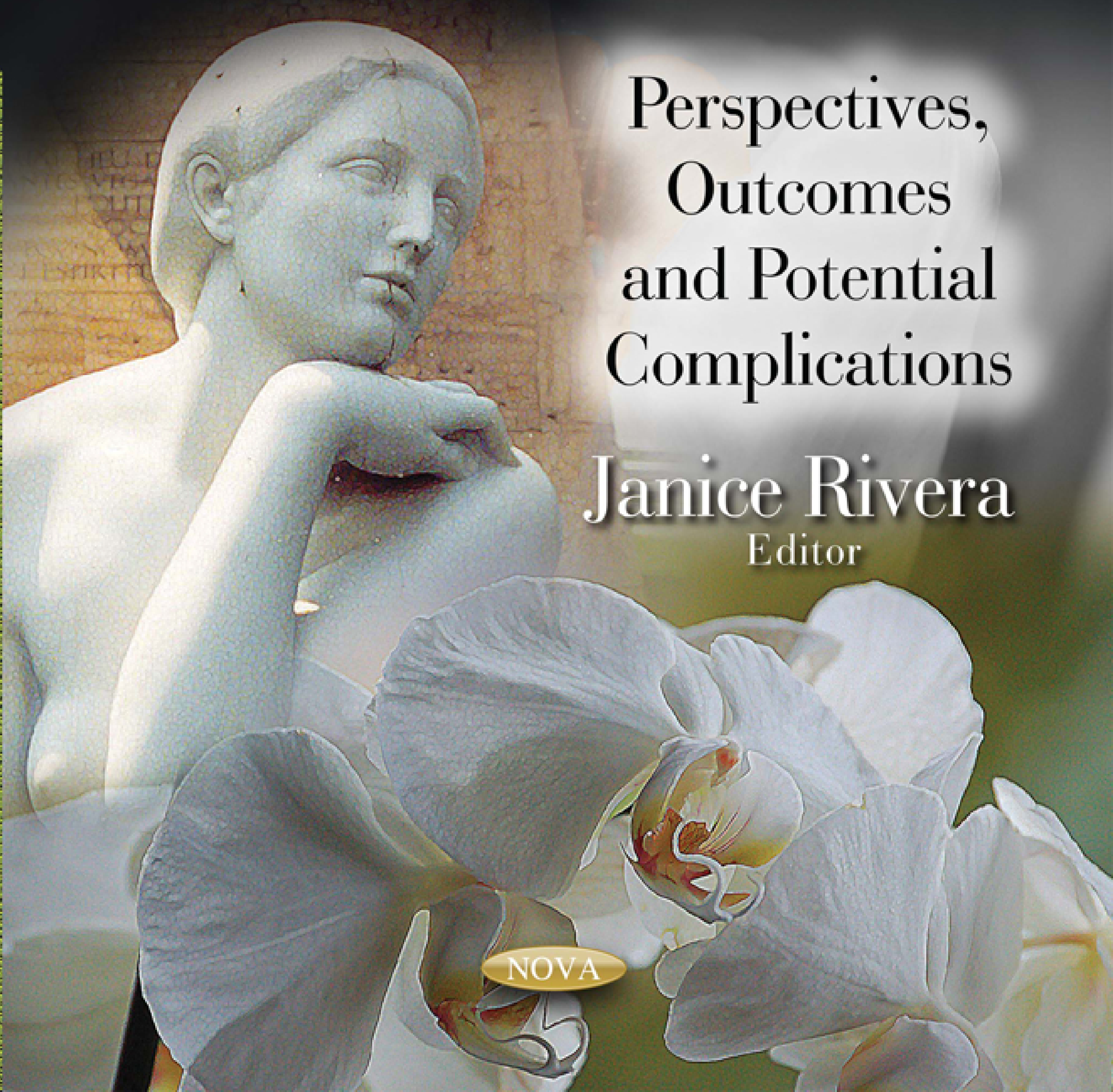
Surgery - Procedures, Complications, and Results

Breast Reconstruction

Perspectives, Outcomes and Potential Complications

Janice Rivera
Editor



Nova Biomedical

NOVA

SURGERY - PROCEDURES, COMPLICATIONS, AND RESULTS

BREAST RECONSTRUCTION

PERSPECTIVES, OUTCOMES AND POTENTIAL COMPLICATIONS

SURGERY - PROCEDURES, COMPLICATIONS, AND RESULTS

Additional books in this series can be found on Nova's website under the Series tab.

Additional e-books in this series can be found on Nova's website under the e-book tab.

SURGERY - PROCEDURES, COMPLICATIONS, AND RESULTS

BREAST RECONSTRUCTION

PERSPECTIVES, OUTCOMES AND POTENTIAL COMPLICATIONS

JANICE RIVERA
EDITOR

NOVA BIOMEDICAL
New York

Library of Congress Cataloging-in-Publication Data

Library of Congress Control Number: 2016954173
ISBN: 978-1-53610-259-8

Published by Nova Science Publishers, Inc. † New York

CONTENTS

PREFACE

This book provides new research in breast reconstruction surgery. Chapter One discusses the reconstruction of the nipple-areolar complex. Chapter Two examines the effect of post-mastectomy radiotherapy on the outcome of implant-based immediate breast reconstruction with or without a cellular collagen matrix. Chapter Three presents tips for safe maneuvering of deep inferior epigastric perforator (DIEP) flaps, as well as the implementation status of 3D imaging technology and its utility with regard to breast reconstruction using DIEP flaps. Chapter Four examines what to do after a free flap failure for breast reconstruction. Chapter Five highlights risk factors leading to higher rates of complications, early signs of complications, ways to monitor postoperative patients, and a systematic approach to treatment for breast reconstruction. Chapter Six reviews how to manage complications in free flap breast reconstruction. The last chapter studies patient satisfaction following autologous or heterologous breast reconstruction.

Chapter One - Nipple areolar reconstruction (NAC) progressed in parallel with breast reconstruction. Being a part of the complex process of the reconstruction of the breast, it also respresents an important asset in the evaluation of the overall quality of this process. Patients associate this stage with the end of the treatment and with a sense of completeness.

It can be done during the primary or secondary breast reconstruction or later. Ideal reconstruction of the NAC requires symmetry in position, size, shape, projection, texture, and pigmentation.

Numerous techniques for nipple-areola complex (NAC) reconstruction are described. NAC reconstruction techniques comprise of composite nipple grafts, local flap, flaps with autologous graft augmentation, flaps with alloplastic augmentation and flaps with allograft augmentation.

The local flaps are the most frequently described techniques for the nipple reconstruction with no significant difference in complications' rate among the various types of techniques. In literature, complications in nipple reconstruction are almost 50% after graft, 8% after local flap, and 5% in case of flaps with autologous graft/alloplastic/allograft augmentation, while complications in areola reconstruction are 10% after graft, and less than 2% after areola tattoo. Flaps appear to be more reliable than grafts in nipple reconstruction, while tattoo is thought to be safer than graft in areola reconstruction.

The loss of projection is considerable (45%-75%). Overcorrection of 25-50% of the desired result is advisory when adopting local flaps, in order to prevent loss of projection. The use of flaps with autologous graft/alloplastic/allograft augmentation (cartilage, fat, calcium hydroxylapatite, acellular dermal matrix, collagen) showed a minor loss of nipple projection but may expose to a relative increased number of postoperative flap necrosis.

Chapter Two - Implant-based immediate breast reconstruction has evolved rapidly over the past decade. The emergence of human, porcine, and bovine acellular collagen matrices (ACM) has had significant impact resulting in a marked rise in implant-based immediate reconstructions. The matrices are used to provide improved lower pole coverage of the reconstructed breast enabling a one-stage reconstruction with a fixed volume implant or an expander in cases where a larger volume reconstruction is required. This is in contrast to the technique of complete submuscular tissue expander reconstruction, which was associated with limited implant or expander volume as well as restricted lower pole projection. Understandably, implant-based immediate breast reconstruction with ACM is therefore increasingly utilised in oncological and risk reducing settings.

