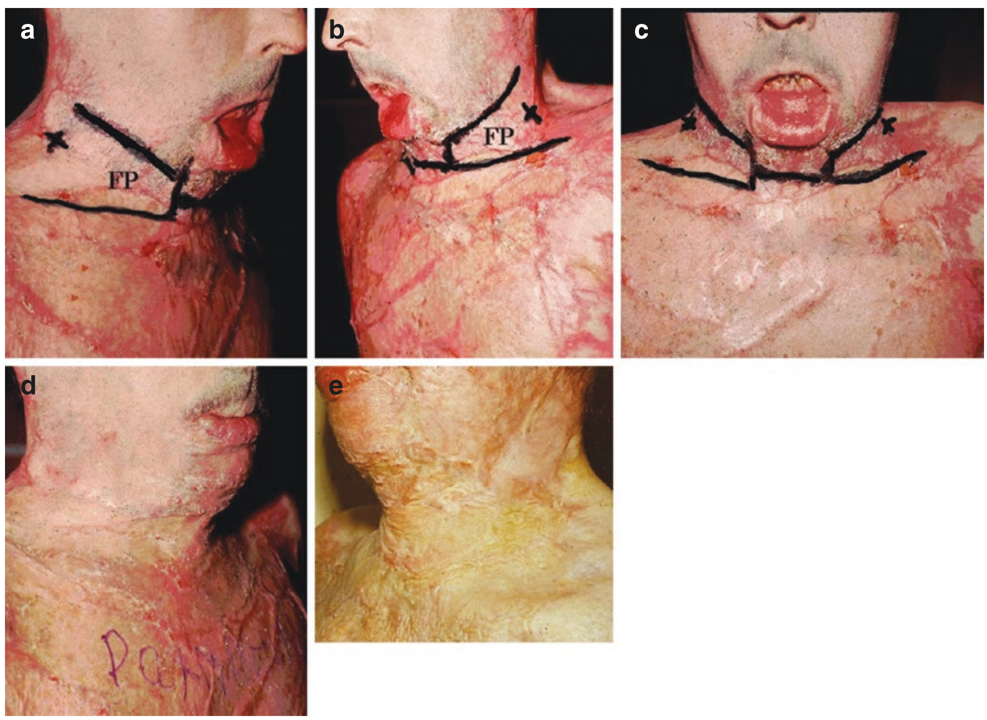

Fig. 13.8 Results of mentosternal scar fusion treatment in adults with two scar-fascial (in mature scars) trapezoid flaps, prepared on the lateral neck surfaces, the wounds beside the flaps covered with skin transplants. (**a**, **b**, **c**) Pre-surgery, trapezoid flaps (*FP*) planned (one flap includes tissue of each lateral surface) flap; (**d**, **e**) result of first stage (2 months after reconstruction)

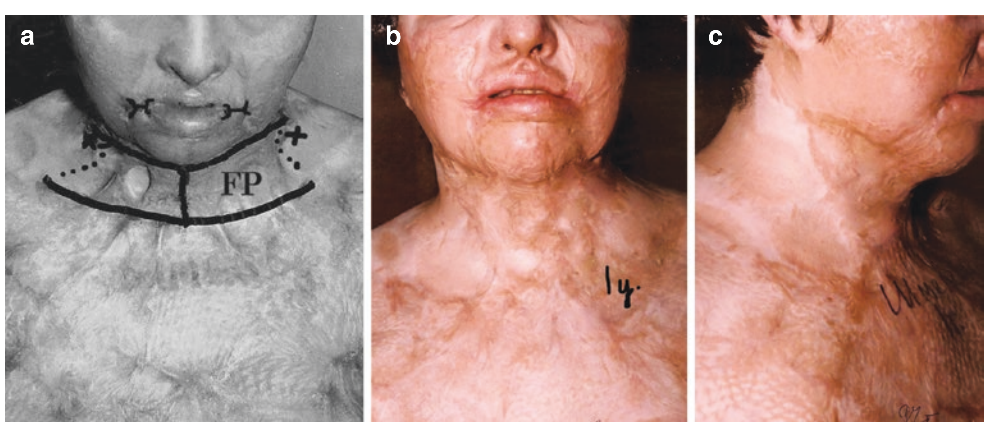

Fig. 13.9 Follow-up results (5 years after surgery) after severe total neck contracture treatment with scar-fascial trapezoid flaps; microstomia (edge contracture) released with trapezoid flaps. (**a**) Pre-surgery, planning; (**b**, **c**), contracture released, neck contours and submandibular angle restored

Conclusion

Neck total (anterior) contracture is fully eliminated with one pair of local new scar-fascial trapezoid flaps alone or in combination with skin transplants. This technique is single-stage, can be performed early after burns and is indicated if reconstruction with adipose-cutaneous flaps is impossible or not desired. Two factors prevent contracture recurrence: the trapezoid scar-fascial flaps continue to grow, and the shrinkage of skin transplants is of a degree that does not cause recurrence.

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14 Lateral Truncal Medial Contractures: Anatomy and Treatment with Local Adipose Scar Trapezoid Flaps

Introduction

Trunk burns result in various complications, deformities, and contractures. Contracture of the lateral surface of the trunk is a serious complication that limits movements of the spine; in children, scoliosis can develop. Therefore, lateral truncal contracture should be the subject of early surgical treatment. The method currently used is stage-by-stage incisions on the contracture scars and skin grafting or Z-plasty. Skin grafts tend to shrink. Triangular flaps are too short to completely eliminate contracture. The need for a more effective surgical technique is apparent. Lateral truncal contracture is caused by scars located on the truncal lateral surface, which form a crescent fold. Both sheets of the fold are scars and according to our classification this contracture belongs to medial type. The fold's sheets have a trapezoid-shaped surface deficit in length, which causes the contracture and creates the scar surface surplus in width, which allows contracture elimination with local trapezoid flaps and leads to good outcomes.

Anatomical Features of Lateral Truncal Contractures

Contracted scars on the lateral truncal surface form a crescent-shaped fold in adults and children (Figs. 14.1 and 14.2). Both fold sheets are scars (medial contracture, flexion medial surface). If the fold is short, or involves trunk anterior and posterior surfaces, breast, axilla, shoulder, and pelvis, it causes shoulder adduction and inguinal contractures. The scars spread from the fold's crest to the anterior and posterior truncal surfaces, smoothing the waist excavation; the breast is deformed and displaced downward (Fig. 14.1). Scoliosis may develop in children. Each scar sheet and contracted neighboring scars have a surface deficit in length, which causes the contracture and creates the scar's surface surplus in width, which allows contracture elimination with local tissues (Fig. 14.2a, b). After transverse fold dissection with Y-incisions (Fig. 14.2c) and trunk straightening, the appearing wounds, as a rule, take the trapezoid form. Consequently, the size and form of the wound is a scar surface deficit and a cause of contracture. The local flaps must therefore be of a trapezoid shape and match the size and form of the scar surface deficiency (Fig. 14.2c–e). Contracture treatment with local tissue can be described as scar surface deficit compensation with local adipose-scar trapezoid flaps.

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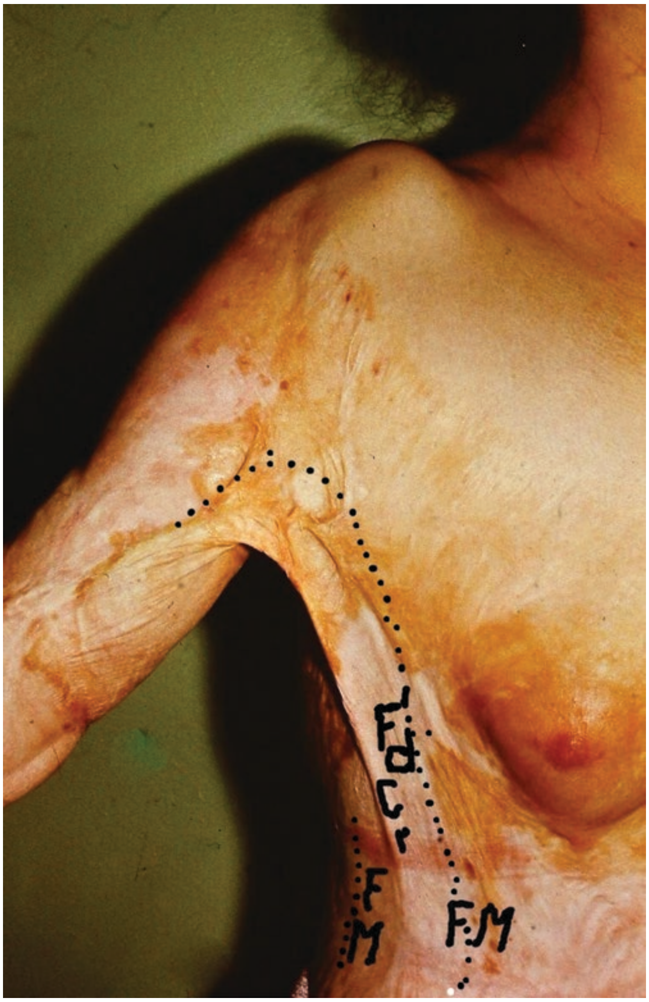

Fig. 14.1 Anatomy of lateral scar truncal contracture. Vast scars caused multiple contractures (trunk, shoulder joint, breast). Scars formed a long fold (*Fd*), both sheets of which are scars (*FM*); crest of the fold (*Cr*). The crescent fold spreads from iliac bone to elbow; both sheets of the fold are scars—sign of medial contracture

Fig. 14.2 Scar surface deficit as real cause of truncal medial contracture. (**a**, **b**) Trunk covered with skin transplants; fold along lateral surface of trunk caused medial contracture: both sheets are scars; planning two pairs of adipose-scar trapezoid flaps (*FP*); *FM* flexion medial surface, scars; (**c**) flaps mobilized; anatomy of wound: *FP* flap; *Dt* scar surface deficit in both halves of the wound, which has trapezoid form; *DW* donor wound; (**d**) flaps counter-transposed; (**e**) end of operation, contracture released

Elimination of Lateral Truncal Medial Scar Contracture with Trapeze-Flap Plasty [1]

For contracture release and trapezoid wound closure with local tissues, the fold and neighboring contracted scars should be converted into trapezoid flaps. This is achieved by Y-shaped radial incisions of contracted tissues, because the fold has a crescent form (Figs. 14.2, 14.3, and 14.4). The radial incisions and flaps are marked prior to surgery. The distance between the lines at the fold's crest is 4–5 cm, which determines the width of the flaps' end. The number of flaps to be planned depends on the contracture severity and the length of the fold. Since the fold is crescent-shaped, the end of the flap is narrower than the flap's base, thus forming the trapezoid shape.

Mild-to-moderate contracture has a short fold that is located below and lateral to the breast (Fig. 14.3). The long fold along its extent is converted into trapezoid flaps; shoulder adduction contracture is reconstructed simultaneously, using a specific local-flap trapezoid procedure (Figs. 14.4 and 14.5). Scars located proximally and distally from the opposite transposed flaps can be excised and the wound is primarily closed or skin grafted (Fig. 14.4). The fold on its extent is converted into trapezoid adipose-scar flaps. The flap surfaces are usually enough for elimination of both contractures (Fig. 14.3).

Surgical details (Figs. 14.2 and 14.3): The sheets of the fold are divided by an incision along the fold's crest. With radial Y-shaped incisions corresponding to the marked lines, both sheets are transected. The flaps are mobilized with the full subcutaneous fat layer, which guarantees a steady blood circulation. Contracted fascia covering truncal muscles can also be transected as part of the flap. After adipose-scar flap elevation, the trunk straightens with some over-correction. The wound accepts a trapezoid shape. The flaps are then transposed one toward another with tension until the flap end reaches the base of the opposite flap. Because of flap tension, the bases of the opposite flaps come closer; the neighboring skin of anterior and posterior truncal surfaces is displaced on a wound; the wound becomes narrower and the soft tissues are squeezed. As the wound surface is diminished, the flap surface becomes sufficient for wound closure, and contracture is eliminated without skin grafting. If the contracture is not completely released by one flap pair, one or two pairs of adipose-scar flaps are additionally elevated, until the contracture is eliminated completely. After complete contracture release and counter flaps transposition, rough scars can be excised. It was also observed that operational scars among burn scars have no tendency for hypertrophic growth.

The contracted scar and fold located on the truncal lateral surface smooths waist excavation and changes the form and position of the breast. The breast is displaced laterally/posteriorly and downward. Therefore, the trapezoid adipose-scar flaps are planned below the submammary fold level and posterior to it (Fig. 14.4a, c). After contracture release and trapezoid adipose-scar flap counter transposition, the lateral trunk accepts the normal form, and the position of the breast is normalized (Fig. 14.4b, d).

Scars covering the trunk and axillary region can form several contractures along the long fold. The fold in axilla can split, forming an anterio-posterior edge shoulder adduction contracture. Since the contracted scar can cause scoliosis in children, early operation is indicated. Both contractures are eliminated in one stage, as shown in Fig. 14.5.

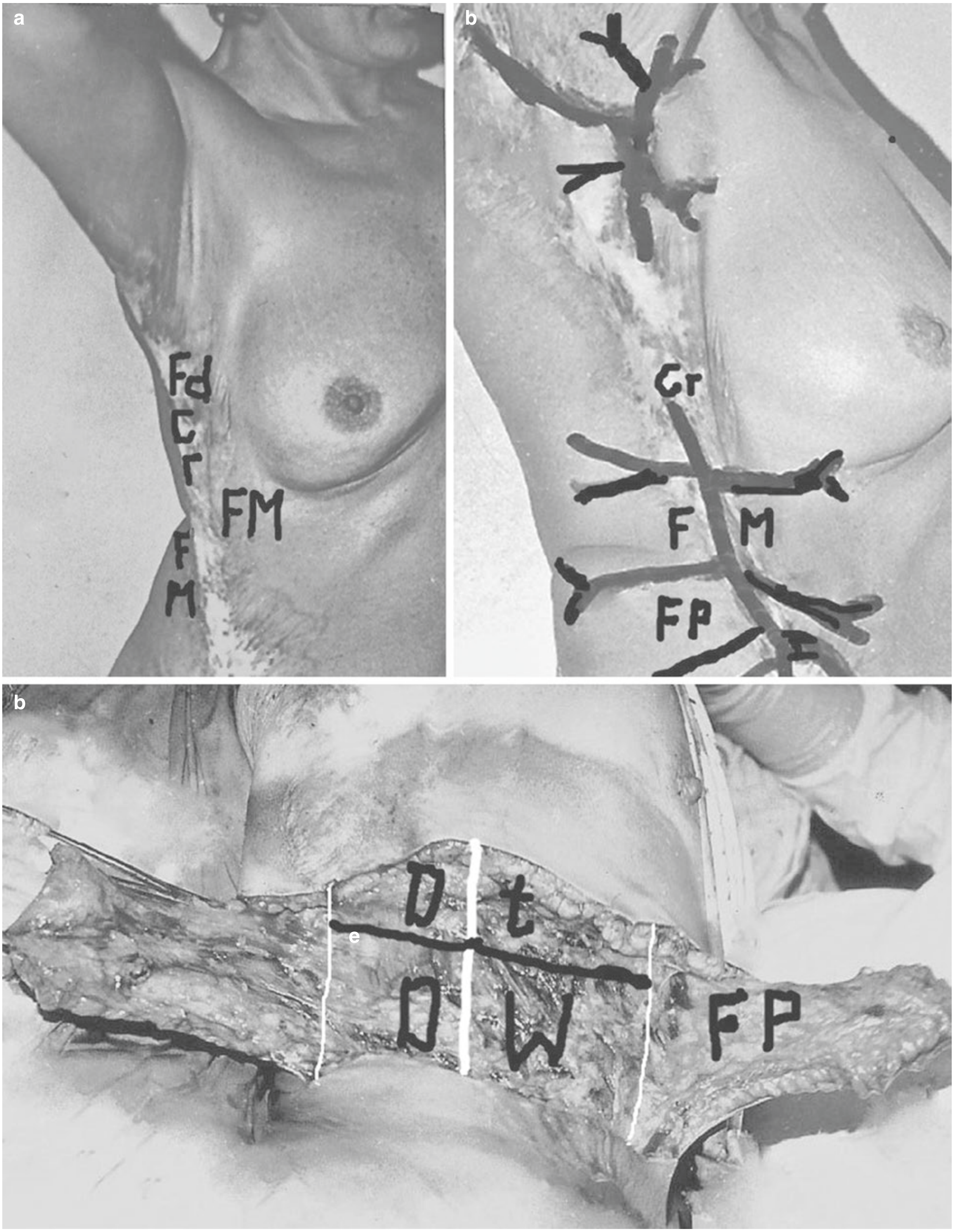

Fig. 14.3 Elimination of lateral truncal medial contracture and posterior axillary edge contracture with trapeze-flap plasty. (**a**) Before surgery, contracture anatomy: *Fd* fold, *FM* scar sheets of the fold; *Cr* crest of the fold; (**b**) planning truncal contracture elimination with one pair of adipose-scar trapezoid flaps (*FM*); (**c**) axillary contracture was first removed with two trapezoid flaps; truncal adipose-scar trapezoid flaps mobilized, two trapezoid wounds appeared; flaps and wounds (scar surface deficit or contracture cause) marked; (**d**) 5 days after reconstruction of the truncal and axillary contractures; (**e**) 2 years after reconstruction: contractures eliminated, good functional and cosmetic outcomes

Fig. 14.3 (continued)

Fig. 14.4 Lateral truncal medial contracture elimination with one pair of adipose-scar trapezoid flaps (two cases). (**a**, **c**) Before surgery: right-side lateral truncal contracture, flaps planning below submammary fold level; (**b**, **d**) 2 weeks and 1 week after reconstructions: contracture is eliminated, waist excavation and breast form and position are restored; flaps are alive

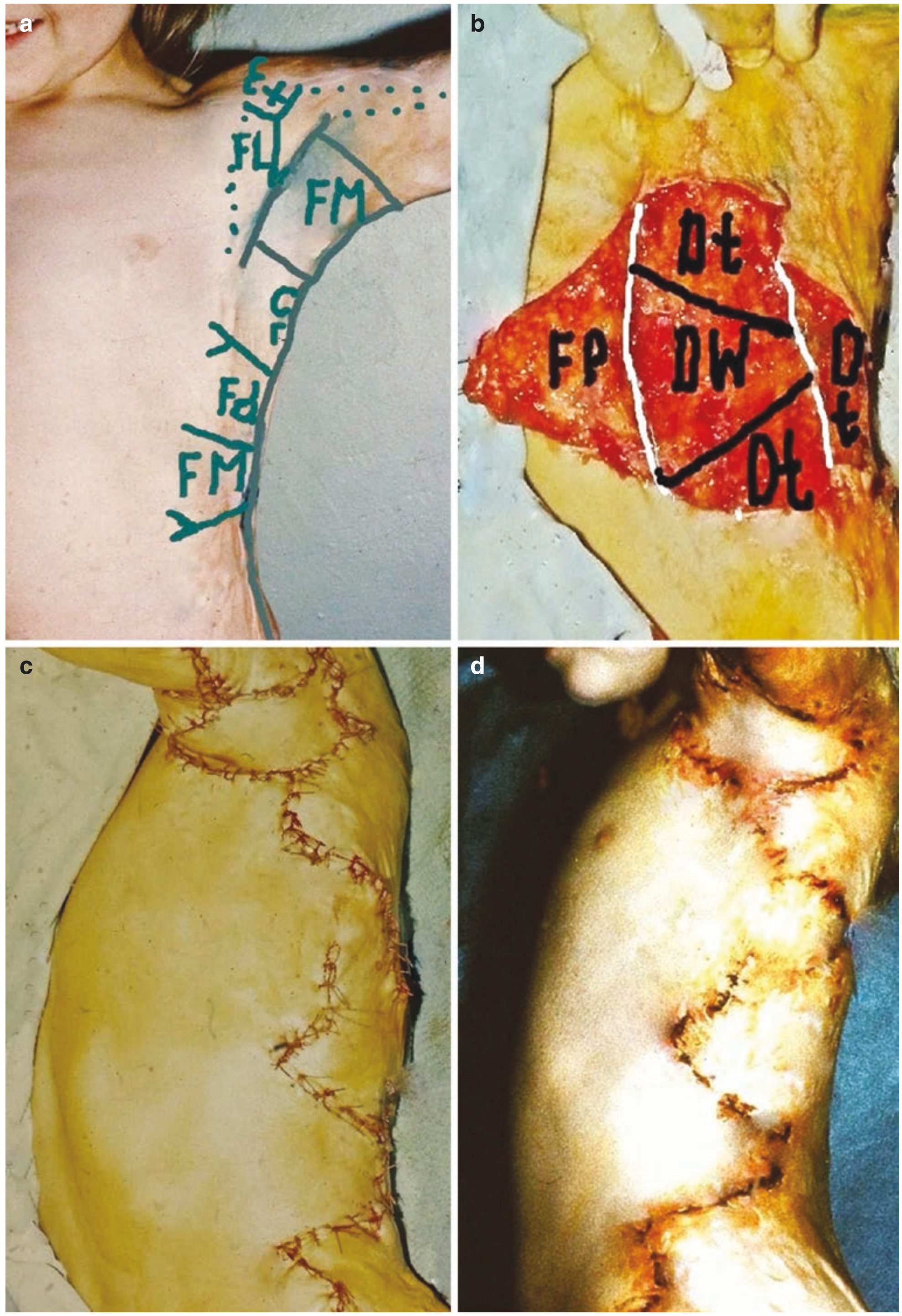

Fig. 14.5 Anatomy and treatment of medial severe truncal lateral contracture and bilateral edge shoulder adduction contracture in children. (**a**) Anatomy; *FM* flexion medial surface, both fold sheets are scars; *Fd* fold; *Cr* fold crest; planning: three pairs of adipose-cutaneous trapezoid flaps marked on lateral trunk; (**b**) adipose-scar trapezoid flap mobilized from left (anterior) fold sheet; anatomy of wound: *FP* flap; *DW* donor wound; *Dt* scar surface deficit. Right (posterior) sheet dissected with Y-incision, trapezoid wound (Dt-deficit) appeared; (**c**) truncal contracture is eliminated with counter flaps transposition; the shoulder contracture is eliminated with quadrangular subcutaneous pedicle flap; (**d**) 2 weeks after surgery: flaps are alive, contractures completely removed; contours of the trunk and axilla are restored

Conclusion

Immature keloid scars do not present a contraindication for surgery; after reconstruction, the scars become more level, softer, and thinner. The lateral truncal contractures are completely eliminated with the single-stage trapeze-flap plasty. Tissue necrosis, flap loss, or other postoperative complications did not occur. The flap's tension and soft tissue compression disappear 2–3 months after surgery due to growth of the stretching tissues. The surface of the trapezoid adipose-scar flaps does not decrease. In children, the flaps continue to grow, preventing contracture recurrence and scoliosis. Surgical scars become scarcely visible among the mature burn scars.

Reference

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15 Restoration of the Shape, Location, and Skin of Severely Burn-Damaged Breast

Anatomy of the Burn-Damaged Breast

Burns of the anterior chest wall in prepubescent females result in scar contracture. The scars covering the breast bud are unyielding and stretching. If the release of the contracture is ill-timed, during the period after puberty, the breast parenchyma develops and grows under scars, acquiring a hypoplastic and flattened form. The breast is deformed, and the mound is often partially or completely smoothed out. The breast shifts toward the area of least resistance, and the contours of the breast are undefined (Figs. 15.1 and 15.2). Scar contractures lead to significant breast asymmetry and displacement of the nipple-areolar complex. Often, the opposite breast and lateral truncal surface are deformed by contracted scars that are removed simultaneously. This is the most severe form of postburn breast deformity, the resurfacing of which still poses a challenge for plastic surgeons.

Fig. 15.1 Anatomy of postburn right breast: tissue defect, contracture, and deformity (flattened breast, inframammary fold smoothed out)

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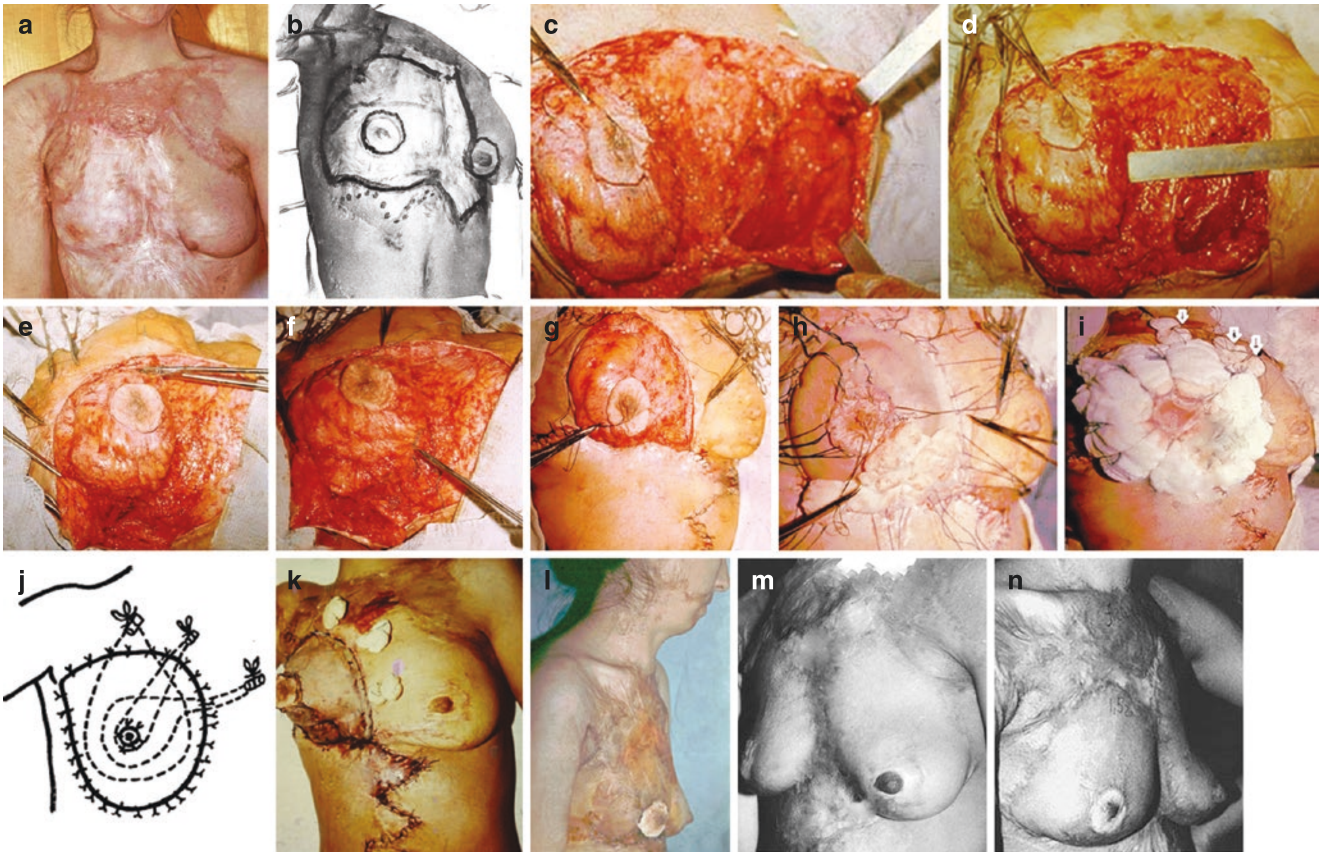

Fig. 15.2 New technique of postburn damaged breast reconstruction using scar excision, parenchyma mobilization, forming sutures, and skin grafting. (**a**) Before surgery. Right breast flattened and hypertrophic, contracture of the left breast; (**b**) borders of scar excision; (**c**, **d**) deformed scars excised and scar areolar island is preserved; breast parenchyma is mobilized; (**e**, **f**) forming sutures are placed; suture ends pierce the skin beyond the wound; (**g**) the breast formation is complete, abdominal scars are excised, primary wound closure is done; (**h**) breast covered with split skin transplants; (**i**) tie-over dressing, sutures tied over tampons (arrows); (**j**) forming suture placement (scheme); (**k**) 7 days after operation, three forming sutures tied over tampon, transplant and abdominal flaps alive; (**l**) 3 months after surgery; (**m**, **n**) result (1 year and 5 years after surgery)

Surgical Technique [1]

The most adequate and effective method for treating severe breast contractures should be able to restore all three components of the deformity: shape, location of the breast and nipple-areolar complex, and breast skin.

The breast parenchyma borders are visually and palpably defined and marked (Fig. 15.3a). A round scar area is marked in the nipple-areolar area corresponding (matching) to the diameter of the undamaged breast; the suture is led through the round-scar area (Fig. 15.2c, d). This suture will serve as a breast holder during surgery.

The mild-to-moderate edge anterior axilla contracture is eliminated in one stage with breast reconstruction (Fig. 15.3a–d); the severe total axilla contracture release, which lessens the breast scar tension, should precede the actual breast reconstruction (Fig. 15.4). Then, all the scars are excised over the entire parenchyma surface (Fig. 15.2b, c). The incision is made down to the chest wall fascia (Fig. 15.2c). The displaced part of parenchyma along with the fat layer is detached from the fascia to the borders of the undamaged opposite or normal breast (Fig. 15.2d, e) (in cases of bilateral deformities). The symmetrical form and positioning are achieved by circularly led sutures, using the mattress stitches, which are led through the fat layer through different levels of the breast (Fig. 15.2e, f; see also Fig. 15.6d). The suture ends are led out through the skin and beyond the wound area and are affixed in a place opposite the breast displacement.

The first forming suture is led out near the scar-areola, and with the use of tension the nipple-areolar complex positioning is normalized. Using the second or second and third forming sutures led out near the base and the middle area of the breast, the symmetrical form and positioning corresponding to the positioning of the undamaged breast is achieved. Special attention is given to the recreation of the inframammary fold. At this preliminary stage of correction, the ends of the strained sutures are led out and tied into untightened knots around tampon (Fig. 15.2e). The wound around the breast is then narrowed down with the transposition of mobilized adjacent chest or abdominal wall tissues (Fig. 15.2f). The breast wound is covered with a thick split-thickness skin graft, which is affixed to the adjacent tissues using the tie-over bolster dressing in the compression state for 5 days (Fig. 15.2d, e). Prolene (3/0) sutures are used; they are left in for about 3 months. During this time the form and the positioning of the breast can be corrected if necessary using traction of the untied sutures; the skin transplants, under which the scar tissue is being formed, are stabilized. Skin transplant and the scar tissue growing under the skin graft hold the shape and positioning of the breast; the sutures can be removed at this stage. The result is shown in Fig. 15.2i–k, and the scheme of reconstruction in Fig. 15.2j. The use of forming sutures is indicated in all cases of severe breast deformity (Figs. 15.2, 15.3, 15.4, 15.5, 15.6, 15.7, 15.8, and 15.9) regardless of the method used for wound coverage (skin grafting, flap expansion, free flap, etc.) (Figs. 15.3 and 15.4).

There are many variations of breast skin and parenchyma deformities, depending on the extent and depth of injury. In all cases, the ultimate goal is to preserve healthy skin, which, if possible, should undergo expansion. Regardless of the method selected for wound covering, the technique of parenchyma formation remains unchanged (Fig. 15.5a–f).

Often, the opposite breast and lateral truncal surface are deformed by contracted scars, which are removed simultaneously (Figs. 15.2 and 15.6a–h).

The deficit of breast parenchyma is compensated for by mobilization of a fat flap laterally and below from borders of the normal breast where the flap's pedicle is located (Fig. 15.7). The fat flap includes a deep subcutaneous fat layer, which is separated from the fascia, covering the thoracic muscles. Mobilized from the periphery, the flat fat flap is displaced to the parenchyma, modeling the needed form. The flap is fixed to parenchyma with catgut; only after that are the modeling sutures used (Figs. 15.7c, 15.8, and 15.9).

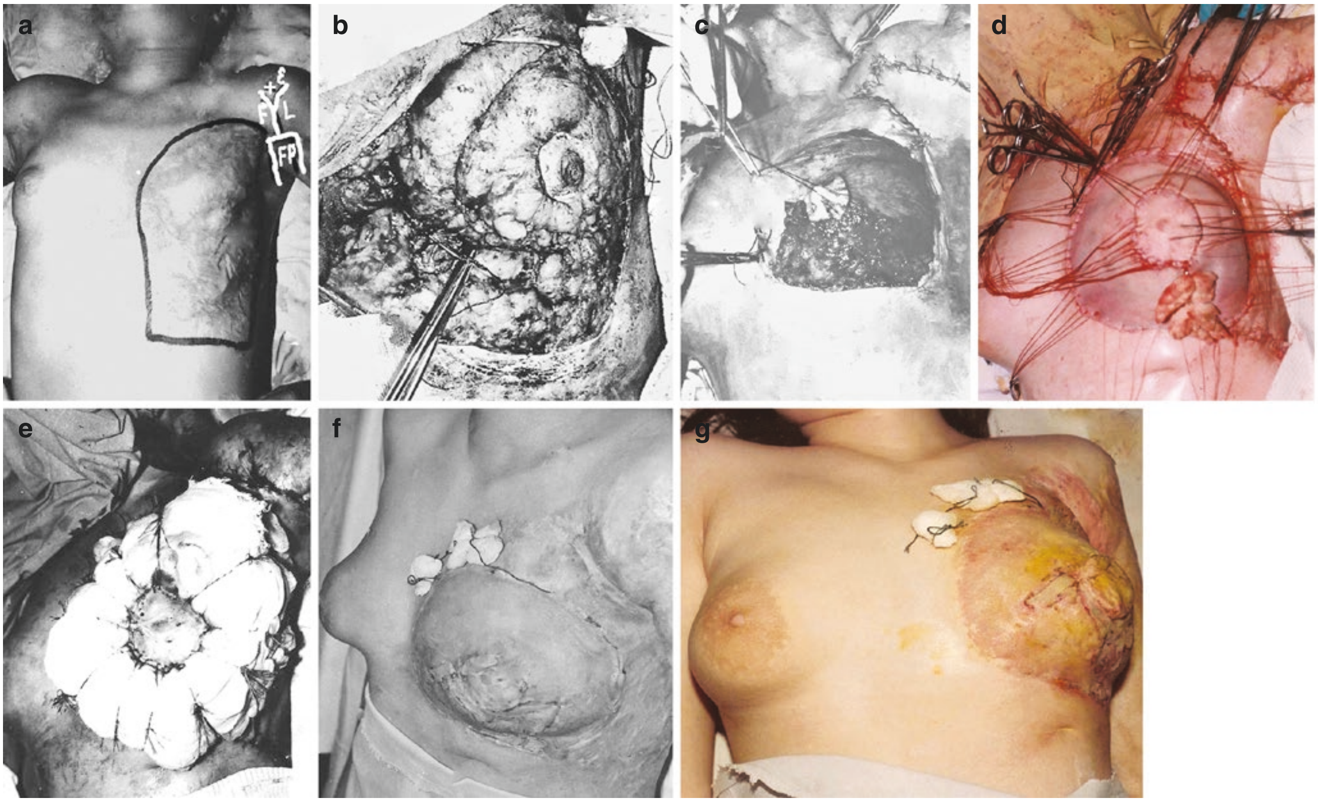

Fig. 15.3 Restoration of the severely deformed left breast using forming sutures, and edge anterior axilla contracture elimination with one adipose-cutaneous trapezoid flap elevated from axillary fossa (trapeze-flap plasty). (**a**) Pre-surgery: scar boundaries and axilla trapeze-flap plasty delineated: *FP* flap, "+"—joint rotation axis; *FL* scars on joint flexion lateral surface; (**b**, **c**) axilla contracture released, scar excised, parenchyma mobilized, forming circular suture is led through fat layer; (**d**) formed breast covered with adjacent tissue displacement and skin transplant; the axillary contracture is released with trapeze-flap plasty; (**e**) compression by tie-over bolster dressing; (**f**, **g**) 3 weeks after surgery, two forming sutures tied over gauze tampons, small zones of transplant necrosis, and wound skin grafted

Fig. 15.4 Severe deformed breast reconstruction after severe total shoulder adduction contracture elimination. (**a**) Before surgery, severe right breast deformation and total shoulder adduction contracture; (**b**) first, total shoulder adduction contracture eliminated with quadrangular subcutaneous pedicle flap and skin transplants (10 days after surgery); (**c**) 6 months later: scars over breast parenchyma are excised, the breast is formed from flattened parenchyma and the subcutaneous fat layer; lateral truncal contracture is released with local tissues and skin transplants; the large wound is covered with skin transplants; (**d**, **e**) 2 years after surgery

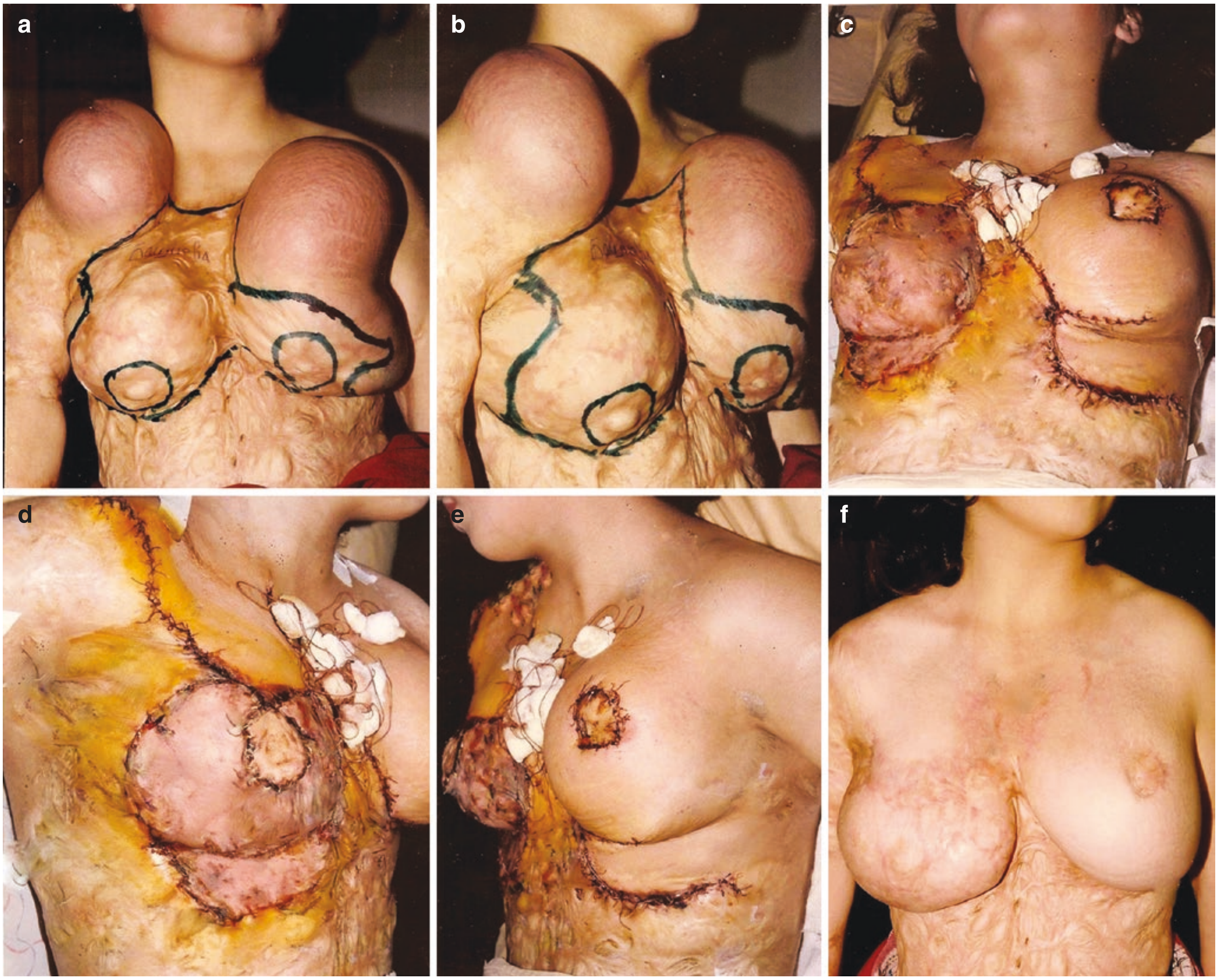

Fig. 15.5 Postburn breast reconstruction with expanders, parenchyma formation, and skin transplant. (**a**, **b**) Severe deformities of both breasts, remnant and adjacent tissue extension with expanders; (**c**–**e**) 10 days after surgery. (**f**) Forming sutures restored the symmetrical shape and positioning of both reconstructed breasts despite the use of various skin resurfacing methods: extended healthy tissues (left breast) and skin transplants (right breast)

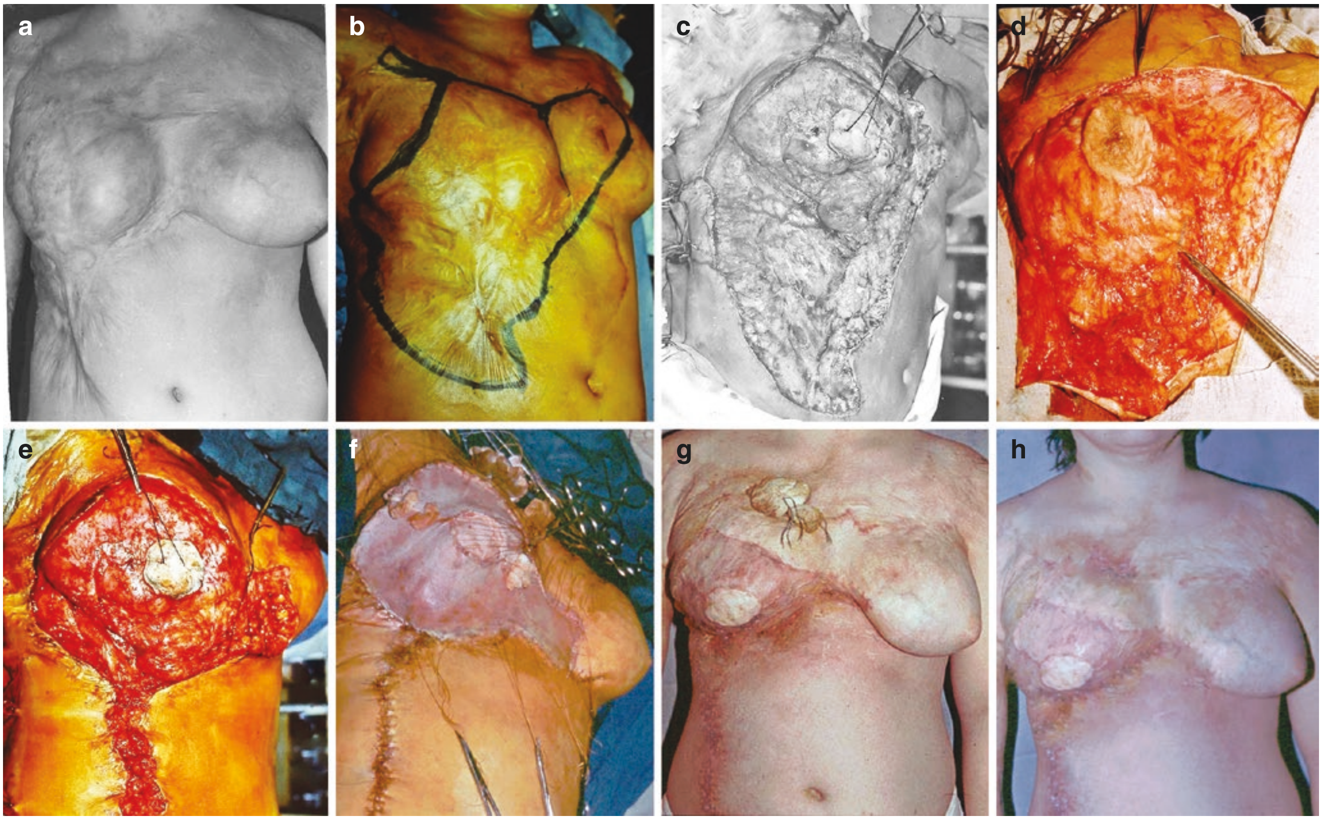

Fig. 15.6 Reconstruction of the breast was accomplished using forming sutures; and severe abdominal scar deformity excision with primary wound closure. (**a**) Before surgery: severely contracted, deformed, and displaced right breast, severe trunk deformation; (**b**) planning, borders of scar excision; (**c**, **d**) scars removed, flattened parenchyma connected with forming sutures; (**e**) during operation; (**f**) breast covered with skin transplants; (**g**) 1 month after surgery, ends of forming sutures connected over gauze tampons beside the skin transplant; (**h**) 1 year after operation: breast grows; its size, form, and skin are close to normal

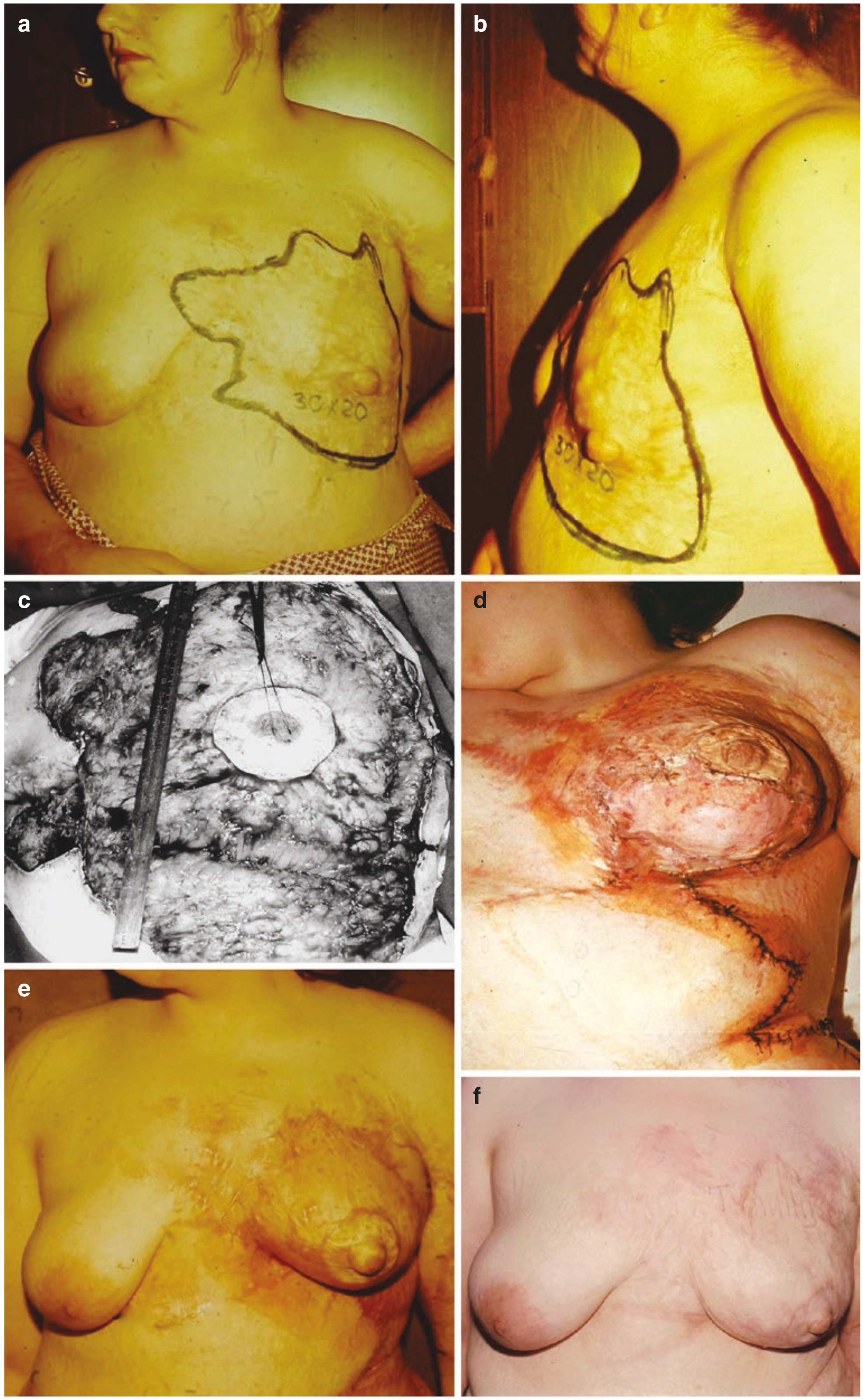

Fig. 15.7 The deformed breast with severe soft tissue deficit reconstructed by addition to parenchyma neighboring fat layer and the forming sutures. (**a**, **b**) Before surgery: flattened left breast, inframammary fold smoothed out, planning of scar excision; (**c**) scars excised, flattened parenchyma and neighboring fat layer separated from thoracic muscles symmetrically with the borders of the undamaged breast; (**d**) due to forming sutures, parenchyma and fat layer accepted a form similar to that of the undamaged breast; (**e**, **f**) follow-up result: breast continued to grow and preserved normal shape, position, and skin (3 years after surgery)

Fig. 15.8 Reconstructed right breast has normal shape, size, and positioning. The breast grows during pregnancy. Two years and 6 months after surgery

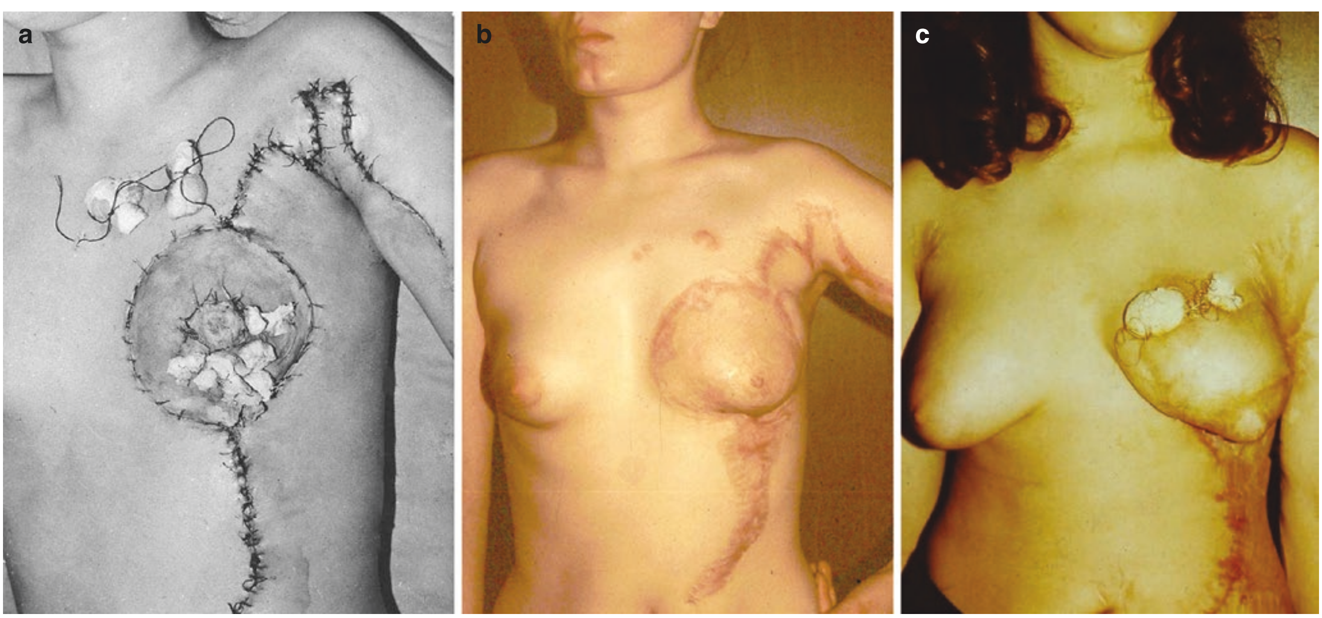

Fig. 15.9 Two examples of results of left breast restoration with forming sutures and skin grafting; left shoulder edge anterior contracture elimination with trapeze-flap plasty. (**a**) Case 1: 5 days after breast reconstruction and shoulder joint contracture release; two forming sutures support the breast's form; edge shoulder adduction contracture eliminated with one axillary adipose-cutaneous trapezoid flap; skin transplants without complication; (**b**) 6 months after surgery: breast form, location, and skin close to contralateral healthy breast; edge anterior shoulder adduction contracture eliminated; breast-axillary region has good appearance. (**c**) Case 2: 2 months after reconstruction; forming sutures support the normal shape of the breast

Conclusion

The mobilized breast parenchyma did not die off. The form and the positioning of the breast and nipple-areolar complex remaind stable. The breasts enlarged over time, which decreased or smoothed the asymmetry of the breasts. It was noticed that the earlier the reconstruction surgery took place in the post-pubertal period, the lower the occurrence of hypoplasia and the better the results. During pregnancy, the reconstructed breast was enlarged symmetrically with the undamaged breast. Skin transplants gradually transformed into well-functioning skin with regard to all its characteristics (color, elasticity, and texture), and the breast surface was leveled.

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16 Shoulder Edge Anterior Adduction Contracture: Anatomy and Treatment with Axillary Adipose-Cutaneous Trapezoid Flap

Introduction

The shoulder adduction contracture is the most common of all large joint contractures; it restricts all upper limb function. Therefore, much attention is given to treatment of its postburn outcome. Because the shoulder rests in the adducted position, skin graft shrinkage becomes inevitable, and techniques based on triangular flaps are anatomically not substantiated and contracture is often not released fully. Based on careful study of the anatomical features of contractures, a more efficient surgical technique for edge scar shoulder adduction contracture elimination was developed.

Shoulder Edge Adduction Contracture Anatomy

Functional Zones of the Shoulder Joint Surface

Before surgery, the surface of the shoulder joint is divided into functional zones: extension surface (*E*) and flexion surface (*F*) (Fig. 16.1). The boundary between them passes along the joint rotation axis level ("+"). The joint F-surface has a curvature (*Cr*) of nearly 90°, caused by the pectoralis major muscle edge. The curvature divides the F-surface into two zones: flexion lateral (*FL*) and flexion medial (*FM*). The dividing line passes along the anterior edge of the axillary fossa (*Cr*). The FL surface spreads from the anterior edge of the axillary fossa to the joint rotation axis ("+"). The FM surface lies between the fossa edges (axillary fossa).

Anatomy of Shoulder Joint Edge Anterior Adduction Contracture

Edge shoulder contracture is caused by scars covering the flexion lateral surface (*FL*) and forming scar sheet of the fold (*Fd*) (Fig. 16.2a, b). Contracture has specific anatomical features and clinical signs: (1) contracted scars are located on the joint anterior flexion lateral surface, which includes the fold (*FL* and *Fd*); (2) the fold presence, which passes along the anterior edge of axillary fossa; (3) the fold consists of two sheets having different qualities: the lateral sheet is scar, a continuation of scars of the flexion lateral surface; the medial sheet is healthy skin, a continuation of the axillary fossa skin; and (4) the crest of the fold is the edge of scars. The fold is a new anatomical formation, tissue surface surplus of scars and healthy skin, participating in scar surface deficit compensation and contracture elimination.

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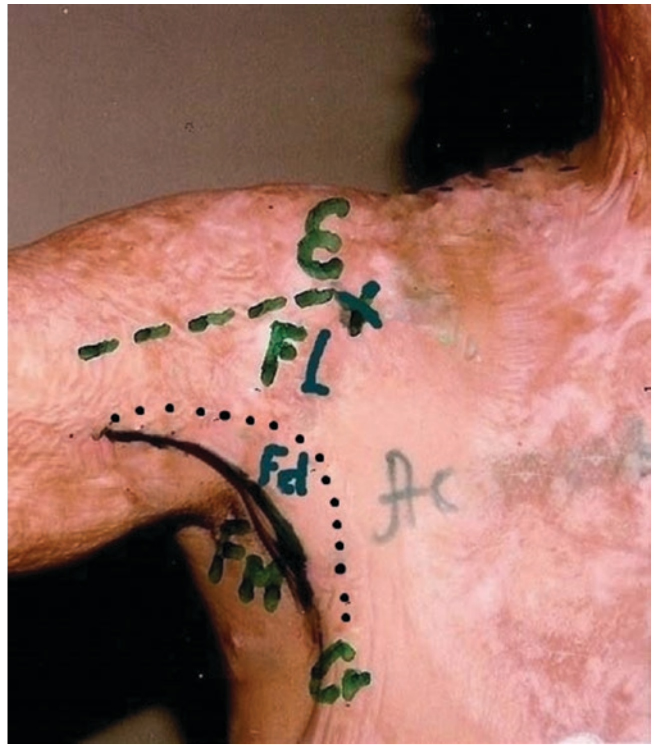

Fig. 16.1 Functional zones of joint surface and edge shoulder contracture anatomy. *E* extension surface; "+" joint rotation axis. *F* flexion surface is divided by curvature on flexion lateral (*FL*) and flexion medial (*FM*) surfaces; scars of FL surface grow distally and form the *Fd* fold along the fossa's edge; *Cr* crest of fold is edge of scars

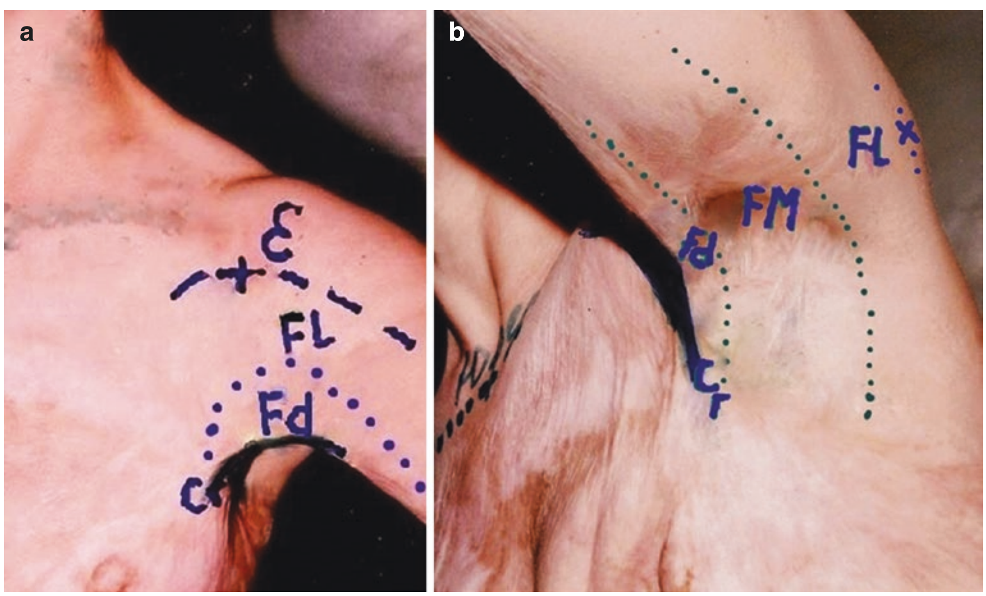

Fig. 16.2 Anatomy of edge shoulder anterior adduction contracture. (**a**) E extension surface; *FL* flexion lateral surface. Scars located on flexion lateral surface form the fold along an edge fossa, which has crescent shape; "+" joint rotation axis; *Fd* the fold consists of two sheets; the lateral sheet of the fold is scars and continuation and a part of the flexion lateral (*FL*) surface and scar surface surplus; *Cr* crest of the fold is the edge of scars and is located between the flexion lateral and flexion medial surfaces. (**b**) *FM* the flexion medial surface is axillary fossa, healthy skin; *Fd* the medial fold's sheet is healthy skin, continuation of FM surface, healthy skin surplus

Scar Fold's Sheet Surface Deficit Is True Contracture Cause

Contracture is caused by the scars covering the *FL* surface and spreading from the fold crest to the joint rotation axis. Thus, the fold elongates the contracted scars in width. Simultaneously, growing distally, scars of the flexion lateral surface and fold undergo contraction, and scar surface in length, between the shoulder and chest wall, becomes insufficient and the scar surface deficit appears, which causes a shoulder adduction. Contracture treatment is aimed at scar surface deficit compensation. Therefore, it is important to know scar surface deficit form, size, and location in order to choose an adequate flap and technique. The size and form of the surface deficit is estimated in the following way: The fold's sheets are divided with an incision along the fold crest. Then, the scar is dissected with a perpendicular Y-incision from the fold's crest to the joint rotation axis. After shoulder abduction, as a rule, the trapezoid-shaped M-wound appears on the anterior shoulder joint surface or scar surface deficit (*Dt*), or real contracture cause (Figs. 16.3, 16.4b, and 16.5c). The wound or scar surface deficit in length is maximal at the fold's crest and spreads, subsiding, to the shoulder joint rotation axis where a M-lineal size equals 4–5 cm in length. With shoulder abduction, the wound edge divergence is more severe and the M–end of the wound becomes twice as long and straight. Consequently, the adequate contracture elimination technique consists of scar surface deficit compensation with the corresponding (trapezoid) form and size of the flaps.

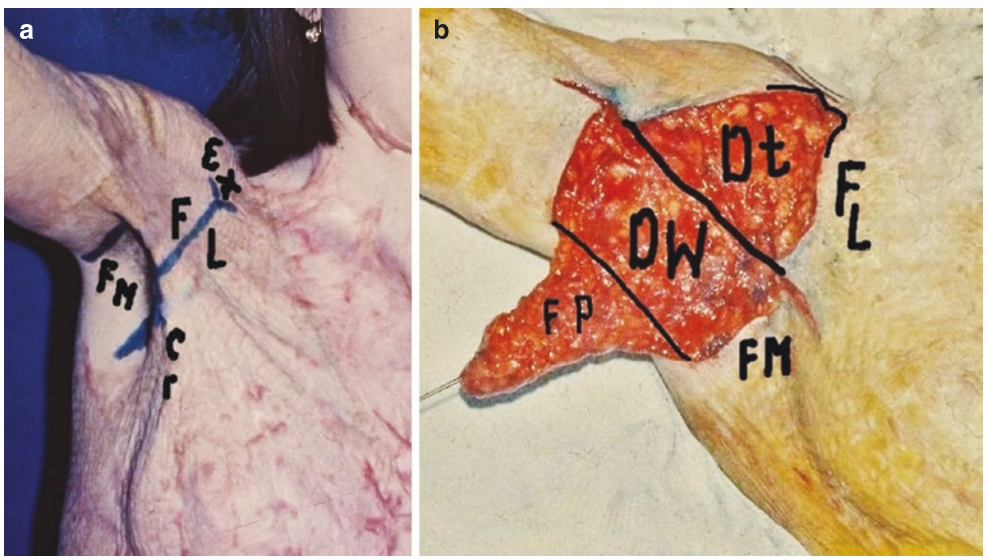

Fig. 16.3 Trapezoid scar surface deficit of anterior *FL* flexion lateral surface and lateral fold's sheet is contracture cause. (**a**) *E* extension surface; "+" joint rotation axis; *FL* flexion lateral surface from the fold's crest to the joint rotation axis; the lateral fold's sheet is scar tissue, the medial sheet is healthy skin; the crest of fold is edge of scars; *FM* the flexion medial surface or axillary fossa is healthy skin. Scars of FL surface, growing distally, form a fold along the fossa edge; the lateral sheet of the fold is scars and part of the FL surface; the medial fold's sheet is part of the FM or fossa's skin. Defining contracture cause and planning of operation: solid lines: Y—scars of FL surface incision from the fold crest to the joint rotation axis; line of sheet division; borders of the trapezoid flap in axilla or FM surface; (**b**) the fold's sheets divided with an incision along the crest, contracted scars dissected with a Y-incision to the joint rotation axis (symbol "+"), a large wound appeared, which is *Dt*—scar surface deficit trapezoid form (upper of line), maximal deficit is at fold crest and spreads to the "+"—joint rotation axis, where it is nearly 5 cm in length; trapezoid adipose-cutaneous flap—*FP*—mobilized; *DW* donor wound

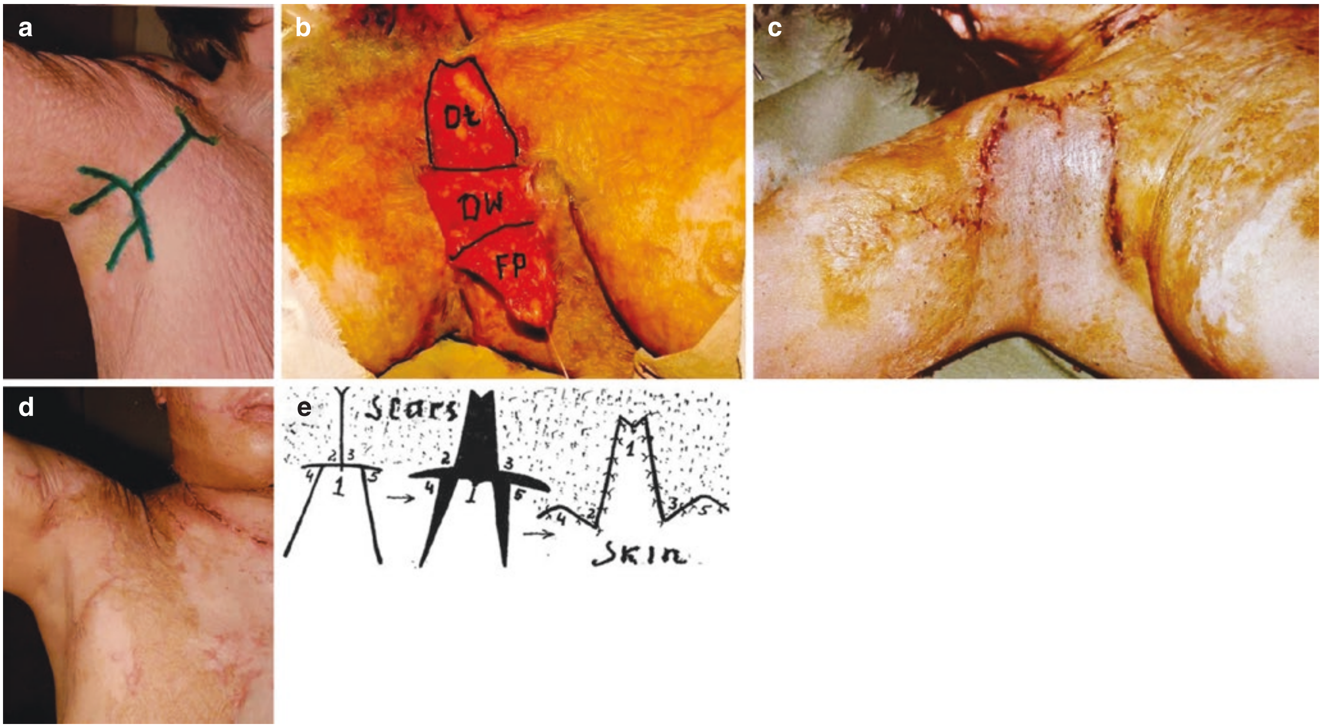

Fig. 16.4 Shoulder edge mild-to-moderate anterior adduction contracture elimination with one axillary adipose-cutaneous trapezoid flap. (**a**) Pre-surgery, planning; (**b**) the fold's sheets are separated with an incision along the fold crest; contracted scars of the FL surface are dissected with a Y-incision, a trapezoid wound (scar deficit [*Dt*] and contracture cause) appeared (upper strip), trapezoid adipose-cutaneous flap (*Fp*) mobilized; *DW* donor wound; (**c**) 10 days after operation: contracture released, flap alive; (**d**) follow-up results: normal joint function and contours; (**e**) scheme of trapezoid-flap plasty with one flap

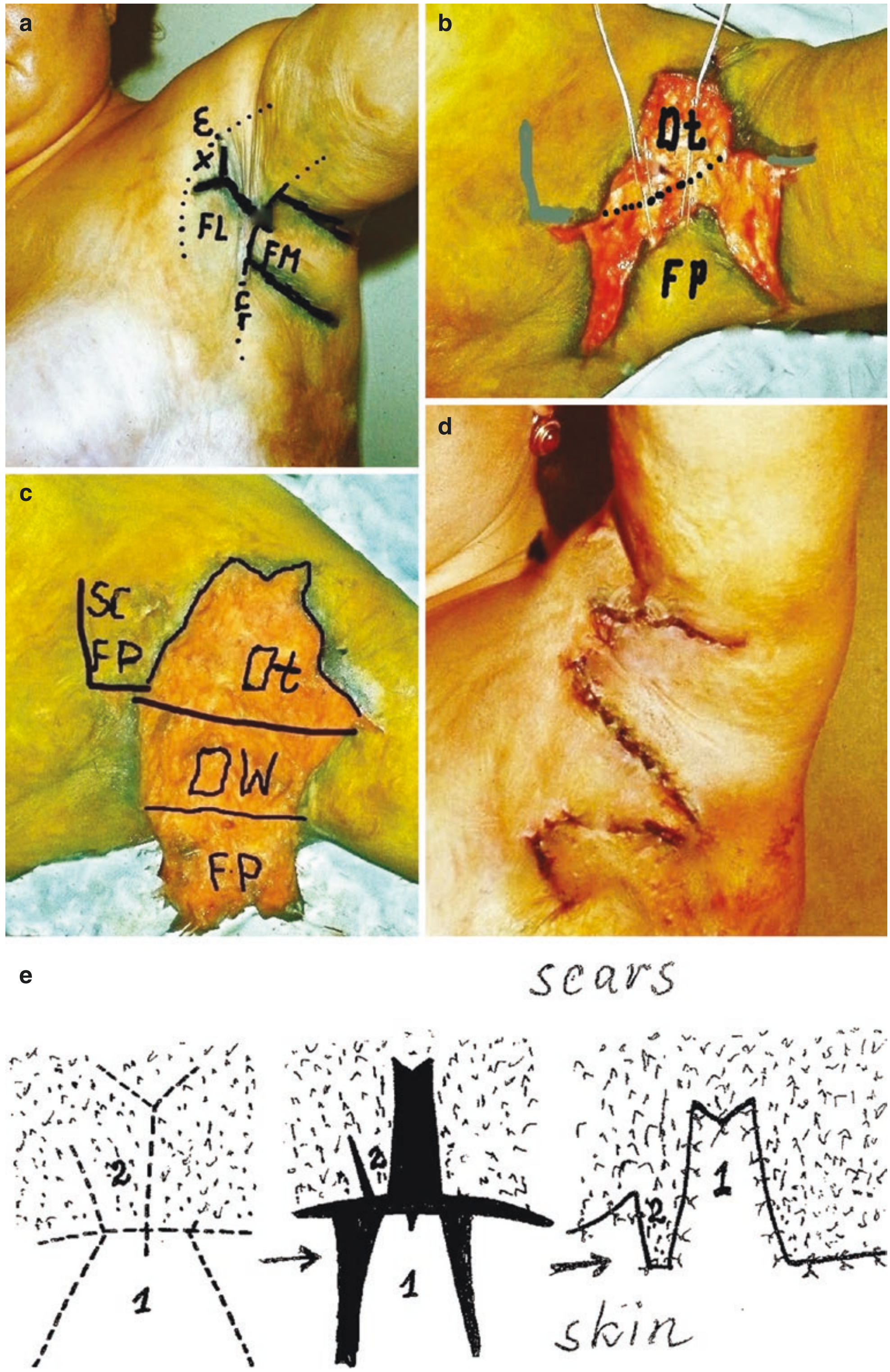

Fig. 16.5 Elimination of edge shoulder adduction contracture with two trapezoid flaps. (**a**) Before surgery: *E* joint extension surface is skin: "+" joint rotation axis; *FL* flexion lateral surface is scars and caused contracture; *FM* axillary fossa is skin; planning of operation: lines for incisions: along fold's crest, *Y*—line for contracted scar dissection from the crest to joint rotation axis; trapezoid flap marked in fossa. (**b**) Fold's sheets separated, scars of FL surface and fold dissected with a Y-incision; (**c**) large wound or *Dt* scar surface deficit trapezoid form (upper strip) appeared; *FP* main trapezoid flap mobilized, small "scar FP" mobilized for *DW* donor wound covering beside the main flap; (**d**) 10 days after operation; flaps alive, contracture eliminated with two flaps; (**e**) scheme of operation

Surgical Technique [1]

Several variants of trapezoid-flap plasty were developed depending on contracture and scar surface deficit severity.

Mild-to-Moderate Contracture Reconstruction with One Trapezoid Flap

Planning consists of marking four lines: (1) a line along the fold's crest; (2) a perpendicular line for scar dissection; and (3) two trapezoid flap borders (Fig. 16.4a). With experience, it became clear that the flap had to be planned to be 30–40% wider than the estimated wound width. With the first incision along the fold's crest, the sheets are divided, and the scars are separated from healthy skin; next, the perpendicular Y-shaped incision dissects the scar and subcutaneous fat layer to the pectoralis major muscle fascia from the fold's crest to the joint rotation axis. Nearly 3 cm to the joint rotation axis level, the incision is split at 45°, forming a 90° angle. The Y-shaped incision separates the scars on the lateral joint extension surface (*FL*) from the tissue of the joint extension (*E*) surface, and thus allows for an easy scar edge divergence and complete contracture release. At the time of shoulder abduction, the scar's edges diverge, and the wound accepts an M-shape (Figs. 16.4c, d and 16.5c). Pectoralis major fascia is incised (not excised) if it restricts shoulder adduction. Then, the flap, including the medial sheet and axillary fossa adipose-cutaneous layer, is elevated to the opposite axillary edge (latissimus dorsi muscle). The deep axillary fat layer and lymph nodes covered with superficial fascia remain in situ. The flap's end, nearly 6 cm in width, is perpendicularly dissected, nearly 3 cm in depth, to correspond to the M-shaped wound's end. The flap's width should exceed the wound, because during traction the flap becomes narrower and longer.

The flap is advanced on the wound with moderate tension and sutured to the wound's border. As a result of flap advancement with tension, the flap's base and axillary edge approached the opposite axillary edge, diminishing the donor wound; axillary fossa become narrower or obliterated as latissimus dorsi and pectoralis major edges reach each other. Then, the angles of the scar sheet are connected to the flap's base, covering the donor wounds beside the flap (Fig. 16.4c). This is trapezoid-flap plasty with one flap (Fig. 16.4e).

Elimination of Shoulder Edge Contracture with Two Trapezoid Flaps

In cases of more severe contractures and scar surface deficiency, two-flap plasty is performed (Fig. 16.5). After the division of the sheets, scar dissection with a Y-incision, and shoulder abduction, the wound's edges are separated, and the trapezoid wound appears (Fig. 16.5b, c, upper strip). The trapezoid flap mobilization and its transposition on the wound are similar to the previous variant, but more severe scar surface deficit does not allow for the angles of scar sheet to reach the flap's base and cover the donor wounds beside the flap (main adipose-cutaneous flap). In such a condition, the one trapezoid adipose-scar flap is prepared from the scar sheet with a radial incision. The adipose-scar flap has to include a full subcutaneous fat layer; the width of the flap's end is nearly 4 cm, and the flap's length is usually shorter than the main flap. The end of the scar flap approached the flap's base of the main adipose-cutaneous flap, and borders of the flaps are sutured covering the donor wound beside the main adipose-cutaneous flap. Donor wounds of the adipose-scar flap are covered with transposition of healthy skin (Fig. 16.5d).

Elimination of Severe Shoulder Edge Contracture with Three Trapezoid Flaps

When the surface deficit is large, the axillary flap resurfaces only part of the wound (Fig. 16.6d); the donor wounds beside the main flap are covered with two adipose-scar trapezoid flaps prepared from the lateral scar sheet (Fig. 16.6e–g); the scheme of reconstruction with three trapezoid flaps is shown in Fig. 16.6h.

Results of severe shoulder edge adduction contracture treatment are shown in Fig. 16.7; a large fold creates scar surface surplus sufficient for severe scar surface deficit compensation and contracture elimination with local trapezoid flaps (three-flap plasty).

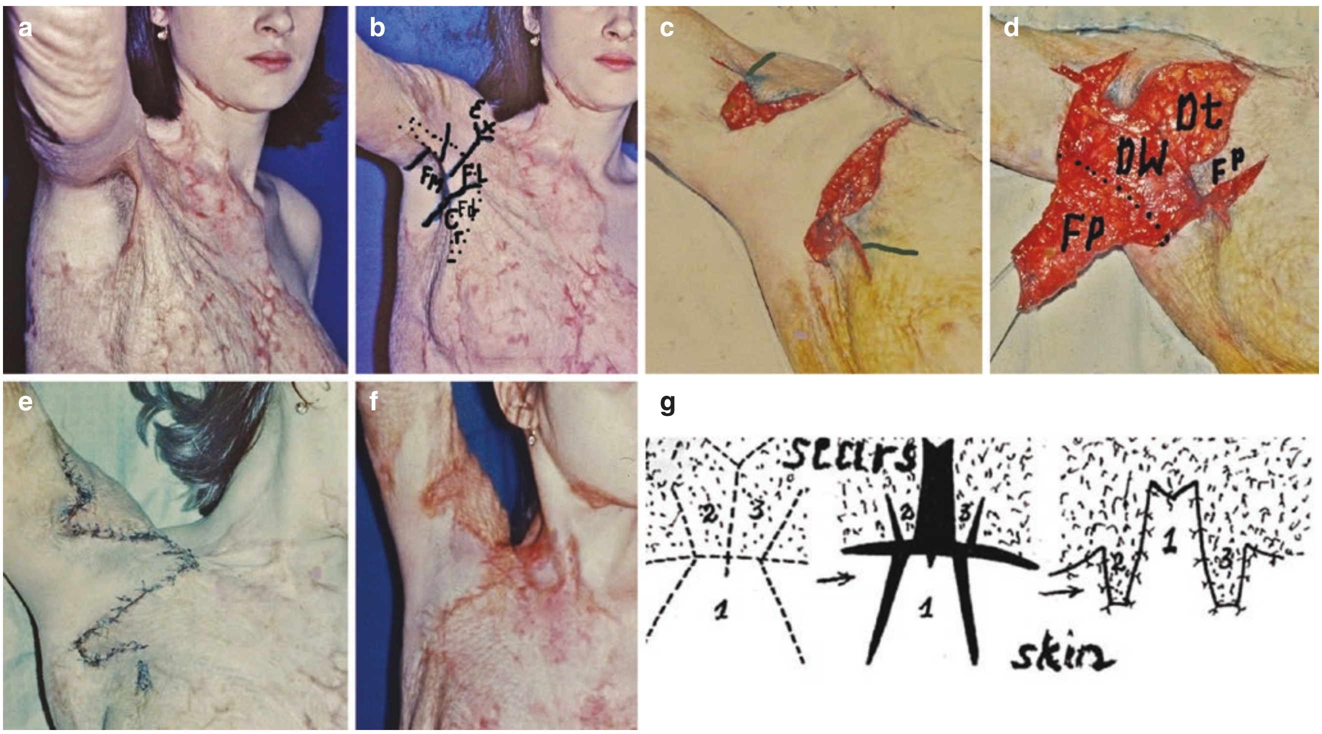

Fig. 16.6 Edge shoulder anterior adduction contracture elimination with three trapezoid flaps (continuation of Fig. 16.3). (**a**) Pre-surgery view. Scars covered *FL* joint flexion lateral surface; scars, growing distally, formed the fold located along the fossa's edge; axilla fossa undamaged. (**b**) Anatomy contracture and operation planning. *E* joint extension surface, "+" joint rotation axis; FL surface spreads from the fold's crest to the joint rotation axis; lateral sheet of the *Fd* fold is part of FL surface; *Cr* crest of the fold; *FM* flexion medial surface is healthy skin and donor site. Planning three-flap plasty: main adipose-cutaneous trapezoid flap from axilla and two adipose trapezoid-scar flaps from FL surface and fold (*Fd*). Lines of incisions for three-flap plasty, *Y*—line for contracted scar dissection from the fold crest to the joint rotation axis: (**c**) scars of FL surface dissected, not all trapezoid wound covered with axillary trapezoid flap; adipose-scar trapezoid flaps planned; (**d**) wound anatomy: *FL* scar dissected; *Dt* scar surface deficit; *FP* flaps; *DW* donor wound; *FP* axillary adipose-cutaneous flap and adipose-scar trapezoid flaps; (**e**) 7 days after contracture elimination with three-flap trapezoid-flap plasty; (**f**) follow-up result; (**g**) scheme of three-flap plasty

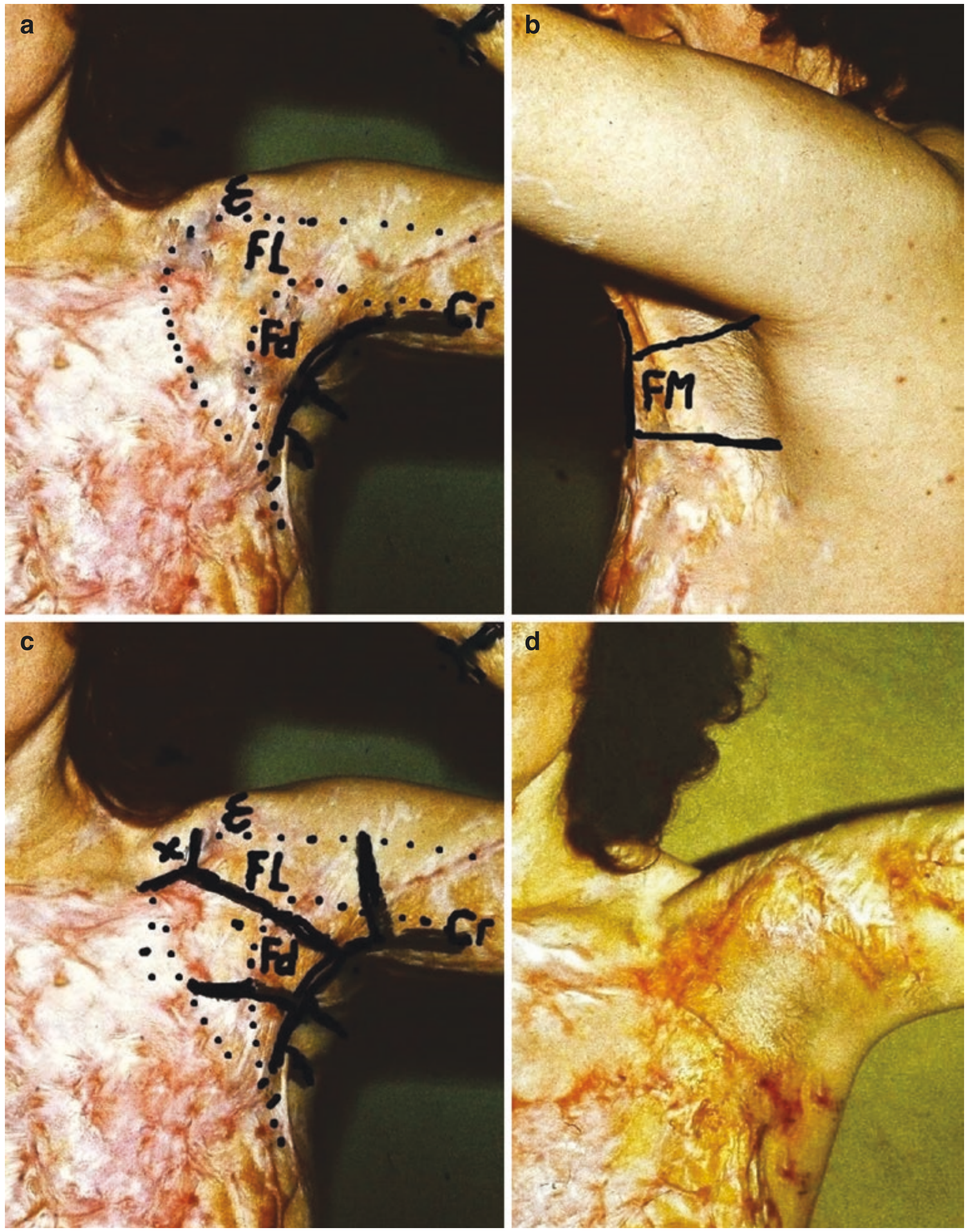

Fig. 16.7 Results of severe edge anterior contracture treatment with three trapezoid flaps. (**a**) Pre-surgery, anatomy: contracture caused with scars of *FM* flexion lateral surface and *Fd* fold's scar lateral sheet; *Cr* crest of the fold; *E* joint's extension surface: (**b**) medial fold's sheet and *FM* axillary fossa is healthy skin; adipose-cutaneous trapezoid flap from all axilla marked; (**c**) planning: *FL* flexion scar lateral surface dissection with Y-incision; two adipose-scar trapezoid flaps marked for donor wound covering beside the main flap; (**d**) 6 months after surgery: contracture eliminated, contours of axilla restored, surface of axillary flap increased

Severe Edge Contracture Treatment with Axillary Adipose-Cutaneous Flap and Skin Transplants in Children and Adults

When the scar surface deficit is very significant, it is impossible, after axillary flap transposition, to prepare flaps from the scar sheet and cover the donor wounds beside the flap. The operation consists of elevation of a trapezoid adipose-cutaneous flap, including the medial fold's sheet and entire axillary fossa, and using them to cover the central wound zone; rough scars on the shoulder and chest wall are excised, and wound is skin grafted (combined trapezoid-flap plasty) (Figs. 16.8a–c and 16.9a–f). The flap's end is sutured to the end of the wound; the lateral edges of the flap are fixed to the wound's soft tissues; the wounds beside both sides of the flap are covered with skin transplants and tie-over dressings. The adipose-cutaneous flap, harvested from axilla, is drained; for small adipose-scar flaps, thin passive silicone tubes are used. No upper limb immobilization is needed. The operated limb is placed in the abduction position with the patient in bed; further abduction is supported by the patient himself. Excellent functional and good cosmetic outcomes are achieved (Fig. 16.9f). Scars on the shoulder and chest wall are excised and wounds are skin-grafted. Edge elbow contracture is released simultaneously using trapezoid-flap plasty (Fig. 16.8c). The axilla's edge suspension and wound division on the shoulder and thoracic wall prevent negative influence of skin graft shrinkage on outcomes of axilla reconstruction; these two factors prevent axillary contracture recurrence in case of treatment by combined technique. Therefore, neither compression nor abduction devices are needed after surgery.

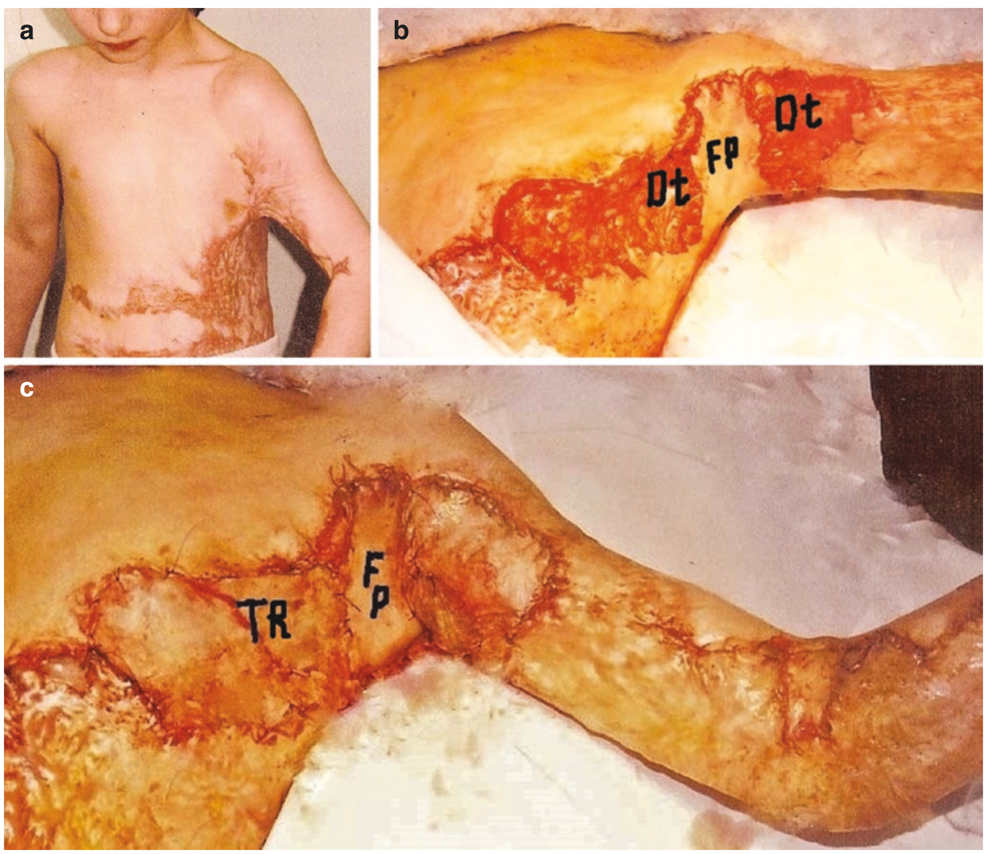

Fig. 16.8 Severe edge shoulder anterior adduction and edge elbow flexion contracture elimination in a 5-year-old girl, using axillary and elbow adipose-cutaneous trapezoid flaps; rough scars excision on chest wall and shoulder and wound's skin grafting. (**a**) scars covered shoulder joint anterior FL and elbow FL surface, causing edge contractures, lateral surface of the trunk and inner surface of upper extremity; (**b**) operation: contracted scars dissected with a Y-incision from the edge fold crest to the joint rotation axis in axilla and elbow, rough scars excised; axillary and elbow adipose-cutaneous trapezoid flaps mobilized and transposed on wounds of FL surfaces, ends of flaps sutured to the wound border; the lateral edges of the axillary flap are fixed to the wound tissue; edge elbow contracture is eliminated with two-trapezoid-flap plasty; (**c**) 7 days after surgery: flap (*F*) and skin transplants (*G graft*) alive, both contractures removed completely. The flap suspends axilla at a normal level, the big wound divided into two: shoulder and chest, every wound skin grafted separately; skin transplants look normal

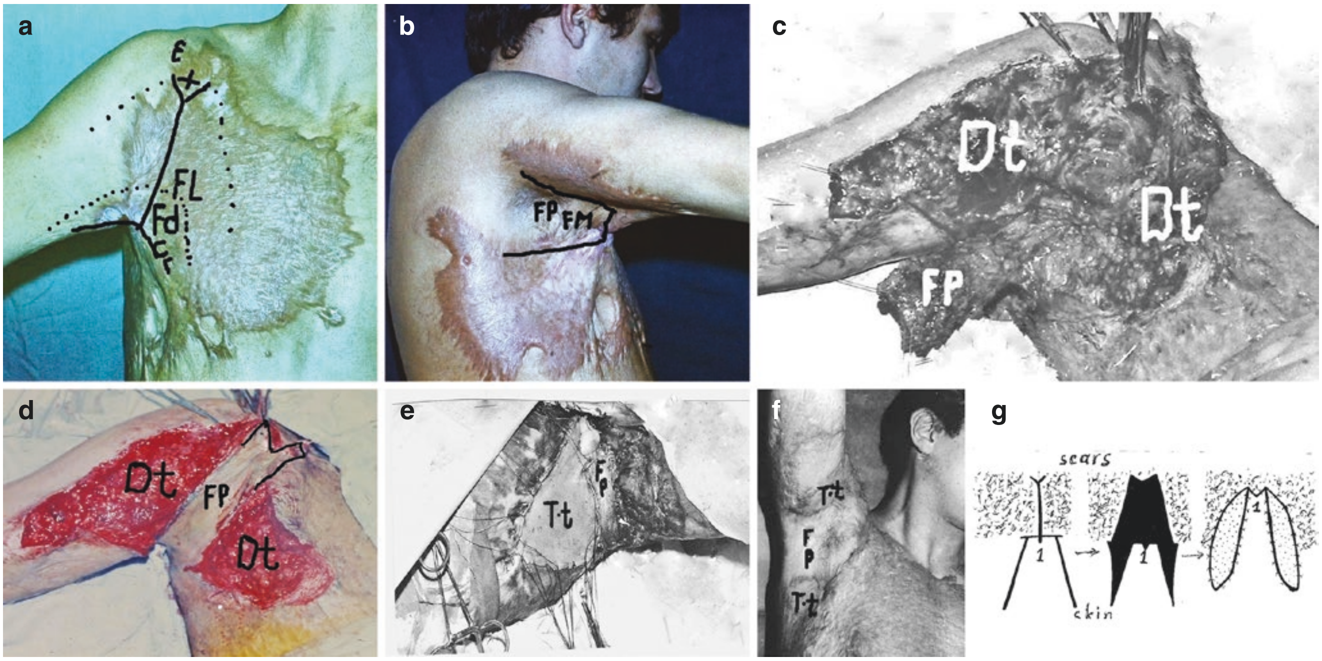

Fig. 16.9 Severe edge shoulder adduction contracture was completely eliminated with one trapezoid flap and skin transplants: (**a**, **b**) before surgery, anatomy: *FL* flexion lateral surface; *FM* flexion medial surface; E- extension surface; *Fd* fold; *Cr* crest of the fold; "+" joint rotation axis; trapezoid flap planning; Y-line for contracted FL scar dissection, trapezoid flap from *FM* flexion medial surface or axilla; (**c**) contracted scars dissected and *FP* adipose-cutaneous flap mobilized, *Dt* severe scar surface deficit (large wound); (**d**) central wound zone covered with *FP* trapezoid flap; flap divided large wound in two, shoulder and thoracic, located beside the axilla; (**e**) both wounds beside the flap covered with skin grafts; (**f**) result (2 years after operation); total contracture eliminated, flap's surface was increased significantly, hairs growing in normal location; (**g**) combined trapezoid-flap plasty (scheme)

Conclusion

Edge shoulder contractures were completely eliminated and shoulder abduction (180°) was achieved with an axillary adipose-cutaneous trapezoid flap. Mild-to-moderate contractures were eliminated with one flap. Moderate contractures were released with two or three trapezoid flaps: in addition to the main flap, one or two adipose-scar trapezoid flaps were mobilized for the donor wound covering beside the main flap. The fold is converted in the flaps on all its extents. Severe adduction contracture is eliminated with one axillary trapezoid flap in combination with skin transplants: the wounds beside the flap were skin-grafted. The flap suspended the axilla and divided the large axillary wound into two separate areas—shoulder and thoracic. These two factors prevented shrinkage of skin transplants and recurrence of contracture.

Reference

1. Grishkevich VM. Postburn edge shoulder adduction contracture: anatomy and elimination with trapeze-flap plasty—a new approach. J Burn Care Res. 2012;33:e234–42.

Edge Shoulder Adduction Contracture in Pediatric Patients: Anatomy and Treatment

17

Introduction

Shoulder adduction contractures in children restrict upper limb motion, which delays joint development and curves the shoulder bone and spine; therefore, surgical reconstruction should be performed as soon as contracture forms. Scars on the chest wall in children are prone to excessive abnormal growth and severely disturb the child and parents. Most edge axillary contractures are treated with techniques based on triangular flaps (Z-plasty and their modifications and combination), but few articles have been devoted to follow-up outcomes. Triangular-flap techniques have many known disadvantages, skin transplants are prone to shrinkage, and regional pedicle flap use is traumatic for pediatric patients. In pediatric patients, edge shoulder anterior contracture and scar deformity of the shoulder joint anterior surface are fully eliminated with the use of the whole axillary adipose-cutaneous flap. This new technique and its results are presented in this chapter.