Post-mastectomy radiotherapy remains a key adjuvant treatment modality as it improves locoregional control as well as overall survival in breast cancer patients. However, its use in patients who have undergone implant-based reconstruction can be detrimental with potential for complications such as infection, mastectomy flap necrosis, capsular contracture, and explantation necessitating revisional surgery. Therefore, managing this group of patients requires careful multidisciplinary approach and planning. The main purpose of this review article is to examine the effect of post-mastectomy radiotherapy on the outcome of implant-based immediate breast reconstruction with or without acellular collagen matrix. The authors will additionally examine the literature to determine if there is any potential protective benefit of ACM usage in patients who receive post-mastectomy radiotherapy. The review will also attempt to identify potential strategies that can be utilised to improve outcome in these patients. The strategies will focus on patient and surgical risk factors, alternative reconstructive options including autologous reconstruction, as well as adjunctive surgical techniques to improve patient outcome.

Chapter Three - Progress in microsurgery techniques has popularized the use of the perforator flap, which enables minimal invasion into the donor site without sacrificing muscle. In breast reconstruction as well, one procedure that has become increasingly common is the transplantation of subcutaneous fat from the lower abdomen as a deep inferior epigastric perforator (DIEP) flap to the affected area. Recent developments in 3D imaging are also quite significant, allowing for 3D photography and 3D printing to be done even at the individual patient level. The authors have also come to rely more heavily on 3D imaging technology for breast reconstruction employing DIEP flaps, and have reported on its utility. In the present chapter, the authors focus on the authors' experiences thus far, and present tips for safe maneuvering of DIEP flaps, as well as the implementation status of 3D imaging technology and its utility with regard to breast reconstruction using DIEP flaps.

Chapter Four - Free flaps for breast reconstruction are among the most used procedures nowadays. Most common free flap procedures are DIEP, SGAP, IGAP, FCI and gracilis. The success rates in experienced centers range between 93-97%. Failure of a free flap can have many causes and the result can be a disaster for the patient, with loss of the new breast and donor area scars or other complications. When a salvage procedure fails, the question raised is what to do next.

Choosing an implant or expander-based procedure can be a good choice for these patients. Choosing a second free flap can be a risky procedure, taking into consideration the psychological effect of another failure. When the gluteal area or thigh is used as a donor site, the other one can be used for harvesting. If DIEP was used, this donor area cannot be used again, and other locations should be selected.

The cause of the failure should be carefully evaluated. When prothrombotic systemic disease is ruled out and the quality of recipient vessels are suitable for anastomosis, a second free flap can be used.

Chapter Five - Breast reconstruction using free flaps is a procedure often performed by plastic surgeons. Like any other procedure, it is not without complications, which may occur whether it is an immediate or delayed, unilateral or bilateral reconstruction, with or without pre- or post-operative radiotherapy, in obese or smoking patients. Both the clinical setting and the surgeon's experience are closely related to the rate of these complications.

Complications may imply hematomas, infections, vascular impairment, partial or total flap loss, wound dehiscence, hypertrophic scars or donor site complications. More specific to the use of microsurgical techniques are vascular complications: arterial or venous thrombosis and venous congestion.

How do we avoid complications and, if despite all methods of prevention, complications arise, how do we deal with them? The most severe and feared are vascular complications. If they occur, a challenging decision must be made: do we "watch and wait", use conservative methods to prevent impairment, or return the patient to the operating room. Timing of this decision by balancing clinical and objective findings will be the focus of this chapter. For instance, hematomas can lead to external vascular obstruction, and unrecognized or delayed recognition of vascular thrombosis will lead to partial or even total flap loss. Sometimes, partial flap loss is more challenging to deal with in the long-term than total flap loss.

What the authors intend to highlight in this chapter are: risk factors leading to higher rates of complications, early signs of complications, ways to monitor postoperative patients, and a systematic approach to treatment.

Chapter Six - Breast cancer treatment remains on the forefront of healthcare in the United States, affecting nearly one in eight women in their lifetime. With increasing awareness and policy changes, such as the Women's Health and Cancer Rights Act of 1998, breast reconstruction rates have continuously climbed over the last two decades, a nearly 35% increase since 2000. Breast reconstruction with free autologous tissue, gaining widespread popularity in the 1990's, can provide a natural, aesthetic breast shape while avoiding many of the pitfalls associated with implant-based reconstruction. The number of available donor sites and flap types has also increased dramatically in recent years. Today, autologous tissue constitutes close to 20% of breast reconstruction.

Chapter Seven - "Health" cannot be defined anymore just from a physiological point of view, a good self-esteem, sexuality and quality of life are essential for a healthy patient. Today medicine is more and more direct towards the patient, giving them more choices, control and information. To be able to accurately measure health care outcomes, patient satisfaction data cannot be disregarded.

Every year, more than 60,000 American patients are subjected to a mastectomy, a surgery that is highly mutilating especially for young women, and from this 20-40% will undergo a breast reconstruction. In front of a large variety of solutions the patient should be aware of her opportunities. Whether or not a candidate for an autologous, prosthetic or autologous and prosthetic breast reconstruction the patients should know what to expect.

What is, indeed, the best technique, an autologous or a heterologous reconstruction? And if it is an autologous, which one gives the best results: the abdominal flaps (pedicled or perforator) the latissimus dorsi flap, the gluteal flaps or a combination of flaps with prosthetic reconstruction? In the past years, a large number of studies assessing patient satisfaction and quality of life were published, comparing different techniques (autologous versus autologous, autologous versus heterologous, heterologous versus heterologous) in their attempt to improve patient health-care.

Lately, there is a unanimous finding that shows that patients are mostly satisfied, and have a higher long-term satisfaction following an abdominal autologous breast reconstruction, when compared to any other reconstruction techniques.

In: Breast Reconstruction
Editor: Janice Rivera
ISBN: 978-1-53610-245-1

Chapter 1

RECONSTRUCTION OF THE NIPPLE-AREOLAR COMPLEX

Dragos Zamfirescu[1,*], Lucian Fodor[2], Matei Iordache[3] and Andreea Bularda[3]

[1]Zetta Clinic, Bucharest, Romania
[2]Plastic and Reconstructive Surgery Unit, Cluj Napoca, Romania
[3]Bucharest Emergency Hospital, Bucharest, Romania

ABSTRACT

Nipple areolar reconstruction (NAC) progressed in parallel with breast reconstruction. Being a part of the complex process of the reconstruction of the breast, it also respresents an important asset in the evaluation of the overall quality of this process. Patients associate this stage with the end of the treatment and with a sense of completeness.

It can be done during the primary or secondary breast reconstruction or later. Ideal reconstruction of the NAC requires symmetry in position, size, shape, projection, texture, and pigmentation.

Numerous techniques for nipple-areola complex (NAC) reconstruction are described. NAC reconstruction techniques comprise of composite nipple grafts, local flap, flaps with autologous graft augmentation, flaps with alloplastic augmentation and flaps with allograft augmentation.

[*] Corresponding author: Dragos Zamfirescu; dragoszamfirescu@gmail.com.

The local flaps are the most frequently described techniques for the nipple reconstruction with no significant difference in complications' rate among the various types of techniques. In literature, complications in nipple reconstruction are almost 50% after graft, 8% after local flap, and 5% in case of flaps with autologous graft/alloplastic/allograft augmentation, while complications in areola reconstruction are 10% after graft, and less than 2% after areola tattoo. Flaps appear to be more reliable than grafts in nipple reconstruction, while tattoo is thought to be safer than graft in areola reconstruction.

The loss of projection is considerable (45%-75%). Overcorrection of 25-50% of the desired result is advisory when adopting local flaps, in order to prevent loss of projection. The use of flaps with autologous graft/alloplastic/allograft augmentation (cartilage, fat, calcium hydroxylapatite, acellular dermal matrix, collagen) showed a minor loss of nipple projection but may expose to a relative increased number of postoperative flap necrosis.

Keywords: nipple reconstruction, flap, cartilage, skin graft

INTRODUCTION

Reconstruction of the nipple and the areola was first introduced as a concept in the 1940s and has evolved ever since in parallel with reconstruction of the breast following cancer treatment, leading to the development of countless techniques, but lacking a complete list until now. The nipple-areola complex is the last phase of breast reconstruction, albeit a very important part in this elaborate process. It is associated with a sense of completeness and of reaching the last stage of the treatment. It is usually performed in the second or third stage of the process, frequently after radio- and chemotherapy have been performed. Reconstruction has to take into consideration symmetry in all aspects: position, size, texture, shape, permanent projection and pigmentation. Nipple reconstruction is usually the first phase and can be undertaken using local flaps, grafts or flaps consisting of autologous graft, allograft or alloplastic augmentation, while the use of tattooing and of skin grafting have been described for areolar reconstruction as frequent and easy possibilities. Although considered a simple surgery, reconstruction of the nipple and areola has important psychological aspects when evaluating the quality of the entire reconstructive process [1-4].

HISTORY

The history of the nipple-areola complex (NAC) reconstruction began in the 1940s with Adams using the labial minus grafts for reassembling [5, 6]. Evolution followed some 30 years later with the nipple-sharing concept introduced by Millard which harvested tissue from the contralateral nipple [7]. This journey of progression over time included diverse grafts (toe pulp, cartilages) [8], then flaps composed of local flaps (such as the T flap in the 1980s) [9], culminating with the 1980-1990 period when the traditional flaps were defined, such as the F flap, Z flap, star flap or skate flap. Finally, synthetic materials have been used alongside allografts in the newest techniques.

INDICATIONS

Normal Areola Characteristics

One of the first aspects to be taken into consideration when planning a nipple-areolar complex reconstruction is the aspect of the normal areola. The normal areola is generally placed where the most projection can be achieved on the reconstructed breast. Several measurements and aspects should be taken into consideration, such as size, shape, diameter and color, adapting them to the contralateral breast [10].

Measurements should be made so as to symmetrize the two NACs, adapting the distance between the areola to the inframammary fold and the distance between the nipple and the notch, matching those of the normal nipple [11].

The real challenge arises when a bilateral reconstruction is required. In this case, several standard numbers are taken into consideration: an areola medium diameter of 4 cm, with a nipple of 1.3 cm in diameter and 0.9 in projection [12].

Timing

One of the most important aspects of the problem is time. The timing of the operation results from a multidisciplinary decision. Frequently it is performed 3-5 months after the last operation, as adjuvant therapy may hinder correct healing [13].

Patient Selection – A Multidisciplinary Decision

The whole treatment process results from the decisions made by a multidisciplinary team that consists of an oncologist who conducts the work and the surgical team formed by a general surgeon and/or a plastic surgeon [10].

Many patients are candidates for a reconstructive procedure. Most surgical operations performed for breast cancer use a skin-sparing mastectomy which frequently leads to the loss of the nipple, with an important psychological impact by affecting the aesthetic aspect and the sense of completeness [3].

Although nipple-sparing mastectomies provide a big upgrade in the psychological matter, they are rarely performed mostly due to the characteristics of the tumor, such as its adjacency to the nipple or its size.

Surgical Techniques

Surgical techniques vary, based on the possibilities offered by the type of the previously practiced mastectomy (nipple-sparing versus skin-sparing), the quality of the local skin, the presence or absence of scars, the excess and the aspect of the contralateral NAC complex, the surgeon’s preference and last, but not least, the patient’s choice [10, 14].

Achieving Long-Lasting Projection

Representing perhaps the ultimate objective of the NAC reconstruction, achieving long-lasting projection is the result of the action of two factors: the flap’s contraction and the retraction forces of the local tissues that act upon the flap. The first is an inevitable effect, taking place to different extents from patient to patient but leading to loss in projection and/or volume. The second can be influenced by wisely choosing a variant with a subdermal pedicle which releases the flap from the adjacent tissues and provides vascularization through the subdermal plexus, which is a far better option than the vascularization provided by the subcutaneous tissue or by scarred or previously irradiated tissues [1].

Nipple Projection Loss

The main issue in the reconstruction of the nipple is the postoperative loss that may occur, either in terms of projection or of volume, regardless of the technique used [15]. Consequently, it is recommended that the reconstructed nipple be double the size of the intended future form [16, 17].

RECONSTRUCTION OF THE NAC

Reconstruction of the nipple-areolar complex can be divided into its two main components: reconstruction of the areola and reconstruction of the nipple [1].

I. Nipple Reconstruction

If the volume of the contralateral nipple is big enough, it can be used as a graft for the future nipple. Otherwise, the preferred option is that of a local flap, such as the F flap, the Z flap, the skate flap or the star flap.

1) Composite Nipple Graft

Amongst the different procedures used for nipple reconstruction, the nipple-sharing technique remains a frequently used option when the contralateral nipple is prominent [5, 7]. Taking advantage of the fact that it uses the same kind of tissue, it represents a good option when a 5-6 mm projection excess is present, making these patients the ideal candidates [10].

The first phase of the operation consists in performing de-epithelialization of the new site for the nipple. Then the distal half (40-50%) of the existing nipple is removed and sutured at the site of the new nipple, while the donor nipple can be closed by using interrupted sutures covered by a tie over or purse-string suture. The last step is reconstruction of the areola which can be harvested from the contralateral one if there is an excess of tissue or from other sites (i.e., the inner thigh) [18, 19] Figure 1.

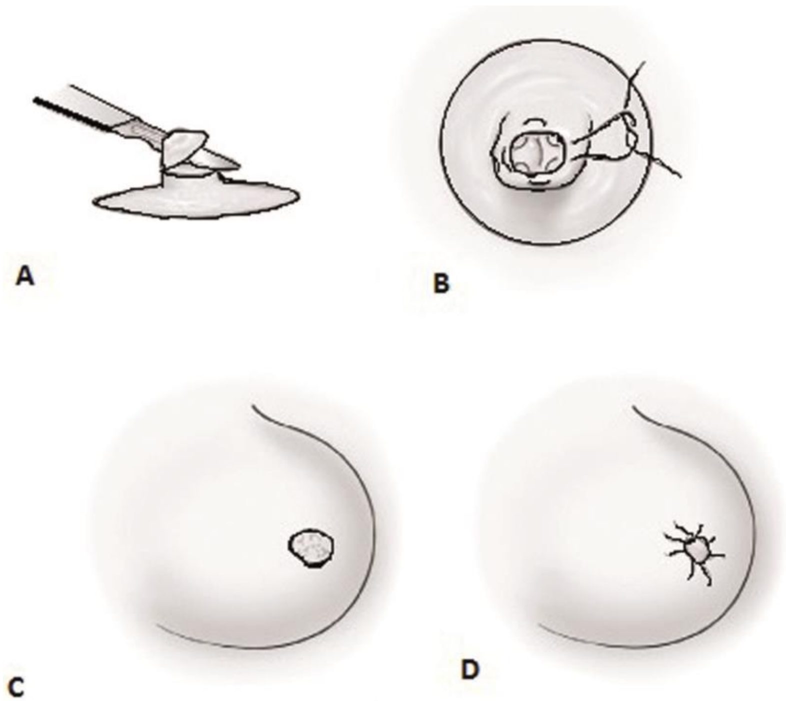


Figure 1. Nipple reconstruction with composite graft. A. Harvesting the composite graft from the contralateral nipple. B. Closing the donor site. C. Deepithelialization at the position of the new nipple. D. Suturing of the composite nipple graft.

This is a suitable technique in cases of large nipples. Above all other surgical options, it best matches the attributes of the contralateral nipple when it comes to shape, structure, color or long-term projection [20].

Unfortunately, the use of this procedure is sometimes limited, mostly because of patients' reservations considering potential complications, such as morbidity of the donor site or discomfort for the patient, fear or unacceptance of contralateral surgery or decrease in that nipple's sensation. Also, surgeons seem loathe to use the healthy nipple because of the risk of morbidity, including pain, numbness or scarring [20].

Comparing the reconstructed nipple to the other one, it needs to be mentioned that overall satisfaction was good. In a study performed on 57 patients, Zenn et al. found that the overall appearance satisfaction was high (in 96% of patients). The same study proved a small decrease in sensation, 47% in the donor site lot weighed it to be normal, compared to 35% of the patients who had their nipples reconstructed. The largest discrepancy lay in that of the comparison between the erectile functions of the nipples, with 87% of the patients declaring that the donor nipple had normal erectile function, compared to only 42% of the patients who declared that they had erectile function 3 months after the operation [21].