Contracture Anatomy (Fig. 17.1)

Edge shoulder adduction contracture in children and adults is caused by scars that cover and deform the anterior shoulder joint flexion lateral (*FL*) surface from the fossa edge to the joint rotation axis ("+") and neighboring regions of the shoulder and trunk (Fig. 17.1). The scars, growing distally on the shoulder and chest wall, involve the skin of the axillary fossa (flexion medial [*FM*] surface), forming the crescent fold located along the anterior of the axillary fossa edge. The fold consists of two different quality sheets: the lateral (according to axilla) sheet is scar tissue and part (continuation) of FL surface scars; the medial sheet and axilla are healthy skin and the best donor site. The crest of the fold (*Cr*) is the edge of scars (Fig. 17.1b).

These four anatomical and clinical signs are pathognomonic for edge shoulder contractures. Contracted scars, spreading from the fold crest to the joint rotation axis, can be nearly 8 cm in width. Part of this length is the fold, which is a new anatomical structure, presenting surplus surfaces of scars, healthy skin, and good plasty tissue allowing treatment of edge contracture with local flaps. At the same time, in the lateral scar sheet and scars of FL surface, there is a surface deficit in length (cause of the contracture). Scar surface deficit spreads from the fold crest to the joint rotation axis and has trapezoid form (Fig. 17.2a, b; see also Fig. 17.7b). Scars, covering the anterior joint surface, the shoulder, and trunk surface, are rough, uneven, and present a serious cosmetic defect. Consequently, the contracture elimination can be achieved via two methods: (1) with scar dissection and surface deficit compensation with axillary trapezoid flap, scars remain in situ; and (2) contracture release and part of contracted deformed scars on the anterior surface of the joint, shoulder, and thoracic wall are excised, and the wound is resurfaced with whole adipose-cutaneous axillary flap (Fig. 17.3a–d).

V. M. Grishkevich, M. Grishkevich, *Plastic and Reconstructive Surgery of Burns*,
https://doi.org/10.1007/978-3-319-78714-5_17

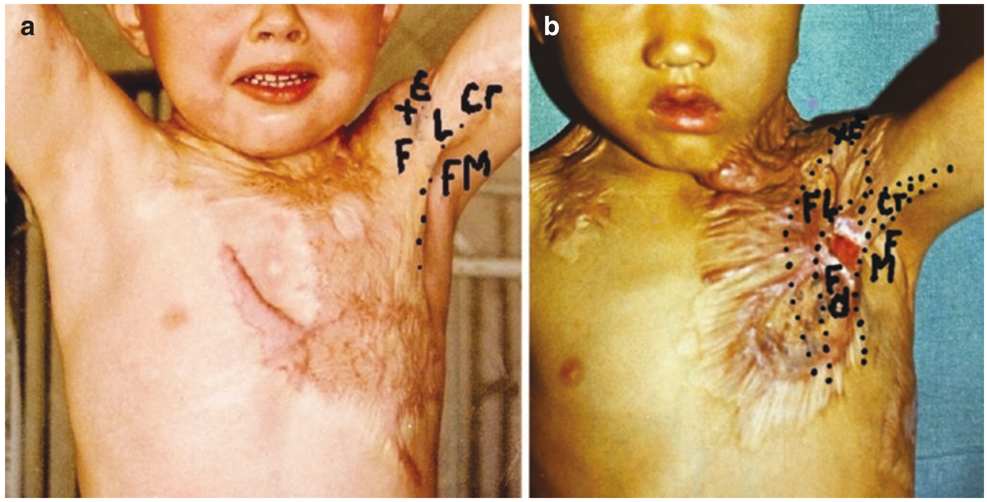

Fig. 17.1 Anatomy of shoulder edge scar anterior adduction and edge elbow flexion contracture and its treatment with whole axillary adipose-cutaneous flap. (**a**, **b**) Two pediatric patients, left shoulder severe edge contractures caused by scars covering anterior *FL* left shoulder joint flexion lateral anterior surface, chest wall, and lateral neck. *E* joint extension surface; "+" joint rotation axis; *FL* flexion lateral surface; *Fd* fold scar ulcer; *Cr* crest of the fold with ulceration; *FM* flexion medial surface

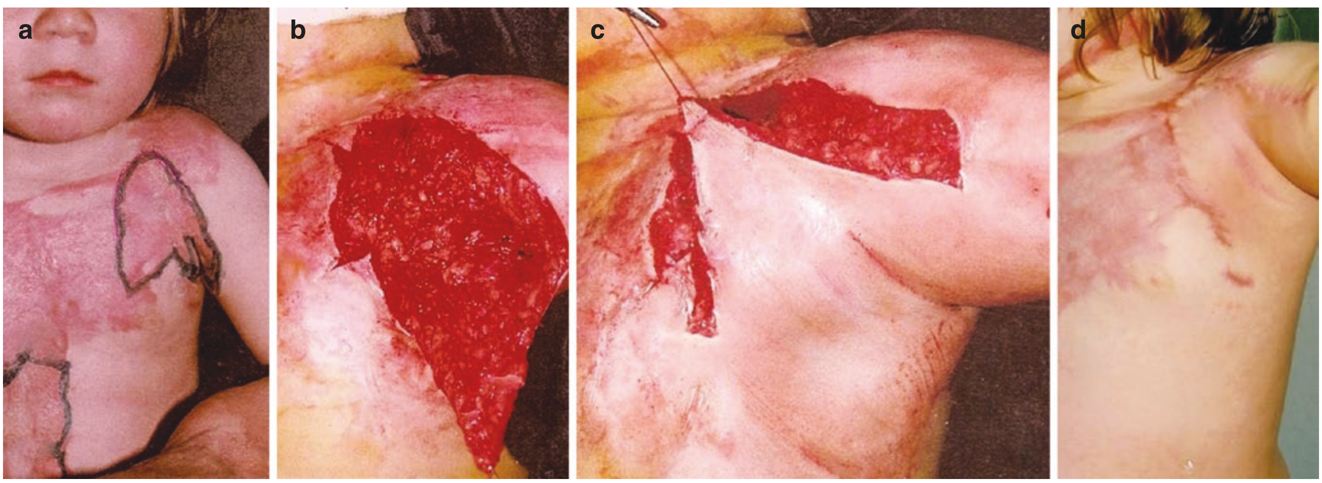

Fig. 17.2 Edge shoulder anterior adduction contracture treatment by immature contracted scar excision and wound covered with axillary whole adipose-cutaneous flap. (**a**) Pre-operative view (two-year-old girl): edge shoulder contracture with fresh scars, covering *FL*—shoulder joint anterior flexion lateral surface, thoracic, and abdomen walls; borders of scars marked to be excised; (**b**) scars excised, whole axillary adipose-cutaneous flap mobilized; (**c**) flap transposed on the wound; (**d**) 1 month after operation: contracture eliminated, scar deformity reduced

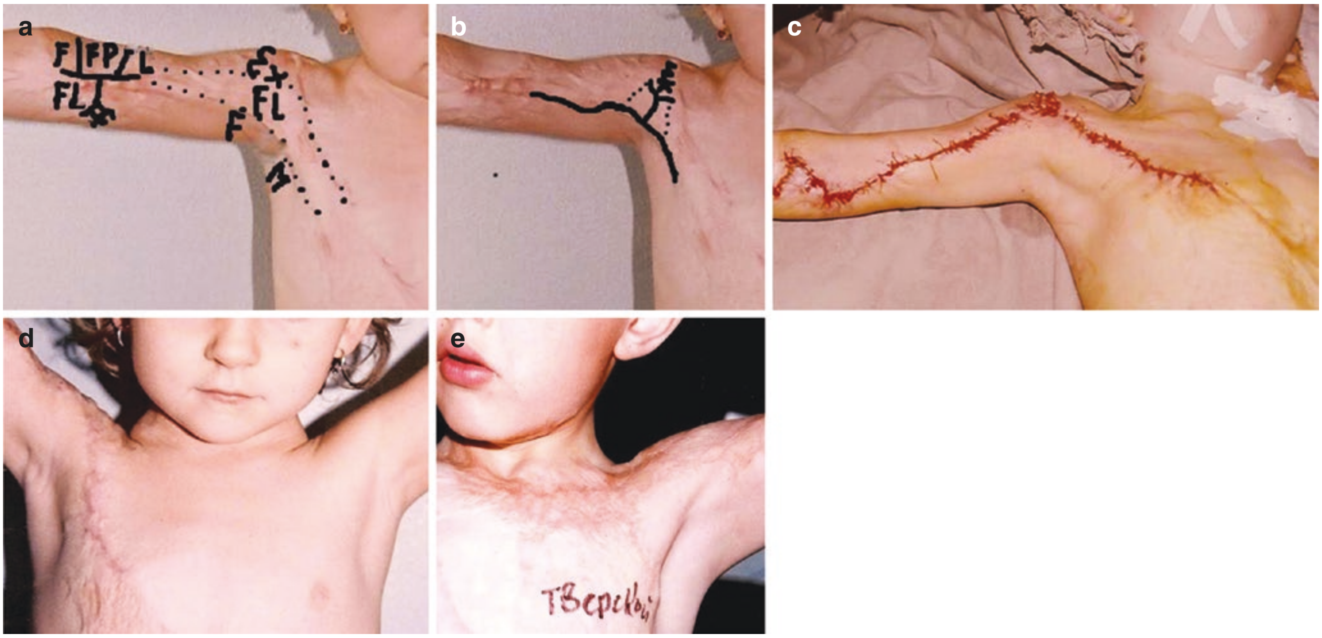

Fig. 17.3 Shoulder and elbow edge contractures and deformation treatment with axilla flap (shoulder) and elbow with trapezoid-flap plasty. (**a**, **b**) Scars of FL surface formed crescent-shaped fold along anterior axillary edge and flexion lateral surface of elbow; lateral scar fold sheet is a continuation and part of FL surface; medial sheets and FM axillary and elbow fossa surface are healthy skin; *E* joint extension surface; "+" joint rotation axis; (**c**) scar of FL surfaces (including lateral scar sheet) excised, whole adipose-cutaneous flap of axilla, chest wall and inner shoulder surface mobilized and transposed on the wound with tension and covered the wound; edge elbow contracture eliminated with elbow trapezoid adipose-cutaneous flap; (**d**) shoulder edge contracture eliminated, contours of axilla region preserved; maturation of operation scars not complete (3 months after surgery) (**e**) Next case: 1 year after reconstruction of patient from fig 17.1: excellent functional and aesthetic outcomes

Technique for Simultaneous Removal of Scar Shoulder Contracture and Deformity and Elbow Edge Flexion Contracture [1]

Anatomy and surgery planning is shown in Fig. 17.2a,b: (solid line—scars incision; dotted line—scars excision; "+"—joint rotation axis; *E*—extension surface; *FL*—flexion lateral surface; *FM*—flexion medial surface). Scars that cause contracture (*FL*) are separated from the healthy skin (*FM*) with an incision along the fold crest and then dissected with a perpendicular Y-incision from the fold crest to the shoulder joint rotation axis ("+") and separate scars from the tissue of joint extension surface (*E*) for complete contracture release (incision lines in Fig. 17.3b; see also Fig. 17.5a). A trapezoid wound appeared on the anterior joint flexion lateral surface (Fig. 17.2b; see also Fig. 17.7b). The whole axillary adipose-cutaneous flap is elevated without cutting healthy skin. The flap includes the healthy medial fold sheet, the adipose-cutaneous layer of axilla to the latissimus dorsi edge, and neighboring inner shoulder and lateral truncal regions. The deep axillary fat layer with lymphatic nodule remains in situ. The flap is advanced on the anterior shoulder joint surface with tension (Fig. 17.2c and 17.3c). According to the surface that was covered with the flap, the scars on the anterior shoulder joint surface and neighboring areas of the shoulder and chest wall were excised. The flap is transposed on the wound again and sutured with two-layer sutures, starting from the joint rotation axis level. Deep tissue layers are connected to the wound edge with non-absorbable sutures to prevent the growth of excessive operation scars.

Due to tissue/flap tension, the adjacent healthy adipose-cutaneous layer of shoulder extension surface (*E*) and chest wall is displaced, covering the wounds on the shoulder and chest wall; the posterior edge of axillary fossa (m. latissimus dorsi) is moved to the anterior axillary edge, narrowing or obliterating the axillary fossa and reducing the donor wound. All these factors allow for transposition of the flap on the anterior shoulder joint surface up to the joint rotation axis, covering the wound and restoring the shoulder joint and neighboring zones. Thus, almost the entire axillary adipose-cutaneous layer is transposed on the joint anterior FL surface, compensating for the scar surface deficit, eliminating the contracture, and reducing the scar deformity in cosmetically important zones. The wound is drained and shoulder immobilization is not needed. Edge elbow contracture is eliminated simultaneously with trapezoid-flap plasty (Fig. 17.3). The extended adipose-cutaneous layer grows since the squeezed tissue plays the role of expander; the transposed skin did not change natural properties; axillary fossa accepts normal contours (Figs. 17.3d and 17.2e).

Scars covering the breast and shoulder can be excised; the wound, covered with the flap, decreases deformity of the breast and shoulder (Figs. 17.4 and 17.5). A wide scar excised on the shoulder zone of a 5-year-old girl is shown in Fig. 17.6a, b.

This method is effective for treatment of severe shoulder edge adducted contractures and scar deformity (Figs. 17.7 and 17.8). Neck contracture can be removed simultaneously (Fig. 17.9).

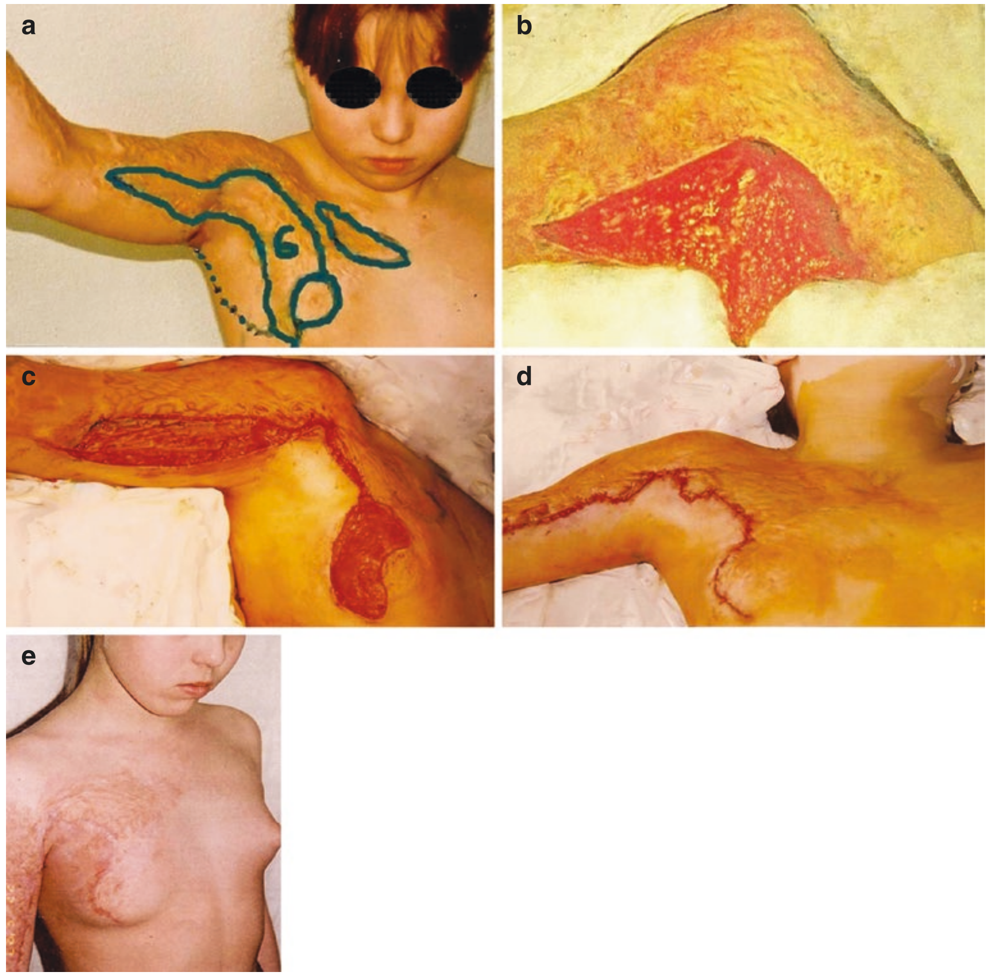

Fig. 17.4 Edge shoulder contracture and scar deformity (breast included) treatment. (**a**) Pre-surgery view: scars covered *FL*—flexion anterior surface, edge shoulder anterior adduction contracture, shoulder joint anterior surface and breast deformity, planning of operation; (**b**) flap mobilized; (**c**) scars excised, including breast area and shoulder, wound closed with axillary healthy tissue; (**d**) end of operation; (**e**) result (18 months after surgery): adduction contracture and breast deformity eliminated

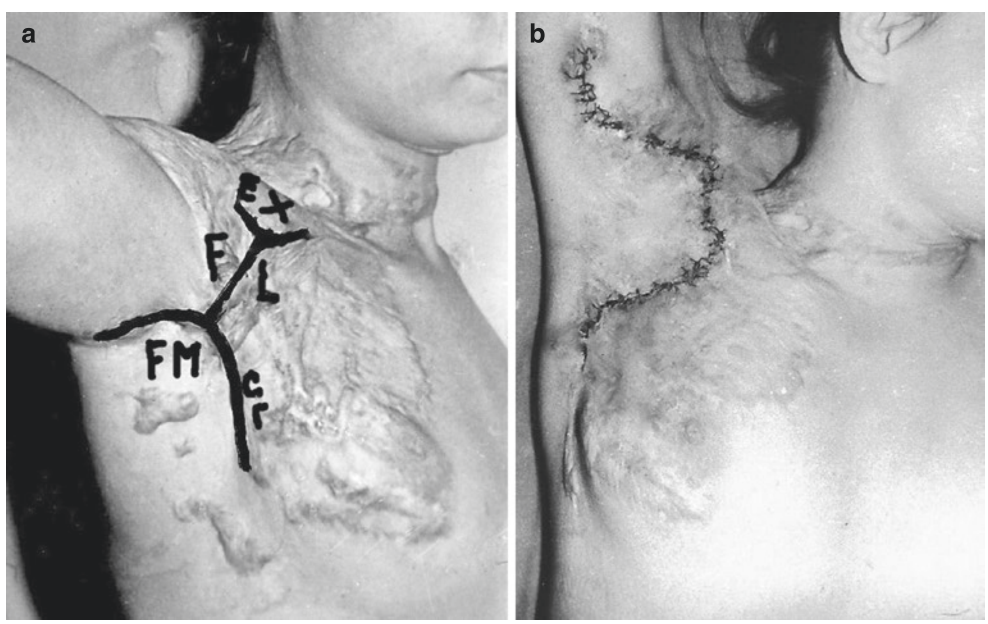

Fig. 17.5 Shoulder edge adduction contracture, deformity of joint surface and breast treatment with axilla adipose-cutaneous flap (**a**, **b**)

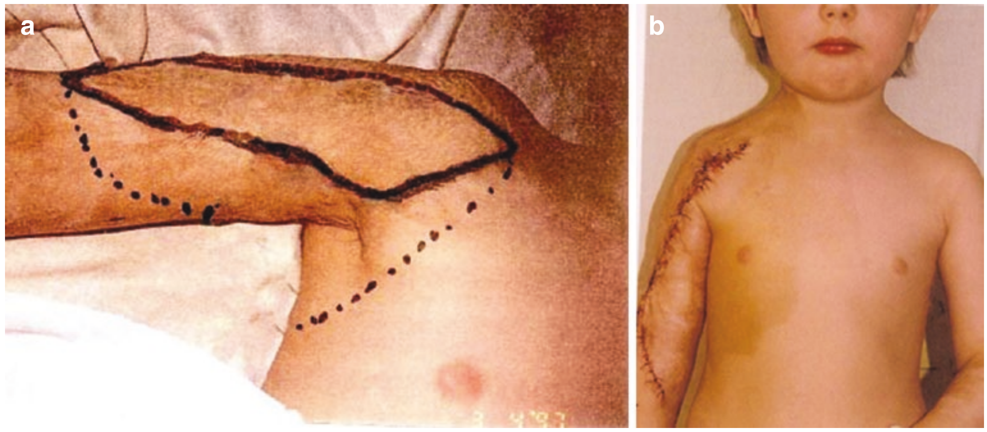

Fig. 17.6 Results of edge shoulder scar adduction contracture treatment and deformity by scar excision on shoulder joint anterior surface and shoulder; the wound covered with axillary adipose-cutaneous whole layer. (**a**) Planning: solid line—scar excision; dotted line—borders of adipose-cutaneous layer elevation; (**b**) 7 days after operation: transposed tissue alive; operation scars beside the anterior edge of axillary fossa

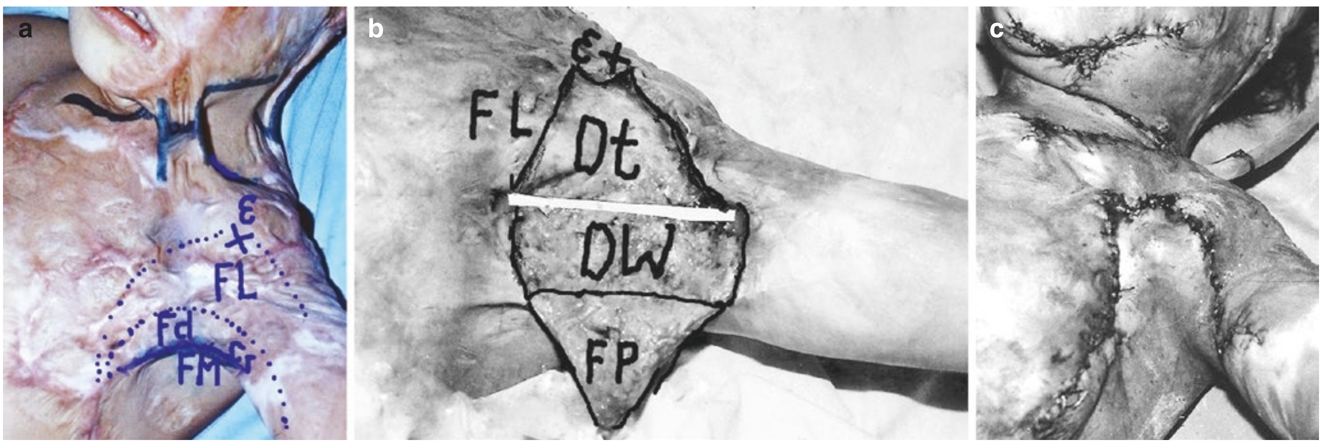

Fig. 17.7 Severe edge shoulder adduction contracture treated with axilla flap and neck lateral contracture release with counter-transposition of trapezoid adipose-scar flaps. (**a**) Pre-surgery, contracture, and deformity anatomy: *E* joint extension surface; "+" joint rotation axis; *FL* scarred FL surface; *Fd* fold; *Cr* crest of the fold; *FM* joint FM surface (axilla fossa); (**b**) anatomy of wound after scar release and flap mobilization: *Dt* scar surface deficit of FL surface; *DW* donor wound; (**c**) 5 days after surgery

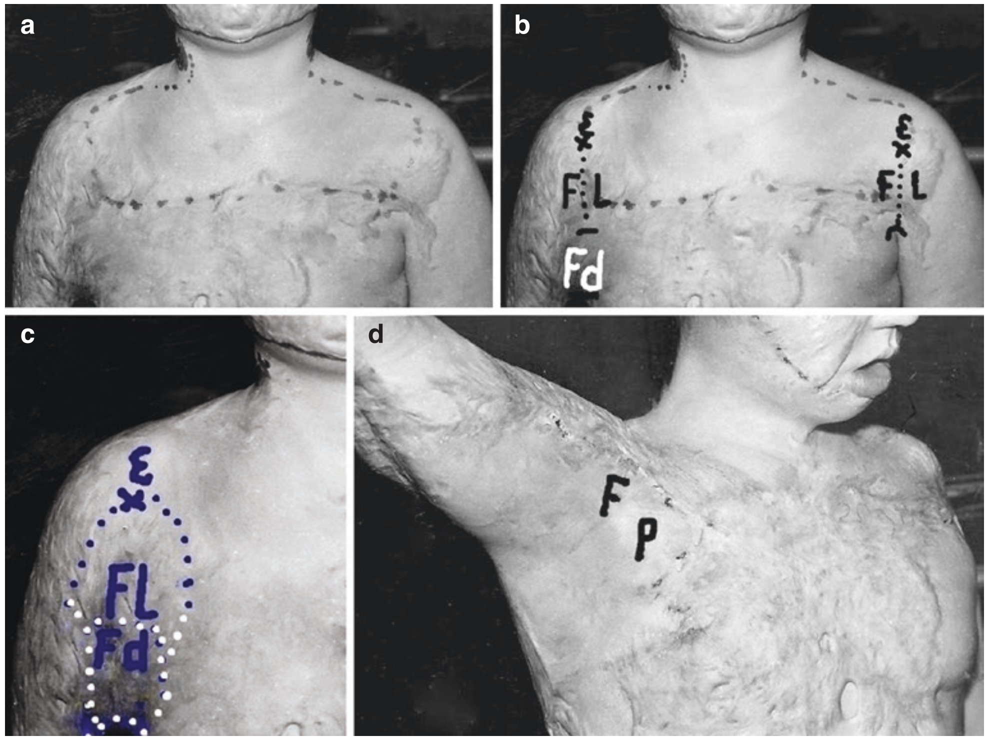

Fig. 17.8 Severe contracture and deformity treatment with new technique. (**a**, **b**) Pre-surgery, severe contracture, edge of axilla descended; (**c**) anatomy of severe shoulder contracture (accepted marks); (**d**) good functional and cosmetic outcomes after treatment with axillary adipose-cutaneous flap

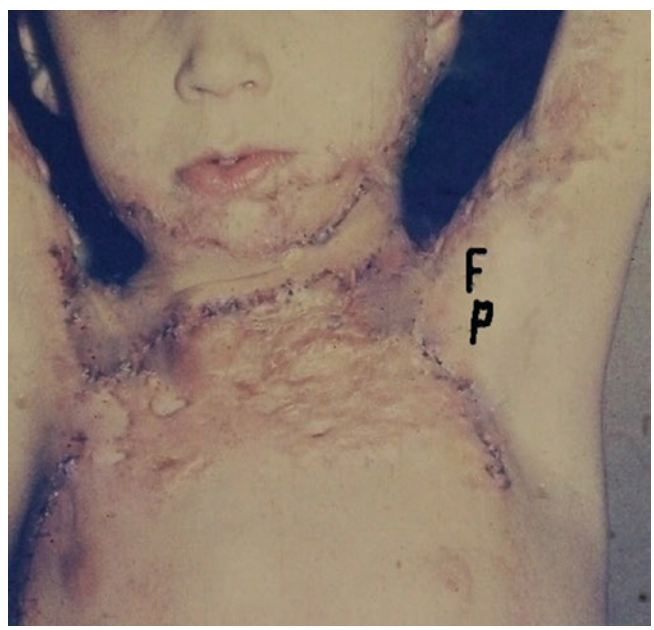

Fig. 17.9 Result of shoulder joint contracture and deformity treatment with axilla flap (FP) and neck contracture with thoracic lateral flap (2 weeks after surgery)

Conclusion

In children, there are possibilities for the simultaneous removal of the edge shoulder adduction contracture and a decrease in deformity of the joint surface, shoulder, and breast with scar excision and using an adipose-cutaneous flap of axilla and neighboring regions. No flap loss or other serious postoperative complications were observed. Squeezed by the flap, the underlying soft tissues play the role of an expander, ensuring active growth of distended skin.v Two to three months after surgery, the flap surface becomes larger; tissue tension of the flap and neighboring tissue gradually disappears; axillary fossa accepts normal outlines. Follow-up results are good: full shoulder abduction (180°) and rotation are normal, and the donor site is not injured.

Reference

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18 Shoulder Edge Posterior Adduction Contracture: Anatomy and Treatment with Axillary Adipose-Cutaneous Trapezoid Flap

Introduction

The shoulder posterior adduction contracture is of the edge type. In the literature, however, this contracture has several names and falls under numerous classifications that do not reflect the true contracture anatomy. The main surgical technique for posterior contracture treatment is Z-plasty, based on triangular flaps that are small/short and cannot fully reach the joint rotation axis and release contracture. Moreover, the triangular, propeller, rectangular, or rhomboid flaps do not match the scar surface deficit. As a result, surgical rehabilitation of a burned patient with shoulder scar contracture is far from perfect. Our observations showed that the edge posterior scar contracture can be successfully treated with undamaged tissue from the axilla region. This newly developed technique was tested on many patients and yielded excellent outcomes. Thus, the technique based on axillary adipose-cutaneous trapezoid flap(s) and trapezoid-flap plasty is the best option to treat shoulder edge posterior contracture. Anatomy, details of the technique, and results are presented in this chapter.

Functional Zones of the Shoulder Joint Surface in Edge Posterior Contracture, Formation, and Anatomy

Functional Zones of the Shoulder Joint (Fig. 18.1)

When planning surgery, it is necessary to divide the shoulder joint surface into flexion (*F*) and extension (*E*) (Fig. 18.1a, b); the boundary between them passes along the joint rotation axis level ("+" symbol). This aspect is not highlighted in the literature, but it is the basis for understanding joint contracture formation and type. The flexion zone (*F*) of big joints has anterior and posterior curvatures of nearly 90° caused by the latissimus dorsi and pectoralis major muscle edges, which divide it into two parts: flexion lateral (*FL*) and flexion medial (*FM*) surfaces. The dividing line passes along the edge of the axillary fossa (the muscle edges create the edge of the axillary fossa). The curvatures form two zones: *FL* anterior and posterior, which spread from the edge of the fossa to the joint rotation axis. The zone between the fossa's edges (axillary fossa) is the *FM* surface. With burns to this area, the shoulder adducts to the chest wall and thus prevents the fossa or joint FM surface from sustaining injury. The FL surface spreads from the posterior edge of the joint fossa, or crest (*Cr*) of the fold (*Fd*) (in the case of edge posterior contracture) to the joint rotation axis level. The flexion medial surface lies between the fossa edges.

Edge Posterior Contracture Formation (Fig. 18.1)

Contracture-type formation depends on the location of the contracted scars: shoulder edge posterior contracture is caused by scars covering the posterior flexion lateral surface; the FM and extension surfaces remain undamaged (Fig. 18.1a–e). Attempts to abduct the shoulder traumatizes scars and they begin to progressively grow distally, between the shoulder and chest wall, approaching them and forming adduction shoulder contracture. Scars, growing distally, involve the skin of the

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axilla fossa. As a result, the crescent fold is formed (*Fold*), connecting and moving the shoulder to the chest. The fold continues to grow extensively (Fig. 18.1a, b).

Anatomy of Edge Shoulder Posterior Contracture (Fig. 18.1)

(**a**) Joint posterior FL surface covered with scars; (**b**) scars form the fold that passes along the joint fossa's posterior edge. (**c**) The fold consists of two sheets; the lateral sheet is scars and continuation of scars of flexion lateral (*FL*) surface. The medial sheet is healthy skin and is part of the axilla fossa skin or flexion medial (*FM*) surface; (**d**) the crest (*Cr*) of the fold is the edge of the scars. The fold is a new anatomical structure made up of surface surplus scar and healthy skin. The fold's sheet, or tissue surplus, plays a decisive role in edge contracture elimination with local flaps. The scars of the FL surface and lateral scar sheet of the fold have surface surplus in width (from the crest fold to the joint rotation axis) and surface deficit in length—the distance between the shoulder and chest wall—which causes contracture.

Thus, the shoulder posterior adduction contracture has the following specific anatomical features and clinical signs:

(a) The shoulder edge posterior contracture is caused by contracted scars that cover the shoulder joint posterior flexion lateral surface and form the fold (*FL* and *Fold*; Fig. 18.1b).
(b) The fold passes along the posterior axillary fossa edge.
(c) The sheets of the fold are of different quality: the lateral fold sheet (according to axilla) is scar tissue and continuation of scars of FL surface; medial fold sheet and axillary fossa (*FM*) is healthy skin (Fig. 18.1a, b).
(d) The crest of the fold (*Cr*) is the edge of scars (Fig. 18.1a–c).

The fold's sheets are new anatomical structures, tissue surface surplus scars and healthy skin—capable of, in conjunction with the axillary flap, scar surface deficit compensation and contracture elimination.

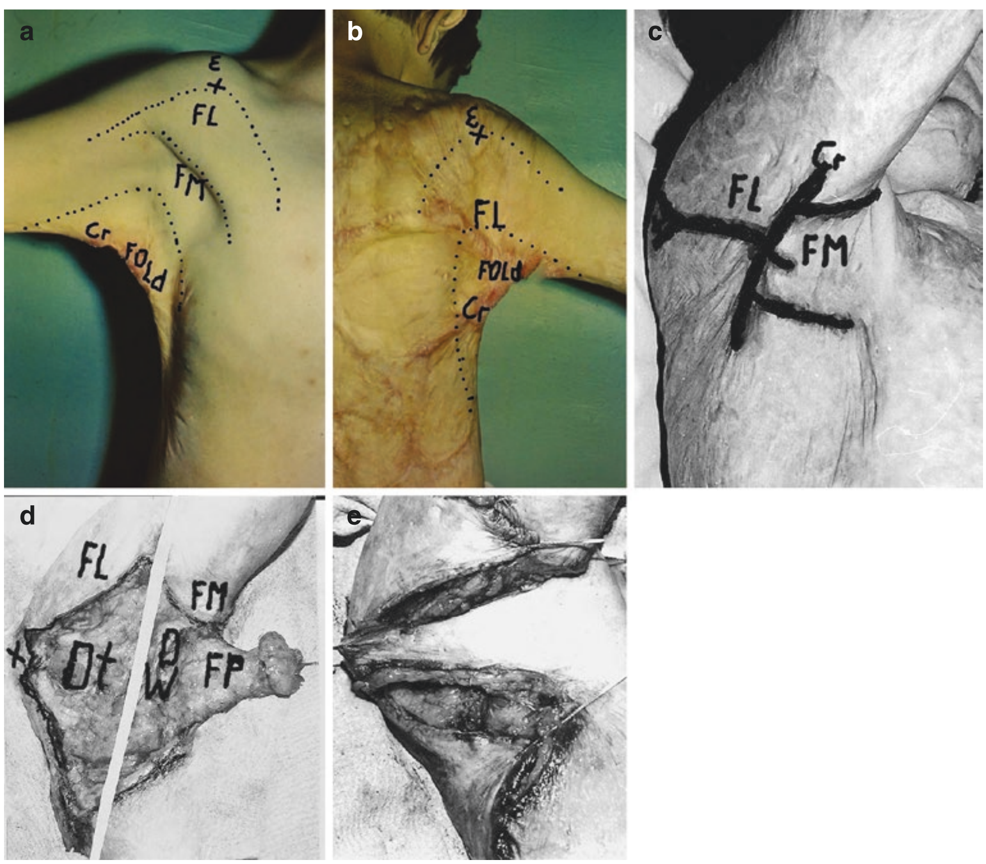

Fig. 18.1 Functional zones, anatomy, and scar surface deficit of shoulder edge posterior adduction contracture. (**a**) Anterior view: all surfaces: FL, FM, and medial fold sheet are healthy skin; *E* extension surface; *FL* flexion lateral surface; *Cr* crest of the fold; *Fold*; "+" joint rotation axis. (**b**) Posterior view: vast fold; *FL*—flexion lateral surfaces and fold's lateral sheet is scar tissue and contracture cause. *E* joint extension surface; "+" joint rotation axis. (**c**) Scar of *FL*—flexion lateral surface and lateral sheet of the fold are scars. Joint zones, anatomy and contracture cause: "+" joint rotation axis; *FL* flexion lateral surface covered by scars that form the fold; the lateral sheet of the fold is part of FL surface and scars, *FM* flexion medial surface is skin. Planning trapezoid flap in axilla and Y-line for scars dissection from fold crest to the joint rotation axis and separated scars from tissue of joint extension (*E*) surface. (**d**) Scars dissected with Y-incision from the *Cr*—fold crest to the joint rotation axis and separated from *FM*—flexion medial surface by an incision along the fold crest; *FP*—flap mobilized; *DW*—donor wound; contracture released; large wound or *Dt*—trapezoid scar surface deficit appeared, which is the real cause of contracture. (**e**) The flap transposed on the wound and scar surface deficit compensated; scar sheet covered the donor wounds beside the flap

Trapezoid Scar Surface Deficit Is the Real Cause of Contracture

Scars, growing distally and forming the fold, increase the flexion lateral surface (*FL*) from the fold crest to the joint rotation axis. Simultaneously, the scars undergo contraction in length, which shortens the scar's distance between the shoulders and the chest wall, causing the contracture (Figs. 18.1c–e and 18.2a, b). Planning trapezoid-flap plasty and defining scar surface deficit is shown in Figs. 18.1c, 18.2a, and 18.4c). After dissection of contracted scars of the flexion lateral surface, from the fold crest to the joint rotation axis with Y-incision, a large trapezoid wound appears, consisting of: *Dt*—scar surface deficit; *DW*—donor wound; *FP*—flap. Consequently, the treatment lies in the scar surface deficit compensation with a trapezoid flap—*FP* (Figs. 18.1d, e, 18.2b, c, f, and 18.3c, d).

Scar surface deficit is determined as follows: (1) with an incision along the fold crest, the sheets of the fold are separated, and scars are separated from healthy skin; (2) then, contracted scars are dissected with a Y-incision, the splitting end of which separates contracted scars from healthy skin of the joint extension (*E*) surface. Separation of contracted scars from both sides, healthy skin of the joint fossa and tissue of the extension surface (*E*), is the basis of complete contracture release using trapezoid flaps and trapezoid-flap plasty.

During shoulder abduction, the wound edges diverge, and the M-form wound straightens to nearly 5–6 cm in length. If needed, the split ends of the Y-incision during surgery are lengthened along the joint rotation axis level.

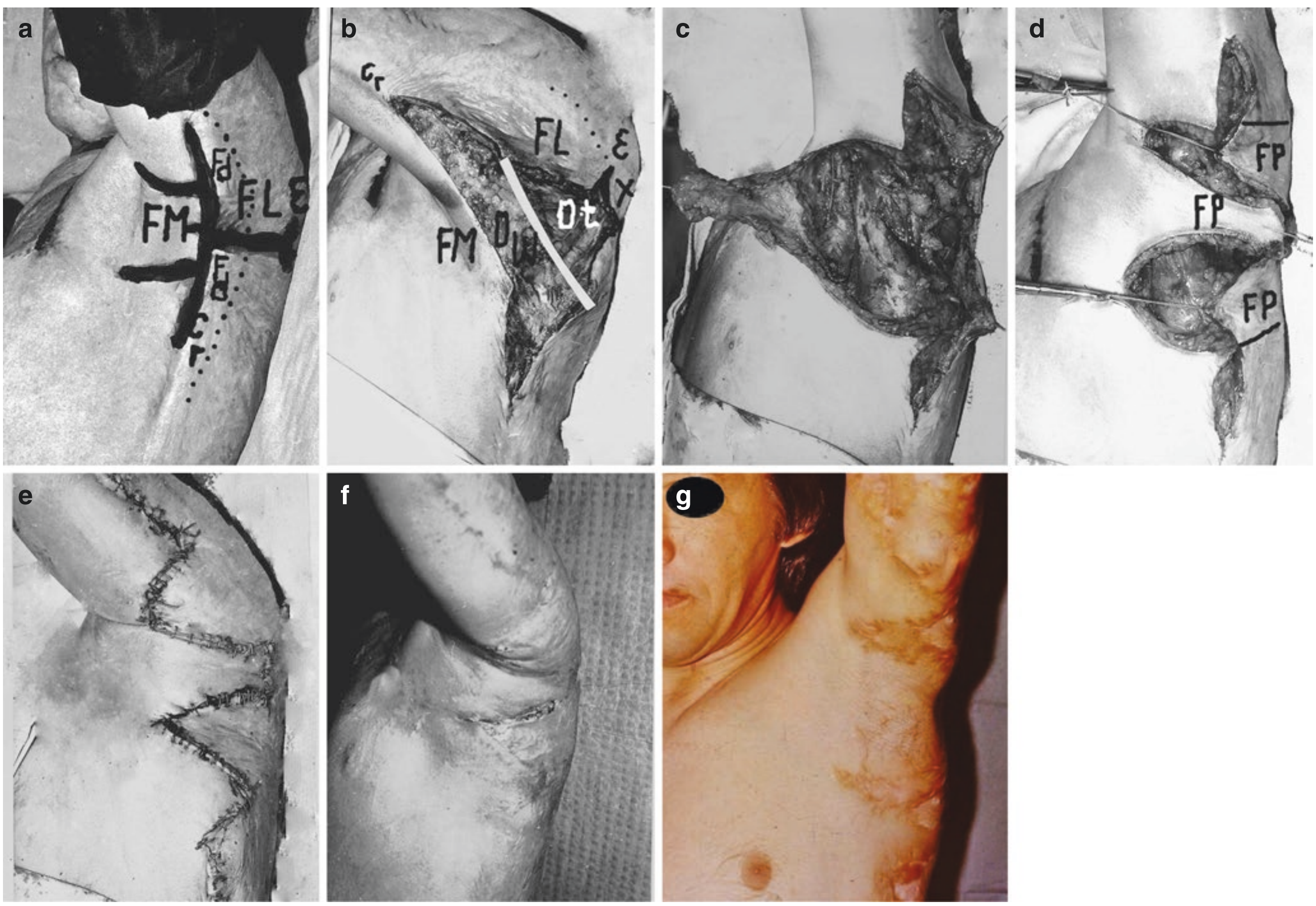

Fig. 18.2 Treatment of severe left shoulder edge posterior contracture, caused by scar surface deficit of joint *FL*—flexion lateral surface and lateral fold sheet, by three trapezoid flaps. (**a**) Pre-surgery, anatomy of edge contracture and surgery planning: *E*—extension surface; "+"—joint rotation axis; *FL* and *Fd* (fold)—flexion lateral surface and lateral sheet of the fold are scars and contracture cause. *FM*—flexion medial surface and medial fold sheet is healthy skin and donor site; *Cr*—crest of the fold. Axillary trapezoid flap includes all fossa (FM surface); Y-line of contracted scar dissection of posterior FL surface and fold (*Fd*) from fold crest (*Cr*) to the joint rotation axis ("+"); (**b**) contracted scars dissected by Y-incision and contracture released; large trapezoid wound *Dt*—scar surface deficit appeared (right from strip), M-form wound's end on joint rotation axis level, nearly 5 cm in length; *DW*—donor wound. *FM*—healthy skin of fossa or FM surface; (**c**–**e**) trapezoid flap mobilized, transposed on the wound; large donor wounds beside the flap are covered by adipose-scar trapezoid flaps taken from the scar sheet, fully compensating for the deficit and fully eliminating contracture. (**f**) Three weeks after reconstruction and (**g**) 2 years after surgery: excellent functional and cosmetic outcomes

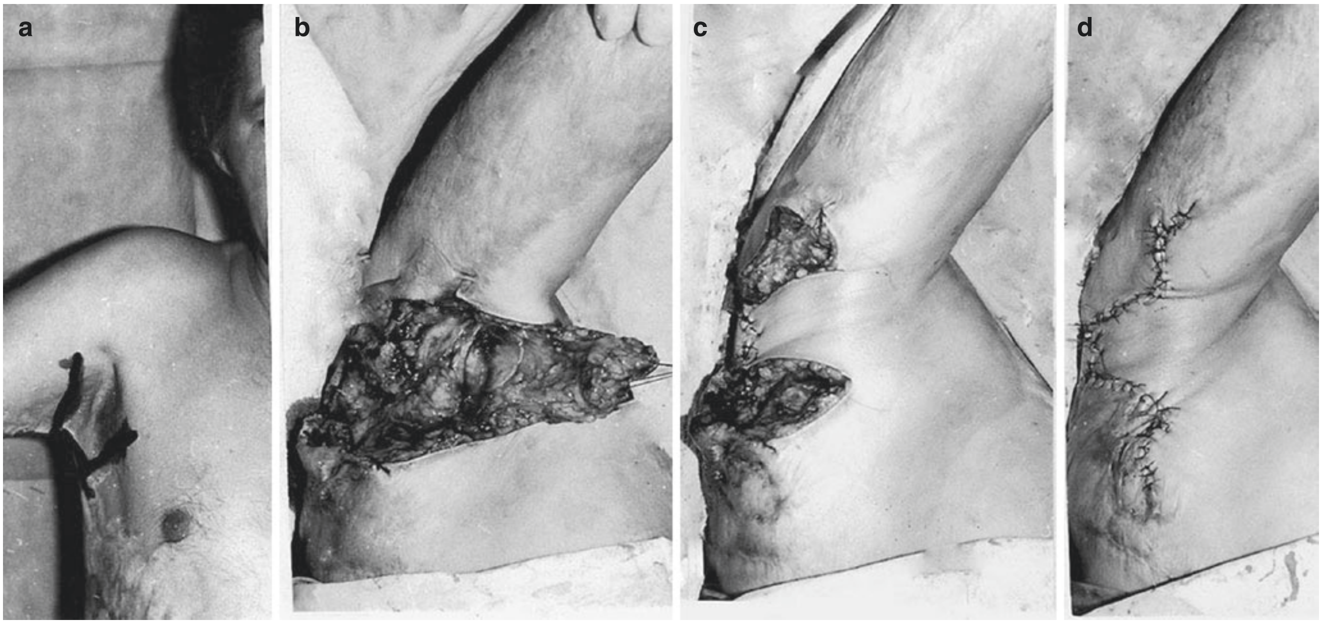

Fig. 18.3 Moderate shoulder edge posterior contracture treatment with one trapezoid flap. (**a**, **b**) Before operation, contracted scars of posterior FL surface formed the fold, lateral sheet of which is scars; planning: one trapezoid adipose-cutaneous flap in axillary fossa marked and mobilized; (**c**) flap covered the wound and compensated for the scar surface deficit; (**d**) donor wounds beside the flap primarily closed by transposition of scar sheet angles to the flap's base

Edge Shoulder Posterior Contracture Treatment Is Scar Surface-Deficit Compensation with Trapezoid Flaps [1]

Common technical details that are used in all cases are as follows (Fig. 18.2):

(a) The fold's sheets are separated on all fold borders with an incision along the crest of the fold up to the edge of the latissimus dorsi muscle;
(b) The scar of the flexion lateral (*FL*) surface and lateral fold sheet is dissected with a Y-shaped incision from the fold crest to the joint rotation axis; after shoulder abduction, *Dt*—trapezoid wound appears, as a rule, reflecting the form and size of the surface deficit of scar fold sheet;
(c) Adipose-cutaneous flap (*FP*) is mobilized from the medial fold sheet and axillary fossa according to the size and form of the wound (Figs. 18.1d and 18.2c, d);
(d) The trapezoid flap is transposed on the wound with tension, thus compensating for the surface deficit and eliminating contracture with excellent outcomes (Figs. 18.2d–g and 18.4e).

For donor wound coverage beside the main flap, adipose-scar and adipose-cutaneous trapezoid flaps are prepared from both fold sheets and neighboring tissues and are counter-transposed, covering the donor wounds (Figs. 18.2c–e, 18.3d, and 18.5d, e). Depending on the severity of the contracture, the fold's length, and its protrusion, the reconstructive technique has technical peculiarities.

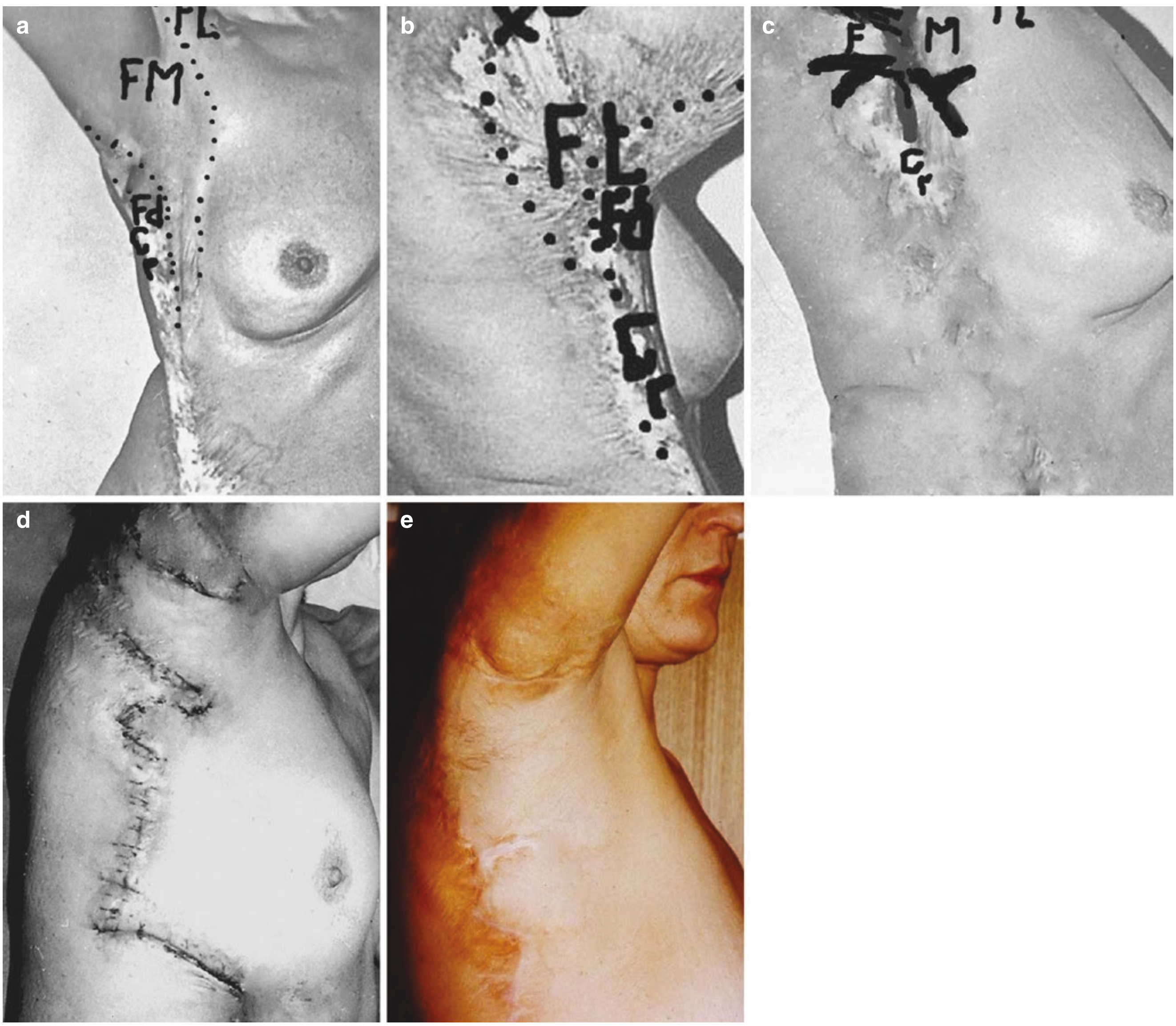

Fig. 18.4 Elimination of moderate edge shoulder adduction contracture with three trapezoid flaps. (**a**, **b**) Anatomy: scars on flexion lateral surface (*FL*) and scar fold sheet (*Fd*) cause adduction contracture; flexion medial surface (*FM*) and medial fold sheet is healthy skin; (**c**) planning: Y-lines for contracted scar dissection from the fold crest to the joint rotation axis ("+"); line along the crest for scars separating from the healthy skin, trapezoid flap marked in axilla; (**d**) three-trapezoid-flap plasty performed: flaps alive, contracture released (2 weeks after surgery); (**e**) follow-up results (2 years after reconstruction): complete function and axillary contours restored

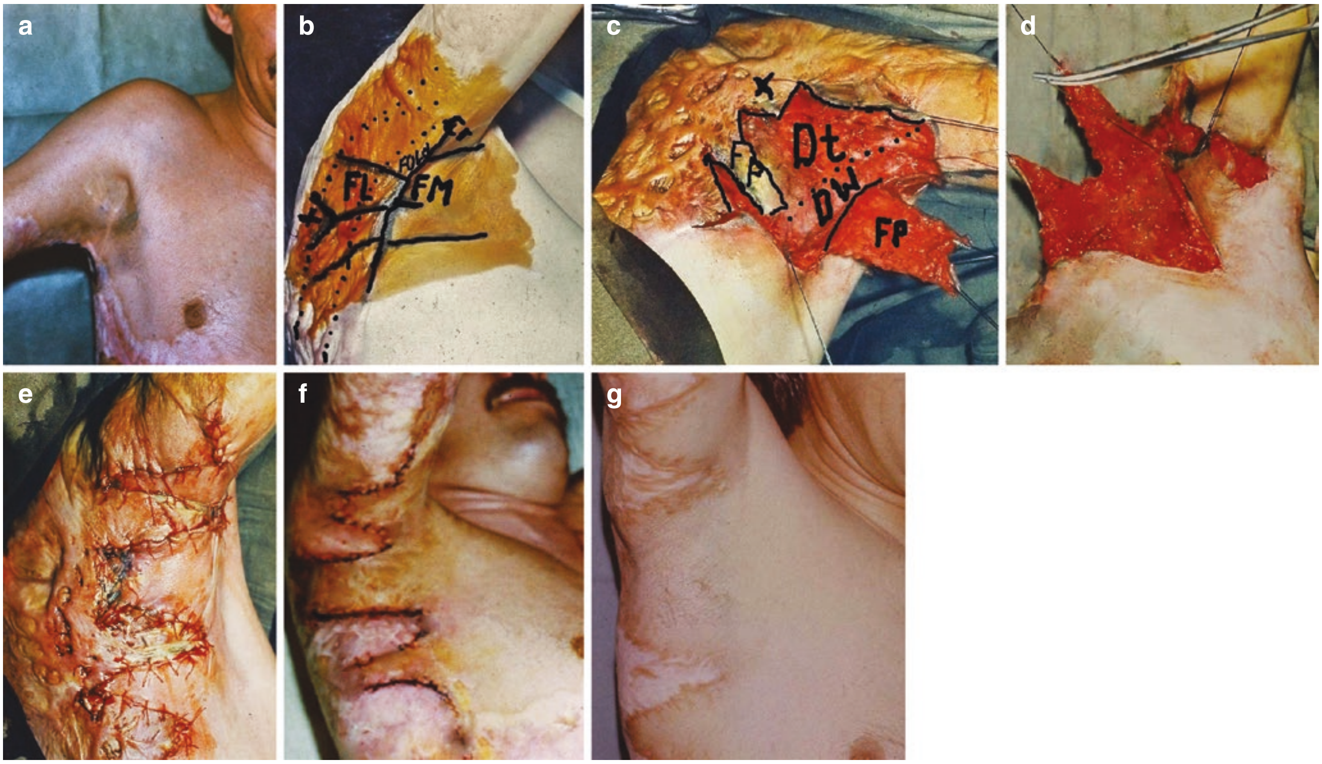

Fig. 18.5 Severe edge shoulder posterior contracture elimination with multiple adipose-cutaneous and adipose-scar trapezoid flaps. (**a**) Pre-surgery view; (**b**) zones: *FL* flexion lateral posterior surface, covered by scars that formed the fold; *Cr* crest of the fold; "+" joint rotation axis; *FM* flexion medial surface and medial fold sheet is healthy skin; three-flap plasty planning; (**c**) contracted scars dissected by Y-incision from the fold crest to the joint rotation axis, *Dt*—trapezoid wound or scar surface deficit (contracture cause) of FL surface and lateral scar sheet appeared with M-shaped end; axillary adipose cutaneous flap mobilization; (**d**, **e**) for complete contracture release and scar surface deficit compensation, several additional adipose-cutaneous and adipose-scar trapezoid flaps elevated; end of operation; (**f**) 2 weeks after surgery: contracture eliminated, flaps alive; (**g**) excellent functional and cosmetic outcomes (3 years after reconstruction)

Shoulder Edge Adduction Contracture Treatment with One Adipose-Cutaneous Axillary Flap

Posterior edge shoulder contracture elimination with one axillary trapezoid flap is shown in Figs. 18.2 and 18.3. An excellent donor site for this flap is the axillary fossa and medial fold sheet, which are used in all cases. Planning of the operation is shown in Figs. 18.2a and 18.5b. It is often necessary to increase the size of the trapezoid flap at the time of the operation for complete contracture elimination. The operation consists of separation of the crescent fold sheet, and the scar sheet and subcutaneous fat layer are dissected from the fold crest to the shoulder joint rotation axis (Figs. 18.2b and 18.5c). After shoulder abduction, the scar border divergence forms a trapezoid-shaped wound (Figs. 18.1d, 18.2b and 18.5c). The trapezoid flap is mobilized according to the wound's form and size. The medial fold sheet and the axillary fossa's adipose-cutaneous layer, up to the pectoralis major muscle, are included in the flap. A deep axillary fat layer and lymphatic nodules remain in situ. The flap's end includes a part of the fold crest; its width is nearly 5–6 cm. The trapezoid flap is transposed on the wound with tension. As a result of flap tension, the axillary edges approach the donor wound. The flap's tension displaces neighboring E-tissues to the joint's FL surface, contributing to in FL surface and donor wound covering and contracture elimination. The M-shaped flap end is sutured with the scar's M-form wound end. The wound beside the flap is covered with lateral sheet angles (Figs. 18.2c–e and 18.5c).

Posterior Edge Shoulder Contracture Elimination with Three Trapezoid Flaps

If contracture and scar surface deficit are severe (Fig. 18.4a–c), the angles of the scar sheet cannot approach the flap's base; therefore, two additional trapezoid adipose-scar flaps were mobilized from the scar sheet and transposed on the wounds beside the main flap (Fig. 18.4b–d). Beside the scar flaps, wounds are covered with flaps of the medial healthy sheet (Fig. 18.4c, d).

Shoulder Edge Severe Posterior Adduction Contracture Treatment with Multiple Adipose-Cutaneous and Adipose-Scar Flaps

Severe contractures are usually caused by a long, well-protruded crescent fold. At first, the central zone of contracture is reconstructed in the usual manner, with three trapezoid flaps (Fig. 18.5a–d). Then the fold's sheets on all its extents are converted to the trapezoid flaps, which resulted in full contracture release with some over-correction (Fig. 18.5e–g).

Severe edge posterior contracture (next case) causing a long and wide crescent fold is treated with several adipose-cutaneous and adipose-scars trapezoid flaps. At first, the reconstruction is directed towards contracture release and restoration of axilla using typical three-flap plasty (see planning in Fig. 18.6a, b). The entire semilunar fold is converted into trapezoid flaps by radial Y-dissections. The flap's surface is usually enough for complete scar surface deficit compensation and contracture elimination (Fig. 18.6c).

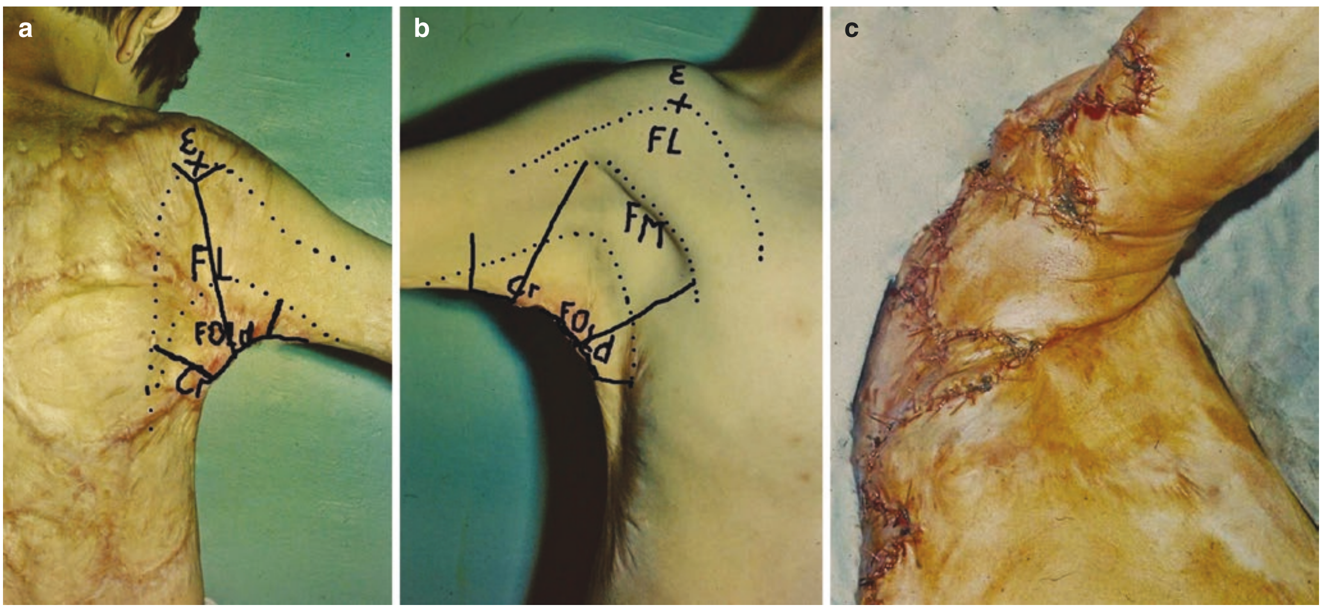

Fig. 18.6 Severe edge posterior shoulder adduction contracture, caused by scar of FL posterior surface and long and wide fold. (**a**) Pre-surgery, posterior view, anatomy: Extension surface; "+"—rotation axis, *FL*—scar flexion lateral surface and fold (fold's lateral scar sheet is part of FL surface); planning: Y-line from the fold crest to the joint rotation axis for contracted scar dissection and two adipose-scar flaps from the lateral fold sheet and FL surface. (**b**) Anterior view: anterior FL and FM surfaces and medial sheet of big fold is healthy skin; three flaps from heathy skin—one axillary and two from medial fold sheet. (**c**) Counter-transposed flaps, scar surface deficit compensated, contracture eliminated, and axillary region restored; flaps alive (7 days after operation)

Severe Axillary Posterior Edge Adduction Contracture Treatment in Children

After severe edge posterior contracture release in children, it is useful to excise the wide strips of rough scars on the shoulder and chest wall with primary wound closure (Fig. 18.7).

Contracture in a pediatric patient, caused by severe scar surface deficit, is eliminated with a combined technique: axillary trapezoid flap and skin transplants (Fig. 18.8). After complete contracture release with a Y-incision, a large trapezoid wound or scar surface deficit appears. A severe scar surface deficit does not allow the use of the scar sheets for donor wound covering because of the severe divergence of the dissected scars (Fig. 18.8c). In the presented children, the axillary adipose-cutaneous flap was elevated from the fossa and medial fold sheet (*FM*, *Fd*) and transposed on the wound with tension, covering the central joint axillary zone; with wounds beside the flap, on the chest wall and shoulder, skin grafted (Fig. 18.8d, e). Adipose-cutaneous flap was stable and suspends the axilla and posterior fossa edge. The wounds beside the flap are displaced on the shoulder and chest wall (Fig. 18.8c–e). Since the axilla is protected (suspended) with the flap, shrinkage of the skin transplants (*T.t*) does not lead to contracture recurrence.

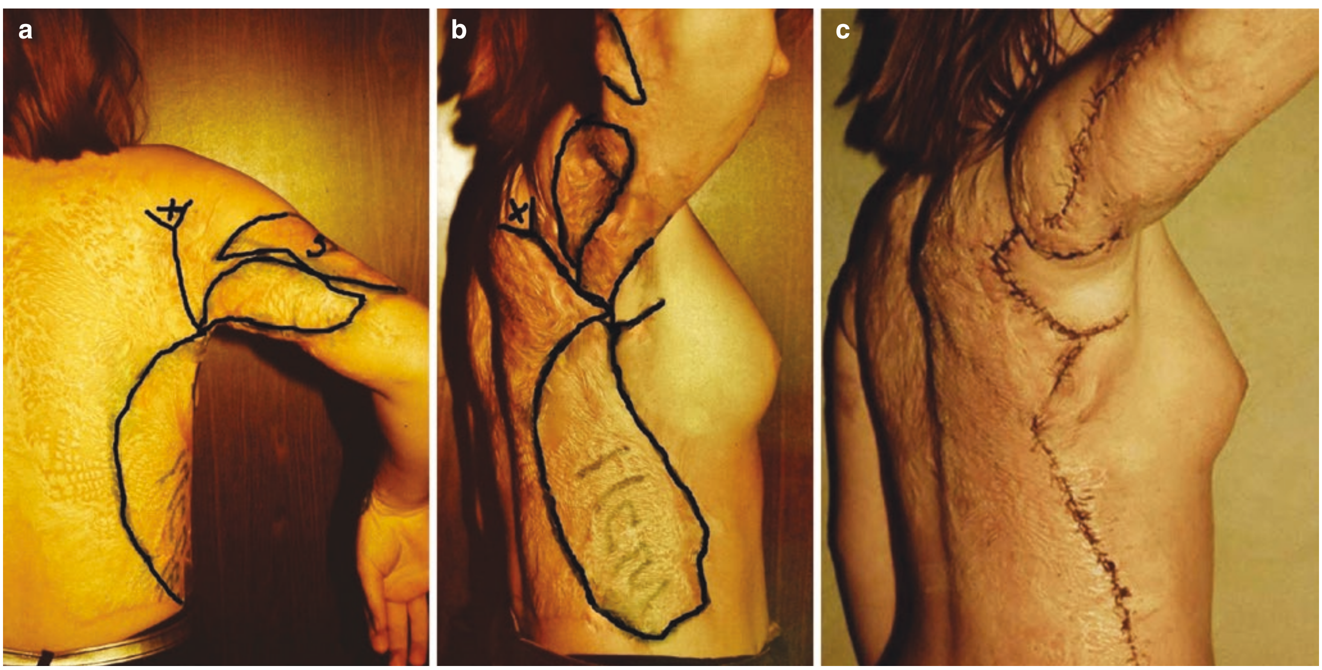

Fig. 18.7 Severe posterior edge contracture elimination and deformed scar excision on the shoulder and chest wall. (**a**, **b**) Pre-surgery view: severe adduction contracture, scars covered the posterior surface of the joint FL surface, chest wall, and shoulder; planning: Y-shaped line of FL surface scars dissection and borders of axillary trapezoid adipose-cutaneous flaps, scars excision on shoulder and chest wall; (**c**) contracture released with axillary adipose-cutaneous trapezoid flap, deformed scars removed, and wounds primarily closed; stitches of inner row were hidden; contracture eliminated, significant improvement in appearance

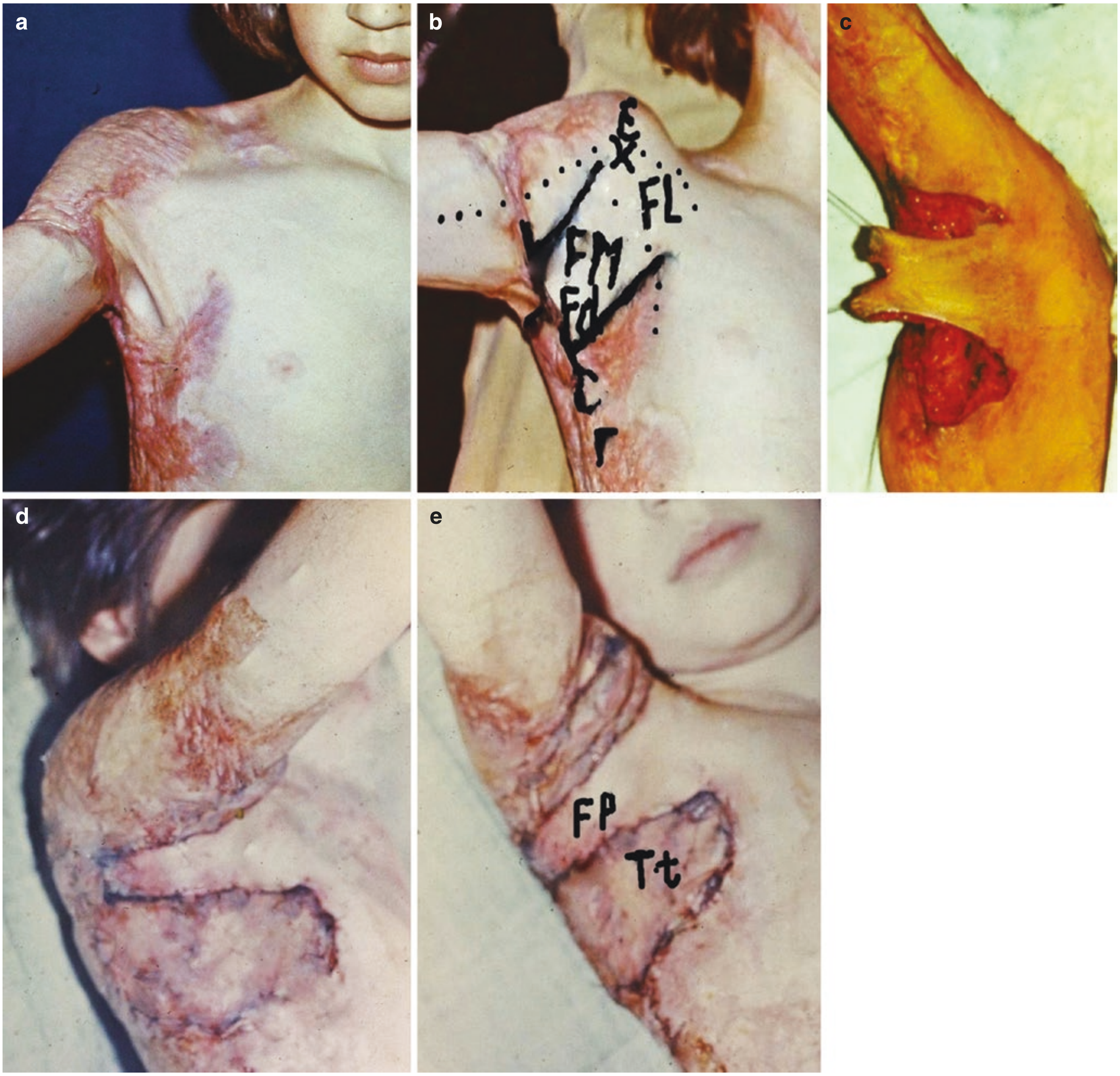

Fig. 18.8 Severe edge shoulder posterior contracture of 7-year-old girl; treatment with an adipose-cutaneous axillary trapezoid flap and skin transplants. (**a**) Anatomy; (**b**) planning axillary trapezoid flap; (**c**) contracted scars dissected, large wound appeared; mobilized axillary trapezoid flap; (**d**, **e**) 2 weeks after surgery: central joint zone of flexion lateral surface covered with the flap (*F*), wounds on chest wall and shoulder skin transplants (*TR*); flap and transplants alive

Conclusion

Shoulder edge posterior contracture is caused by trapezoid surface deficit of scars, covering the joint's flexion lateral posterior surface, and the scar sheet of the crescent fold. The fold is a surface surplus, which in conjunction with the axillary fossa's flap and (rare) skin transplants, can be used to completely eliminate posterior edge contracture of all grades of severity. Mild-to-moderate contracture is eliminated with a local adipose-cutaneous flap only; severe contracture is eliminated using a combined method. An axillary trapezoid flap covers the wound on the FL surface and compensates for scar surface deficit, suspends axilla, and divides the large wound on the shoulder and thoracic area, where shrinkage of skin transplants is insignificant. The flap preserves a stable position for axilla and prevents recurrence of contracture. All these factors explain why the new method yields excellent outcomes without re-contractures and repeated reconstructions.

References

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19 Bilateral Shoulder Edge Adduction Scar Contractures: Anatomy and Treatment

Edge Shoulder Bilateral Contracture Formation and Functional Zones

Bilateral shoulder adduction contracture is a result of widespread, deep burns, with the scars covering the shoulder joint but not the axillary fossa. The literature lacks information on treatment. Triangular techniques do not yield satisfactory outcomes. The scars on the shoulder and chest wall restrict the use of propeller and other local flap forms. Therefore, fasciocutaneous and musculocutaneous flaps become an alternative technique to correct bilateral shoulder contractures [1, 2]. Our experience proved that shoulder bilateral adduction contracture is successfully eliminated with axillary trapezoid flaps, using one- or two-stage trapezoid-flap plasty [3].

Edge shoulder bilateral adduction contracture is caused by burns and scars, covering both the joint flexion lateral (*FL*) surfaces (flexion anterior and posterior) from the crests (*Cr*) of the fold to the joint rotation axis ("+") and neighboring surfaces of the shoulder and thoracic wall. During wound healing, scars grow distally between the shoulder and chest wall anteriorly and posteriorly (Fig. 19.1). Moving distally, scars involve the healthy skin of the axillary fossa. As a result, crescent-shaped folds form along the anterior and posterior edges of the axillary fossa. The scars' lateral fold sheets are part of the FL surfaces, which become wider (distance from the fold crest to the joint rotation axis).

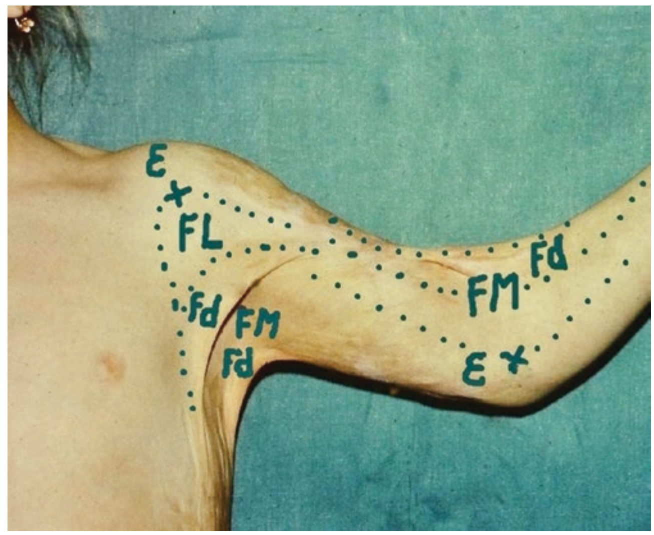

Fig. 19.1 Anatomy and functional zones of the shoulder joint surface in a case of bilateral edge shoulder adduction contracture. Contracture caused by scars covering the flexion lateral anterior and (*FL*) forming posterior sheets of the folds. Scars, growing distally between the shoulder and chest wall, form the semilunar folds (*Fd*) along the edges of the axillary fossa; *Cr*—crest of the fold. Lateral fold sheets are scars and part of FL anterior and posterior surfaces; these scars cause the contracture. *E*—Joint extension surface; "+"—joint rotation axis. The flexion medial surface (*FM*) or axillary fossa and medial sheets of the folds as part of the flexion medial surface, are healthy skin and the donor site. The folds are new tissue formations and present a surface surplus of scars and healthy skin, allowing the elimination of bilateral edge shoulder adduction contractures with local tissues

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Anatomy of Shoulder Edge Bilateral Adduction Contracture

Shoulder edge bilateral contracture has specific anatomical and clinical features and signs (Figs. 19.2 and 19.3) [3].

(a) Contracture is caused by scars that cover the joint flexion lateral (*FL*) surfaces, shoulder, and chest wall.
(b) Scars of the flexion lateral surfaces grow distally, involving the healthy fossa skin and forming the folds (*Fd*), which pass along the edges of axillary fossa between the flexion lateral (*FL*) and flexion medial (*FM*) surfaces.
(c) The fold consists of two different quality sheets: the lateral fold sheets are scars and are the continuation of the flexion lateral surfaces; the medial fold sheets and axillary fossa (flexion medial surface, *FM*) are healthy skin.
(d) The crest of the fold (*Cr*) is the edge of scars.

These four anatomical features and clinical signs determine the scar contracture name, edge. These features are always present regardless of edge contracture location and severity. Scars located on the joint's extension surface do not participate in contracture formation. The symbol "+" marks the joint rotation axis. In the case of edge shoulder bilateral contracture, the distance from the fold crest to the joint rotation axis (the width of contracted scars covering the joint flexion lateral surface) is 6–8 cm in children and 10–12 cm or longer in adults. The fold becomes a new anatomical formation that creates the surface surplus scars and skin used for contracture elimination. At the same time, scars are contracted in length and shorten the distance between the shoulder and chest wall, causing adduction contracture. The axillary fossa stays undamaged; the medial sheets of the fold increase the skin surface of the axilla.

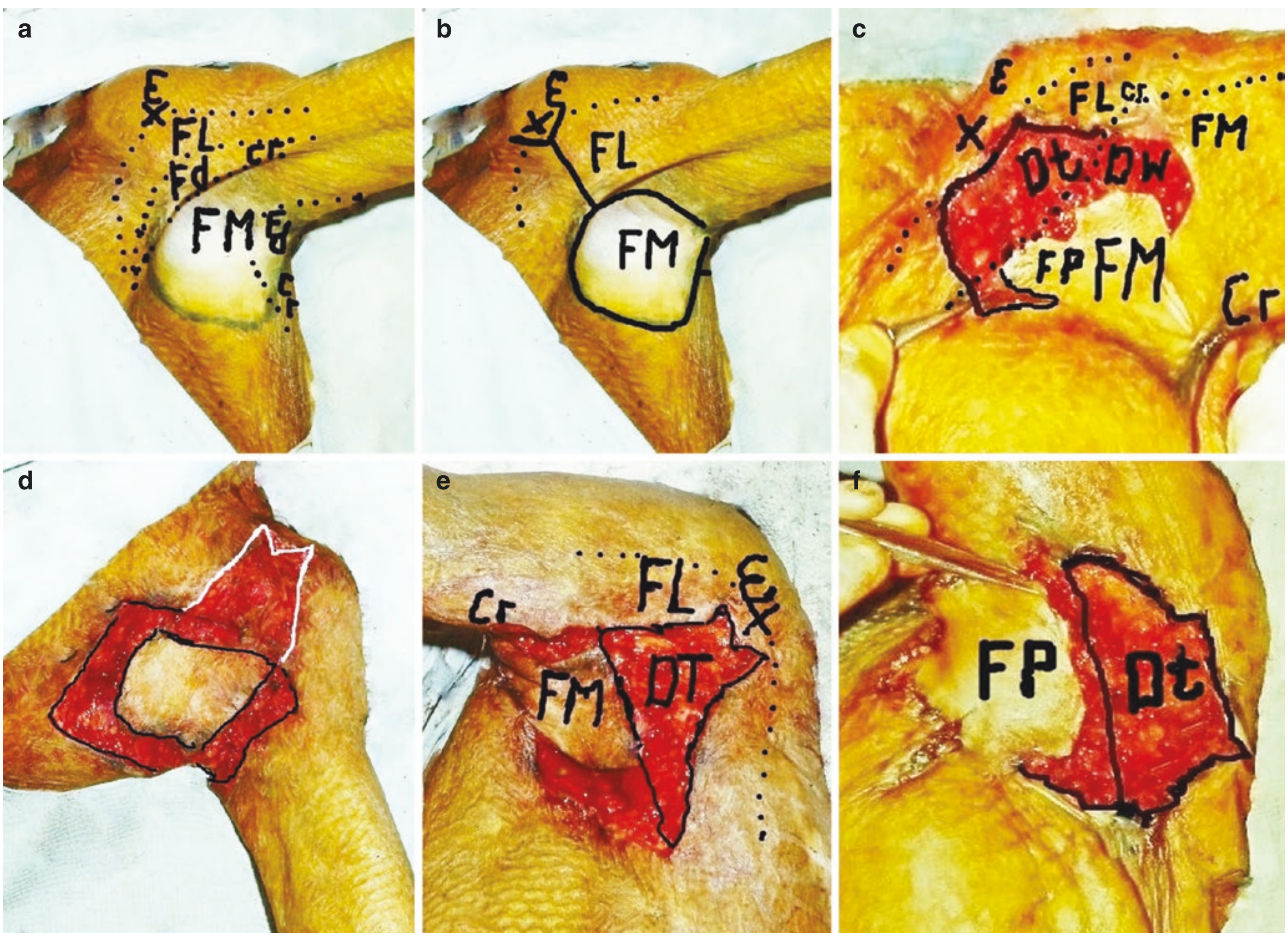

Fig. 19.2 Definition of scar surface deficit of anterior and posterior flexion lateral surfaces (form, size, and location) as the real cause of contracture. (**a**) Anatomy and joint's functional zones: *E*—Joint extension surface; "+"—joint rotation axis; *FL*—flexion lateral surface from the fold's crest to the joint rotation axis; scars of FL surface, growing distally, involve skin of FM surface and form the fold (*Fd*). Therefore, the lateral fold sheet is scars and part of FL surface, and the medial fold sheet is healthy skin. The crest (*Cr*) of the fold is the edge of scars. Contracture caused by scars covering the FL surfaces and scars of the lateral fold sheet; (**b**) planning: borders of the quadrangular flap involves all healthy skin of *FM*—flexion medial surface or axilla; Y-lines for scar dissection from fold crests to the joint rotation axis; (**c**) dissected scars of the anterior FL surface and the fold's scar sheet, large trapezoid wound or surface deficit (*Dt*) appeared; *DW* donor wound; *FP* flap; (**d**) flap (*FP*) mobilized from periphery and displaced on the axilla bottom; (**e**) posterior FL surface and scar sheet dissected, Dt of FL scar surface deficit or wound appeared; shoulder abduction is at 90°. (**f**) Then, shoulder abducted to 180°—the scar edge divergence changes the M-wound into a lineal form, the wound doubled in size, because the wound's edges freely diverged. These trapezoid wounds (anterior and posterior) are the real size and form of scar surface deficit (*Dt*) and are the cause of the bilateral contracture

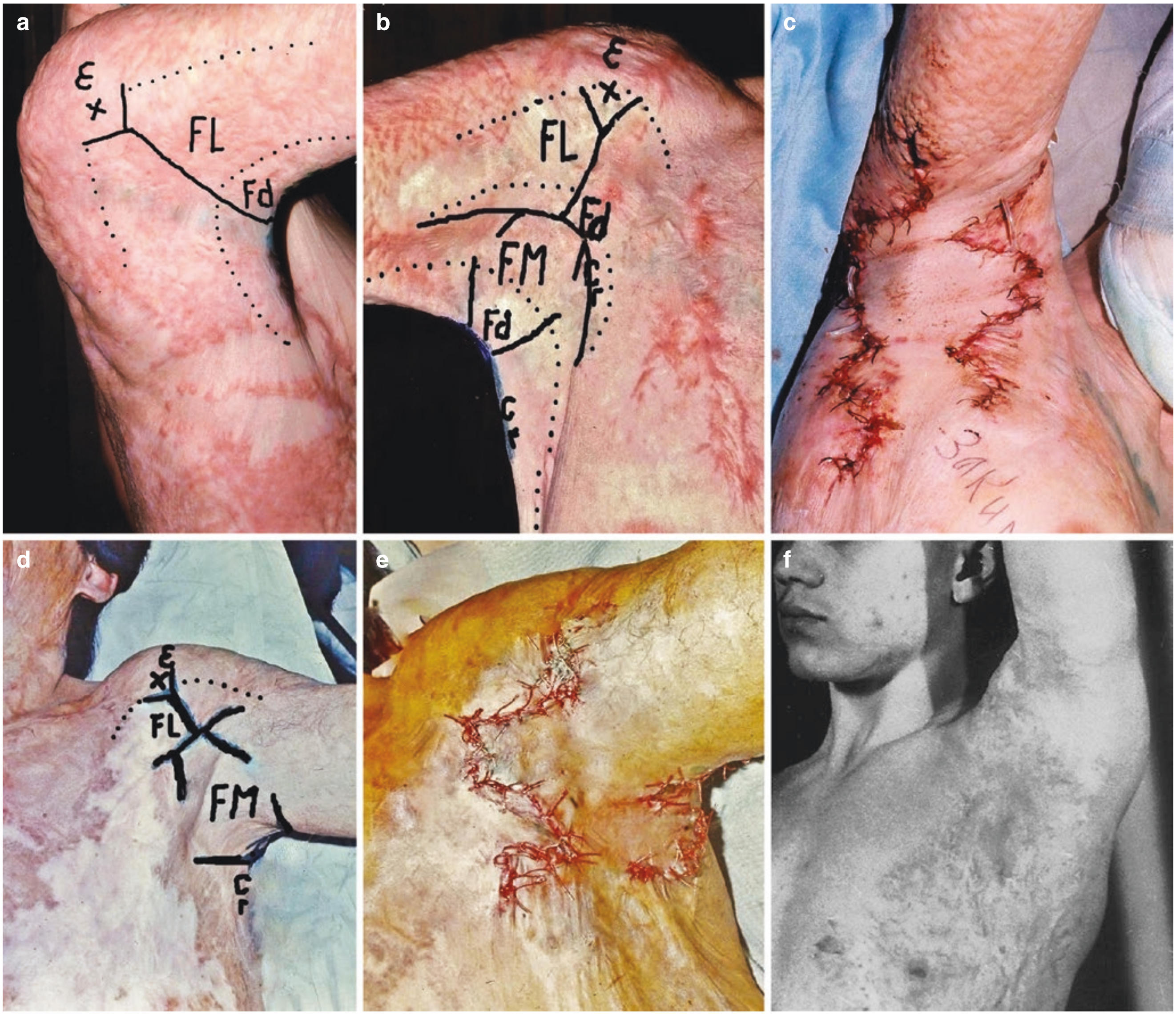

Fig. 19.3 Bilateral severe shoulder adduction contracture treatment using one-stage trapezoid-flap plasty and result. Case 1: (**a**, **b**) Presurgery posterior and anterior views: joint zones and contracture anatomy: Extension; *FL* flexion lateral surfaces and lateral sheets of both folds (*Fd*) are scars; *Cr* crest of the fold; "+" joint rotation axis; *FM* flexion medial surface; planning posterior and anterior edge contracture release: solid lines—incisions; dotted lines—contracture anatomy; *FM*—flexion medial surface or axillary fossa, where two trapezoid flaps with common pedicle are marked, lines of the fold sheets division, Y-lines for scars of *FL*—flexion lateral surfaces and lateral scar fold sheets dissection from the fold crest to the joint rotation ("+") axis; (**c**) end of operation: trapezoid adipose-cutaneous flaps compensated trapezoid scar surface deficit, donor wounds beside the flap covered with flexion lateral fold sheet displacement. Contracture released and contours of axilla restored. Case 2: (**d**) Bilateral mild-to-moderate shoulder edge contracture caused by scars of *FL*—flexion lateral surfaces and scars of the lateral fold sheets; *FM*—axilla, flexion medial surface; medial fold sheet is continuation of joint FM surface. Planning of one-stage operation; (**e**) trapezoid scar surface deficit of FL surfaces was covered with trapezoid adipose-cutaneous axillary flaps, which consist of one-third of fossa and medial sheets; donor wounds beside the flaps are covered with lateral scar fold sheets, whole or adipose-scar trapezoid flap prepared from scar sheet; (**f**) good follow-up result

Surface Deficit of Contracted Scars Is Contracture Cause

The scars of FL surfaces, growing distally, form the folds (*Fd*), and thus increase scar flexion lateral surfaces in width from the fold crest (*Cr*) to the joint rotation axis on the lateral scar sheet of the fold (Figs. 19.1 and 19.2a). At the same time, these scars undergo contraction in length and adduct the shoulder to the chest wall, causing contracture. This scenario leads to scar surface deficit in length, between the shoulder and the chest wall. In other words, the edge contractures are caused by the scar surface deficit (*Dt*) in length, covering the flexion lateral surface from the fold crest to the joint rotation axis (Fig. 19.2b–f).

Scars of flexion lateral surfaces include the fold, and it becomes wider (from fold crest to joint rotation axis). Simultaneously, these scars undergo contraction in length (between shoulder and chest wall) and this shortens the distance between the shoulder and the chest wall. After dissection of contracted scars from the fold crest to the joint rotation axis with Y-incision scars, a large trapezoid wound appears (Fig. 19.2b, c, e, f). Contracture treatment is concluded in scar surface deficit compensation by converting the healthy axillary skin to the trapezoid subcutaneous pedicle flaps and transposition of these flaps on the joint's anterior and posterior surfaces and axilla suspension.

Bilateral Shoulder Edge Contracture Treatment [3]

Depending on contracture severity and axillary fossa condition, reconstruction of bilateral edge shoulder adduction contractures is performed using one-stage or two-stage procedures, with local flaps alone or in combination with skin transplants.

One-stage reconstruction is performed if contractures are mild-to-moderate, the deficit in the lateral fold sheets is not severe, and the axillary region has enough healthy skin for the bilateral contracture elimination with local flaps in one stage (Fig. 19.3).

Two-stage bilateral shoulder adduction contracture treatment is indicated for severe shoulder bilateral edge contractures (Fig. 19.4). First, the more severe contracture is released, and the wound is covered with a large adipose-cutaneous trapezoid flap, prepared from axilla as in cases of one-sided contracture treatment (Fig. 19.4a). Four to six weeks later, after skin tension has disappeared due to growth of stretching skin, the contracture of the other axilla side is removed with the same procedure (Fig. 19.4a–c, left joint; Fig. 19.4d–g, right joint).

Bilateral edge shoulder contractures in children are successfully eliminated with a quadrangular subcutaneous pedicle flap (Fig. 19.5). If the scars cover a wide surface, only the axillary fossa has healthy skin. The scars displace the axillary tissue downward, which increases the scar surface deficit (Fig. 19.5a). The planning of the operation is shown in Fig. 19.5b. With incisions along both fold crests, the sheets are divided, and scars are separated from healthy skin; all axillary healthy skin is included in a quadrangular flap (Fig. 19.5d). Using perpendicular Y-shaped incisions, scar sheets are dissected anteriorly and posteriorly to the joint rotation axis. Y-incisions also separate contracted scars of FL surfaces from tissue of the joint extension surface (*E*), which has not participated in contracture formation, and thus facilitates the divergence of the scar edges and completes contracture release (Figs. 19.2, 19.4e, and 19.5d, e). The flap of healthy axillary fossa tissue (skin and subcutaneous fat layer) is separated from the scars and mobilized from the periphery; the tissues in the central zone of the axillary fossa remain in situ and serve as a subcutaneous pedicle. The flap has steady blood circulation and severe stretches of the flap in the anterio-posterior direction allow its ends to connect with the wounds' edges anteriorly and posteriorly on the shoulder joint level (Fig. 19.5d–g). The wounds beside the flap are primarily closed, starting from the flap's ends (Fig. 19.5f–h). Truncal medial (Fig. 19.5i) and elbow edge contracture (Fig. 19.5c) are eliminated simultaneously using trapezoid-flap plasty, with good results (Fig. 19.5j).

Bilateral shoulder edge adduction contracture can be eliminated with an island of healthy skin preserved in axillary apex (Fig. 19.6). After a widespread burn of the axillary region, the island of healthy skin in the cupola can be preserved with a round (Fig. 19.6a–c) or quadrangular shape (Fig. 19.6d–g). In both cases, the severe anterio-posterior shoulder adduction contracture in adults is also treated with the subcutaneous pedicle flap and primary wound closure or skin grafting. The island axillary flap is mobilized from the periphery, displaced on the axilla's bottom, and transposed in an anterio-posterior direction with tension. Due to flap tension, (a) the edges of pectoralis major and latissimus dorsi muscles approach each other and the axillary fossa is obliterated; and (b) the healthy tissue of the axilla is used for surface deficit compensation and wound covering in the anterior and posterior joint's flexion lateral surface. As a result, the flap's ends reach the wound edges at the joint rotation axis level and thus suspend the axilla at the normal level or with some overcorrection. The axilla suspension with the trapezoid subcutaneous pedicle flap prevents contracture recurrence (Fig. 19.7a–d). The presented flaps and techniques allow elimination of the bilateral adduction contracture with local tissues, and avoid skin grafting per se, as well as the use of complex regional pedicle and free flaps, in most cases.