2) Traditional Flaps

The local flaps are the most frequently described techniques for the nipple reconstruction with no significant difference in complications' rate among the various types of techniques. In literature, complications in nipple reconstruction are almost 50% after graft, 8% after local flap, and 5% in case of flaps with autologous graft/alloplastic/allograft augmentation, while complications in areola reconstruction are 10% after graft, and less than 2% after areola tattoo [4]. Flaps appear to be more reliable than grafts in nipple reconstruction.

a. Skate Flap

Initially described in 1984 by Little, the skate flap is a widely used traditional flap, thus leading to multiple attempts over time to modify it. Taking into consideration the fact that one of the important aspects in reconstruction is symmetry, the skate flap is a good option when a projected appearance is desired, offering a long-lasting effect [22, 23].

The design of the flap consists in a central axis, a line that is tangential to the base of the nipple. It is recommended to rotate it so as the line does not include the flap's limbs or its central part [23]. The line, which also represents the diameter of the new areola, will be the base for the flap. Its length should be three times that of the nipple circle. Afterwards the line is split into three and a semicircular line that unites the two edges of the line is drawn. The dissection begins from the lateral third progressing towards the center of the flap, from thin to thick, including a layer of approximatively 7-8 mm of fat in the middle part of the nipple, thereby offering bulk and vascularization to the nipple [10, 23] Figure 2.

Special care must be taken not to dissect beyond the base of the flap. Subsequently, the two lateral thirds, or the wings of the flap, are rotated, encircling the base and then sutured one to the other. The last phase of the nipple reconstruction is the suturing of the central third to the other two-thirds [22, 23].

The conventional design consists of the de-epithelization of the rest of the areola and covering it with a full-thickness graft [24, 25].

Having a good long-term projection rate over time attested to by multiple studies, the skate flap represents a widely used flap variant for reconstruction of the nipple [10]. When it comes to disadvantages of using the skate flap, nipple projection loss should be mentioned, varying from 40% to 75% [26, 27].

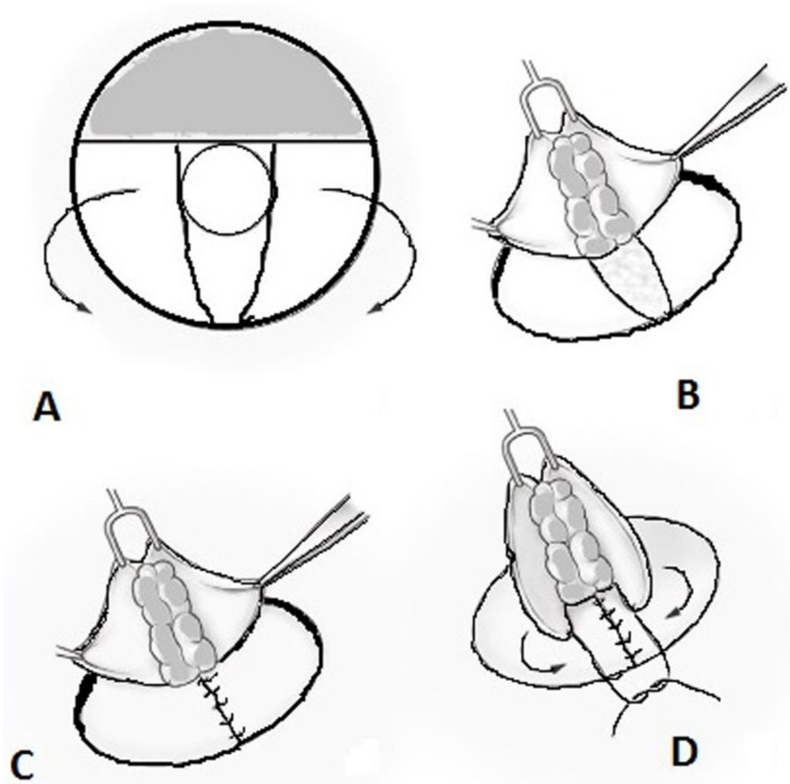


Figure 2. Skate flap. A. The superior part is deepithelializated. B. The wings of the skate are split thickness dissected and the central part is elevated with dermis and fat. C. Closing of the donor defect of the body. D. The wings covered the body to form a cone.

b. Star Flap

The star flap consists of three wings with the same base, beginning from a central point. As in the case of the skate flap, the width of the central wing establishes the nipple's width. The dissection begins from the lateral flaps, raising them carefully as to include subcutaneous fat, continuing to the central wing [22]. One of the lateral wings is rotated around the base of the nipple and sutured into position. Then the other wing is also rotated, suturing it to the base of the previous one. In the final phase, the central wing covers the previous two, forming the tip of the reconstructed nipple. The final aspect results in a T scar [28] Figure 3.

Although it is a good option with excellent results, it has the downside that, due to its final form, it may lead to skin ischemia, postponing the curative process. Another noteworthy disadvantage of the star flap is the lack of projection [10, 29].

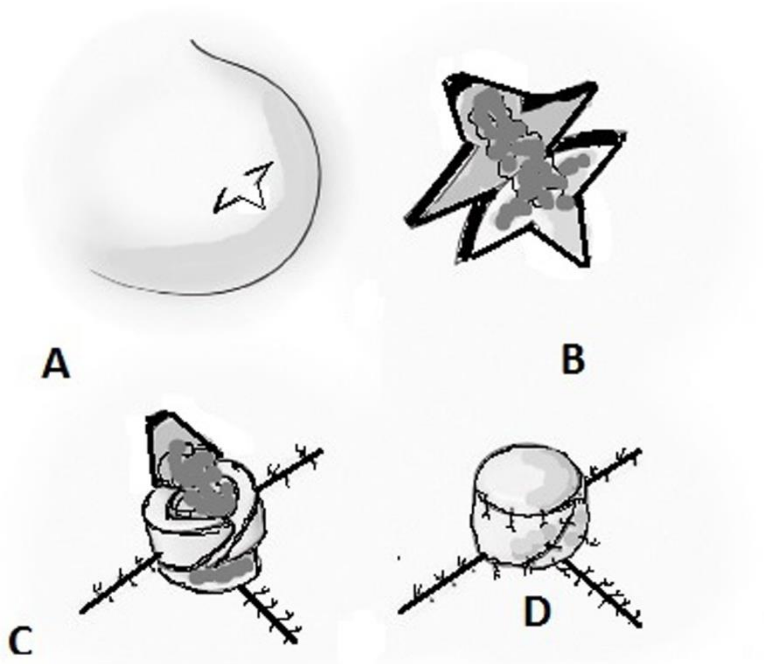


Figure 3. The rays of the star are elevated including subcutaneous fat tissue. One of the lateral wings is rotated around the base of the nipple and sutured into position. Then the other wing is also rotated, suturing it to the base of the previous one. The central wing covers the previous two, forming the tip of the reconstructed nipple.

c. F Flap

An alternative for nipple reconstruction, the F flap is a good option when the contralateral nipple cannot be used, either because it is too small or because the patient refuses, or if the cancer was bilateral. It consists of an adipocutaneous flap which has two limbs and permits primary closure. The two limbs, which are vascularized from the same central base, are then folded into each other. The two limbs can be created asymmetrically based on the new nipple's size [30, 31] Figure 4.