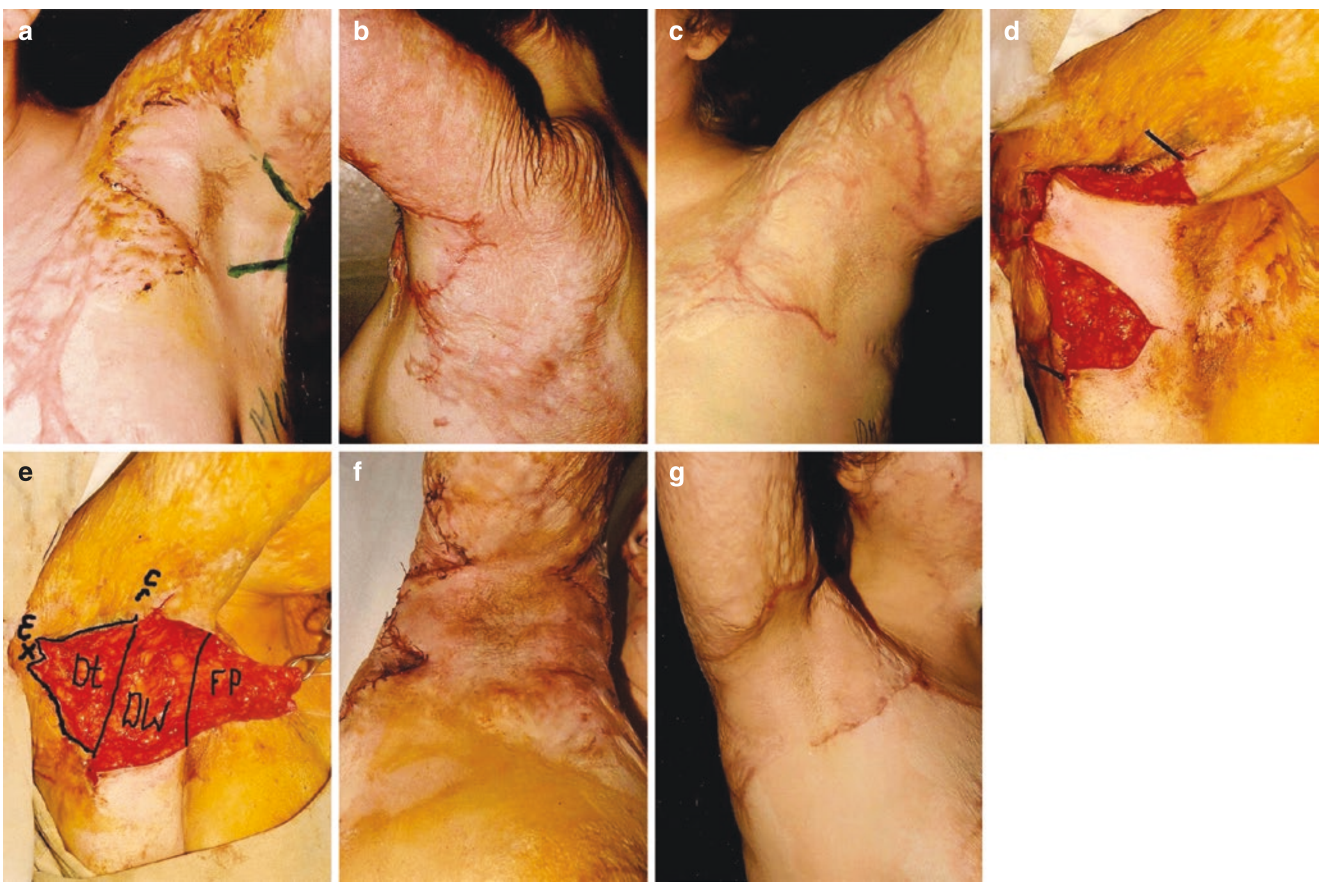

Fig. 19.4 Case 1: Two-stage bilateral axillary edge contractures treatment with trapezoid adipose-cutaneous flaps. (**a**) Left shoulder joint: anterior contracture removed 3 weeks before, planned trapezoid flap for posterior contracture release; (**b**, **c**) contracture eliminated, axillary contours restored. Case 2: Two-stage bilateral edge right axillary contracture treatment with trapezoid adipose-cutaneous flaps. (**d**) Anterior edge contracture released before; scars on posterior FL surface and scar sheet dissected with Y-incision, *Dt*—trapezoid wound appeared (scar surface deficit and real contracture cause), *FP*—trapezoid adipose-cutaneous flap mobilized; *DW*—donor wound. Anatomy: *E*—joint extension surface; "+"—joint rotation axis; *Dt*—scar surface deficit; *Cr*—crest of the fold; (**e**) mobilized flap covered wound and scar surface deficit compensated; (**f**) donor wounds beside the flap covered with adipose-scar trapezoid flaps prepared from the scar sheet and *FL*—scar flexion lateral surface; contracture released; (**g**) follow-up (2 years after surgery): excellent functional and cosmetic outcomes

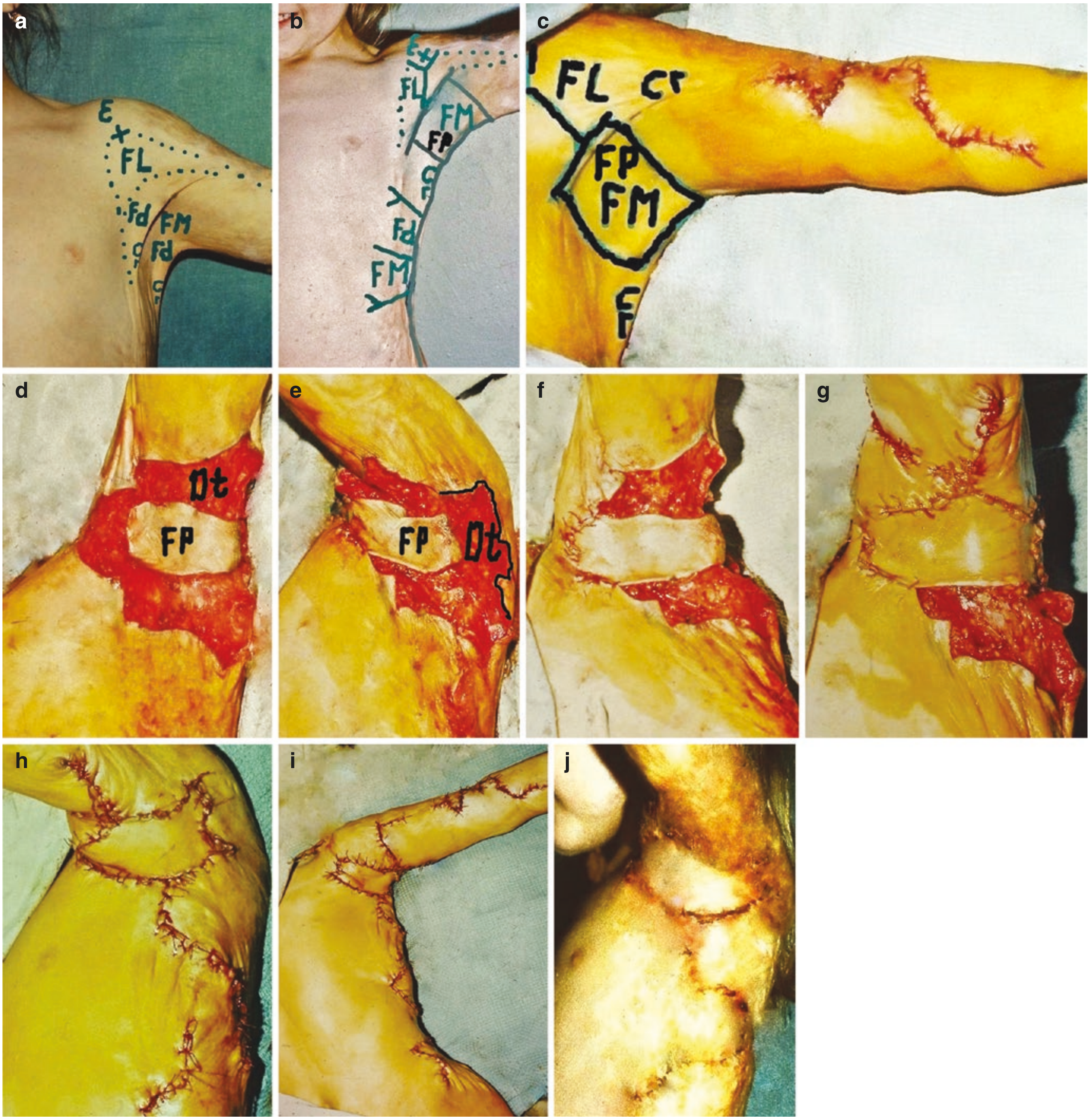

Fig. 19.5 One-stage elimination of contractures, different form and location, with trapezoid-flap plasty in children: two big joints and lateral truncal contractures. (**a**) Pre-surgery, anatomy of bilateral left axillary adduction contracture: *E* extension, *Fl* flexion lateral and *FM* flexion medial surfaces; "+" joint rotation axis, *Fd* fold; *Cr* crest of the fold. (**b**, **c**) Planning bilateral shoulder contracture treatment with a quadrangular subcutaneous pedicle flap, edge elbow contracture release first (**c**) with cubital adipose-cutaneous trapezoid flap; (**d**–**h**) lateral truncal elimination with three pairs of adipose-scar trapezoid flaps; (**i**) end of all operations; (**j**) 2 weeks after surgery: all contractures eliminated without complications

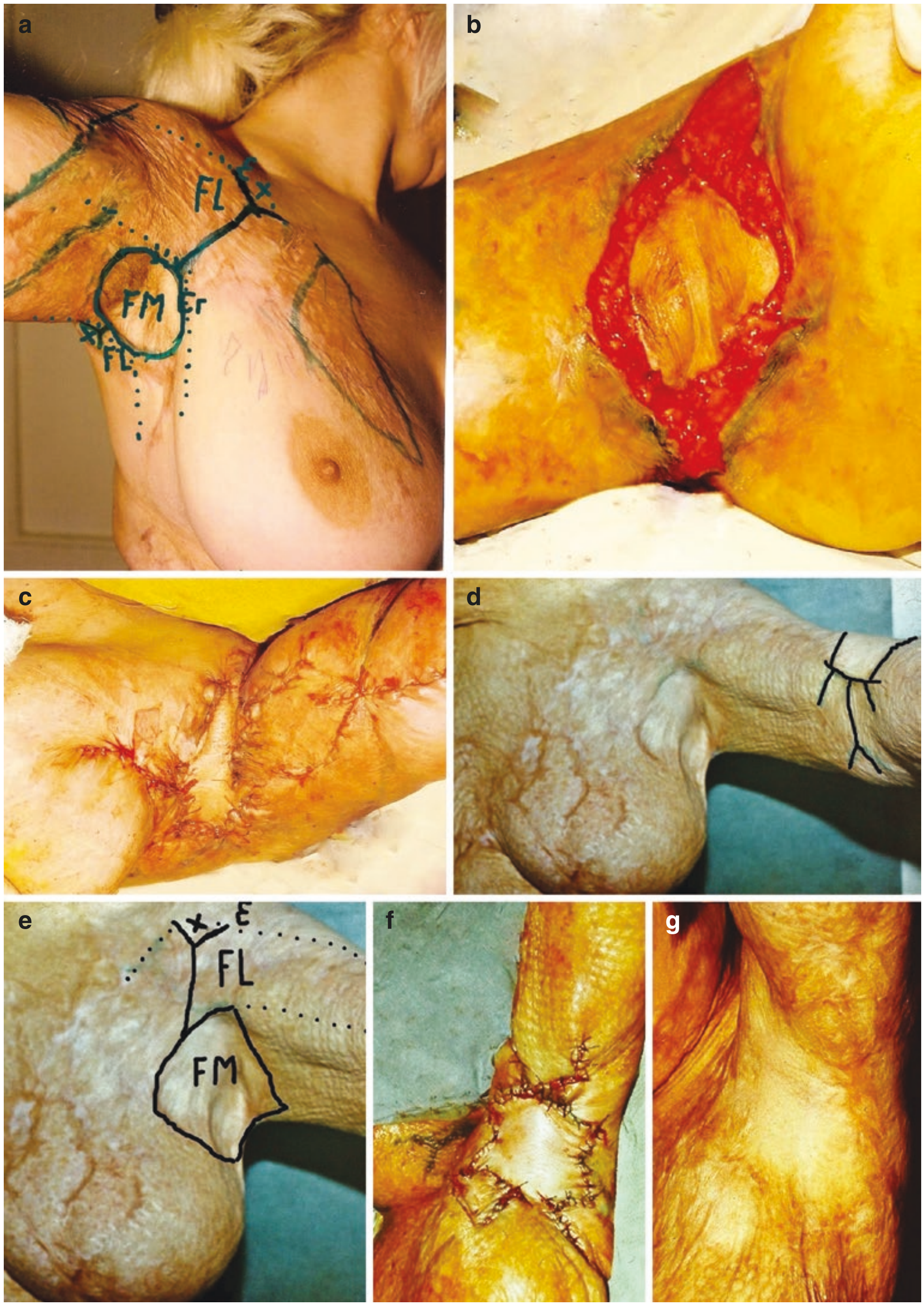

Fig. 19.6 Case 1: Shoulder adduction contracture treatment using an island of healthy skin in axillary cupola. (**a**) Pre-surgery, functional joint zones, planning; *E* joint extension surface; "+" crest of the joint; *FL* flexion lateral surfaces; *FM* flexion medial surface, axilla island of healthy skin; (**b**) contracture released by Y-incisions of FL surfaces anteriorly and posteriorly; island of healthy skin mobilized on periphery; (**c**) ends of the flap extended in anterio-posterior direction and sutured to the wound's edges; 7 days after operation: flap alive, contracture fully released; central axilla is the healthy skin or subcutaneous pedicle flap, which extended in anterio-posterior direction; wounds beside the flap covered with neighboring adipose-scar tissues, starting from flaps' ends; contracture released with island of healthy skin and surrounding scars. Case 2: (**d**) Severe shoulder anterio-posterior edge adduction contracture elimination with the quadrangular subcutaneous pedicle flap containing healthy skin and scars; pre-surgery view: (**e**) planning; (**f**) scars on anterior and posterior *FL*—flexion lateral surfaces dissected with Y-incision; flap mobilized from the periphery, displaced on axillary bottom, extended in anterior and posterior direction and sutured with wound borders; donor wounds primarily closed, displacing neighboring adipose-scars; (**g**) follow-up results: contracture completely released, axilla restored

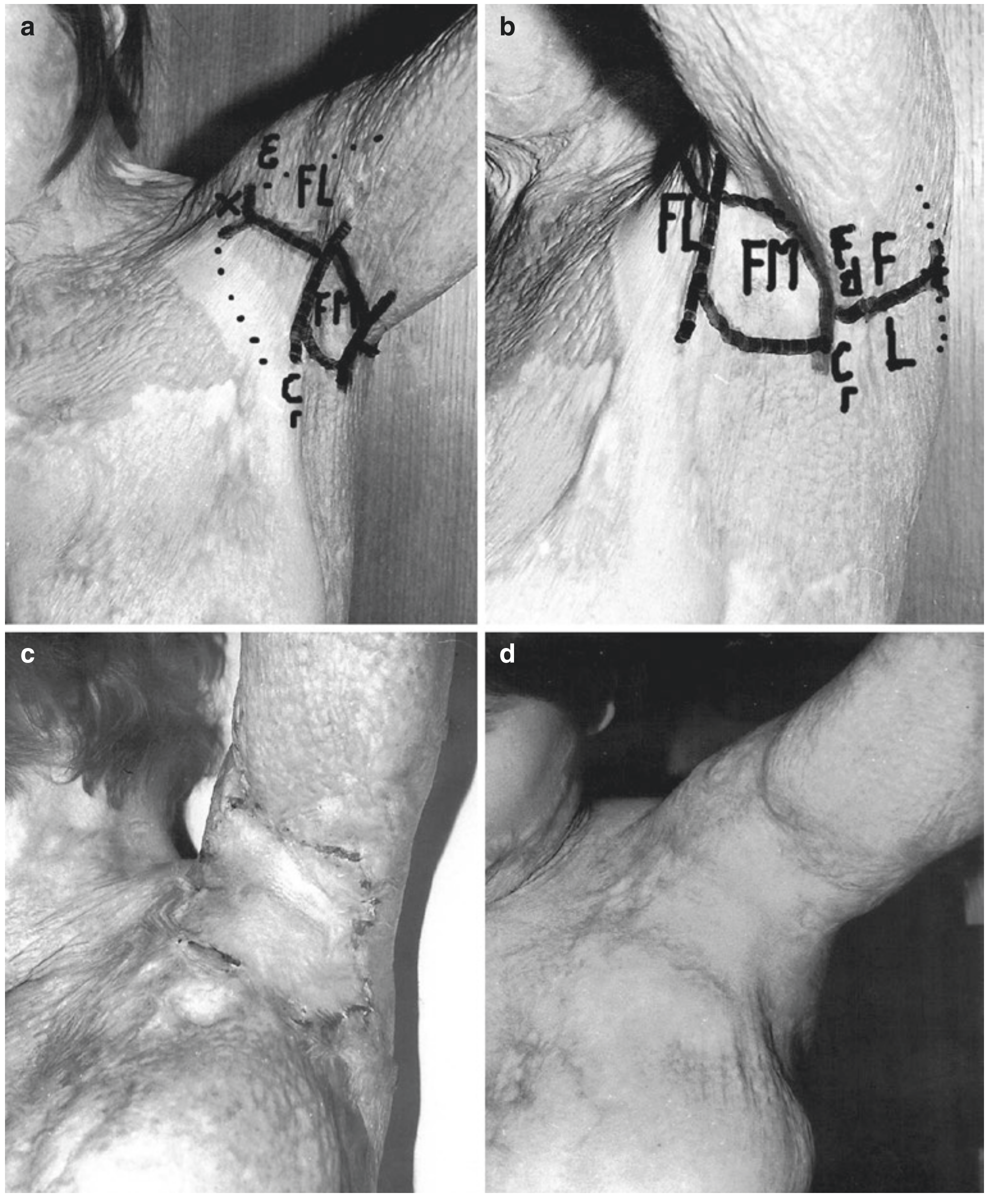

Fig. 19.7 Results of bilateral edge shoulder adduction contracture treatment with axillary subcutaneous pedicle flap. (**a**, **b**) Pre-surgery: anatomy of anterior and posterior view of contracture and planning: *E* joint extension surface; "+" joint rotation axis; *FL* flexion lateral surfaces and lateral sheets of the fold (*Fd*) are contracted scars, which caused the contractures; *FM*—healthy skin of fossa included the medial sheet of the *Fd*—fold; Y- line of contracted scars dissection from fold crest to the joint rotation axis; *Cr* crest of the fold; (**c**) 2 weeks after reconstruction; (**d**) follow-up results: contracture eliminated and axillary region restored

Conclusion

Bilateral edge shoulder adduction contractures are fully eliminated with axillary trapezoid subcutaneous pedicle flaps in one or two stages, and shoulder abduction is completely achieved. Despite severe tension, the adipose-cutaneous axillary fossa flaps are alive. After reconstruction, stretching of the flaps and surrounding tissues gradually diminishes owing to skin growth; axillary fossa accepts normal shape. Follow-up results and general appearance of the shoulder joint region are improved significantly with time. No contracture recurrence takes place, and reoperation is not required.

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20 Total Shoulder Adduction Contracture Treatment with Preserved Skin in Axilla Apex: Anatomy and Treatment

Introduction

Total shoulder adduction contracture is caused by extensive scars covering the flexion lateral and flexion medial shoulder joint surfaces and neighboring and regional areas. In some cases, a small island of healthy skin is preserved in the axilla apex because, during the burn, the shoulder takes an adducted position. Because of severe scar surface deficit, a large wound appears after contracture release; therefore, a large flap is needed for reconstruction. Treatment is complicated by shrinkage of skin transplants in the axillary region, which causes re-contracture. If the chest wall (donor site) is injured, the flaps can't be used, and this further complicates reconstruction. The problem is more apparent in pediatric patients. For such cases, we developed a new reconstructive technique based on the use of island skin in the form of a subcutaneous pedicle flap by which, after releasing contracture, the axilla is suspended and the large wound is divided into two parts: shoulder and thoracic. This simple and safe method prevents transplants from shrinking and contractures from recurring.

Contracture Anatomy

Shoulder adduction contractures are characterized by scars that cover the joint from three sides: flexion lateral anterior and posterior, and flexion medial (axillary) (Fig. 20.1a, b). Wide-spreading scars on neighboring areas involve the shoulder and lateral truncal surface. The island of healthy skin is confined by these scars. As a result, a cavity is formed, connecting with the outside space through a small round orifice 2–3 cm in diameter (Figs. 20.1, 20.2, and 20.3). The cavity bottom and lateral wall are healthy skin surface, of which no more than half is the fossa's surface. The entire axillary region is turned downwards. The hairs continued to grow, which is seen through the orifice (Fig. 20.4a). In most cases, the island of healthy skin in the cupola is open, located deeper than the surrounding scarred skin transplant (Figs. 20.5b). The qualities of the surrounding scars and skin transplants are also varied (e.g., even, rough, thin, thick, less or more matured, mildly or severely contracted).

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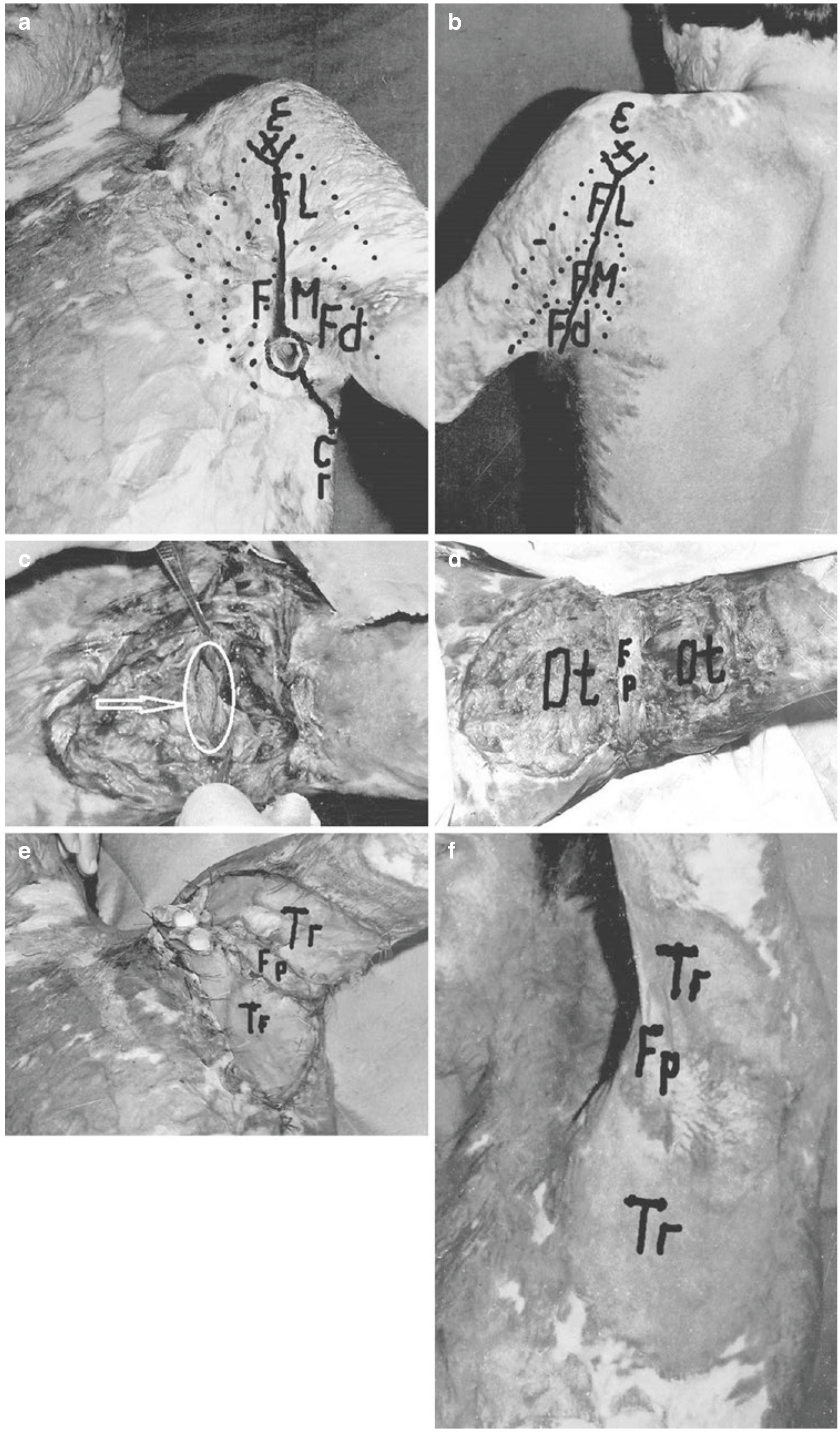

Fig. 20.1 Total (severe) shoulder adduction contracture treatment with confined island of healthy skin of the axillary apex and skin grafting. (**a**, **b**) Contracture anatomy: *E* joint extension surface; "+" joint rotation axis; *FL* flexion lateral surface; *FM* flexion medial surface; *Fd* fold. Pre-surgery: total severe adduction contracture, wide-spreading scars, scars displaced axilla downward; small orifice leading to confined skin; planning: line around orifice and lines for contracture release by scar dissection with Y-shaped incisions from the orifice to the joint rotation axis; (**c**) *I*—island skin; after scar dissection, and freed orifice from scars, a large wound appeared and healthy skin seen in the axillary center; (**d**) *FP*—flap; *Dt*—scar surface deficit with confined healthy skin converted into a narrow subcutaneous pedicle flap, its ends connected with wound edges on the anterior and posterior joint surfaces, the large wound divided into two: thoracic and shoulder, flap suspended axilla to normal level; (**e**) wounds beside the flap were skin grafted; (**f**) 2 years after reconstruction: full shoulder abduction, flap (island healthy skin) became doubled in width, hair grows; skin transplants (*Tr*) look like normal skin; axillary fossa restored

Fig. 20.2 Conversion of confined island of healthy skin into a narrow flap and fixation of it in the central axilla. (**a**, **b**) Before the operation, joint zones and contracture anatomy are marked: *E* joint extension surface; "+" joint rotation axis; *FL* flexion lateral surfaces covered by scars (contracture cause); *FM* flexion medial surface covered by scars; planning: Y-lines of contracted scar dissection on FL surfaces anteriorly and posteriorly from the island skin to the joint rotation axis; (**c**) the skin of the cavity is converted into a flap (*FP*), the ends of which are sutured to the wound's borders anteriorly and posteriorly. The flap suspends the axilla with over-correction and divides the wound into shoulder and thoracic segments, which are the cause of *Dt*—scar surface deficit and contracture; (**d**) end of operation, wounds (scar surface deficit) beside the flap are primarily closed, starting from the flap's ends; (**e**) results: contracture fully released with local tissues, axillary region restored (**f**) converting the cavity's healthy skin into subcutaneous pedicle flap (scheme)

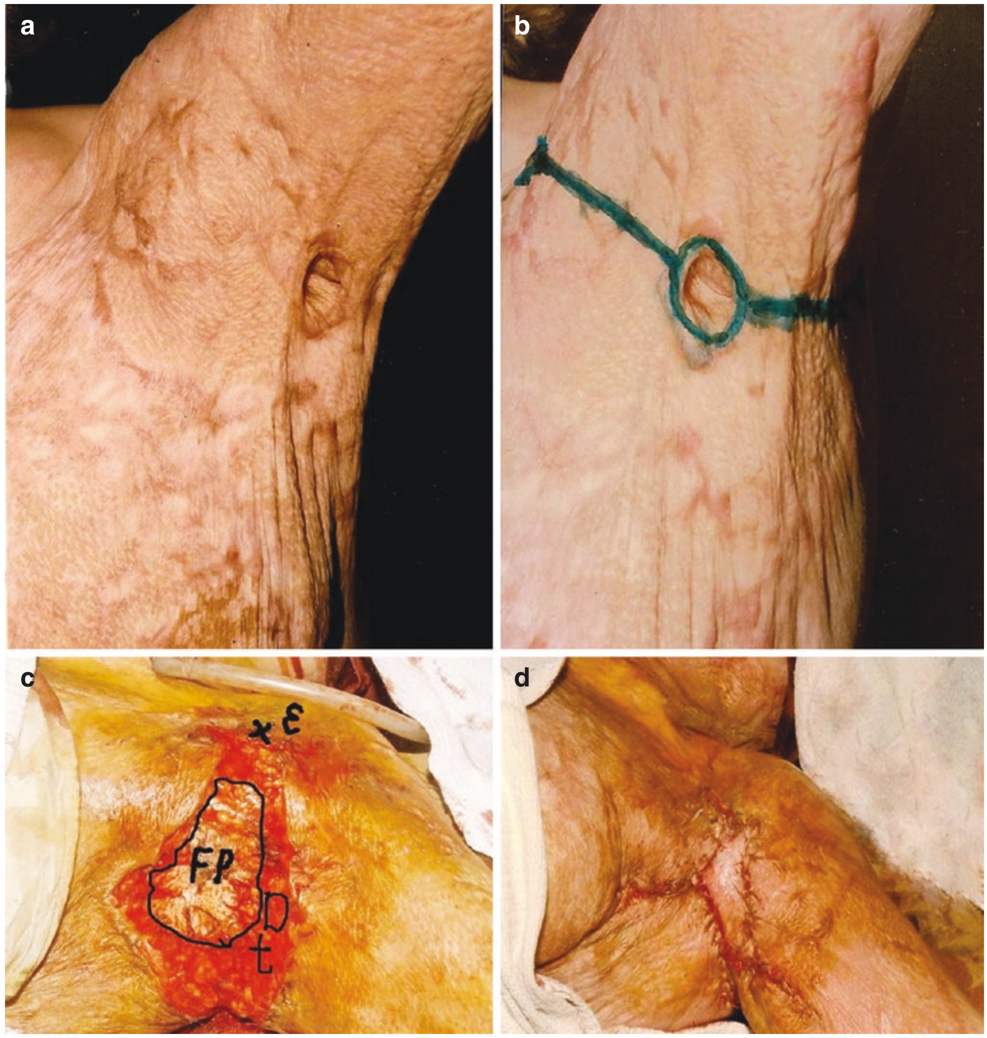

Fig. 20.3 Result of total shoulder adduction contracture treatment using confined island of healthy skin and local tissue. (**a**, **b**) Before operation and planning, Y-lines for contracted scar dissection anteriorly and posteriorly from the orifice to the joint rotation axis; (**c**) healthy skin of the cavity was isolated from scars and converted into *FP*—flap oriented in anterio-posterior direction; wound or *Dt*—scar surface deficit appeared around the flap; *E*—joint extension surface; "+"—joint rotation axis. (**d**) Ends of the flap connected with wound borders anteriorly and posteriorly; the wound beside the flap primarily closed; the flap covered the central axillary zone; contracture was eliminated with the flap from island skin and neighboring tissues of the shoulder and chest wall, transposed to axilla for the donor wound covering

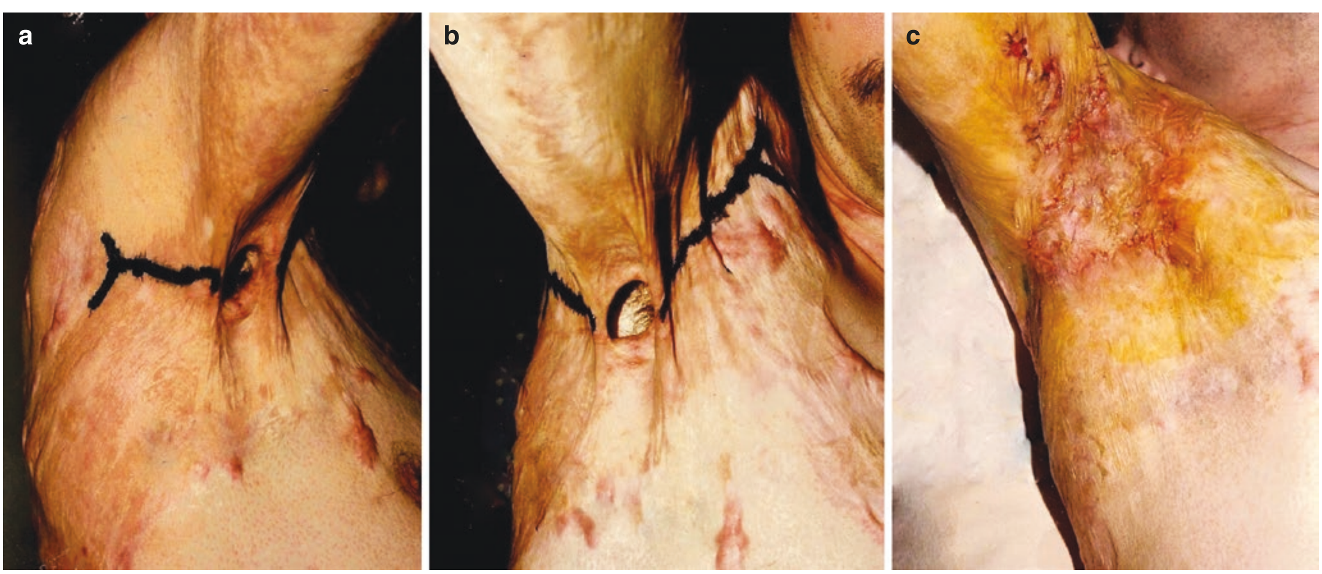

Fig. 20.4 Result of total shoulder adduction contracture treatment with confined island of healthy skin, being converted to a long subcutaneous pedicle flap. (**a**, **b**) Pre-surgery view; hairs of cupola in the orifice; planning: Y-lines from the orifice to the joint rotation axis of contracted scar incision; (**c**) healthy skin of the cupola is mobilized from the periphery and converted into lineal adipose-cutaneous subcutaneous pedicle flap, the ends of which connected with the wound's borders anteriorly and posteriorly; wounds or scar surface deficit covered with local tissues, starting from the flap's ends; 2 weeks after reconstruction: the flap is alive, the axillary region restored, and contracture is completely eliminated

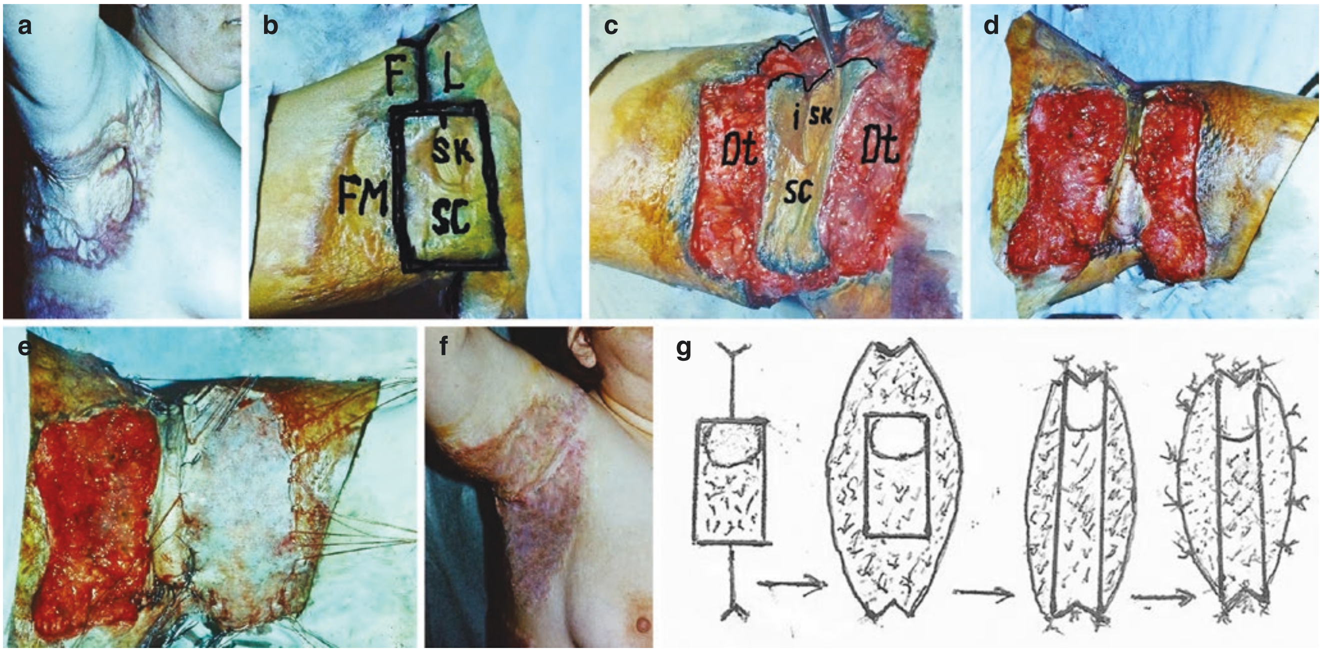

Fig. 20.5 Small confined island of healthy skin incorporated into quadrangular adipose subcutaneous pedicle flap. (**a**) Before surgery: small confined island of healthy skin; (**b**) borders of scar quadrangular subcutaneous pedicle flap, scars attached to healthy skin; Y-lines of contracted scar dissection from the flap's borders to the joint rotation axis; (**c**) contracture released, rectangular scar flap mobilized, the scars of the anterior end of the flap incised, so that healthy skin was exposed and formed the anterior part of the flap; the flap is displaced to the bottom of the axilla; (**d**) the flap extended in anterior-posterior direction, its ends sutured with the wound borders at joint rotation axis level; (**e**) large wounds or scar surface deficit beside the flap are covered with skin transplants; (**f**) result (3 weeks after surgery): the flap and skin transplant are alive, contracture is released completely; (**g**) scheme of operation

Surgical Technique

Three forms of the surgical procedure were elaborated and used depending on the contracture severity and its anatomical features.

Surgery of Total Severe Shoulder Contracture with Confined Island Skin

The planning line around the orifice and two Y-shaped lines from the orifice anteriorly and posteriorly up to the joint rotation axis level or to the healthy skin borders (Figs. 20.1a, b and 20.2a, b). Following the lines, the scars are dissected; after shoulder abduction, a big wound is formed; the skin that formed a cavity remains in situ (Figs. 20.1c and 20.3c). Then, the island skin was separated from scars near the orifice; skin which formed a cavity is dissected from the shoulder and trunk, leaving a nearly 3 cm bridge, and the half-cavity walls are converted in a pedicle flap of nearly 4 cm in width (Fig. 20.1d). The healthy skin is additionally crosscut from the shoulder and trunk sides for all healthy skin conversion in the strip-shaped subcutaneous pedicle flap. All island skin is converted into the subcutaneous pedicle flap. The flap is transposed in anterior and posterior directions with tension, and the flap's ends are sutured first with the anterior and then with the posterior wound borders (Fig. 20.1d). The extended flap, having steady blood circulation, covers the central axillary zone, suspends the axilla, divides the large wound on the shoulder and thoracic, squeezes soft tissues, and approaches the axillary fossa's edges, making the wound smaller. Due to flap tension, the adipose-cutaneous layer of the upper shoulder joint extension surface *(E)* is displaced downward, reducing the wound in anterior-posterior direction; the distance between the anterior and posterior wound edges is shortened. The stable suspension of the axilla and divided wound is the key for a successful operation and basis of new surgical method (Figs. 20.1d, 20.2c, and 20.5d).

Shoulder Contracture and Scar Surface Deficit with Confined Island Skin Is Moderate

The donor wounds beside the flap are primarily closed, starting from the flap's ends (Figs. 20.3 and 20.4). As a result, the axilla is restored, and contracture is eliminated in full (Figs. 20.3d, e and 20.4c).

Small Island Axillary Skin can be Incorporated in Quadrangular Scar Flap (Fig. 20.5a, b)

The small island of skin is added to the quadrangular adipose-scar subcutaneous pedicle flap. The island skin located inside the flap is freed by the scars' excision from the periphery; the skin located at the end of the scar flap is freed with a scar incision from the end (Fig. 20.5c, d). Then the flap is displaced anteriorly and posteriorly with tension. The axilla is elevated with some over-correction. Because the flap steadily suspends the axilla and the large wound is divided into two (shoulder and thoracic), the skin transplants, covering the wound on the chest wall and shoulder inner surface, are less prone to shrinkage, which prevents contracture recurrence (Fig. 20.5f).

Conclusion

The shoulder scar adduction contractures are released completely using the island of healthy skin of the axillary apex. Despite severe tension, all flaps are alive. Depending on scar surface deficit severity, the wounds beside the flap, on the shoulder and trunk, are covered with skin grafts. Skin transplants grow well with the underlying wound tissues; its shrinkage is minimal. The extended flap and surrounding tissue continue to grow, its tension disappears, and axillary contours are gradually restored. Over time, the skin transplant converts into well-functioning skin, tolerating an axillary condition without ulceration. Thus, the longer the period after reconstruction, the better follow-up results are observed. The flap's surface size enlarges significantly; hairs grow well, and the skin transplant has an even surface without visible shrinkage. This new method of contracture release, axilla suspension and wound resurfacing with skin transplants or local tissues-makes surgery simple, safe, and prevents contracture recurrence.

21 Shoulder Medial Adduction Contracture: Anatomy and Treatment with Local Adipose Scar Trapezoid Flaps

Introduction

The axillary fossa rarely suffers burns because the shoulder takes an adducted position during injury. Considering that shoulder contractures comprise 38% of the total number of burn contractures of the big joint [1], 8–10% of them are shoulder medial adduction contractures. The shoulder medial adduction contracture is not highlighted in existing classifications or in articles focusing on treatment of scar contractures of the shoulder. This factor is the reason we know almost nothing about shoulder medial adduction contracture, including its anatomy, clinical pictures, and methods of surgical treatment. Therefore, our task was to explore all aspects of this burn's consequences in adults and children.

Shoulder Medial Adduction Contracture Anatomy and Scar Surface Deficit

Medial shoulder-adduction contracture is a result of burns and scars of the joint axillary fossa, or joint flexion medial (*FM*) surface, and the inner surface of the shoulder and truncal lateral surfaces (Fig. 21.1). Scars are traumatized when the shoulder is in abduction, and this stimulates connective scar tissue to grow. Therefore, scars of the axilla, growing distally and contracting, smooth the fossa and descend the axilla and form a crescent fold, the crest (*Cr*) of which passes along the medial line of the axilla. Shoulder medial contracture is considered to be total contracture; therefore, specific reconstructive techniques to eliminate shoulder medial contractures have not yet been developed.

Protrusion of the pectoralis major and latissimus dorsi muscles' edges forms a curvature of the joint surface. The axillary fossa, formed between the muscle's edges, covered by scars, looks like a big fold (Fig. 21.1a). The sheets of the crescent fold are scars, spreading from the fold's crest (*Cr*), which pass along the medial line of the joint FM surface to the pectoralis major and latissimus dorsi muscles' edges. The crescent fold is a new anatomical structure, scar surface surplus that allows medial contracture elimination with local flaps without skin grafts and pedicle flaps [1]. The joint flexion lateral (*FL*) and extension (*E*) surfaces are healthy skin or covered with scars, and do not participate in shoulder adduction contracture formation. At the same time, scar contraction leads to scar deficit formation in length between the shoulder and the chest wall (Fig. 21.2), causing the contracture. For adequate reconstructive technique choice and the flap's form, it is necessary to determine the form and size of the scar sheet surface deficiency. This is estimated using the following steps: scar sheets are divided with an incision along the fold's crest; the sheets are cross-cut from the fold's crest to the axillary fossa edges with radial (perpendicular) Y-incisions. After shoulder abduction, the wound of each sheet and flap accepts, as a rule, a trapezoid form, consisting of trapezoid parts: *FP* flap; *Dt* deficit; and *DW* donor wound (Figs. 21.1 and 21.2). As the fold has a crescent form, radial incisions, as a rule, convert the fold's sheets into trapeze-shaped flaps (*FP*).

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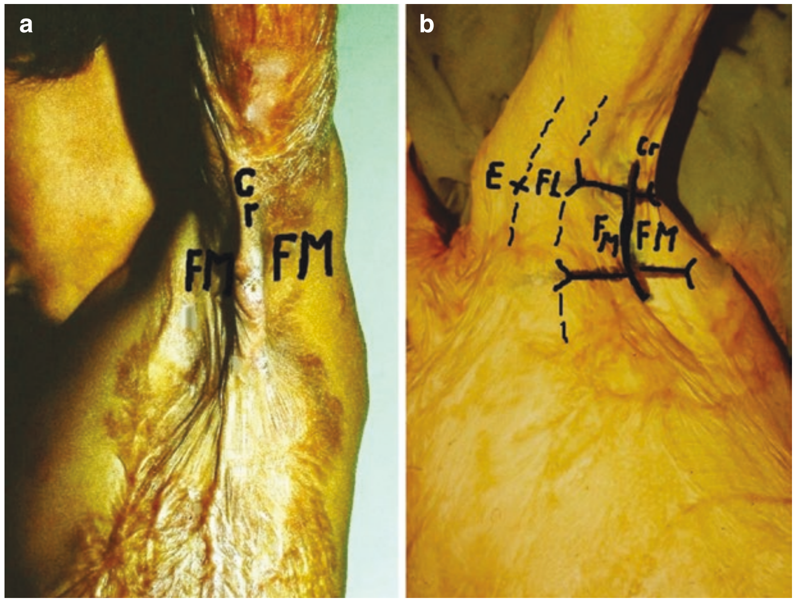

Fig. 21.1 Functional zones of the shoulder joint and anatomy of shoulder medial-adduction contracture. **(a, b)** Shoulder adduction is caused by scars covering the axillary fossa or flexion medial surface (*FM*) up to the axillary edges or the flexion lateral (*FL*) surface and forming the semilunar fold, the crest of which (*Cr*) passes along the medial axillary line. With time, all the fossa or FM surface is transformed in the crescent fold, both fold sheets are scars; the axilla is shifted downward; scars on the shoulder joint's flexion lateral surface (*FL*) and extension surface (*E*) do not participate in contracture formation; Symbol "**+**" is the joint rotation axis level. Planning of operation: two trapezoid flaps are marked

Fig. 21.2 Anatomy of shoulder medial adduction contracture

Surgical Reconstruction of Medial Shoulder Adduction Contracture with Adipose Scar Trapezoid Flaps [2]

Shoulder Medial Adduction Contracture Elimination with One Pair of Trapezoid Flaps (Fig. 21.3a–d)

This technique is used when contracture is mild and the scar's fold is short. One pair of trapezoid flaps is planned in the central axillary region (Figs. 21.1b and 21.3a). The first incision passes along the fold's crest and divides the fold's sheets; then, with two radial (perpendicular) Y-incisions, the fold sheets (scars and subcutaneous fat layer) are dissected from the fold's crest to the axillary fossa's edges or the flexion lateral surface (*FL*). The Y-shaped incision allows for maximizing the release while minimizing the need for further prolongation of the scars dissection on the flexion lateral surface (*FL*). The distance between incisions at the fold's crest is about 5–6 cm (flap end's width). The flaps are mobilized, including a superficial axillary fat layer; the deep fatty layer with lymphatic nodules remains in situ. The flaps are elevated up to the muscles, forming axillary edges (pectoralis major and latissimus dorsi). The fat layer provides for the flap's steady blood circulation and prevents the flap from shrinking after surgery. Mobilized flaps, located opposite each other, advance toward each other with tension until the flap's ends approach the base of the counter flap. Then, the flap's ends are sutured to the wound's edges and with each other, and the flap's end to the flap's base (Fig. 21.3b, c). The wounds that remain near the flap's base had been primarily closed, connecting the edges along the shoulder and trunk. The scars, forming "dog ears," are excised. Owing to flap tension, the flap's bases and muscles' edges, forming axillary edges, approach each other and shorten the distance between axillary edges. The donor wound becomes smaller and narrower, which allows for connecting the flap's ends to the base of the opposite flaps. As a rule, a good result is achieved (Fig. 21.3d).

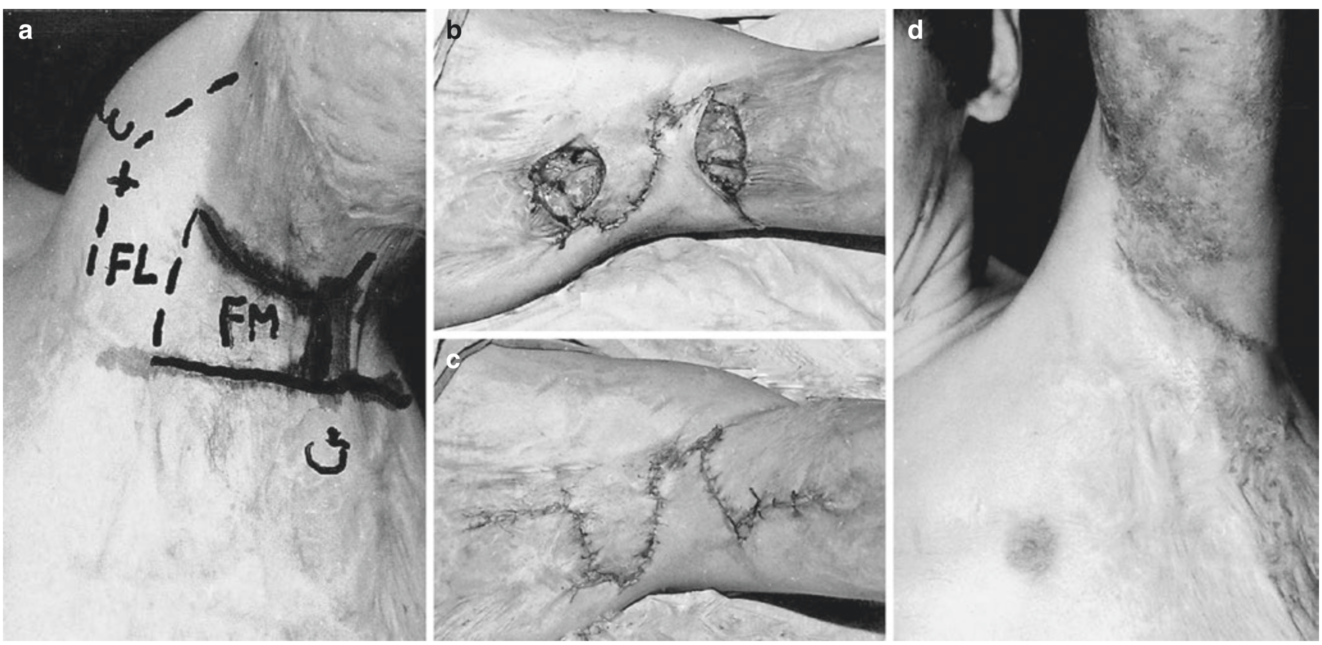

Fig. 21.3 Medial shoulder adduction contracture elimination with one pair of adipose-scar trapezoid flaps. **(a)** Contracture anatomy: scars cover FM surface or fossa, all fossa are converted into semilunar fold, both sheets of the fold are scars; *FL* flexion lateral and *E* extension surfaces are healthy skin; *Cr* crest of the fold; planning: one pair of trapezoid flaps involved all of the FM surface; **(b)** after cross-cutting of the fold with radial Y-incisions and an incision along the fold crest, the two adipose-scars flaps are mobilized and counter transposed on the wound; flaps covered the axillary fossa's zones; shoulder adduction, the common wound appeared, which is divided by the central strip on two trapezoid wounds reflecting the form and size of the scar surface deficit and donor wound (*DW*); technique of wound covering with two adipose-scar trapezoid flaps; **(c)** the donor wounds primarily closed starting from flap's end and base; counter transposed flaps covered the wound, scar surface deficit compensated, and contracture eliminated in full; **(d)** follow-up result

Trapeze-Flap Plasty with Two Pairs of Trapezoid Flaps (Fig. 21.4a–d)

Medial-to-severe shoulder medial-adduction contracture *in children* is eliminated with three pairs of adipose-scar trapezoid flaps (Fig. 21.4). If the contracture is more severe and the fold is long, two pairs of adipose-scar flaps are planned (Fig. 21.4a, b) and elevated. The main pair of flaps covers the central axillary region, and the other two pairs are placed beside the main pair (Fig. 21.4c). Counter-transposed flaps cover the wound, and scar surface deficit is compensated with good functional and cosmetic results (Fig. 21.4d).

Fig. 21.4 Shoulder medial-adduction contracture treatment with two pairs of adipose-scar trapezoid flaps. **(a)** Before the operation; axilla has view of fold; **(b)** anatomy: FM surface or fossa covered with scars causing contracture; *FL* surface, *Cr* crest of the fold; Y-radial lines of sheets dissections, *Cr* fold's crest; planning two pairs of trapezoid flaps by the fold radial incisions; **(c)** 7 days after surgery; **(d)** excellent functional and good cosmetic outcomes 1 year after reconstruction

Trapeze-Flap Plasty with Three Pairs of Trapezoid Flaps (Fig. 21.5a–e)

In adults, if the scar fold is long, usually in cases of moderate and severe contractures, the fold's sheets are dissected with radial Y-shaped incisions along all its length. Because the fold has a semilunar shape, the radial incisions convert the fold's sheets into trapezoid flaps regardless of the number of incisions made (Fig. 21.5b–d). Planning lines and incisions spread from the fold crest to edges of the fossa or edges of muscles that form the joint fossa (pectoralis major and latissimus dorsi muscles) (Fig. 21.5b–d). Thus, the scars of flexion lateral surfaces (FL) do not participate in medial contracture formation and its treatment. After shoulder abduction, trapezoid wounds appeared beside the trapezoid flaps (Figs. 21.2d, f and 21.5c, d). A surface of adipose-scar flaps is usually sufficient for scar surface deficit compensation and contracture elimination (Fig. 21.2e).

In children (Fig. 21.6), the severe scar surface deficit, causing the shoulder adduction contracture, is fully compensated and contracture is eliminated with counter-flaps' transposition of two pairs of trapezoid flaps. The plan for one pair of trapezoid flaps proved to be insufficient for full contracture release (Fig. 21.6c). Therefore, the number of trapezoid adipose-scar flaps increased at the time of the operation (Fig. 21.6d). Excellent follow-up results are shown in Fig. 21.6e.

Shoulder medial adduction contracture can be combined with the elbow edge contracture (Fig. 21.7). Both contractures are eliminated in one stage, using a specific form of trapeze-flap plasty. Elbow contracture is removed first, then the shoulder reconstruction becomes simpler. During the operation, the number of adipose-scar flaps was increased to accomplish contracture release.

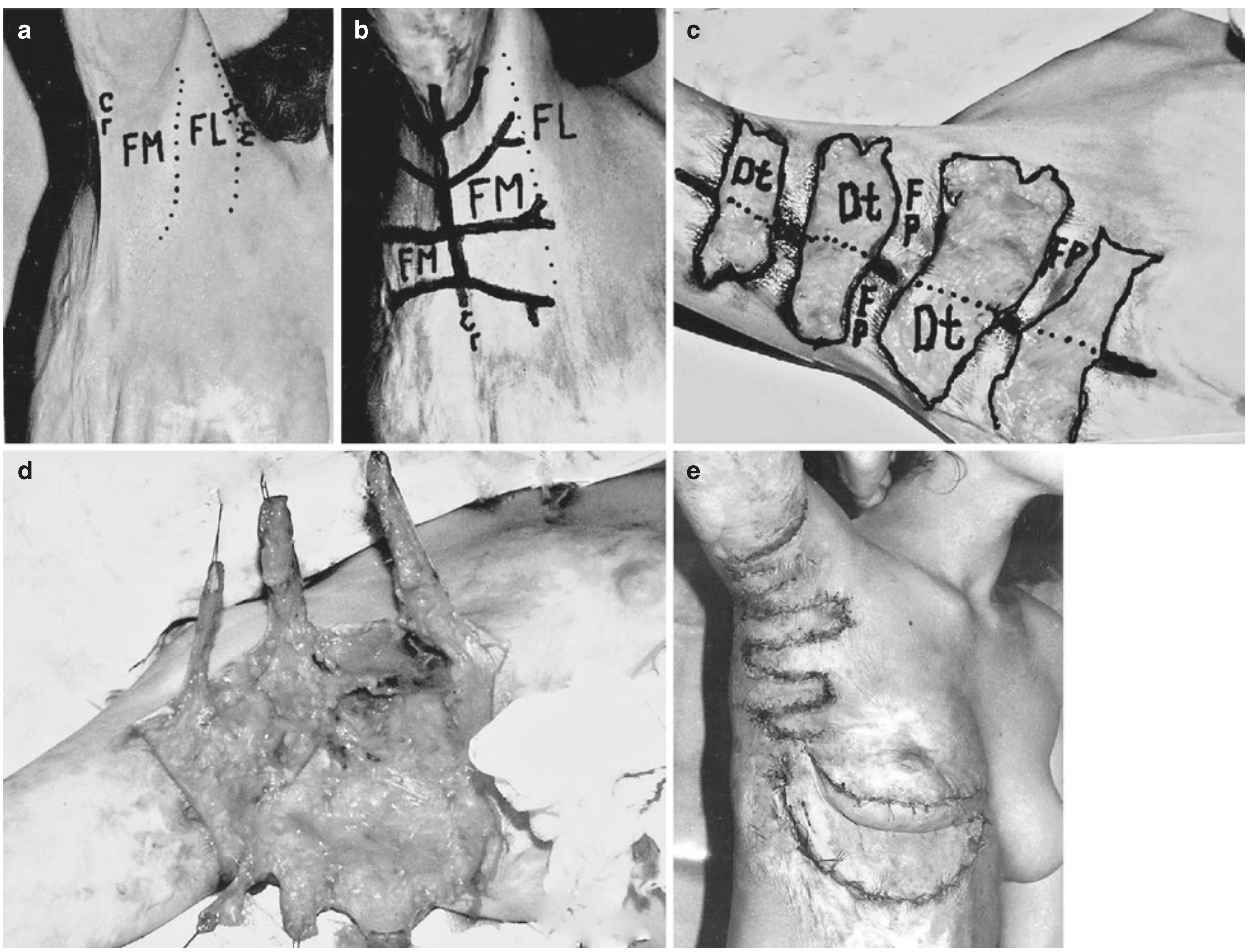

Fig. 21.5 Medial-adduction shoulder contracture treatment with three pairs of adipose-scar trapezoid flaps. **(a)** Contracture anatomy: contracted scars cover the axillary fossa or flexion medial surface (*FM*) and form a long semilunar fold, the crest (*Cr*) of which passes along the middle axillary line; both fold's sheets are scars and have surface deficit in length (contracture cause) and surface surplus in width; flexion lateral (*FL*) surface is healthy skin; "**+**" joint rotation axis; *E* joint extension surface; **(b)** planning of three pairs of adipose-scar trapezoid flaps; Y-lines of scars incisions from the fold crest to the edges of fossa or FL surface; **(c)** after contracture release with a Y-shaped incision, trapeze-shaped flaps (*FP*) and wounds or scar surface deficit (*Dt*) appeared; **(d)** mobilized flaps consist of the scars and superficial fat layer of axilla; **(e)** counter transposed flaps covered the wound, scar surface deficit was compensated; the contracture is completely eliminated (7 days after surgery, flaps are alive)

Fig. 21.6 Severe shoulder medial adduction contracture elimination in a 5-year-old girl. (**a**, **b**) Anatomy: contracted scars cover flexion medial surface (*FM*); *FL* flexion lateral surface is healthy skin; "**+**" joint rotation axis; *E* joint extension surface; one pair of trapezoid adipose-scar flaps planned; (**c**) adipose-scar flaps are mobilized, two trapezoid wounds appeared (strips marked) in the zone of every fold's sheet; anatomy wound: *DW* donor wound; *Dt* surface deficit; *Fp* flap; (**d**) two flaps were insufficient for complete contracture release; therefore, two additional flaps were elevated, and strips of scars excised on shoulder and lateral trunk; (**e**) excellent functional and cosmetic outcomes (2 years after surgery)

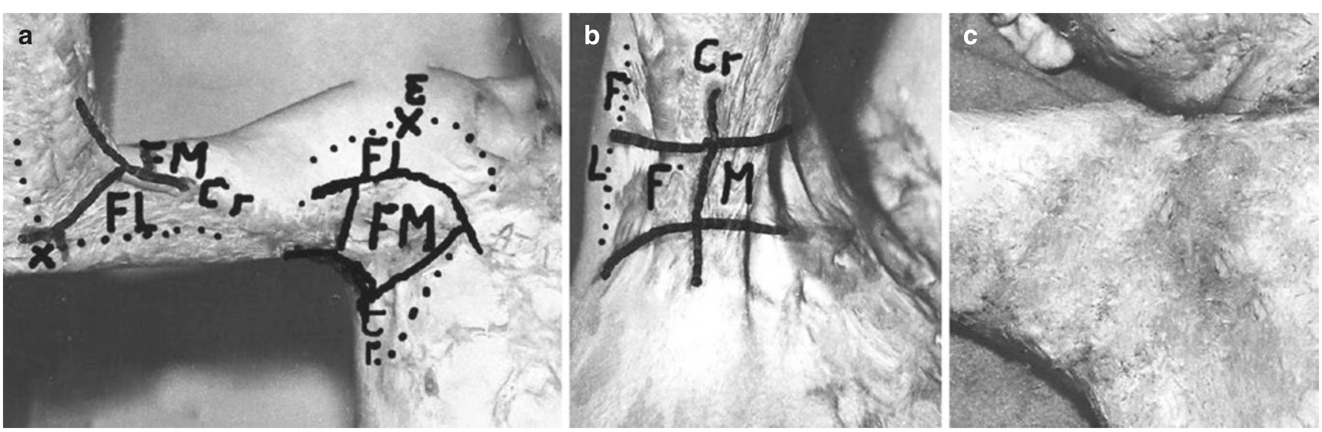

Fig. 21.7 Shoulder medial severe adduction contracture and elbow edge contracture elimination simultaneously, elbow first, in a 7-year-old boy. (**a**) Functional zones in case of shoulder medial and elbow edge contractures; (**b**) planning reconstruction with one pair of adipose-scar trapezoid flaps; (**c**) contracture released without complication

Conclusion

In all cases, medial shoulder adduction contractures can be fully eliminated with trapeze-flap plasty, without skin grafting and pedicle or free flaps. After opposite transposition of one or several pairs of adipose-scar flaps, the medial axillary line passes through the flap's middle. Consequently, the elongation of the maximal tension area (axillary medial line) equals the sum of widths of all flaps minus the length of the fold's crest involved in plasty. Elongation reached 150–200%, which is sufficient for complete scar surface-deficiency compensation, contracture release (180% of abduction), and wound covering. No flap loss or other post-operative complications occurred. With time, the flaps' surfaces became more leveled and gradually increased, especially in pediatric patients. Therefore, no contracture recurrence took place and re-operation was not needed. Over time, the axillary region accepted normal contours and form; scars in axillary fossa did not experience ulceration and did not cause any discomfort. Operation scars are not prone to excessive growth, and stay nearly invisible. The full range of the shoulder's joint motion is achieved.

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22 Shoulder Total Adduction Contracture After Burns: Anatomy and Treatment with Quadrangular Local Subcutaneous Pedicle Flap

Introduction

Contracted scars and skin grafts covering the shoulder joint flexion lateral (FL) and flexion medial (FM) surfaces cause a total adduction contracture. Scars have severe surface deficit (Dt), excluding use of the local flap techniques. Skin transplants in the axilla shrink and contracture recurs; the big flaps used present a traumatic and deforming procedure. To prevent skin transplants from shrinkage and contractures from recurring, we developed a new technique based on axilla suspension with scar quadrangular axillary subcutaneous pedicle flap and skin transplants. Excellent outcomes have elevated the level of rehabilitation of burn patients with severe shoulder edge adduction contractures. This surgical method and results of its implementation are presented below.

Anatomy, Formation, and Cause of the Total Shoulder Adduction Contracture

Total (severe) shoulder adduction contracture is caused by contracted scars covering the joint flexion surfaces (Fig. 22.1; *FL* + FM or circularly). Scars tightly surround the joint, folds or scar surface surplus is absent. Scars can affect one or both shoulder joints and the joints' neighboring zones (inner shoulder and lateral truncal surface) and donor sites used to elevate flaps (Fig. 22.1a–c). Vast scars have a severe scar surface deficit, excluding local-flap plasty. Two anatomical total shoulder contractures exist: (a) the axillary fossa is obliterated and displaced downward, the shoulder is fused with the chest wall, and the entire axillary region is deformed (Fig. 22.1a, b); (b) in most patients, the scar's surface in the projection of the axil-

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lary fossa, between the shoulder and the trunk, is flat and relatively even (Fig. 22.1d). The surface is formed by scars or skin transplants and can serve as a donor site. After contracture release with incision and shoulder abduction, it becomes evident that a large scar surface deficit (wound) is present, spreading on three sides of the joint: axillary (where it is maximal), anterior, and posterior up to the joint rotation axis ("**+**") (Fig. 22.1c). The deficit is maximal in the axilla and reaches the joint rotation axis anteriorly and posteriorly. The thoracodorsal skin or scar-fascial pedicle flap, which is often used, can cover only a small part of the wound or scar surface deficit. The flat scar, located in the axillary fossa projection, serves as the donor site for adipose-scar quadrangular subcutaneous pedicle flap construction, which is the basis of a new reconstructive technique. Vast spreading scars are especially dangerous for children. Upper extremity development is retarded and the shoulder bone curves (Fig. 22.1a, b). Therefore, an early reconstruction is indicated. The technique is designed to achieve the following goals:

(a) Full contracture release of its entire extent.
(b) Formation in the central axillary zone with quadrangular subcutaneous pedicle adipose-scar flap.
(c) Stable axilla suspension with local quadrangular flap.
(d) Prevention of skin transplant shrinkage and contracture recurrence (see Figs. 22.2f, 22.3e, 22.4c, and 22.5e).
(e) Making the reconstructive technique more efficacious and reliable, safe, and less traumatic.

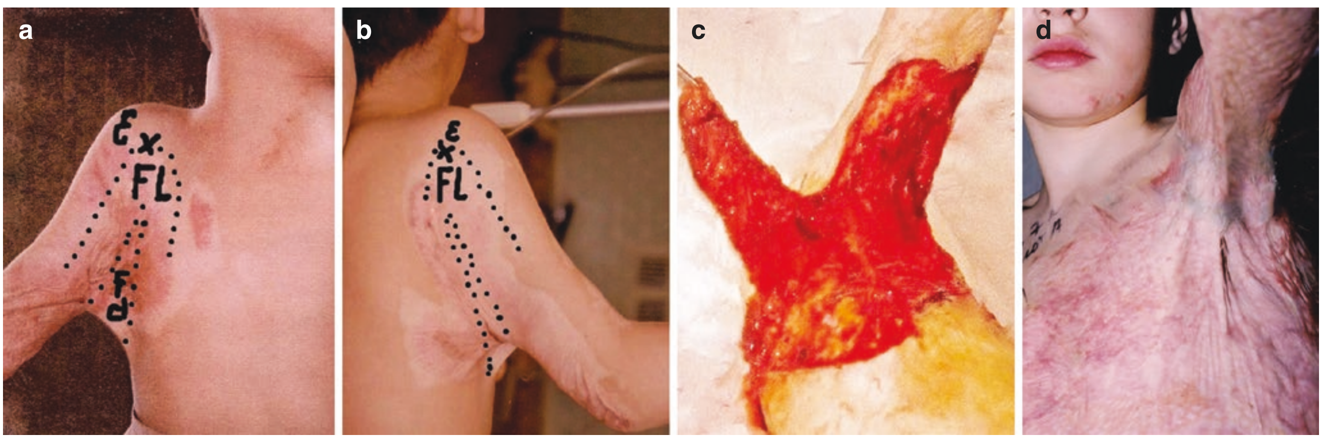

Fig. 22.1 Total shoulder adduction contractures: two anatomical forms. (a, b) Common anatomical features of the first form, anterior and posterior view: (**a**) scars tightly surround the shoulder joint on three sides: anterior, posterior, and axillary, shoulder fused with the chest wall, no FM surface and fold; *E* joint extension surface; "**+**" joint rotation axis; *FL* flexion lateral surface; *Fd* short fold and FM surface covered with scars; (**b**) scars cover trunk and shoulder, axillary fossa obliterated and turned downward; (**c**) after contracture release by scars dissection, large wound or scar surface deficit appeared; neighboring pedicle flap can cover only part of the wound and scar surface deficit. (**d**) The second form is characterized by the following anatomic features: (*1*) the shoulder is free; (*2*) axillary fossa is deformed and descended; (*3*) deformed axilla has a flat surface of scars between the shoulder and chest wall, in axillary fossa projection

Surgical Technique

Contracture anatomy and anatomy of a scar surface deficit are marked by accepted letters [1]. Planning of the operation consists of quadrangular local scar flap design in the axillary region, or axillary fossa projection and anterio-posterior direction (Fig. 22.2a). Two Y-shaped lines are drawn on the anterior and posterior shoulder joint surface from the flap ends of the flap up to the joint rotation axis level for scar incision and contracture release by separating contracted scars from tissues of the joint extension surface (**E**), by continuation of incisions along the joint rotation axis level. As a result, the end of the wounds or scar surface deficit on FL surfaces accept an M-shape (Fig. 22.3b). The quadrangular figure's width is approximately 6 cm; its length is nearly 12 cm. These parameters can be changed depending on the patient's age and the form of the scar surface in the axillary region. The scars and subcutaneous fat layer are dissected according to lines (Fig. 22.2b). Simultaneously with shoulder abduction, the flap is mobilized from its borders by incisions parallel to the trunk and inner shoulder surfaces, the pectoralis major and latissimus dorsi flap's edges, gradually deepening the flap on the axillary bottom. After complete contracture release from three joint sides and shoulder abduction, the big wound is formed around the flap: on the axilla, chest wall, inner shoulder surface, and on the anterior and posterior shoulder joint surfaces (Figs. 22.2b and 22.6b–d). The anterior flap end is sutured to an M-shaped wound edge on the anterior joint surface; then, the posterior flap's end is connected to the posterior wound edge with significant tension of the flap (Fig. 22.2c). Thus, the axilla is turned upward to its normal level or some over-correction and is fixed with the flap in a stable suspended position. Because of tension, the axilla is elevated and narrowed; the flap becomes longer, but narrower; the tissues located above the joint rotation axis (**E** – joint extension surface) are displaced downward, diminishing the distances among the wound edges in an anterio-posterior direction; axillary fossa edges approach each other. All these factors reduce the wound surface. The wounds beside the lap, on the chest wall, and on the inner shoulder surface are covered most often with skin grafts (Figs. 22.2d, 22.3d, and 22.6d), fixed in compression condition with tie-over dressing. Results are functionally and cosmetically good (Figs. 22.2e, f, 22.4e, 22.5c, 22.6e, and 22.7c). The scheme of the operation is shown in Fig. 22.2g.

The quadrangular adipose-scar flap has steady blood circulation; therefore, its traction in the anterio-posterior direction is safe. The anatomy of the wound after flap mobilization and descending on the axillary bottom and consecutive steps of surgery is shown in Fig. 22.6: *Dt* scar surface deficit; *FP* flap. The stretched flap steadily suspends the axilla at the normal or over-corrected level and divides one large wound into two—thoracic and shoulder—which have a solid basement. These two factors ensure that the skin transplants do not shrink (Figs. 22.2f, 22.4e and 22.5c). The steady blood circulation allows elimination of severe contractures, where the flap's tension is needed.

Total shoulder adduction contracture is often combined with breast deformity and lateral truncal contracture (Fig. 22.4a, b). In such cases, the shoulder and truncal contractures are released first, which facilitates breast reconstruction. Figure 22.4f shows the scheme of reconstruction, the anatomy of total shoulder contracture, and the anatomy after surgery.

Total shoulder adduction contracture is often observed in children, i.e., in five of eight cases (Figs. 22.3a, b, 22.4, 22.5 and 22.7). The reconstruction is performed more easily and with greater success in pediatric patients than in adults.

In children, total shoulder adduction contracture of both joints is a result of vast burns and scarring of the chest wall (Fig. 22.5). After skin grafting, a flat surface can appear between the shoulder and the chest wall (Fig. 22.5b). Reconstruction with a quadrangular subcutaneous pedicle flap is performed simultaneously, early, and yields perfect outcomes (Fig. 22.6e).

This technique yields good results in small children (Figs. 22.5, 22.6, and 22.7).

Large wound and severe scar surface deficit around the flap can be covered with a combined method as shown in Fig. 22.8b–d: the wound at the flaps' ends is covered with local tissues; the last surface of wounds is skin grafted.

Good functional and cosmetic outcomes are the results of several factors:

(a) Contracted scars are dissected with Y-incisions and contracture is released from the fold's crests up to the joint rotation axis anteriorly and posteriorly, and separated from the tissue of the joint extension (**E**) surface.
(b) Flap mobilization from the periphery and displacement of the flap on axillary bottom level.
(c) The axilla is stably elevated at a normal level, which prevents contracture recurrence.
(d) The large wound and scar surface deficit is divided by the flap into the shoulder and thoracic, which are separately covered with skin transplants (Fig. 22.6).
(e) The shrinkage of skin transplants does not change the position of the flap, which prevents contracture recurrence and preserves normal contours of the axillary region.

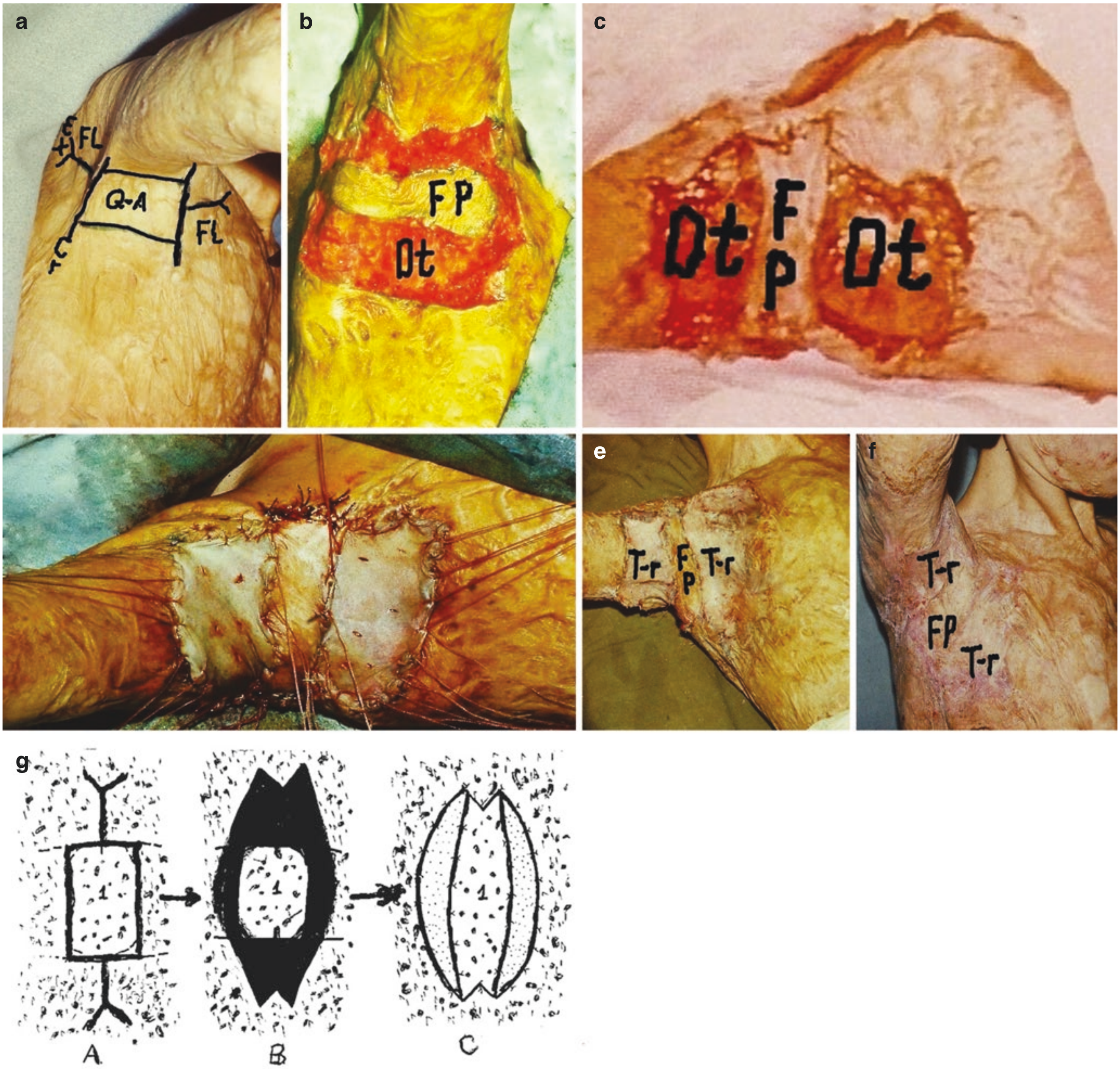

Fig. 22.2 Surgical technique for total shoulder adduction scar contracture elimination with quadrangular local subcutaneous pedicle scar flap and skin grafts. (**a**) Pre-surgery view; contracture anatomy: *FL* and *FM* joint surface covered by scars, axillary region descended (has flat Q-A- flap marked); "+" joint rotation axis; planning: quadrangular flap in axilla; Y-lines for scars dissection from flap to "+" axis; *FP* flap; (**b**) scars dissected according to lines, island quadrangular subcutaneous pedicle scars flap (*FP*) mobilized from the periphery and displaced to the bottom of the axillary fossa; wound or scar surface deficit (wound) around flap after Y-dissection of scars trapezoid wounds appeared on FL surfaces; (**c**) flap's edges connected to the wound edges on joint rotation level; flap's borders fixed to underlying wound tissue; central axillary area is formed with the flap (*FP*); flap suspends axilla at a normal level; two wounds—shoulder and thoracic—beside the flap, Dt scar surface deficit; (**d**) wounds beside the flap skin-grafted; (**e**) 2 weeks after surgery: flap (*FP*) and skin transplants (*Tr*) alive; (**f**) 2 years after surgery; good functional and cosmetic outcomes; scar flap (*FP*) and skin transplants (*Tr*) well-tolerated axillary condition, no signs of skin transplants shrinkage; (**g**) scheme of operation

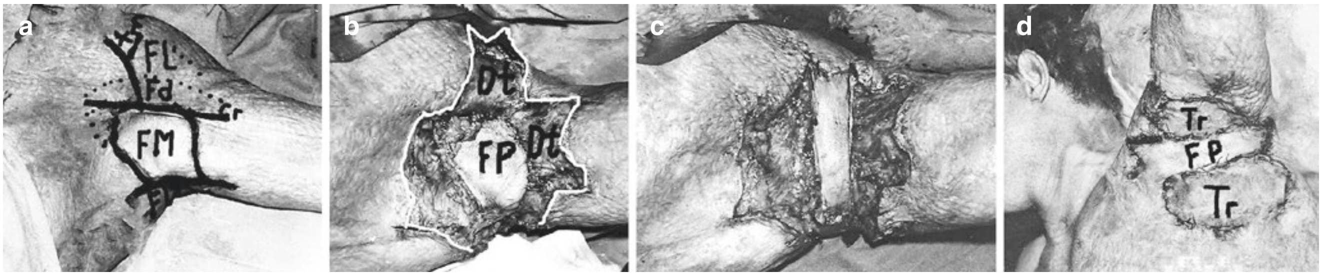

Fig. 22.3 Results of total left shoulder adduction contracture treatment in a girl with quadrangular subcutaneous pedicle flap. (**a**) Pre-surgery, flat surface (*FM*) in axillary fossa projection; *Cr* crest of the fold; planning of operation; (**b**, **c**) operation; (**d**) 7 days after surgery: contracture released, flap and transplants alive

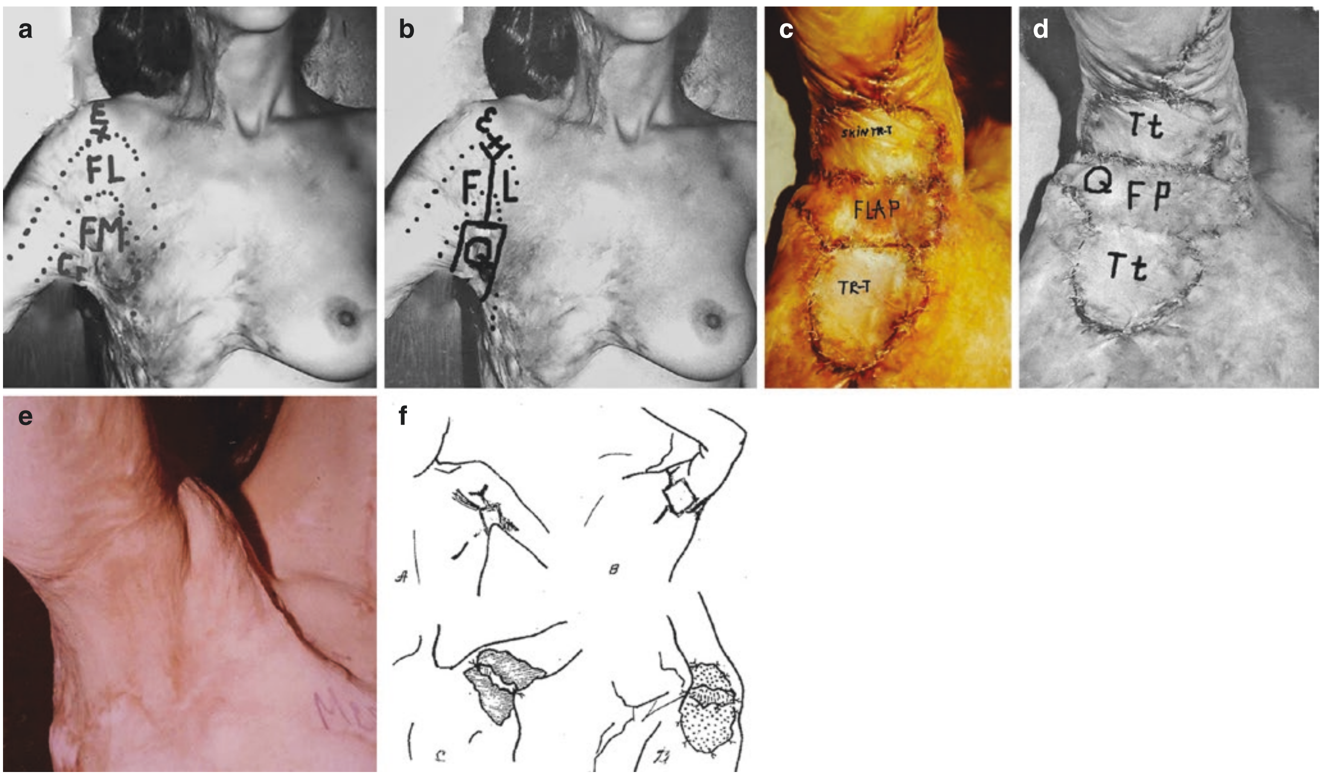

Fig. 22.4 Results of total shoulder contracture treatment before breast reconstruction. (**a**) Pre-surgery, anatomy: *E* joint extension surface, "+" joint rotation axis; *FL* flexion lateral and *FM* flexion medial surfaces displaced downward and converted in the fold; *Cr* crest of the fold (*Fd*); planning; (**b**, **c**) reconstruction with quadrangular subcutaneous pedicle scar flap (*F*); (**d**) central axillary zone is flap (*FP*), wounds beside the flap on the shoulder and chest wall skin-grafted (*Tr*) without complications; (**e**) excellent outcome results

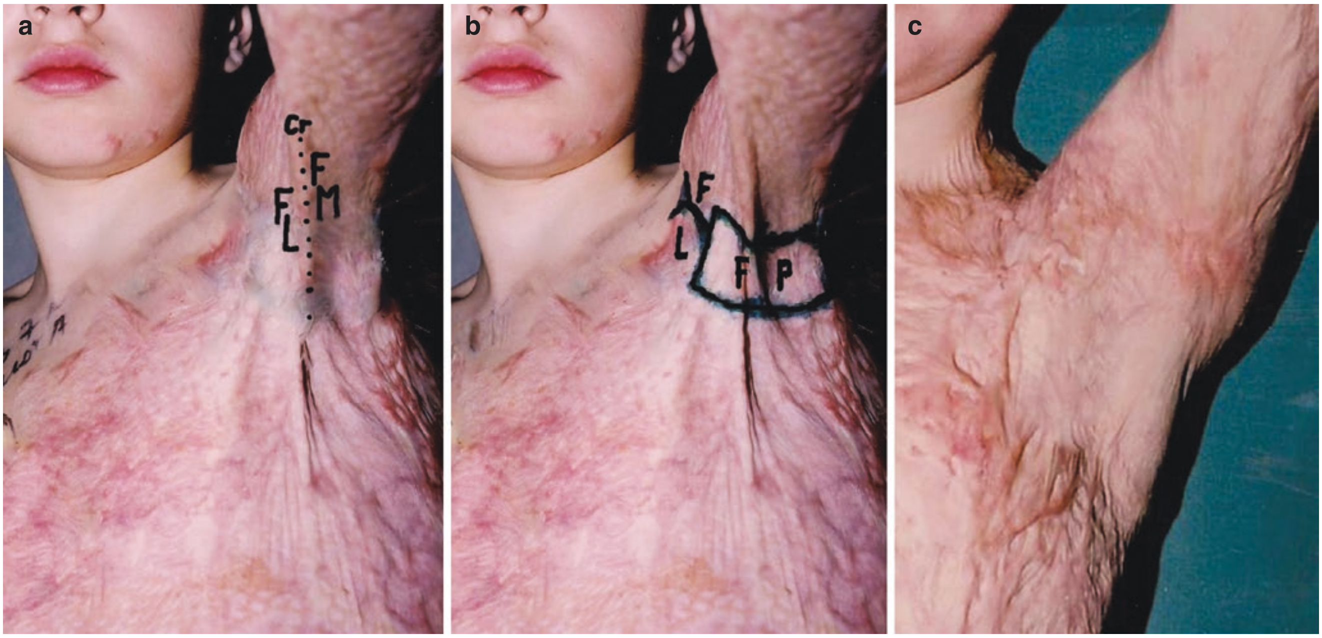

Fig. 22.5 Elimination of total shoulder adduction contractures of both shoulders in small children (5-year-old girl), caused by immature scars and contracted skin grafts (4 months after grafting), with local quadrangular adipose-scar subcutaneous pedicle flap and skin transplants. (**a**) Vast deep burns; (**b**, **c**) contracture anatomy: extension, FL and FM surfaces covered with scars; axillae descended, shoulders severely adducted; (**d**) end of operation: (**e**) 2 years after reconstruction: excellent functional and good aesthetic outcomes

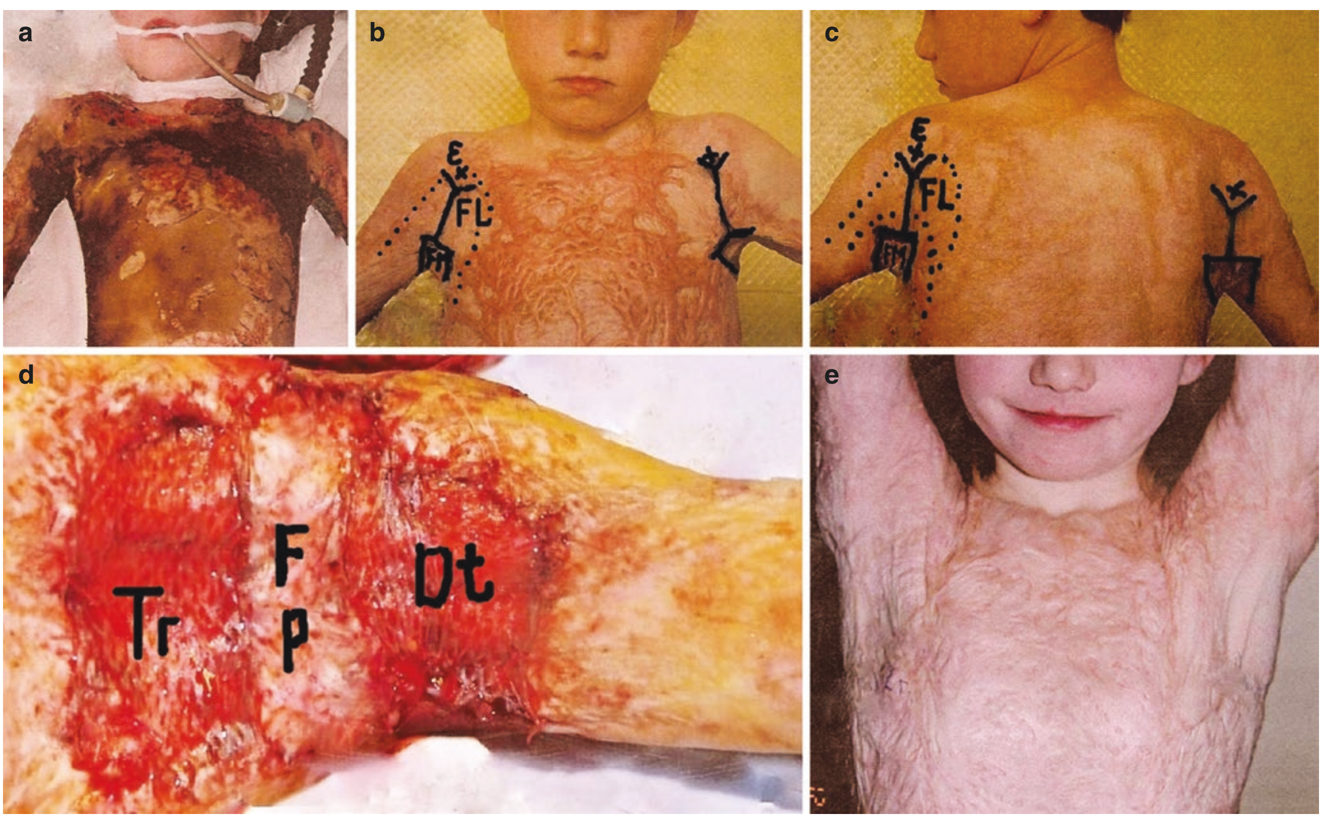

Fig. 22.6 Details of severe total adduction contracture elimination. (**a**) Anatomy: scars covered all of the axillary region, planning of operation: flap and lines for scars dissection on the flexion lateral surfaces; (**b**) quadrangular subcutaneous pedicle flap (*FP*) mobilized from the periphery and displaced to axillary bottom; trapezoid wounds or scar surface deficit on FL surfaces and around the flap; wound beside the flap (*DT*) scar surface deficit, triangular (**c**, **d**) flap (*FP*) extended in anterio-posterior direction (*F*), flap's ends connected with wound borders on joint rotation axis level; flap stable, suspended axilla and a divided large wound on the shoulder and thoracic, which are covered with skin transplants (*T*)

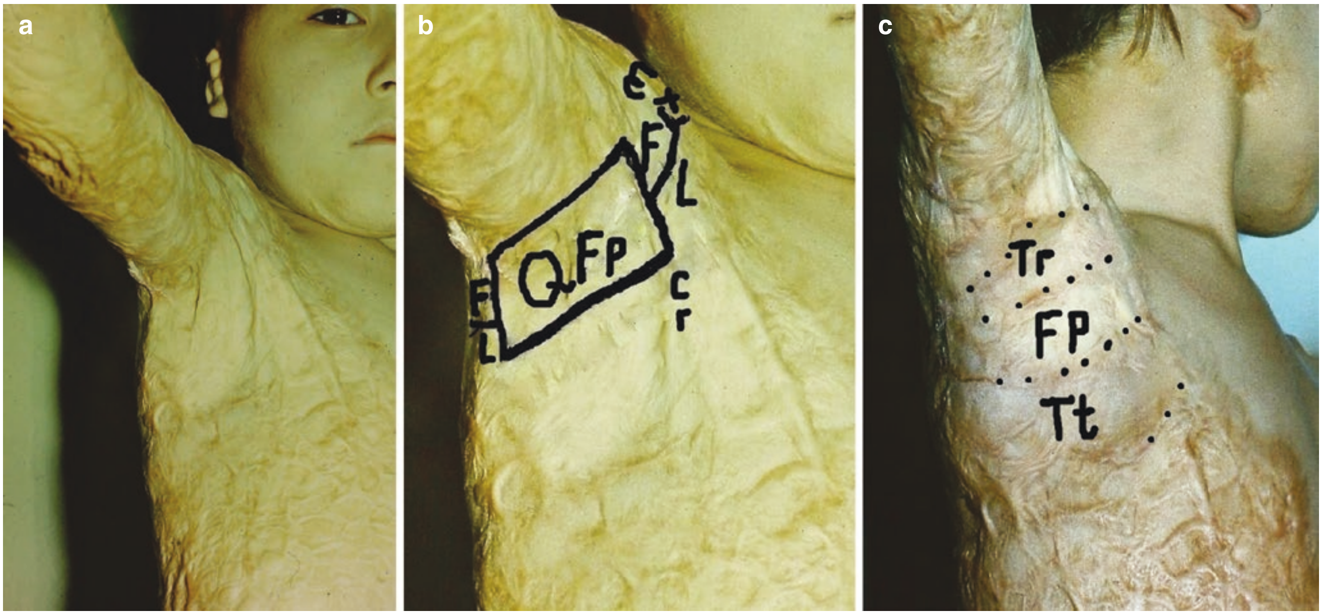

Fig. 22.7 Result of total shoulder adduction contracture treatment in small children (5-year-old boy) with quadrangular adipose-scar subcutaneous pedicle flap. (**a**, **b**) Pre-surgery and planning. (**c**) Results, 2 years after reconstruction: excellent functional and good cosmetic outcomes, normal development of upper extremity

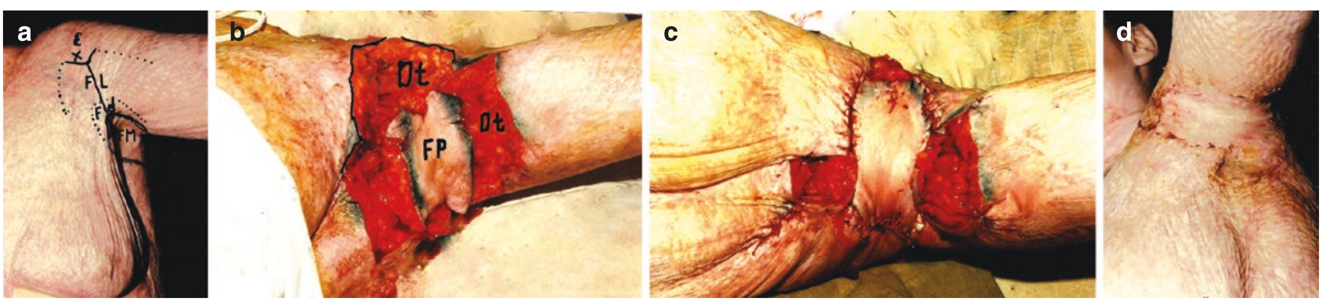

Fig. 22.8 Variant of donor wound covering in case of total axillary contracture treatment with a quadrangular adipose-scar subcutaneous pedicle flap. (**a**) Anatomy of contracture and planning of the operation; (**b**) scars of FL surfaces dissected with Y-incisions, and trapezoid wounds (*D* scar deficit) appeared; flap (*F*) mobilized from the periphery and displaced on the axillary bottom; (**c**) flap extended in anterio-posterior direction, ends of the flap connected with the wound borders at the joint rotation axis level; flap axilla elevated and stably suspended. Nearly half of the donor wound is covered with local tissues, starting from the flap's ends; (**d**) the central zone of donor wounds is covered with skin transplant located between the extended flap and scars; no contracture recurrence. A combined method of large donor wound resurfacing is anatomically justified

Conclusion

The new technique discussed here allowed elimination of most total (severe) shoulder adduction contractures. Quadrangular scar subcutaneous pedicle flaps had steady blood supply; therefore, no flap loss or other serious postoperative complications took place. Functional long-term results were excellent. With time, the flap's and neighboring tissues' tension disappears due to tissue growth. The level of axilla is stable and normal; transplants on the shoulder and chest wall gradually transform into well-functioning skin. The scar flaps and skin grafts tolerate the axillary conditions well, without macerations and ulcerations. The axilla region preserves normal form and contour. Upper extremities in children develop normally. The method is simple, less traumatic, safe, reliable, and allows one to avoid more complex procedures, contracture recurrence, and repeated surgical interventions.

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23 Elbow Edge Flexion Contracture: Anatomy and Treatment with Local Trapezoid Flaps

Introduction

Burn scars of elbow flexion lateral surfaces, growing distally, form a fold along the elbow fossa's edges, connecting and approaching the shoulder and arm. Scars that undergo repeat trauma from joint movement actively grow more aggressively. The ulcers on the fold crest limit the use of the extremity because of pain. Therefore early reconstruction is needed. Triangular local flap techniques are most often used. Our observations showed that triangular scar flaps are short, their ends have unstable circulation, and necrosis often occurs. The triangular flap's form does not match the scar surface deficit (which is the cause of the contracture). The different qualities of the fold's sheets and the counter-transposed flaps do not allow surgeons to achieve good outcomes. The resulting incomplete contracture release leads to recurrence and repeated reconstructions. Our experience shows that the most effective local-flap technique to completely eliminate edge elbow contracture is trapeze-flap plasty, based on trapezoid elbow healthy flap and flaps prepared from the fold's sheets.

Anatomical Features of Edge Elbow Contractures [1]

Functional Zones and Anatomy (Fig. 23.1)

First, functionally and clinically, the surface of the elbow joint is divided into extension (*E*) and flexion (*F*). The dividing line passes between them through the joint rotation axis ("**+**" symbol). The joint flexion surface is divided with curvatures (edges of joint fossa) on two zones: flexion lateral (*FL*) and flexion medial (*FM*). The flexion lateral surface spreads from the edge of the cubital fossa or fold's crest (*Cr*) to the joint rotation axis. Scars grow distally and involve skin of cubital fossa; as result, the fold is formed along the fossa's edge. The fold consists of a lateral scar sheet, which is a continuation of scar of the flexion lateral surface, and a medial sheet, which is a continuation of the fossa's skin. Thus, the fold is a new anatomical structure, scar and skin surface surplus, playing an important role in contracture elimination.

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Edge elbow contracture has specific anatomical features and clinical signs.

(a) Contracture is caused by scars located on the flexion lateral surface and scars of the fold, spreading from the fold crest to the joint rotation axis (Fig. 23.1a).
(b) The scars of the flexion lateral surface form the crescent fold, which is part of the flexion lateral and medial surfaces and passes along the edge of the cubital fossa, between the FL and FM surfaces (Fig. 23.1b).
(c) The fold consists of two different quality sheets: the lateral sheet is scars; the medial sheet is healthy skin.
(d) The crest of the fold (*Cr*) is the edge of scars. All scars from the fold crest to the joint rotation axis participate in contracture formation and equal 6–8 cm. The fold can be short and located in the elbow joint region, or can spread on neighboring joints. A fold's crest is usually rough, thick, and often ulcerous.

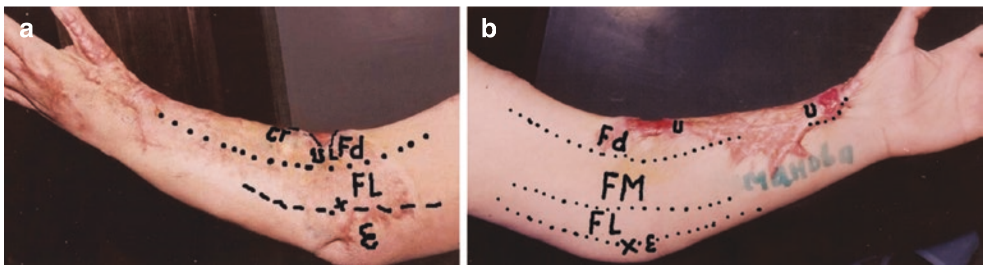

Fig. 23.1 Anatomy of postburn edge flexion left elbow contracture. (**a**) The joint's surface is divided on extension (*E*) and flexion (*F*). Curvature of joint surface divides flexion surface into flexion lateral (*FL*) and flexion medial (*FM*). Scars cover the flexion lateral surface of the left elbow and wrist and form the crescent-shaped fold (*Fd*); ulcerous crest (*Cr*) of the fold passed along the lateral edge of cubital fossa. Contracture is caused with scars of FL surface with lateral scar sheet of the fold. (**b**) Flexion medial (FM) (cubital fossa) surfaces and the medial fold's sheet are healthy skin. Symbol "**+**" is the joint rotation axis level from where the joint E surface begins; fold (*Fd*); fold's crest (*Cr*), ulcers in elbow and wrist zones

Scar Surface Deficit Is a Cause of Edge Elbow Contracture (Figs. 23.2, 23.3 and 23.4)

The scar of the flexion lateral (*FL*) surface and scar sheet of the fold sheet have surface deficit (*Dt*) in length, which is the real cause of contracture (Fig. 23.2b). The scar surface deficiency spreads down, gradually decreasing from the fold's crest, where it is maximal, and reaches the joint rotation axis where it is 4 cm in length along the joint rotation axis level (Fig. 23.2b). To choose an appropriate reconstructive technique and the shape and size for a flap, the size and form of the scar sheet length deficit must be known. To estimate the latter, it is first necessary to separate the scar sheet from the healthy sheet by an incision made along the whole fold's crest. Then, the scar sheet should be cross-cut by a perpendicular Y-incision from the crest of the fold all the way to the joint rotation axis. The incision end is Y-shaped near the humerus epicondyle for the scar's separation from joint extension tissue (*E*), which leads to better wound border divergence and contracture release. After full elbow extension, the wound, as a rule, accepts a trapezoid shape that equals the size and the shape of the scar surface deficiency. The medial fold sheet and cubital adipose-cutaneous layer were used as the donor site for trapeze-flap preparation and contracture elimination.

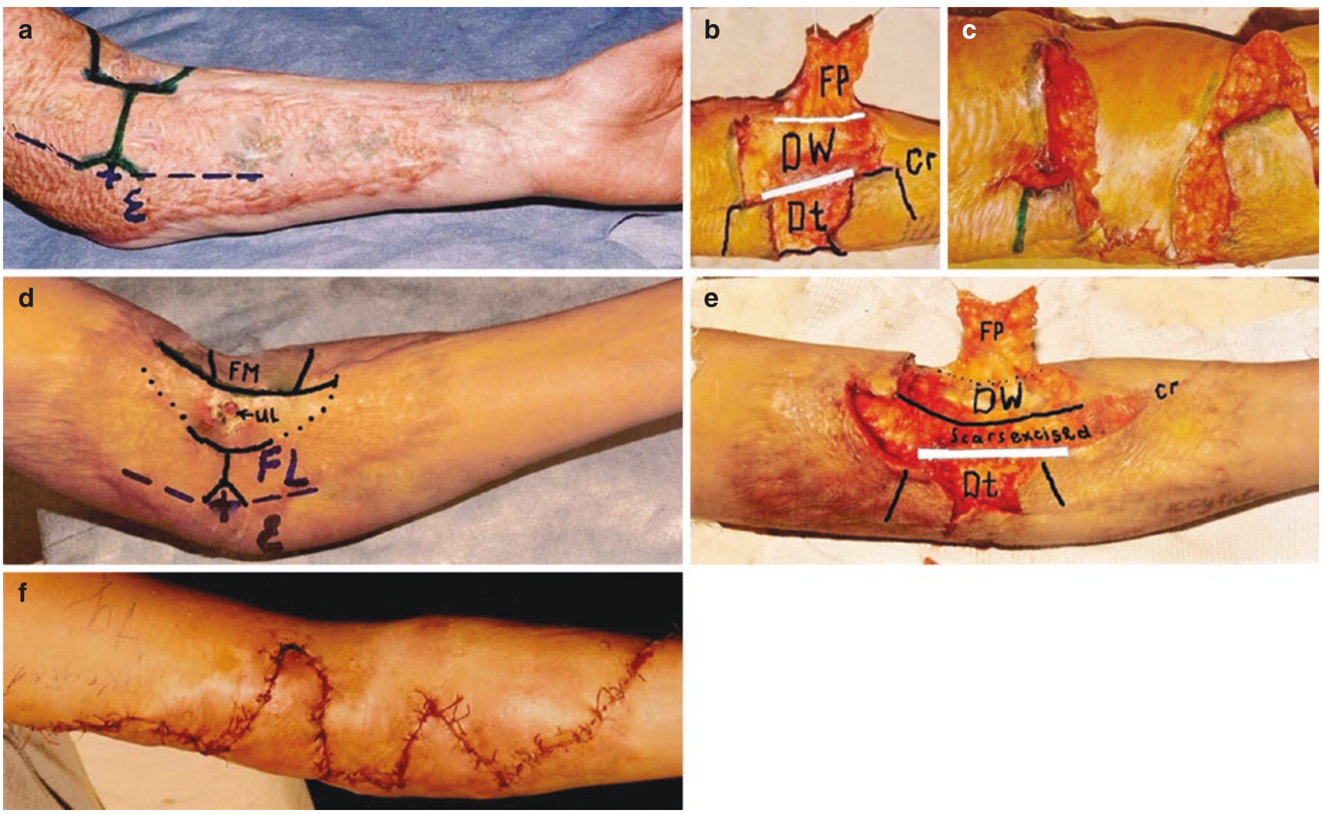

Fig. 23.2 Edge elbow contracture is caused by surface deficit of scars located on elbow flexion lateral (*FL*) surface. Case 1: (**a**) Contracture cause: scars on joint FL surface spread from the fold crest (Fig. 2d, UL) to the joint rotation axis ("+"); flexion medial (*FM*) surface or elbow fossa is healthy skin. Planning of operation: one-flap trapeze-flap plasty. (**b**) Scars dissected with a Y-incision (Fig. 2d, UL) to the joint rotation axis, trapezoid flap mobilized: *Dt* trapezoid wound appeared or real scar surface deficit and contracture cause; flap (*FP*), donor wound (*DW*); (**c**) trapezoid elbow flap (*F*) covered wound, and scar surface deficit compensated for. Two addition trapezoid flaps planned to elevate for complete contracture elimination. Case 2: (**d**) Anatomy and planning the same; (**e**) ulcerous crest excised, trapezoid wound or scar surface deficit appeared (*Dt*); trapezoid elbow flap mobilized (*FP*), two adipose-scar flaps planned for donor wound covering; (**f**) counter-transposed flaps scar surface deficit compensated, contracture eliminated, elbow contours restored; 7 days after surgery: flaps are alive, complete rehabilitation

Edge Elbow Contractures Treatment with Trapeze-Flap Plasty [1]

Edge Elbow Contracture Elimination with One Adipose-Cutaneous Trapezoid Flap (Fig. 23.3)

Mild-to-moderate edge elbow contractures are removed with one flap prepared from the healthy fold's sheet and cubital fossa (Fig. 23.3a). A preliminary drawing (contours) of the flap and scar incision is performed before surgery; the flap's shape matches the wound but should be wider than the expected wound by 30–40%. With the first incision, the scar sheet is separated from the healthy sheet along the whole fold's crest, and the rough scars with ulcers are excised. With a perpendicular Y-shaped incision from the fold's crest to the joint rotation axis, the contracture is released. The incision's end should be Y-shaped near the humerus epicondyle for complete contracture release. As a rule, a trapeze-shaped wound is formed after joint extension (Fig. 23.3b, c). Then, the trapezoid flap is mobilized with the healthy skin and subcutaneous fat layer of the medial sheet and all cubital fossa. The width of the flap's end is approximately 4–6 cm; the end of the flap includes a part of the fold's crest. The flap's base is wider than the end and is located on the contralateral edge of the cubital fossa. The flap is advanced on the wound with tension (Fig. 23.3d). Flap tension allows for the flap's base approach to the scar's sheet; the flap displaces the lateral and back elbow skin to the anterior joint surface, toward the wound. As a result of flap tension, the soft tissues are squeezed, and the joint zone becomes smaller; the donor wound is narrowed and covered with the displaced adjacent healthy skin. All these factors allow the flap's end to approach the wound's border near the humerus epicondyle. The scar surface deficit is compensated for, and the donor wound is covered with healthy skin (Fig. 23.3c–e). A single trapezoid flap is sufficient for mild edge elbow contracture release, especially in children.

Fig. 23.3 Edge elbow flexion contracture elimination with one trapezoid flap. (**a**) Pre-surgery, scars causing edge contracture are located on *FL*—joint flexion lateral surface and fold; planning trapezoid flap in cubital fossa and Y-line for scars dissection; (**b**) incisions according to lines, FL surface separated from joint E surface and FM surface; *Dt*—scar surface deficit (wound) has a trapezoid form and spreads from the fold's crest to the joint rotation axis; (**c**) *FP*—adipose-cutaneous flap mobilized, Dt, donor wound (*DW*); (**d**) trapezoid flap (*F*) covered the wound, compensated scar sheet surface deficit, contracture eliminated; (**e**) 2 weeks after reconstruction: contracture fully eliminated, contours of elbow region restored

Moderate Elbow Contracture Treatment with Three Trapezoid Flaps (Fig. 23.4)

If contracture and scar sheet deficiency are more severe, the adipose-cutaneous flap, prepared from the healthy fold's sheet and elbow fossa, covers the central part of the wound; the donor wounds beside the main flap are covered with the adipose-scar trapezoid flaps prepared from a scar sheet (three-trapeze-flap plasty). The donor wounds beside the scars' flaps are covered with a healthy sheet's triangular flaps (Fig. 23.4a–c). Scars at the fold crest often undergo ulceration.

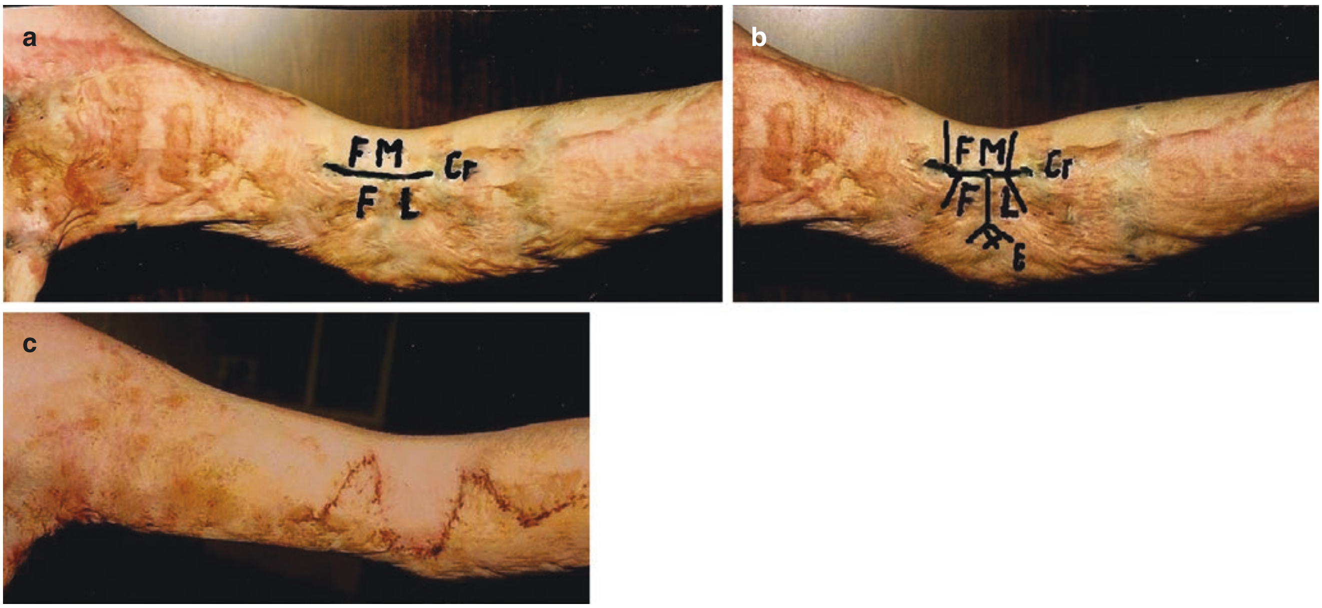

Fig. 23.4 Three-trapeze-flap plasty for moderate edge elbow contracture elimination. (**a**) Pre-surgery; contracture anatomy; *FL*—flexion lateral surface covered with scars causing contracture; *FM*—cubital fossa or flexion medial surface is healthy skin; *Cr*—crest of the fold; (**b**) planning: main healthy adipose-cutaneous trapezoid flap from the medial fold's sheet and cubital fossa (*FM*); two small trapezoid adipose-scar flaps from the scar sheet (*FL*) for the donor wound covering; (**c**) mobilized flaps (*F*) opposite transposed, compensated scar surface deficit and complete contracture eliminated

Treatment of Multiple Contractures (Figs. 23.5, 23.6, 23.7 and 23.8)

Severe edge elbow and shoulder adduction contractures are eliminated by cutting the long fold into trapezoid adipose-cutaneous and adipose-scar flaps (Fig. 23.5). Contracted scars often spread over the arm and shoulder, and a long fold is formed, which causes a contracture of the corresponding shoulder, elbow, wrist joints, and breast (Fig. 23.4a). Edge elbow and shoulder contractures are eliminated with a healthy cubital fossa and axillary fossa trapezoid flaps (Fig. 23.5b, c). The fold is converted with Y-shaped radial incisions into a trapezoid flap (Fig. 23.4a, d). After scar sheet dissections, the trapezoid flaps and wounds appear (Fig. 23.5c and 23.7b), reflecting the size and form of the scar surface deficit. Due to the surface surplus in the fold's sheets, the flaps' surfaces are sufficient for full contracture elimination and scar surface deficit compensation without skin transplants and regional flaps (Fig. 23.5e, f). Treatment of elbow and wrist contractures is shown in Figs. 23.6, 23.7 and 23.8.

Treatment of edge elbow and wrist contractures is complicated by scar ulceration (Figs. 23.2 and 23.6); a painful wound is located on the rough, thick, immature scars of the fold's crest. Ulcerations of the fold's top do not change the surgical technique: the rough scars with ulcers are excised and the reconstruction is carried out in the usual manner, using trapeze-flap plasty.

In all cases, using the trapeze-flap plasty technique that is specific for treatment of edge and medial contractures, the contractures of the edge elbow and medial wrist are eliminated simultaneously (Figs. 23.7 and 23.8). The surface of axillary fossa and sheets of the fold converted in trapezoid flaps are sufficient for scar surface deficit compensation, complete contracture elimination, and restoration of the upper extremity appearance without skin grafting, flaps' necrosis, or contracture recurrence.

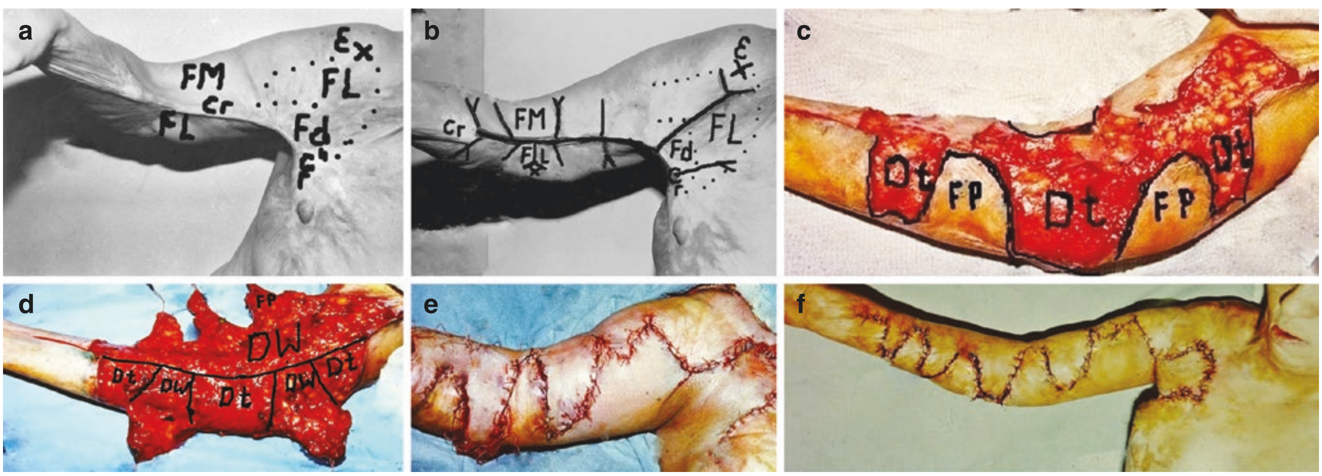

Fig. 23.5 Severe edge flexion elbow and shoulder adduction contractures elimination with multiple trapezoid adipose-cutaneous and adipose-scar flaps. (**a**) Before surgery: contractures caused by scars covering the flexion lateral surface (*FL*); scars form the long fold (from wrist to breast) located along the medial edge of cubital and axillary fossa; the lateral fold's sheet is scars and continuation of scars of FL surface; the medial sheet and cubital and axillary fossa are healthy skin (donor sites); (**b**) planning: a conversion of the fold in trapezoid flaps with radial incisions; the main flap mobilized from cubital and axillary fossa for elbow and axilla contracture release; (**c**) after contracted scars dissections with Y-incisions from the fold's crest to the joint rotation axis: trapezoid scar surface deficit (*Dt*) or trapezoid wounds appeared and flaps (*FP*) accepted trapezoid form; (**d**) flaps mobilized, donor wounds (*DW*); (**e**, **f**) results: counter transposed trapezoid flaps compensated scar surface deficit and edge elbow and shoulder contractures eliminated without complications

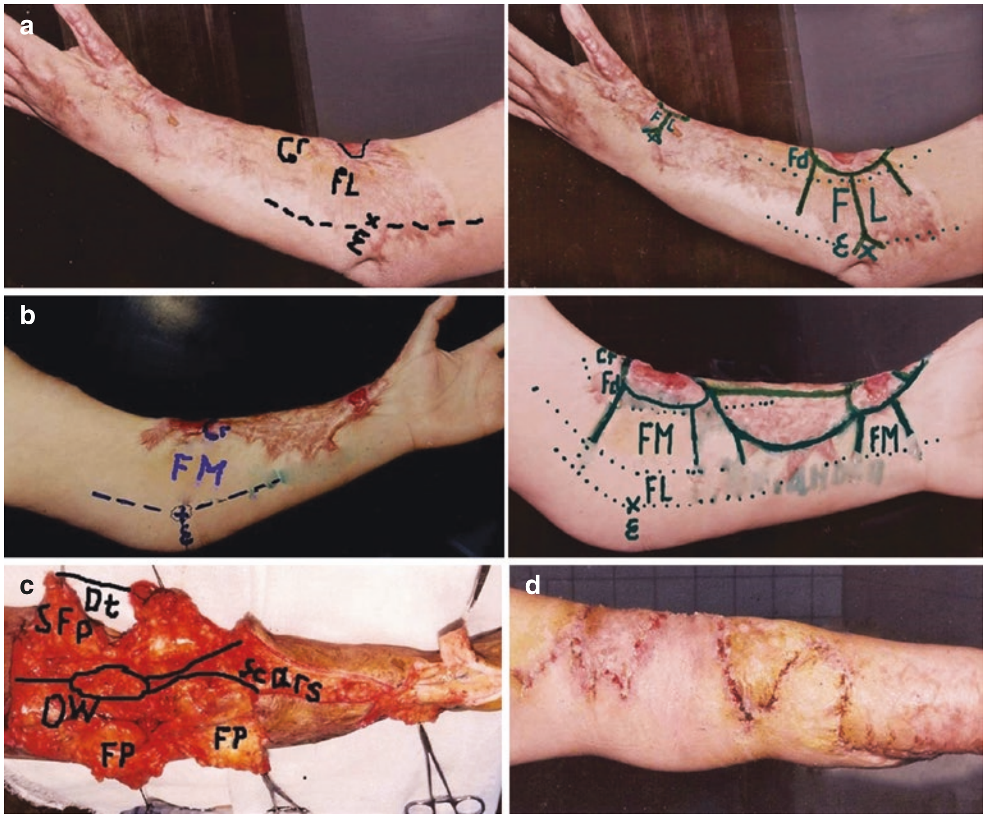

Fig. 23.6 Elimination of severe edge elbow and wrist contractures with trapezoid flaps (continuation of Fig. 23.1). (**a**, **b**) Anatomy: contractures caused with scars, covering FL surface, and lateral scar fold's sheet; ulcers of scars over the elbow and wrist; the fold located along lateral edge of the cubital and axillary fossa; lateral fold's sheet (*FL*) is scars; medial sheet and cubital fossa (*FM*) are healthy skin; crest of the fold (*Cr*); trapeze-flap plasty planning with four flaps and ulcerous deformed scars excision; main flaps are adipose-cutaneous trapezoid cubital or *FM*—flexion medial surface and axillary; (**c**) scars with ulcers excised, trapezoid flaps elevated: two adipose-cutaneous and two adipose-scar; *Dt* scar surface deficit; *FP* flap, *DW* donor wound; (**d**) 2 weeks after reconstruction: flaps are alive; oppositely transposed trapezoid flaps covered the wound, scar surface deficit compensated for, and contracture completely eliminated

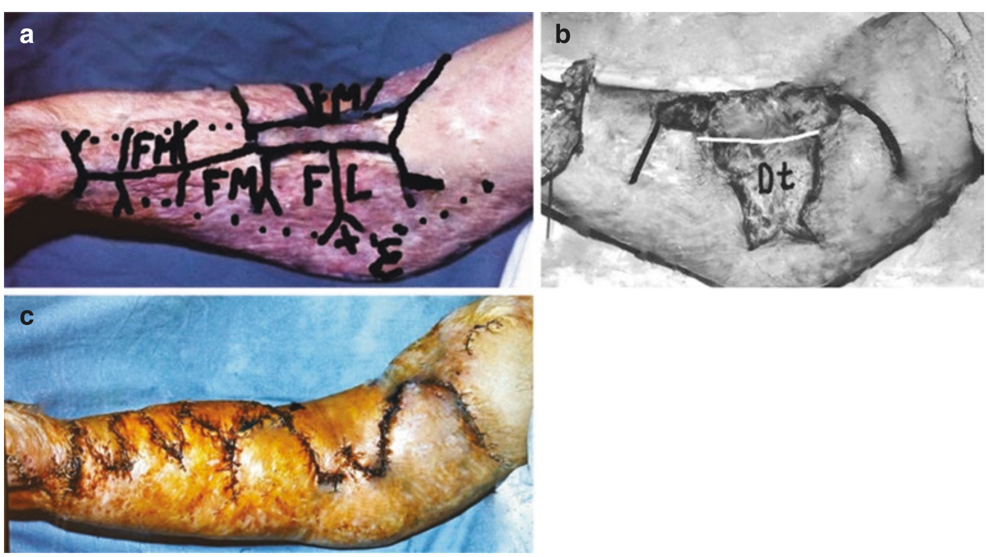

Fig. 23.7 Simultaneous elimination of edge elbow and medial wrist contractures with trapeze-flap plasty. (**a**) Edge elbow contracture caused by scars covering *FL* flexion lateral surface; *FM* flexion medial surface or cubital fossa is healthy skin and is donor site; wrist medial contracture caused by scars located on radial or flexion medial surface; scars formed the long fold, which is surface surplus scar and skin. Specific planning of edge elbow and medial wrist contractures release; (**b**) after dissection of scar with Y-incision, large trapezoid wound or scar surface deficit appeared, which are real causes of contracture; (**c**) skin of cubital fossa and scars causing contractures converted by radial Y-incision in the flaps, counter transposed and eliminated both contractures

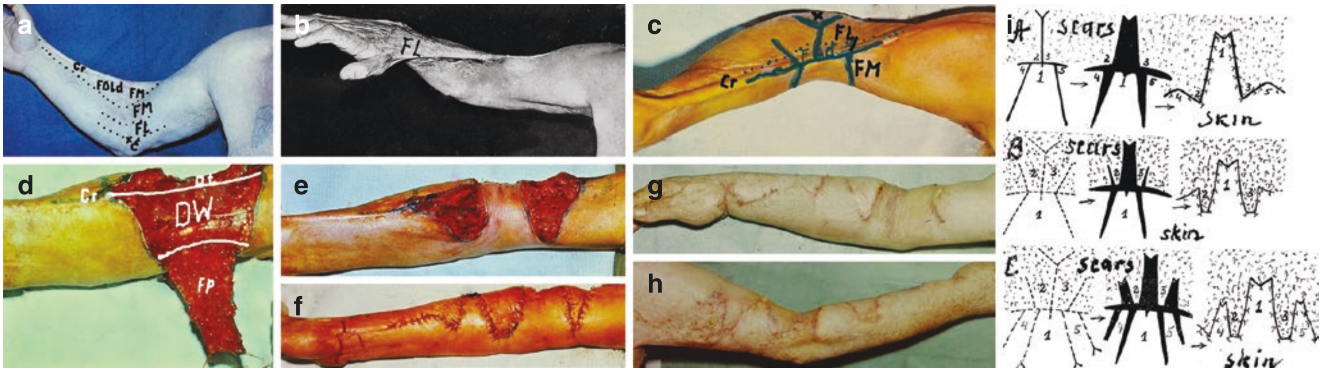

Fig. 23.8 Severe edge flexion elbow contracture elimination with multiple trapezoid flaps. (**a**, **b**) Anatomy: scars covered flexion lateral surface (*FL*) of the elbow and wrist, formed a wide and long fold, and caused both joints edge contractures. Standard contracture marked, *FL* lateral surface is scars, medial (*FM*) surface is skin; both fold sheets are surface surplus scars and skin. (**c**) Planning: typical three-flap plasty. Scars dissected with a Y-incision, *Dt* large trapezoid wound or scar surface deficit appeared; *FP* cubital trapezoid flap mobilized, *DW* donor wound. (**d**–**f**) Operation: elbow and wrist contracture eliminated with local tissues. (**g**, **h**) Three months after surgery: good functional and cosmetic outcomes without skin grafts and regional flaps. (**i**) Variants of trapeze-flap plasty (without skin grafting): one-, three-, and multiple-flap techniques (scheme)

Conclusion

Scar edge flexion elbow contractures are eliminated with trapezoid flaps without skin grafting, regional pedicle, or free flaps. The adipose-cutaneous and adipose-scar trapezoid flaps are large, with a wide end, without acute angles, contain a full subcutaneous fat layer, and do not undergo rotation. Therefore, the flaps have a steady blood circulation, and flap advancement with tension is not dangerous. Flap loss does not occur. In the 3 months after reconstruction, stretching of the skin and mild venous congestion disappear, and the contours of the elbow are restored as a result of healthy skin growth. Follow-up functional results are good: the full range of flexion and extension in operated elbow joints was observed. No recontracture takes place and no reoperation is needed. The stretching healthy skin of the trapezoid flap, located among the scars, and the stretching skin of the adjacent regions, continues to grow until the skin tension disappears completely. Therefore, the results improve with time. In children, the healthy skin grows more intensively, preventing contracture recurrence and providing favorable conditions for normal development of the whole limb. The cubital fossa (donor site) preserves normal skin and contours.

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24 The Postburn Elbow Medial Flexion Scar Contracture Treatment with Trapeze-Flap Plasty

Introduction

Medial contractures are not well studied and we did not find literature devoted to this theme. Therefore, all that is presented below is new. Joint elbow flexion medial contracture is a result of burn and scars of the elbow flexion medial (FM) surface (cubital fossa). Scars restrict extension and impair upper extremity function. Attempts to extend the joint tear scars, fissures appear, and ulcerations are seen more frequently than in other joint contractures. Pain during extension impairs all upper extremity function. Medial elbow flexion contracture should therefore be released early. We studied and treated patients with medial elbow contractures—anatomy and clinical signs—and compared the efficacy of triangular-flap techniques with trapeze-flap plasty. We ascertained that the most effective method for medial contractures is trapeze-flap plasty based on adipose-scars trapezoid flaps.

Joint Elbow Functional Zones and Anatomy of Elbow Medial Flexion Contracture

Functional Zones and Anatomy (Fig. 24.1)

The elbow joint surface is functionally divided into extension (*E*) and flexion (*F*) surfaces. The flexion surface has two curvatures formed by the edges of cubital fossa, which divides the flexion surface into two zones: the joint flexion lateral surface from the cubital fossa's edge to the joint rotation axis. The space between the fossa edges is the flexion medial (*FM*) surface (Fig. 24.1). Medial elbow contracture is caused by scars located on the FM surface. Scars covering the FM surface of the joint, shoulder, and arm undergo contraction and continue to grow. Scars grow, and contraction elevates scars over the cubital fossa and forms a fold along the medial line of the FM surface. Scars approximate forearm to shoulder and cause elbow FM contracture. Attempts to extend the

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elbow stimulate the scar's growth, making the fold wider and longer (Fig. 24.1). The fold consists of two scar sheets that spread from the fold crest to the fossa edges. The fold has a semilunar form and is located on a middle flexion surface of the joint (*FM*); both sheets of the fold are scars. The sheets of the fold have surface surplus in width and a deficit in length (contracture cause). The fold is a new anatomical structure, with scar surface surplus allowing contracture elimination with local flaps. Maximum tension occurs at the crest of the fold (*Cr*) and decreasingly extends to the flexion lateral surface (*FL*) or edges of the cubital fossa.

Medial elbow contracture is characterized by three specific features (Fig. 24.1):

(a) The contracted scars are located on the joint flexion medial (*FM*) surface and form the fold.
(b) The fold is located in the center of the scar medial surface; the fold's crest passes along medial line of the joint flexion surface.
(c) Both sheets of the semilunar fold are scars.

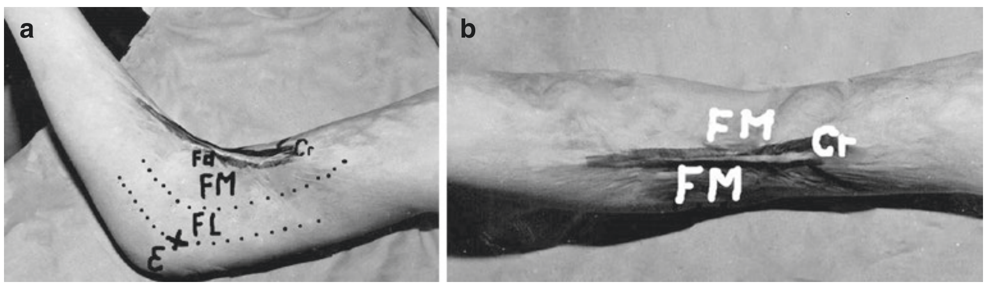

Fig. 24.1 Anatomy of the elbow medial flexion contracture. (**a**, **b**) The joint surface is functionally divided into extension (*E*) and flexion (*F*). Flexion surface curvatures, caused by the edge of cubital fossa, divides flexion surface on flexion lateral (*FL*) and flexion medial (*FM*). Medial elbow contracture is caused by scars located on the flexion medial surface (*FM*), and the scars form a fold (*Fd*). The fold has semilunar form and its crest (*Cr*) passes along the medial line of the joint flexion surface; both sheets of the fold (*Fd*) are scars; in the fold's sheets there is surface surplus in width and deficit in length in the sheets (contracture cause). Maximum tension occurs at the crest of the fold (*Cr*) and decreasingly extends to the flexion lateral surface (*FL*) or edges of elbow fossa

Scar Surface Deficit as the Real Cause of Contracture (Fig. 24.2)

The maximum tension of scars covering the elbow FM surface occurs at the top of the fold (*Cr*) and is equal in both sheets. The tension of the sheets (scar surface deficit), subsiding, reaches the edges of cubital fossa, and, going sideways, forms a trapezoid scar surface deficit, which is the real cause of contracture, and is equal in both sheets (Fig. 24.2c).

To choose an appropriate plasty method and flap shape, one must know the size and the form of the scar surface deficiency. To estimate the latter, it is first necessary to cross-cut the scars with radial Y-incisions from the fold's crest all the way to the edges of fossa. To complete releasing of the scar tension, the end of the incision should be Y-split to separate the scars of the FM surface from skin of the FL surfaces. As a rule, a trapeze-shaped wound was formed despite how many incisions were made (Fig. 24.2c, d). The best way to convert the fold's sheets into trapezoid flaps and fully release the contracture is to separate the fold's sheets by incision along the crest of the fold and cross-section of sheets with radial Y-incisions (Fig. 24.2b). Incisions with bifurcate ends (Y-shaped) separate scars of the FM surface from tissues of the FL surfaces, which allows unrestricted wound edges divergence. This is necessary for a full contracture release. Because of the semilunar shape of the fold and the radial direction of the incisions, trapeze-shaped flaps are formed and Y-incisions form trapeze-shaped wounds (Fig. 24.2c). In most cases the excess of the scar surface is sufficient to make up for the deficiency of length (Fig. 24.2e, f). The scheme of plasty with trapezoid flaps is shown in Fig. 24.2g.

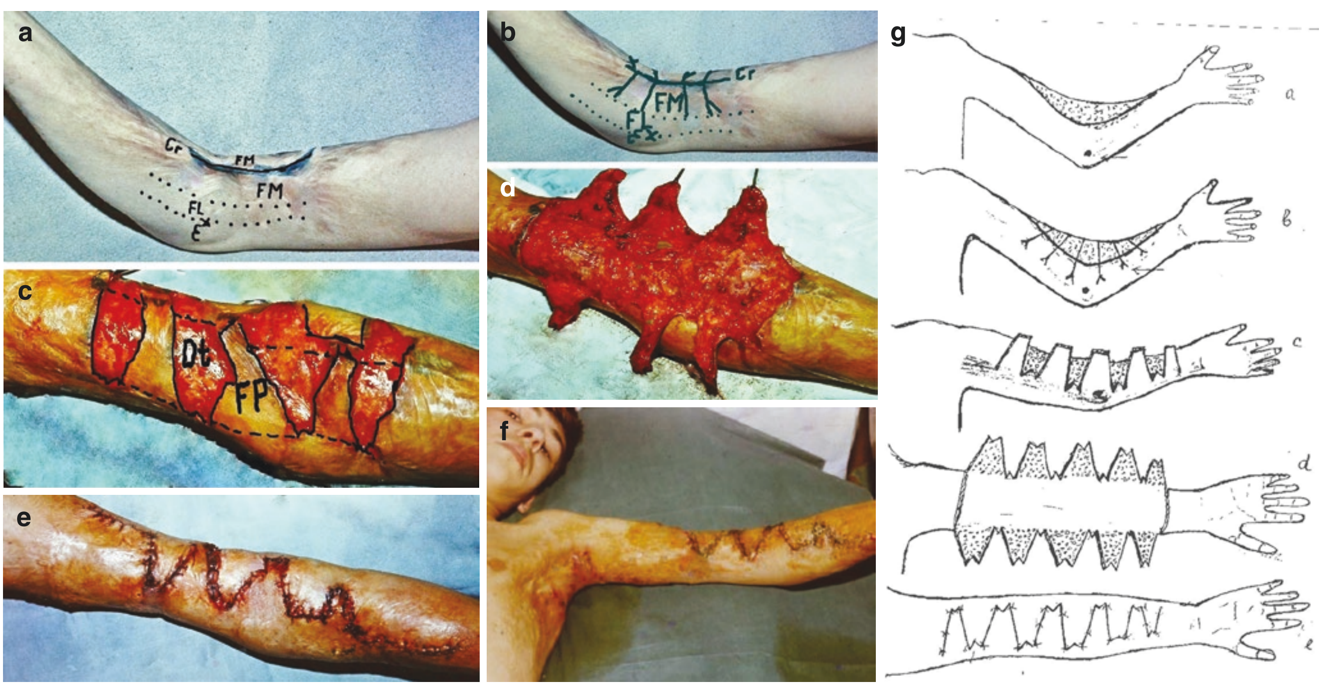

Fig. 24.2 Scar surface deficit is the flexion medial contracture cause. (**a**, **b**) Anatomy of elbow medial contracture and planning of scar surface deficit to define and trapeze-flap plasty, the radial Y-lines/incisions of semilunar fold up to edges of the fossa make trapeze-shaped figures/flaps; (**c**) fold cross-cuttings with Y-shaped incisions, elbow joint extended, the trapeze-shaped wound (scar surface deficit—*Dt*) and flaps (*FP*); (**d**) mobilized three pairs of adipose-scar flaps; (**e**, **f**) opposite flap transposition covered the wound, scar surface deficit was compensated, and full contracture was eliminated (5 and 14 days after surgery); (**g**) scheme of the trapeze-flap plasty treatment of elbow medial contracture

Surgical Techniques [1]

Anatomy and Features of Trapeze-Flap Plasty (Figs. 24.1, 24.2, 24.3, 24.4, 24.5, and 24.6)

Scars on the joint elbow flexion medial (*FM*) surface takes the form of the semilunar fold (*FD*). The scar sheets spread from the fold's crest to the edges of the elbow fossa or the joint flexion lateral (*FL*) surfaces. The scars of the FM surface (sheets) are tightly connected to the tissues of both FL surfaces. Therefore, for a full contracture release and effective use of the scar surface surplus, the sheets should be separated between themselves first, and every sheet partly separated from the tissue neighboring joint zones (*FL*). In this example, scars sheets are partly separated by Y-incisions from tissue of both flexion lateral (*FL*) surfaces. This is a common principle of operation for scar contractures having folds and surface surplus: the fold's sheets are separated with an incision along the fold's crest; scars are partly separated from the neighboring joint zone with a Y-incision, which at the same time radially dissects contracted scars. The planning of surgery (incisions) is shown in Fig. 24.2b. The distance (length) between cross-cuttings is 3–5 cm, which forms the width of the flaps' ends. The width of the flap's base reaches 6–8 cm. An all fat layer is included within the flap; a deep fascia remains in situ (Fig. 24.2d). The length of the scar-adipose flaps varies. It equals the distance from the crest fold to the level of the edge of cubital fossa or joint FL surface. Both sheets are converted to flaps all along their length (Fig. 24.2d). The quantity of the flaps depends on the fold's length. Adipose-scar trapezoid opposite the flaps are transposed toward one another with moderate tension. The end of the flap reaches the base of the opposite flap (Fig. 24.2e). Thus, the shortage in the scar's length is compensated for by the surplus in the width (Fig. 24.2f). All mild, moderate, and most severe contractures can be released completely with trapeze-flap plasty. The scheme of the operation is shown in Fig. 24.2g. Depending on the fold's length and the severity of contracture, reconstruction is performed with one or several pairs of trapezoid flaps per se, or in combination with skin grafts. Usually, the fold including its full extent is transformed in the flaps. Therefore, the surgical technique has several peculiarities:

1. Reconstruction with one pair of the flaps (Fig. 24.3): The technique is effective if contracture is mild and the fold is short.
2. In the case of more severe contracture, the full extent of the fold is converted in trapezoid adipose scar flaps, suitable for complete scar surface deficit compensation, wound covering, and contracture elimination (Fig. 24.2).
3. The formation of severe contracture is accompanied by a relative decrease of the surface surplus of the fold's sheet, and, therefore, the surface of several pairs of flaps (Fig. 24.4a–d) becomes insufficient for complete wound closure with flaps; the remaining small wound among the flaps had to be skin-grafted (Fig. 24.4e, f).
4. In some cases, the fold is poorly expressed (Fig. 24.5a, b), and trapezoid adipose-scar flaps are short and do not reach the opposite edge of the wound (Fig. 24.5c, d). After counter flap transposition, small wounds remained uncovered, located ahead of the flaps' ends, which are covered with skin transplants (Fig. 24.5e). This combined technique does not decrease the quality of outcomes. As a rule, the contractures were eliminated completely. After surgery, a common gutter splint was used and no special immobilization after surgery was required.
5. The crest of the fold can be subject to ulceration (Fig. 24.6a, b). In such cases, rough scars with ulcers are excised and a pair of the adipose-scar trapezoid flaps is prepared from the fold's sheets, which are counter-transposed; wounds beside the flaps are primarily closed (Fig. 24.6c–e).

The mild-to-moderate elbow medial scar flexion contracture is caused by a slightly expressed scar surface deficit. Therefore, the contracture is usually eliminated with one pair of adipose-scar trapezoid flaps (Fig. 24.3).

Severe Elbow Medial Contracture Treatment Caused by a Long Fold (Fig. 24.4)

The sheets of such folds have a severe scar surface deficit, which is eliminated with several pairs of adipose-scar trapezoid flaps alone or in combination with skin transplants (Fig. 24.4). The formation of severe contracture is accompanied by a relative decrease in the surface surplus of the fold's sheet, and, therefore, the surface of several pairs of flaps (Fig. 24.4a–d) becomes insufficient for complete wound closure with flaps; the remaining small wound among the flaps was skin-grafted (Fig. 24.4f).

Trapeze-Flap Plasty in a Case of Insufficient Width of Scar Fold (Fig. 24.5)

Scanty fold protrusion narrows the fold's sheets and shortens the trapezoid flaps (Fig. 24.5a, b). After mobilization, trapezoid flaps were counter transposed, but the flaps were too short and could not reach the base of the opposite flap (Fig. 24.5d). Such a condition does not contraindicate trapeze-flap plasty. Small wounds at the flap's end are skin grafted (Fig. 24.5c, d). Such a technique does not lower the quality of outcomes (Fig. 24.5e). As a rule, the contractures were eliminated completely. After surgery, a usual gutter splint was used, and no special immobilization after surgery was required.

The crest of the fold can be subject to ulceration (Fig. 24.6a, b). In such cases, rough scars with ulcers are excised and a pair of the adipose-scar trapezoid flaps is prepared from the scar fold sheets, which are counter-transposed, restoring the cubital fossa (Fig. 24.6c, d). Wounds beside the flaps are primarily closed (Fig. 24.6e).

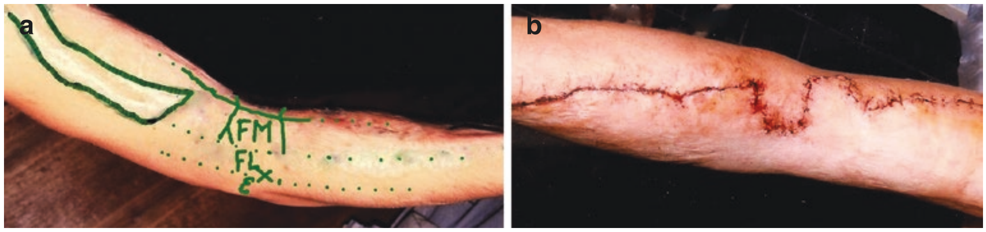

Fig. 24.3 The mild-to-moderate medial elbow contracture treatment with one pair of adipose-scar trapezoid flaps. (**a**) Pre-surgery; anatomy contracture: joint's surfaces: *FM*, *FL*, *E*, and "+" (fold crest); operation planning: one pair of adipose-scar trapezoid flaps in the zone of the flexion medial surface, strip of scars to be excised; (**b**) mobilized adipose-scar flaps counter-transposed, wound covered, and contracture eliminated; 7 days after surgery: contracture released, flaps alive; scars on the shoulder excised

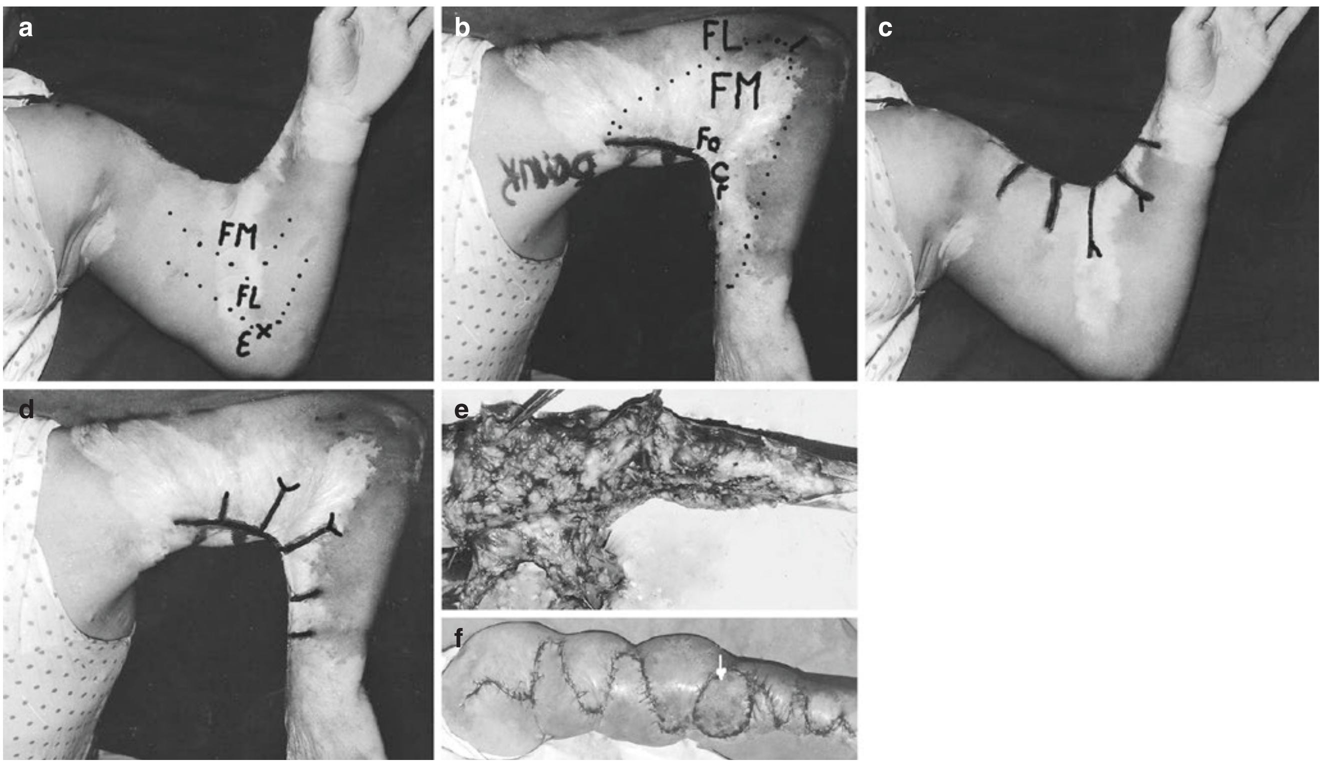

Fig. 24.4 Severe medial elbow contractures elimination using several pairs of trapezoid flaps and skin transplants. (**a**–**d**) Pre-surgery view, anatomy: *E*, *FL*, *FM*, *Cr*, "+"—deformed joint's surfaces; wide and long semilunar fold, four pairs of flaps marked, the Y-lines spread to the joint fossa's edges to the flexion lateral (*FM*) surface; (**e**) mobilized adipose-scar flaps; (**f**) wound covered with opposite flaps transposition, a small wound skin grafted (7 days after operation), complete elbow extension, flaps alive

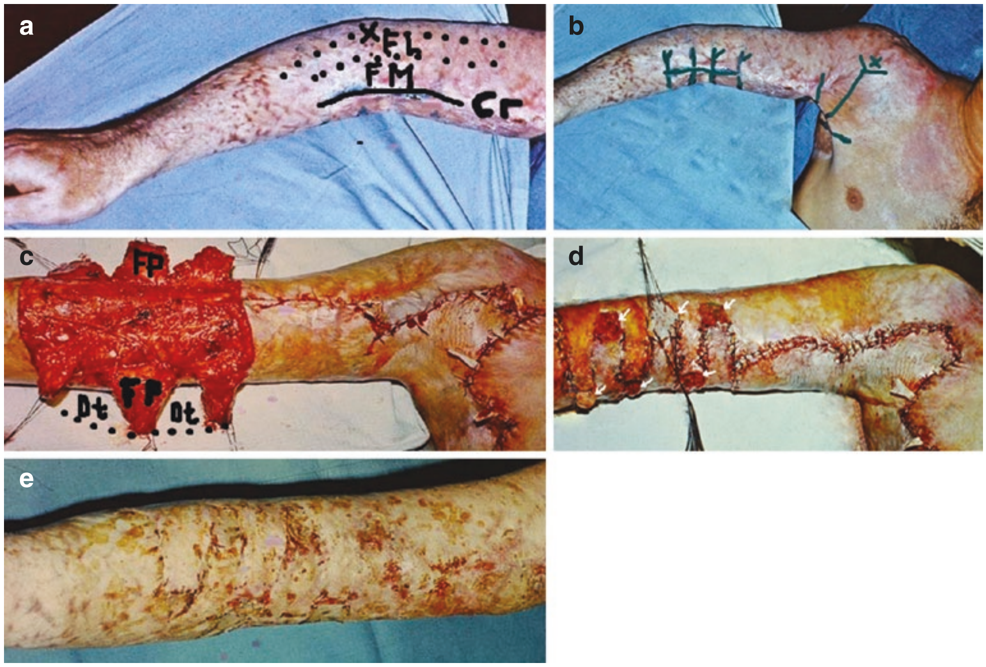

Fig. 24.5 Medial elbow contracture treatment in a case of narrow fold with short trapezoid adipose-scar flaps. (**a**, **b**) Pre-operation, joint functional zones and contracture anatomy: *FL* the flexion lateral surface and *FM* flexion medial surface are scars; *Cr* crest of the fold, both sheets of the fold are scars; "+" joint rotation axis. Planning: three pairs of trapezoid flaps marked in elbow (*FM*) zone and three flaps in the axilla for edge anterior shoulder adduction contracture treatment; (**c**) short flaps (*FP*) mobilized; the space between flaps equal to scar surface deficit (*Dt*) in size and form; shoulder edge contracture eliminated; (**d**) counter-transposed short flaps did not achieve basement of opposite flaps; therefore, small wounds at the flap's end (arrows) were covered with skin transplant. (**e**) Results: contracture fully eliminated, flaps and skin transplants alive (2 weeks after surgery)

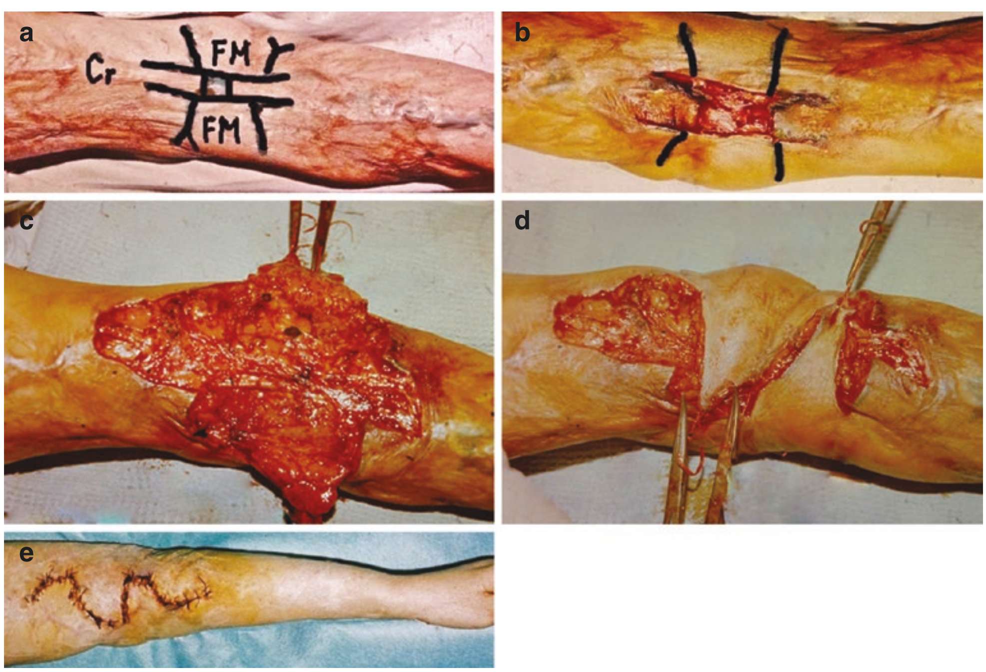

Fig. 24.6 Treatment of medial elbow contracture, complicated by ulcerous condition of fold's crest, using trapeze-flap plasty. (**a**, **b**) Pre-surgery; anatomy of elbow medial contracture with fold's crest ulceration: *FM* the flexion medial surface has big fold; *Cr* crest of the fold with ulcer, two adipose-scar trapezoid flaps marked, all FM surface of elbow included in the one pair of flaps, ulcerous crest marked and excision; (**c**) rough scars with ulcer excised; two trapezoid adipose-scar flaps mobilized; (**d**) flaps counter-transposed. (**e**) Seven days after surgery: flaps alive, donor wounds beside the flaps primarily closed. Contracture completely released, elbow region looks well

Consequences Following the Opposite Transposition of Flaps

This method of plasty involves several constituents:

(a) A flap that stretches throughout the opposite transposition brings the bases of the opposite flaps together. Thus, the edges of the wound and tissue of joint flexion lateral (*FL*) surfaces are displaced on FM surface being shifted by the flap's traction. The wound, therefore, becomes narrower.

(b) The skin of the joint flexion lateral surfaces (*FL*) is displaced forward, reaching over the flexion medial (*FM*) surface and partially covering the wound. Simultaneously, the skin of the joint's extension (*E*) surface is displaced to the lateral surface of the joint (*FL*).

(c) Soft tissues undergo compression due to the stretching of the flaps. The area where the joint is positioned, the adjacent zones of the arm and the shoulder, become thinner. Thus, the surface of the flaps and the lateral and back surface of skin increases relative to the decreased wound. This allows transmitting the end flaps to the base of the opposite flaps, covering the wound, and omitting the skin-grafting procedure. Due to the transposition of the flaps, the length of the medial flexion surface increases. Consequently, the sheets of the fold, the skin of lateral and extension surfaces of the joint, and adjacent zones of the arm and shoulder, all participate in the trapeze-flap plasty, making it especially effective.

Conclusion

Trapezoid flaps have a wide end and base and do not undergo rotation; they include the complete underlying fat layer and therefore are not subject to necrosis. Because of these features, the stretching of flaps does not pose a danger. Due to these features, flap loss, contracture recurrence, and repeated surgery do not occur. The soft tissues, which underwent compression, serve as expanders, prompting the healthy skin and scar flaps to grow. In approximately 2–3 months, the skin tension and compression disappear due to the growth of undamaged skin. One may very rarely encounter the superficial necrosis of the flaps' ends. No edematous problems or compromises in venous return have been observed if all the fatty tissues are included in flaps. The wounds were healed under dressing without further complications. The full range of the joint's flexion and extension has been noted in all patients. Due to the flaps' stretching, scars become more even. The borders (edges) of the flaps are unnoticeable. The features of the trapeze-flap plasty guarantee excellent functional and good cosmetic results.

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25 Total Elbow Flexion Contracture Treatment

Introduction

Total elbow contracture is a result of vast burns and scars covering the entire flexion (two lateral and medial) surfaces. Scars often injure the extremity circularly and involve the wrist and hand. Scars tightly surround the joint and neighboring regions without a fold. For the most part the scars are rough, thick, solid, red, and painful. Such contractures cannot be treated with local tissues. A regional flap can cover only the joint zone; normal skin between the scars is cosmetically unacceptable. However, functional and cosmetic effects can be achieved by vast mature scar excision through intermediate layer and wound resurfacing with whole skin transplants.

Anatomy

After severe vast circular burns of the upper extremity, scars cover the elbow joint and neighboring segments of the limb and wrist circularly (Fig. 25.1) or surround both joints' flexion medial (*FM*) and flexion lateral (*FL*) surfaces (Fig. 25.2a, b) without a fold formation. Because no excess tissue exists, this contracture cannot be reconstructed with local flaps. All attempts to extend the elbow make the scars more disfigured—rough, thick, ulcerated, firm, and thus not suitable for plasty (Figs. 25.1, 25.2 and 25.3). Therefore, in addition to functional disorders, limb disfigurements bother the patients as well.

Fig. 25.1 Total elbow, wrist, and hand contractures caused with circular immature scars without folds

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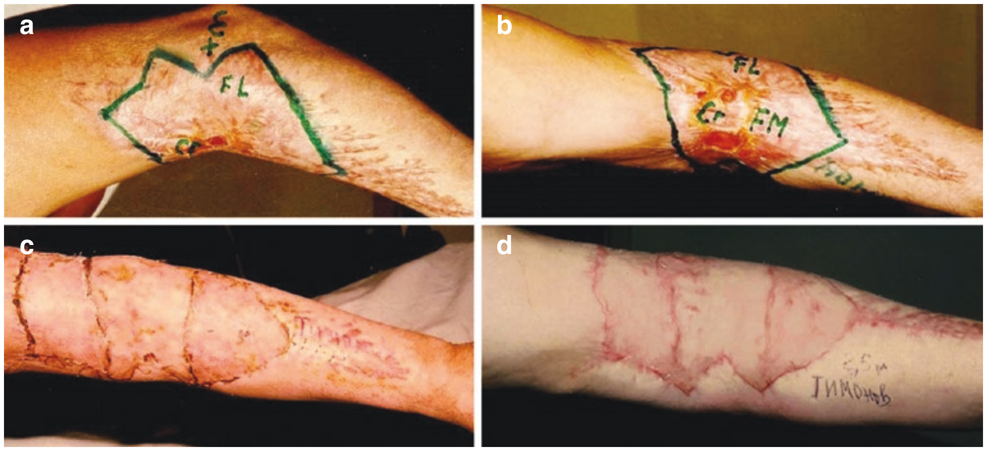

Fig. 25.2 Total elbow contracture caused with local rough ulcerous scars. (**a**, **b**) Pre-surgery view; elbow joint's functional surfaces: *E* extension; "+" symbol joint rotation axis; *FL* flexion lateral surface; *FM* flexion medial surface; *Cr* crest of the fold; boundaries of scars excision (solid line); (**c**) 2 weeks after vast excision of scars through intermediate layer and skin-grafting, transverse placed whole skin transplants look good; (**d**) 2.5 months after surgery: good functional and cosmetic outcomes

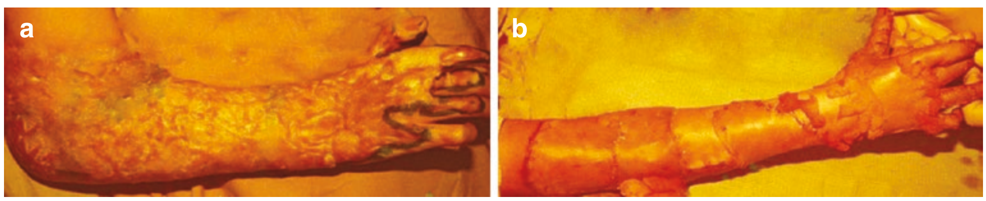

Fig. 25.3 Total elbow, wrist, and dorsal hand contractures and deformity treatment with mature scars excision through intermediate layer and the wound cover with whole skin transplants. (**a**) Pre-surgery view. (**b**) Operation: scars fully excised through an intermediate layer with minimal bleeding, wound covered with whole skin transplants, placed transverse; duplication of transplants' edges and fixed among themselves and wound tissue with metallic staples

Surgical Treatment

When planning treatment, two factors, function and cosmetic appearance, should be considered. The reconstruction of the contracture consists of excision of vast rough scars by removing a long strip, nearly 3 cm in width, through an intermediate layer, which is formed from the inner scar's layer and has poor vascularity. The wound is covered with split whole skin transplants placed transversely (Figs. 25.2c, 25.3b, and 25.4b); edge transplants are duplicated and transplants are fixed through them to wound tissue with U-stiches (Fig. 25.3a, b). Pedicle and free flaps are used only if the joint zone is injured with the soft tissue defect, since the flap's skin resembles the patch. Because the elbow joint's position at rest is an extension, the skin graft easily responds to stretching, using a regular gutter splint. With time, the transplants become normal skin, and there is no threat of re-contracture. The wider the scars that are excised, the better the outcomes (Fig. 25.4a, b).

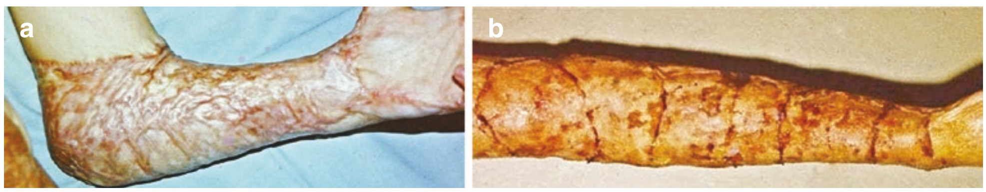

Fig. 25.4 Result of total elbow and wrist contracture treatment with scar excision through intermediate layer and skin grafting. (**a**) Before operation: severe contractures caused circular keloid scars; (**b**) 10 days after surgery: transplants alive, contractures released

Conclusion

Total elbow contracture occurs as a result of vast burns that also injure the neighboring zones, joints, and hand. The formed scars are rough and thick; thus, they impair upper limb function and create a severe cosmetic defect. Severe scar surface deficits exclude contracture release with local tissues. Reconstruction, therefore, is aimed at function restoration and maximal removal of the cosmetic defect. The procedure is done by excision of contracted deformed scars through the intermediate layer and wound covering with split whole skin transplants taken from the lateral surface of the hip joint. Scar excision without injuring the fat layer prevents shrinkage of the skin transplants. Wider scars are removed, and better outcomes are achieved.

Suggested Reading

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Wrist Scar Contracture, Hand Deviation: Anatomy and Treatment with Trapeze-Flap Plasty

26

Introduction

Hand burns can be complicated by scar contracture of the radial or ulnar wrist and hand border. The contracture restricts mobility of the hand. Multiple techniques are currently used to release scar tension. We have tested most of these techniques in our practice, and the results have been unsatisfactory. The use of local triangular pointed flaps posed obvious limitations. A literature review confirmed that the management of hand border/wrist contractures has not been sufficiently studied. This chapter describes the anatomical features of scar border contractures of the wrist and presents an effective method for contracture elimination with the use of trapeze-flap plasty.

Medial Ulnar and Radial Wrist Scar Contracture and Hand Deviation

Anatomy of Wrist Scar Contracture and Hand Deviation (Figs. 26.1 and 26.2)

Three types of wrist scar contractures occur: medial (most often), edge, and total. Medial contractures are a result of burns of the ulnar (Fig. 26.1) or radial (Figs. 26.2, 26.3 and 26.4) wrist border. Edge wrist contracture forms scars covering the dorsal or palmar wrist surfaces (Fig. 26.5). In cases of medial contractures, scars form the crescent fold along the wrist's border, causing radial or ulnar hand deviation. Both sheets are scars. Scars located on the dorsal and palmar wrist surfaces also form a crescent fold along the wrist border, but only one sheet consists of scars; the other sheet and adjacent wrist surface are healthy skin (Fig. 26.5a, b). The fold and neighboring scars have surface deficit in length, which is the cause of the contracture; both sheets of

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the fold are new anatomical structures—scar and skin surface surplus, allowing elimination of both types of wrist contracture—medial and edge—with local flaps. The flaps are absent in total contractures, making any local-flap technique application impossible.

The scar surface deficit is the contracture cause, and the goal of the treatment is scar surface deficit compensation. Therefore, the first step of surgery is to determine the scars' surface deficit form, size, and location; then, an adequate flap planning for scar surface deficit compensation and contracture elimination takes place.

Scar surface deficit definition: The fold's sheets are separated with an incision along the fold's crest (*Cr*); the fold/contracted scars are dissected with radial/perpendicular Y-incisions. After hand straightening, the wound accepts, as a rule, a trapezoid form of wound or scar surface deficit (*Dt*) (Fig. 26.1d). Since the fold has a semilunar (crescent) shape, the radial lines and Y-incisions transform the sheets into trapeze-shaped flaps (*FP*) (Fig. 26.1d, e). This means that contracture treatment is concluded in scar surface deficit compensation with trapezoid flaps, which can be prepared from the fold's sheet (Fig. 26.1c, d). In cases of edge contracture, a Y-incision dissects contracted scars on the dorsal or palmar wrist surface (Fig. 26.5). A trapezoid wound appears. The plan for scar surface deficit compensation and contracture elimination is shown in Fig. 26.5c. The larger the fold, the greater the surface surplus in the sheets, which is used for medial and edge wrist contractures elimination.

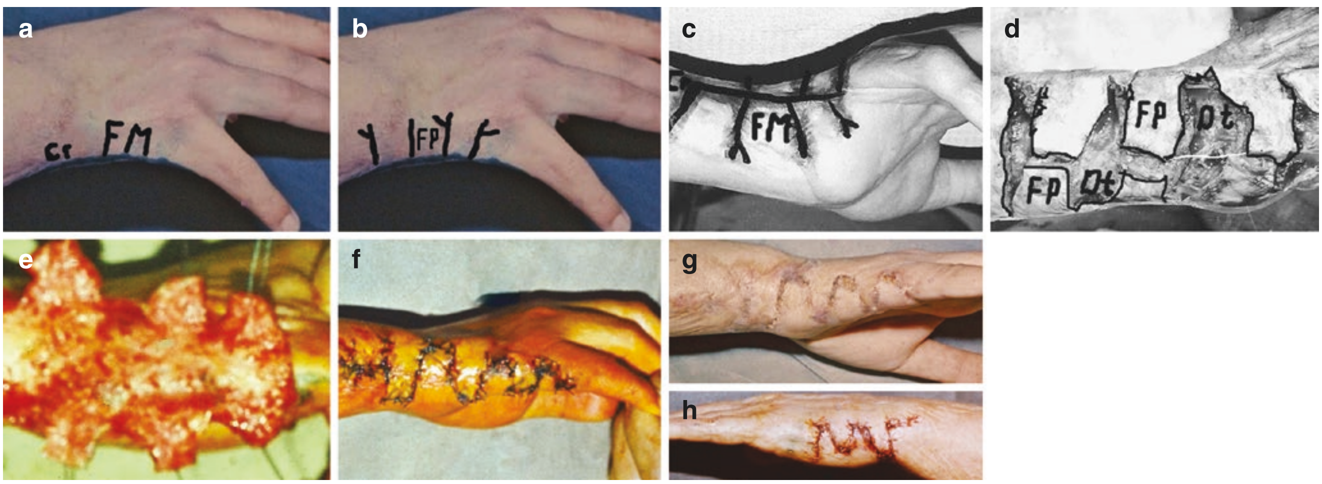

Fig. 26.1 Right wrist ulnar medial contracture and hand deviation: anatomy and treatment with trapeze flap plasty. Case 1: (**a**) Contracture caused by scars covered the ulnar flexion medial (*FM*) surface of wrist and the ulnar border of the hand; scars formed a semilunar fold, the crest (*Cr*) of which passes along the central zone; contracted scars have a surface deficit in length that causes the contracture. Both sheets of the fold are scars and have a surface surplus in width; (**b**, **c**) flap (*FP*) planning by radial Y-lines for converting flexion medial (*FM*) surface and sheets of the crescent fold into trapezoid flaps; (**d**) after fold incisions and hand straightening: the trapezoid wounds or scar surface deficit (*Dt*) of FM surface and flaps appeared that accepted trapezoid form (trapeze-shaped scar sheet deficit in length); (**e**) adipose-scar flaps mobilized; (**f**) trapezoid flaps counter transposed and fully contracture released; (**g**) contracture and deviation of hand eliminated in full; no flap loss, plasty zone lengthened by more than 100% (2 weeks after reconstruction). Case 2: (**h**), Ulnar left wrist medial contracture eliminated with two pairs of adipose-scar trapezoid flaps (5 days after surgery)

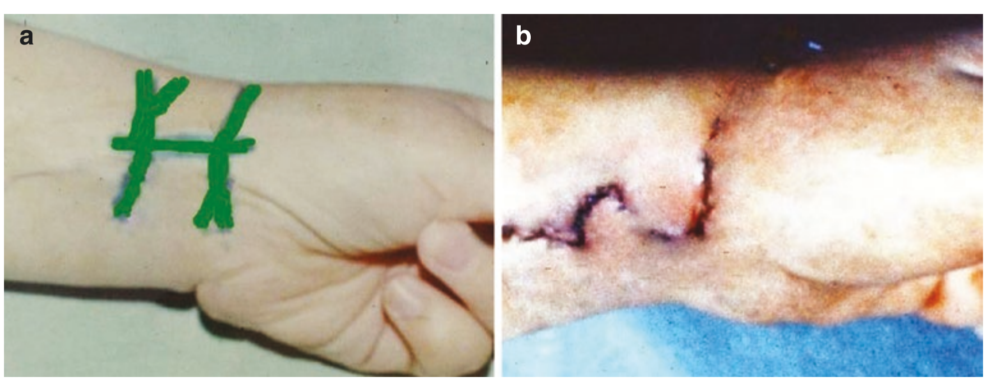

Fig. 26.2 Medial mild-to-moderate wrist contracture elimination with two opposite-located adipose-scar trapezoid flaps. (**a**) Pre-surgery view, the scar fold is located along the radial side of the wrist; both sheets of the fold (joint flexion medial surface—*FM*) are scars; planning contracted scars dissection for flaps formation (Y-lines); (**b**) mobilized adipose-scar trapezoid flaps counter transposed, scar surface deficit compensated, and contracture eliminated (10 days after surgery)

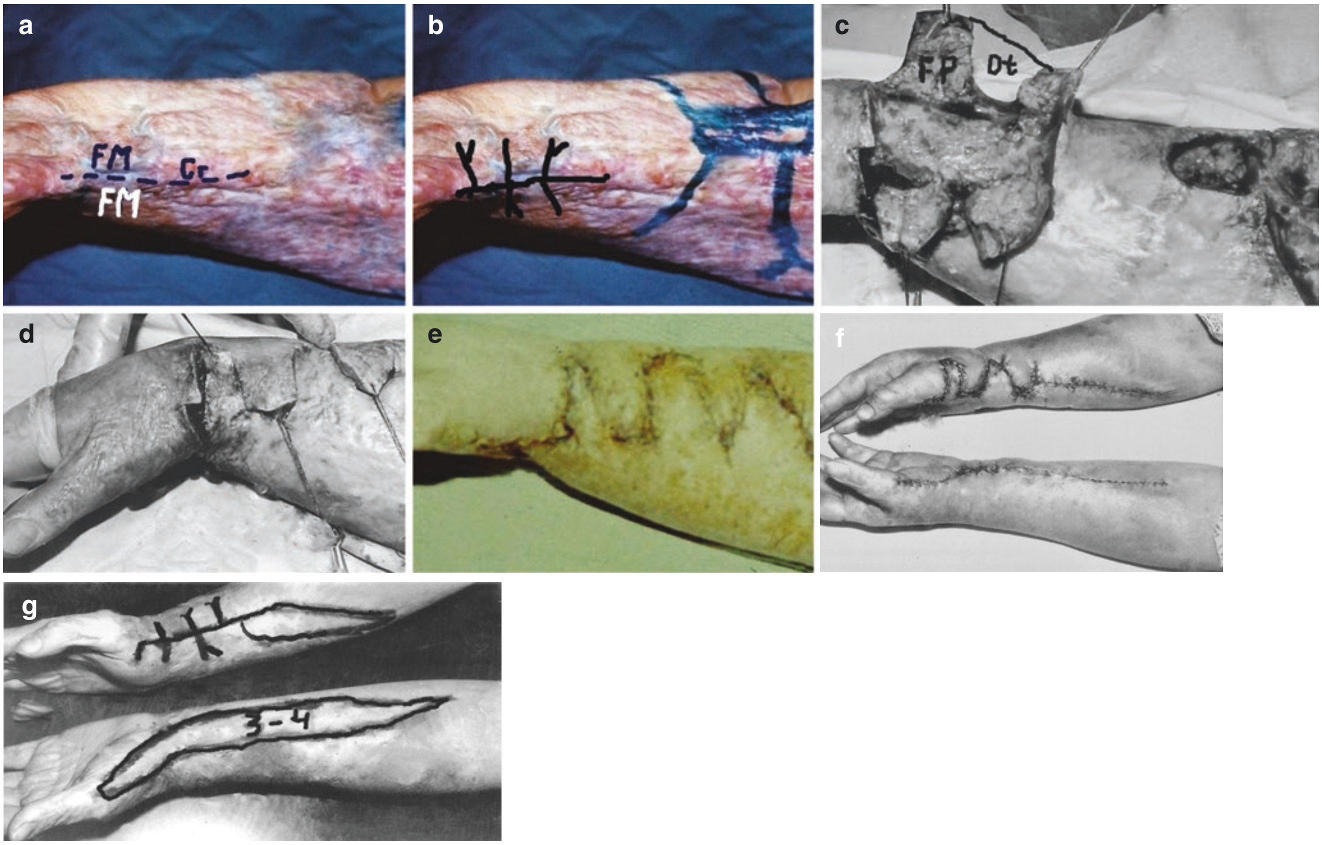

Fig. 26.3 Medial radial wrist treatment with two pairs of trapezoid flaps and edge elbow contracture elimination with trapeze-flap plasty. (**a**) Pre-surgery: severe medial contracture of the wrist, thumb, and hand deviation caused by scars covering flexion medial surface (*FM*); *Cr* crest of the fold; (**b**) planning two pairs of adipose-scar trapezoid flaps; (**c**) flaps mobilized; surface deficit (*Dt*) is equal to the space between the two mobilized flaps, has a trapezoid form, and is the real cause of the contracture; (**d**) flaps transposed one toward the other; (**e**) 2 weeks after reconstruction: no flap loss, no contracture; thumb, hand, and wrist accepted normal outlines. Case 2. Medial radial right wrist contracture elimination with two pairs of trapezoid adipose-scar flaps. (**f**) Planning of operation; (**g**) result (5 days after surgery). Deformed contracted scars on left wrist excised and wound primarily closed

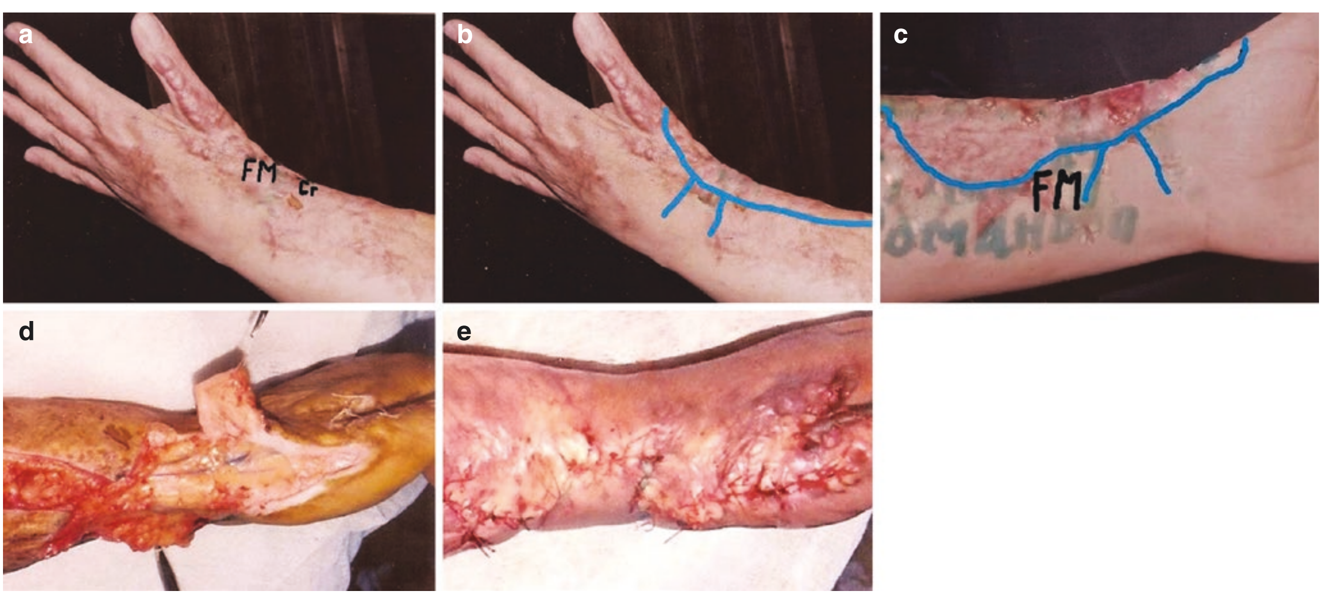

Fig. 26.4 Severe radial medial wrist contracture treatment caused immature ulcerous scars. (**a**) Pre-surgery: contracture caused by rough, thick, and ulcerous scars covered wrist radial flexion medial surface (*FM*). Scars formed a long and wide fold; *Cr* crest of the fold; (**b**, **c**) wrist's dorsal and palmar surfaces; marked scars to be excised and two trapezoid flaps; (**d**) scars excised and pair of adipose-scar trapezoid flaps mobilized; (**e**) flaps counter transposed and covered the wound of wrist joint, the wound beside the flaps primarily closed; contracture released (end of operation)

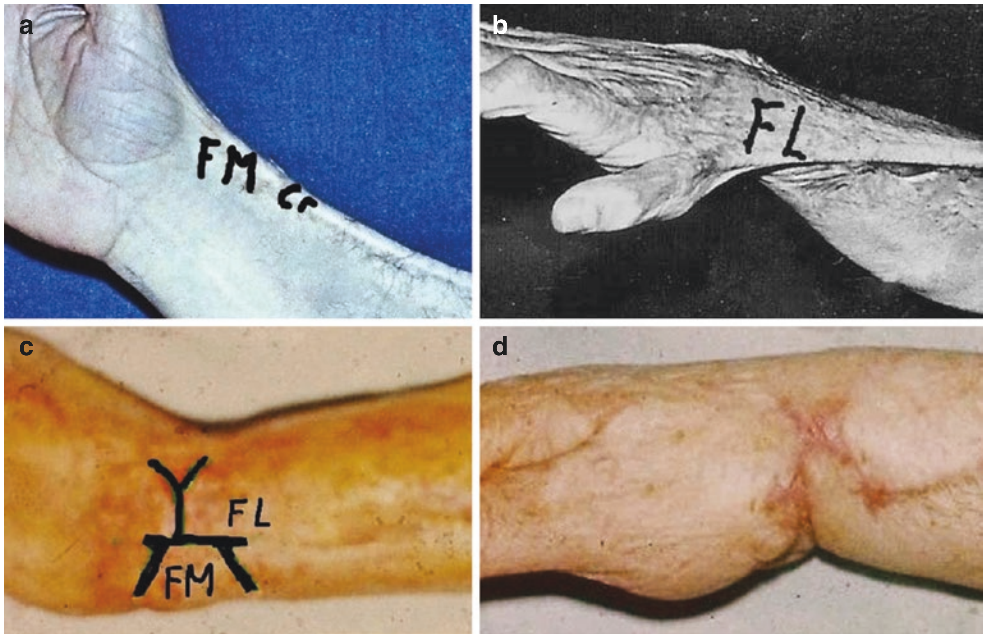

Fig. 26.5 Edge wrist contracture anatomy and elimination with trapezoid flap. (**a**, **b**) Pre-operation: contracture caused by the scars covering the dorsal surface of the wrist, hand, and arm; scars formed a long and wide fold, crest of the fold (*Cr*); the dorsa flexion lateral surface (*FL*), including the dorsal fold sheet, is scars; the palmar or flexion medial (*FM*) joint surface and palmar fold's sheet is healthy skin; (**c**) planning trapeze-flap plasty: Y-line for *FL*—scars on flexion lateral surface dissection; trapezoid flap planned on flexion medial surface (*FM*) or wrist palmar healthy tissues. (**d**) Contracture eliminated with one adipose-cutaneous trapezoid flap, normal joint's form and function

Surgical Techniques for Medial Wrist Contracture (Hand Deviation) Elimination

The fold's presence and the surface's surplus in scar sheets allow reconstruction using local tissue flaps (Figs. 26.1, 26.2, 26.3 and 26.4) [1]. The planning consists of the following: a line along the fold's crest and several radial or perpendicular Y-lines, which are the edges of trapezoid flaps. In all cases the fold has a semilunar/crescent form and, therefore, the radial line marks trapezoid figures. Scar surface deficit is maximal at the fold's crest and then subsides, eliminating the sheet's surface deficiency (real contracture cause) in length, the deficiency has a trapezoid form (Fig. 26.1d). Depending on the fold's length, one or several pairs of trapezoid flaps are planned. The flap's end is located at the top (crest) of the fold; the flap's base is situated on the back and palmar wrist surfaces. The optimal distance between radial lines at the fold's top equals 3 cm; this distance matches the width of the flap's end. The flap's base is wider than the top because of the semilunar shape of the fold.

The sheets of the fold are first separated by one incision along the fold's crest. Following the contoured lines, the radial Y-incisions convert both semilunar sheets into trapeze-shaped flaps. The scar and fat layer incisions are extended toward the back and the palmar surface of the wrist until the scar tension is fully released and the hand and the fifth finger and the thumb reach a normal position. The incision's ends are split (Y-incision) to completely eliminate the scar tension and divergence of wound borders (Fig. 26.3). The flaps are mobilized with the full fat layer (trapezoid adipose-scar flaps) and transposed toward each other with tension application until the flap end reaches the base of the opposing flap (Fig. 26.2f). Because of the tension, the bases of the opposite flaps come closer; the skin of the back and palmar surfaces of the wrist are displaced, partially covering the wound. The soft tissues are squeezed because of existing flap tension. As a result, the wound becomes narrower; the surface of the wound is decreased significantly, which enables the surgeon to close the wound with the opposite flap's transposition. Because of the counter transposition of the flaps, the flaps' middles correspond to the central wrist border line or the zone of maximal tension. This means that the plasty zone doubles, at least, in length. This allows full contracture elimination with only flaps; neither skin-grafting nor pedicle flaps are needed. The gain rate equals the sum of all flaps' width in their middle, minus the length of the fold's crest involved in plasty.

Medial wrist contractures are eliminated with one (Fig. 26.2a, b), two (Fig. 26.3b, c), or three pairs (Fig. 26.1) of adipose scar trapezoid flaps, depending on contracture severity, fold length, and neighboring joints involved.

Ulcerous scars of medial contractures on the fold's crest are excised, and reconstruction is carried out with counter transposition of the adipose scar trapezoid flaps (Fig. 26.4).

Edge Wrist Scar Contracture

Reconstruction of Edge Wrist Contracture (Fig. 26.5)

The reconstruction is accomplished with the technique used for the edge contracture release of the other location. The sheets are divided, the contracture is released with a Y-incision of the scar sheet, and the trapezoid wound (scar surface deficit) that appears is covered with the adipose-cutaneous trapezoid flap prepared from the healthy skin of the sheet and wrist per se, or in combination with adipose-scar trapezoid flaps taken from the fold's scar sheets (Fig. 26.5c, d).

Total Wrist Scar Contractures

Anatomy and Reconstruction (Figs. 26.6 and 26.7)

Vast and deep burns of the upper limb result in the formation of circular scars that tightly surround the wrist joint without fold and scar surface surplus. With time, the scars can become rough, thick, and painful, causing disability. Restriction of motion of the hand and the scars' deformity of the upper limb indicate the need for reconstruction after scar maturation. If the scars are cosmetically acceptable, the contracture is released with an incision only (Fig. 26.6); rough keloid scars should be widely excised (Fig. 26.7). In both cases, the wound is resurfaced with whole split skin transplants. Because the wrist at rest is in a straight position, the shrinkage of the skin grafts is minimal and the results, both functional and cosmetic, are good. After the reconstruction, a common gutter splint supports the hand in a straightened position; it is used for 2–4 weeks. Skin transplants are transformed in normal skin functionally and cosmetically.

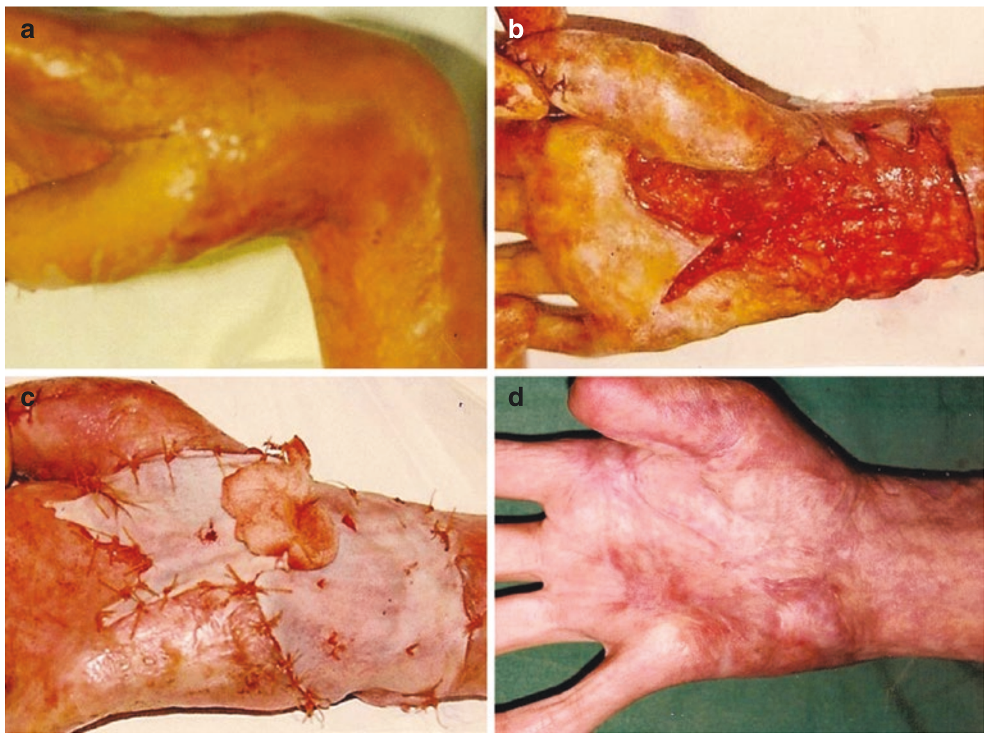

Fig. 26.6 Severe wrist flexion contracture treatment by contracted scars dissection in different directions and skin grafting. (**a**) Pre-surgery; (**b**) scars dissected and contracture released; the wound is scar surface deficit; (**c**) the wound is covered with skin transplant; (**d**) follow-up result: good functional and cosmetic outcomes

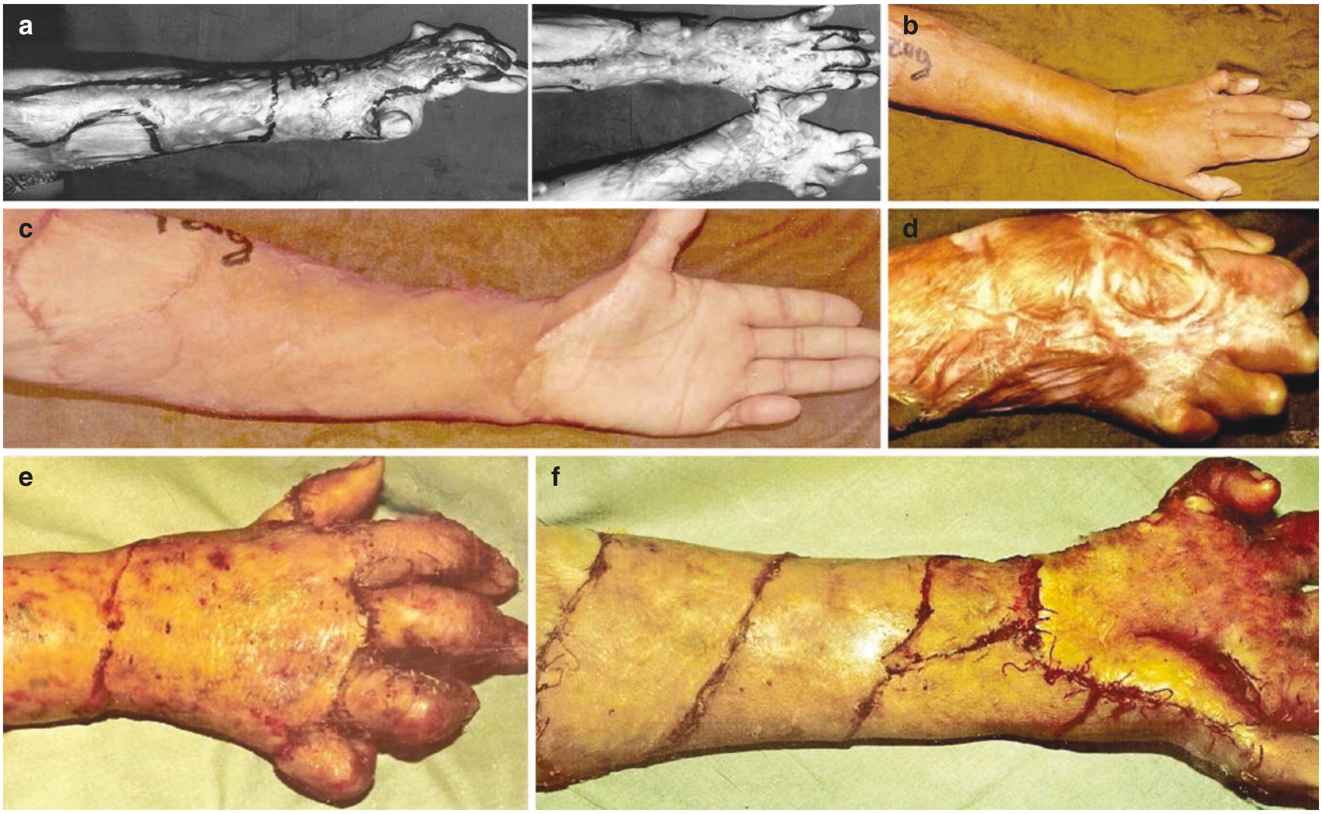

Fig. 26.7 Both wrist contractures caused by circular keloid scars and eliminated with scar excision through intermediate scar layer and skin grafting. (**a**–**c**) Before surgery, left wrist: rough thick keloid scars, circularly surrounding wrists and hands, removed; wrist and hand restored, 1 year after surgery; (fifth finger's PIP joint damaged). (**d**–**f**) Right hand: scars excised through intermediate layer, interdigital commissures and first web spaces and commissural fossa restored with adipose-cutaneous trapezoid flaps taken from interdigital fossa; wounds of the wrist and hands resurfaced with whole skin transplants (10 days after surgery)

Conclusion

Using trapeze-flap plasty, the medial and edge wrist scar contractures caused by a scar's fold located on the ulnar and radial borders of the wrist are eliminated completely. The trapezoid wounds appear after contracted scars are dissected with Y-incisions; wounds are fully closed, and the scar surface deficit is compensated by the counter transposition of trapezoid flaps prepared from the fold's sheets and neighboring healthy skin (edge contracture). The adipose-scar flaps have stable blood circulation, which prevents tissue necrosis and other postoperative complications; the flap's surface does not decrease, and no contracture recurs. Total wrist contracture is released with two methods: Contracture release with scars' incisions and skin grafting (Fig. 26.6); but wide rough scar excision through intermediate layer and wound resurfacing with wide split skin transplants, placed transversely (Fig. 26.7), is cosmetically acceptable.

Reference

1. Grishkevich VM. Postburn hand border contractures and eliminating them with trapeze-flap plasty. J Burn Care Res. 2010;31:286–91.

First Web Space Postburn Scar Contractures: Anatomy and Elimination with Local Trapezoid Flaps

27

Introduction

First web space contractures commonly occur in dorsal, palmar, and total hand burns and can significantly affect overall hand function because thumb abduction and opposition are either impaired or lost. The functional deficiencies include loss of grasp and loss of key pinch. A first web space adduction contracture justifies surgical intervention. Despite the abundance of surgical methods, the problem of reconstruction of the first web space has not been solved. No comparative studies have reviewed the effectiveness of various methods of reconstruction. Based on our personal clinical observations, we identified the three basic anatomical types of thumb adduction contractures and developed methods of reconstruction for each type. With the use of these plasty methods, all web space scar contractures can be eliminated completely and definitively.

Basic Types of Thumb Adduction Contractures

The three anatomical types of web space contractures can be categorized as *edge* (dorsal and palmar), *medial*, and *total contracture*.

Edge adduction contractures often develop in patients who have sustained either dorsal (Fig. 27.1a) or palmar hand burns (Fig. 27.1b). A crescent-shaped fold forms along the dorsal or palmar edge of the web space dip. The lateral sheet (in relation to web space dip) of the fold is scarred; the medial sheet and web space are healthy skin. The contracture is caused only by the scar's sheet because of a scar surface deficit in length that is present between the first and second metacarpals and the second metacarpal and the proximal phalange of the thumb. The scar sheet surface deficiency spreads from the fold's crest to the trapeziometacarpal joint level. The scar sheet length deficiency has a trapezoid shape (Fig. 27.2b, c). The scar sheets have a surface surplus in width. The presence of the fold allows contracture elimination using local flaps (Figs. 27.2d–f and 27.3a–c).