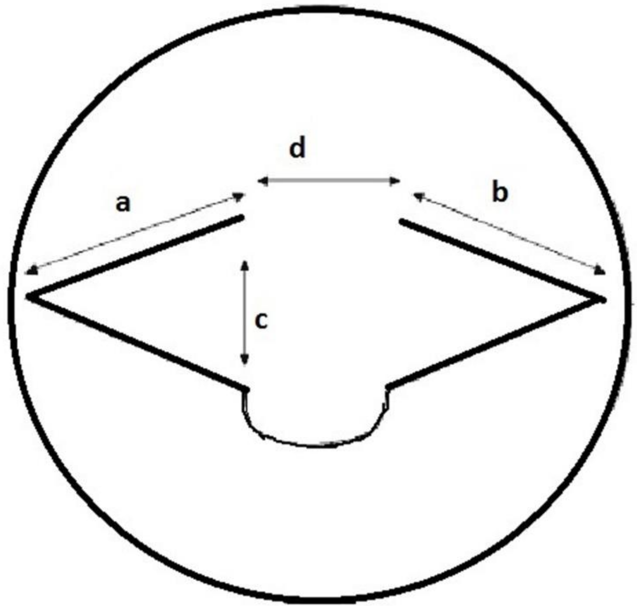


Figure 4. A, B are side flaps. C is the central flap, covering the nipple. The tip of the A flap is sutured to point E. The tip of the B flap is sutured to point D.

In the first phase the selected area is tattooed, after which the two flaps are raised with all the layers of the skin, including the underlying adipose tissue used for the best results in nipple volume. The volume increases proportionally to the thickness of the skin. The two limbs are crossed, usually placing the longest one more inferior than the other [30, 31].

d. Z Flap

The Z flap has been described in several pathologies, although it is a rather new technique. A good option for treatment of the inverted nipple [32, 33], it is also employed when the quality of the skin is not optimal or when the local circumstances are not favorable for an F flap [30]. In addition, it has been described as an alternative in the reconstruction of the nipple.

Although it has two limbs, as the previous flap, each of them has its own pedicle. Two separate pedicles translate into a more reliable vascularization, thereby lowering the possibility of necrosis. The areola's position is set and, following the same manner as in the case of the F flap, it is tattooed in the new spot [30, 31].

The design of the flap consists of two pedicles equal in width and in distance one from the other and with the future nipple [32]. The flaps are raised similarly to the F flap, in full-thickness, after which they are sutured directly one to the other, being careful not to roll nor plicate them [33]. An important aspect to take into consideration is the thickness of the two limbs which should be equal to half of the future nipple [30] Figure 5.

There are several complications which may occur at some time after the operation, such as: initial inadequate nipple projection or loss of nipple projection over time, necrosis (a rare complication that may occur if one of the two pedicles is insufficient), or fading of the areola [30, 33].

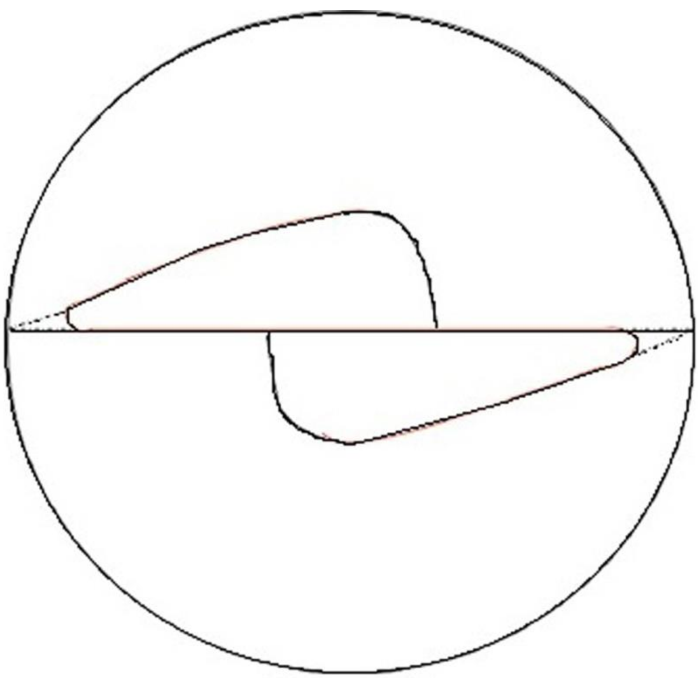


Figure 5. Z. The two pedicles are equal in width and in distance one from the other and with the future nipple. The flaps are raised similarly to the F flap, in full-thickness, after which they are sutured directly one to the other. The thickness of the two limbs which should be equal to half of the future nipple.

e. C-V Flap

The name of the flap describes it accurately. This flap is formed of three limbs, the V representing the shape of two identical limbs placed one opposite to the other, both starting from the center of the flap. The third limb is C-shaped or has a circular display with its diameter created so as to have the same width as the V parts [22] Figure 6.

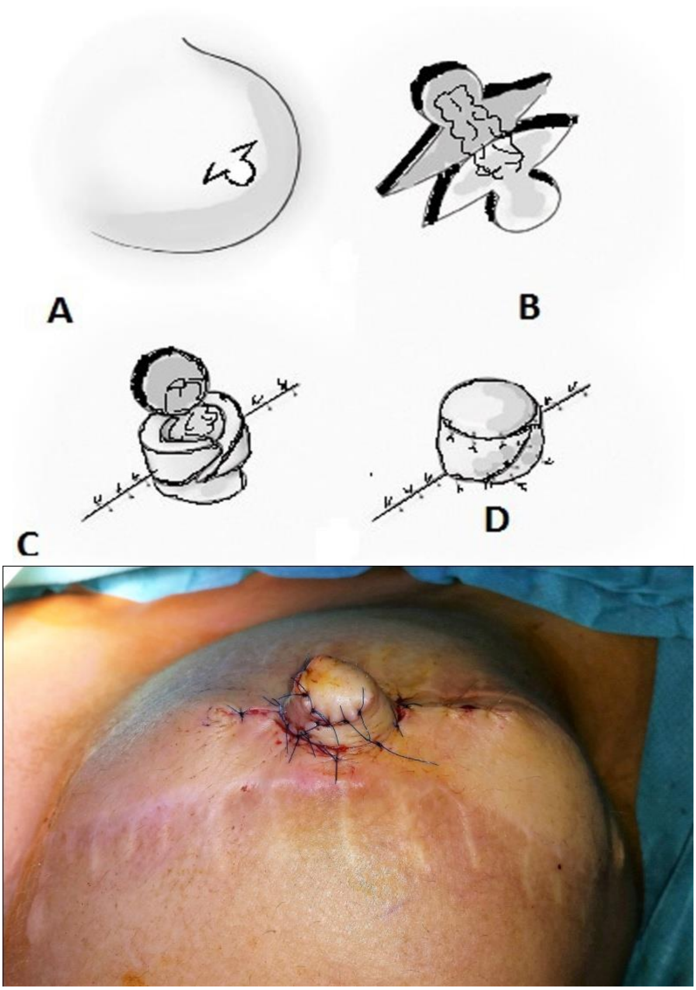
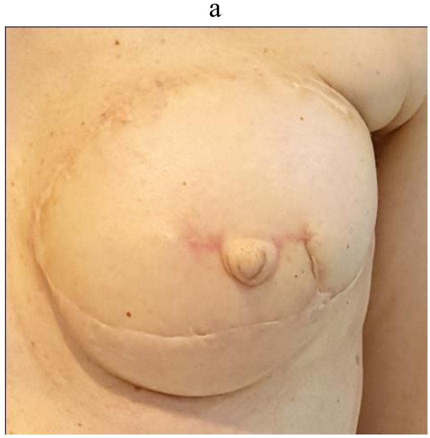


Figure 6. A, B. The two lateral wings are elevated including subcutaneous fat tissue. One of the lateral wings is rotated around the base of the nipple and sutured into position. Then the other wing is also rotated, suturing it to the base of the previous one. The central wing covers the previous two, forming the tip of the reconstructed nipple.

The two V flaps will be the foundation of the nipple, offering projection. They are sutured together in a similar manner to the skate flap by rotating them along the future base. The C part is placed over these two, forming a rounded tip [22] Figure 7A-D.

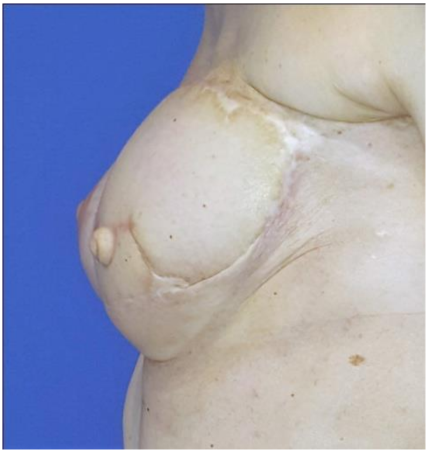
Several studies have proven the good overall results of the C-V flap [34, 35]. Losken et al. proved maintaining of the projection at 5 years after reconstruction with an 81% overall satisfaction rate, while Valdatta et al. showed that, although a 32% projection loss was noticed after a year with a 17% increase in diameter, the volume of the neonipple was maintained.

a



b

Figure 7. (Continued).



c

d

Figure 7. A-D. Nipple reconstruction by the CV (CU) flap. Preop drawing of the flap and 8 months postop result.

3) Purse-String Flap Techniques

These types of flaps have the advantage of creating projection of the NAC complex by mobilizing the adjacent breast tissue. There are several of these procedures, such as the bell flap, the top hat flap or the double opposing periareolar/purse-string flap [36].

The *bell flap* was first described in 1996 by Eng. Named after its design, it facilitates slight areolar projection by suturing it in a purse-string manner [37]. Since its effects are transitory, with a possible projection loss of up to 73% after 1 year, the use of the bell flap has been actively limited to cases of small contralateral nipple projection [26].

The *top-hat flap* is not a true flap on its own. This technique implies the placing of four incisions, 2-4 mm one from the other. The projection of the nipple is established by the tension formed from a nonabsorbable string suture that passes from one incision to the adjacent one. Gamboa-Bobadilla et al. found this technique to be successful with a 6 mm nipple projection 18 months after the operation and a 90% overall reconstruction satisfaction [38].

The *double opposing periareolar flap* is derived from the skate flap. It was designed to offer both projection of the nipple and good scarring of the donor site. This technique elevates the lateral wings with slim layers of fat, while the central part is elevated with subcutaneous fat so as to grant projection [22]. Particular to this flap is the fact that the areolar contour is incised, allowing the areolar flaps to glide along the subcutaneous layer. Subsequently, the nipple is formed in a similar manner to those described before. Shestak's result in a study conducted in 2007 described no flap losses and no dehiscence. Nipple projection was constant with comparable results to those of the skate flap [39, 40].

4) Flaps Adjacent to Scars

Unlike the previously mentioned flap techniques, these flaps are designed to avoid compromised blood supply scarred tissue. Several of these flaps are the S Flap, the Double Opposing Tab Flap or the H Flap [10].

They consist of the creation of a circle with a diameter three times the size of the new nipple, which centers it. Afterwards, having the mastectomy scar as the central line, the different letters or shapes are drawn, leading to the formation of two identical flaps. They are then lifted and sutured, beginning from the base and ending at the tips. The next step implies the de-epithelization for the future areola which will be harvested and processed to meet the required shape [10, 30].

These flaps are a good choice for reconstruction, being a durable option over time, especially in terms of nipple projection [41].

5) Flaps with Autologous Graft Augmentation

This concept was introduced in an attempt to overcome the main problem of projection loss after local flap reconstruction. The alternatives include the use of fat or cartilage grafts [1, 42].

Fat grafting is an easy and increasingly popular technique. It harvests fat from the abdomen or from other regions, processing it and injecting it into the location of the future nipple which was previously drawn. After some time, the fat is resorbed and then the flap can be formed and sutured. This type of grafting is particularly useful for patients with thin subdermal fat [43].

Cartilage grafts offer good nipple projection and represent a rather simple alternative. They can be harvested either from the costal cartilage (Figure 8 A-D) or from the ear and then covered by a skin graft or a flap. Although it is believed that they offer long term projection [34, 35], cartilage grafts are not widely used and accepted due to donor site morbidity.

Guerra and colleagues proved excellent results in their study of 454 patients which used a costal cartilage graft and an arrow flap. Their patients lost only 4% of the cartilage graft due to ischemia or infection [44].

a

b

c

d

Figure 8. A-D. Nipple projection with costal cartilage graft harvested on the time of breast reconstruction and banked in the inframammary fold pocket

6) Flaps with Alloplastic Augmentation

Being one of the newest techniques employed for nipple reconstruction, this method uses materials such as calcium hydroxyapatite or hyaluronic acid, which provide a durable projection but, being non-self, may lead to infection and exclusion [3, 45, 46].

7) Flaps with Allograft Augmentation

Representing a top-of-the-generation product, the acellular dermal allograft is an increasingly popular method for nipple reconstruction as it has the best properties of an implantable material, with little to no rejection or resorption, rarely leading to infections and having a small projection loss [1]. The material is cut according to the required size, rolled upon itself, and then sewn to the adjacent tissue [47, 48].

An alternative to the previous allograft augmentation techniques is the Cook nipple, a cylinder forged to erase size errors which could lead to inequality [1].

8) Loss of Projection

The loss of projection is considerable (45%-75%). Overcorrection of 25-50% of the desired result is advisory when adopting local flaps, in order to prevent loss of projection. The use of flaps with autologous graft/alloplastic/allograft augmentation (cartilage, fat, calcium hydroxylapatite, acellular dermal matrix, collagen) showed a minor loss of nipple projection but may expose to a relative increased number of postoperative flap necrosis [4].

II. Areolar Reconstruction

The two most commonly performed techniques for areolar reconstruction are tattooing or skin grafting, or a combination of the two [1]. Skin grafting, when employed, is usually performed at the same time as the nipple reconstruction and has the advantage of a similar texture to the contralateral nipple, while tattooing is usually performed 6-8 weeks later than the nipple reconstruction [1, 49].

1) Skin Grafting

The full-thickness graft is the choice when it comes to skin grafting. It has to meet the required size of the reconstructed areola. The donor site from which it can be harvested is usually the inguinal crease, although it can also be gathered from the contralateral areola, the retroauricular region, the upper region of the internal thigh/groin region, the inferior abdomen, or whenever there is excessive breast skin [50].

Following the harvest of the graft, the next required step involves the processing of the recipient site by de-epithelization that serves as a reliable base for the graft. The graft is then binded to the bed, using interrupted, nonabsorbable sutures [51].

Skin grafting has the advantages of providing an aspect that resembles that of a normal areola; it has the required texture, it is normally pigmented and it has a wrinkled surface [1].

2) Tattooing

Tattooing may be the first choice in the reconstruction of the areola [52]. Although it may seem less natural, it can be preferred as it has the advantage of not requiring a donor site (Figures 9-11). In most cases, unilateral tattooing is used when the color is easy to reproduce, and bilateral in cases of pale areolae. Usually it consists of a mix of colors (based on titanium oxide and iron) [53, 54] tattooed successively which best reproduce the aspect of the areola, avoiding a less natural effect of the reconstruction. Tattooing is performed first if the nipple is reconstructed using a graft but, in the case of using a flap, the harvest site will be tattooed first, the rest after skin closure [1]. There are times when tattooing is recommended to be done several weeks after the nipple reconstruction, with the mention that it may be required to be a tone darker because the color fades a bit in time [55].

a

Figure 9. (Continued)

b

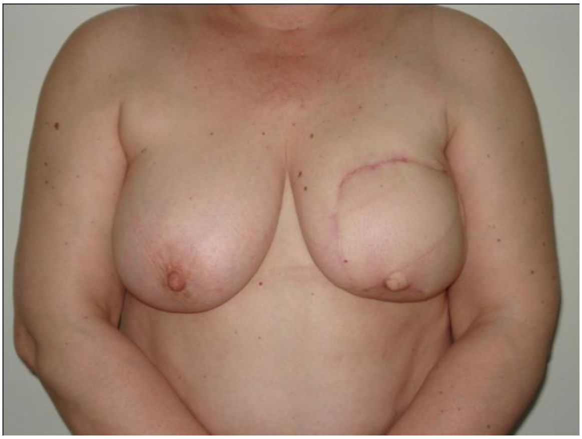
c

d

Figure 9. Complete breast reconstruction, including areola tattooing

Special care must be taken with the technique used. Placing the ink superficially leads to its loss, while placing it deeper results in the macrophages disposing of the ink. Either way, the result is premature pigment fading [55]. Furthermore, the sterility of the operation is also an aspect, as it may lead to viral transmission or disease.