Medial adduction contracture develops in patients who have sustained burns of the first web space fossa (Fig. 27.1c). As a result, a crescent fold is formed at the medial part (center) of the web space, bringing the thumb and the second metacarpal together. Both sheets of the fold are scars with a surface deficiency in length and surface surplus in width. The scar sheet surface deficiency spreads from the fold's top to the trapeziometacarpal joint level. The scar sheet length deficiency has a trapezoid shape and has a surface surplus in its width. The presence of the fold allows contracture to be eliminated by using local flaps.

Total thumb adduction contracture (Fig. 27.1d) is always severe and develops in cases of extensive deep hand burns. The scars brings the thumb and the second metacarpal together and replace the web space. The web space is either eliminated completely or is very shallow. The fold is not formed. Besides the thumb adduction, the first web space,

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as a rule, is shallow and deformed in all contracture types, mostly in medial and total contractures. Therefore, the web space resurfacing can be achieved by compensating the scar deficiency and restoring the web space depth and contour. It is necessary to consider that the thumb assumes the adduction contracture position when at rest. Therefore, the first web space is prone to re-contracture after skin grafting.

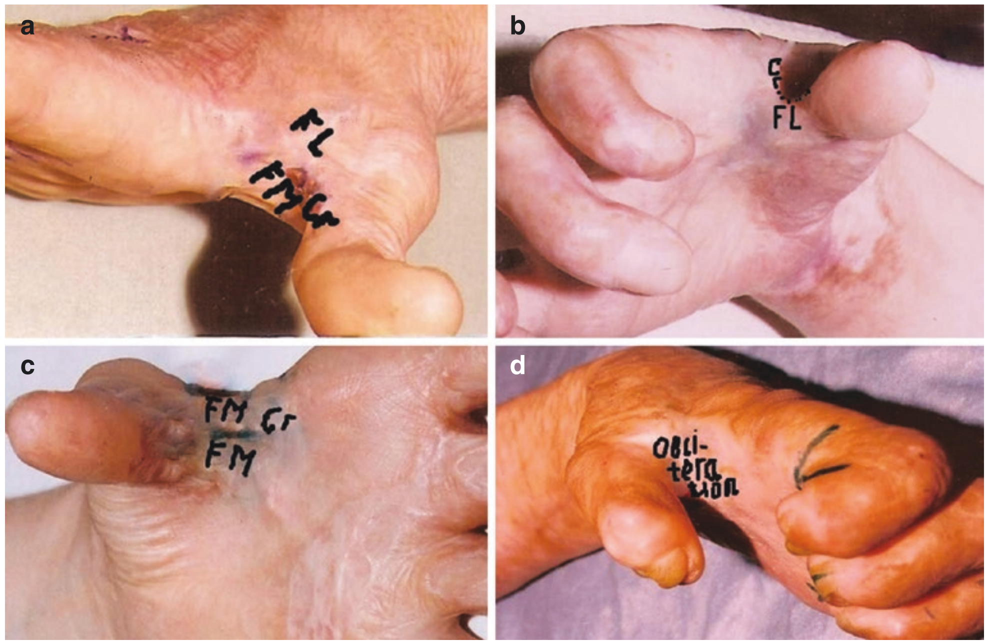

Fig. 27.1 Three basic types of web space (thumb) contractures: (**a**, dorsal) and (**b**, palmar) edge contractures caused by semilunar fold in which one sheet (*FL*) is scarred, and the other (*FM*) is healthy skin; (**c**) medial contracture caused by FM scar's fold in which both sheets are scars; (**d**) total adduction contracture without a fold. Different local flap plasty methods are planned: trapezoid flap for edge and medial contracture, subdermal pedicle flap for total web space contracture

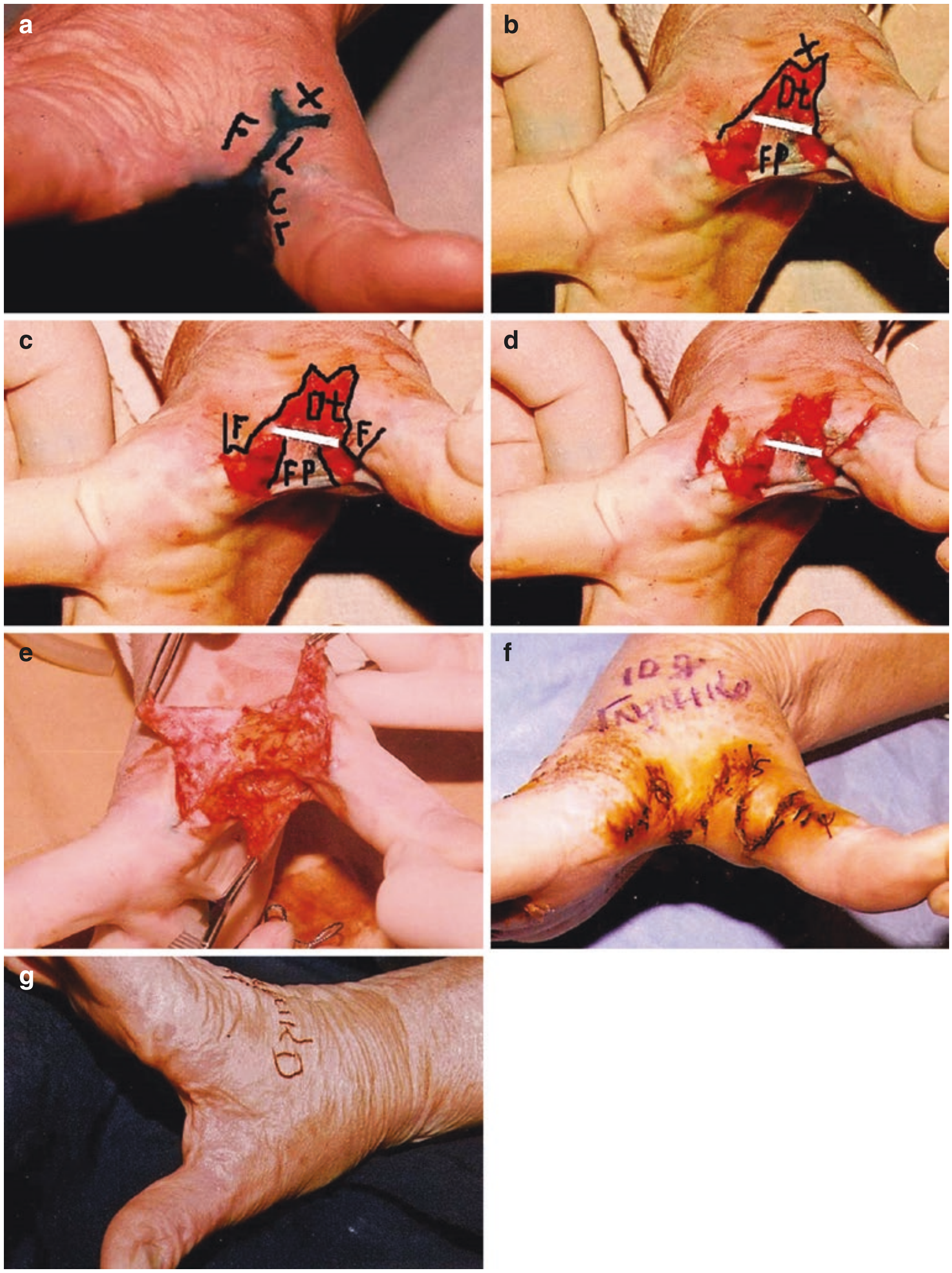

Fig. 27.2 Edge adduction contracture of first finger elimination with three-flap trapeze-flap plasty. (**a**) Edge dorsal adduction contracture, *FL*—scar fold's sheet and flexion lateral surface; planning operation with one trapezoid flap, Y-line for scars dissection; *Cr*—crest of the fold; (**b**) contracture released, trapezoid wound or scar surface deficit (*Dt*) appeared (upper of white strip); one flap (*Fp*) was insufficient for scar surface deficit compensation; (**c**, **d**) two additional adipose-scar trapezoid flaps elevated from the scar sheet; (**e**) three trapezoid flaps mobilized; (**f**) 10 days after surgery, flaps are alive, contracture is released; (**g**) 3 years after surgery; (**h**) trapeze-flap plasty variants for dorsal edge web space contractures (scheme): ($\mathbf{h_a}$) one-trapeze-flap plasty; ($\mathbf{h_b}$) three-trapeze-flap plasty; ($\mathbf{h_c}$, $\mathbf{h_d}$) combined trapeze-flap plasty (one flap and skin grafts)

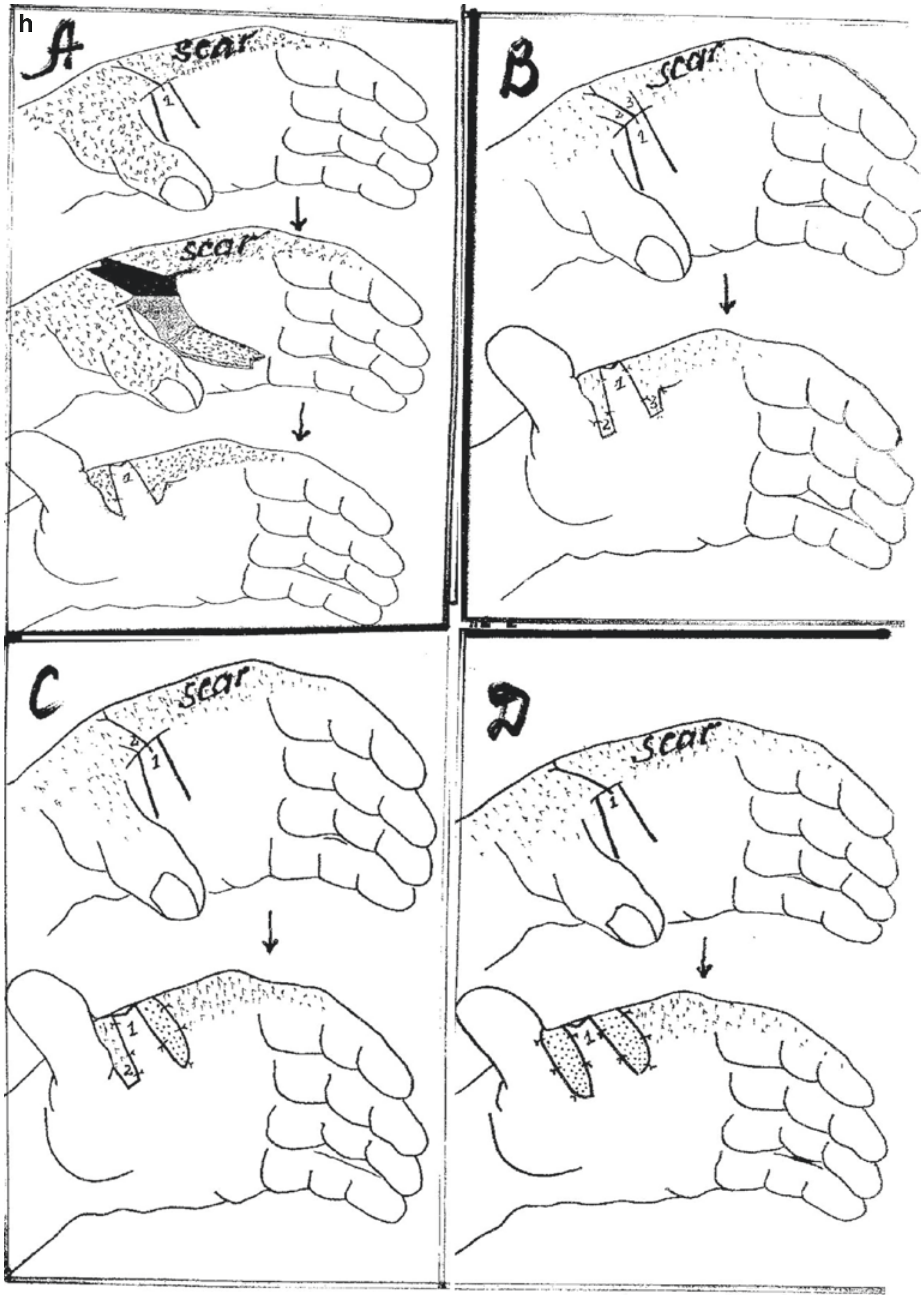

Fig 27.2 (continued)

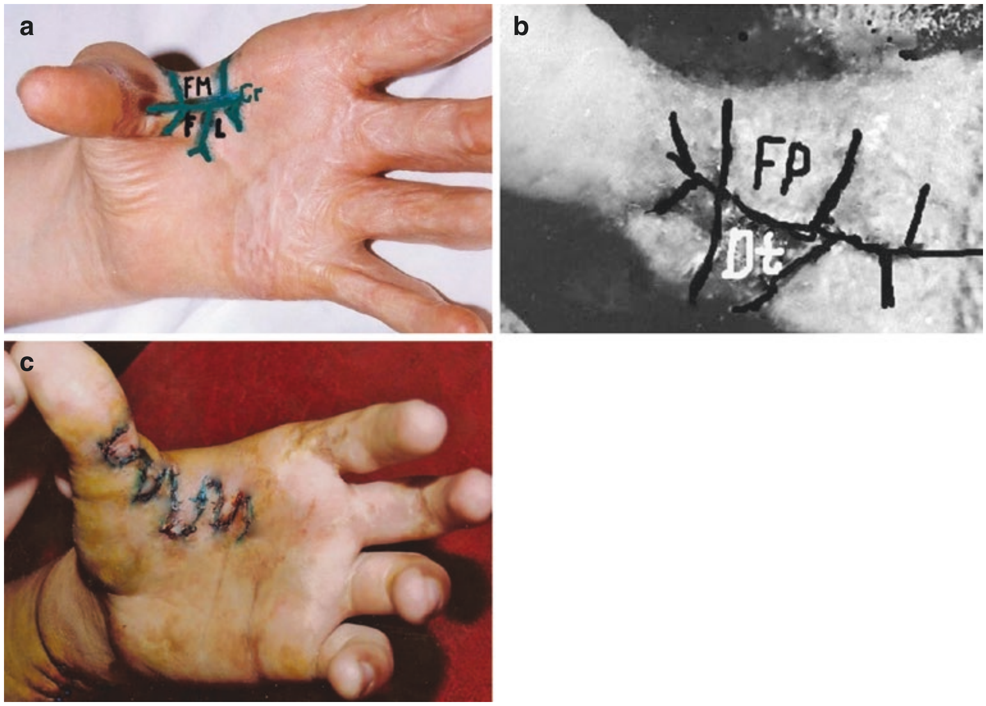

Fig. 27.3 Palmar edge adduction contracture treatment with trapezoid flaps. (**a**) Before operation, planning three-flap plasty; contracture anatomy: *FL* scar flexion lateral surface and fold's sheet; *FM* flexion medial surface fold's sheet is healthy skin; *Cr* crest of the fold; Y-line for contracted scars dissection; (**b**) scars sheet dissected with the Y-shaped radial incisions, large trapezoid wound or *Dt*—scar surface deficit and contracture cause appeared; *Fp*—main flap from FM surface is healthy skin; additional flaps planned; (**c**) eight trapezoid adipose-cutaneous and adipose-scar flaps mobilized, counter transposed and contracture released in full (10 days after reconstruction); (**d**) variants of trapeze-flap plasty for palmar edge contracture treatment (scheme): ($\mathbf{d_a}$, $\mathbf{d_b}$) one- and multiple-flap plasty; ($\mathbf{d_c}$, $\mathbf{d_d}$) combined techniques

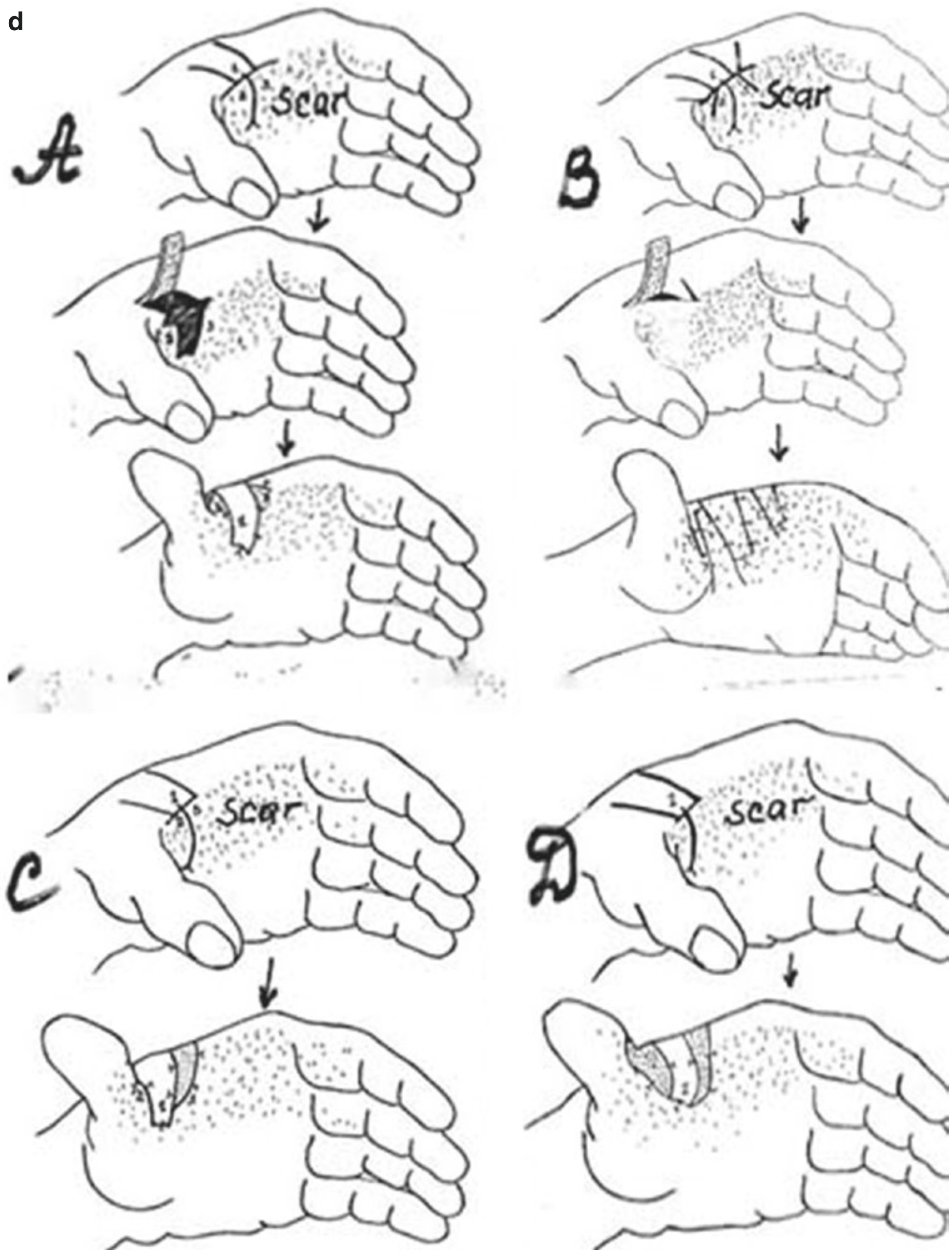

Fig 27.3 (continued)

Three Technique Types of Adduction Contractures Elimination [1]

Edge Contractures Management (Figs. 27.2 and 27.3)

Mild-to-moderate edge contracture is eliminated with three trapezoid flaps. The method consists of the compensation of trapeze-shaped scar sheet surface deficit by an adipose-cutaneous trapezoid flap, prepared from the healthy contralateral fold sheet and web space tissues. With the incision along the fold's crest the sheets are separated. The scar sheets and the fat layer are dissected perpendicularly with a Y-incision from the top of the fold to the level of the trapeziometacarpal joint on the hand's dorsal or palmar surface. The end of the incision is split (Y-shaped) to achieve a better divergence of the wound borders. The thumb and the first metacarpal are fully abducted. As a rule, a trapeze-shaped wound is formed (Figs. 27.2a and 27.3b). A similar trapezoid adipose-cutaneous flap, wider than the wound by 20–50%, is prepared from the medial sheet and web space tissues. The flap is transposed on a wound with tension; due to flap traction, the palm skin is displaced and covers part of the donor wound. Small donor wounds of one or both sides of the main transposed flap are covered with trapezoid adipose-scar flaps that are prepared from the scar sheet (Fig. 27.2c–e). The palmar edge thumb adduction contracture is eliminated by the same trapeze-flap plasty. The adipose cutaneous trapezoid flap is elevated from the healthy skin of the medial sheet and web space/fossa (Fig. 27.3). The flap is transposed on the trapeze-shaped wound in the zone of scar sheet dissection; therefore, the scar sheet deficit is compensated for and the contracture is fully eliminated. The donor wound is covered with healthy skin displaced from the hand's dorsum surface, or with small adipose-scar trapezoid flaps prepared from the scar sheet (Fig. 27.3a–c). The edge contracture is released with some over-correction.

Medial Contracture Management (Figs. 27.4 and 27.5)

The fold's scar sheets are separated by an incision along the fold's crest. The fold sheets are transformed into flaps by radial Y-incisions on all their extents, forming trapezoid wounds. Because the fold has a crescent shape, the flaps accept a trapezoid shape as well (Fig. 27.4a, b). The flaps are elevated with the fat layer. When the contracture is mild and the fold is short, only one pair of flaps is mobilized. If the adduction contracture and scar surface deficit are severe and the fold is long, several flap pairs are elevated. The base of the central pair of flaps is located near the trapeziometacarpal joint level, creating over-correction. Then, the thumb and first metacarpal are abducted to the normal position. The web space deepens due to the dissection of soft tissues, and, if necessary, the fascia of the adductor and first dorsal interosseous muscles are also dissected. The oppositely located flaps are transposed toward each other with moderate tension (Fig. 27.4c). The central pair is transposed first. As a result, the web space accepts a normal depth and contours. In cases of severe contractures and scar surface deficit, the fold is short, and only one pair of flaps can be elevated. With the counter flaps transposition, the central part of the web space is formed (Fig. 27.5a–c). The remaining small wounds are to be skin-grafted. Counter transposed adipose-scar trapezoid flaps with tension make deeper and suspend first web space with over correction, preserve skin transplants from shrinkage and contracture recurrence.

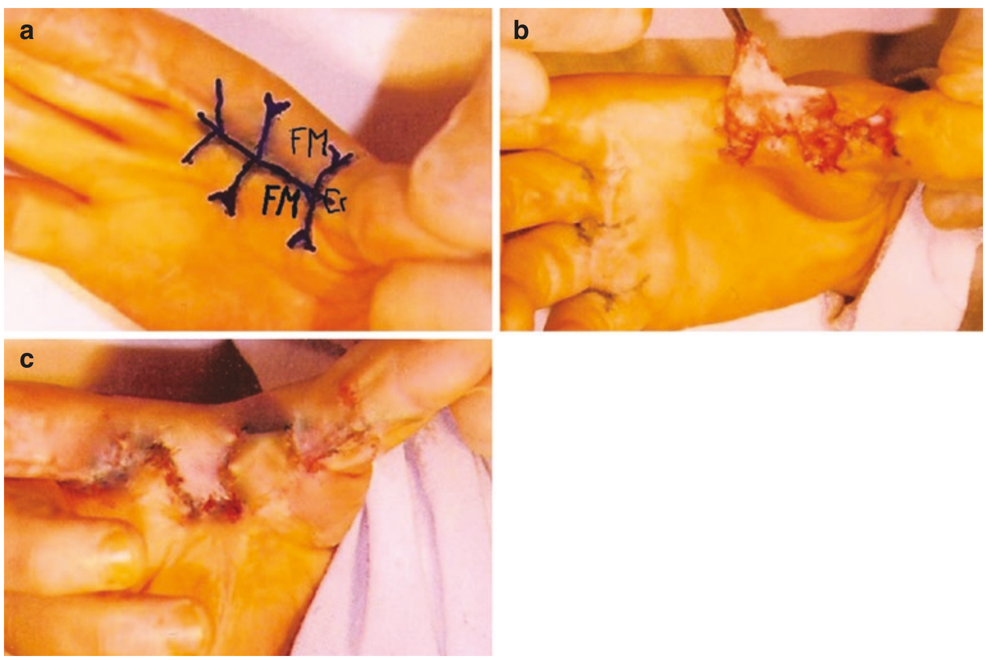

Fig. 27.4 Medial adduction contracture elimination with trapeze-flap plasty. (**a**) Scars at first web space, the fold formed, both fold's sheets are scars. Two pairs of trapezoid adipose-scar flap planned from fold's sheets and flexion medial surface (*FM*); crest of the fold (Cr); (**b**) fold with Y-incisions dissected, trapezoid flaps and wounds appeared; flaps mobilized; (**c**) counter transposed flaps scar surface deficit compensated and contracture eliminated; (**d**) variants of contracture release with flaps per se ($\mathbf{d_a}$, $\mathbf{d_b}$) and in combination with skin grafts (scheme)

d

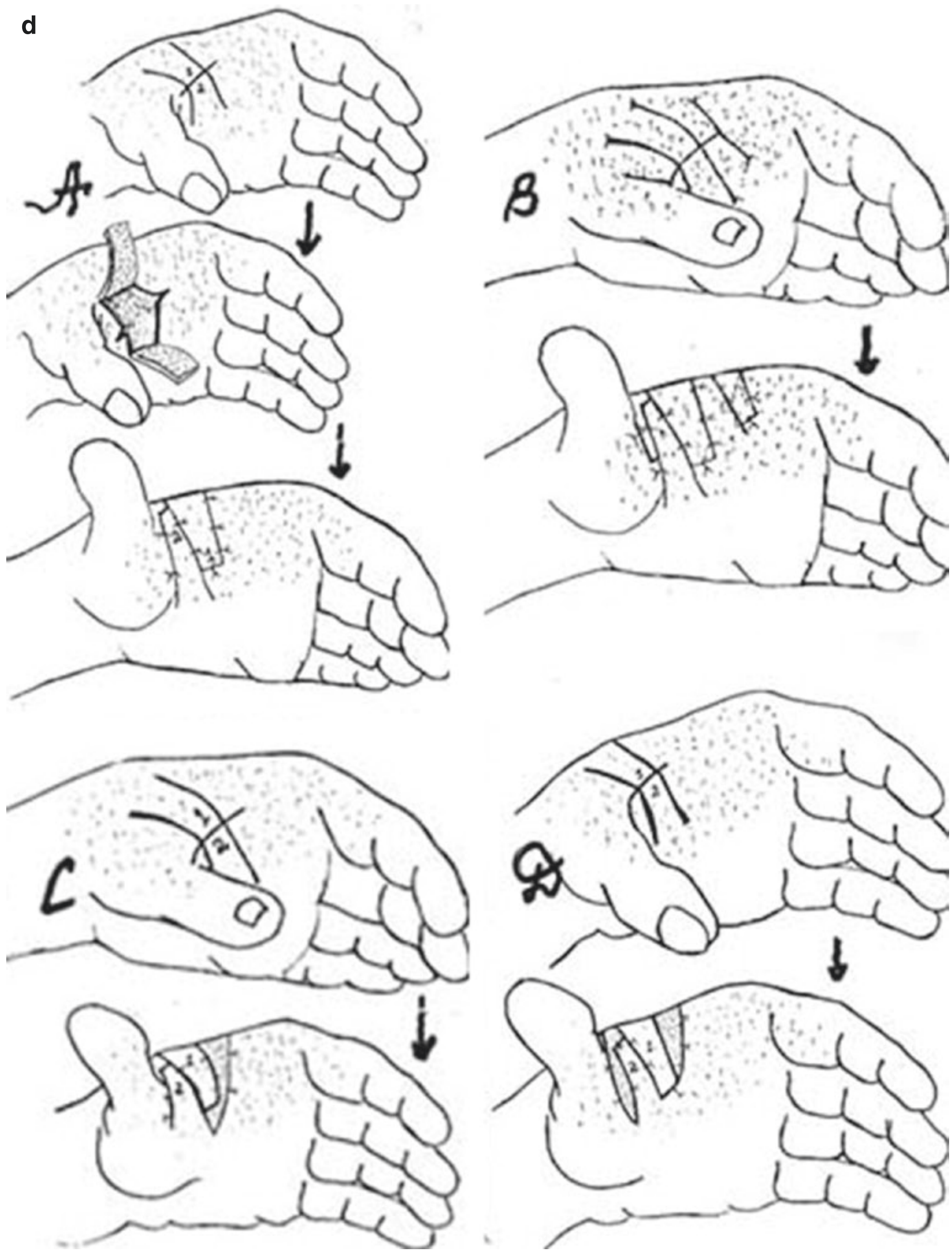

Fig 27.4 (continued)

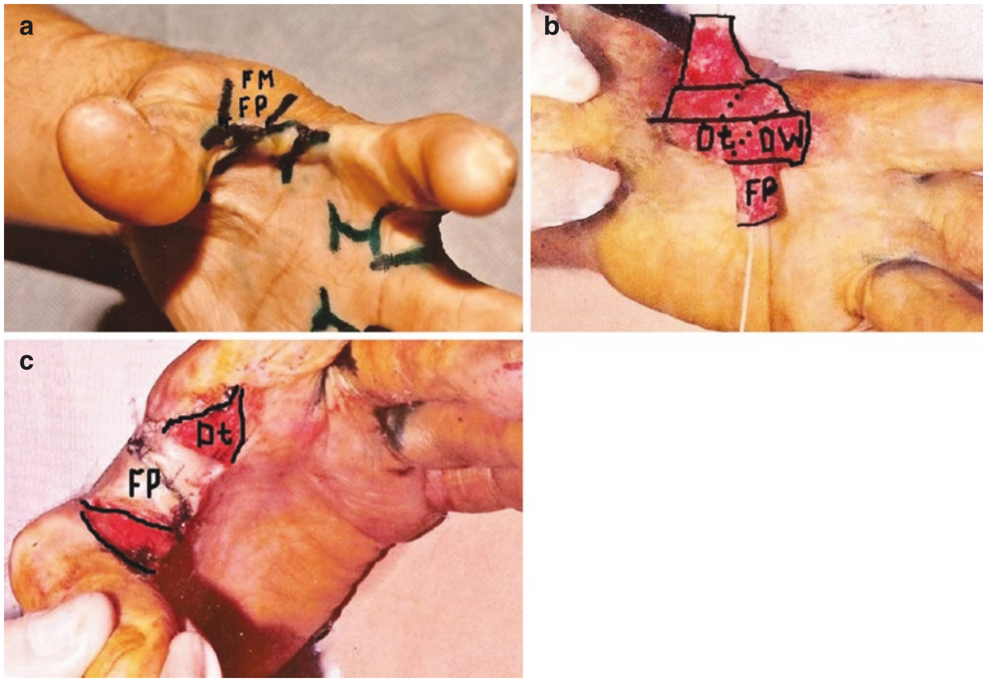

Fig. 27.5 Severe medial adduction contracture release with trapezoid flaps and skin grafts. (**a**) Contracture caused with scars covered all first FM surface or web space; scars formed a fold in the central zone; both fold's sheets are scars. One pair of trapezoid flaps (*FP*) planned; (**b**) trapezoid adipose-scar flaps mobilized; large wound appeared, which consists of two parts (between strips) according to two sheets of the fold; half of the wound consists of scar surface deficit (*Dt*) and donor wound (*DW*); scar surface deficit equals surface of all wound minus surface of both flaps; (**c**) counter-transposed flaps formed at the bottom of the web space, compensated part of scar surface deficit; wounds beside the flaps present the real contracture cause and are covered with a skin transplant; (**d**) scheme of medial mild-to-severe adduction contractures elimination with flaps ($\mathbf{d_a}$, $\mathbf{d_b}$) and in combination with skin transplants ($\mathbf{d_c}$, $\mathbf{d_d}$)

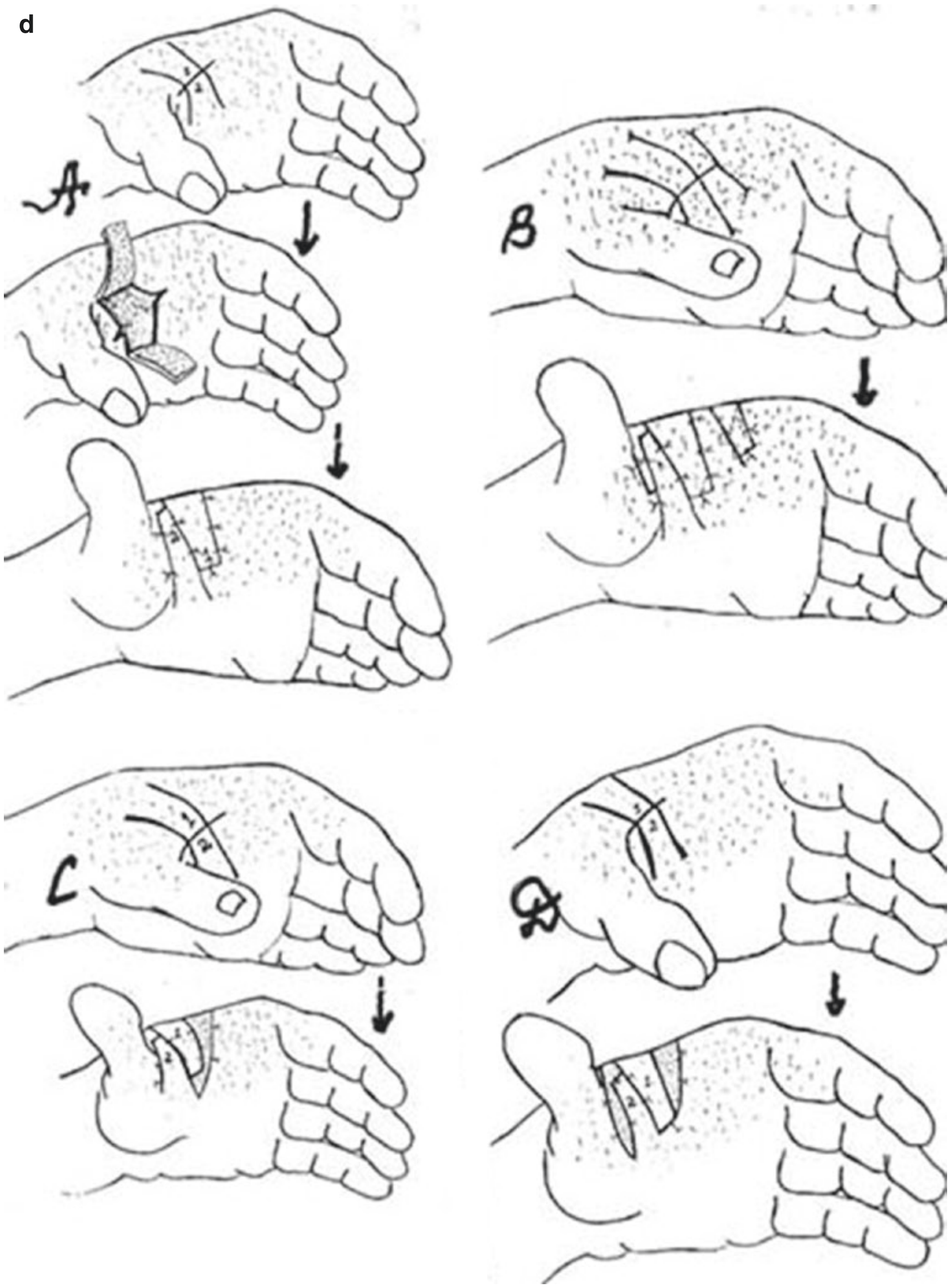

Fig 27.5 (continued)

Total Thumb Adduction Contracture Elimination (Figs. 27.6 and 27.7)

Reconstruction consists of the web space contracture release and the bottom depth formation with the local quadrangular scar subcutaneous pedicle flap (Fig. 27.6). The contracture is eliminated with the incision of scars around the flap, and dorsal and palmar web space surface up to the trapeziometacarpal joint level. The flap is displaced over the web space bottom (Fig. 27.6b, c). After the thumb and first metacarpal abduction, the flap's ends are connected to the wound edges on the dorsal and palmar surfaces of the hand. The flap suspends the web space level in a normal position, preventing contracture recurrence. The wounds on both sides of the flap are skin-grafted. Suspending the first web space in a normal level flap also prevents shrinkage of skin transplants. No special splinting is required. Reconstruction with quadrangular flap and skin grafts allows for restoration of very severe thumb adduction in children (Fig. 27.7).

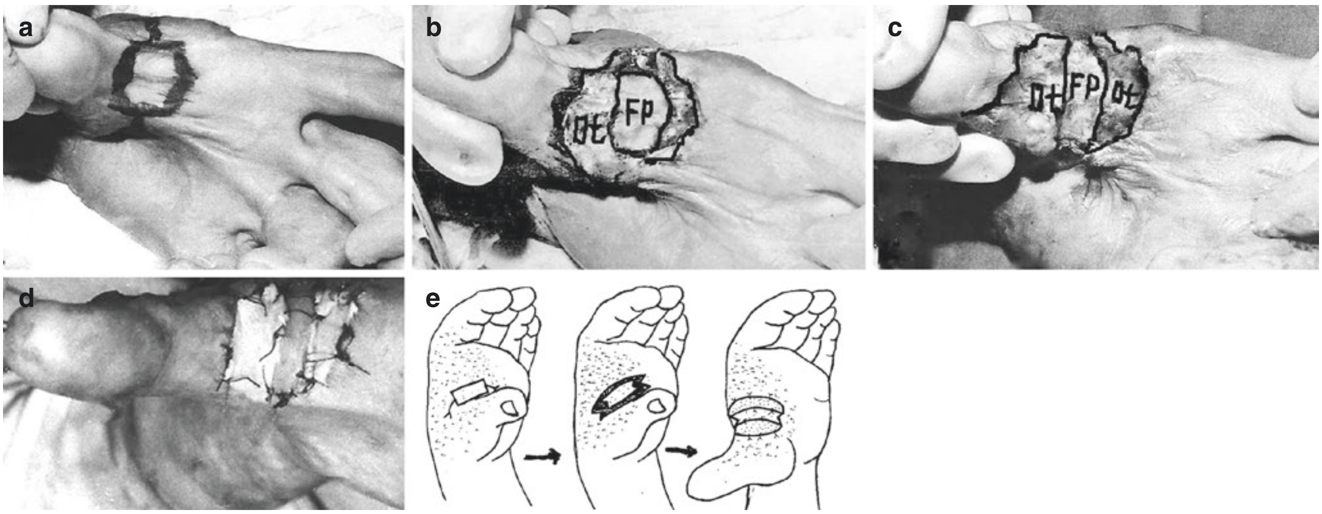

Fig. 27.6 Total first web space contracture treatment with quadrangular scar subcutaneous pedicle flap and skin grafts. (**a**) Planning; (**b**) flap (*FP*) isolated from neighboring scars with incision, flap's borders mobilized from periphery and subcutaneous pedicle flap (*FP*) displaced at commissure bottom; (**c**) ends of the flap sutured with wound's edges anteriorly and posteriorly with tension; wounds beside the flap (*FP*) is *Dt* or *D*—scar surface deficit and cause of the contracture; (**d**) wounds covered with skin transplants; (**e**) scheme of the operation

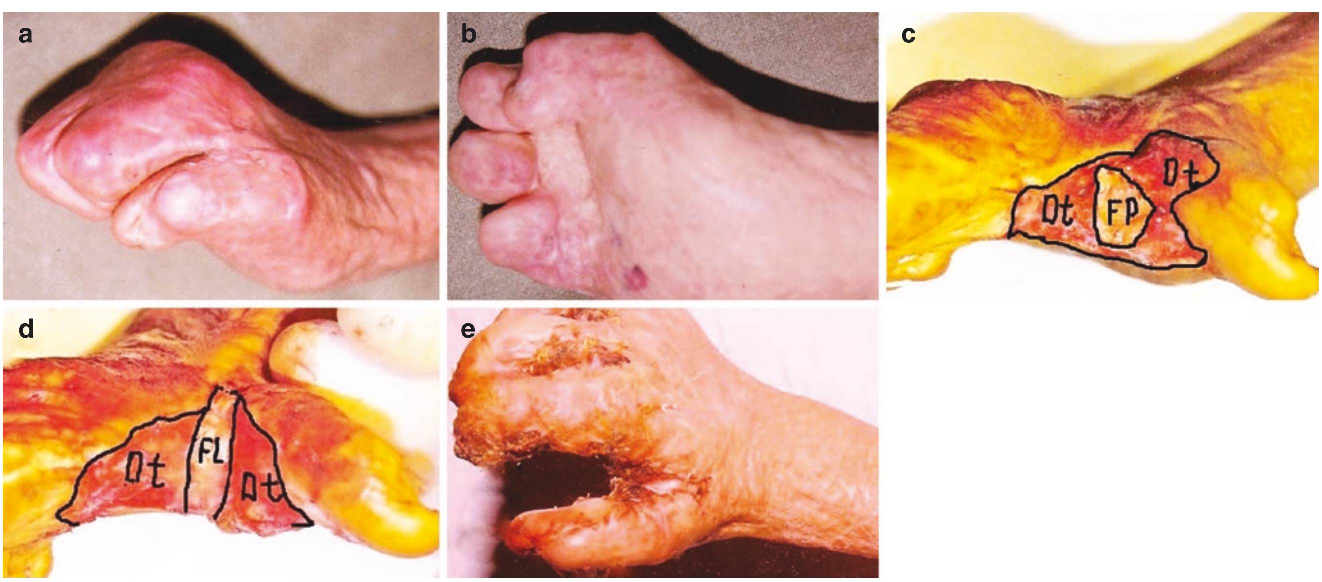

Fig. 27.7 Severe total first web adduction contracture treatment with scar quadrangular subcutaneous pedicle flap and skin grafts. (**a**, **b**) Preoperative view; (**c**) prepared subcutaneous pedicle flap (*FP*) displaced at commissural bottom, wound around the flap is *Dt*—scar surface deficit and contracture cause; (**d**) ends of the flap sutured with scar edges with tension; (**c**) wounds skin grafted, first web space restored

Dorsal Edge Thumb Adduction Contracture Treatment Is Part of Dorsal Hand Surface Resurfacing (Fig. 27.8)

A dorsal hand surface deformity is usually associated with the edge of the thumb adduction contracture, caused by the fold in which the lateral/dorsal sheet is scar tissue and the medial sheet and fossa are healthy skin. Reconstruction in such cases consists of a wide scar excision, including the first web lateral/dorsal scar sheet of the fold. The dorsal edge of the web space is restored with the trapezoid adipose-cutaneous flap prepared from the healthy medial fold sheet and the first web fossa (Fig. 27.8a, b). The flap's end is fixed to wound tissues with 2–3 catgut sutures. The flap restores the depth of the first web space, web space contours, and prevents skin transplants shrinkage and re-contracture after skin grafting.

Follow-up results of the first web space reconstruction with trapeze-flap plasty is shown in Fig. 27.9.

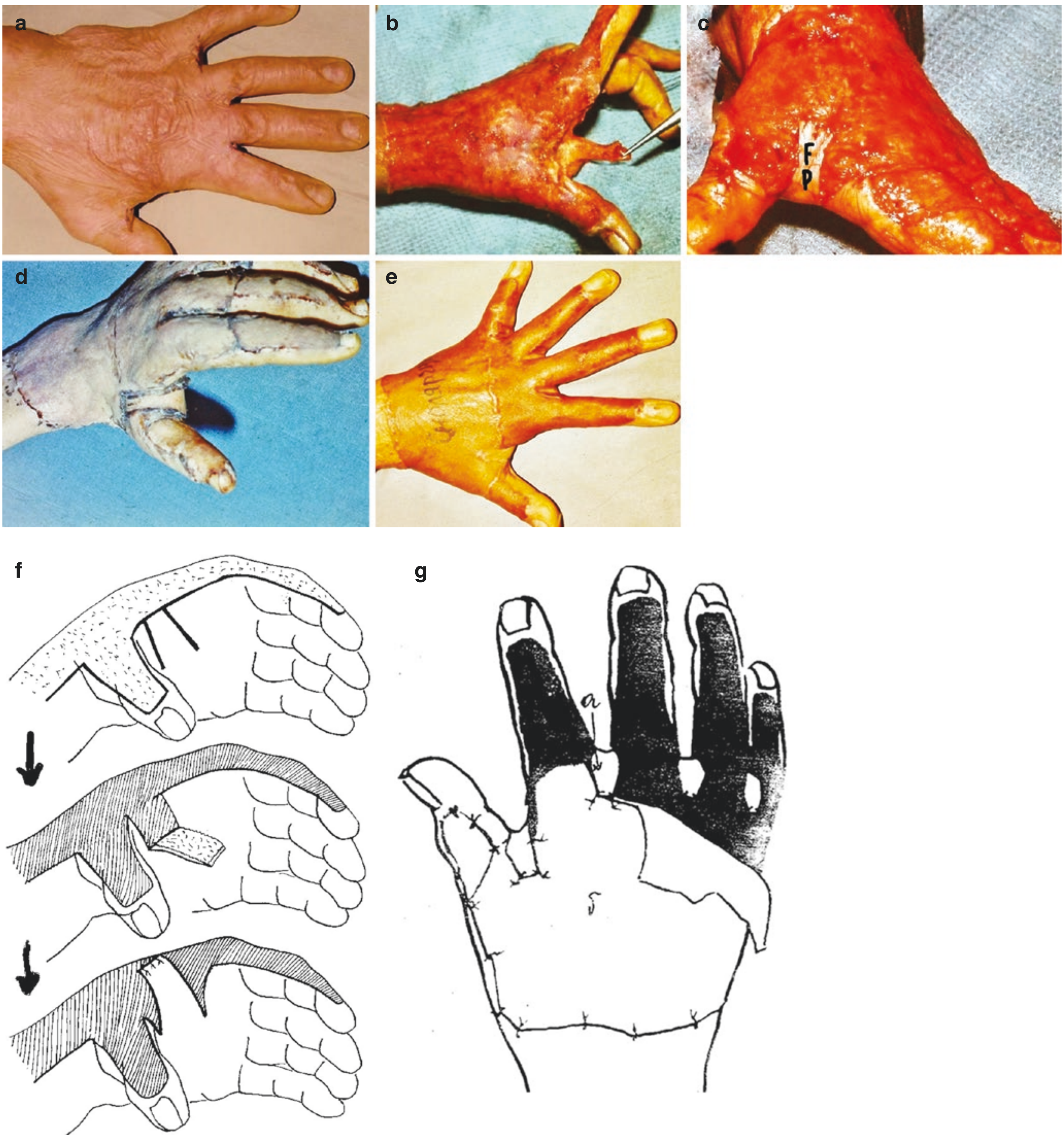

Fig. 27.8 First web space contracture release as part of hand dorsum resurfacing. (**a**) Pre-surgery: scars deformity of dorsal left hand, edge dorsal syndactyly and first web space adduction contracture; (**b**) scars excised through intermediate layer without bleeding, trapezoid flap mobilized from first web space; (**c**) flap's end fixated to dorsal hand tissue with catgut threads; (**d**, **e**) 10 days and 1 year after surgery, respectively; (**f**, **g**) scheme of reconstruction

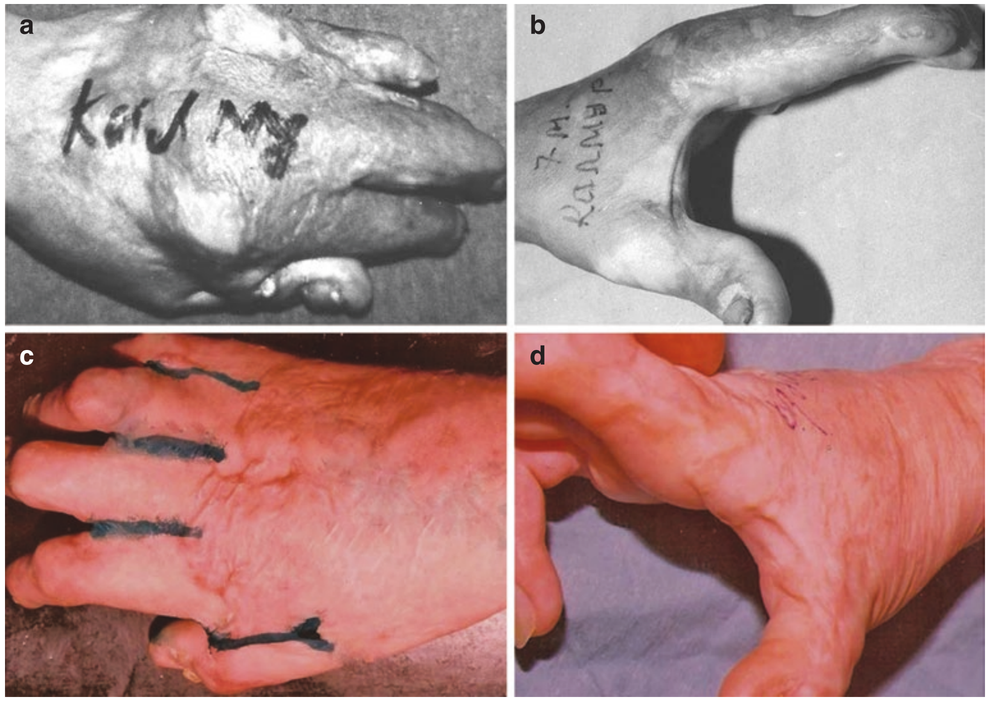

Fig. 27.9 Follow-up results of severe adduction contractures elimination with trapezoid flaps in combination with skin grafts. (**a**, **b**) Case 1. (**c**, **d**) Case 2

Conclusion

Good results were achieved, as a rule: a full range of thumb abduction and its movements, and complete and definitive restoration of the web space. No re-operation was needed for any cases. The trapeze-flap plasty increases the length of the fold's top zone from 100 to 200%. Severe contractures, particularly total contractures, can be caused by injuries of the fascia that surround adduction and dorsal interosseous muscles, the first metacarpophalangeal joint, and the trapeziometacarpal joint. Even though the adduction was not completely liquidated during surgery, only contracted sheets of muscles need to be dissected. Daily living exercises accomplish full hand rehabilitation. No flap loss or other post-operative complications occur with the use of this technique. The flap's fixation to the depth of the web space with moderate tension for three weeks. Adipose-scar flaps and skin transplants did not shrink, their surface did not decrease, and everyday labor and pressure were well tolerated.

Reference

1. Grishkevich VM. First web space post-burn contracture types: contracture elimination methods. Burns. 2011;37:338–47.

28 Postburn Dorsal and Palmar Interdigital Scar Contractures: Anatomy and Treatment

Introduction

A frequent consequence of dorsal hand burns is the interdigital scar commissural contracture (syndactyly), characterized by a fold that forms along the edge of the interdigital fossa, smoothing and deforming the commissural groove and slant. Finger motion restriction and cosmetic defect are indications for surgery, most commonly performed in burn patients. Multiple reconstructive options exist to restore the interdigital space, but the optimal technique, producing perfect functional and good cosmetic (anatomic) results, is yet to be identified. Vast experience in this field allowed us to determine that commissural contractures can be classified into two types: edge dorsal and palmar, and total. Because the interdigital fossa is small, medial contracture cannot form. Interdigital contracture is caused by a scar surface deficit located on the hand's dorsal or palmar surface; that deficit has a trapezoid form and treatment is concluded with plasty with trapezoid flaps taken from interdigital fossa.

Anatomy of Dorsal Interdigital Edge Contractures: Formation, Anatomy, and Scar Surface Deficit as Contracture Cause

After studying the anatomy of several thousand scar syndactylies, the results of treatment that uses existing reconstructive techniques showed that (1) treatment of the interdigital commissural scar contractures is tangled; (2) contracture anatomical features are not researched sufficiently; and (3) the suggested techniques are far from perfect [1]. It is necessary, therefore, for research to continue, as the problem of a preferable technique choice persists.

Anatomy of Dorsal Commissural Contracture

Dorsal commissural contractures are the result of dorsal hand surface burns. At the time of the burns, the fingers adduct; therefore, half of the proximal interphalangeal space (groove and slant) is injured with the dorsal hand to the same degree. The fingers are adducted while the wound is healing; therefore, contracted inelastic scars cover nearly half of the interphalangeal space, smoothing and deforming the groove and slant and forming a crescent-shaped fold along the dorsal edge of interdigital fossa (Figs. 28.1a and 28.2a). The fossa between the metacarpal bone heads also becomes smoothed (Fig. 28.2b). The fold, as a hood, partially or fully covers the proximal half of the interdigital space (fossa). The lateral (dorsal) sheet (in relation to interdigital fossa) of the fold consists of scars and is the cause of the contracture because of surface deficiency (*Dt*) (Figs. 28.1c and 28.2c). The contracted scar's surface deficiency extends from the fold's crest (where it is maximal) to the metacarpal bone heads and has a trapezoid form (Figs. 28.1c and 28.2c). The medial fold's sheet is healthy skin that spreads over the interdigital undamaged fossa. The fold's crest is the edge of the scars. Thus, the dorsal commissural scar contracture is identified as the edge type, having four specific anatomical characteristics:

(a) scars cover the dorsal surface of the hand and the fold is formed;
(b) the fold passes along the dorsal interdigital fossa edge;
(c) the crescent-shaped fold consists of two distinctively different sheets: scar lateral (according to the interdigital fossa) and healthy skin medial sheet;
(d) the crest of the fold is the edge of scars.

These four clinico-anatomical features characterize the edge scar contractures regardless of their localization.

V. M. Grishkevich, M. Grishkevich, *Plastic and Reconstructive Surgery of Burns*,
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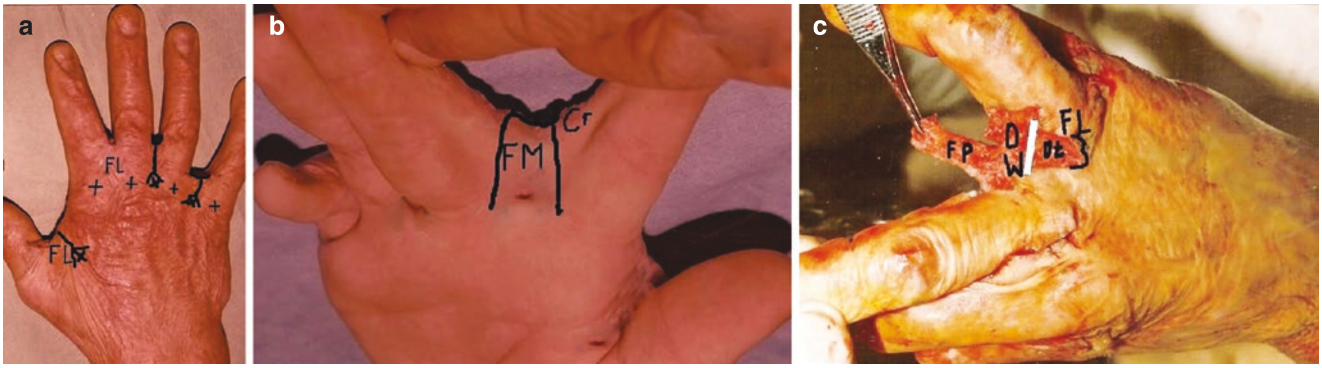

Fig. 28.1 Anatomy of postburn dorsal interdigital contracture (syndactyly). Case 1: (**a**) Dorsal edge interdigital scar contracture is caused by scars covering the dorsal hand; scars smoothed commissural groove and slant, formed fold along dorsal edge of interdigital fossa; in the fold, *FL*—lateral (dorsal) fold's sheet is scars; "+" symbol—heads of metacarpal bone's heads; Y-lines of contracted scars dissection; (**b**) palmar side: *FM* the medial sheet and fossa are healthy skin; *Cr* crest of the fold. Case 2: (**c**) After the dorsal fold's sheet dissection with Y-shaped incision from the fold's crest to the metacarpophalangeal joint, a trapezoid wound appeared, which is *Dt* scar surface deficit and cause of contracture; *FP* trapezoid flap mobilized, *DW* donor wound

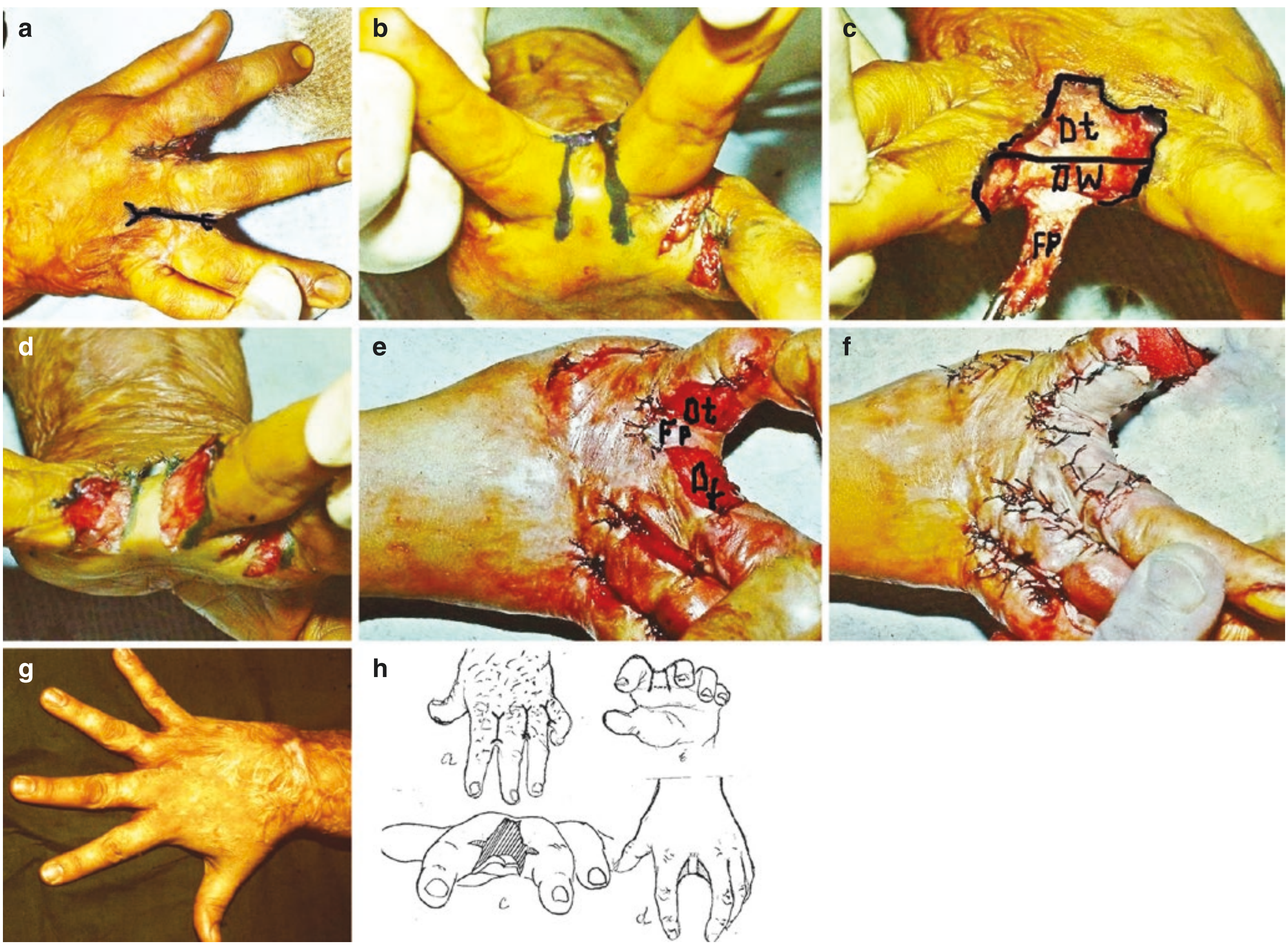

Fig. 28.2 Dorsal interdigital commissural contractures elimination with trapeze-flap plasty. (**a**, **b**) Pre-surgery, planning: Y-shaped line for contracture release from the fold's crest to the metacarpal bone heads; a line along fold's crest for sheets separation; two lines in the interdigital fossa are the flap's contours; palmar or FM fold's sheet, fossa and 2 mm of palm are healthy skin and included in the flap (*Fp*); (**c**) after scar sheet dissection and finger abduction, the wound or scar surface deficit (*Dt*) appeared in trapezoid form (above the white strip; lower, donor wound (DW); *FP* trapezoid adipose-cutaneous flap mobilized; *Dt* scar surface deficiency (cause of contracture) spreads from the fold's crest to the metacarpal bone heads; (**d**, **e**) flap (*Fp*) advanced on the wound with tension and sutured with border of scars, forming the groove and slant; donor wounds on the lateral surfaces of proximal phalanges appeared, which were split skin grafted; (**f**) flap (*Fp*), deficit of skin surface (*Dt*); flap (*Fp*); (**g**) follow-up results: contracture fully eliminated; commissural groove, slant and fossa's depth restored; (**h**) scheme of operation

Scar's Surface Deficit as the Real Cause of Contracture

Commissural edge contracture is caused by the scar sheet surface deficiency, which is necessary to determine as the basis for treatment: reconstruction involves scar surface deficiency compensation with a flap of a similar shape (Figs. 28.1, 28.2, and 28.3). The scar surface deficiency is measured as follows: The lateral (dorsal) scar sheet of the fold is separated from the medial healthy sheet with an incision along the fold's crest; then, the contracture is released with the scar sheet dissection from the fold's crest to the metacarpal bone heads, or metacarpophalangeal joints' rotation axis with a Y-incision. The Y-incision (which does not go beyond the rotation axis level) is necessary for complete wound border divergence and contraction release. After fingers' abduction, the wound, as a rule, takes on a trapezoid form, reflecting the size and form of scar surface deficiency regardless of contracture severity. This fact, that scar surface deficiency (the real cause of contracture, groove and slant deformity) has a trapezoid form, is a key for understanding the selection process for the flap's form needed for adequate burned commissure restoration. The form/shape of the scar surface deficiency, which is a trapeze, is used as grounds for development of the new approach and technique for the most effective commissure resurfacing. Thus, it becomes clear that the most suitable reconstructive technique for contracture release, interphalangeal groove and slant restoration, should be based on use of the flap of a similar form (trapezoid) (Figs. 28.2c and 28.3c). This further explains why triangular local flap plasty (Y-V plasty and Z-plasty and their modifications) are unable to adequately compensate for scar surface deficit, fully release contractures, and restore the interphalangeal groove and slant.

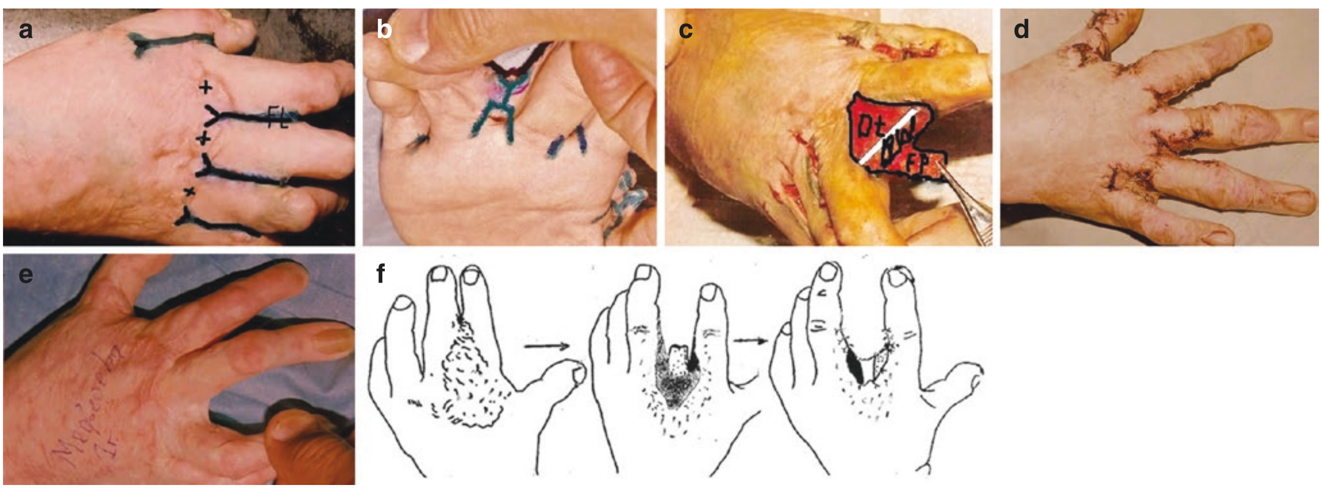

Fig. 28.3 Technique for severe dorsal commissural contracture treatment and result. (**a**) Anatomy: contracture involved most of the proximal phalanges, *FL*—lateral sheet of the fold; "+"—metacarpal bones heads; a Y-shaped line for contracted scars' dissection from the fold's crest to the metacarpal bone heads; (**b**) palmar surface: line for dissection of scars between the proximal phalanges from the fold's crest to notch, proximal of which the flap's contours are outlined; (**c**) contracted scars dissected, *FP* flap mobilized, white strip divided the wound on upper trapezoid scar surface deficit (*Dt*), and lower donor wound (*DW*); (**d**) wounds, which appeared after separation of the proximal phalanges, primarily closed; (**e**) result (1 year after operation): contractures removed, commissural grooves, slants and fossa's depths fully restored; (**f**) scheme of reconstruction

Elimination of Interphalangeal Edge Contractures (Syndactyly) with Trapeze-Flap Plasty

Reconstruction consists of three parts:

(a) complete contracture release;
(b) commissure restoration with the trapezoid flap; and
(c) wounds on the medial surface of proximal phalanges are covered using skin transplants.

The success of reconstruction depends on the optimal donor site choice, that is, the one that would allow the necessary flap size and shape with minimal deformity. Selection of the interdigital fossa for trapezoid flap elevation is the most important component of the new approach for commissural contractures treatment. The techniques for dorsal and palmar commissural contracture treatment are distinctively different.

Dorsal Edge Contracture Elimination (Figs. 28.2 and 28.3)

Planning consists of drawing four lines in each contracted commissure: the first goes along the fold's crest; the second is a Y-shaped line perpendicular to the first one, passing through the center of the interphalangeal space from the fold's crest to the metacarpal bone heads; the third and fourth lines outline the trapezoid flap's borders in interdigital fossa (Fig. 28.1c, d); and the last lines end on the palm, 2 mm proximally to the palmar interdigital fold's crest (Fig. 28.1d). The width of the flap's end should be wider, by one-third, than the wound's width between the metacarpal bone heads' level, should equal 5–7 mm, and should include a part of the fold's crest. The flap's base is wider than its end according to the wound's form. In all cases, the flap's width should exceed the wound by one-third. The flap's length is approximately 25 mm and varies (as does the width), depending on the measurement of the hand (adult vs. children). The length is 2–2.8 times greater than the width (middle parts of the flap). The specifics of the flap can be summarized as follows: the flap's end is wide, the subcutaneous fat layer is included in the flap, supplying steady blood circulation, and the flap does not undergo rotation. Therefore, tissue necrosis and flap loss does not occur despite the flap's tension during its transposition on the wound; and the ratio value (length to width) has no practical meaning or application due to the qualities of the flap, which make it viable.

Technical Details

First, the fold's sheets are separated with an incision along the fold's crest; then, with a Y-shaped incision, scars and the subcutaneous fat layer are dissected from the fold's crest to the metacarpal bone heads (Figs. 28.2 and 28.3). The split end of the Y-incision separates scars of the lateral scar sheet of the fold from scars of the dorsal hand. After the fingers' abduction, the trapeze-shaped wound appears (Figs. 28.2e and 28.3c). The wound reflects the form and size of the scar surface deficiency and suggests the flap be further raised. According to the wound size and form (scar surface deficiency), but approximately one-third wider, a trapezoid flap is mobilized. The flap, which has a wide end and no acute angles, includes the skin and subcutaneous fat layer of interdigital fossa, supplying steady blood circulation despite the number of contractures on one hand. The flap's base includes the interdigital palmar fold and about 2 mm of palmar skin, which makes the flap longer and allows for contracture over-correction. After flap elevation, the interdigital commissure (fossa) is deepened, which shortens the wound's length (in anterio-posterior direction) and makes the flap relatively longer. The raised flap shrinks and appears narrower than it really is and appears to be in photos; moreover, the flap is advanced on the wound with tension and becomes longer and also narrower. Using two to three sutures, the flap's end is connected to the wound's edge at the level of the metacarpal bone heads and the borders of the dissected scar sheet and flap (Fig. 28.2f, g). Thick scar edges are thinned by an excision of inner scar layer up to 2–3 mm for better flap adaptation. Due to the interdigital fossa deepening and flap transposition with tension, the small donor wounds (nearly 1 cm in diameter) are formed on the lateral surface of proximal phalanges (Fig. 28.2g), which are covered with split skin grafts (Fig. 28.2h). The transposed flap covers the wound, compensates for scar surface deficiency, and restores interdigital commissure and interphalangeal groove and slant (Fig. 28.2d–f). The scheme of the operation is shown in Fig. 28.2h. Selection of the interdigital fossa as donor site for trapezoid flap elevation is a second component of the new approach and technique. The split skin transplant for proximal phalanges' donor wound covering is harvested from the inner shoulder's surface; the donor wound is primarily closed. All commissural contractures are reconstructed in one-stage surgery. After reconstruction, the severely deformed hand appeared normal, and restoration of commissures plays an important role in this outcome.

Treatment of Severe Contracture Caused by Fusion the Dorsal Surfaces of Proximal Phalanges (Fig. 28.3)

The fused proximal phalanges are separated up to the medial healthy sheet, where a small dimple is present (Fig. 28.3b). Rough scars on the fingers are excised; thick scars are made thinner by excising the inner scars' layers, and the wound of the proximal phalanges is primarily closed (Fig. 28.3d). After that, the commissure is reconstructed using the technique described above. After scar sheet dissection up to metacarpal heads with Y-shaped incision and finger abduction, the trapezoid wound appears (Fig. 28.3c), reflecting scar surface deficiency. According to the wound's size and form, the adipose-cutaneous from the fossa flap is elevated. Wounds on the dorsal end of the proximal phalanges are primarily closed. The transposed flap restores form commissure and covers part of the wound, eliminates the contracture, and restores the interdigital fossa and interphalangeal groove and slant (Fig. 28.3e).

Edge Dorsal Commissural Contracture Elimination Is a Part of the Total Dorsal Hand Resurfacing (Fig. 28.4)

Dorsal hand deformation with scars causes dorsal edge commissural contracture (Fig. 28.4a). Hand resurfacing includes complete scars excision with the dorsal sheet of the fold, restoration of the first web space and interdigital commissures with a trapezoid flap (fossa, groove and slant). After scar excision through the intermediate layer, no bleeding occurs because the fat tissue stays undamaged and covered with a thin layer of mature connective tissue. Trapezoid adipose-cutaneous flaps are prepared from the medial fold's sheet and interdigital fossa (Fig. 28.4b). The flap is transposed on the wound and its end is fixed with catgut sutures among metacarpal bone heads (Fig. 28.4c). The dorsal hand surface is resurfaced with whole split skin transplants; wounds on the inner surfaces of the proximal phalanges are covered separately (Fig. 28.4f–j). The scheme of hand resurfacing is shown in Fig. 28.4e.

Fig. 28.4 Commissure restoration simultaneously with total dorsal hand resurfacing. Case 1: (**a**) Before operation: extreme severe deformation of the dorsal hand, fingers grow together; (**b**) scars removed together with the lateral sheet of the fold through the intermediate layer without bleeding; trapezoid flap is mobilized from fossa and medial fold's sheet; (**c**) the flap's end is fixed to tissue among the metacarpal bone heads; (**d**) result of operation: contracture released, groove and slant fully restored, dorsal hand surface resurfaced; (**e**) scheme of reconstruction. Case 2: (**f**) pre-surgery; (**g**) scars excised, flap mobilized, and end fixed to the wound's tissue. Case 3: (**h**, **i**) keloid scars covered dorsal surface of both hands; (**j**) dorsal surface of hands and commissures restored, syndactyly eliminated

Palmar Edge Contracture Anatomy and Treatment

Anatomy of the Palmar Edge Commissural Contracture (Fig. 28.5)

Palmar commissural contracture is a result of hand palmar surface burns. While the wound is healing and scarring, the existing palmar fold spreads in a distal direction, fusing the proximal phalanges and forming the palmar interdigital contracture. The fold consists of two sheets (Fig. 28.5a, b): the medial sheet, which is healthy skin that spreads on undamaged interdigital fossa, and the palmar (lateral) sheet (scars spreading over the palm). The contracture is caused by the palmar scar sheet's surface deficiency. After the sheets' separation with an incision along the fold's crest, and scar (palmar) sheet dissection with a Y-shaped incision to complete contracture release and fingers abduction, the wound, as a rule, accepts a trapezoid form (Fig. 28.5c).

The trapeze-shaped wound reflects the size and form of the scar sheet deficiency. Consequently, effective contracture elimination requires a flap with a shape similar to that of the wound (trapezoid). Planning consists of drawing four lines: (1) along the fold's crest for separation of scars from healthy skin; (2) a Y-shaped line indicating the level and form for contracted scars' dissection (middle length of proximal phalanges); and (3) two lines—the lateral contours of the flap. Thus, the adipose-cutaneous flap includes the skin of interdigital fossa and medial (healthy) sheet of the fold. The base of the flap is located on the palm, laterally from the fossa's edge by 2–3 mm (Fig. 28.5a, b).

Surgical Details (Fig. 28.5)

The first incision separates the scar lateral (palmar) fold sheet from the medial healthy sheet. With a perpendicular Y-shaped incision, the contracture is released from the fold's crest to the metacarpal bones' heads. (A Y-shaped incision is a necessary component, ensuring easy scars' edges' divergence and complete contracture release.) As a rule, a trapezoid wound is formed after the fingers' abduction (Fig. 28.5c, below the white strip), reflecting the size and form of the scar surface deficiency. According to the trapeze-shaped wound's size, the adipose-cutaneous flap is raised in interdigital fossa (Fig. 28.5c, above the white strip). For neurovascular bundle preservation, the incisions are directed parallel to the lateral surfaces of the proximal phalanges. After the fossa's deepening, the flap is transposed on the wound with tension, eliminating contracture, and restoring the interdigital commissure (Fig. 28.5d). The wounds located beside the flap, on the lateral surfaces of proximal phalanges, are split skin-grafted. As a result, the scar sheet surface deficiency is compensated, the contracture is fully released, and commissural groove and slant are fully restored (Fig. 28.5e). A scheme for this operation is shown in Fig. 28.5f. After circular hand burns, dorsal or palmar commissural scar contractures can be combined with the finger flexion contractures. Both contractures are released simultaneously; the commissures are restored first.

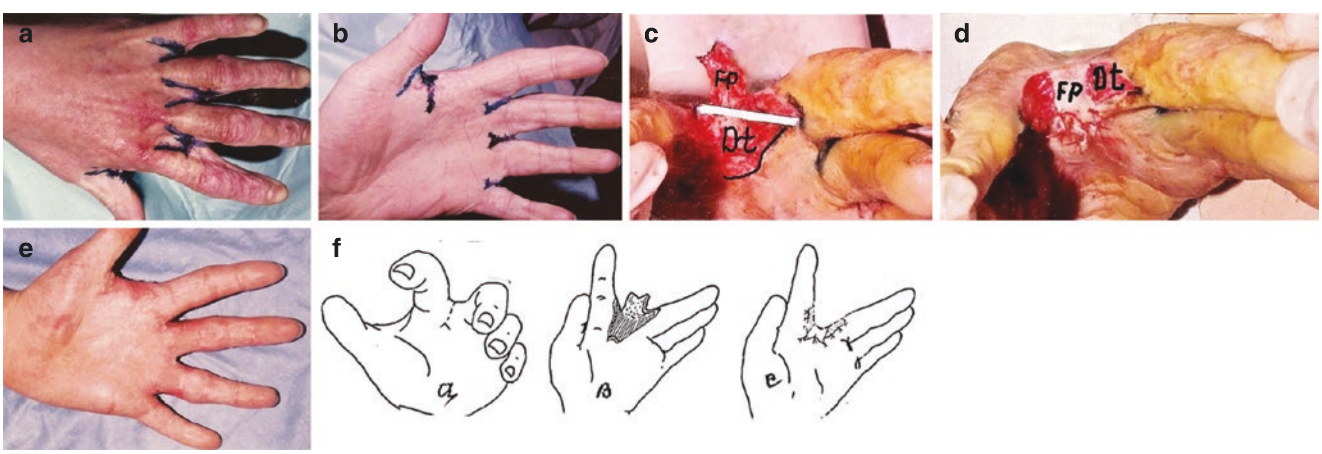

Fig. 28.5 Palmar interdigital commissural contracture treatment. (**a**, **b**) Anatomy: interdigital edge palmar contracture is caused by scars covering the palm and flexion surface of fingers; scars, growing distally among the fingers, involve the skin of the fossa and form the fold located along the palmar fossa's edge; palmar sheet of the fold is scars and contracture cause; dorsal sheet and fossa are healthy skin and donor site. Planning of operation: flap dorsal; Y-lines for contracted scars dissection and marked flap's borders; (**c**) after scars' dissection, the *Dt*—trapezoid and donor wounds and scar surface deficit are formed (below white strip); *FP*—adipose-cutaneous flap elevated; (**d**) transposed flap restored bottom of fossa, wounds on proximal phalanges (scar surface deficit) were covered and deficit compensated with skin transplants; (**e**) results: contracture removed, all commissural components completely restored; (**f**) scheme of the operation

Total Interdigital Contractures, Anatomy, and Treatment

Two forms of total contractures exist: (1) Inner surfaces of fingers are fused with scars; and (2) a flat scarred surface formed between the fused fingers, in projection of interdigital fossa (Fig. 28.6a, b).

Interdigital fusion has a severe scar surface deficit; therefore, any local-flap technique is impossible to use; contracture is released with skin transplants. The flat surface in fossa projection presents the scar surface, allowing contracture release with the quadrangular subcutaneous pedicle flap and skin transplant (Fig. 28.6a, b). The flap (Fig. 28.6c, d) is separated from neighboring scars and mobilized on the periphery; contracted scars are dissected up to the joint rotation axis level anteriorly and posteriorly with a Y-shaped incision; the interdigital space is deepened, and the flap is displaced on the commissural bottom, on the normal interdigital fossa's level (Fig. 28.6c). Then, the flap's ends are transposed anteriorly and posteriorly with tension and connected with the wound's edges (Fig. 28.6d). The flap suspends a commissure steadily, and thus prevents the re-contracture. Because the flap is placed on the fossa's bottom, the wounds appear on proximal phalanges, which are skin grafted.

Results of severe dorsal commissural contractures reconstruction with trapeze-flap plasty are shown in Fig. 28.7 (three patients).

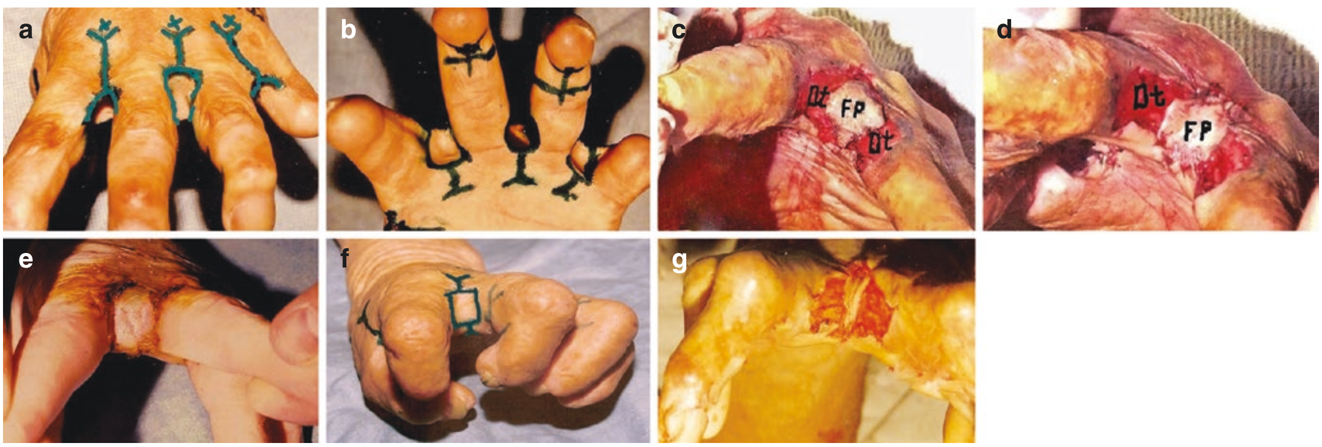

Fig. 28.6 Total interdigital contracture treatment with quadrangular local subcutaneous pedicle flap. Case 1: (**a**, **b**) among proximal phalanges there is a flat surface, flap marked, and Y-shaped scar dissection; (**c**) *FP*—flap mobilized from the periphery and displaced to commissure bottom; wounds appeared on proximal phalanges or *Dt*—scar surface deficit; (**d**) the flap's ends are connected with wound edges anteriorly and posteriorly with tension; wounds on proximal phalanges are skin grafted; (**e**) result. Case 2: (**f**) total syndactyly, planning reconstruction with quadrangular subcutaneous pedicle flap; (**g**) contracture released, fossa's bottom and commissural slant restored; wounds on proximal phalanges are scar surface deficit are covered with skin transplants

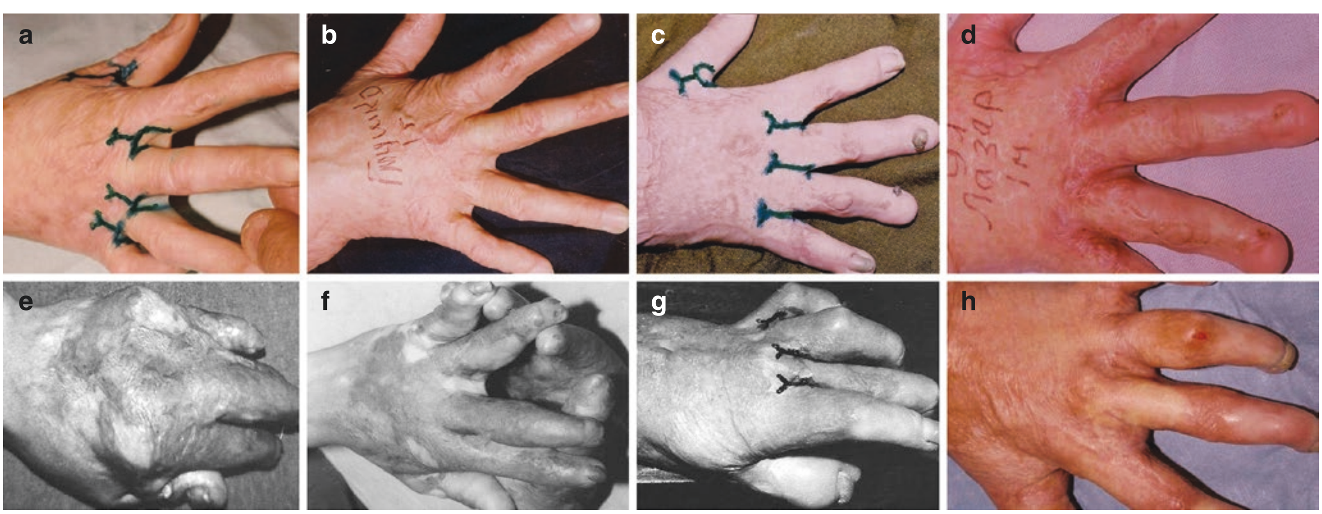

Fig. 28.7 Follow-up results of postburn edge dorsal commissural contractures elimination with trapeze-flap plasty: (**a**, **b**) 1 year after surgery; (**c**, **d**) contracture in 9-year-old child; (**e**, **f**) and (**g**, **h**) severely deformed hand: scar surface deficit (contracture cause) compensated by fossa's flaps, hand dorsal surface resurfaced with skin transplants, interdigital fossa, interphalangeal groove, and slant restored

Conclusion

Dorsal and palmar edge commissural contractures are fully eliminated using trapeze-flap plasty. A normal commissural groove and slant are achieved; the fossa's depth and width are restored. No flap loss occurred. Shrinkage of skin transplants was insignificant and does not affect the initial postoperative depth of interdigital fossa (does not make it shallow). Because skin grafts are placed deep in the fossa (beside the flap), they are barely noticeable. The trapezoid adipose-cutaneous flaps and skin transplants do not shrink; being stretched, the flaps' and surrounding stretched skin continues to grow, restoring and surpassing the initial flaps' width, which prevents contracture recurrence in adults and, more importantly, in pediatric patients. Because of flap growth, the tissue stretching normalized, as did the commissural space and interdigital fossa's depth. With time, the follow-up results improve. As operation scars and grafts matured, flaps became bigger, fully restoring interdigital fossa and commissural groove and slant.

Reference

1. Grishkevich VM. Postburn dorsal and palmar interdigital commissural contractures: anatomy and treatment—a new approach. Adv Biosci Biotechnol. 2013;4:518–30.

29 Postburn Flexion Contractures of Fingers: Anatomy and Treatment with Trapeze-Flap Plasty

Introduction

Scar flexion medial contractures of the fingers are a significant complication of burn injuries of the hand and a frequent cause of patients' disability. The restriction of finger motion is a direct indication for performing reconstruction. The flexion contracture of the fingers poses a challenge for surgeons. The task of surgical treatment consists of complete elimination of contraction by lengthening the flexion surface of a finger, resurfacing of the skin, and the restoration of hand function without recurrence of contracture. Various reconstructive techniques are used and we have tested most of them. The results were unsatisfactory. Pursuing a more effective method for treating such contractures, a trapeze-flap plasty method was developed, which became the preferred reconstructive technique. This chapter describes the anatomy and contracture cause (scar surface deficit), and techniques for medial finger flexion contracture elimination based on trapezoid flaps.

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Anatomical Features of Medial Finger Flexion Contractures

Finger flexion contractures are caused by scars located on the entire finger's flexion surface, which forms the fold, the crest (*Cr*) of which is located along the medial line of the flexion surface of the fingers. The fold has a semilunar (crescent) shape. Both fold sheets are scars. The scar fold is located against one interphalangeal (IP) joint, mostly the proximal IP (PIP) joint, or it occupies both IP joints and all flexion surfaces (Fig. 29.1a, b). Scar sheets of the fold spread from the fold's crest up to the joint rotation axis level. The crest of the fold corresponds to the medial line of the finger flexion surface (medial contracture). The widest part of the fold is usually situated against the PIP joint or the middle phalange. The fold's sheets have a scar surface deficit in length, which causes the contracture; however, a scar surface surplus in width allows contracture elimination with local flaps. The more the fold's protrusion, the more skin surface surplus there is in the sheets. Very often, finger scar contractures are combined with palm and thumb contractures, that is, volar syndactyly; more rarely they are combined with boutonniere deformity and articular structure injuries.

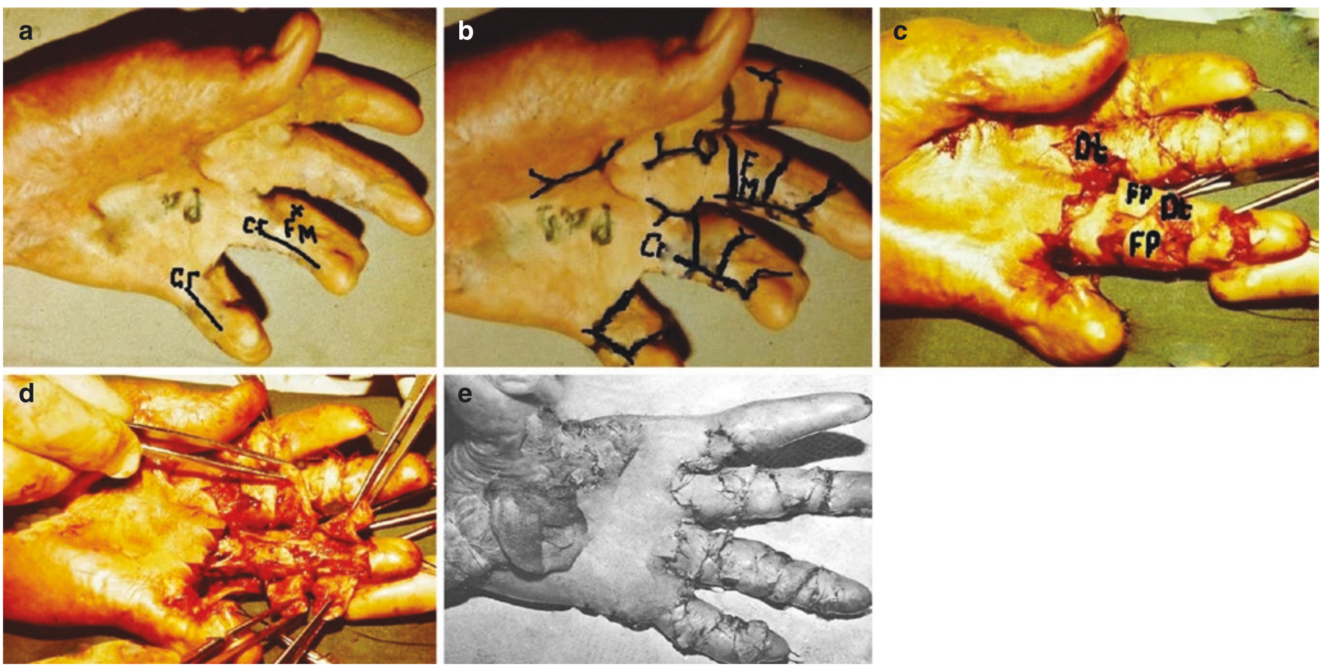


Fig. 29.1 Postburn finger flexion contracture anatomy and elimination with trapeze-flap plasty. (**a**) Before reconstruction: crescent-shaped fold along medial line finger's flexion surface, both fold sheets are scars and spread from the fold crest to the interphalangeal joints axis (medial contracture); (**b**) *FM* flexion medial surface; *Cr* crest of the fold; planning: radial Y-lines mark the flap contours along all sheets from the fold's Cr to joint rotation axis level; (**c**) after radial incisions and finger extension, the flaps (*FP*) and wounds (*Dt* surface deficit) accepted trapezoid shape (trapeze-shaped surface deficit in length); (**d**) trapezoid flaps mobilized with split subcutaneous fat layer and finger's flexion surface delivered from scars; after finger extension, the tendon sheets did not expose, fat layer preserved their integrity; (**e**) opposite transposed flaps covered joint FM surface, small wounds at proximal and distant phalanges covered with full-thickness skin transplants; thumb adduction contracture eliminated simultaneously with trapeze-flap plasty

Scar of Finger Flexion Surface Deficit as the Real Cause of Contracture

The flexion surface of fingers is small and has a round form; therefore, the entire flexion surface belongs to the flexion medial (*FM*) surface and thus causes contracture of the "medial" type (Fig. 29.1a). During wound healing, contracted scars are elevated over the finger flexion surface and a fold forms, the crest of which passes along the medial line of the flexion surface. Therefore, both sheets of the fold are scars, and both spread from the fold crest to the axis of IP joints, have a surface deficit in length (contracture cause) and a surface surplus in width, allowing contracture elimination with local flaps (Fig. 29.1). For adequate contracture elimination it is necessary to know the size and form of the surface deficiency in the fold sheets, because the contracture elimination is based on the compensation of scar surface deficit by flaps of a similar form and size (Fig. 29.1). To estimate the scar deficit it is first necessary to separate fold sheets with incision along the fold crest and cross-cut the scar sheets from the crest of the fold all the way to the joint rotation axis. For complete release of the scar's tension, the ends of incisions should be Y-shaped, which separates the contracted scars of the joint's flexion surface (*FM*) from the scars of the joint's extension surface (*E*). As a rule, after the joint is extended and the wound's edges diverge, a trapeze-shaped wound is formed, or a scar surface deficit (*Dt*), despite the quantity of incisions made, reflecting a real cause of contracture (Fig. 29.1b–d). Consequently, to adequately eliminate the contracture and cover the wound, the local flaps of the same trapezoid shape must be applied. Because the flap has a semilunar form, radial incisions of the fold convert the fold's sheets into trapezoid flaps (Fig. 29.1b–e).

Principles of the Surgical Technique (Figs. 29.1, 29.2, 29.3 and 29.4) [1]

Flap Planning (Fig. 29.1a–c)

Scar flexion contracture elimination of all fingers is a single-stage procedure. The main planning goal is to convert both sheets from the crest of the fold to the joint axis level into trapeze-shaped flaps. The first line is drawn along the fold's crest; then, several radial lines are drawn along the fold's extension; these radial lines spread from the fold's crest to the joint axis level. The end points of the perpendicular incisions must be Y-shaped (2–3 mm, 60°). The distance between the radial lines, if measured at the fold's crest, equals 1–1.5 cm (the width of the flaps' ends). The base of the central pair of the trapezoid figures should be located on the lateral surfaces of the PIP joint (Fig. 29.1b).

Flap Mobilization (Figs. 29.2c and 29.4b)

As a rule, the flaps should be mobilized on the finger that is in the flexion position. The finger is fixed with sutures. According to the marked lines, the sheets are separated along the fold's crest and are then cross-cut by radial incisions. The flaps are mobilized from their end to the base, from the fold crest to the joint axis level. Because of flap mobilization, the contracted finger's flexion surface should be delivered from the scars up to the joint axis level. Depending on the fold length, one or several pairs of flaps are mobilized, completely transforming the fold sheets including all extents into adipose-scar trapezoid flaps (Fig. 29.1). The shorter the fold, the fewer the pairs of flaps that may be formed. The end points of the perpendicular incisions must be Y-shaped (2–3 mm, 60°). The distance between the radial lines, if measured at the fold's crest, equals 1–1.5 cm (the width of the flaps' ends). Since the fold is of a crescent form, trapeze-shaped figures are formed. The fold itself is thus transformed into one or several pairs of these trapezoid figures. The base of the central pair of the trapezoid figures should be located on the lateral surfaces of the PIP joint (Fig. 29.1b).

Finger Extension

The mobilized flaps are fixed by sutures and pulled apart to the sides. The napkin is placed on the finger's wound. Both of the surgeon's thumbs are placed on the wound flexion surface, and the other surgeon's fingers apply pressure to the back surface of the patient's finger. Using moderate-to-severe pressure, the finger is gradually completely extended. Due to pressure upon the wound, the fat layer remains solid and the tendon sheet covered, not exposed or injured (Fig. 29.1d). According to the author's experience, such a finger extension technique plays an essential role in successful finger reconstruction.

Flap Transposition and Wound Covering (Figs. 29.3b and 29.4c)

Once the complete contracture release is achieved, wound coverage is carried out on a fully extended finger. The oppositely located mobilized adipose-scar flaps are transposed toward one another with a mild tension that is harmless due to good blood circulation. The end of one flap reaches the opposite flap's base. First, the oppositely transposed flaps cover the PIP joint flexion zone. The last flaps are then counter-transposed, fully or partially covering the wound surface. Because of the flaps' tension, the opposite flaps' bases approach, the skin of the back finger is displaced on the finger lateral surfaces, the wound is narrowed, and its surface is diminished. The finger's soft tissues are squeezed, and the finger becomes thinner.