The normal evolution after this intervention is performed is that of sloughing and crusting which may go on for as long as 3-5 days. It is recommended that the area be kept moistened with dressings changed daily [1].



a

b

Figure 10. (Continued)

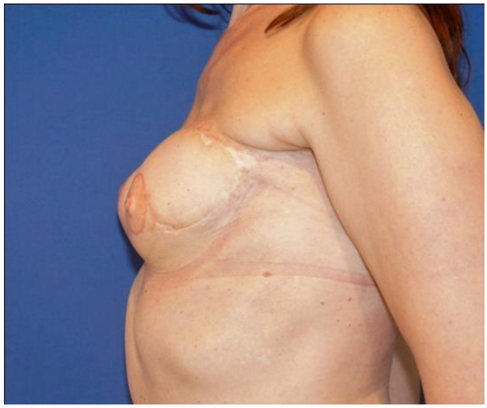
c

d

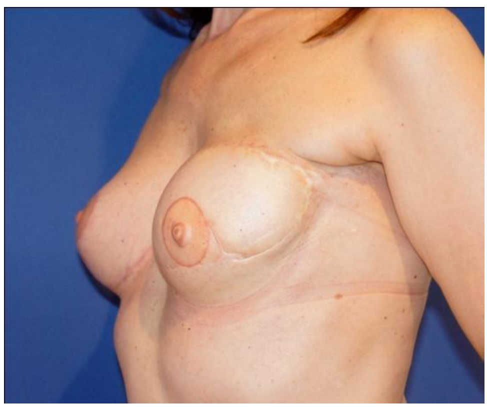
Figure 10. Complete breast reconstruction, including areola tattooing

a

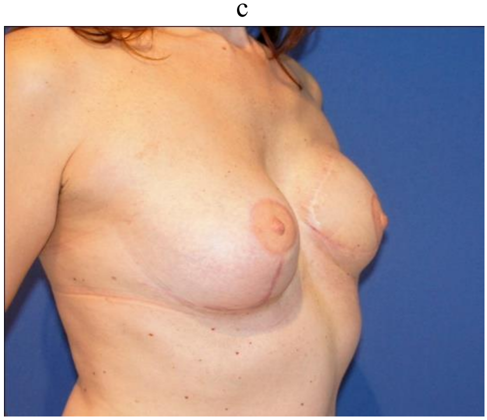
Figure 11. (Continued)



b



c



d

Figure 11. Areola tattooing 8 months after breast reconstruction, symmetrization mastopexy and nipple reconstruction

CONCLUSION

Reconstruction of the nipple-areolar complex is the last step in breast reconstruction. It is associated with a sense of completeness and of success of the whole process. In order to achieve the best results, it must have regard to achieving symmetry with the contralateral NAC complex, placing them in the correct spot, respecting the correct size and color, in a “like to like” manner, preserving the results in time with the least nipple projection or volume loss.

Classically it is formed in two steps, the first being the nipple reconstruction, and the second being the areola reconstruction, performed either by tattooing or by using a skin graft, keeping in mind that the most common complication to counteract is the loss of projection and/or of volume.

Although, in chronological order, reconstruction of the nipple-areolar complex is the last after several other steps, it may be the most important one, being correlated with overall patient satisfaction.

REFERENCES

[1] Nimboriboonporn, A; Chuthapisith, S. Nipple-areola complex reconstruction. *Gland Surgery* 2014;3(1):35-42.

[2] Few, JW; Marcus, JR; Casas, LA; Aitken, ME; Redding, J. Long-term predictable nipple projection following reconstruction. *Plastic and Reconstructive Surgery* 1999;104(5):1321-1324.

[3] Evans, KK; Rasko, Y; Lenert, J; Olding, M. The use of calcium hydroxylapatite for nipple projection after failed nipple-areolar reconstruction: early results. *Annals of Plastic Surgery* 2005;55(1):25-29.

[4] Sisti, A; Grimaldi, L; Tassinari, J; Cuomo, R; Fortezza, L; Bocchiotti, MA; Roviello, F; D'Aniello, C; Nisi, G. Nipple-areola complex reconstruction techniques: A literature review. *European Journal of Surgical Oncology* 2016;42(4):441-465.

[5] Adams, WM. Free transplantation of the nipples and areola. *Surgery* 1944;15:186.

[6] Adams, WM. Labial transplant for correction of loss of the nipple. *Plastic and Reconstructive Surgery* 1946;1949;4:295-298.

[7] Millard, DR Jr. Nipple and areola reconstruction by split-skin graft from the normal side. *Plastic and Reconstructive Surgery* 1972;50(4):350-353.

[8] Brent, B; Bostwick, J. Nipple-areola reconstruction with auricular tissues. *Plastic and Reconstructive Surgery* 1977;60(3):353-361.

[9] Chang, WH. Nipple reconstruction with a T flap. *Plastic and Reconstructive Surgery* 1984;73(1):140-143.

[10] Patel, MK; Nahabedian, YM. Reconstruction of the nipple-areola complex. In: Neligan CP, editor. *Plastic Surgery,* Third edition, Volume 5 - Breast, Elsevier Saunder, 2013.

[11] Mohamed, SA; Parodi, PC. A modified technique for nipple-areola complex reconstruction. *Indian Journal of Plastic Surgery* 2011;44(1):76-80. doi: 10.4103/0970-0358.81450.

[12] Sanuki, J; Fukuma, E; Uchida, Y. Morphologic study of nipple-areola complex in 600 breasts. *Aesthetic Plastic Surgery* 2009;33(3):295-297.

[13] Nahabedian, MY. Nipple reconstruction. *Clinics in Plastic Surgery* 2007;34(1):131-137.

[14] Munhoz, AM; Montag, E; Filassi, JR; Gemperli, R. Immediate nipple-areola-sparing mastectomy reconstruction: An update on oncological and reconstruction techniques, *World Journal of Clinical Oncology* 2014;5(3):478–494. doi: 10.5306/wjco.v5.i3.478.

[15] Bhatty, MA; Berry, RB. Nipple-areola reconstruction by tattooing and nipple sharing. *British Journal of Plastic Surgery* 1997;50(5):331-334.

[16] Kroll, SS. Nipple reconstruction with the double opposing flap. *Plastic and Reconstructive Surgery* 1999;104:511–514.

[17] Little, JW. Nipple-areolar reconstruction. In: Spear SL, editor. *Surgery of the Breast: Principles and Art*. Philadelphia; Lippincott-Raven Publisher; 1998.

[18] Mendelson, BC. Results of nipple areola reconstruction. *Australia and New Zealand Journal of Surgery* 1983;53(1):63–66.

[19] Asplund, O. Nipple and areola reconstruction. A study in 79 mastectomized women. *Scandinavian Journal of Plastic and Reconstructive Surgery* 1983;17(3):233–240.

[20] Lee, TJ; Noh, HJ; Kim, EK; Eom, JS. Reducing donor site morbidity when reconstructing the nipple using a composite nipple graft. *Archives of Plastic Surgery* 2012;39(4):384-389.

[21] Zenn, MR; Garofalo, JA. Unilateral nipple reconstructionwith nipple sharing: time for a second look. *Plastic and Reconstructive Surgery* 2009;123(6):1648–1653.

[22] Riccio, AC; Zeiderman, RM; Chowdhry, S; Wilhelmi, JB. Review of nipple reconstruction techniques and introduction of v to y Technique in a bilateral wise pattern mastectomy or reduction mammaplasty. *Eplasty* 2015;15:e11.

[23] Tyrone, JW; et al. Nipple areola reconstruction. In: Hultman CS editor. *Breast Reconstruction (Breast Disease)* (Vol. 16). IOS Press, 2003.

[24] Little, JW 3rd. Nipple-areolar reconstruction. *Advances in Plastic Surgery* 1987;3(43).

[25] Nipple Areola Reconstruction available on http://www.breastreconstruction.org/SecondaryProcedures/NippleAreolaReconstruction.html. Accessed 31.05.2016.