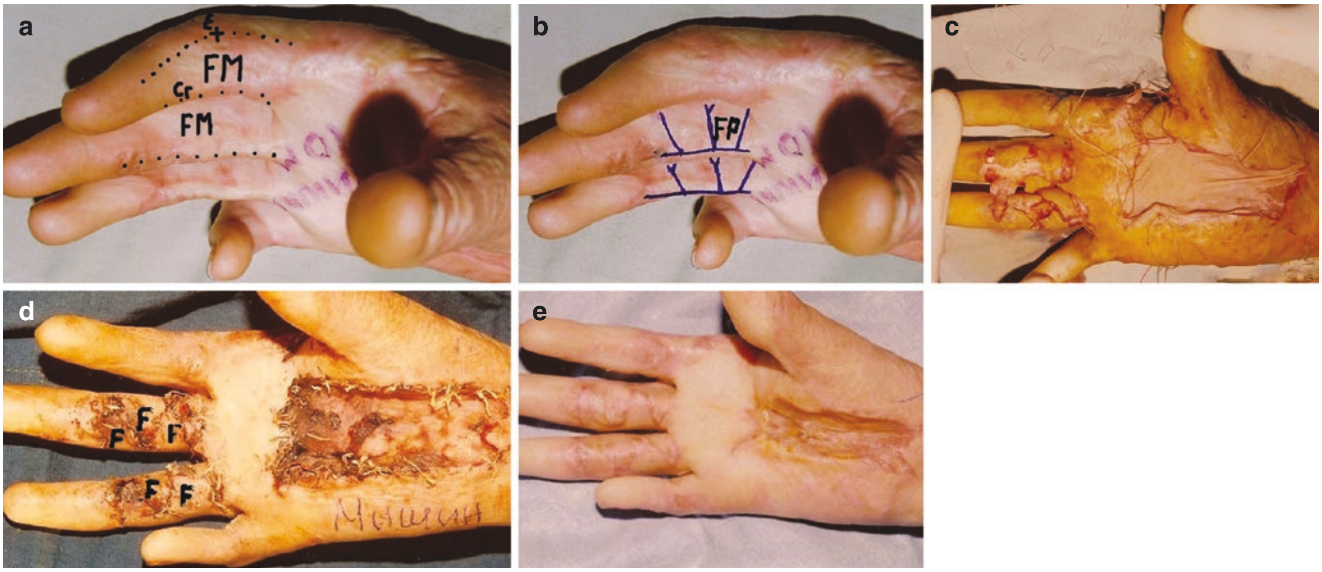


Fig. 29.2 The PIP joint scar contracture (mild-to-moderate) of two fingers eliminated with two pairs of adipose-scar trapezoid flaps without skin grafting. (**a**) Anatomy: *FM* flexion medial surface from the crest (*Cr*) to the joint rotation axis ("**+**"); *E* extension surface; (**b**) trapeze-flap plasty planning (*F*): the radial line spread from the semilunar fold crest to the joint rotation axis level; (**c**) two pairs of trapezoid flaps were mobilized; (**d**) contracture was eliminated with counter-transposition of trapezoid adipose-scar flaps (*F*), palmar contracture was released and wound skin grafted (7 days after surgery); (**e**) results (2 months after reconstruction.); flaps are alive, both fingers' contractures are eliminated fully

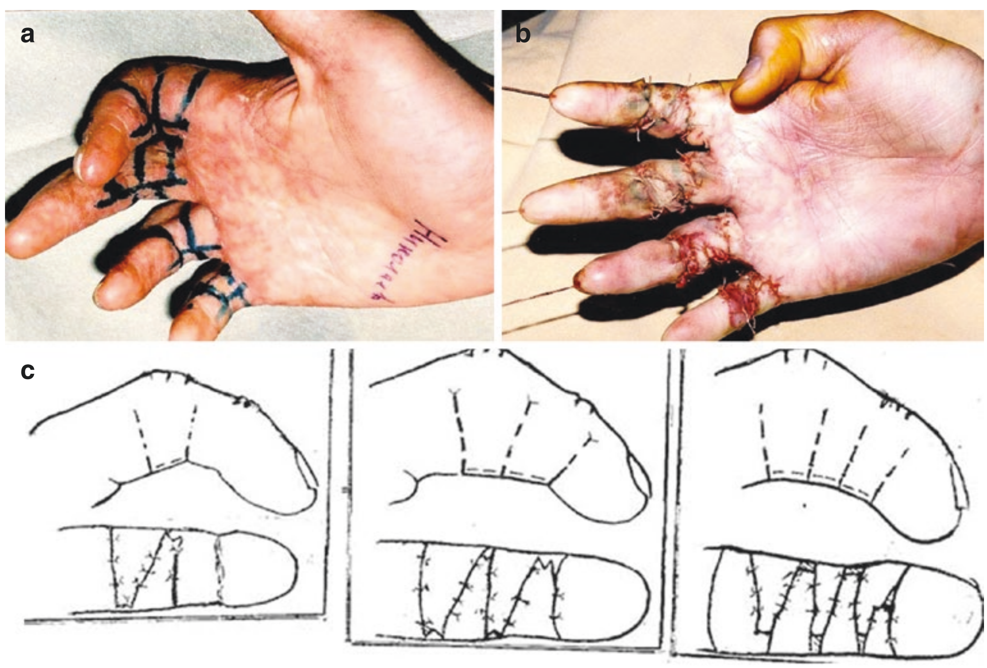


Fig. 29.3 Moderate PIP joints flexion contracture elimination with trapezoid adipose-scar flaps. (**a**) Planning: radial Y-lines for contracted scars dissection from the fold's crest to the joint rotation axis; first pair of flaps is prepared against the PIP joint's rotation axis level; (**b**) reconstruction with one pair (fourth and fifth fingers) and two pairs (second and third fingers) of adipose scar trapezoid flaps; (**c**) one, two, and three pairs of trapeze-flap plasty variants without skin grafting (scheme)

Fig. 29.4 Elimination of severe finger flexion contractures with a combined method. Case 1: (**a**) Preoperative view, severe contractures; two pairs of trapezoid flaps planning; (**b**) adipose-scar flaps (*F*) mobilized; *Dt* surface deficit, *DW* donor wound; (**c**) flaps covered wound; except distal phalanges and base of proximal phalanges, where skin transplant used. Case 2: (**d**) Pre-surgery: short folds; only one pair of trapezoid flaps; *Dt* surface deficit; (**f**) wounds skin grafted, contracture eliminated, and fingers can be prepared; (**e**) transposed flaps (*FP*) covered flexion PIP joint zones, wounds next to the flaps are fully straightened (10 days after surgery): flaps and transplants are alive; (**g**) 2 weeks after reconstruction, there are no complications; (**h**) three variants of finger flexion contractures elimination (scheme)

Surgical Technique [1]

Mild-To-Moderate Contracture Elimination with Trapezoid Flaps Per Se (Figs. 29.2 and 29.3)

Contracture usually involves the PIP joints; therefore, the scar crescent fold is short and moderately expressed. The peculiarities and details of flap planning and finger wound coverage depend on many factors. Mild or moderate contracture is released with trapeze-flap plasty: an incision is made along the fold's crest; then the sheets are dissected with radial Y-incisions perpendicular to the fold's crest toward the joint rotation axis level, and a pair of trapezoid flaps and wounds appear. The main pair of flaps form against the PIP joint and cover it. If all of the scar surface deficit was not compensated, additional flaps are mobilized until complete and unrestricted finger extension is possible. In most cases, the surface surplus of the sheets is sufficient for the scar's surface deficit compensation and contracture elimination (Figs. 29.2d, e and 29.3b, c). Trapeze-flap plasty variants without skin grafting are shown in Fig. 29.3c.

Severe Finger Flexion Contracture Elimination (Fig. 29.4)

In severe contractures, the scar fold can be long (Fig. 29.1a) or short (Fig. 29.4a); the full length of the fold's sheets is then converted into trapezoid flaps and transposed to the base of the opposite flap. If the scar surface deficit in the fold's sheet is severe and the fold is short, the reconstruction is performed with the use of a combined method: counter-transposed flaps cover the PIP or both finger's joint zone, and the small wounds beside the counter-transposed flaps are covered with full-thickness skin grafts (Fig. 29.4b–g). Variants of the combined technique are shown in Fig. 29.4g. If, after surgery, fingers are resistant to full extension, or fingers have a tendency toward flexion, para-osseous, para-articular K-wire, or 18-gauge syringe needles can be used for finger extension. This allows the joint to be fixed in an extended position for several weeks. There is no need for intra-articular K-wire or syringe needle insertion. After the reconstruction of every finger, a small bolster is put on the full-thickness skin transplant without any special fixation; the bolster, as well as all finger surfaces, is covered with a napkin and fixed by circular compression dressing. The finger tip's color serves as an indicator of blood circulation.

Severe finger flexion contracture is often combined with thumb medial contracture in the thenar zone (Fig. 29.5). If fingers have a short fold, only one pair of flaps is prepared, which cover the PIP joint surface (Fig. 29.5a, b). Wounds beside the transposed flaps are skin-grafted. Thumb contracture is usually of the medial type and eliminated with counter-transposition of trapezoid flaps (Fig. 29.5); palm contractures are eliminated simultaneously. After an adequate contracture release, usual splinting during the first 2 weeks and for 1–2 months at night is enough to prevent recurrence of flexion contracture.

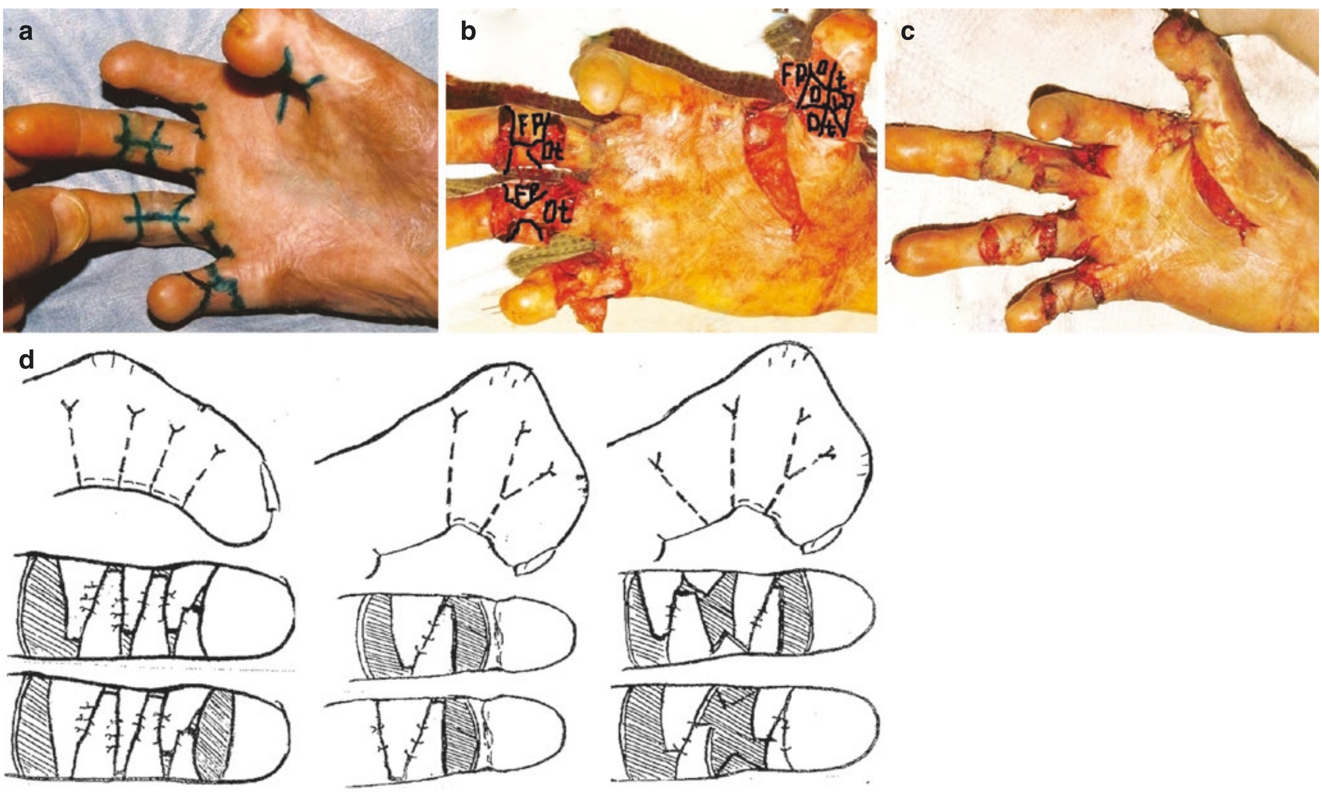


Fig. 29.5 Severely burned fingers, including the thumb, had medial flexion contractures caused by a short scar fold and treated by one pair of trapezoid flaps which covered the PIP joint. (**a**) Pre-surgery view, ankyloses of the second finger PIP joint; planning; (**b**) short fold allows preparation of only one pair of trapezoid flaps for PIP joint covering; *FP* flap, *Dt* surface deficit; *DW* (first finger) donor wound; (**c**) flaps covered PIP joint surface, wounds beside flaps on fourth and fifth fingers are skin-grafted; thumb contracture released with one pair of trapezoid flaps; palm wound is skin-grafted; (**d**) three variants of severe finger flexion contractures elimination with trapezoid flap and skin transplants

Surgical Tactics for Multi-Component Hand Flexion Contracture Elimination

Deep burns of the hand volar surface result in a multicomponent contracture, which includes the flexion contracture of fingers and palm, thumb adduction, and volar syndactyly (Figs. 29.6a and 29.7a, b). All contractures of the hand flexion surface are eliminated in a single-stage procedure that follows this sequence: the adduction of the thumb, flexion contractures of the metacarpophalangeal joints, palmar syndactyly, flexion contractures of the fingers, and contracture of the palm. Each contracture is removed with a special reconstructive technique. The medial scar flexion contractures of fingers are eliminated with the trapeze-flap plasty alone or in combination with skin grafting (also before the postburn boutonniere deformity elimination).

The treatment of severe hand/fingers flexion contractures in children is shown in Fig. 29.7a–g. Severe fingers flexion contracture is reconstructed using a combined method. Contracture of free fingers is eliminated first; the fingers' fusing with the palm is a result of loss of skin on the finger's flexion surface. After the fingers' separation from the palm and palm contracture release, the flexion surface of the fingers and palm are covered with full thickness or thick split skin transplants (Fig. 29.6 and 29.7e). Due to the trapezoid flap's form and good blood supply, small scar trapezoid flaps do not undergo necrosis; the flaps and skin transplants grow proportionally with hand development, and finger flexion re-contracture is prevented.

Fig. 29.6 Method and results of combined reconstruction (trapeze-flap plasty and skin grafting) of the fingers and palm skin grafting. (**a**) Pre-operation: severe flexion contractures of fingers and palms of both hands; (**b**) end of right hand reconstruction; (**c**) 4 months after surgery; (**d**) 3 years after one-staged multiple contracture elimination. **(e)** Left hand: 2 weeks after surgery; **(f)** follow-up result

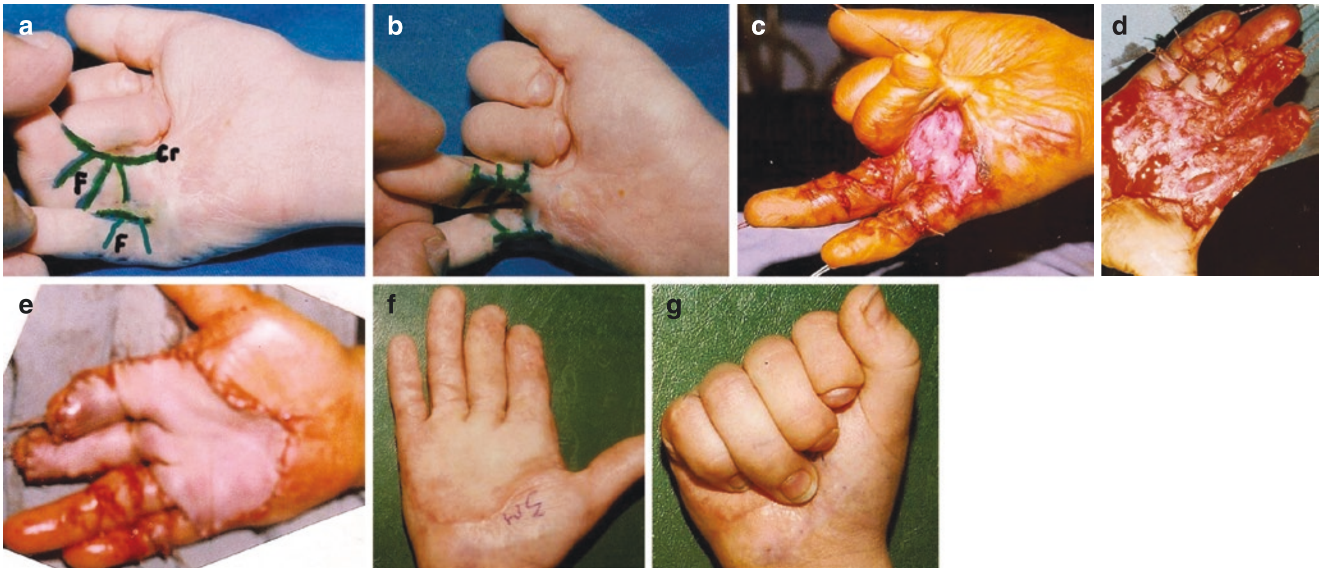


Fig. 29.7 Reconstruction of the severe flexion multiple contracture of right hand in a 6-year-old girl with a combined method (trapeze-flap plasty and skin grafting). (**a**, **b**) Severe flexion contracture of the entire hand palmar surface, fusion of the second and third fingers with the palm, medial contracture and trapeze-flap plasty planning of fourth and fifth fingers, hand hypotrophy, trapeze-flap plasty planning, *F* trapezoid flaps; *Cr* crest of the fold; (**c**) medial contracture of fourth and fifth fingers released with local trapezoid flaps; (**d**) second and third fingers separated from the palm, contracted scars excised on fingers and palm, palmar syndactyly removed with trapezoid flaps taken from interdigital fossa; (**e**) wound covered with a full-thickness skin transplant; (**f**, **g**) results (3 months and 1 year after surgery): finger's flexion and extension as well as anatomy and function of the hand restored; fingers grow, skin transplant looks like normal skin

Total Fingers Flexion Contracture: Anatomy and Treatment

Anatomy (Fig. 29.8)

Circular deep burns of the hand result in total finger contracture development. Scars are usually thin and can be easily torn; they tightly surround the finger without a fold, soft tissues are hypotrophic, and the finger's tendon extension apparatus and articular solid structures are damaged (Fig. 29.8a). The range of motion of interphalangeal joints is severely restricted or absent. Such severe flexion contracture impairs the function of the entire hand and leads to disability. The surgical goal is directed at scar contracture release and straightening of the fingers to achieve a functionally useful condition, and elimination of the scar component of the flexion of the entire hand.

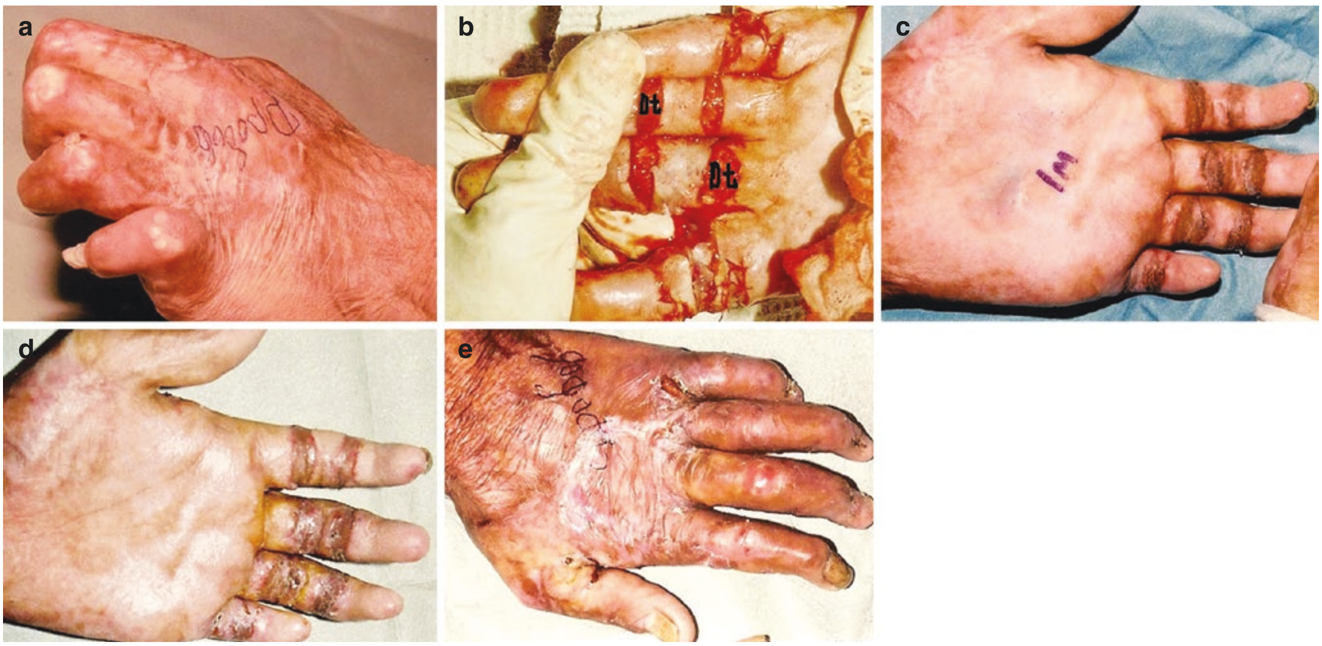


Fig. 29.8 Treatment of total severe finger scar flexion contractures combined with boutonniere deformity and soft tissue hypotrophy. (**a**) Pre-surgery view; (**b**) scar dissected with a transverse double-Y-shaped incision at the middle flexion surface zone of the proximal and middle phalanges. Scars with a thin fat layer are mobilized proximally and distally; scars covering interphalangeal joints stay in situ. Then, the fingers are extended, creating pressure on the wounds. Newly appeared wounds are skin-grafted; *F* flap; *Dt* scar surface deficit; (**c**) full thickness skin transplants alive; *F* flaps; (**d**, **e**) scar component of contracture eliminated; finger's incomplete extension because of tendon extensor apparatus injured (boutonniere deformity)

Surgical Technique (Figs. 29.8 and 29.9)

The contracted scars on the finger flexion surface are dissected transversely in each phalange, not injuring the fat layer, with a Y-shaped double-split incision on the joint rotation axis level. The scars are mobilized with the thin fat layer in the direction of the interphalangeal joints; about 1 cm of scars in the projection of the joint remains in situ. Then, the fingers are extended, not injuring the fat layer, as described above. Because the wounds' edges diverge, the wounds appear in the middle of phalanges, and the tendons are not exposed (Figs. 29.8b and 29.9b). The wounds are covered with full-thickness skin transplants and the fingers are immobilized in a new extension position. This technique significantly improves functional possibilities of the hand (Fig. 29.9d) and allows for tendon extensor apparatus repair (boutonniere deformity) and soft tissue restoration with the groin flap (see Chap. 30).

Fig. 29.9 Technique of total finger flexion scar contracture treatment. (**a**) Pre-operative view: severe flexion contracture of the fingers, hypotrophy of soft tissues; (**b**) contracted scars dissected in the middle surface of all phalanges with double end Y-shaped incision, adipose-scar layer of finger's flexion surface mobilized in the direction of interphalangeal joints, where scars remain in situ; fingers extended by surgeon's finger pressure on contracted finger's flexion surface; planning of treatment, medial thumb contracture with one pair of adipose-scar trapezoid flaps; *F* flap; (**c**, **d**) wounds covered with full-thickness skin transplants; all fingers straightened, skin transplants alive without visible retraction; *F* flaps

Anatomical Features and Treatment of the Fifth and First Finger Flexion Contractures

Anatomy of the Edge of the Fifth Finger Flexion Contracture (Fig. 29.10)

In most cases, like the other fingers, the fifth finger flexion contracture is medial (Fig. 29.10a, b shows the third and fourth fingers). However, the fifth finger differs from other fingers because it is opened, and its flexion lateral (ulnar) surface is not protected by a neighboring finger (Figs. 29.1 and 29.10). Therefore, fifth fingers are injured more severely than other fingers; the open lateral flexion surface of the fifth finger is more severely damaged than its medial flexion lateral surface. As a result, the fold is located not along the middle line of the flexion medial surface (sign of medial contracture), but passes along the ulnar (lateral) edge of the flexion medial surface (Figs. 29.10a and 29.11b, c), and forms an edge flexion contracture. The lateral fold's sheet is scars; the medial sheet and medial flexion surface can be healthy or less damaged skin than the lateral sheet. These anatomical features form the edge contracture, and do not occur in other fingers.

Fifth Finger Medial Type Contracture Treatment (Figs. 29.3 and 29.4)

The fifth finger's flexion contracture is most often reconstructed in a manner similar to reconstruction of the medial contractures of other fingers. Contracture is caused with the fold located along the medial line of the flexion medial surface. Both fold sheets are scars and spread laterally to the interphalangeal joint's rotation axis. Reconstruction is performed using the trapeze-flap plasty; the fold's sheets are converted into adipose-cars flaps, one or two pairs alone or in combination with skin transplants. First, PIP joint is covered with the flaps (Figs. 29.3, 29.4, 29.5, and 29.8).

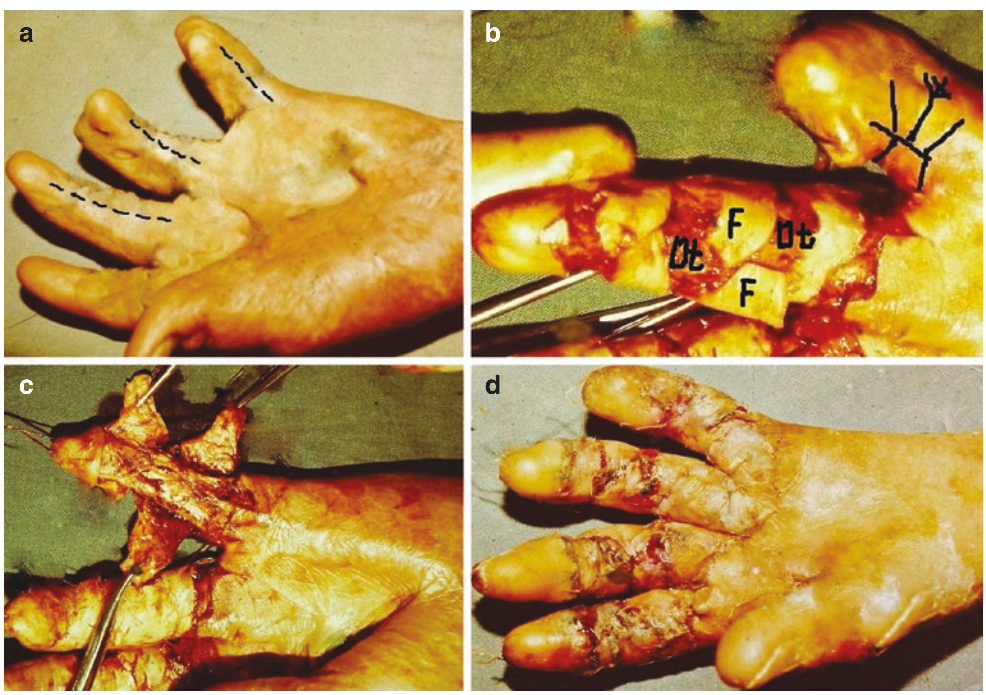


Fig. 29.10 Flexion contracture anatomy peculiarities of the fifth finger. (**a**, **b**) Fifth finger is more severely damaged than other fingers; the lateral ulnar surface of the fifth finger is more severely injured than the flexion medial; the fold of the fifth finger is displaced to ulnar edge of flexion medial surface (the fold of other fingers is located along the middle line of the flexion medial surface); (**c**) reconstruction of two to four fingers' technique as in the case of medial contracture treatment (with a pair of local trapezoid flaps); (**d**) the fifth finger is reconstructed with a technique developed for edge contractures: the main flap from the medial fold's sheet and flexion medial surface, and two trapezoid flaps from the scar lateral (ulnar) sheet and FL surface for the donor wound

Elimination of Edge Contracture of the Fifth Finger with Three Trapezoid Flaps

Depending on the contracture severity and scar sheet's surface surplus, the contracture is removed with local trapezoid flaps (three-flap plasty) (Figs. 29.11 and 29.12). The adipose cutaneous flap is prepared from the medial healthy sheet and the finger's flexion medial surface, which covers the PIP joint; small donor wounds beside the main flap are covered with adipose-scar flaps prepared from the scar's lateral fold sheet.

The severe edge scar contracture of the fifth finger is eliminated with a combined technique: one trapezoid flap is elevated from the medial fold's sheet and it covers the PIP joint; the wounds beside the flap are skin-grafted (Fig. 29.13).

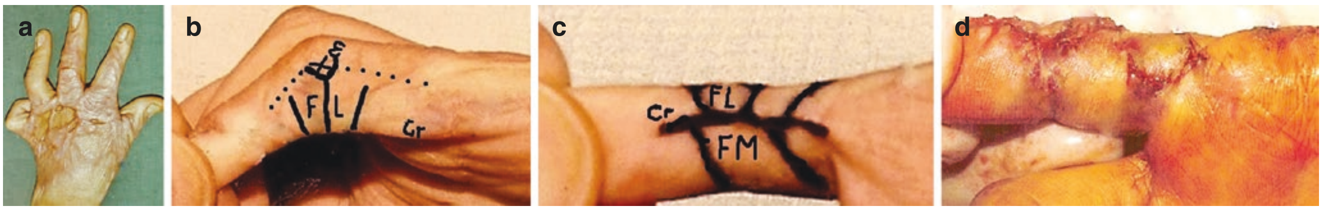


Fig. 29.11 Scar edge flexion contracture of the fifth finger: anatomy and reconstruction with three trapezoid flaps. (**a**) Fifth finger edge flexion contracture in case of hand dorsal burns. (**b**, **c**) Anatomy: *E* joint extension surface; "**+**" joint rotation axis; *Cr* crest of the fold; *FM* flexion medial surface; scars cover the flexion lateral surface (*FL*) of the fifth finger and form a fold crest (*Cr*) passing along the flexion lateral and flexion medial surfaces; lateral fold's sheet is scar and part of the FL surface; medial sheet and flexion medial (*FM*) surface is healthy skin (signs of edge contracture); reconstruction planned with three trapezoid flaps: main adipose cutaneous trapezoid flap—healthy skin and two adipose-scar trapezoid flaps from scar sheet and FL surface; Y-line for contracted scars dissection from fold crest to the PIP joint rotation axis; (**d**) contracture removed with local trapezoid flaps

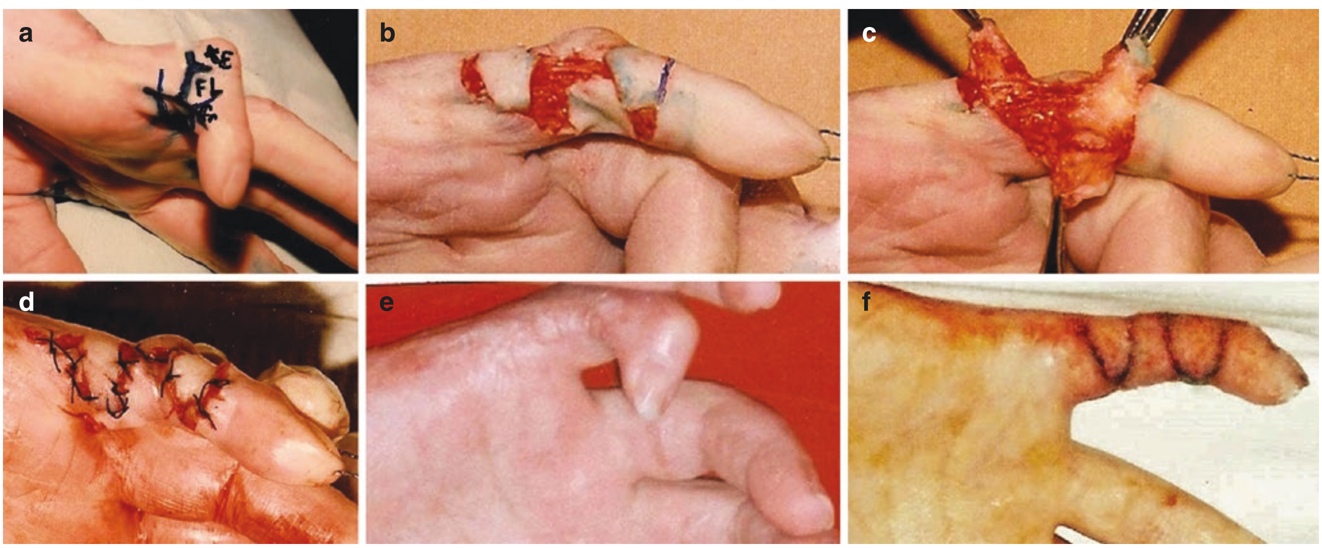
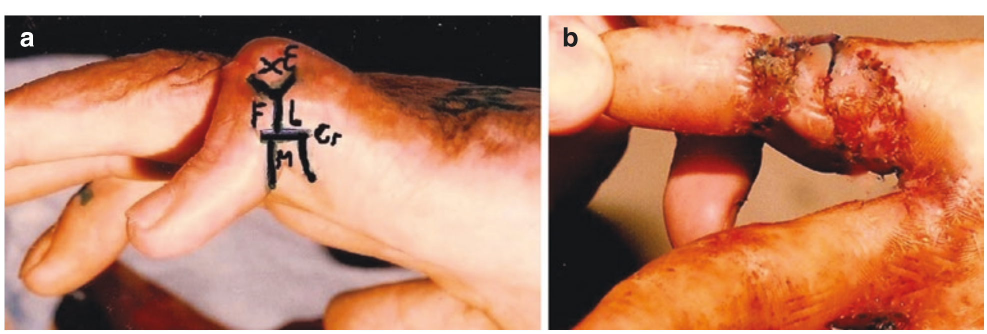


Fig. 29.12 Technical details of edge fifth finger flexion contracture with three local trapezoid flaps. Case 1: (**a**) pre-surgery view, planning: main adipose-cutaneous flap from FM surface and medial fold sheet; two adipose-scar flaps from FL surface and lateral scar sheet for donor wound covering; (**b**, **c**) flap mobilization; (**d**) contracture released, scar surface deficit compensated with counter transposed adipose cutaneous and adipose-scar flaps. Case 2: (**e**, **f**) severe edge contracture, soft tissues hypotrophy; contracture released with three local trapezoid flaps

Fig. 29.13 Severe fifth finger contractures reconstructed with one trapezoid flap and skin transplants. (**a**) Planning trapeze-flap plasty of PIP joint edge contracture; (**b**) trapezoid flap from flexion medial surface covered wound over the PIP joint; wounds beside the flap are skin-grafted



Treatment of Medial Contractures of Fifth Finger and Ulnar Hand, Caused with Long Fold (Fig. 29.14)

Burns of the ulnar surface of the hand's edge can form a long fold and medial contractures of the fifth finger and ulnar hand border (Fig. 29.14a). Fingers and hand zones were reconstructed separately. The active zone of the metacarpo-phalangeal joint remained in situ (Fig. 29.14b–d).

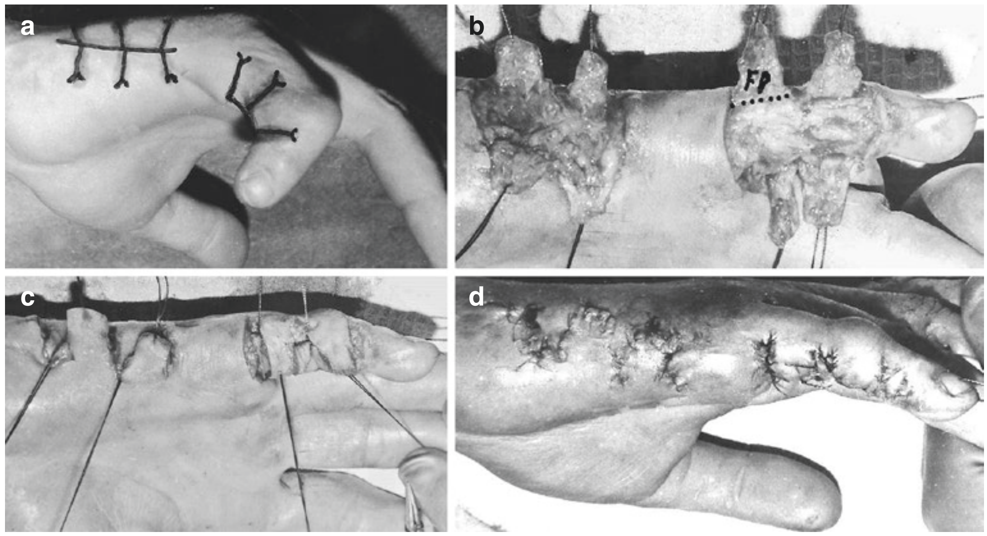


Fig. 29.14 Treatment medial scar contracture caused with long fold involving the ulnar edge of the hand and fifth finger. (**a**–**d**) Release of the contracture of hand and the finger performed separately with two pairs of adipose-scar trapezoid flaps

First Finger Flexion Contracture

Medial contracture of the thumb in the thenar zone is caused by scars that form the fold passing along the medial line of flexion surface or closer to the lateral flexion surface (Figs. 29.15, 29.16, and 29.17). Both fold sheets are scars; therefore, contracture is of the medial type. Elimination of the contractures involves the conversion of the fold's sheets into trapezoid adipose-scar flap and their counter-transposition.

The treatment of severe contracture requires a combined technique: one pair of adipose-scar trapezoid flaps cover the wound against the interphalangeal joint; wounds beside the counter transposed flaps are skin grafted (Fig. 29.16). The first finger is fixed in extension position with a syringe needle para-articularly (Fig. 29.16c). (*FM* joint flexion medial surface and trapezoid flap planning; *E* joint extension surface; "**+**" joint rotation axis.)

A well-expressed long fold is converted into adipose-scars trapezoid flaps on all its extension, and flaps are counter-transposed (Fig. 29.17).

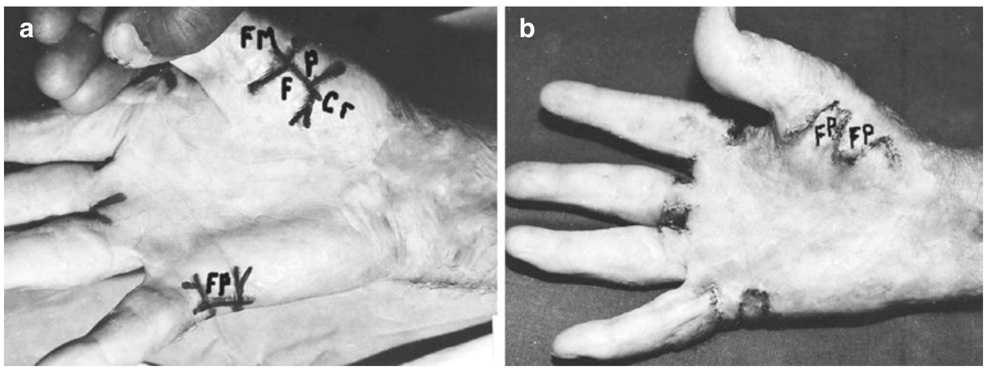


Fig. 29.15 First finger metacarpophalangeal joint medial scar contracture removal with one pair of adipose scar trapezoid flaps. (**a**) Pre-surgery, planning of reconstruction with one pair of flaps; (**b**) counter-transposed flaps released the contracture of metacarpophalangeal joint; simultaneously, adduction contracture of the fifth finger is eliminated by a similar technique

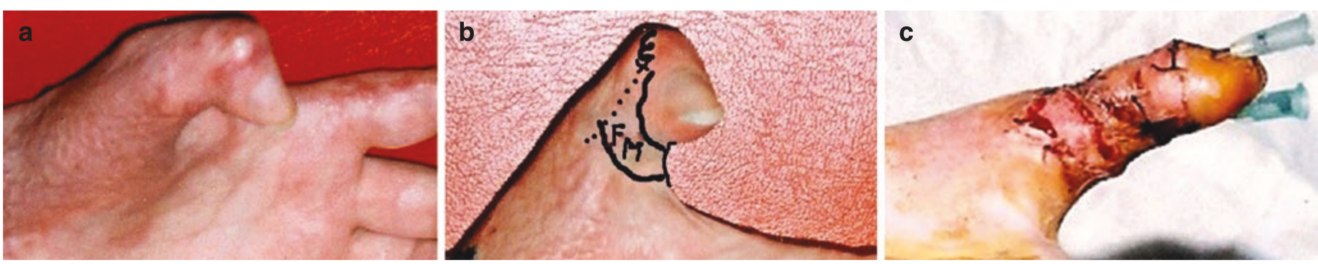


Fig. 29.16 Treatment of severe medial contracture of the thumb with a combined technique. (**a**) Pre-surgery; (**b**) planning plasty with one pair of adipose-scar trapezoid flaps; *FM* flexion medial surface, trapezoid flap; (**c**) counter-transposed flaps covered interphalangeal joint, wounds beside the flaps resurfaced with full-thickness skin transplants. Interphalangeal joint fixed in extension position with two needles para-articularly

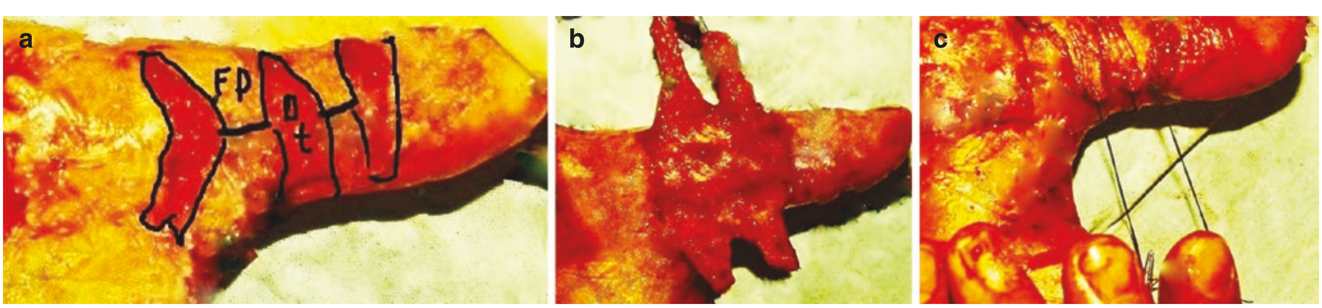


Fig. 29.17 Medial scar contracture of thumb treatment with two pairs of adipose-cutaneous trapezoid flaps. (**a**) Scars dissected with radial incisions; trapezoid scar surface deficit and flaps (*FP*), scar surface deficit (*Dt*) or contracture cause; (**b**, **c**) flaps mobilized and counter-transposed. Contracture released with local tissue

Conclusion

Scars, causing contracture, cover the entire finger flexion surface, and form the fold, both sheets of which are scar (medial contracture). The contracted fold's sheets spread from the fold crest to the joint rotation axis, causing medial flexion contracture of one PIP joint or the entire finger. The fold's sheets have a surface deficit in length, trapezoid form (contracture cause), and surplus in width.

Scar sheets are dissected by Y-incisions, the flexion surface is freed from scars by extension under the surgeon's finger pressure. Trapezoid flaps cover the PIP joint first. Wounds between flaps are covered with full-thickness skin grafts. Fingers extension position stays up to skin graft stabilization. Follow-up results depend on the condition of the fingers. Use of an external device for PIP joint extension combined with mobilization until fully unrestricted passive movements in the joint are restored is absolutely necessary before extensor tendons plasty.

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30 Surgical Treatment of Postburn Boutonniere Deformity

Introduction

Deep burns of the dorsal hand can injure tendon extension apparatus over the proximal interphalangeal (PIP) joint. The defect of the central slip and retinaculum cause displacement of the lateral bands below the joint rotation axis. As a result, the finger (PIP joint) is flexed up to 90° and the extremity becomes disabled. The literature is limited regarding contracture anatomy and evaluation of the efficiency of the existing treatment methods. The problem becomes great if the PIP joint loses its passive extension, if there was intraarticular damage, if the dorsal hand lost soft tissue, and if thin scars were connected with osseous phalanges. Existing publications do not have answers for these problems. In our institute there were numerous possibilities to explore the anatomy of the contracture, to test methods of tendon plasty, and to develop techniques of passive PIP movement restoration and tendon plasty and techniques of adipose-cutaneous layer restoration. Good results have been achieved. All these aspects are presented in this chapter.

Anatomy of Postburn Boutonniere Deformity [1, 2]

All fingers are fixed 90° at the PIP joints without active extension (Fig. 30.1a). The passive movements of the PIP joints are sharply restricted (less than 45°). Many patients have a soft-tissue defect of the dorsum of the hand, and joint capsule and cartilage of phalanges are often injured. We have found that postburn boutonniere deformity has diverse forms.

Anatomical Features (Figs. 30.1 and 30.2)

Postburn boutonniere deformities are divided into two groups:

(a) Those with soft tissue preserved on the dorsal surface of the fingers and hand where the scars are not tightly connected with the bones and joint cartilages of the PIP joint (Fig. 30.1b, c).
(b) Those with a soft tissue defect and damaged PIP joint capsule (Figs. 30.1a and 30.2d). The scars are thin, not folded, and strongly (tightly) connected with the bones and cartilages of the PIP joint. As a result of that, when a finger is passively extended, a transverse scar depression appears over the PIP joint. (Figs. 30.2b and 30.3a). Because the central slip and retinaculum of the extensor, apparatus are damaged over the PIP joint (Fig. 30.2c), the lateral bands are displaced to palmar, below the PIP joint rotation axis (Fig. 30.2c–e).

Functional Features (Figs. 30.1, 30.2 and 30.3)

Functionally, the patients are also divided into two groups:

(a) Those in whom the range of passive movements of the PIP joint is normal or more than 45°, and who were able to achieve a complete unbending of the PIP joint and 80–90° of range of passive movement.

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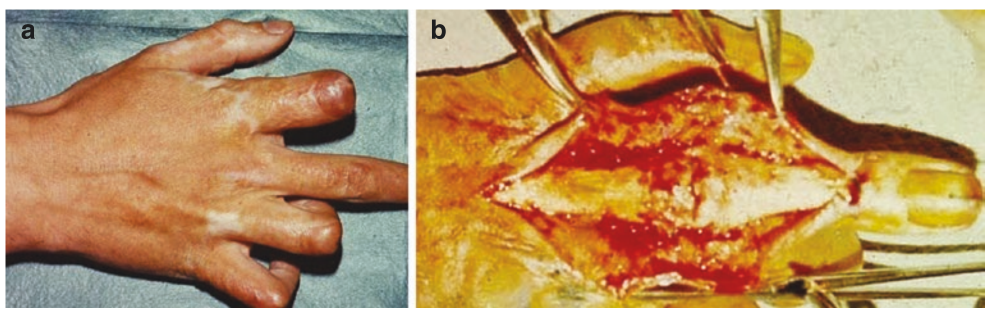
(b) Those with passive movement of the PIP joints of less than 45° and in whom it is necessary to use a distraction apparatus before tendon plasty.

Postburn boutonniere deformity is often aggravated by contractures of the other hand joints: Syndactyly, extension contracture of the carpophalangeal joints, flexed contracture of the fingers caused by the scars located on the palmar surface, and damage of the PIP joints.

These anatomical and functional peculiarities are crucial to therapeutic tactics and the sequence and volume of surgical interventions. The tendon plasty of the extensor apparatus of the joints is successful if the combined contractures of the hand joints are eliminated by initial surgery, passive PIP joint movements are restored to 80–90°, and, along with the tendon plasty, the defect of the soft tissue on the dorsum of the fingers and on the hand as a whole is eliminated with a groin flap.

Fig. 30.1 Anatomy of boutonniere deformity. (**a**) View of hands after deep burns; (**b**) soft tissue of fingers and over the PIP joint preserved; moderate finger's flexion; (**c**) PIP joint capsule preserved; central slip's defect, lateral bands displaced below the PIP joint rotation axis

Fig. 30.2 Anatomy of boutonniere deformity. (**a**) Severe PIP joint flexed, soft tissue of fingers hypotrophy, scars thin; (**b**) joint capsule of PIP joint, phalanges cartilage and suspension apparatus injured



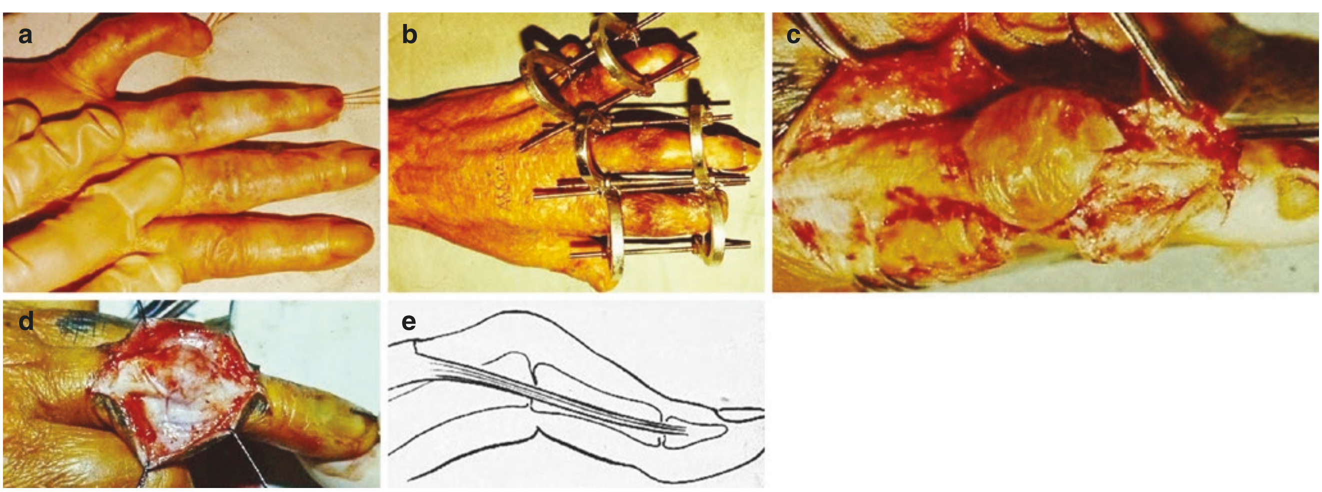


Fig. 30.3 Clinical signs of severe PIP joint injury. (**a**) Transverse scar depression appears above manually extended PIP joint (**b**) while under distraction with apparatus, a depression appears above PIP joints; (**c**, **d**) displacement of the lateral bands below the PIP joint rotation axis; (**e**) scheme of the lateral bands displacement below the joint rotation axis

Preliminary Distraction and Passive Movement Restoration of the PIP Joints

The essence of these operations consists of efforts to: (1) Restore passive movement in the PIP joints before the tendon plasty; (2) eliminate flexion contracture caused by the scar on the palmar surface of the fingers with trapeze-shaped flaps; and (3) reconstruction of the extensor tendons. If passive movement in the PIP joint is severely restricted after contracture release (less than 45 °), then it is caused by capsular damage and joint cartilage changes, and is an indication for the distraction apparatus use. One such device consists of two arcs with cuts at the ends connected with two bars (Fig. 30.4a); the screw units connect the apparatus components and make it possible to move the distal arc, creating distraction. Apparatus application is shown in Fig. 30.4b. By releasing the units, the distal arc is freed from the bars to enable the patient to practice passive movements on his or her own as part of distraction (Fig. 30.5a–c). It takes 4–6 weeks to achieve full extension of the finger, and it takes yet another month to continue the passive movement training. Only then is tendon plasty performed.

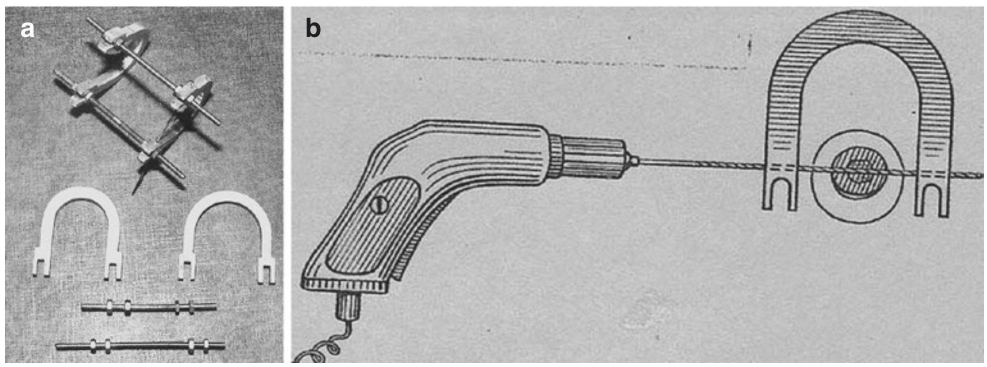


Fig. 30.4 (**a**) The distraction apparatus and (**b**) its utilization

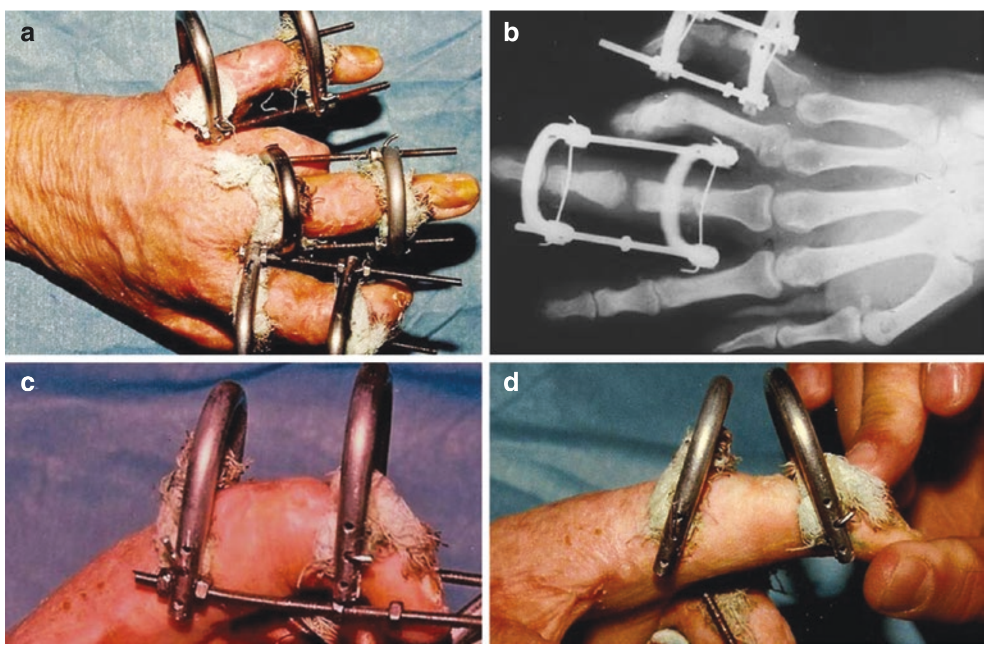


Fig. 30.5 Restoration of PIP joints' passive movements. (**a**) Apparatus on fingers; (**b**) distance between phalanges, forming the PIP joint, increased (in comparison with second finger); (**c**, **d**) periodically distraction is released and finger movements continued manually after that, the distraction is continued until the passive movements of PIP joints become easy and full range

The First Stage of Tendon Extension Apparatus Restoration

Tendon transplant preparation (Fig. 30.6): Our method allows both the return of the lateral bands to their position—above the PIP joint rotation axis—and restoration of continuity of the central slip. We apply a 12-cm-long tendon transplant of the palmaris longus muscle and the flexor carpi radialis muscle (Fig. 30.6a–c).

Lateral bands and central slip mobilization (Fig. 30.7): With an incision along the central line of the fingers' dorsum, the extensor apparatus is opened (Fig. 30.7a, b). The lateral bands are fixed with threads (Fig. 30.7b), the retinaculum is isolated and dissected (Fig. 30.7c); lateral bands displace the upper joint rotation axis (Fig. 30.7d); and the stump of the central slip is separated from the scars, the defect of which amounts to 2–3 cm (Fig. 30.7e).

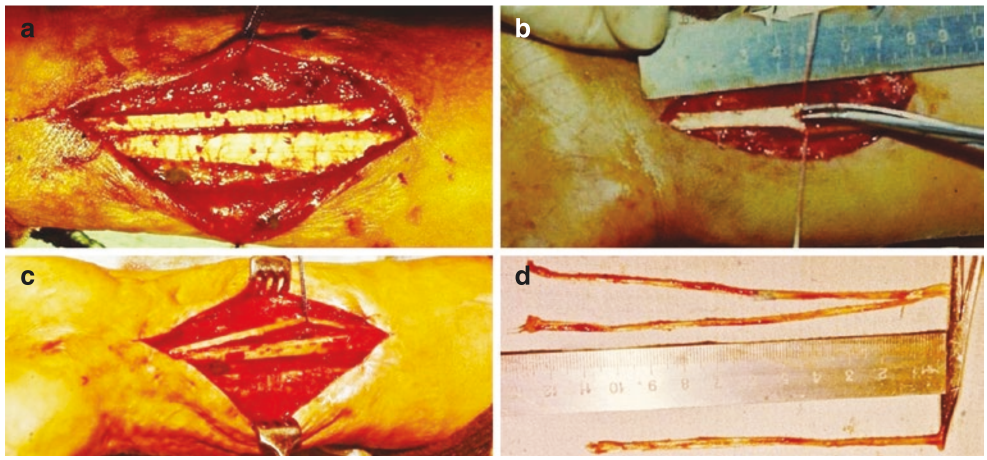


Fig. 30.6 Tendon transplants preparation. (**a**) Palmaris longus and flexor carpi radialis muscles exposed; (**b**) tendon of palmaris longus is split on two transplants; (**c**) one transplant is separated from carpi radialis muscle; (**d**) three transplants, nearly 12 cm each, ready for use

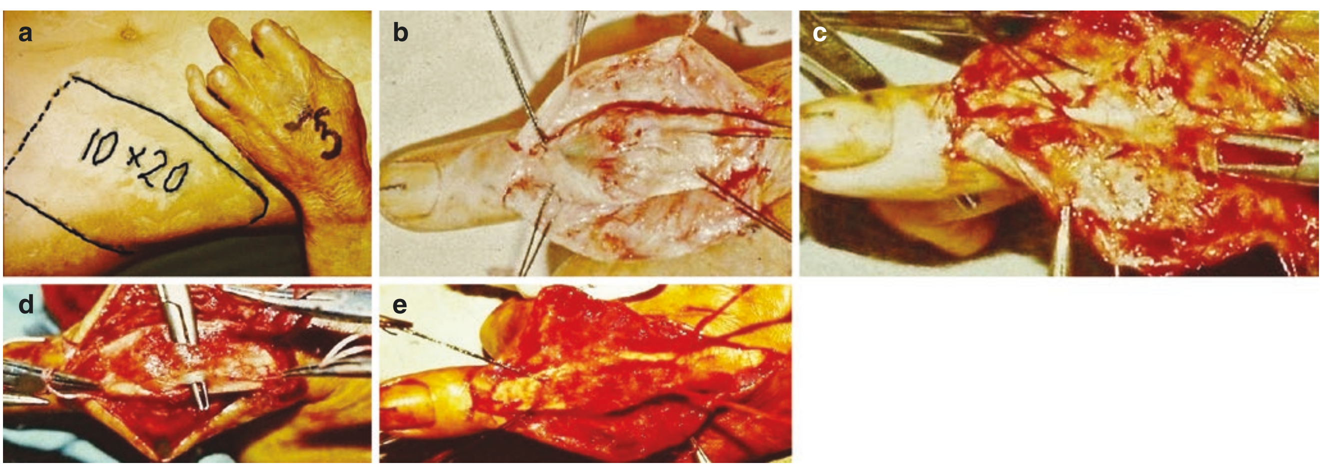


Fig. 30.7 Mobilization of lateral bands and stump of central slip. (**a**) Before operation: boutonniere deformity of the second, fourth, and fifth fingers of the left hand; (**b**) PIP joint's tendon structures opened, lateral bands taken on threads; (**c**) lateral band mobilization and elevation by retinaculum dissection; (**d**) central slip's stump mobilization; (**e**) lateral bands elevated by upper joint rotation axis

Our Technique of Tendon Extension Apparatus Restoration (Figs. 30.8, 30.9, 30.10, 30.11, 30.12, 30.13 and 30.14) [1]

The eight-shaped tendon plasty of the lateral bends is carried out in line with Peacock's method, but one end of the transplant is left 3–4 cm longer than the other tendon's end. The crossing of the ends over the middle phalanges is done as shown in Fig. 30.8a. The shorter end is sutured to the lateral bands and the triangular ligament over the distal (nail) phalanges (Fig. 30.8b). The longer end is rotated proximally and is sutured to the central slip stump over the proximal phalange (Fig. 30.8c). The finger is fully unbent during the plasty and 1 month after the operation. The tendons in all intersections are connected using absorbable threads and are covered by groin flap. Simultaneously, tendon plasty is applied to all the damaged fingers, from the second to the fifth on one hand. After that, the local scars cover transplants or the whole wound is covered with a groin flap (Figs. 30.8d and 30.9b–d). The scheme of our tendon plasty technique is shown in Fig. 30.8e. Results are seen in Fig. 30.8f, g.

At the *second stage*, 3–4 weeks later, the stem of the flap is intersected, the fingers are separated by pairs, and so is the flap; interdigital commissure is restored with trapezoid adipose-cutaneous flap prepared from the interdigital fossa (Fig. 30.12b). At *the third stage* (Fig. 30.9f) after another 3–4 weeks, the rest of the fingers are separated, interphalangeal commissures are formed with a trapezoid flap prepared from the interdigital fossa's skin, and small wounds on the lateral surfaces of proximal phalanges are skin-grafted.

The surplus of subcutaneous fat is excised. One month after the operation, active PIP joint movements are allowed, followed 3 months later by light physical exercises, and standard physical exercises in 6 months' time. Results of the operation are seen in Fig. 30.9f, g.

If soft tissue on the fingers' dorsal surface has been preserved, the wound of every finger is covered (after tendon plasty) with local adipose-scar flaps (Fig. 30.10).

Boutonniere deformity of the fifth finger is a challenge for surgeons. Reconstruction is often finished by PIP joint artrodesis or amputation. Using the new technique presented here, the fifth finger's extension apparatus and its function can be restored completely or significantly improved, and the finger can be saved (Fig. 30.11).

Results of a severely injured dorsal hand reconstruction are shown in Figs. 30.12, 30.13 and 30.14.

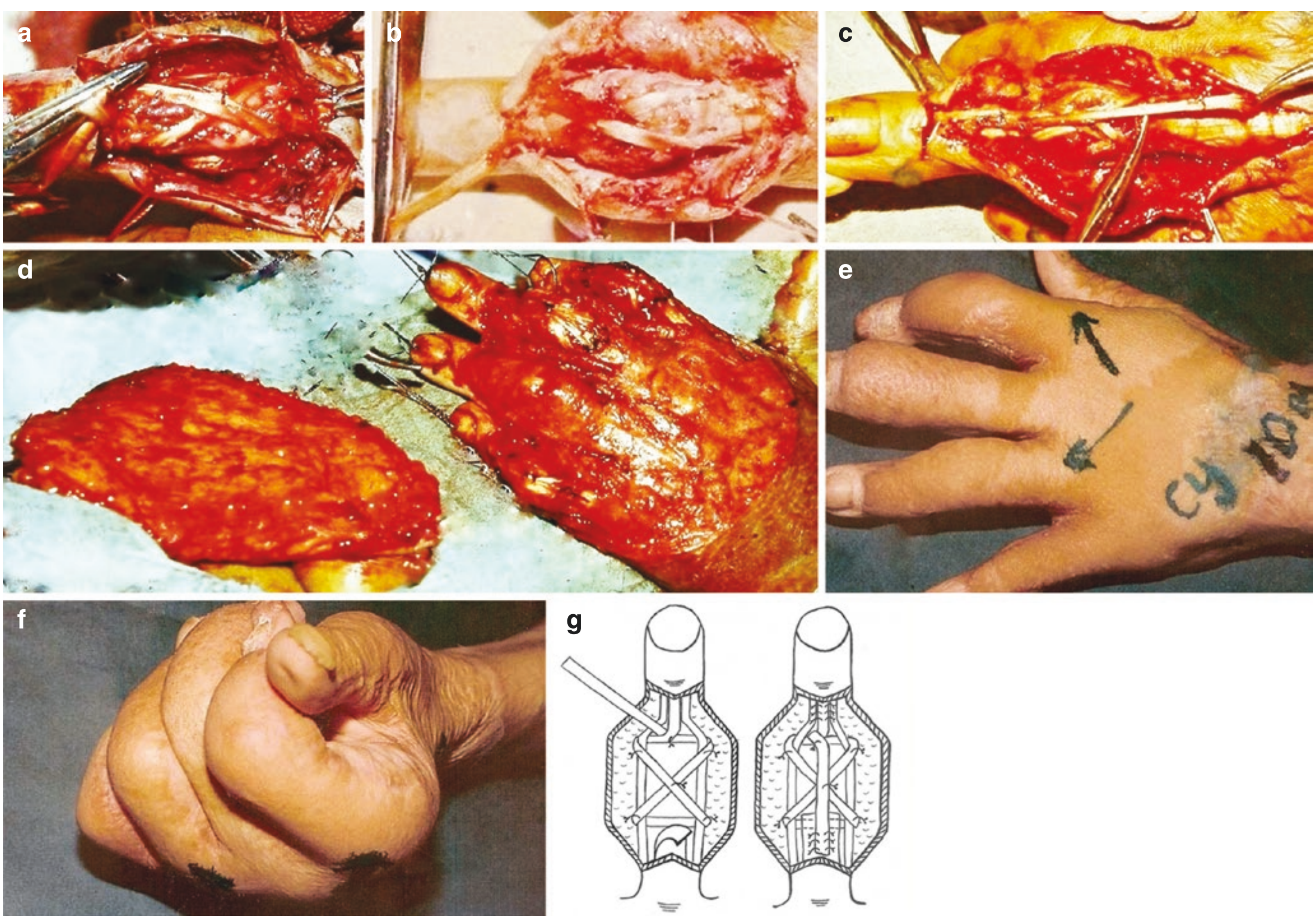


Fig. 30.8 Our tendon plasty technique. (**a**) Lateral bands elevated with Peacock's technique; (**b**) after ends crossing over nail phalange, the short end is sutured with triangular ligaments; (**c**) the long stump is directed proximally and connected with central slip; (**d**) flap borders of neighboring fingers are sutured together, and large wounds are covered with a groin flap; (**e**, **f**) 10 months after surgery; (**g**) scheme of operation

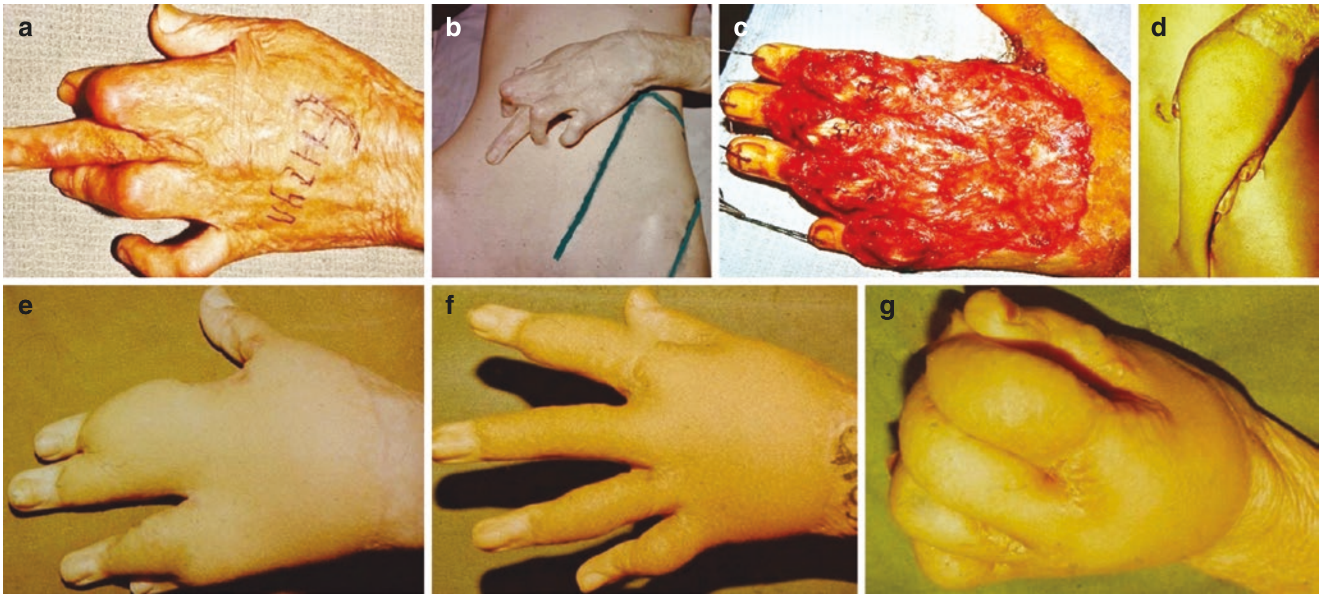


Fig. 30.9 Surgical treatment of boutonniere deformity of the left hand with the syndactyly and soft-tissue defect (the third stage). (**a**) Before the operation (left hand): boutonniere deformity of the second, fourth, and fifth fingers; (**b**) boundaries of scars excision and groin flap; (**c**) after tendon plasty of the second, fourth, and fifth fingers is performed, the fingers are sutured together and scars are removed. (**c**, **d**) Second stage: wound covered with the groin flap; (**e**) fingers separated by pairs (second stage). (**f**, **g**) Third stage: the fingers are separated and commissures restored (2 years after operation)

Fig. 30.10 Results of surgical treatment of postburn boutonniere deformity and dorsal syndactyly; tendon transplants covered with local flaps. Case 1: (**a**, **b**) right hand, second, third, and fourth fingers, using the local scar flaps for the wound and tendon transplant covering and trapezoid flaps of interdigital fossa for dorsal syndactyly elimination. Case 2: (**c**, **d**) second and fourth fingers' extension apparatus restored (3 weeks after reconstruction)

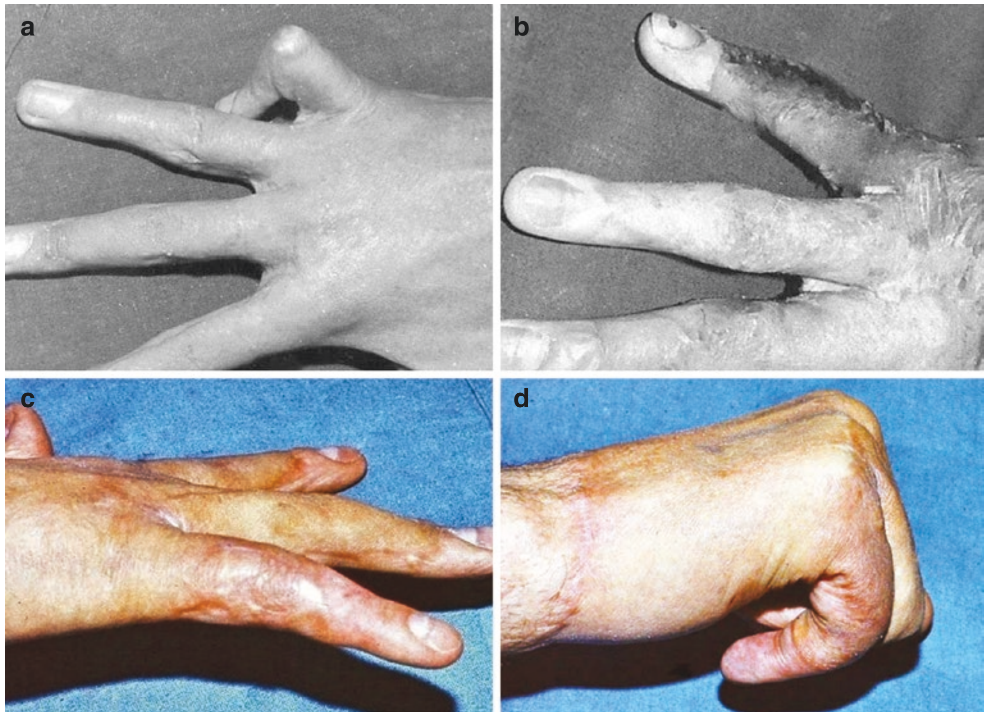


Fig. 30.11 Severe boutonniere deformity of fifth finger treated (authors' technique) and tendon transplants coverage with local adipose-scar flaps. (**a**) Pre-surgery view; first, the hand dorsal surface was resurfaced, including the fifth finger, with skin transplants; (**b**) tendon transplant covered with local adipose-scar flaps (7 days after surgery), flaps alive; (**c**, **d**) 1 year after reconstruction, complete PIP joint's function restored.

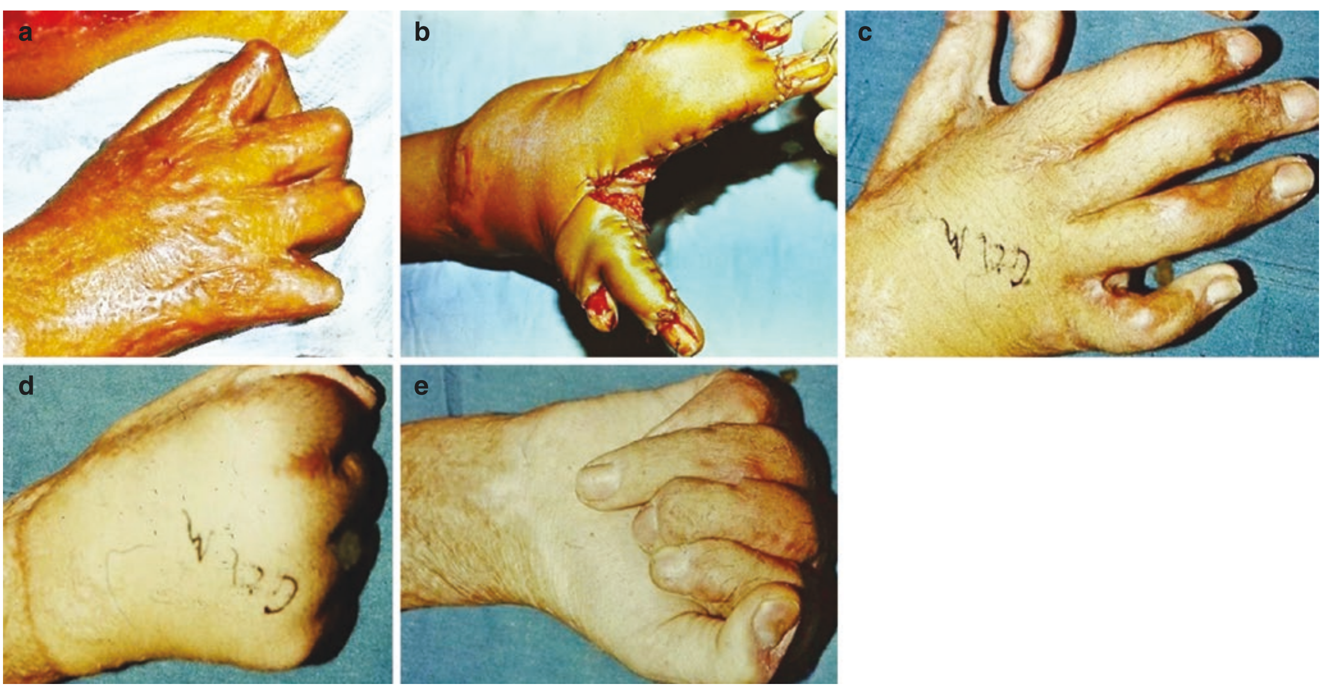


Fig. 30.12 Results of boutonniere deformity surgical treatment. (**a**) Before the operation, right hand, tendon contractures of the second through fifth fingers and dorsal hand soft-tissue defect; damaged PIP joint capsules, and restricted movements (less than 45°). (**b**) Passive PIP joint movements restored with distractors; tendon extensor apparatus restored with original technique, dorsal hand and connected fingers covered with groin flap. Next stages of reconstruction: the hand is separated from the trunk, the fingers are separated by pairs, and the interdigital commissure is restored with the fossa's trapezoid flap; (**c**–**e**) 2 years after reconstruction: good active movements in interphalangeal joints are restored and soft tissue defect of dorsal hand is eliminated

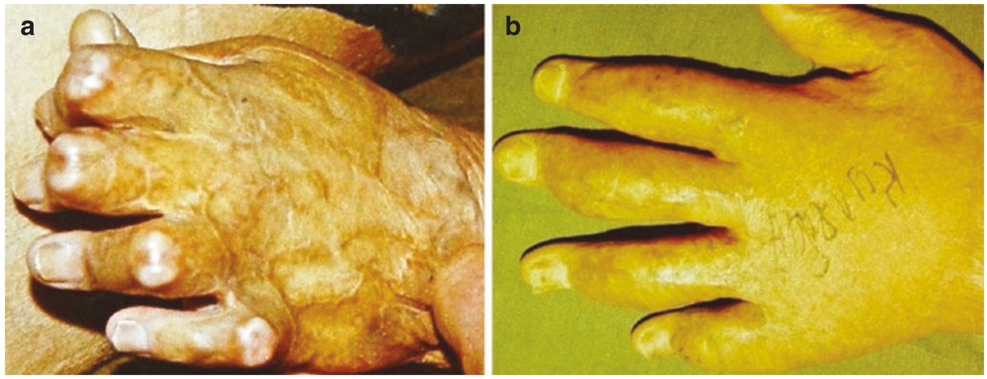


Fig. 30.13 (**a**, **b**) Severe multiple boutonniere deformity elimination with the PIP joints distraction, authors' tendon plasty technique, and soft-tissue defect restoration with the groin flap

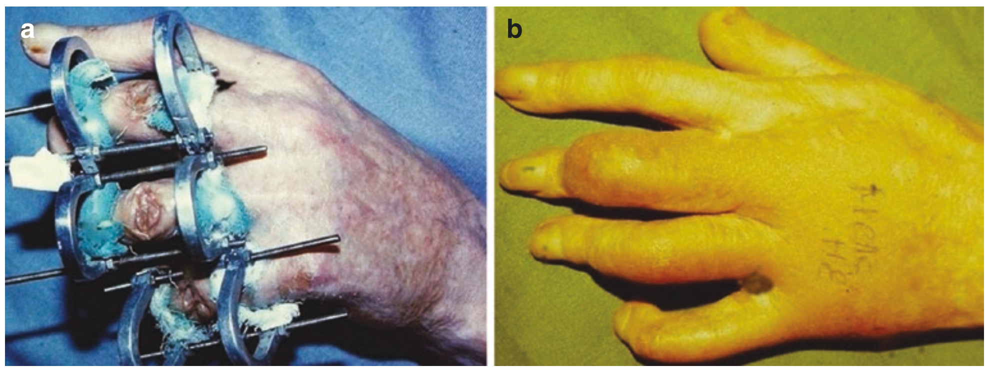


Fig. 30.14 (**a**, **b**) Elimination of severe multiple boutonniere deformity with PIP joint distraction, the authors' tendon plasty technique, and soft-tissue defect restoration with the groin flap

Conclusion

Boutonniere deformity treatment with our technique is indicated for all four fingers and for all grades of contracture severity and soft tissue defects on the dorsal hand. Finger distraction, tendon plasty, and soft tissue on dorsum hand restoration achieve good function and cosmetic outcomes. Both arthrodesis and amputation of the boutonniere deformed fingers should be avoided.

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31 Burned Perineum: Anatomy of Medial Contracture and Reconstruction with Trapezoid Adipose-Scar Flaps

Introduction

Deep burns of the perineum result in contractures that restrict smooth motion and make personal hygiene difficult. Two basic contracture types exist: (1) *medial*, in which scars form the fold of the perineum; and (2) *total*, characterized by perineum obliteration. The inelastic scar fold causing tightness and restricting movement is more easily observed with abducted thighs. The transverse scar fold forms below or above the genitals. Scar folds, protruding distally, obliterate the perineum. Scars of the perineum make walking and personal hygiene difficult and this indicates surgery. Total contracture, or perineum obliteration, does not have a transverse fold. The fold is scar surface surplus, allowing medial contracture elimination with local trapezoid flaps.

Anatomy of Perineal Medial Contracture

Anatomy

Postburn scars of the perineum grow distally and form a fold on the surfaces of the inner thighs (Figs. 31.1 and 31.2). The fold, growing transversely below or above genitalia, prohibits abduction of the the thighs and walking. The fold is a new anatomic structure, with scar surface surplus determining possibilities for the use of local-flap techniques. The length and the width of the fold vary from case to case and depend on many factors (contracture severity, burn treatment methods, age, etc.). Both sheets of the fold are scars (the main sign of medial contracture). Scar surface surplus is usually sufficient for contracture elimination with the local flaps of the fold sheets having surface deficit in length.

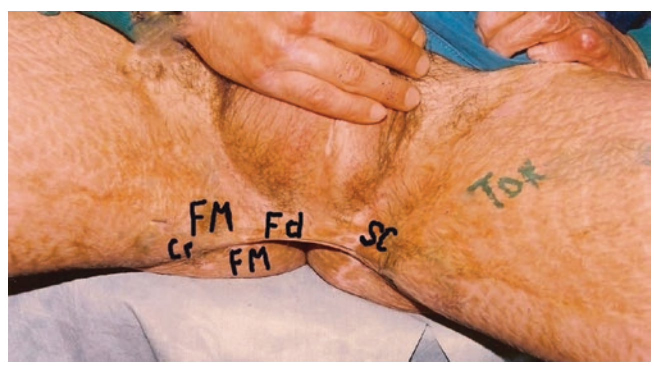

Fig. 31.1 Anatomy of medial perineal contracture. Moderate contracture of the perineum caused by a crescent scar fold located below genitalia; *SC* scars; *Cr* crest of the fold, both sheets (*FM*) of the fold are scars, which have a scar surface deficit in the length (contracture cause) and surface surplus in width allowing contracture treatment with local tissue

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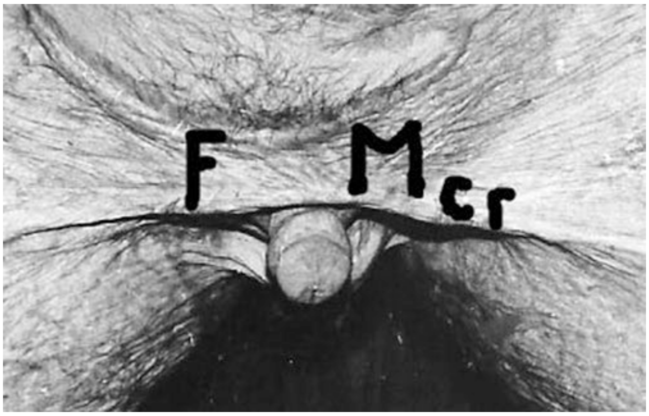

Fig. 31.2 Medial contracture is caused by the crescent scar fold located above genitalia; *FM* scar sheets of the fold; *Cr* crest of the fold

Scar Surface Deficit as Contracture Cause

Together with increasing surface (surplus) in width, scar contraction continues. This causes shortening of the length of the scar surface, which in turn causes surface deficit in length between the inner surfaces of the thighs. As a result of scar contraction, the width of the scars between the thighs increases. This means that contracture treatment should be accomplished by scar release and scar surface deficit compensation. The scar fold has surface deficit in length (contracture cause) and surface surplus in width (Figs. 31.1 and 31.2). The deficit in surface length causes contracture. To plan and prepare the adipose-scar flaps effectively, it is important to know the form, size, and distribution of this deficit. The deficit can be determined using the following method: First, the incision passes along the fold crest (*Cr*) and separates the sheets. The sheets are then cross-cut with a Y-incision until complete scar tension release is achieved (Figs. 31.3a, b and 31.4b, c). For the best divergence of the

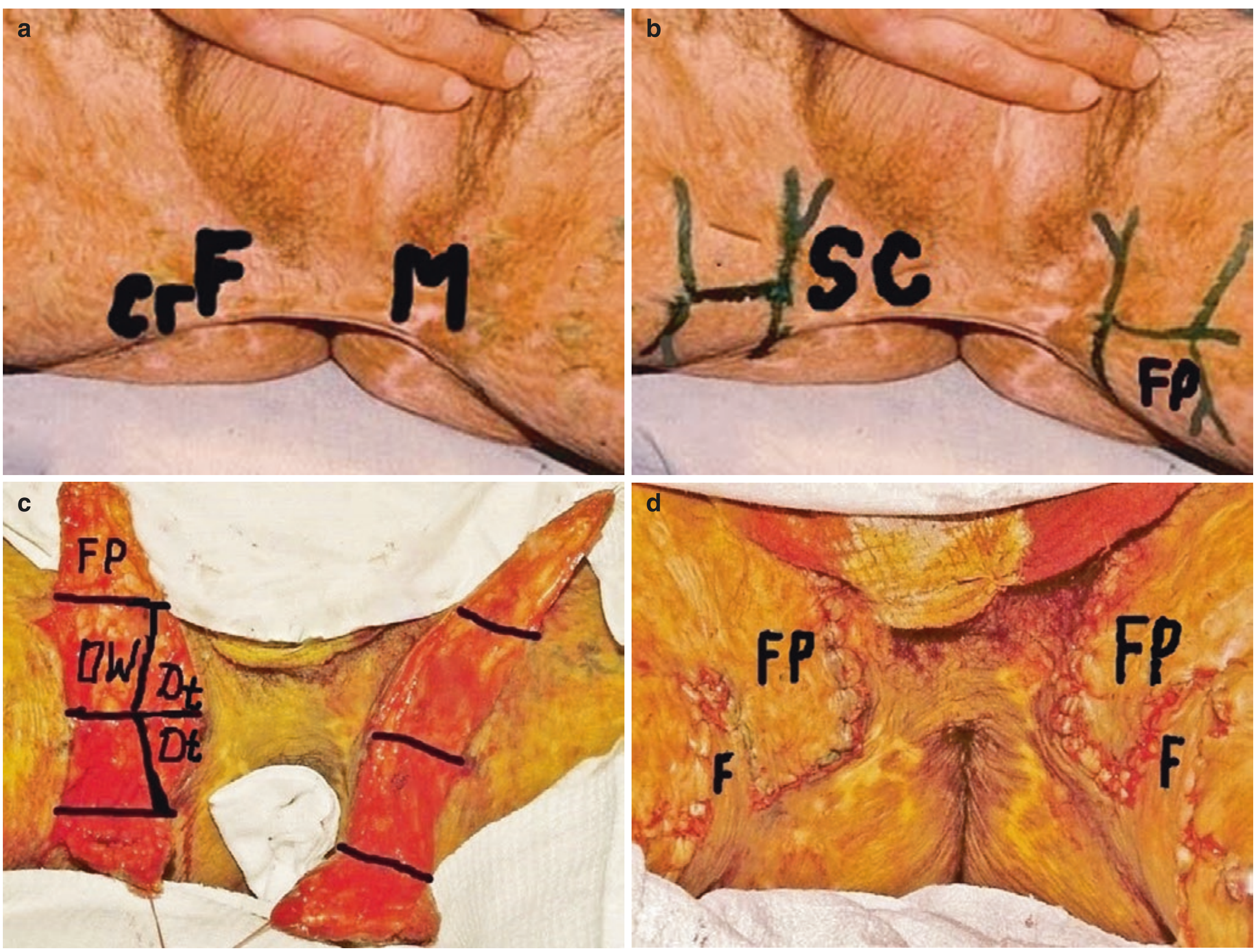

Fig. 31.3 Elimination of moderate medial contracture of the perineum with two pairs of trapezoid adipose-scar flaps. (**a**) Anatomy of medial contracture of perineum: Contracture caused with scars which form a fold below genitalia: both sheets of which are scars (FM) *Cr* crest of the fold below genitalia. (**b**) Two pairs of adipose-scar trapezoid flaps (*Fp*) planned, one pair on the thigh away from the center of the perineum; radial lines for trapezoid flap formation; (**c**) wound anatomy: *Fp* flap; *DW* donor wound; *Dt* deficit of contracted scars surface; adipose-scar trapezoid flaps mobilized (*Fp*); scar surface deficit (*Dt*) has trapezoid form; (**d**) counter-transposed flaps; (*Fp*) flap scar surface deficit compensated and contracture eliminated

wound edges, the ends of the Y-incision are lengthened. The thighs move further apart, the edges of the wounds widen, and the tension disappears. The lowered perineum returns to its normal position. Thus, as a rule, irrespective of the number of cross-incisions, trapezoid-shaped wounds and adipose-scar trapezoid flaps are formed on the inner thighs in the area of each dissected sheet. This suggests that the best reconstructive perineum procedure is the one that uses the flaps that match the form (shape) of the wound, and the procedure is to be called the trapezoid-flap plasty method.

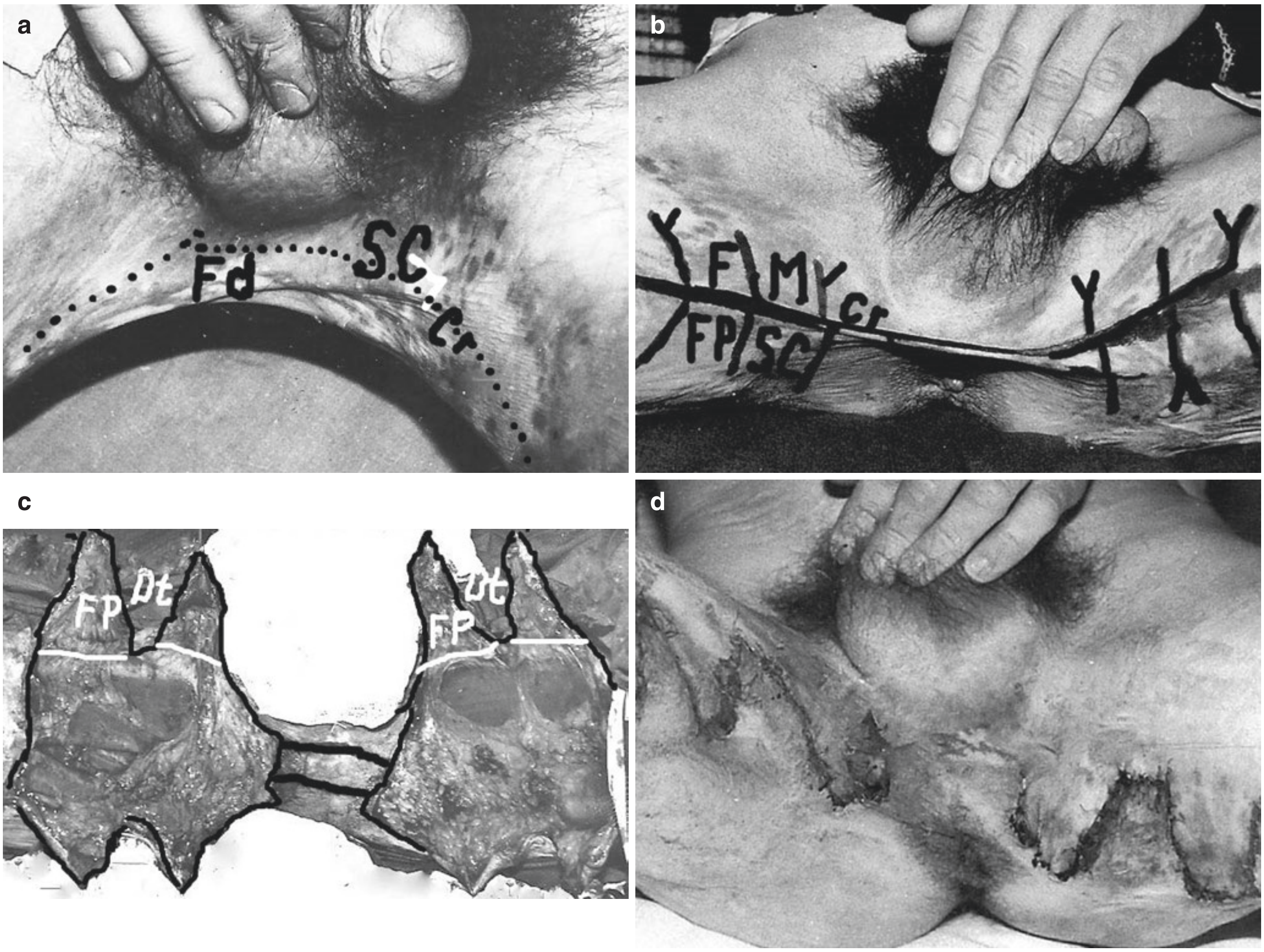

Fig. 31.4 Elimination of moderate-to-severe perineum contracture with four pairs of trapezoid flaps. (**a**) Pre-operative view: crescent scar fold is located below genitalia; (**b**) surgery planning: radial lines on medial thighs for converting sheets into trapezoid flaps; *B*—*FM*—flexion medial surface, scar sheet of the fold; *Cr*—crest of the fold; incision along the fold crest and radial Y-cross-incisions of the fold; mobilized four pairs of trapezoid adipose-scar flaps; (**c**) flaps mobilized, space between the flaps (*FP*) is trapezoid scar surface deficit (*Dt*); (**d**) wound covered, scar surface deficit compensated and contracture eliminated by counter-transposition of the trapezoid flaps; 1 week after surgery

Elimination of Perineal Medial Contractures with Trapeze-Flap Plasty [1]

Specific surgical features depend on contracture severity and the location of the transverse fold (i.e., below or above genitalia).

Elimination of Mild-to-Moderate Contracture with Two Pairs of Adipose-Scar Trapezoid Flaps (Fig. 31.3)

Planning consists of drawing the lines of radial cross-incisions of the fold on both inner thighs and the longitudinal line on the crest of the fold (Fig. 31.3a). The middle portion of the contracture on the perineum itself and the pubic zone are not included in plasty. The interval between cross-incisions is about 4 cm, and it determines the width of the flap points. The base of each flap is 1.5 times wider than its ends.

The first incision on top of the fold on both thighs separates one sheet from another. Then, the radial cross-incisions are performed, which form flaps. The wider the fold, the longer the flaps. The longer the fold, the more flap pairs are prepared. For the best divergence of the wound edges and contracture release, the ends of each radial incision are Y-shaped. Better results are achieved if contracture is released with some over-correction. After trapezoid adipose-scar flaps mobilization, two trapezoid wounds appear, reflecting the form and size of the scar tissue deficit, which is the true cause of the contracture (Figs. 31.3b and 31.4d). Both sheets of the fold are scar surface surplus, allowing contracture treatment with local tissue.

Then, applying moderate tension, mobilized adipose-scar flaps are transposed toward each other so the apex of one flap reaches the base of the opposite flap, covering the narrowed wound (Fig. 31.3c). The tension of the adipose-scar flap is harmless, as flap scars are not distensible and the circulation in the underlying blood vessels of the hypodermic layer is preserved.

Perineum Reconstruction with Four Pairs of Trapezoid Adipose-Scar Flaps (Fig. 31.4)

Planning and flap mobilization are typical (Fig. 31.4b). Moderate-to-severe contracture is caused by the presence of a longer semilunar fold, with a more excessive scar surface deficit (Fig. 31.4c). Scar sheets of the fold on all its borders are converted into adipose-scar trapezoid flaps, two or three pairs on each thigh. The central perineal zone is not included in plasty (Fig. 31.4c). Mobilized flaps and wounds accept the trapezoid form (Fig. 31.4c). The surfaces of counter-transposed flaps are sufficient for scar surface deficit compensation and complete elimination of contracture (Fig. 31.4d).

Treatment of the Medial Perineal Contracture Caused by the Fold Located Above Genitalia (Fig. 31.5)

Scars covering the perineum and abdomen wall can form a fold located above the genitalia. Reconstruction is performed using trapezoid-flap plasty. Several pairs of flaps are planned on each thigh; the central part of the fold remains in situ (Fig. 31.5a) and disappears after contracture release. Mobilized adipose-scar flaps are oppositely transposed and compensate for the scar surface deficit, fully cover the wound, eliminate the contracture, and significantly improve the appearance of the deformed area (Fig. 31.5b).

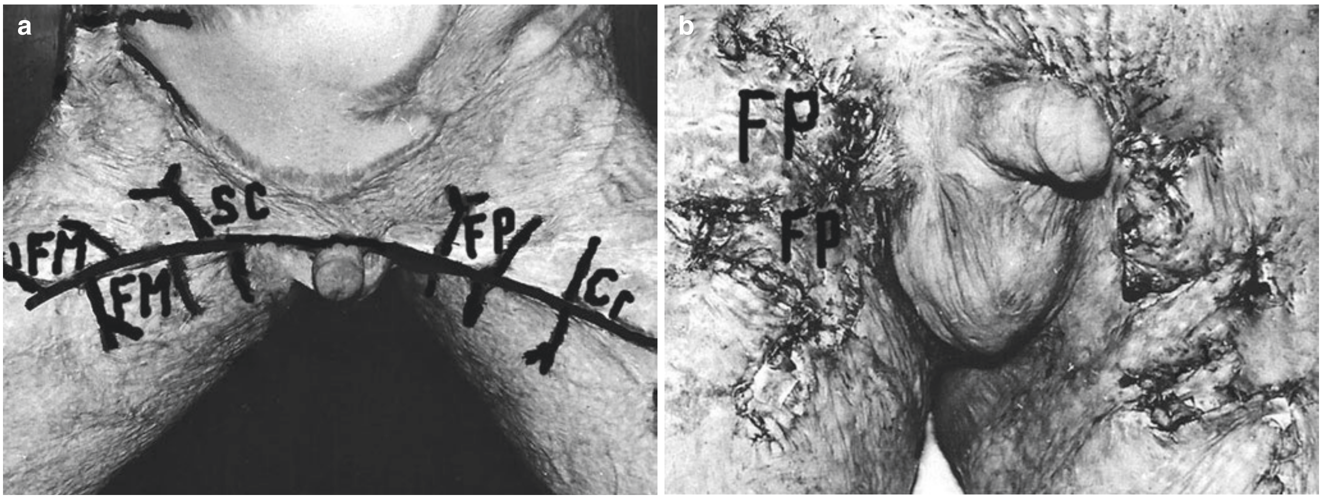

Fig. 31.5 Surgical treatment of the perineum contracture caused by scars covering a wide region and forming a semilunar fold located above genitalia. (**a**) Anatomy of contracture: *FM* flexion medial surfaces; *FP* flaps; *Cr* crest of the fold; pre-operative view: crescent scar fold is located on the front of genitalia; planning: radial Y-lines for contracture release; both sheets of the fold are scars, converted into trapezoid flaps with radial incisions of the fold; (**b**) results (5 days after surgery): contracture completely eliminated with counter-transposed adipose-scar trapezoid flaps

Conclusion

Counter-transposition of trapezoid adipose-scar flaps achieves full elimination of the perineal contracture. The fold in the middle of the perineum and above the genital area and abduction contracture disappears without intervention on the perineum itself and the pubic zone. Because of the transposition of the flaps, the zone of maximum tension, i.e., the top of the contracture fold, is elongated by 2–3 times. It is equal to the sum of widths of the middle part of all flaps minus the sum of widths of the points of the flaps of one sheet of a fold. The flaps have no sharp angles, their apices and bases are wide, and they do not undergo rotation. The mobilized adipose-scar flaps are easily transposed to the opposite side of the wound. Well-preserved blood circulation prevents complications (total or partial flap loss), and the flap surface does not contract; therefore, contracture does not recur.

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Postburn Perineum Obliteration: Elimination of Perineal, Inguinal, and Perianal Contractures with the Groin Flap

32

Anatomy of Total Perineum Contracture

Deep burns of the perineum result in perineal obliteration, severe hip adduction contracture, and perineum deformation, which restrict the hip's normal motion. These burns also make personal hygiene difficult (Fig. 32.1). Perineum obliteration (also called total perineal contracture) is often combined with genitalia injury and inguinal and perianal contractures. Elimination of such a complex perineal contracture is a challenge for surgeons.

Total perineal contracture (perineal obliteration) forms without a fold; therefore, the local flap technique cannot be used. The common reconstructive method consists of scar dissection on the thigh and skin grafting. Because thighs are positioned in adduction when at rest, skin transplants in the perineal region usually shrink, and contracture recurs. Perineal contracture is released using Z-plasty. However, the perineal obliteration, inguinal, and anal orifice contractures can be more successfully eliminated with a pedicle groin flap (Fig. 32.2).

Fig. 32.1 Perineum obliteration or total perineal contracture

Fig. 32.2 Groin flap planning

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Surgical Technique of Total Perineum Contracture Treatment

The groin flap boundaries are shown in Fig. 32.3 [1]. One-third of the flap's width is located below the inguinal ligament; two-thirds of the width is located above the inguinal ligament. The flap's base is located 4 cm laterally from the femoral artery. The flap extends beyond the anterosuperior iliac spine. Such groin flap design, with the flap's length of 20 cm and width of 10 cm, does not pose danger. The flap's length equals the distance from the flap's base to the rear border of the perineal contracted scars, which needs to be released. The flap's width or surface is sufficient to compensate for the perineal scar deficit.

First, the groin flap is elevated, including the skin and full subcutaneous fat layer, with fascia superficial and superficial circumflex iliac vessels. The donor wound is primarily closed. The flap has a steady axial blood circulation. For adequate perineum reconstruction, it is necessary to prepare a wide groin flap. In such cases, it is appropriate to cover a part of the donor wound with a superficial inferior epigastric artery flap that has a common base with the groin flap (bilobe flap, Fig. 32.3). The donor wound of the epigastric flap is primarily closed. On closure of both donor wounds, the scars are dissected along the inguinal fold and medial perineal line. The scars around the anal orifice are excised; the rectum is mobilized at a 3-cm extension. After the thighs' abduction and complete contracture release, the groin flap is placed over the wound. The central flap zone is fixed with sutures to fascia along the inguinal fold and the middle of the perineum. The rectum end, fixed with sutures, is led through the flap's end orifice and sutured with the flap skin. The flap borders are sutured with the scar wound borders. The under-flap space is drained. A silicone tube (three small tubes in this case, Fig. 32.3d, e) is covered with antibiotic gauze and inserted in the rectum for 3–5 days. A good result is shown in Fig. 32.3f–h.

In case of perineal and bilateral inguinal fold obliteration, two bilobe flaps are used (Fig. 32.4). The "dog-ear" usually appears near the flap's base and is removed several months later. The "dog-ear" has a surface surplus that is used for adjacent deformed region correction or genitalia reconstruction.

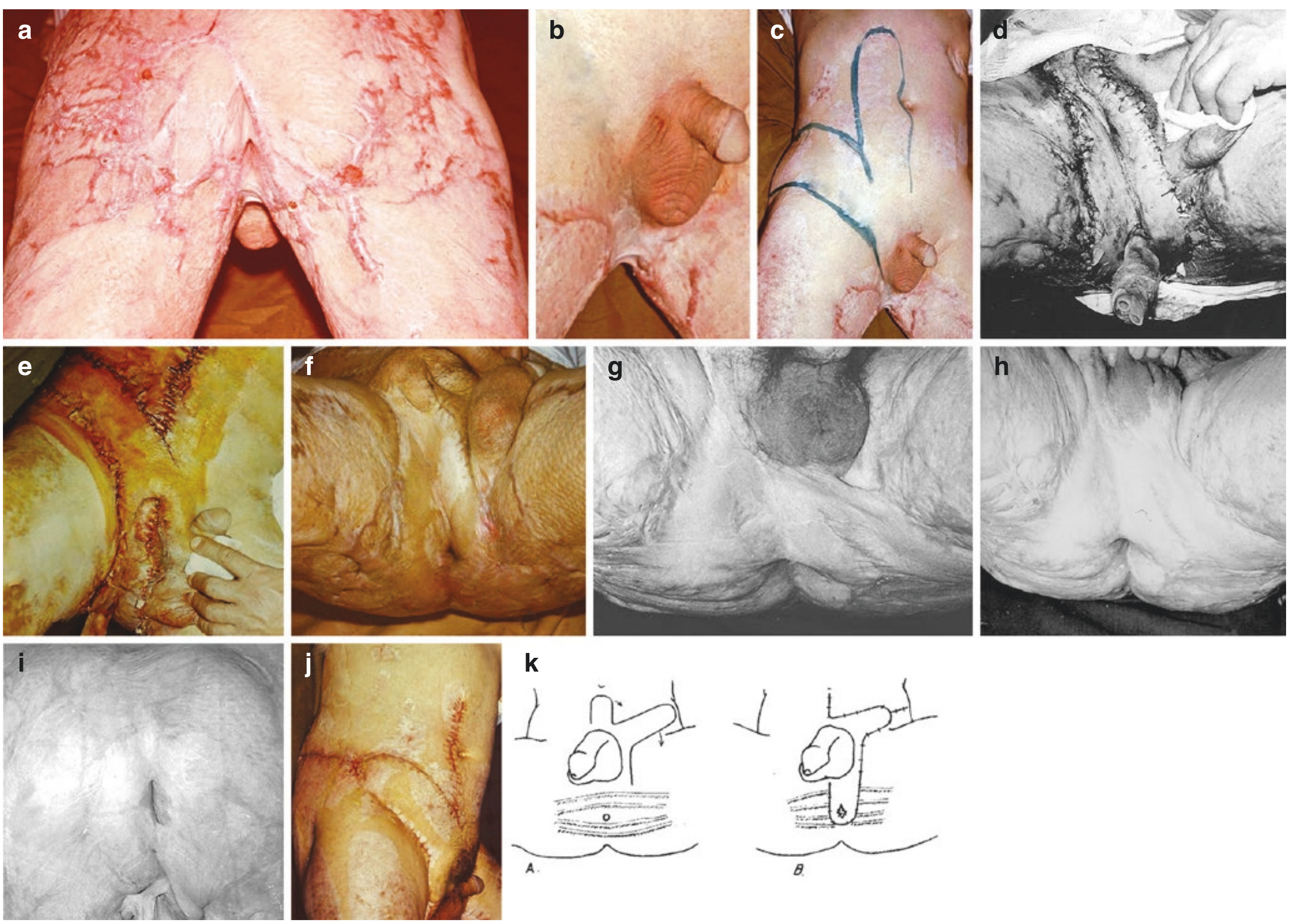

Fig. 32.3 Perineal, inguinal, and anal contracture reconstruction with bilobe groin flap. (**a**, **b**) Pre-surgery perineum obliteration (view posterior and anterior); (**c**) bilobe (groin and hypogastric) flap planning; (**d**, **e**) end of surgery: groin flap covered inguinal, perineal, and anal regions, three silicone tubes inserted in rectum; epigastric inferior donor wound primarily closed, part of groin flap donor wound covered with epigastric inferior flap, "dog-ear" at flap base; (**f**) 3 weeks after operation; (**g–i**) 5 years after reconstruction: all three contractures (perineal, inguinal, and anal) eliminated in full; (**j**) view of donor site; (**k**) perineum reconstruction with groin flap (scheme)

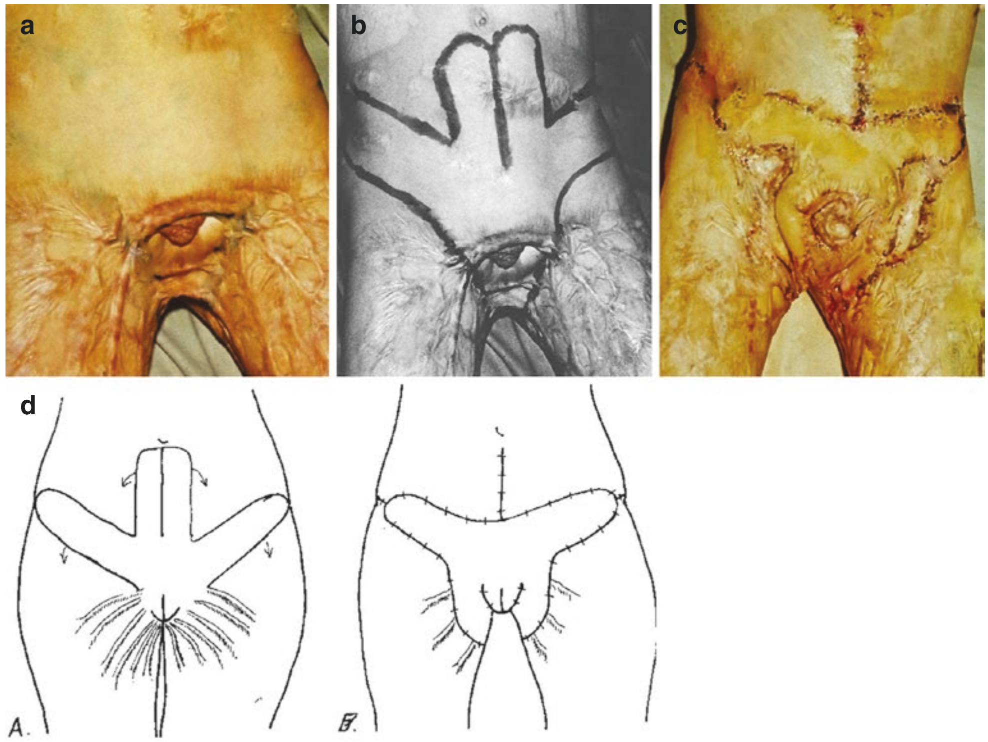

Fig. 32.4 Obliterated perineum and bilateral inguinal contracture elimination with two bilobe (groin and inferior epigastric) flaps. (**a**) Pre-surgery; (**b**) boundaries of two bilobe flaps depicted; (**c**) 2 weeks after reconstruction: inguinal and perineal contractures eliminated, next treatment stage directed to genitalia reconstruction; (**d**) scheme plasty with two bilobe flaps

Conclusion

Perineal, inguinal, and perianal contractures are eliminated using the groin flap. Groin flaps are alive; there is no tissue necrosis, flap loss, or other postoperative complications. The flaps do not shrink, their surface does not decrease, there is no contracture recurrence, and the flap's skin preserves its quality (elasticity, color, and texture). The full thigh abduction (approximately 80°) and hip joints' range of motion are achieved. The level flap surface and full hip motion allow for easy personal hygiene. The anal orifice opened freely during defecation. There was no skin inflammation around the anus. The donor place deformity is esthetically acceptable. In children, the groin flap continues to grow; this prevents contracture recurrence.

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33 Knee Edge Scar Flexion Contractures: Anatomy and Treatment

Introduction

Specific anatomical features of knee flexion contractures are the result of burns located on the flexion lateral (FL) joint surface (medial or lateral), flexion medial (FM) surface (popliteal area), or all three surfaces (both lateral and medial) together. Corresponding with scar location, three anatomical contracture types form: edge (lateral and medial), medial, and total. An edge contracture has a fold that is a surface surplus of scars and skin. The cause of the contracture is a scar surface deficit of a trapezoidal form. We proved that the best-matched flap is trapezoid-shaped and taken from the popliteal fossa. The tissue surplus is sufficient for complete contracture using trapeze-flap plasty without skin grafts and triangular flaps.

Functional Zones of the Knee Joint Surface

Before surgery, the knee joint surface is divided into a flexion surface (*F*) and extension surface (*E*); the line between them passes along the joint rotation axis level ("+") (Fig. 33.1). The joint's flexion surface is divided by the joint's surface curvature (edge of popliteal fossa) into the *FL* flexion lateral and *FM* flexion medial surface. Burns and scars, injuring the lateral knee flexion surface (*FL*), cause the edge flexion contracture; scars located on the FM surface (popliteal fossa) cause a knee medial flexion contracture.

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Fig. 33.1 Function zones of the knee joint's surface. Case 1: (**a**, **b**) knee joint zone functionally is divided into flexion (*F*) and extension (*E*) surfaces; the boundary between them is the joint rotation axis ("+"); the flexion surface is divided by curvature on flexion lateral (*FL*) and flexion medial (*FM*, popliteal fossa); the line between them and the crest of the fold passes along the edge of popliteal fossa. Case 2: anatomy of severe knee edge flexion contracture (right knee). (**c**): Lateral view: *E* extension surface; "+" joint rotation axis; *FL* flexion lateral surface of joint and all extremity lateral surface covered with rough scars, hypotrophy of leg and foot and deformation; big fold (*Fd*), lateral sheet which is made up of scars and continuation of the FL surface; (**d**) posterior view: crest (*Cr*) of the fold passes along the lateral edge of the popliteal fossa; *FL* flexion lateral and *FM* flexion medial surfaces and *Fd* fold; flexion medial surface (*FM*) and medial sheet of the fold are healthy skin. (**e**) Medial view: flexion medial (*FM*), FL surfaces and lateral sheet of the fold are healthy skin

Formation and Anatomy of Knee Edge Flexion Contracture

Knee edge flexion contracture has four specific anatomical features and clinical signs (Fig. 33.1c, d):

(a) Burns and scars causing knee edge contracture are located on the joint flexion lateral (*FL*) surface.
(b) Contracted scars of the FL surface grow distally, approaching the thigh and the leg, involve healthy skin of the popliteal fossa, and thus form a crescent fold along the popliteal fossa edge.
(c) The fold consists of scars on the lateral sheet (continuation of scars of the joint FL surface), and the medial sheet that is healthy skin and part of the FM surface.
(d) The fold's crest (*Cr*) is the edge of the scars.

These four anatomical features determined the name of this type: edge. Both sheets of the fold are new anatomical structures, and the surface surplus of scars and skin, the tissue of which is used with FM tissue (popliteal fossa) for knee edge flexion contracture elimination with local trapezoid flaps.

The fold's length and its protrusion vary from case to case, depending on the contracture severity. Contracted scars spread from the fold's crest to the joint rotation axis; scars located in the two segments (thigh and leg), forming the joint flexion contracture, have the scar surface deficit, which is the real cause of the contracture (Figs. 33.2c, 33.3b, and 33.4c).

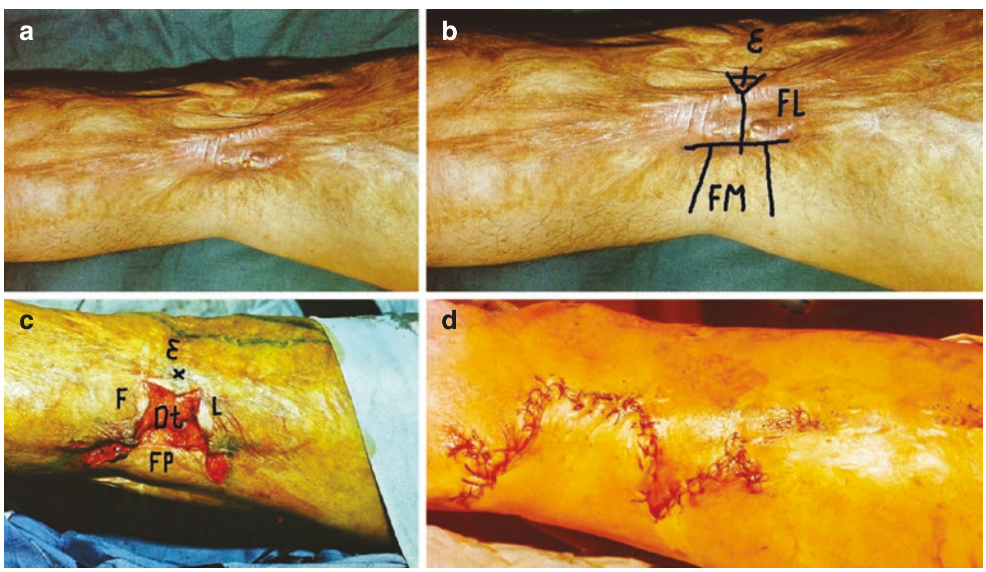

Fig. 33.2 Scar surface deficit is the cause of the contracture. (**a**, **b**) Contracture caused by the scar on the joint flexion lateral (*FL*) surface; scars spread to the joint rotation axis ("+"); *E*—joint extension surface does not participate in contracture formation; small fold and lateral sheet of the fold; *FM*—popliteal fossa is healthy skin and the donor site; planning reconstruction with one popliteal trapezoid flap; (**c**) contracted scars dissected with a Y-incision from the fold crest to the joint rotation axis, a trapezoid wound appeared, reflecting *Dt* scar surface deficit; *F* trapezoid knee flap; *E* extension surface; "+" joint rotation axis; *FL* flexion lateral surface; *FP* flap; (**d**) for complete contracture release, a trapezoid adipose-cutaneous flap is mobilized in popliteal fossa and scar surface deficit is compensated (one-flap-trapeze-plasty)

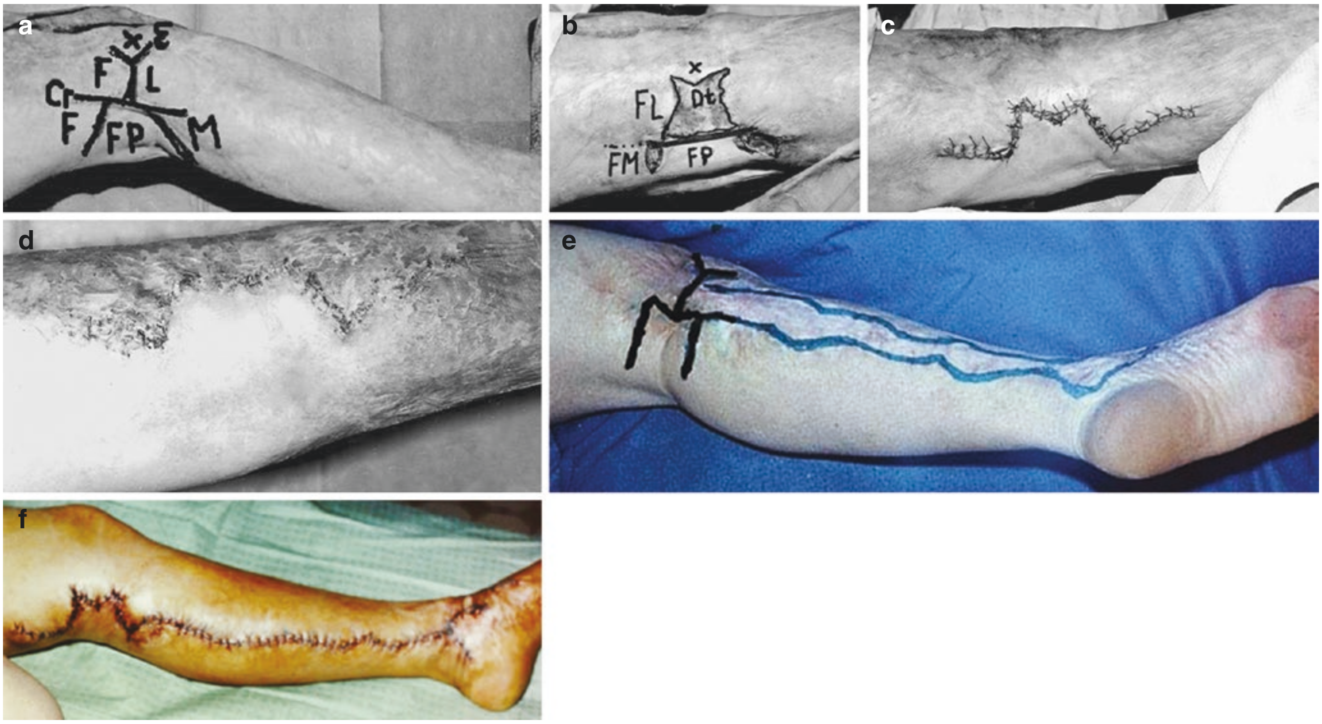

Fig. 33.3 Mild-to-moderate knee edge contracture treatment with one adipose-cutaneous trapezoid flap. Case 1: (**a**) pre-surgery: contracture anatomy and scar surface deficit: scars on *FL* flexion lateral surface; *FM* popliteal fossa or flexion medial surface (donor site) is healthy skin; *FP* flap planning; *E* joint extension surface, "+" joint rotation axis; (**b**) after FL contracted scars dissection with a Y-shaped incision, a trapezoid wound (*Dt* scar surface deficit) appeared; *Fp* flap mobilized; (**c**, **d**) flap compensated scar surface deficit and contracture released. Case 2: (**e**, **f**) edge knee contracture elimination with an adipose-cutaneous flap; strip of scars excised

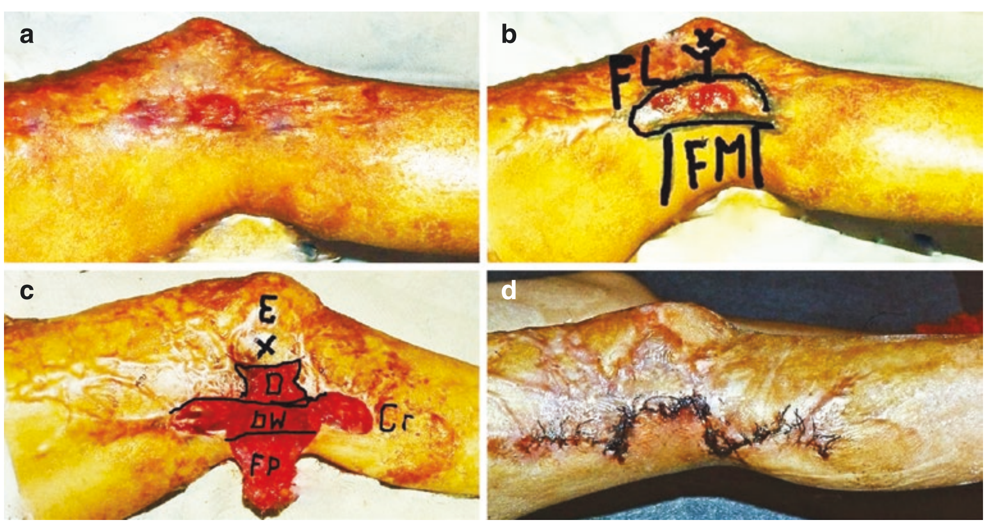

Fig. 33.4 Knee edge contracture treatment in case of scar ulceration. (**a**, **b**) Pre-surgery: ulcerous scars along fold's crest; *FL* flexion lateral, *FM* flexion medial surface; *E* extension surface; "+" joint rotation axis; planning trapezoid flap and incision of scars; (**c**) scar excised, a Y-shaped scar incision; a trapezoid wound/deficit (*D*) appeared; donor wound (*DW*); trapezoid adipose-cutaneous flap (*FP*) mobilized; (**d**) contracture eliminated by scar surface deficit compensation with one adipose-cutaneous trapezoid flap, donor wounds primarily closed

Scar Surface Deficit as Edge Contracture Cause

The knee edge contracture is caused only by the scar of the FL surface and scar sheet of the fold in which there is a surface deficit in length between the thigh and leg, which spreads from the fold's crest to the joint rotation axis (Fig. 33.2). The form and size of the scar's surface deficiency (the reason for contracture) must be determined first. The form and size of the scar surface deficiency is estimated using the following steps: According to lines, the scar sheet is separated from healthy skin of the FM surface with an incision along the fold's crest; then, with a perpendicular incision, scars are dissected with a Y-incision from the fold's crest to the joint's rotation axis level, where the incision's end is split 45°, forming a 90°angle. Split incision separates contracted scars of the FL surface from the joint extension tissue—(*E*). After joint extension, a trapezoid wound appears, which reflects, as rule, the real scar surface deficiency. The wound shape suggests that a flap should have a trapezoid form. Both sheets have a surface surplus in width, which allows preparation of a trapezoid flap from the healthy sheet and popliteal fossa (Fig. 33.2c).

Edge Contracture Elimination Techniques [1]

Reconstruction of Mild-To-Moderate Contracture with One Trapezoid Flap

Planning consists of drawing several lines: one along the fold crest separating scars from healthy skin; a Y-shaped perpendicular line for scars dissection, with a split end of 45° necessary for complete contracture release and full scar divergence without incision prolongation beyond the joint rotation axis. Two lines below the crest line mark the boundaries of the flap (Fig. 33.3a). The first incision separates the scar sheet from the healthy skin; then, the scar's subcutaneous fat layer is dissected with a Y-incision from the fold crest up to the joint rotation axis. According to the wound size and form, but 30% wider, the adipose-cutaneous flap is mobilized in the popliteal area up to the opposite popliteal fossa's edge, including the medial fold's sheet and all subcutaneous fat layers. The wound's end flap's end is nearly 5 cm in length and includes part of the fold's crest; the flap's length equals a distance among the popliteal fossa's edges (8–10 cm). The flap's end can be incised nearly 2 cm in depth for connecting with the same form "M" of the wound's edge (Fig. 33.3c). The flap is transposed on the wound with tension until the flap's end achieves a wound's end; the angles of the scar sheet cover the wound beside the flap (Figs. 33.2d and 33.3c, f).

One-Flap Plasty in Case of Fold's Crest Scars Ulceration

The scars in the popliteal area often undergo ulceration at the fold's crest (Fig. 33.4). Ulcerous scars are excised first; then, contracted scars are dissected with a Y-shaped incision; according to the trapezoid wound that appears, a flap is mobilized then covers the wound; scar surface deficit is compensated, and contracture is fully released (Fig. 33.4b–d).

Reconstruction of the Edge Knee: Moderate Contracture with Three Trapezoid Flaps

In cases of more severe contracture and scar surface deficit (Fig. 33.5), three adipose-scar trapezoid flaps are planned (Fig. 33.5a). When contracted scars are dissected from the fold's crest to the joint rotation axis, a trapezoid wound appears, which matches the scar surface deficit. Prepared from the medial sheet and popliteal fossa adipose-cutaneous trapezoid flap, it covers the central zone of the lateral knee joint surface; the donor wounds beside the flap are covered with adipose-scar trapezoid flaps (Fig. 33.5b), prepared from the scar sheet (three-flap technique). With time, the surface of the flap grows significantly. Reconstruction with three trapezoid flaps yields good functional and cosmetic outcomes (Fig. 33.5c).

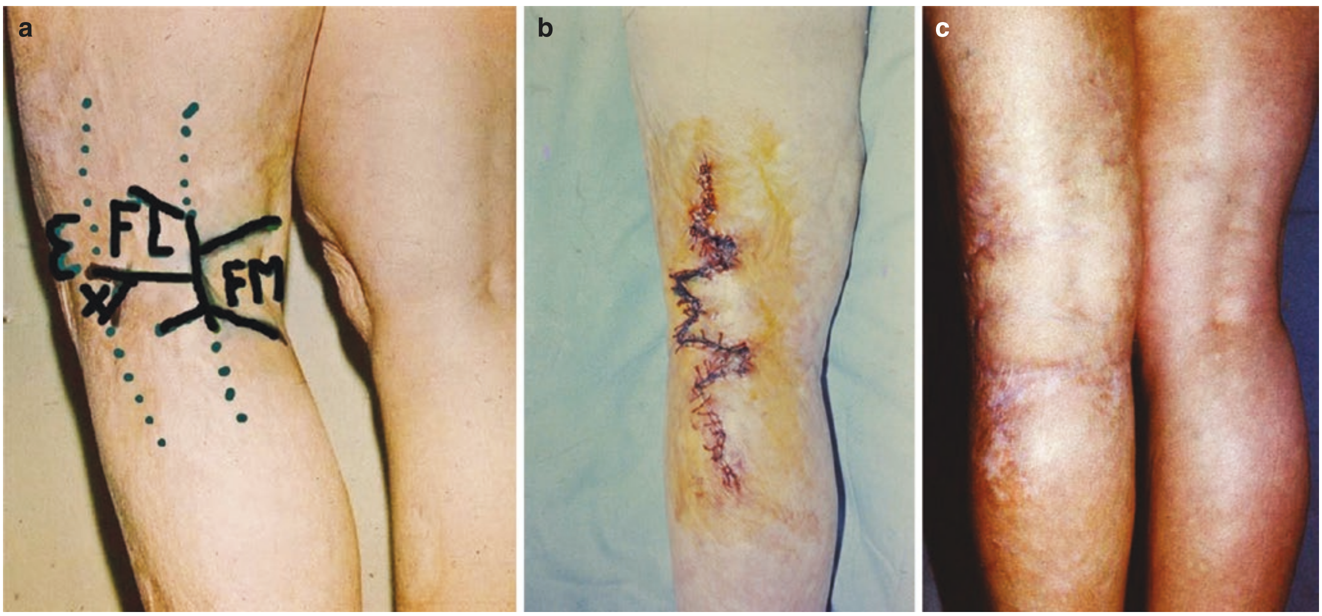

Fig. 33.5 Edge left knee contracture treatment with three trapezoid flaps. (**a**) Pre-surgery view: functional zones: *E* extension; "+" joint rotation axis; *FL* flexion lateral; *FM* flexion medial surface; three-trapeze-flap plasty planning: popliteal adipose-cutaneous trapezoid flap and two adipose-scar flaps for donor wound covering; (**b**) 5 days after reconstruction, flaps alive, contracture fully released; (**c**) 2 years after surgery: excellent functional and cosmetic outcomes, contracture fully eliminated, flap's surface significantly increased, normal knee contours

Elimination of Severe Edge Knee Flexion Contracture by Converting the Long Fold in Trapezoid Flaps

Severe edge knee contracture is caused by wide scars that cover the joint flexion lateral (*FL*) surface and neighboring regions and form a long fold (Fig. 33.6a, b). Treatment consists of conversion of the fold's sheet and neighboring skin of the joint FM surface on all its extents into trapezoid adipose-cutaneous and adipose-scar flaps. The main flap includes all of the popliteal fossa's adipose-cutaneous layer and covers the joint flexion lateral surface. The flaps' surface and neighboring tissue are sufficient for complete scar surface deficit compensation and contracture elimination (Fig. 33.6e).

Fig. 33.6 Treatment of severe right knee edge contracture with multiple trapezoid flaps. (**a**) Pre-surgery: anatomy of contracture (lateral view): *E* extension surface; "+" joint rotation axis; *FL* joint flexion lateral surface; *Fd* fold (lateral scar sheet of the fold), scar covered the lateral surface of the right lower extremity, forming a long fold along the popliteal fossa's edge; scar deformity and hypotrophy of the foot, ankle, and leg; (**b**) *FL* flexion lateral surface, *FM* flexion medial surface *Cr* crest of the fold. Lateral sheet of the fold is scars, medial sheet and popliteal fossa is healthy skin; *C*—planning of several adipose-cutaneous flaps from healthy tissue and adipose-scar flaps from scar tissue for donor wounds covering; (**c**) after contracted scar dissection, a trapezoid wound appeared (right of strip), a trapezoid adipose-cutaneous flap elevated; during operation, additional flaps mobilized from healthy and scar tissues; (**d**) 2 weeks after reconstruction: flaps are alive, contracture is released completely by counter transposition of the trapezoid flaps; (**e**) follow-up results (2 years after surgery): complete contracture eliminated, the adipose-cutaneous flaps became larger

Knee Edge Scar Flexion Contracture Elimination by Contracted Scars Excision and Wound Covering with Mobilized Popliteal Adipose-Cutaneous Whole Layer

In children under 10 years of age, mild knee edge contracture and scar deformity, caused by scars located on the lateral knee joint, hip, and leg surfaces, can be removed by scar excision and primary wound closure (Fig. 33.7) due to good tissue elasticity and displacement of the adipose-cutaneous layer. Scars are excised 5–6 cm in width, and the wound is closed by approaching the wound edges (without mobilization). Wound edges are connected with two or three rows of stitches; deep tissues are approximated with non-absorbable sutures.

Knee edge contracture release is useful in combination with scar excision on the leg and thigh (Fig. 33.8); scar excision in the knee zone and trapeze-flap plasty is accomplished at first; then, the scars are excised, starting from the flap, and the wound is primarily closed step-by-step for preventing venous congestion. The wound edges are approached with an inner row of non-absorbable sutures.

Knee edge contracture and deformity caused by rough scars covering the lateral surface of the knee, thigh, and leg pose a significant cosmetic problem (Figs. 33.9, 33.10, and 33.11). Therefore, the treatment is successful if contracture release is combined with scar excision. The wound is primarily closed due to the underlying thick soft tissue layer. First, the contracture is eliminated by scars dissection from the fold's crest to the joint rotation axis with a Y-shaped incision. Then, a suitable trapezoid adipose-cutaneous flap is mobilized and transposed on the trapezoid wound for scar surface deficit compensation. Starting from the flap's base, the scar strip is excised proximally and distally in short steps, and the wound is primarily closed with an inner row of non-absorbable stiches. Elimination of knee edge contractures with trapeze-flap plasty and simultaneous excision of the deforming scars on the thigh, knee, and leg restore the joint's function and significantly improve the appearance of all extremities, as shown in Figs. 33.9, 33.10, and 33.11.

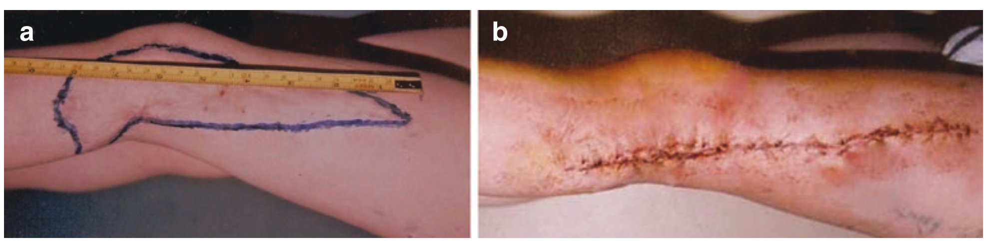

Fig. 33.7 Knee edge contracture in small children treated by contracted scar excision and entire popliteal adipose-cutaneous layer transposition on the wound. (**a**) Pre-surgery; planning; (**b**) strip of scars excised 4–6 cm in width; adipose-cutaneous layer of popliteal fossa transposed on the wound, contracture and deforming scars eliminated

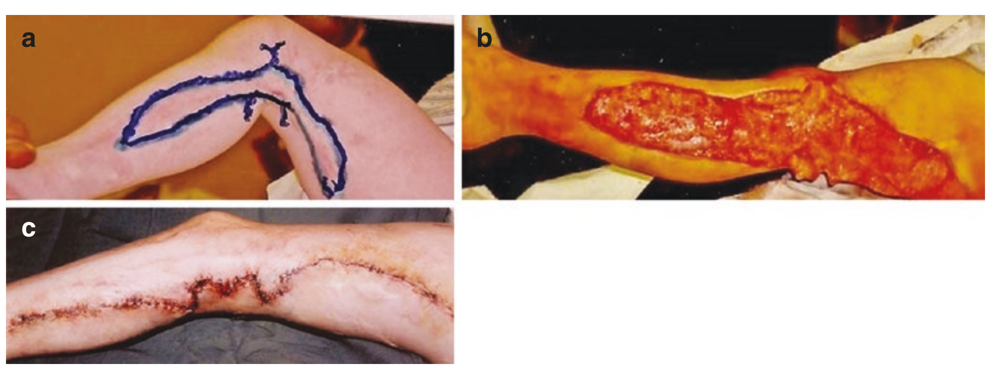

Fig. 33.8 (**a**–**c**) Knee edge contracture treatment by wide scar excision and contracture release with popliteal adipose-cutaneous flap

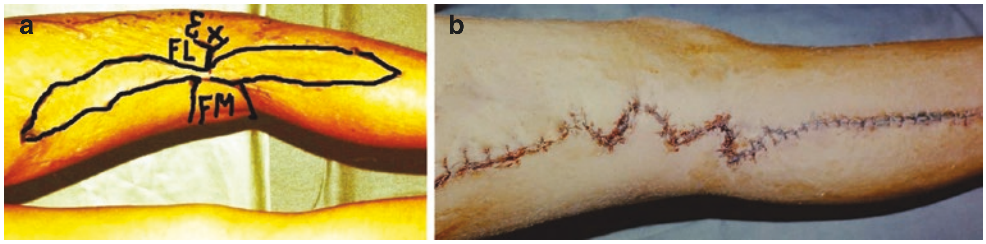

Fig. 33.9 Right knee edge scar contracture release with trapeze-flap plasty and rough scar removal on leg and thigh. (**a**) Pre-surgery, joint zones; *E*—joint extension surface; "+"—joint rotation axis; Y-line for contracted scars incision up to joint rotation axis; *FL*—flexion lateral surface covered with scars; edge of scars along the lateral edge of fossa where the fold crest is; scars to be excised are marked; *FM*—flexion medial surface is heathy skin where popliteal adipose-cutaneous flap marked; (**b**) strip of deformed scars excised, contracted scars dissected with a Y-incision up to the joint rotation axis, flap mobilized and trapezoid wound (scar surface deficit) covered with a flap; wounds beside the flap are primarily closed, starting from the flap; flap is alive, scar surface deficit is compensated, contracture is eliminated with one trapezoid flap, and appearance of reconstructed zone is improved

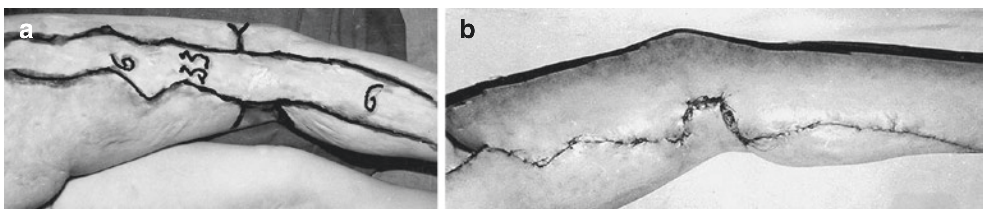

Fig. 33.10 Removal of right knee edge contracture and hypertrophic scars on the thigh and leg. (**a**) Pre-surgery, planning of contracture and deformity elimination; (**b**) contracture removed with one popliteal adipose-cutaneous flap; large zone of scars was excised; wounds primarily closed starting from the flap, simultaneously with scars excision

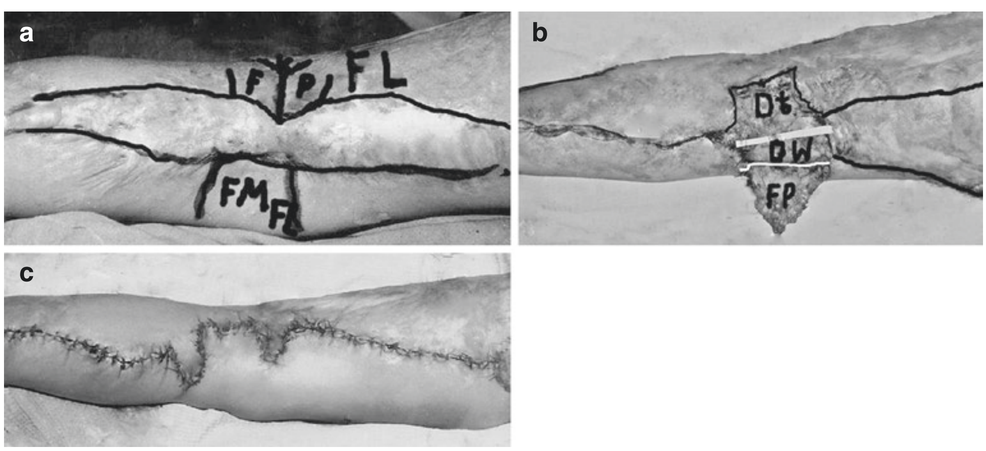

Fig. 33.11 Removal of edge contracture and deformity of left knee, caused with rough scars. (**a**) Pre-surgery, *FL* joint flexion lateral scar surface; *FM* flexion medial surface is healthy skin; planning three-flap trapeze-flap plasty and excision rough scars; (**b**) scars excised on the leg, contracted scars dissected with a Y-incision to the joint rotation axis, trapezoid large wound or *Dt* scar surface deficit appeared; *FP* popliteal flap mobilized, and *DW* donor wound appeared; (**c**) end of operation: scar on the sigh excised, contracture released with three trapezoid flaps; main popliteal adipose-cutaneous flap compensated scar surface deficit, two flaps prepared from scars of joint FL surface for donor wound covering; appearance of extremity improved and contracture eliminated

Conclusion

Knee edge flexion contractures are fully eliminated with trapeze-flap plasty without complications. Depending on contracture severity, the different number of adipose-cutaneous and adipose-scar trapezoid flaps is used. Main donor site is undamaged popliteal fossa and sheets of the fold. The adipose-cutaneous popliteal flap surface after surgery is significantly increased. Follow-up results are functionally excellent; the knee joint area accepts normal contours, and the donor site (popliteal fossa) preserves normal form. In children, the whole popliteal adipose-cutaneous flap transposed on the wound with tension, is alive. Simultaneous trapeze-flap plasty with rough scar excision and primarily wound closure in children eliminates contracture and improves the appearance of the reconstructed zone.

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34 Knee Medial Scar Flexion Contractures After Burns: Anatomy and Treatment

Introduction

Knee medial contractures form after burns of the knee posterior surface (flexion medial [FM]). The anatomy and treatment of this contracture type is not explored and highlighted in the literature. When wounds from burns are healing, scars form a fold that covers the entire popliteal fossa. In the fold's sheets is a surface deficit in length (contracture cause) and a scar surface surplus in width, allowing medial contracture elimination with local adipose-scar trapezoid flaps. Fold sheets have a surface deficit in length of a trapezoidal form, which is the real cause of contracture. These trapezoid observations enabled us to develop a technique to convert fold sheets into trapezoid flaps and to eliminate contracture with a local trapezoid flap. Rough, ulcerous scars should be excised and wound skin grafted.

Functional Zones and Anatomy of Knee Joint Flexion Medial Contracture (Fig. 34.1)

Scars that cause knee medial flexion contracture cover the joint's *FM* flexion medial surface or popliteal fossa; the flexion lateral (*FL*) surface stays undamaged (Fig 34.1b, c). Scars in the popliteal area form a crescent fold (*Fd*), the crest of which is located along the medial line of popliteal fossa; both sheets of the fold are scarred (*FM*) and spread from the fold's ulcerous crest to the popliteal fossa's edges (*FL*) (Fig. 34.1b, c).

These three anatomical features determine the name for this type: *medial*. Both scar sheets of the fold have a surface deficiency in length (cause of a contracture) and surface surplus in width, which allows treatment of the contracture with local flaps. The fold can be small and short or may spread to the thigh and leg. Thus, flexion contracture of the knee joint has specific anatomical features and signs, shown in Fig. 34.1. Contracture is caused by a scar surface deficit in length, the maximal tension is along the fold's crest; therefore, ulcers at first appeared along the fold's crest.

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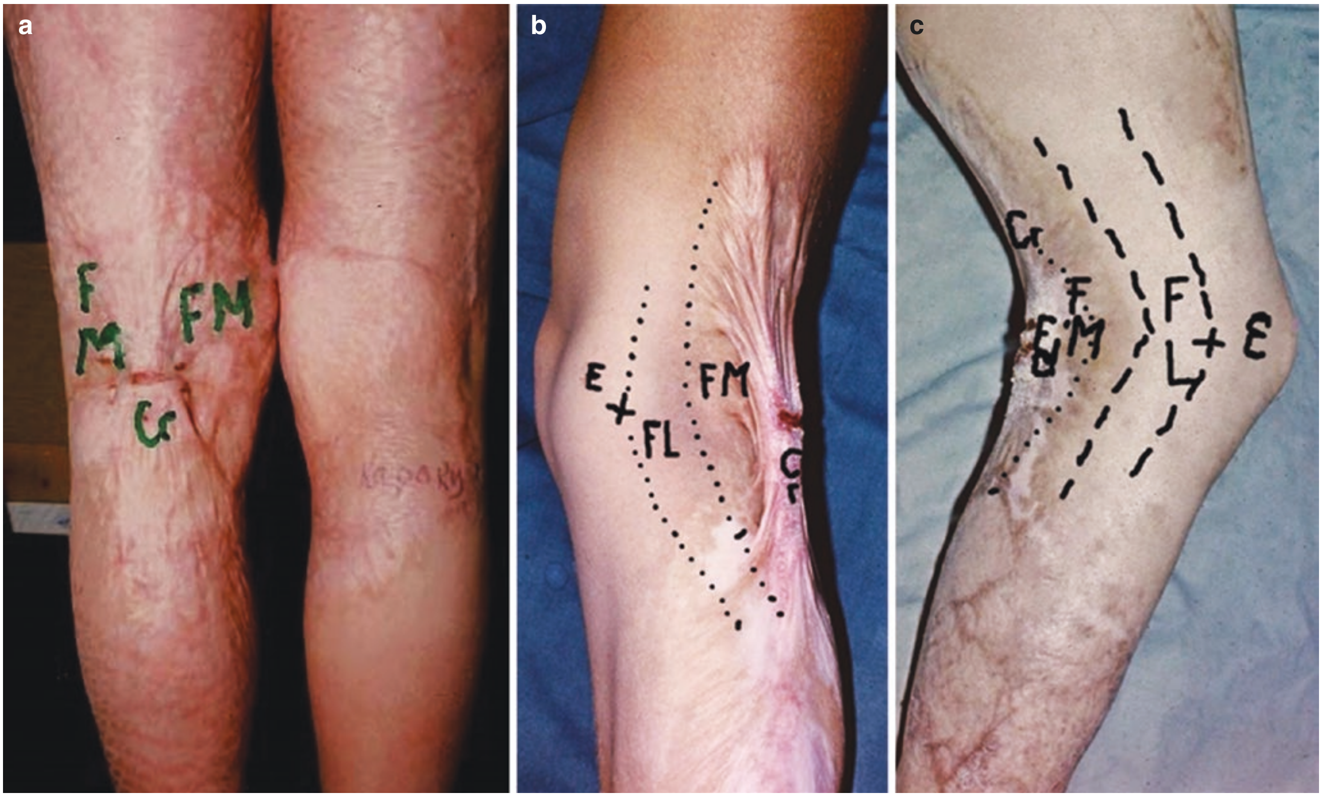

Fig. 34.1 Knee joint's functional zones and medial scar contracture anatomy. (**a**) Left knee: the flexion medial (*FM*) surface (popliteal fossa) is covered with scars that formed the fold, ulcerous crest (*Cr*) of the fold passed along the medial fossa line. (**b**, **c**) The fold (*Fd*) has a semilunar form, both sheets of the fold are scars and spread from the fold crest to the edges of the popliteal fossa or flexion lateral surface (*FL*); the flexion lateral surface does not participate in contracture formation; symbol "+"—joint rotation axis; *E*—joint extension surface

Scar Surface Deficit Is the Cause of the Knee Medial Contracture (Fig. 34.2)

The sheets of the fold are scars and have a surface deficit in length, causing joint flexion contracture; maximal tension (deficit) is at the crest of fold and spreads to the edges of popliteal fossa. In addition, the fold sheets are new anatomical structures, a surface surplus that allows the contracture to be eliminated with local tissue (Figs. 34.2 and 34.3). The scar surface deficit or contracture cause is estimated in the following way (Fig. 34.2a–c): The fold sheets are divided with an incision along the fold's crest; contracture is released by a perpendicular Y-shaped incision from the fold crest to the popliteal fossa edges; the split end of the incision sepa-

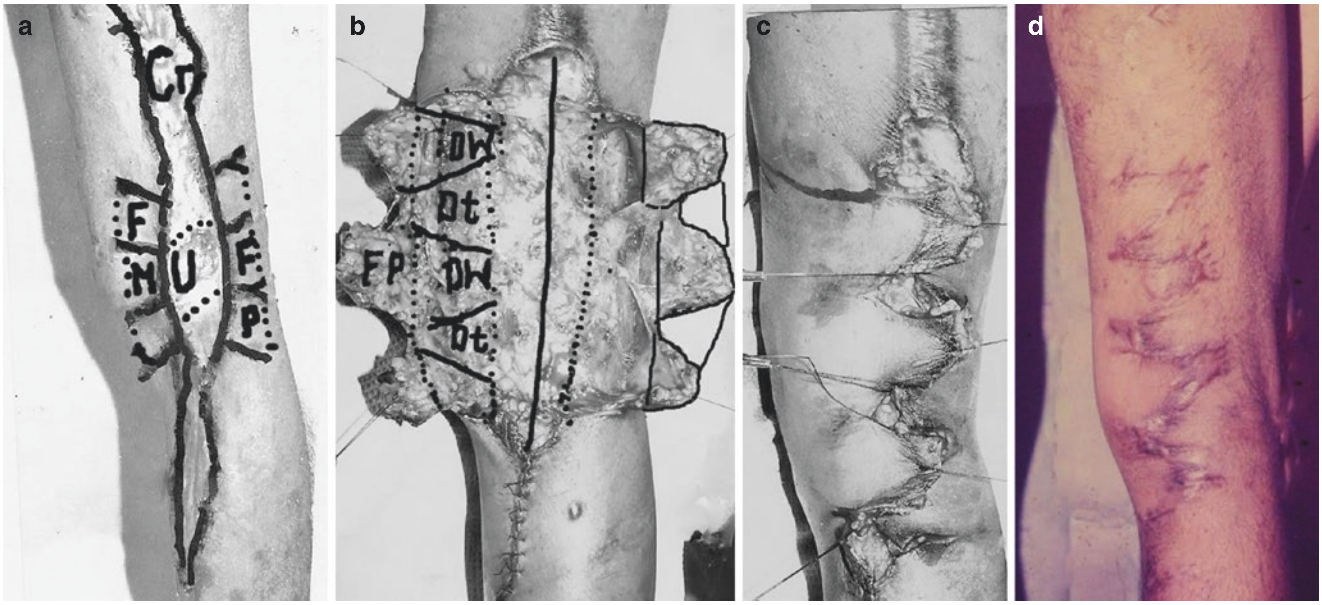

Fig. 34.2 Scar surface deficit in sheets of the fold and flaps has a trapezoid form. (**a**) Before operation: long ulcerous (*UL*) fold, planning: three pairs of trapezoid flaps marked. (**b**) After sheet separation and cross-cut with Y-shaped incisions, flaps and wounds (distance among the flaps) accepted trapezoid form; (**c**) counter flap's transposition compensated scar surface deficit and complete contracture eliminated; (**d**) follow-up results: contracture released, knee appearance normalized

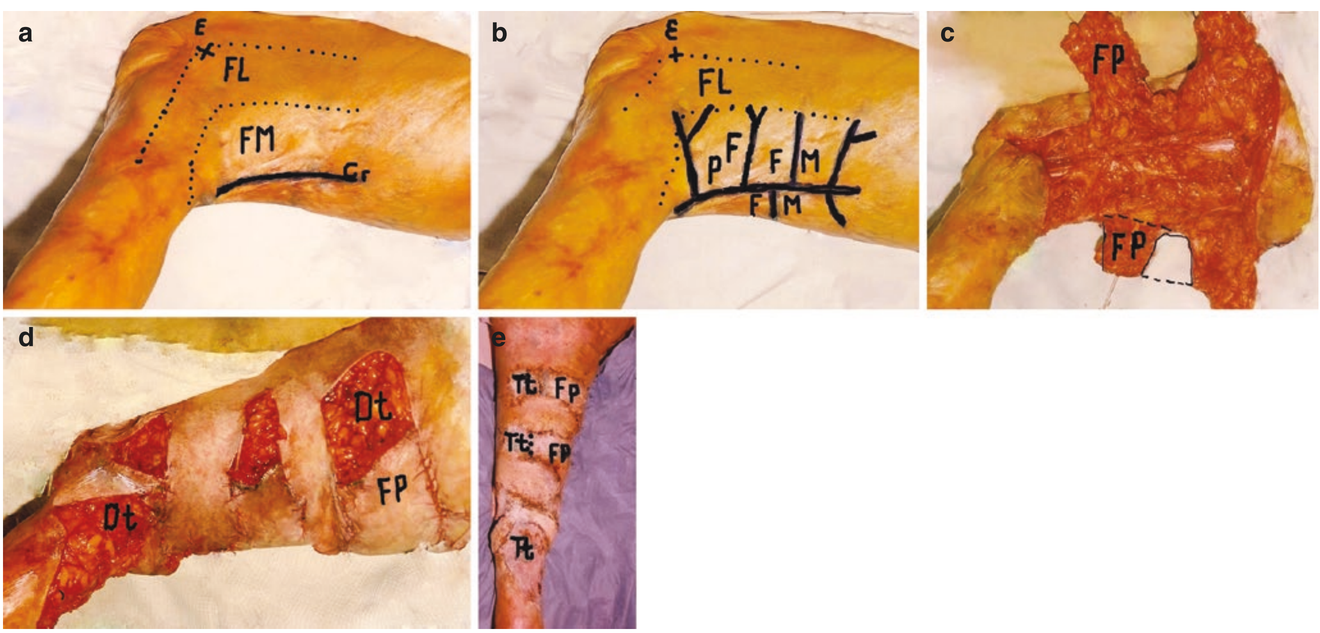

Fig. 34.3 Knee severe medial contracture treatment with trapeze-flap plasty (accepted abbreviation used). (**a**, **b**) Before operation, planning by radial Y-incision; (**c**) semilunar fold is dissected by radial incisions, which formed adipose-scar trapezoid flaps mobilized, scar surface deficit (*Dt*) in both fold's sheets (the space among trapezoid flaps) has trapezoid form; (**d**) counter-transposed flap (*F*) covered most flexion surface, residual wound/deficit (*Dt*); (**e**) 10 days after surgery: flaps (*Fp*) and transplants (*Tt*) are alive and contracture release is complete

rates scars of the fold's sheets from the tissue of both flexion lateral surfaces; therefore, the wound edges of dissected scars diverge freely, allowing full release of contracture. After joint extension, as a rule, the trapezoid wound appears in both scar sheets, which is widest at the fold crest and spreads, subsiding, to the popliteal fossa edges where the wound's end is 4–5 cm wide (Fig. 34.2b). Consequently, adequate contracture treatment of knee medial contracture can be performed by means of surface deficiency compensation with the trapezoid flaps (Fig. 34.2b–d).

Scars in the popliteal area undergo severe tension while the patient is walking; therefore, the scars tear first in the maximal tension zone (fold crest), and scars in the popliteal area often become pathological—rough, thick, red, keloid—and unfit for plasty (Fig. 34.4). Because of tension, scars tear, a small wound gradually converts to a chronic ulcer, and the normal scars become pathological, and should be excised.

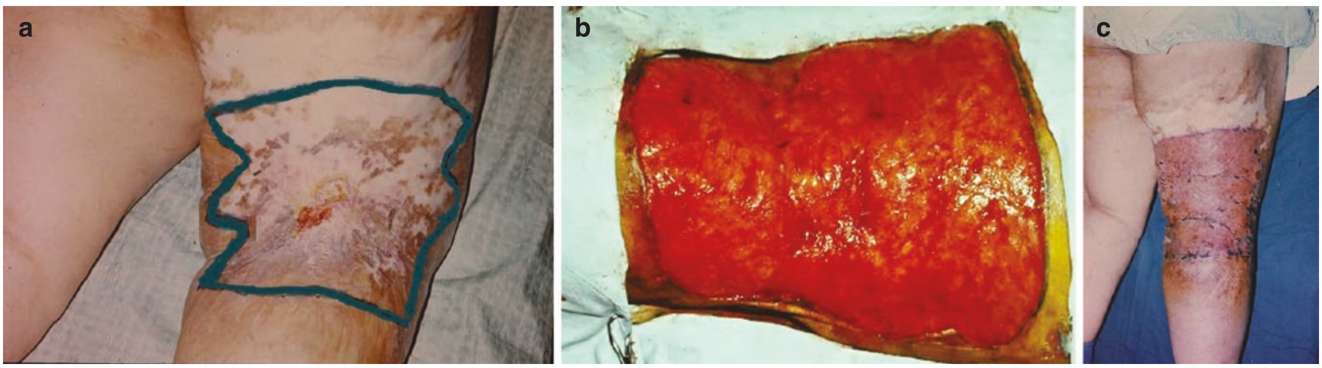

Fig. 34.4 Knee medial contracture treatment by wide flat (without fold) pathological scars excision through the intermediate layer without bleeding and skin grafting. (**a**) Pre-operation: rough ulcerous scars covering the popliteal area; (**b**) scars excised through the intermediate layer, no bleeding, the fat layer uninjured; (**c**) the wound is covered with split skin grafts, contracture released, transplants are alive

Knee Medial Contracture Elimination Techniques [1]

Reconstruction with Trapeze-Flap Plasty (Figs. 34.2 and 34.3)

Two procedures have been used. If scars of the fold are pliable and thin, the fold sheets' scars are used for plasty. The goal is to fully convert the fold's sheets in the flaps (Fig. 34.2a). The ulcerous fold's crest is excised, and the fold's sheets are divided along the entire fold's crest. As the fold has a crescent form, the Y-shaped incisions from the fold's crest to the popliteal fossa's edges convert the sheets in the flaps which, as a rule, take on a trapezoid form; after knee extension, the wounds also take on a trapezoid form (Fig. 34.2a).

The flap's end is nearly 5 cm in width and includes part of the fold's crest; the flap base corresponds to the popliteal fossa's edge. Scars and full subcutaneous fat layers are included in the mobilized flap, with a steady blood supply. Flaps are counter-transposed with tension. The flap's ends approach the opposite flap's base (Fig. 34.2b). Depending on contracture severity and fold length, one or several pairs of the flaps are elevated until contracture can be fully released and the wound covered with flaps. In the case of severe contracture, the fold is expressed insufficiently, and the flaps cover the central knee flexion zone; residual wounds were skin-grafted (Fig. 34.3). The rate of lengthening always exceeds 100% (the sum of all flaps in their middle width minus the length of the crest involved in plasty).

Wide Pathologic Scars Excision and Skin Grafting (Figs. 34.4, 34.5, and 34.6)

Scars covering the popliteal area were often pathologic (rough, thick, solid, and ulcerous) which impossible to convert in the flaps. Such matured scars are excised through the intermediate layer, which is formed during maturation of the scars' inner surface and has a scanty number of vessels. Only after the scars' excision can the knee be extended, with caution. To prevent tearing of the fatty layers, the surgeon lays his or her palm on the wound, creating pressure during knee extension. The split transplants, placed on such a wound's transverse surface, grew well; their shrinkage is minimal and contractures are eliminated completely.

Knee medial scar flexion contractures of both joints are eliminated simultaneously. Rough and ulcerous scars are excised through the intermediate layer in rhombus form (Fig. 34.5a, b) or butterfly (Fig. 34.4), and wounds are skin-grafted. If scars in one popliteal zone are not pathologic, trapeze-flap plasty is indicated (Fig. 34.5d, right knee).

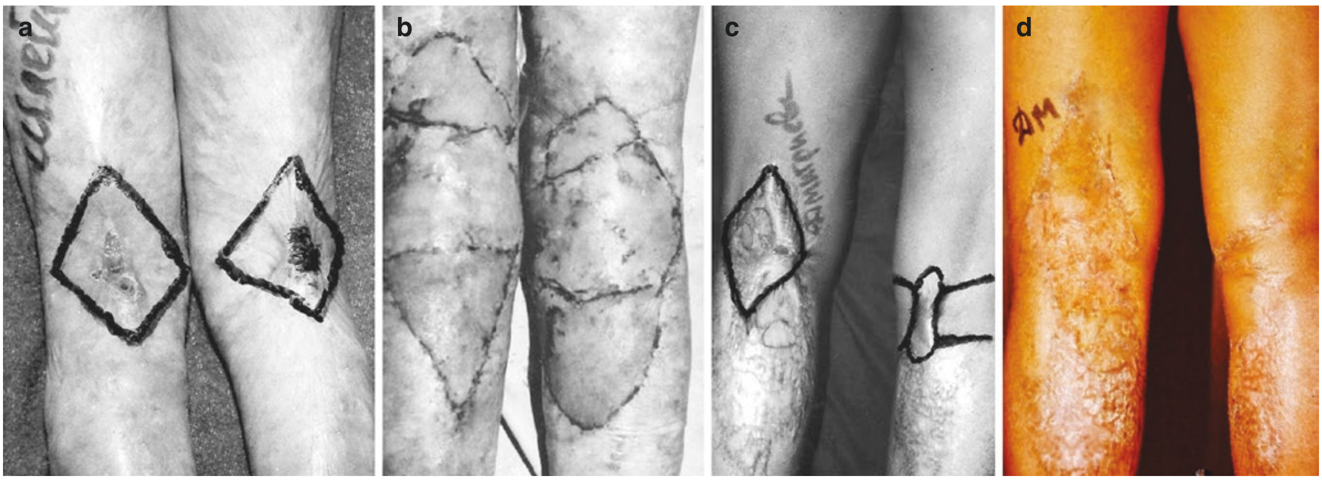

Fig. 34.5 Case 1: Ulcerous pathologic scars caused knee medial contracture; (**a**) before surgery: rough scars, ulcer along the crest of the fold; planning of scars excision in the rhomboid form; (**b**) contracted scars excised on both knee and wound skin grafted (10 days after surgery); skin transplants look well. Case 2: (**c**, **d**) Contracture of left knee caused by rough ulcerous scars and treated with skin grafting; right knee contracture caused by scar fold eliminated simultaneously with one pair of adipose-scar trapezoid flaps; good follow-up results

Fig. 34.6 Follow-up result of the knee medial contracture treatment with scar excision and skin grafting. (**a**) Before surgery: pathologic ulcerous scars in the popliteal zone; (**b**) scars excised through an intermediate layer without fat tissue injury and bleeding; the wound is skin-grafted; (**c**) 2 years after reconstruction: contracture released in full, no shrinkage of skin transplants, no re-contracture and ulceration

Conclusion

After trapeze-flap plasty, no scar flap loss was observed; good follow-up results were achieved. After excision of scars, skin transplants cover large wounds without complication and are functioning well during all phases of observation, without signs of ulceration and re-contracture.

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1. Grishkevich VM. Postburn knee flexions contractures: anatomy and methods of their treatment. Trop Med Surg. 2013;1:147.

35 Total Knee Flexion Contracture After Burns: Anatomy and Treatment

Introduction

Circular burns and scars of the lower extremity constrict soft tissues of the knee joint and the distal segment of the lower extremity, severely restricting joint motion and causing tissue hypotrophy. Scars in the popliteal zone suffer from intense tension during walking, resulting in tears and progressing to nonhealing ulcers. If the passive range of motion in the knee is preserved, then scars can be excised through the intermediate layer and the wound covered with skin graft. In cases of intra-articular restriction of complete extension, scar excision and grafting are combined with the use of an orthopedic external fixation/traction device.

Contracture Anatomy

After vast and deep burns, scars tightly constrict the knee, creating severe scar surface deficit without a scar fold (Fig. 35.1). Reconstruction with local flaps is not possible. These anatomical criteria are characteristic of total contracture. As a result of severe tension on scars of the posterior knee surface when the joint is extended, scars progressively degenerate to thick, firm, rough pathologic scars, prone to necrosis and ulceration. Along with the severe scar contracture, deep burns may injure the articular structures, adding to the contracture's severity and making it difficult to treat.

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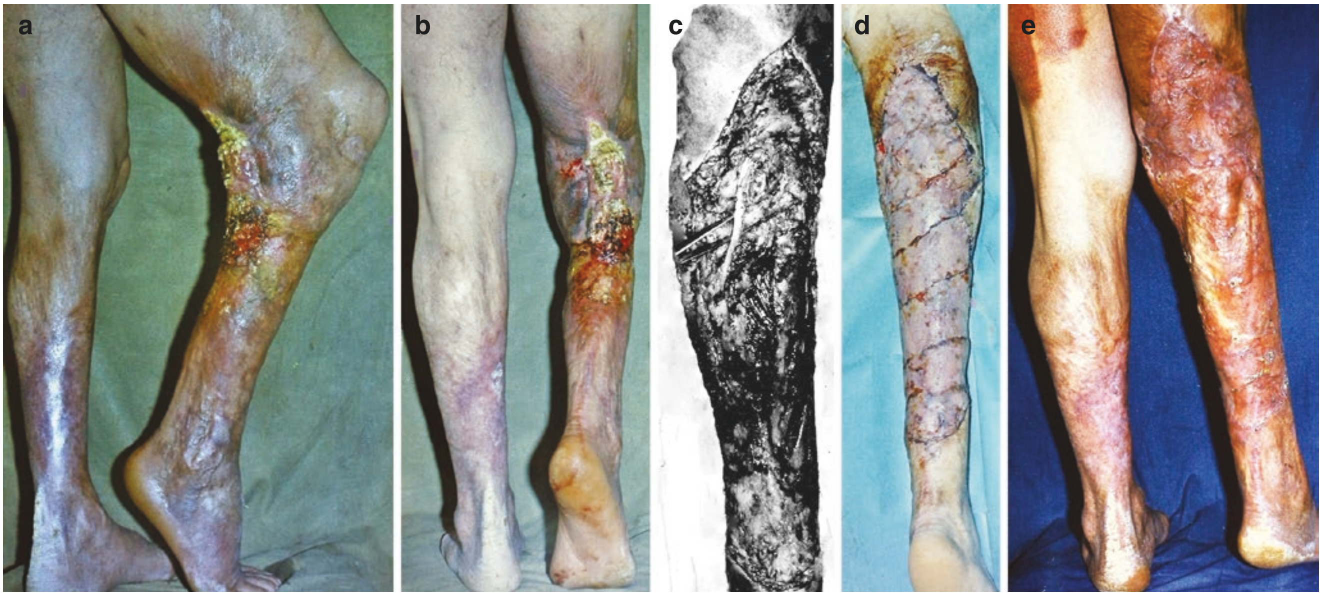

Fig. 35.1 Severe right knee scar flexion contracture with large ulcer and soft tissue hypotrophy. The entire affected extremity surface was treated by excision of all pathologic scars and skin grafting. (**a**, **b**) Presurgery view. (**c**) Pathologic scars with ulcer excised in one block, exposed nerves and vessels covered with fat tissue transposition; (**d**) large wound covered with whole skin split transplants (2 weeks after plasty, transplants alive); (**e**) 2 months after reconstruction: knee contracture is fully released, compensatory ankle contracture is diminished, skin transplants look good, and the leg has become thicker

Total Knee Contracture Treatment

The operation consists of excision of pathologic and ulcerated scars in the popliteal area and lateral joint surfaces. Manual knee extension is combined with pressure on the wound by the surgeon's palm to prevent tearing of fat tissue and exposure of solid structures. If total contracture is complicated by ulcers (Figs. 35.1a and 35.2a), pathologic scars are excised in one block; the exposed blood vessels and nerves (Figs. 35.1b and 35.2c) are covered with the local fat tissue transposition; the wound is covered with skin transplants (Figs. 35.1c–e and 35.2c, d). Only mature scars undergo excision when the inner layer of the scars is converted into pliable connective tissue without numerous capillaries found in immature scars. Such scars are easier to remove without bleeding in one segment through the intermediate layer. Skin transplants placed on such wounds grow well onto underlying tissue without forming hematomas or necrosis.

Successful reconstruction is achieved if all pathologic scars are fully excised. After surgery, the operated extremity becomes thicker and skin transplants look well without ulceration. For treatment of the articular knee contracture, an orthopedic external traction device is applied (Fig. 35.3). After surgery, the usual gutter splint is applied for 3–5 weeks.

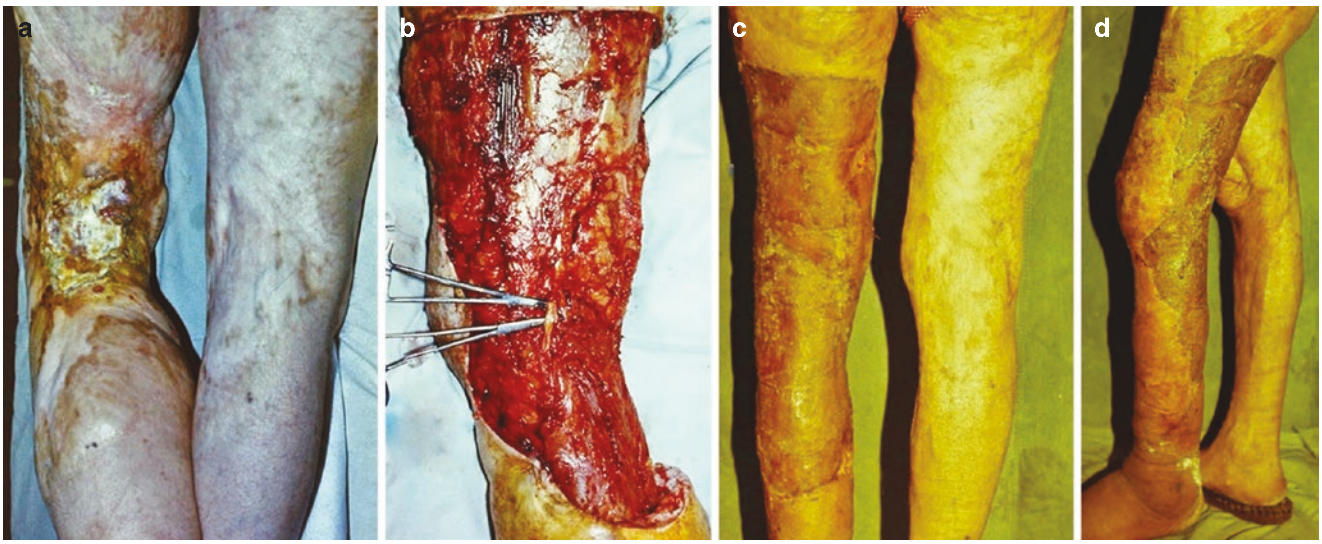

Fig. 35.2 Severe total knee contracture with lympho-venous insufficiency treatment with wide excision of ulcerous scars and skin grafting. (**a**) Pre-operative view; scar with pathologic ulcers covering all the popliteal zone; the distal segment of the damaged leg is much thicker than the healthy side. (**b**) Scars excised through intermediate layer, no bleeding, the fat layer is not injured, covered with a thin layer of connective tissue; an exposed nerve is covered with local fat tissue. (**c**, **d**) The wound is covered with whole split skin transplants; 6 months after reconstruction: good functional and cosmetic results

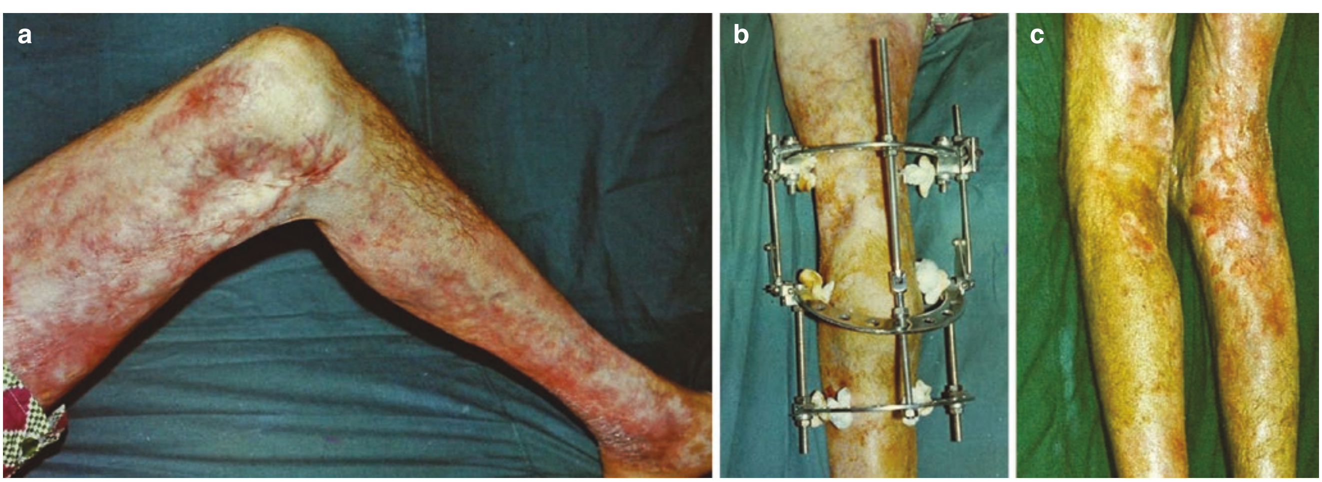

Fig. 35.3 Severe total knee contracture caused by contracted scars and injured solid articular structures, which is treated using an external traction device and skin transplant. (**a**) Pre-surgery: severe contracture, atrophic soft tissue; (**b**) contracted scars in popliteal fossa excised and wound skin grafted, distractor applied; (**c**) flexion contracture compensated and knee joint straightened

Conclusion

Total knee contracture is successfully eliminated by wide excision of all pathologic, ulcerous scars and skin grafting. An external traction device should be used if the joint cannot be extended fully after all contracted scars are excised or if contracture is caused by injury of the joint itself and its support structures. The skin transplants, covering a large wound, turn into a well-functioning skin; therefore, wide scar excision and skin grafting significantly improves the overall extremity appearance.

Suggested Reading

1. Grishkevich VM. Postburn knee flexions contractures: anatomy and methods of their treatment. Trop Med Surg. 2013;1:147.

36 Ankle Edge Dorsiflexion Scar Contractures: Anatomy and Treatment with Trapeze-Flap Plasty

Introduction

Postburn ankle scar contractures cause functional limitations of affected extremities and create a serious cosmetic defect; patients cannot use normal footwear and therefore need surgical reconstruction. The anatomical features of ankle dorsiflexion contractures and their treatment have been covered in the literature far less than those of other joint contractures, and their treatment is still a challenge for many surgeons. Our comparative data show that the anatomically substantiated technique is trapeze-flap plasty, which yields excellent outcomes because the local trapezoid flaps cover the scar surface deficit (cause of contracture).

Anatomy of Edge Ankle Dorsiflexion Scar Contracture

The ankle joint's surface is divided functionally into a flexion (*F*) surface and an extension (*E*) surface. A line passes between them through the malleolar apex or joint rotation axis ("+") (Fig. 36.1). The flexion anterior surface is divided into flexion lateral (*FL*) and flexion medial (*FM*) surfaces; a boundary passes along the curvature of the flexion surface (Fig. 36.1). During wound healing, the crescent fold forms along the edge anterior and the lateral ankle surface (Fig. 36.1b). Scars cover the FL surface and form the lateral fold's sheet; the medial fold's sheet is healthy skin that spreads on the FM surface. The crest of the fold (*Cr*) is the edge of scars (these anatomical features reflect the name for this type, edge) (Fig. 36.1b).

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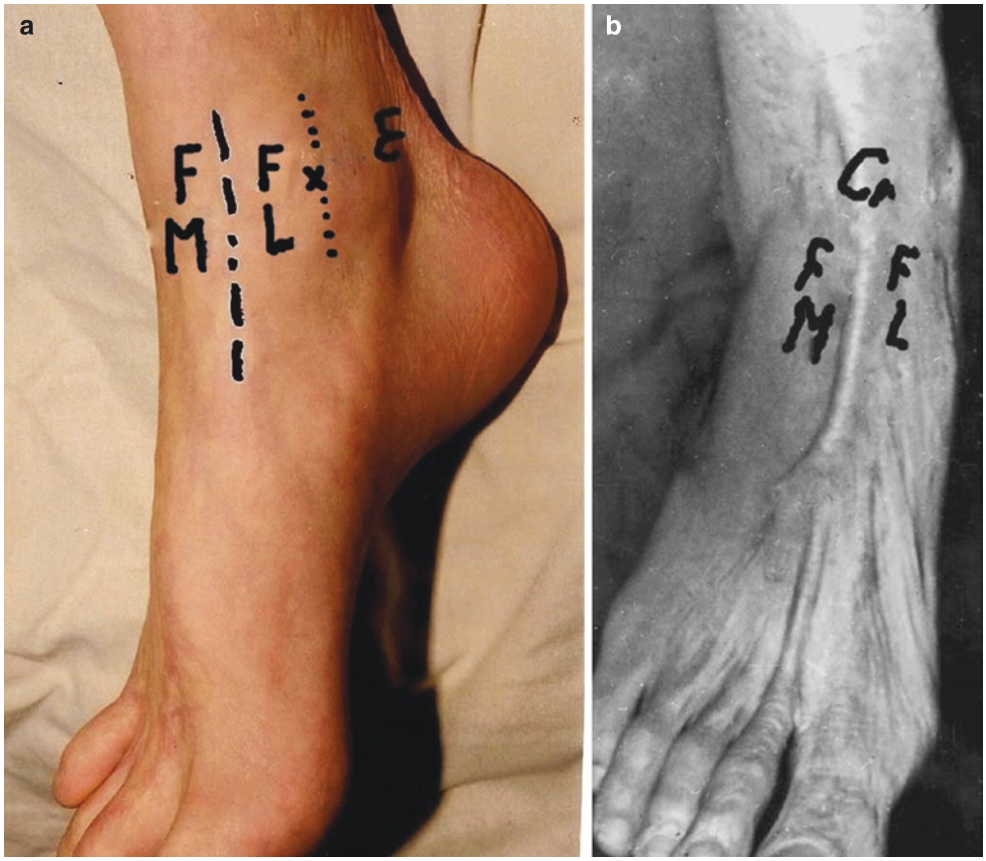

Fig. 36.1 Ankle joint functional surfaces. (**a**) Healthy ankle: joint surface of the healthy ankle is divided into flexion (*F*) and extension (*E*); the dividing border between them passes through the malleolar apex ("+"). The flexion surface of the healthy ankle joint is divided into flexion anterior/medial (*FM*) and flexion lateral (*FL*), located among joint flexion anterior/medial (*FM*) and joint extension/posterior (*E*) surface. Curvature between FM and FL is less well expressed than in other large joints. (**b**) Anatomy of edge scar contracture: (*1*) scars cover FL surface; (*2*) scars form the fold along edge of FL surface; (*3*) Different quality of fold sheets: lateral is scars,part of scars of FL surface; medial is healthy skin and part of FM surface; (*4*) crest of the fold (*Cr*) is edge of scars

Scar Surface Deficit Is the Real Contracture Cause [2]

Contracture is caused by scars that cover the joint flexion lateral surface (*FL*) and form the fold, the scar sheet of which participates in contracture formation. Scars have a surface deficit in length (Fig. 36.2), maximal along the fold's crest. The scar surface deficit spreads to the joint rotation axis where it has a lineal meaning, nearly 3–4 cm in width (Fig. 36.2b), which causes the contracture. The fold is a new anatomical structure, with a surface surplus of scars and healthy skin, and allows scar surface deficit compensation with local tissue. The scars have surface deficiency in length and form (reason for contracture) is determined by a first step because reconstruction is aimed at compensating for the deficiency with one or more adequate flaps. The form and size of the scar surface deficiency is estimated using the following steps: The sheets are divided with an incision along the fold's crest, and a Y-shaped incision perpendicular to the crest dissects the scar sheet from the fold's crest to the malleolus, where the incision is split at 45°. After ankle dorsi-extension, the wound, as a rule, accepts a trapezoid form, reflecting the form and size of scar surface deficiency, which is maximal at the fold's crest and spreads, subsiding to the ankle joint rotation axis (Fig. 36.2); the trapezoid flap's form is necessary for deficiency compensation and contracture elimination becomes obvious.

Fig. 36.2 Anatomy and contracture cause/scar surface deficit of the left ankle edge contracture. (**a**) Right ankle: scars cover the joint flexion lateral (*FL*) surface; the flexion medial surface is healthy skin. A fold is formed between the flexion lateral and flexion medial surfaces. The fold consists of two sheets: the lateral fold's sheet (*FL*) is scars; the medial sheet and adjacent flexion medial (*FM*) surface are healthy skin; the crest (*Cr*) of the fold lies between them, where the edge of scars is; (**b**) after scar sheet dissection with a Y-shaped incision and contracture release, the wound (*Dt*—scar sheet surface deficit) accepts trapezoid form (to the right of the white strip), which is the real cause of the contracture). Trapezoid flap (*FP*) mobilized

Treatment of Edge Ankle Dorsiflexion Contractures with Trapezoid Flaps

Anatomical features of edge contractures (severity, fold length, and protrusion) lead to the use different variants of trapeze-flap plasty [1].

One-Trapeze-Flap Technique

The mild-to-moderate edge ankle contracture is removed with one flap, prepared from the medial healthy fold sheet and skin of the ankle anterior surface. The planning (Fig. 36.3a, d) consists of several lines: The line along the fold's crest; a perpendicular line on the scar's sheet with a Y-shaped end at the head of the malleolus; and two lines marking the flap's borders in ankle joint projection. With the first incision along the fold's crest, the sheets are separated. The Y-shaped incision then dissects the scar sheet to the malleolus (scars and subcutaneous fat layer). After full ankle extension, a trapezoid wound is formed (Figs. 36.2b and 36.3b). According to the wound's form and size, the adipose-cutaneous trapezoid flap is elevated. The end of the flap is 4 cm wide; the flap's length is about 5–6 cm. The flap is transposed on the wound with moderate tension (Fig. 36.3c, f, g). The tension of the flap causes the flap's base to approach the scars, and neighboring skin of the opposite side of the ankle is displaced to the anterior ankle surface, covering the narrowed donor wound. Due to flap tension and neighboring tissue displacement, it was feasible to transpose the flap's end to the malleolus and the angle of the scar sheet to the flap's base, thus covering the donor wound, compensating for the scar deficit, and eliminating the contracture in full. Rough scars are excised simultaneously on the leg and the wound is primarily closed (Fig. 36.3b, c, f, g). Extension contracture of the fifth toe was simultaneously removed with trapeze-flap plasty (Fig. 36.3e, f).

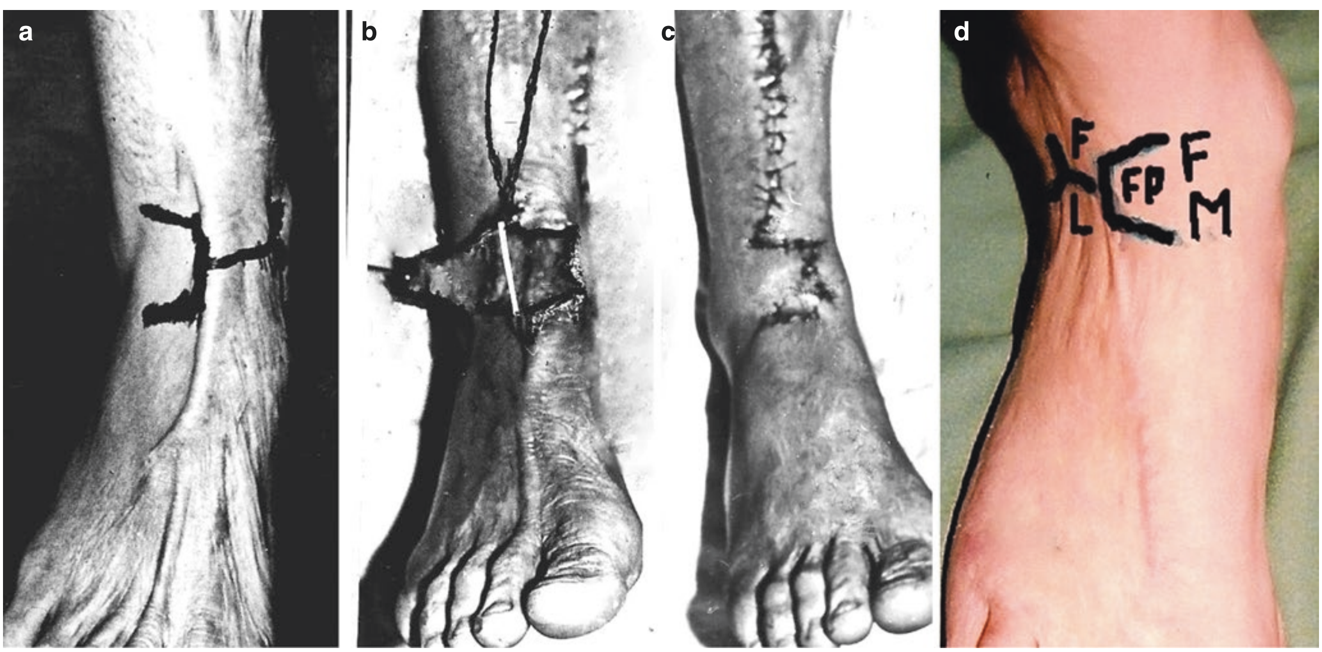

Fig. 36.3 Mild-to-moderate ankle edge and toe contracture elimination with one adipose-cutaneous trapezoid flap. Case 1: (**a**) contracture caused with scars located on the lateral joint surface, the scars form a crescent-shaped fold; the medial fold sheet and anterior ankle surface are healthy skin; (**b**) flap mobilized on ankle anterior surface and (**c**) compensated scar surface deficit and contracture eliminated; 5 days after surgery, the flap is alive. Case 2: (**d**–**f**) edge ankle contracture is eliminated with one trapezoid adipose cutaneous flap (*SC* scars; *FL* flexion lateral surface). Case 3: (**g**) edge contracture released with one trapezoid flap and strip scars excised on the lag. Simultaneously removed contractures of toes; (**h**) scheme of ankle edge contracture elimination with one adipose-cutaneous trapezoid flap

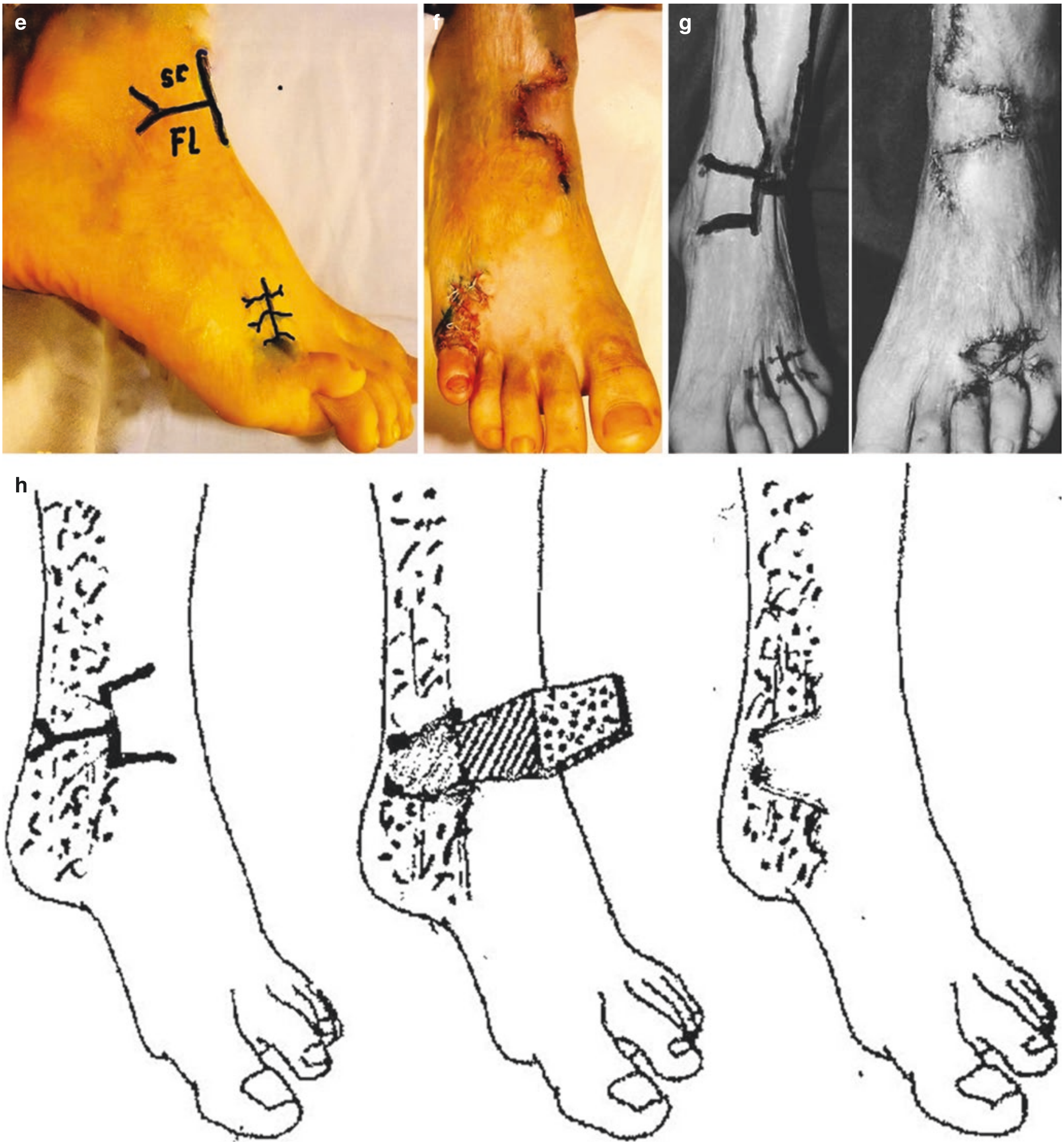

Fig. 36.3 (continued)

Treatment of Moderate Edge Ankle Contracture with Three Trapezoid Flaps (Fig. 36.4)

In cases of moderate contracture, the scar sheet surface deficiency is more severe; thus, the surface of one flap is not sufficient and the angles of scar sheets could not reach the flap's base and donor wound cover beside the flap's borders. In such cases, three flaps are planned (Fig. 36.4a, b). The main adipose-cutaneous flap formed the ankle central flexion area; both trapezoid adipose-scar flaps are raised from the scar's sheet for donor wound covering at both sides of the main flap (Fig. 36.4c). The size of the adipose-scar flaps depends on the size of the wounds beside the adipose-cutaneous flap but is always smaller than the main flap. The full subcutaneous fat layer is included in all flaps. The scheme of the operation is presented in Fig. 36.4d.

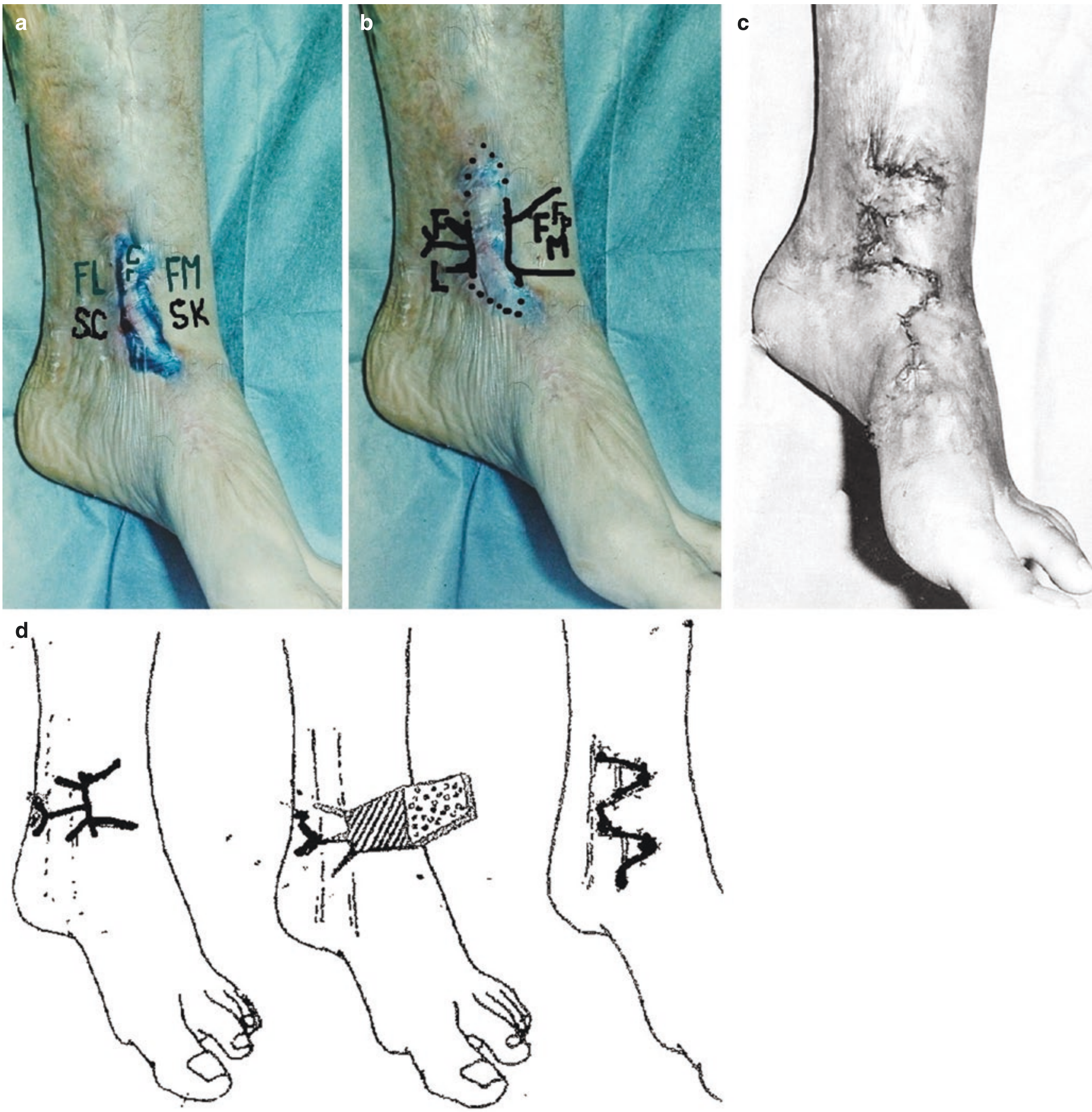

Fig. 36.4 Moderate-to-severe ankle flexion contracture elimination with three trapezoid flaps. (**a**) Pre-operative view: contracture caused by scars (*SC*) located on lateral joint surface (*FL*), joint anterior surface or flexion medial (*FM*) is healthy skin (*SK*); *Cr*—rough scars; (**b**) three-flap plasty planning: main adipose-cutaneous flap (*FP*) on anterior ankle surface (*FM*) and two small flaps from scar sheet (*FL*) for donor wound covering beside the main flap; planning; (**c**) 7 days after operation: contracture is released, scar sheet's surface deficit is compensated, flaps are alive, ankle contours are restored; (**d**) scheme of three-flap trapeze-flap plasty

Treatment of Severe Edge Both-Ankle Contractures with One Trapezoid Flap and Skin Grafts

Widespread, deep burns cause rough deformity and defect of the soft tissue of the ankle joint region and foot and leg. An extensive area of scarring and a deficit of undamaged skin make reconstruction challenging (Fig. 36.5a). Burns of the ankle lateral flexion surface leave healthy skin on the joint medial flexion surface, where a trapezoid flap is planned on each ankle surface of which there is insufficient skin for scar surface deficit compensation. Therefore, only one trapezoid adipose-cutaneous flap is planned (Fig. 36.5b, right ankle, and 36.5d, left ankle of the same child). Severe scar sheet surface deficit (wounds), which has a trapezoid form (Fig. 36.5c, e), does not allow the scar sheet to cover the donor wound, which is located beside the flap. The flap involves the medial fold sheet and anterior ankle surface; the flap's base is at the malleolus. The mobilized flap is transposed on the wound with moderate tension and its end is connected to the wound's edge near the malleolus (Fig. 36.5c, e, right and left ankle, respectively). As a result, the central zone of the ankle anterior surface is covered with a healthy adipose-cutaneous layer; the wounds at both sides of the flap are skin-grafted (Fig. 36.5f). The result and scheme of simultaneous severe edge contracture reconstruction with combined trapeze-flap plasty of both ankles is shown in Fig. 36.5f, g.

Fig. 36.5 Severe both ankles edge contractures elimination with trapezoid flap and skin transplants. (**a**) Pre-surgery, both ankles: contractures caused by scars located on medial joints' surface, leg with ulcers, defect of distal foot, hypotrophy tissues; scars formed long crescent folds in which the medial sheets are scars; the lateral sheets and anterior joint surfaces are healthy skin; (**b**) right ankle: planning reconstruction with one adipose-scar trapezoid flap; Y-line for contracted scars dissection; (**c**) right knee: scars dissected, trapezoid wound or scar surface deficit (*Dt*) appeared; trapezoid flap (*FP*) mobilized; left picture: contracted scars of FL surface dissected, trapezoid wound or scar surface deficit (*Dt*) appeared; trapezoid flap (*FP*) mobilized. Right picture: trapezoid flap covered most of the wound; (**d**) left ankle: planning one-flap trapeze-flap plasty; (**e**, *left*) scars dissected with a Y-incision; trapezoid wound (scar surface deficit *Dt*—appeared, trapezoid flap (*FP*) mobilized; (right picture: flap covered central part of wound; wounds beside the flaps skin grafted; (**f**) (2 years after reconstruction with trapezoid flap and skin transplants. (**g**) Reconstruction with flap and skin grafts (combined trapeze-flap plasty, scheme)

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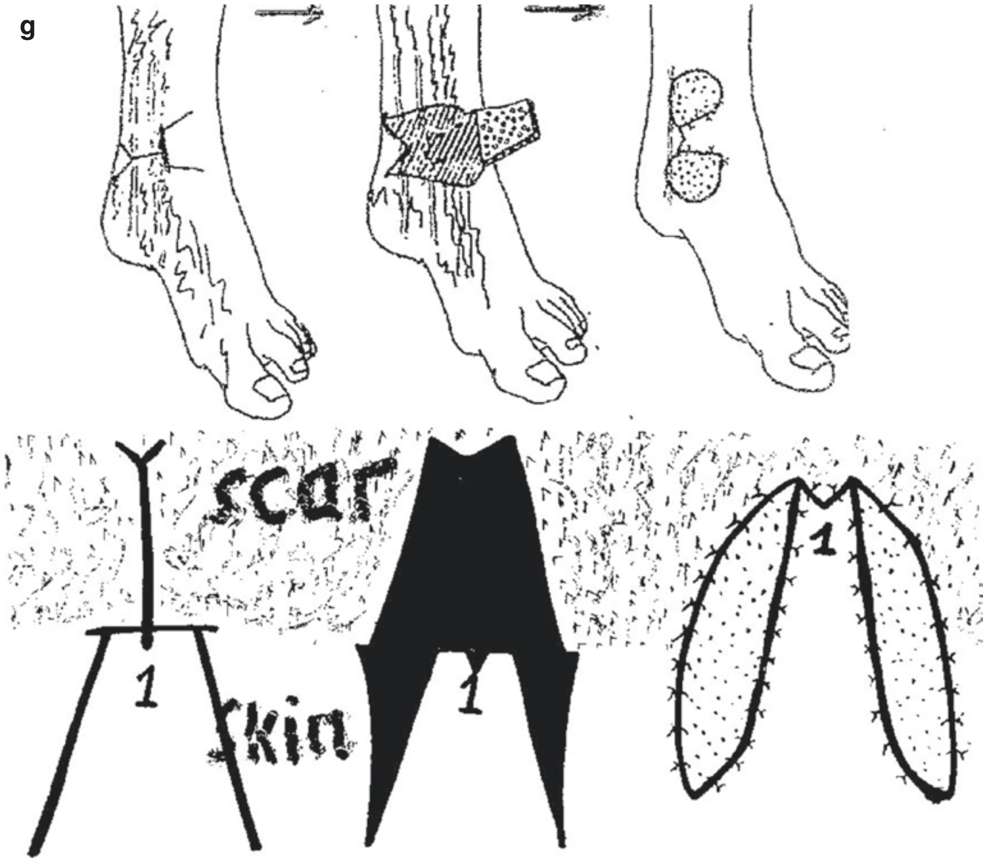

Fig. 36.5 (continued)

Conclusion

Dorsiflexion ankle edge contractures are completely eliminated using trapezoid flaps alone or in combination with skin grafts. No flap loss takes place. Skin transplants grow well with the underlying tissue. Repeated reconstruction is not needed. Small hematomas are removed with transplant incision on the fifth day. The adipose-scar trapezoid flap does not shrink; it continues to grow, more so in pediatric patients, preventing contracture recurrence.

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37 Medial Ankle Dorsiflexion Contractures and Techniques for Their Treatment

Introduction

Burns and scars of the ankle anterior surface and dorsal foot restrict joint dorsi extension, walking, and the wearing of shoes, and present a severe cosmetic defect. Foot development is delayed in children. Early reconstruction is therefore indicated along with simultaneous correction of all contractures and deformities. Scars form a fold, which is the scar surface surplus. The real contracture cause is the scar surface deficit in length. The presence of scar surface surplus in width allows for contracture elimination with local flaps. Treatment with triangular flaps does not allow for complete contracture release. Trapezoid-flap plasty is more efficient per se or in combination with skin transplantation. Rough mature scars undergo excision through an intermediate layer and wounds are covered with whole skin transplants.

Functional Zones of Ankle Joint and Anatomy of Ankle Medial Flexion Contracture

Functional Zones of Ankle Joint Surface in Medial Contractures (Fig. 37.1)

The ankle joint's surface is divided functionally into flexion surface (*F*) and extension surface (*E*). A dividing line passes between these surfaces through the malleolar apex or joint rotation axis ("+"). The flexion surface is divided into flexion lateral (*FL*) and flexion medial (anterior) (*FM*) surfaces; a boundary passes along the curvature of the flexion surface, between the anterior and lateral surfaces. The curvature of the ankle joint flexion surface is less expressed than in other big joints. The joint extension surface is located behind the malleolus. Ankle medial contracture is caused by scars covering the joint *FM* or anterior surface.

Anatomy of Ankle Medial Flexion Contracture

Medial dorsiflexion contracture is characterized by scars located on the joint anterior surface (*FM*), which form a crescent fold, the crest of which is located along the medial joint line. Both sheets of the fold are scars and spread from the fold crest (*Cr*) to the joint flexion lateral (*FL*) surface (Fig. 37.1a, b). Malleolar zones ("+") are healthy skin. The fold is a new anatomic structure, the scar's surface surplus. The contracted scars have surface deficiency in length (cause of contracture) and surface surplus in width, which allows contracture elimination with local flaps. The fold can be small and short, or it may spread to the leg and foot, causing toe extension contractures.

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The form and size of the scar sheet surface deficiency in length is estimated in the following way (Fig. 37.1c, d): The fold sheets are divided with an incision along the fold's crest; the contracture is released by a perpendicular Y-shaped incision to both malleolus; after ankle dorsi extension, the wounds of both sheets, as a rule, accept a trapezoid form. Consequently, adequate contracture elimination can be performed by means of surface deficit compensation with trapezoid flaps. Anatomy of contracture release with two radial Y-incisions and flap mobilization is shown in Fig. 37.1d (*FP* flap; *Dt* scar surface deficit; *DW* donor wounds).

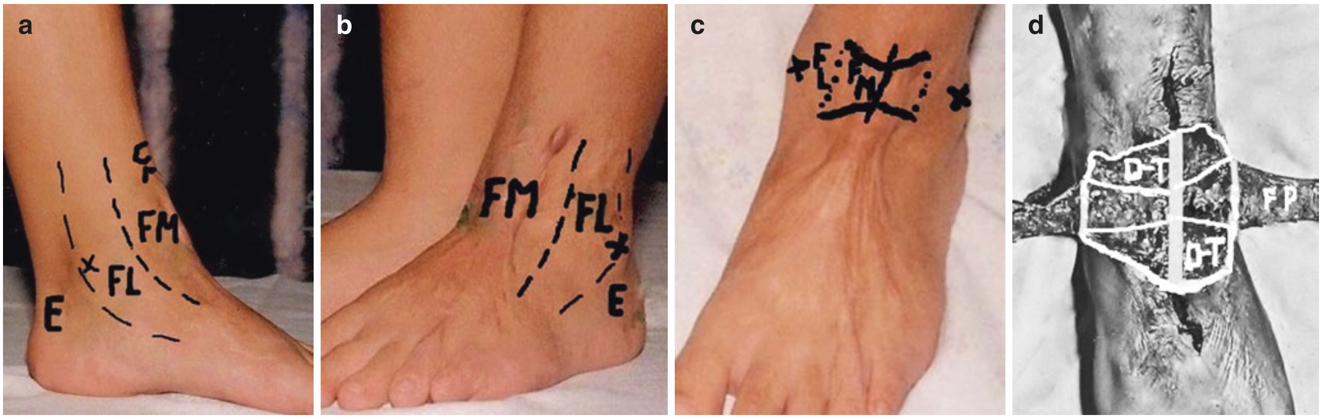

Fig. 37.1 Functional zones of ankle joint, anatomy, and scar surface deficit of ankle medial scar contracture. (**a**, **b**) Scars cover the joint flexion medial (*FM*) or anterior surface; scars form the fold, the crest (*Cr*) of which passes along the joint medial line; *FL*—flexion lateral zone located between malleolus ("+"—joint rotation axis) and joint anterior (*FM*) surface; *E*—extension surface; (**c**) scar surface deficit (contracture cause) determining: radial lines mark one pair of trapezoid flaps in FM zone; (**d**) flaps mobilized and joint extended: two trapezoid flaps and wounds appeared laterally from the middle line; wounds beside the flaps' central zones have trapeze-shaped scar surface deficit, which is maximal at the medial line; lateral wound edges are the scar surface deficit DT at the boundary between FL surfaces

Medial Dorsiflexion Ankle Contracture Treatment with Trapezoid-Flap Plasty

The fold's sheets (on all their extents) from the fold crest to the malleolus, had to be converted into flaps of a form (trapezoid) similar to that of the scar surface deficiency [1]. Because the fold has a crescent shape, the fold's sheets could be converted into trapezoid flaps only with radial Y-shaped incisions. Depending on contracture severity and the fold's length, one, two, or several pairs of adipose-scar trapezoid flaps are mobilized.

Medial Contracture Elimination with Two Pairs of Trapezoid Adipose-Scar Flaps

Moderate-to-severe contracture is caused by a long fold in which the scar surface deficit cannot be removed with one pair of flaps. The long fold allows for preparation of two pairs of trapezoid flaps (Fig. 37.2a, b). Planning (Fig. 37.2a) consists of drawing several lines: one line along the fold crest and four radial lines, outlining two pairs of trapezoid flaps in the central ankle zone. The distance between radial lines (incisions) at the fold crest (flap width) is about 4 cm; the flap length covers all ankle anterior surfaces to the malleolus. Radial lines convert the fold sheets into trapezoid figures because the fold has a crescent shape. Following the tracing lines, the sheets along the fold crest are divided and trapezoid flaps are mobilized, including a full subcutaneous fat layer that secures steady blood circulation. The flaps are counter-transposed, covering the wound and elongating the surface by more than twice its previous length.

After adipose scar flap mobilization, a large wound appears, consisting of two trapezoid wounds (Fig. 37.2b, beside white strip), reflecting the form and size of the scar surface deficit, or real contracture cause. Transposed opposite flaps fully compensate for the scar surface deficit and eliminate contracture (Fig. 37.2c). In all cases, it is profitable to transform the fold on all its extensions into the trapezoid flaps, creating some over-correction. The result is shown in Fig. 37.2d.

It is often clear during surgery that a planned pair is insufficient for complete contracture release (Fig. 37.3a, b); additional pairs of adipose-scar flaps are mobilized until the contracture is fully released (Fig. 37.4a, b).

Multiple trapezoid-flap plasty and a variant of trapezoid-flap plasty for ankle medial contracture treatment are shown in Fig. 37.4.

Flexion contractures of ankle, leg, foot, toes, and syndactyly are eliminated simultaneously by trapezoid-flap plasty and V-Y technique (Fig. 37.5; *FP* flap; *Dt* deficit of scar surface; *DW* donor wound where flaps are elevated).

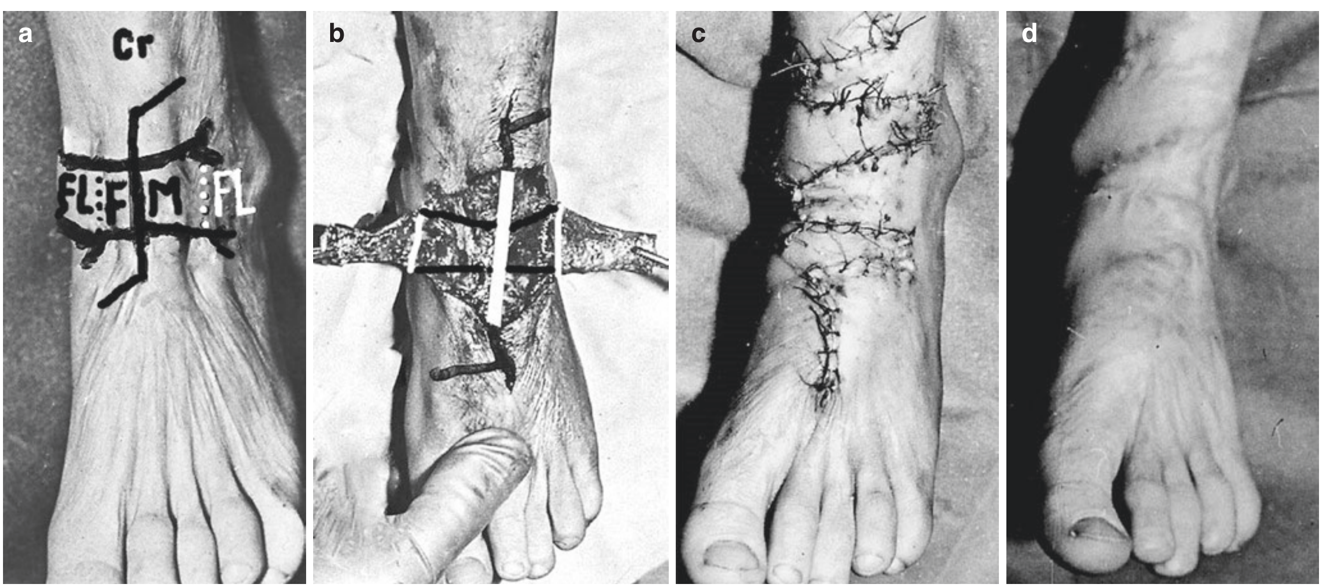

Fig. 37.2 Ankle medial contracture is removed with two pairs of trapezoid adipose-scar flaps. (**a**) Pre-operative review, planning two pairs of the flaps; (**b**) adipose-scar flaps mobilized, scar surface deficit has the form of two trapezoid figures depicted with white strips; (**c**) counter transposed flaps compensate scar surface deficit and eliminate contracture (end of operation); (**d**) good follow-up result

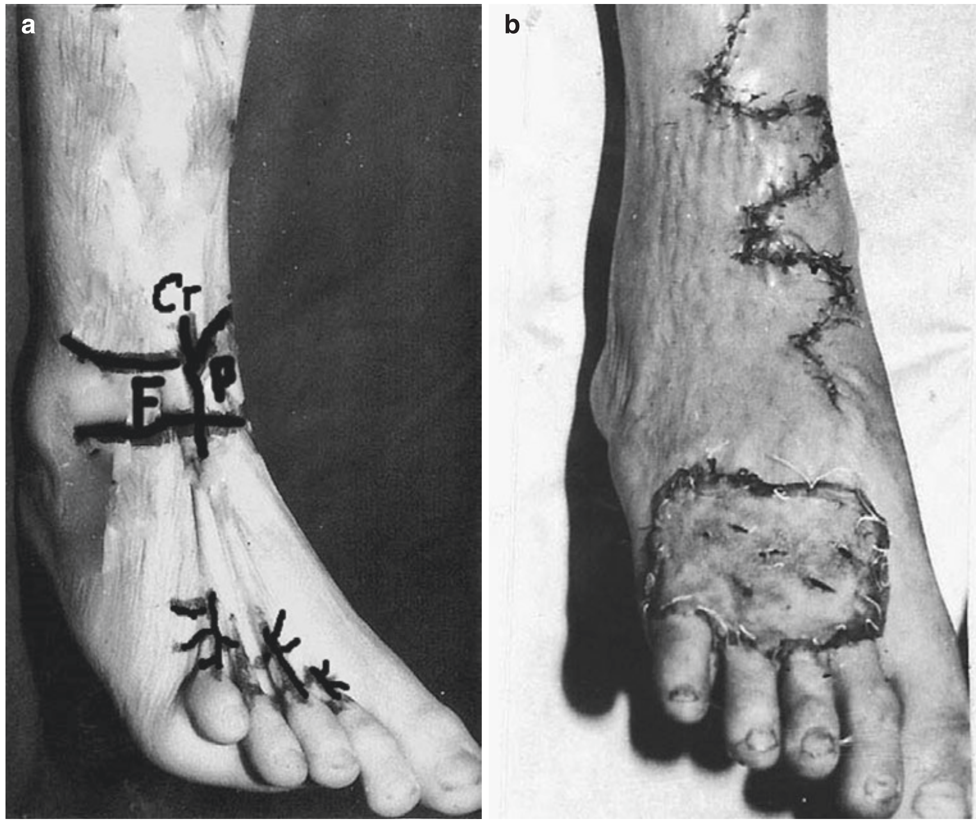

Fig. 37.3 The number of pairs of flaps increased during the operation. (**a**) Moderate ankle medial contracture; one pair of trapezoid flaps was planned; (**b**) two flaps were not enough, so two additional adipose-scar trapezoid flaps were elevated; complete contracture released

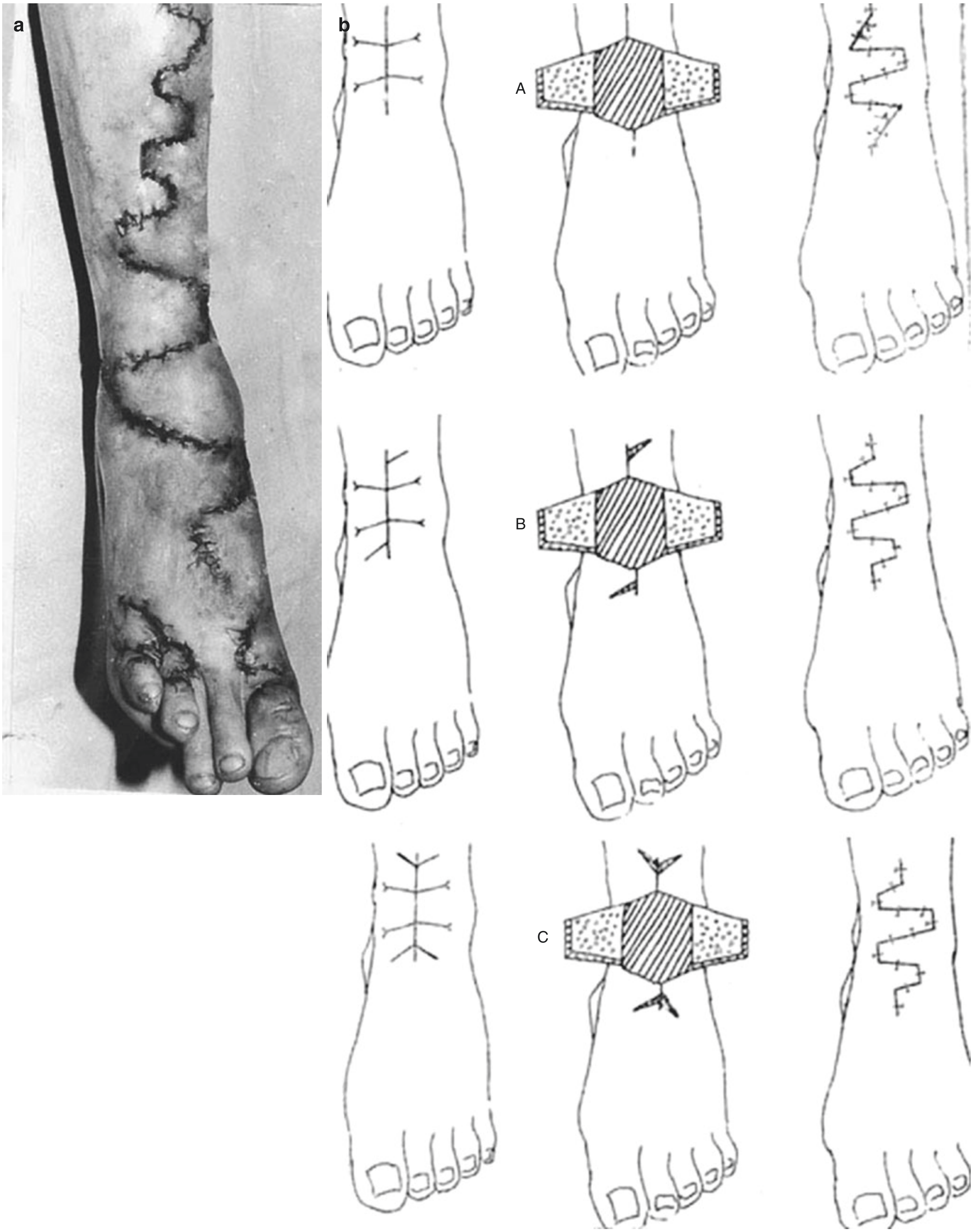

Fig. 37.4 Severe ankle contracture released by converting the long fold's sheets in trapezoid adipose-scar flap and its counter transposition. (**a**) Result of reconstruction: all scar flaps are alive, complete contracture is eliminated; (**b**) variants of ankle medial flexion contracture treatment with trapezoid flaps (**A**—one pair of flap method; **B**—treatment with two pairs of flaps; **C**—three-pairs, or more, are used if the fold is long and contracture severe)

Fig. 37.5 Ankle medial dorsiflexion, dorsal foot, toes syndactyly and extension contractures reconstruction with trapeze-flap and V-Y pasties. (**a**) Pre-surgery, planning; (**b**) dorsal foot contracture released with V-incision; two trapezoid flaps planning (**c**) adipose-scars trapezoid flaps (*FP*) mobilized; (**d**) step of reconstruction; flaps (*FP*) counter transposed; (**e**) end of operation, all contractures removed with local flaps

Conclusion

Ankle medial dorsiflexion contracture is caused by the scar's fold, located on the joint's flexion medial surface. Both sheets of the fold are scars, in which there is a trapezoid scar surface deficit in length (true cause of the contracture) and a scar surface surplus in width. The contracture is released with trapezoid-flap plasty: the fold's sheets are converted into one or more pairs of trapezoid flaps that are counter-transposed.

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38 Total Ankle Contracture: Anatomy and Treatment

Introduction

Burn scars of the distal part of the lower extremities are often complicated by being rough, thick, and hard. Scars in this region are predisposed to excessive growth, which impairs all forms of motion. Walking increases the size of the contracture. The distal segment of the extremity has a thin subcutaneous fat layer, and the relatively low blood circulation in scars stimulates keloid tissue growth. Such scars create serious functional and cosmetic problems. Therefore, these scars should be excised. Scars should be mature, and they should be excised through the intermediate layer, which can be accomplished without bleeding. Skin transplantation follows without complications.

Anatomy

In an ankle contracture, rough, thick, contracted scars tightly surround the ankle and neighboring regions without a fold (Fig. 38.1). The scar surface deficit, which is the reason for contracture, is severe; therefore use of the local-flap technique is not recommended. In most cases; burns have also injured the leg and foot. The rough, thick scars are prone to ulceration.

Fig. 38.1 Total ankle contracture caused by keloid scars. Thick, rough scars; severe foot deformation

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Surgical Technique

Reconstruction is performed using wide mature scar excision through the intermediate layer; a large wound is covered with whole split skin transplants (Figs. 38.2 and 38.3) [1]. The scar must be mature, which allows the subcutaneous fat layer to remain in situ, undamaged, and with only light bleeding. Skin transplants are fixed to each other and to the underlying tissue with U-shaped sutures; a gauze bolster is tied above, creating compression on the transplant (Fig. 38.2c). Skin grafts and wound tissues grow together more effectively when more sutures are placed, yielding better results. After reconstruction, the ankle joint is fixed with a gutter splint for wound healing; after skin grafting, a compression is applied to the transplants.

Wide scar excision and the wound covering with whole split skin transplants yield good outcomes (Figs. 38.3, 38.4, and 38.5).

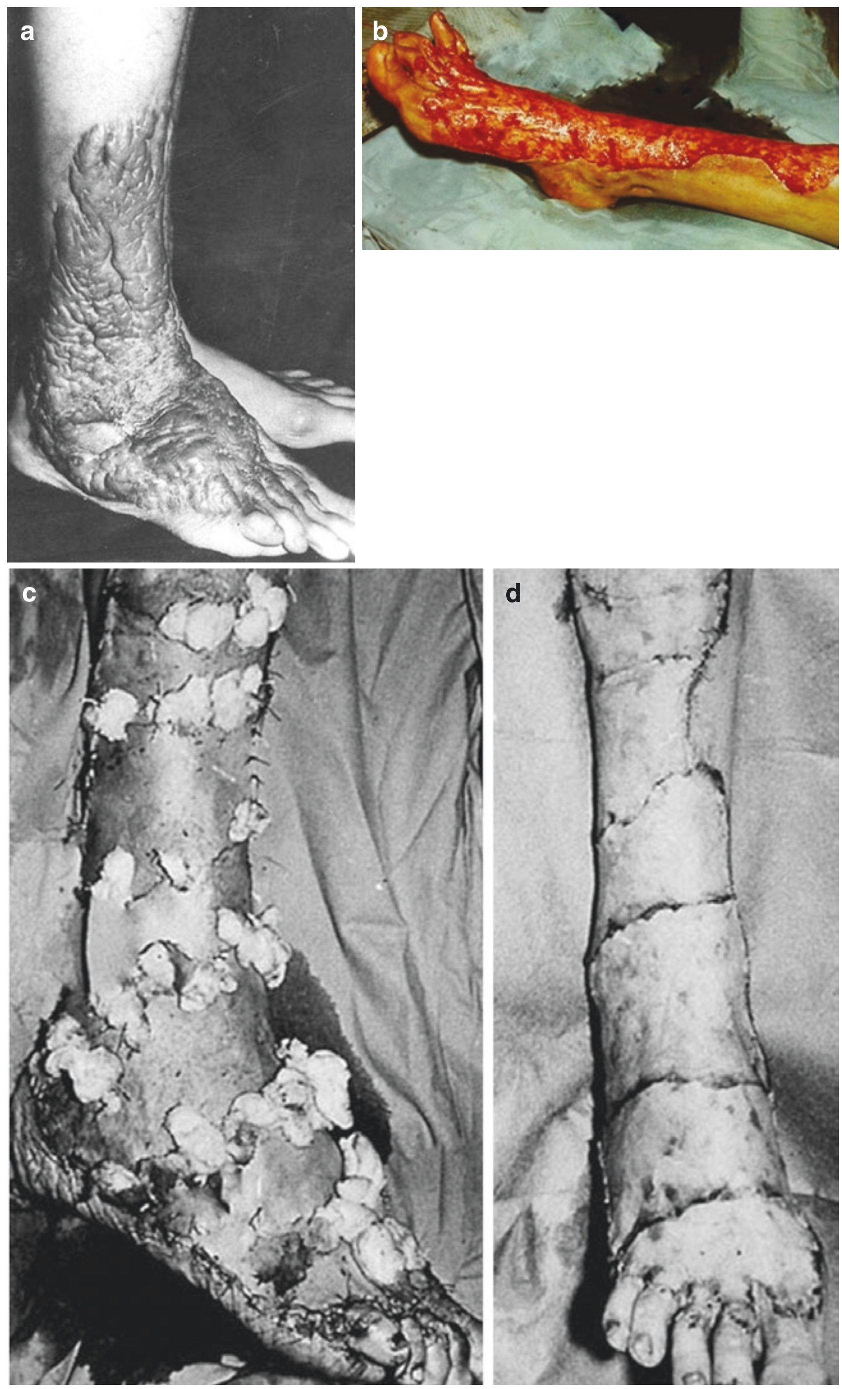

Fig. 38.2 Contracture and scar deformation treatment by scar excision and skin grafting. (**a**) Rough, thick, keloid scars covered ankle and neighboring regions; (**b**) scars excised, dissecting connective tissue under scars, no bleeding; (**c**) wound of ankle, foot, and leg covered with whole skin transplants and fixed with wound tissue with U-shaped sutures; edges of transplants have excess skin; (**d**) 2 weeks after surgery: transplants are alive and contracture is removed

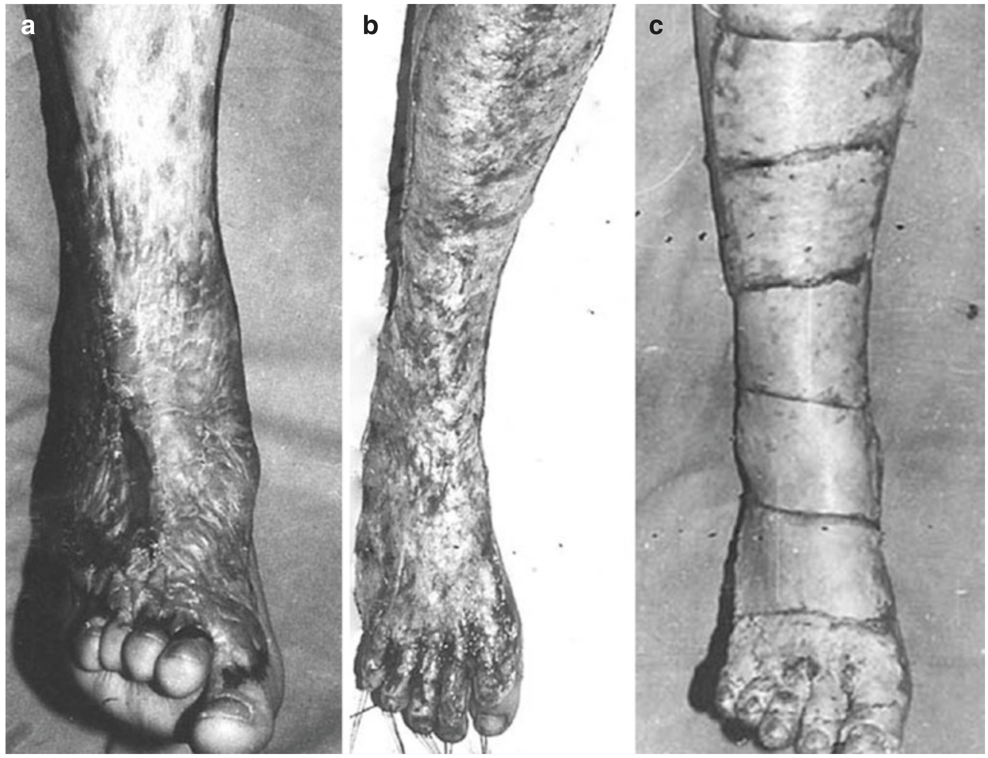

Fig. 38.3 Total ankle contracture is caused by pathologic ulcerous scars. (**a**) Pre-operation: pathologic scars covered the ankle, foot, and leg, caused toe extension contracture; ulcer on ankle; (**b**) all pathologic scars excised through the intermediate layer; the fat layer was not damaged; therefore, the wound is “dry” without bleeding; syndactyly removed with trapezoid-flap plasty; (**c**) the wound is skin-grafted, contracture released, and ankle contours restored (10 days after reconstruction)

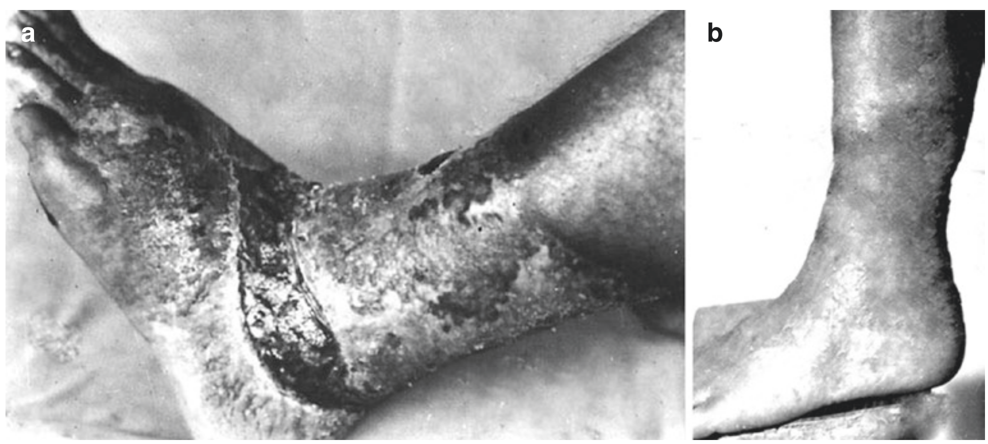

Fig. 38.4 Follow-up results of surgical treatment of total ankle and foot contractures and deformations caused by pathologic ulcerous scars. (**a**) Pre-surgery; (**b**) 2 years after scar excision and wound coverage with the whole split skin transplants

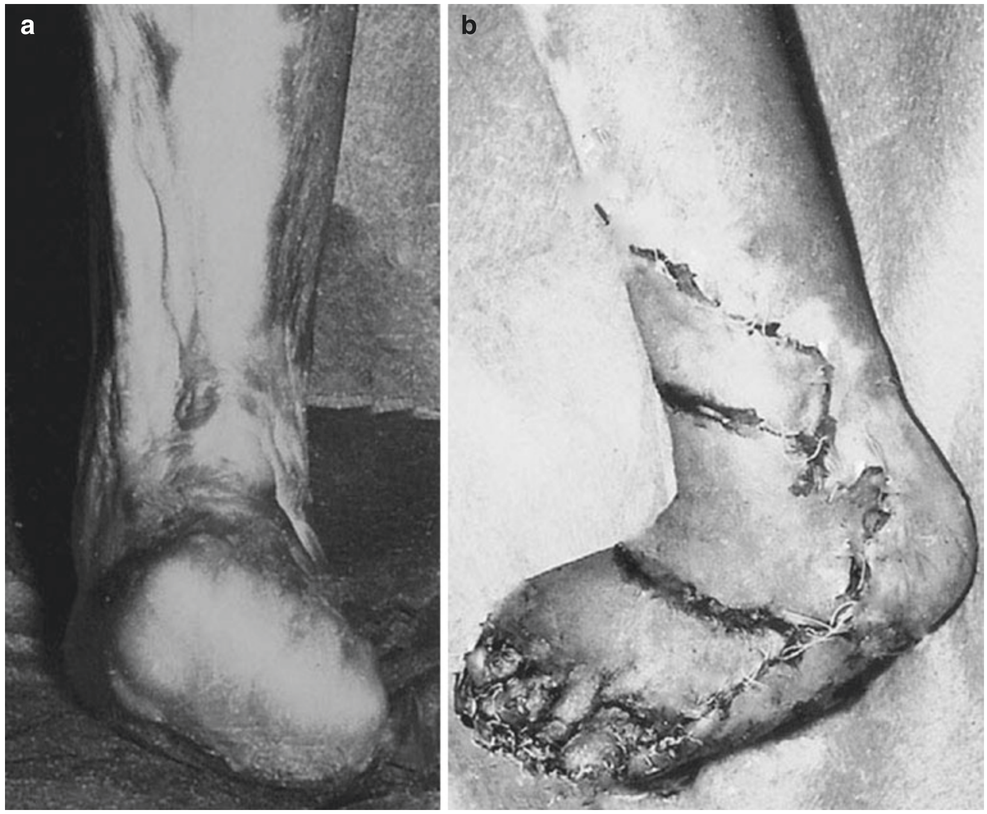

Fig. 38.5 Severe deformed left ankle and foot reconstructed in child using wide scar excision, toe separation, and the wound covered with whole split skin transplants. (**a**, **b**) Ten days after surgery

Conclusion

Ankle dorsiflexion total contracture and scar deformation is often complicated by pathologic scars prone to ulceration. Reconstruction consists of pathologic scar excision without damaging the fat layer and wound coverage with whole split skin transplants. Scar excision eliminates soft tissue constriction and joint contracture and normalizes lymphovenous circulation and lower extremity development.

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39 Proximally-Based Sural Adipose-Cutaneous/Scar Flap in Elimination of Ulcerous Scar Soft Tissue Defect Over the Achilles Tendon and Posterior Heel Region

Introduction

Scar ulcers that spread over the Achilles tendon and posterior heel disturb patients by causing pain, impeding hygiene, and creating difficulty in finding appropriate shoes. This region naturally endures pressure, so effective reconstruction is based on flap use. The most popular flaps currently used are distal sural fascial-cutaneous flaps, calcaneal artery skin flaps, and free flaps. These flaps, however, are insensate, can create soft-tissue excess, and cause donor site morbidity. Ulcerous soft-tissue defects over the Achilles tendon and posterior heel after burns, frostbite, and trauma were studied and reconstructed using a proximal sural adipose-cutaneous flap, the anatomy of which was studied on the lower extremities of cadavers.

Anatomy of Ulcerous Soft Tissue Defects and Proximally-Based Sural Flap [1]

An ulcerous scar surface, for which reconstruction is performed, consists of two zones: the Achilles tendon (nearly 8 cm in length) and the posterior heel (4 cm in length); their combined length totals 12 cm (Fig. 39.1a). The size of ulcers varied from 4 to 7 cm in length and 3–6 cm in width. The form and size of ulcers and soft-tissue defects varied from case to case. Tissue defects and surrounding pathologic scars, which had to be excised, are significantly larger than ulcers. Pathologic scars are typically rough, thick, solid, and can cover the foot, ankle, and leg (Fig. 39.2a). The base and edges of the ulcers' bottoms are gray scars without signs of regeneration. Ulcer scars are tightly connected with the tendon and calcaneal bone. The flap is planned based on the tissue defect and its size and form (Figs. 39.1a and 39.2b). The flap is 20–22 cm in length and can be divided into two segments: vertical (nearly 10–12 cm in length), which covers the lower third of the leg, and horizontal (8 cm in length), which is harvested from the lateral foot, between the malleolus and plantar edge. The flap's base is situated on the posterior-lateral legs for preserving the sural nerve. The posterior flap's border is the wound's edge; the anterior border advances the malleolar apex. The flap's width is about 6–7 cm. The flap consists of skin/scars, a full subcutaneous fat layer, and includes the sural nerve and lesser vein; the blood inflow comes through the peroneal and anterior tibial artery perforators. The ratio of the vertical part of the flap to the horizontal part varies depending on the level of the tissue defect and wound surface size. The study of donor sites of cadavers' lower extremities showed that the sural nerve, providing sensory innervations, and lesser vein are present in the flap over its entire extension. Several perforators originating from the peroneal and anterior tibial artery form the vessels' net in the subcutaneous fat layer (Fig. 39.2e, f).

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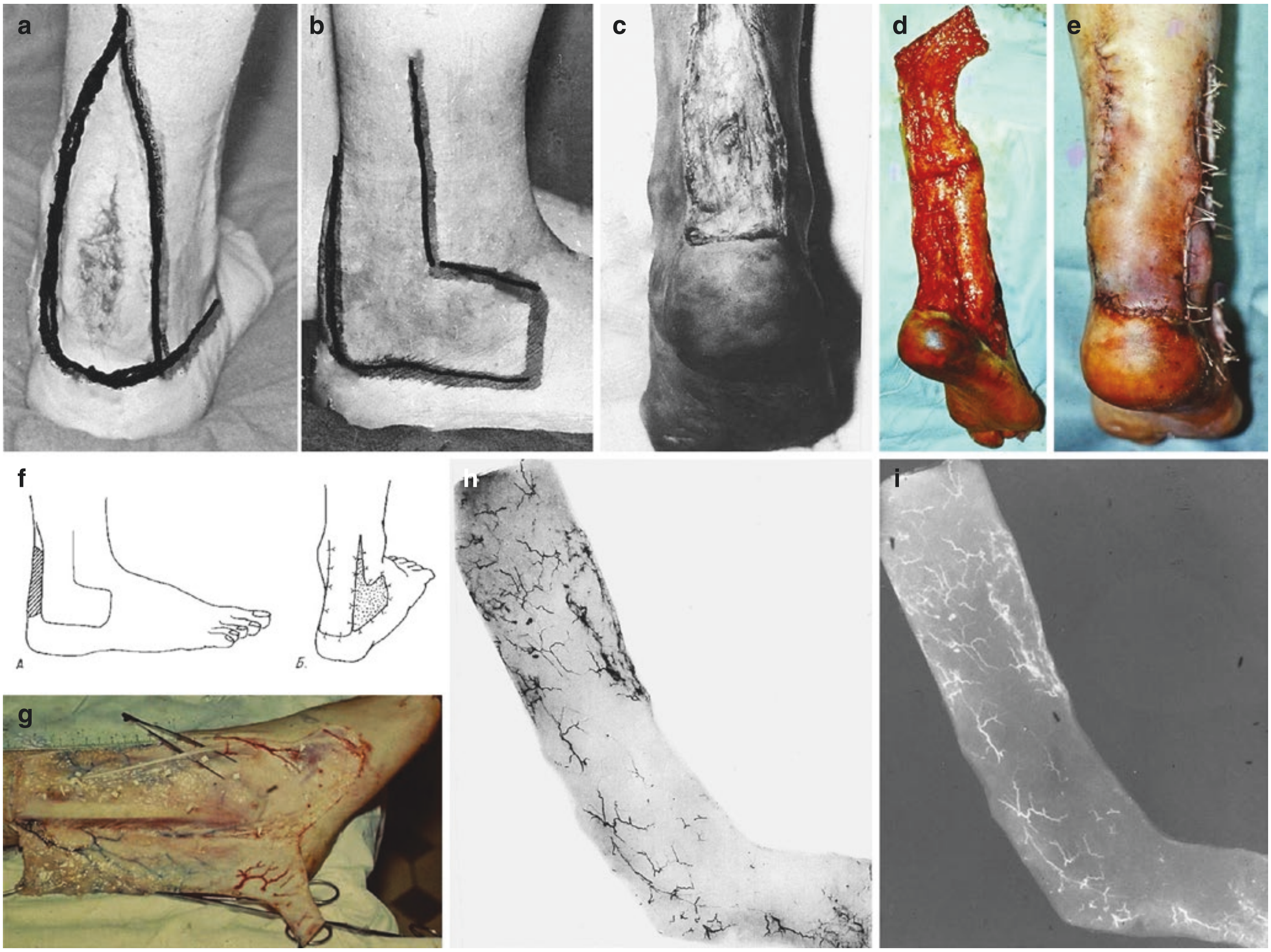

Fig. 39.1 Anatomy of ulcerous scar soft tissue defect over the Achilles tendon and posterior heel and elimination with proximally based sural adipose-cutaneous flap. (**a**) Outline of ulcer (*Ulc*) and pathologic scars over the tendon to be excised; (**b**) flap's (*F*) contours: the vertical part covers the posterior-lateral of distal third of the leg. The horizontal part covers the lateral foot; the flap's length is nearly 20 cm; (**c**) pathologic scars and ulcer are excised, the wound bottom is tendon; (**d**) flap (*F*) mobilized, deep fascia not included in flap; (**e**) minimally rotated flap covered tendon and posterior heel; (**f**) scheme of operation; (**g**) cadaver flap specimens; white dots are perforators; (**a**) sural nerve shown in the flap and entrance of arterial perforators in subcutaneous fat layer (white dots); (**h**, **i**) perforators and blood supply of proximally based sural adipose-cutaneous flap (cadaver specimens)

Fig. 39.2 Big round ulcerous tissue defect of Achilles-calcaneal zone treatment with sural scarred flap. (**a**) Pre-surgery view: big ulcer surrounded by scars; *D* defect, *F* flap; (**b**) scars covered donor site; *F* flap, *SC* scars, planning; (**c**) ulcer excised, flap mobilized; (**d**) flap (*F*) rotated on the wound and covered tendon and posterior heel; (**e**) 1 month after reconstruction: flap is alive, tissue defect is eliminated, superficial scar flap border necrosis, skin graft covering the donor site well; (**f**) scheme of reconstruction

Technique of Ulcerous Soft Tissue Defect Resurfacing with a Proximally-Based Sural Adipose-Cutaneous Flap

The borders of pathologic scars, including the ulcer, are outlined for excision. The flap is also outlined (Figs. 39.1, 39.2, and 39.3). The flap's base corresponds to the upper wound's edge and includes the posterior part of the leg. The posterior flap's border is a lateral scar's edge (wound's edge) that extends distally along the plantar edge on the foot for about 8 cm. The anterior flap's border (line) passes parallel to the rear line, advancing for nearly 6 cm ahead and including the posterior-lateral lower leg, lateral ankle, and foot surfaces. The planned flap is 4–5 cm longer than the wound's length because of shrinkage of mobilized flaps; for tendon and heel coverage the flap is distended in width for complete solid structure coverage, which makes the flap shorter.

The ulcer with pathologic scars is excised in one block, reaching deeply into the healthy skin. The wounds varied from 6 to 20 cm in length and 6 cm in width. Depending on the extent of pathologic scars, wounds are of different shapes: triangular, round, or trapezoid. The wound's bottom is the Achilles tendon and calcaneal bone (Fig. 39.1c). The tendon should be freed from scars posteriorly and laterally. Flap mobilization begins from its end on the foot, according to the deep fascia, which is not included in the flap. Following the fascia, the flap is raised carefully, not injuring the subcutaneous fat layer (Fig. 39.1d). For malleolar apex coverage, the skin of the anterior ankle surface is displaced posteriorly and fixed, with absorbable sutures, to the fascia, posterior to the apex. Then, if the wound narrows in the proximal direction, the flap is placed longitudinally over the tendon and posterior heel and the flap's rotation is minimal (Figs. 39.1 and 39.3); the medial flap's edge is connected to the wound's border, and the lateral flap's border is sutured to the fascia laterally from the tendon (Fig. 39.1e). In the case of a big, round soft-tissue defect, the flap is rotated between 60° and 90° to cover the proximal wound's zone; after fixation, the flap is directed longitudinally (Fig. 39.2a–d).

The scarred flap preserves sensation and has a steady blood circulation supplied through the subcutaneous fat layer, which prevents tissue necrosis; the flap tolerates the pressure of footwear well. Pathologic scars, spreading on the medial ankle region, can be excised and the wound can be skin-grafted (Fig. 39.3d, g).

In all cases, the apex of the malleolus should be covered with adipose-cutaneous layer displaced from the flexion lateral surface (Fig. 39.4).

Ulcerous scar soft-tissue defect after frostbite can be complicated by blood inflow reduction in the leg and foot. In these cases, flap training takes place (delayed reconstruction): the bipedicle elevated sural flap is sutured at the place; 4 weeks later, the reconstruction is successfully completed (Fig. 39.5).

If ulcers and pathologic scars involve the posterior heel (Figs. 39.6a, b and 39.7) or plantar heel (Fig. 39.8a–c), the vertical part of the flap is shorter, and reconstruction is performed using the horizontal flap's segment for the most part.

Ulcers located over the proximal part of the Achilles tendon can be eliminated with a bipedicle sural flap (Fig. 39.9). After flap elevation, it becomes longer and is easily displaced; owing to the presence of plenty of circulation, extension of the flap not dangerous. The donor wound is covered with a skin transplant.

After surgery, a gutter splint is used for the ankle joint support in a rectangular position for 2–3 weeks.

Fig. 39.3 Reconstruction of the Achilles tendon, posterior heel, and medial malleolar region; donor site scarring. (**a**, **b**) Pre-surgery: ulcer and pathologic scars over tendon and posterior heel and medial malleolus; flap planning; (**c**, **d**) operation: scars excised, flap mobilized and placed over tendon and calcaneal bone; (**e**–**g**) result of operation

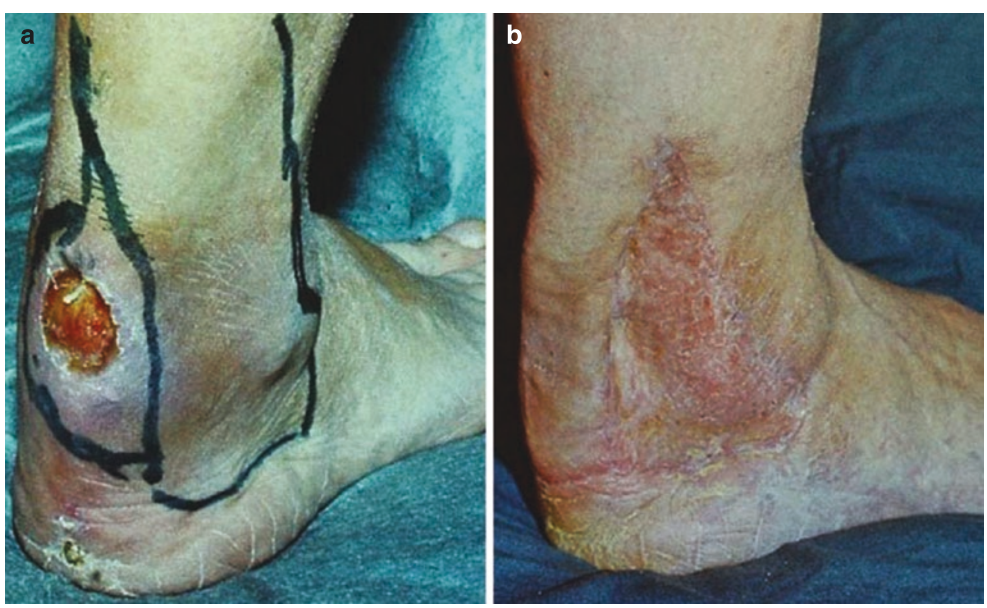

Fig. 39.4 (**a**, **b**) Large round ulcerous soft tissue defect over Achilles tendon successfully eliminated with the proximally based sural flap

Fig. 39.5 Surgical training of the flap in case the ulcerous deep tissue defect of the left heel region after frostbite. (**a**) Pre-surgery: ulcerous tissue defect in Achilles tendon and heel region; (**b**) left leg: bipedicle flap planning and (**c**) elevation (surgical training); (**d**) mobilized trained adipose-cutaneous sural proximally based flap; (**e**) flap-covered Achilles tendon and heel posterior region; donor wound is skin-grafted; (**f**) good follow-up result

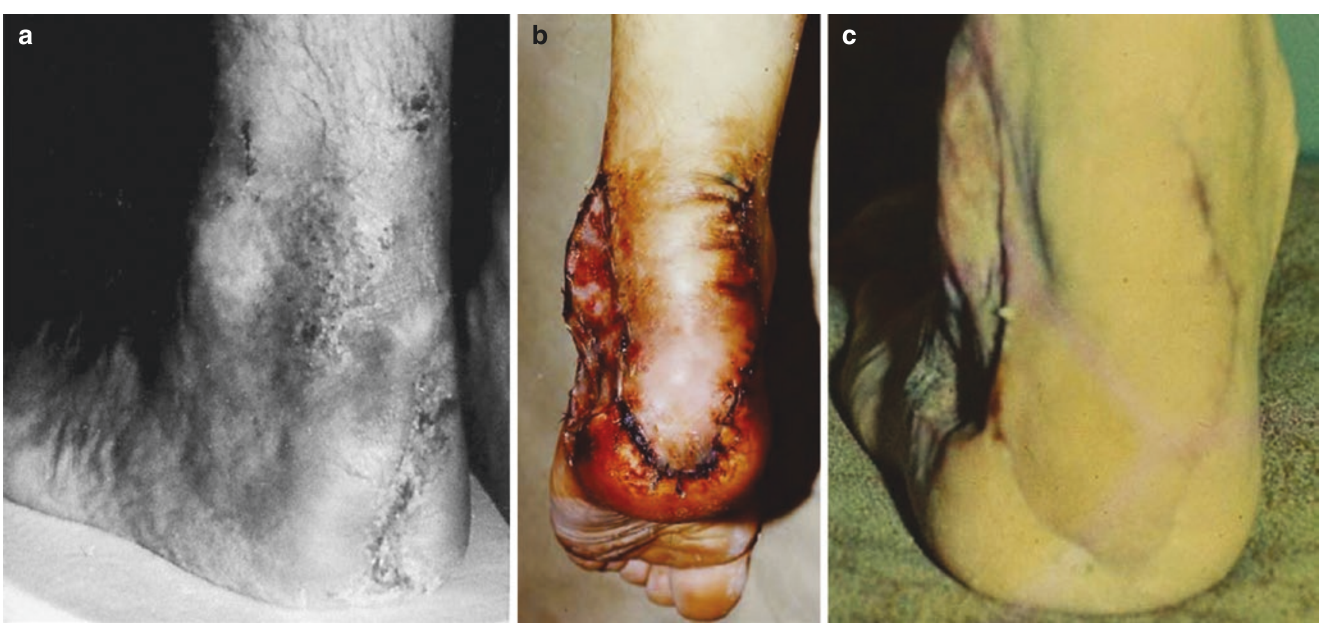

Fig. 39.6 (**a**–**c**) Ulcerous soft-tissue defect over heel treatment mostly with lower flap's segment

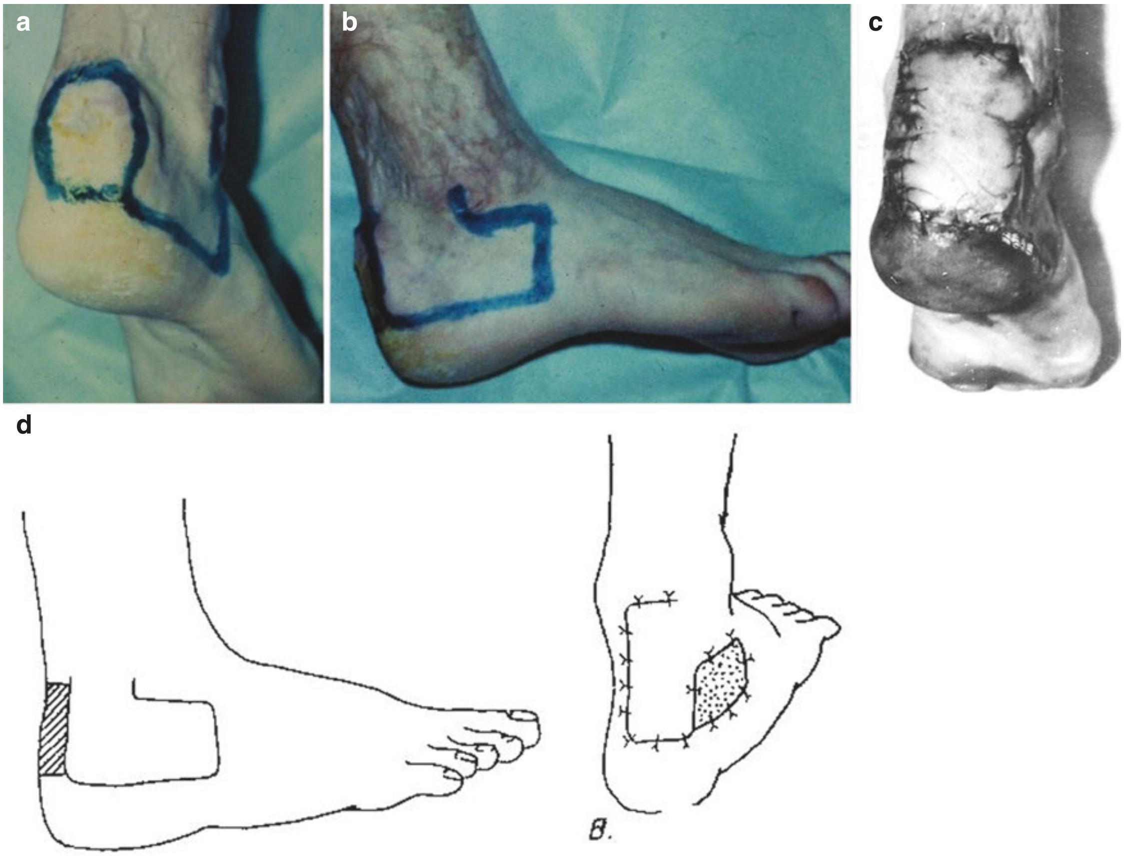

Fig. 39.7 (**a**–**c**) Ulcerous soft-tissue defect over heel treatment mostly with lower flap's segment; (**d**) scheme of plasty; *D* tissue defect, *F* flap

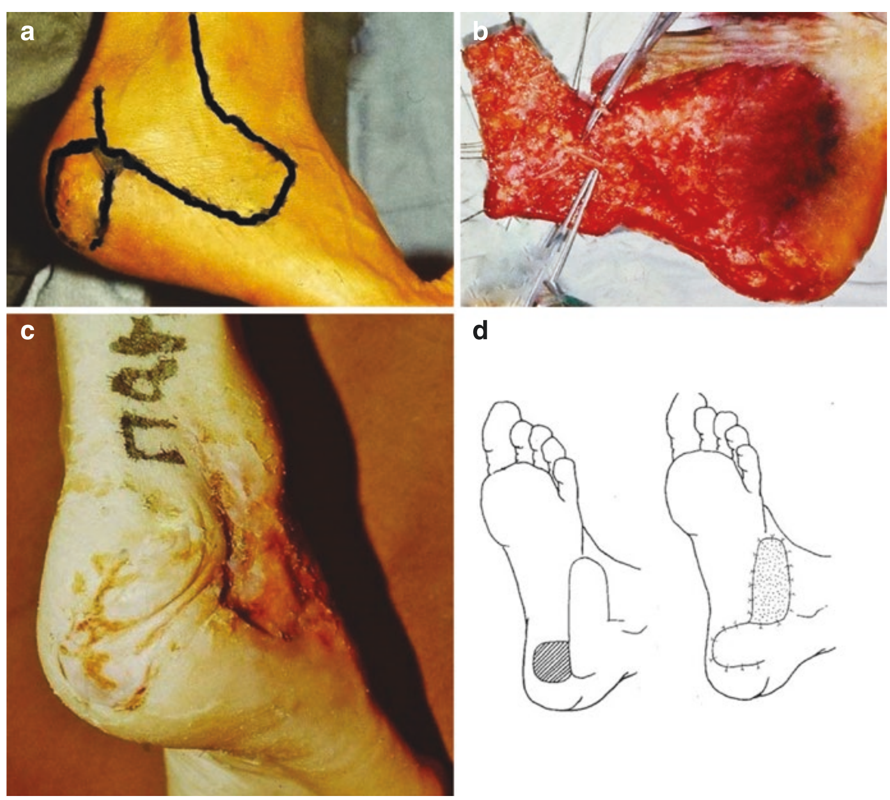

Fig. 39.8 (**a**–**c**) Treatment of ulcerous soft tissue defect in the plantar heel region; *F* flap; *D* tissue defect; (**d**) scheme of operation

Fig. 39.9 Results of elimination of ulcerous soft tissue defect over the proximal part of Achilles tendon with bipedicle sural adipose-cutaneous flap. (**a**) Before operation; (**b**) bipedicle sural flap planning; (**c**, **d**) ulcerous rough scars excised, flap elevated; (**e**) flap displaced posteriorly and covered Achilles tendon; (**f**) donor wound skin-grafted; (**g**) excellent follow-up result (2 years after reconstruction)

Conclusion

The transposed proximally-based sural adipose-cutaneous/scar flaps were alive and completely covered and protected the posterior heel and Achilles tendon, allowing the tendon to move and shift freely. Skin transplants merged well with wound tissues. Necrosis of the distal part of the flap can occur if the leg's arterial flow is obliterated. Marginal superficial flap scar necrosis rarely occurred and had no effect on final outcomes. The skin of the flap preserved sensation and tolerated pressure caused by footwear well. Because the flaps are thin, no tissue excess and no debulking is needed. The flaps continue to grow and become wider because of tension created during the operation. Donor site deformation is minimal, as the soft tissue defect is small; with time, the skin transplant changes into well-functioning, well-matched surrounding skin that can be easily hidden by footwear. Sural nerve cutting caused no complaints regarding disorders of distal foot sensitivity.

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40 Inguinal Scar Contractures: Anatomy and Treatment

Introduction

Scars of the inguinal anterior surface produce a fold along the border with undamaged medial inguinal surface. The contracture prohibits hip joint extension and requires reconstruction. The contracture is of the edge type: the lateral fold sheet and lateral inguinal zone are scar; the medial inguinal zone, sheet of the fold, and upper inner thigh surfaces are healthy skin and are good donor sites. After contracted scar dissection in the inguinal region with a Y- incision, a trapezoid wound appears. The scar surface deficit is compensated for, and the contracture is successfully released with an adipose-cutaneous trapezoid flap taken from above-named donor site. Vast severe abdomen contracture is eliminated by scar excision and wound resurfacing with whole skin transplants.

Edge Inguinal Contracture: Anatomy and Treatment with Thigh Adipose-Scar Trapezoid Flap

Vast burns of the anterior abdomen and thigh surfaces and the inguinal region treated with skin transplantation can result in edge inguinal contracture formation (Figs. 40.1 and 40.2). Such contracture removal requires the use of an adipose cutaneous flap. Widespread skin damage presents a challenge for surgeons. We noticed that the thigh's upper zone is a good donor site for the required flap harvesting.

Anatomy (Fig. 40.1)

Burns and skin transplant covering the inguinal zone are terminated along the curvature where the inguinal region transverses into the perineal zone (Fig. 40.1a). The fold forms along the boundary of scars and healthy skin, among the inguinal and the perineum (Fig. 40.1a). The lateral (inguinal) fold's sheet is scar, the medial sheet (perineal) is healthy skin, connecting with the healthy medial thigh surface and perineum. The lateral fold's sheets have a surface deficit in length, which spreads along the ligamentum inguinal and causes contracture; both sheets are surface surplus, which is used for scar surface deficit compensation. The medial fold's sheet is connected to the inner surface of the thigh, where there is a surplus of adipose-cutaneous layer; therefore, the inner surface of the thigh serves as the optimal donor site for the inguinal edge scar contracture elimination.

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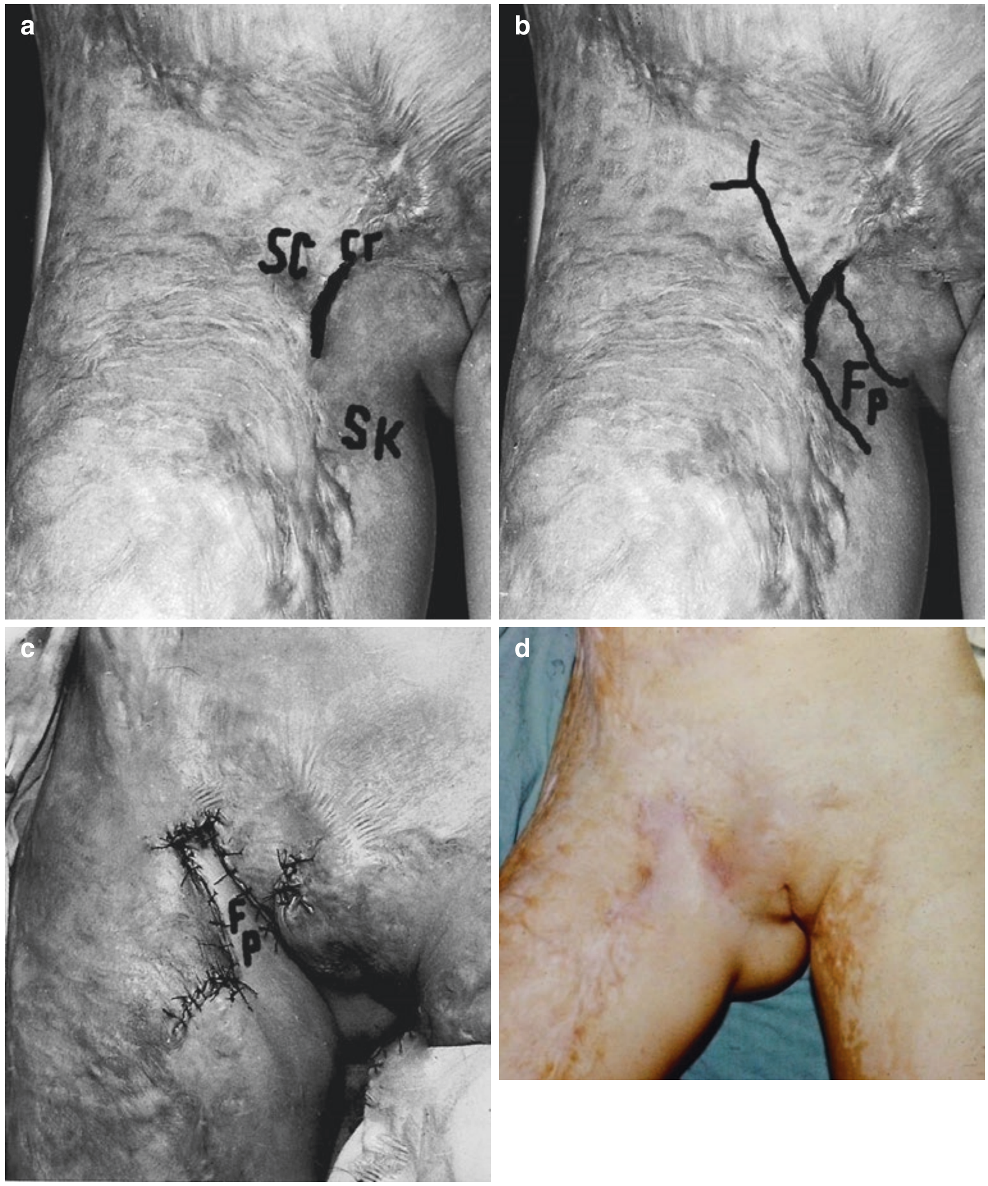

Fig. 40.1 Anatomy of edge inguinal contracture and treatment with trapeze-flap plasty in a 10-year-old female patient. (**a**) *SC* scars; *Sk* skin, *Cr* crest of the fold. Widespread skin transplants covered the inguinal zone and neighboring area of the abdomen and thigh; the perineum and thigh inner surface is healthy skin (donor site); genitalia deformed; (**b**) *FP* flap; planning of operation: Y-line for scars' dissection, separation of scars from healthy skin, trapezoid flap's borders; (**c**) end of operation; *FP* flap (**d**) 3 weeks after surgery: contracture released, appearance of inguinal zone improved

Surgical Technique

Planning consists of marking several lines: One along the fold crest for dividing the healthy skin from scars; a Y-shaped line along the ligamentum inguinal projection, and two lines depicting the borders of the trapezoid flap (Figs. 40.1b, 40.2b, and 40.3a). After the fold's sheet separation and scar dissection with a Y-shaped incision up to complete the inguinal contracture release, the trapezoid wound appeared. Corresponding to the form and size of the wound (scar surface deficit), the thigh adipose-cutaneous flap is elevated.

The upper incision for the flap preparation passes nearly 2 cm distally from the perineal fold. Large veins remain in situ, and almost the entire fat layer is included in the flap. The flap is transposed on the wound with tension and compensates for the scar surface deficit (Fig. 40.2a). Due to the flap's transposition, bulking near the perineal fold disappears, which produces a positive cosmetic effect. "Dog ears" appearing near the flap's base are removed by scar excision (Figs. 40.1c and 40.2c).

As the flap is transposed with tension, it grows intensively, which prevents contracture recurrence in children; in adults, the flap can be narrower than the wound.

Severe inguinal one-side adduction contracture can be combined with the inner and anterior thigh surface (donor site) injury (Fig. 40.4a). If the abdomen wall is undamaged, reconstruction is performed with a bi-lobed groin flap (Fig. 40.4b).

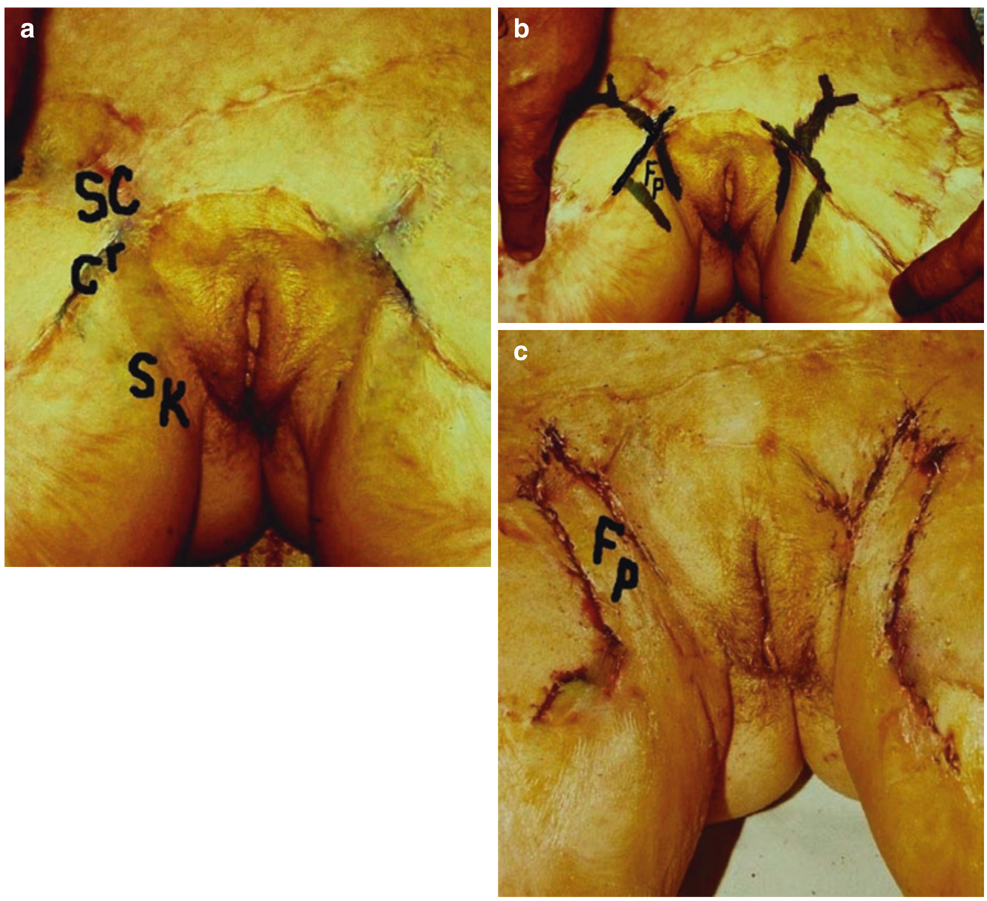

Fig. 40.2 Treatment of severe inguinal contracture, both sides, with thigh trapezoid adipose-cutaneous flaps. (**a**) *SC* scars; *Sk* skin, *Cr* crest of the fold. Abdomen, anterior thigh, and inguinal zones covered with the skin transplant; the fold is formed between the inguinal zone and the perineum, causing inguinal both-side contracture; the lateral fold's sheet is scars; the medial sheet and the neighboring thigh and perineum are healthy skin; (**b**) *FP* flap; planning: lines for contracted scars' dissection with a Y-shaped incision, scar separation from healthy skin, flaps borders on upper inner sigh surface; (**c**) mobilized adipose-cutaneous trapezoid flaps covered the wound and compensated scar surface deficit

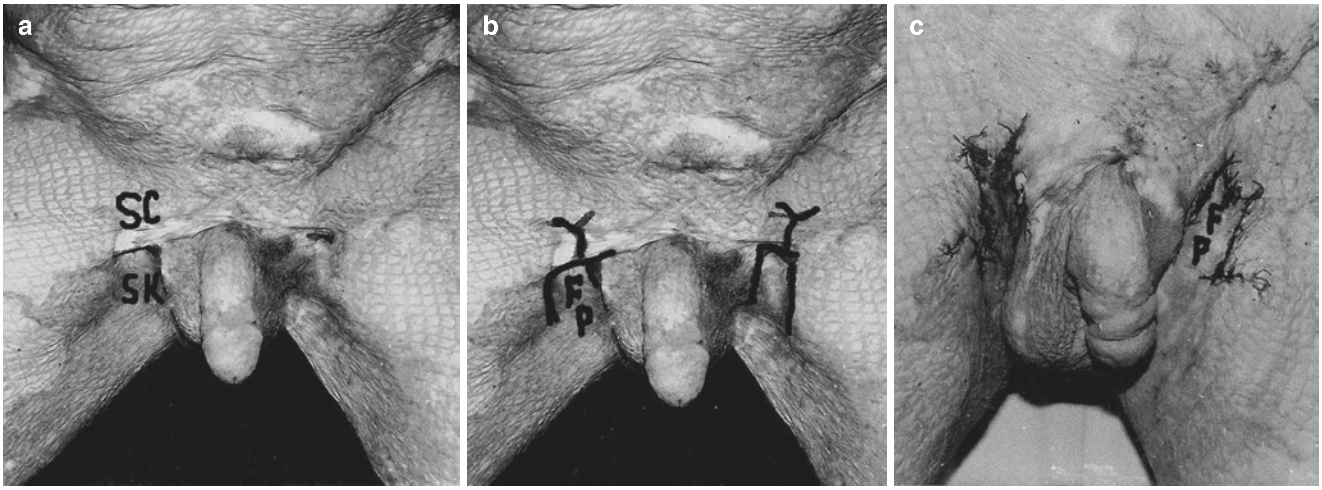

Fig. 40.3 Inguinal two-sided edge contracture anatomy and elimination in an adult male with the thigh adipose-cutaneous trapezoid flaps. (**a**) Pre-surgery: *SC* scars; *Sk* skin; contractures appeared after burns and skin grafting of abdomen, anterior surface of the thigh and inguinal zones; contractures caused by the fold in which the lateral sheet is scars, the medial sheet, perineum, and upper thigh less injured and serve as donor sites; (**b**) operation planning; *FP* flap; (**c**) 7 days after reconstruction: *FP* flap; contracture released, adipose-cutaneous/scar flaps alive

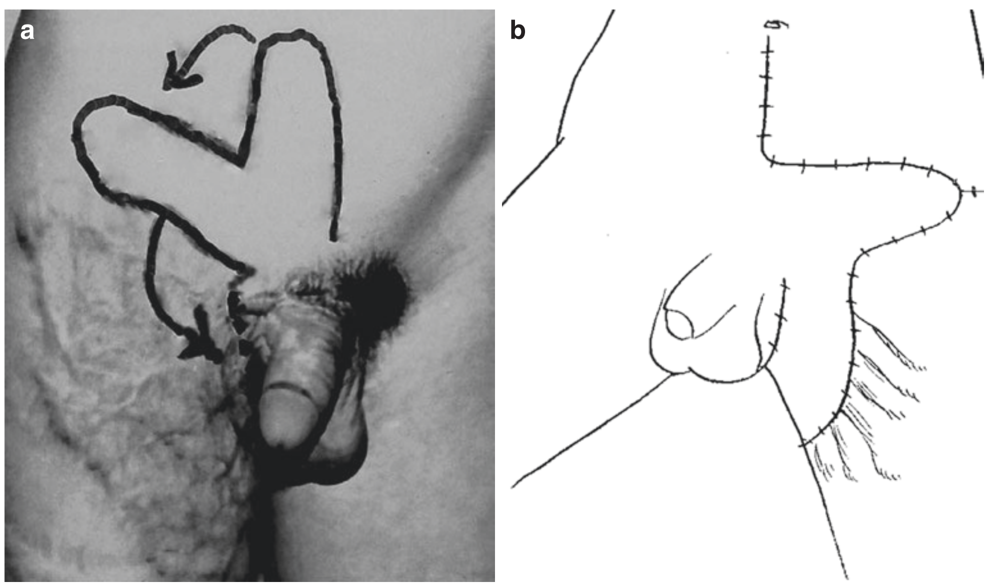

Fig. 40.4 One-side severe inguinal adduction contracture treatment with bi-lobed groin flap. (**a**) Pre-surgery: severe right-sided inguinal contracture with injury to pubis and upper thigh area (donor site); the abdomen wall is healthy; planning of reconstruction with a bi-lobed groin flap; (**b**) view after surgery (scheme)

Total Inguinal Contracture: Anatomy and Treatment

After widespread burns to the body's anterior surfaces, scars deform the form and surfaces of the trunk, inguinal regions, genitalia, and thighs, and cause hip joint flexion contractures (Figs. 40.5, 40.6, and 40.7). A severe scar surface deficit excludes reconstruction with local flaps. Therefore, only dissections and excision of mature scars through the intermediate layer of a large surface, and wound resurfacing with whole split skin transplants, are possible for hip contracture release. This approach significantly improves the appearance of a large region of the body area (Figs. 40.5, 40.6, 40.7, and 40.8).

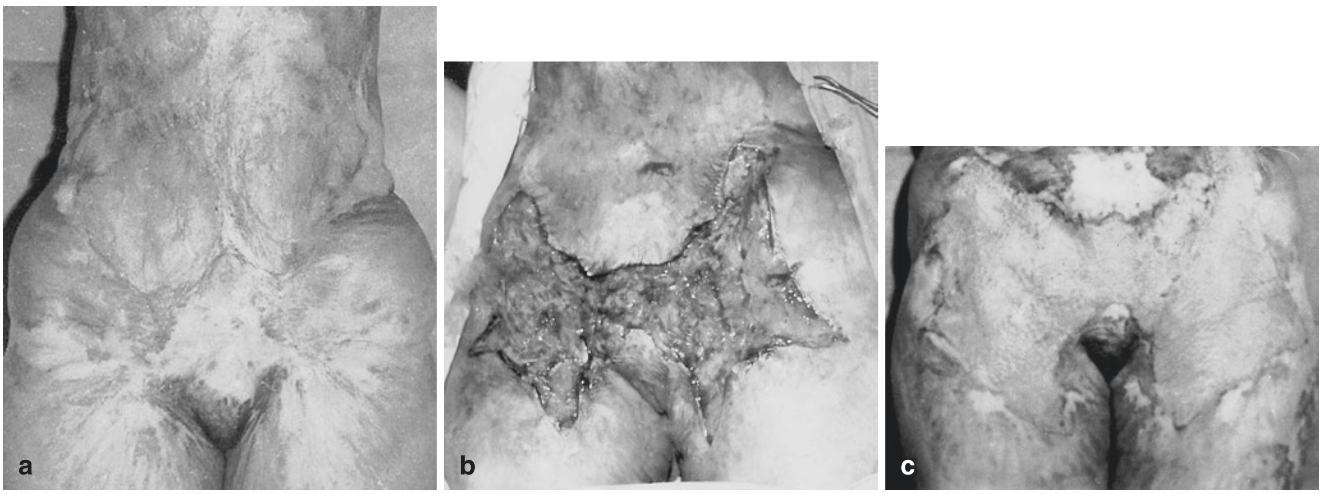

Fig. 40.5 Abdomen inguinal and thigh regions covered with rough contracted scars, causing flexion contractures of thighs and abdomen wall. (**a**) Pre-surgery; (**b**) wound after scars incisions and excision, umbilicus accepted normal position; (**c**) wound covered with skin transplants, deformation less expressive, inguinal contractures released

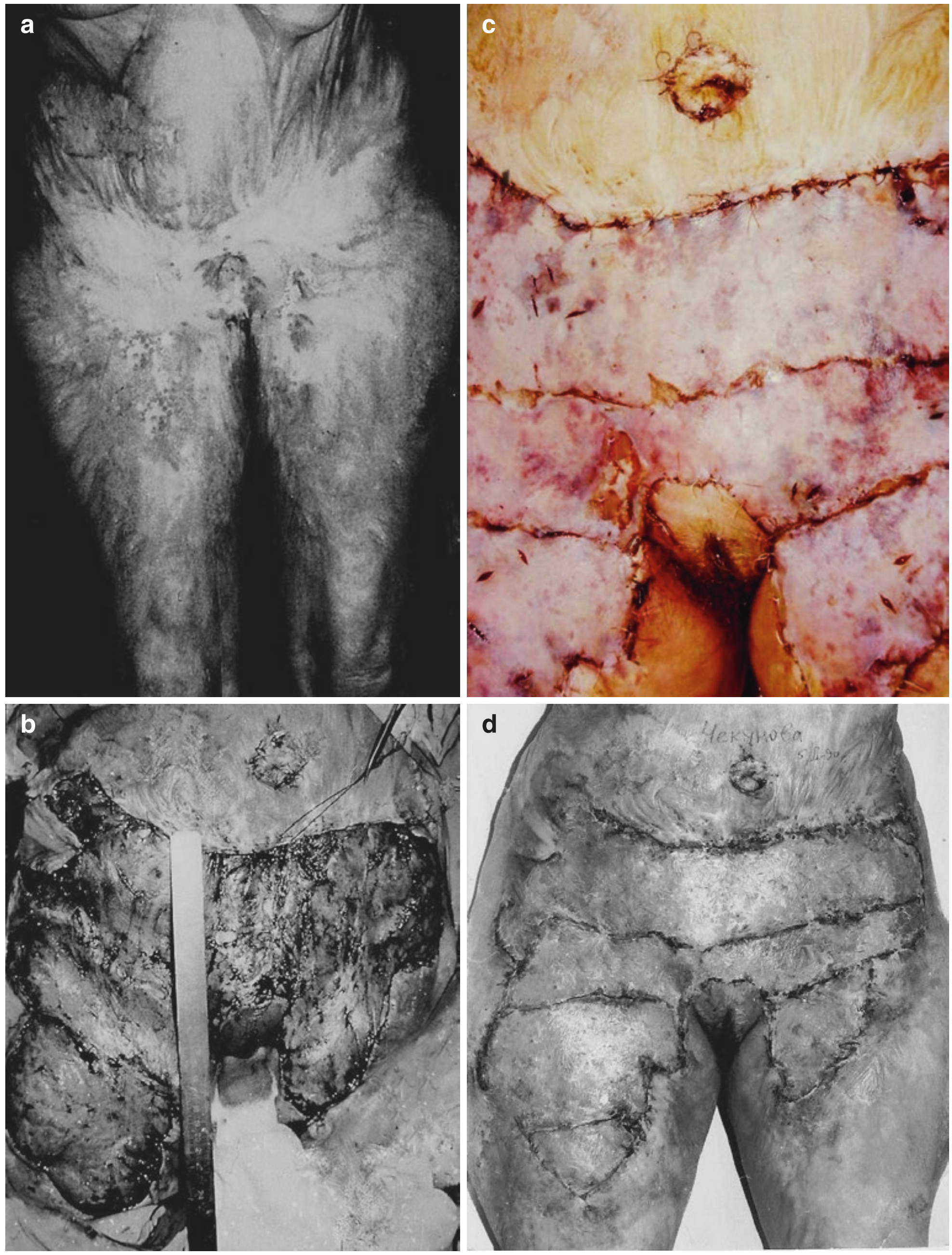

Fig. 40.6 Scars of body anterior surface destroyed abdomen wall, inguinal zones, caused inguinal contractures, deformed thighs and genitalia. (**a**) Before the operation; (**b**) scars excised, umbilicus transferred, genitalia freed from scars, inguinal contractures released; (**c**, **d**) wound covered with whole split transplants; appearance significantly improved, contractures eliminated, transplants alive (one week and three weeks after surgery, respectively)

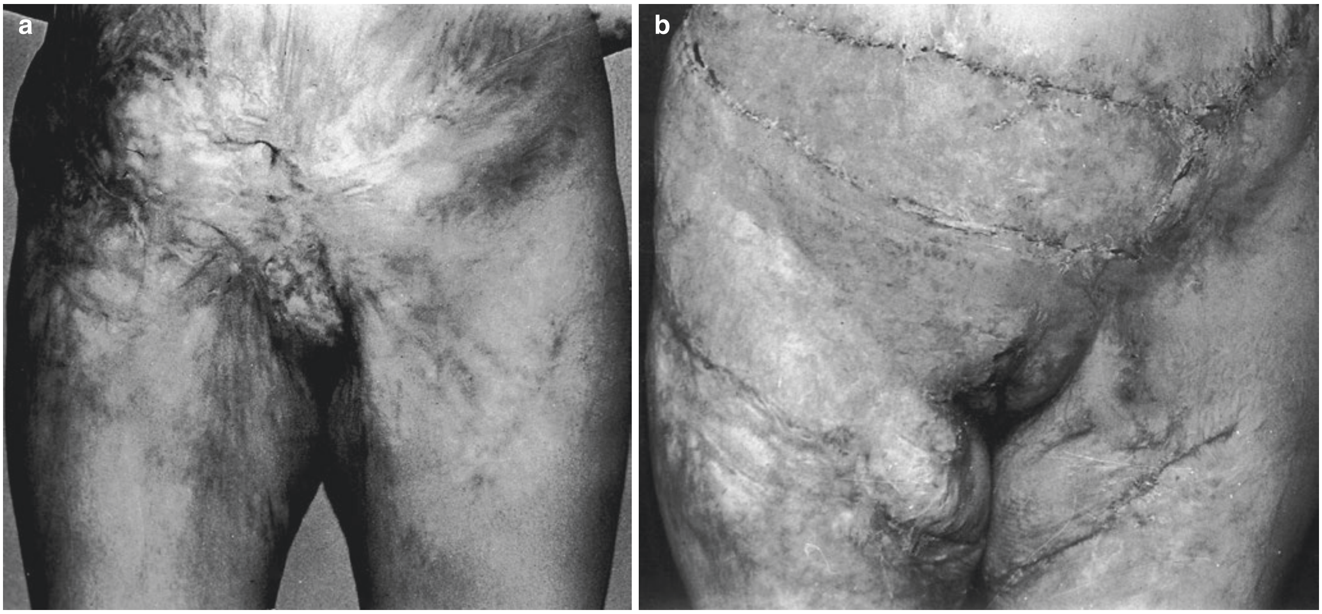

Fig. 40.7 Postburn deformity of the abdomen wall, genitalia, thighs, inguinal contractures (mostly right side). (**a**) Pre-surgery view; (**b**) scars excised, local tissues transposed on the wound, most parts of the wound were skin rafted, inguinal contractures released, umbilicus accepted normal position, deformity became less expressive

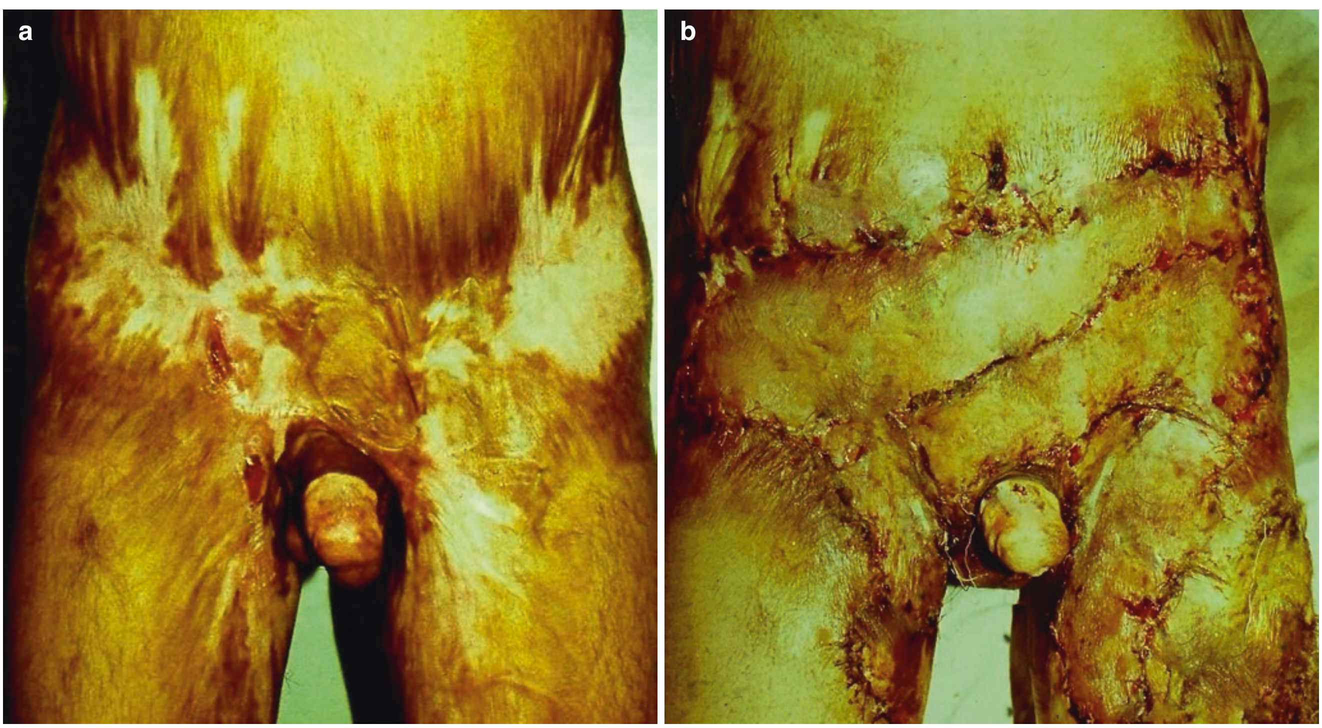

Fig. 40.8 (**a**, **b**) Both total inguinal and lower abdomen wall contracture treatment by wide scar excision and skin grafting in a 5-year-old boy

Conclusion

The edge inguinal contracture is successfully eliminated with the thigh adipose-cutaneous trapezoid flap, which continues to grow, preventing contracture recurrence. The donor place is cosmetically acceptable and more attractive with time after surgery. Total inguinal contracture is treated by contracted scar incision and excision, freed inguinal zones, genitalia, and abdominal wall; large wounds are covered with whole split skin transplant placed transversely.

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