[26] Shestak, KC; Gabriel, A; Landecker, A; Peters, S; Shestak, A; Kim, J. Assessment of long-term nipple projection: A comparison of three techniques. *Plastic and Reconstructive Surgery* 2002;110(3):780-786.

[27] Zhong, T; Antony, A; Cordeiro, P. Surgical outcomes and nipple projection using the modified skate flap for nipple-areolar reconstruction in a series of 422 implant reconstructions. *Annals of Plastic Surgery* 2009;623:591–595.

[28] Gurunluoglu, R; Shafighi, M; Williams, SA; Kimm, GE. Incorporation of a preexisting scar in the star-flap technique for nipple reconstruction. *Annals of Plastic Surgery* 2012;68(1):17-21.

[29] Alfano, C; Tenna, S; Caggiati, A; Campanella, A. Nipple reconstruction by local flaps: a long-term comparative study between star and skate techniques. *Acta Chirurgiae Plasticae* 2004;46(4):127-131.

[30] Fitoussi, A; Berry, MG; Couturaud, B; Salmon, RJ. *Oncoplastic and Reconstructive Surgery for Breast Cancer: The Institut Curie Experience*. 2009.

[31] Fitoussi, A-D; Pollet, A-G; Couturaud, B; Laki, F; Salmon, R-J. Nipple and areola reconstruction by tattooing, "F" and "Z" flaps. *Annales de chirurgie plastique et esthétique* 2008;53(4):348-357.

[32] Lee, J; Lee, S; Bae, Y. Trans-nipple double Z-plasty for benign periareolar disease with inverted nipple. *Aesthetic Plastic Surgery* 2013;37:327-331.

[33] Lee, J; Bae, Y. Correction of inverted nipple using trans-nipple Z-plasty. *Journal of Breast Disease* 2015;3(1):21-25.

[34] Valdatta, L; Montemurro, P; Tamborini, F; Fidanza, C; Gottardi, A; Scamoni, S. Our experience of nipple reconstruction using the C-V flap technique: 1 year evaluation. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2009;62(10):1293–1298.

[35] Losken, A; Mackay, GJ; Bostwick, J 3rd. Nipple reconstruction using the C-V flap technique: a long-term evaluation. *Plastic and Reconstructive Surgery* 2001;108(2):361–369.
[36] Van Laeken, N; Genoway, K. Nipple reconstruction using a two-step purse-string suture technique. *Canadian Journal of Plastic Surgery* 2011;19(2):56-59.
[37] Eng, JS. Bell flap nipple reconstruction – a new wrinkle. *Annals of Plastic Surgery* 1996;36(5):485–488.
[38] Gamboa-Bobadilla, GM. Nipple reconstruction: the top hat technique. *Annals of Plastic Surgery* 2005;54(3):243–246.
[39] Shestak, KC; Nguyen, TD. The double opposing periareola flap: a novel concept for nipple-areola reconstruction. *Plastic and Reconstructive Surgery* 2007;119(2):473–480.
[40] Hammond, DC; Khuthaila, D; Kim, J. The skate flap purse-string technique for nipple-areola complex reconstruction. *Plastic and Reconstructive Surgery* 2007;120(2):399–406.
[41] Kroll, SS; Reece, GP; Miller, MJ; Evans, GR; Robb, GL; Baldwin, BJ; Wang, BG; Schusterman, MA. Comparison of nipple projection with the modified double-opposing tab and star flaps. *Plastic and Reconstructive Surgery* 1997;99(6):1602-1605.
[42] Winocour, S; Saksena, A; Oh, C; Wu, PS; Laungani, A; Baltzer, H; Saint-Cyr, M. A systematic review of comparison of autologous, allogeneic, and synthetic augmentation grafts in nipple reconstruction. *Plastic and Reconstructive Surgery* 2016;137(1):14e-23e.
[43] Bernard, RW; Beran, SJ. Autologous fat graft in nipple reconstruction. *Plastic and Reconstructive Surgery* 2003;112(4):964-968.
[44] Guerra, AB; Khoobehi, K; Metzinger, SE; Allen, RJ. New technique for nipple areola reconstruction: arrow flap and rib cartilage graft for long-lasting nipple projection. *Annals of Plastic Surgery* 2003;50(1):31–37.
[45] Panettiere, P; Marchetti, L; Accorsi, D. Filler injection enhances the projection of the reconstructed nipple: an original easy technique. *Aesthetic Plastic Surgery* 2005;29:287-294.
[46] Lennox, K; Beer, KR. Nipple contouring with hyaluronics postmastectomy. *Journal of Drugs in Dermatology* 2007;6:1030-1033.
[47] Nahabedian, MY. Secondary nipple reconstruction using local flaps and AlloDerm. *Plastic and Reconstructive Surgery* 2005;115(7):2056-2061.
[48] Garramone, CE; Lam, B. Use of AlloDerm in primary nipple reconstruction to improve long-term nipple projection. *Plastic and Reconstructive Surgery* 2007;119:1663-1668.

[49] Vandeweyerm E. Simultaneous nipple and areola reconstruction: a review of 50 cases. *Acta Chirurgica Belgica* 2003;103(6):593–595.
[50] Kargül, G; Deutinger, M. Reconstruction of the breast areola complex. Comparison of different techniques. *Handchirurgie, Mikrochirurgie, Plastische Chirurgie* 2001;33(2):133-137.
[51] Chang, BW; Slezak, S; Goldberg, NH. Technical modifications for on-site nipple-areola reconstruction. *Annals of Plastic Surgery* 1992;28(3):277–280.
[52] Pauchot, J; Fleury, M; Pluvy, I; Oulharj, S; Tropet, Y; Obert, L. Stencil technique for areola tattooing. A simple solution for quickly performed, homogeneous tattoos with regular edges. *JPRAS Open* 2015;3:10-12. doi:10.1016/j.jpra.2014.12.003.
[53] Rees, TD. Reconstruction of the breast areola by intradermal tattooing and transfer. Case report. *Plastic and Reconstructive Surgery* 1975;55(5):620–621.
[54] Spear, SL; Convit, R; Little, JW 3rd. Intradermal tattoo as an adjunct to nipple-areola reconstruction. *Plastic and Reconstructive Surgery* 1989;83(5):907–911.
[55] Garg, G; Thamim GP. Micropigmentation: tattooing for medical purposes. *Dermatologic Surgery* 2005;31(8 Pt 1):928–931.

In: Breast Reconstruction
Editor: Janice Rivera

ISBN: 978-1-53610-245-1

Chapter 2

EFFECT OF RADIOTHERAPY ON IMPLANT-BASED IMMEDIATE BREAST RECONSTRUCTION WITH OR WITHOUT ACELLULAR COLLAGEN MATRIX: POTENTIAL STRATEGIES TO IMPROVE OUTCOME

Baek Kim*[*] *and Rajgopal Achuthan
Department of Breast Surgery,
St. James's University Hospital, Leeds, UK

ABSTRACT

Implant-based immediate breast reconstruction has evolved rapidly over the past decade. The emergence of human, porcine, and bovine acellular collagen matrices (ACM) has had significant impact resulting in a marked rise in implant-based immediate reconstructions. The matrices are used to provide improved lower pole coverage of the reconstructed breast enabling a one-stage reconstruction with a fixed volume implant or an expander in cases where a larger volume reconstruction is required. This is in contrast to the technique of complete submuscular tissue expander reconstruction, which was associated with limited implant or

[*] Corresponding author Email: kimbaek@doctors.net.uk.

expander volume as well as restricted lower pole projection. Understandably, implant-based immediate breast reconstruction with ACM is therefore increasingly utilised in oncological and risk reducing settings.

Post-mastectomy radiotherapy remains a key adjuvant treatment modality as it improves locoregional control as well as overall survival in breast cancer patients. However, its use in patients who have undergone implant-based reconstruction can be detrimental with potential for complications such as infection, mastectomy flap necrosis, capsular contracture, and explantation necessitating revisional surgery. Therefore, managing this group of patients requires careful multidisciplinary approach and planning. The main purpose of this review article is to examine the effect of post-mastectomy radiotherapy on the outcome of implant-based immediate breast reconstruction with or without acellular collagen matrix. We will additionally examine the literature to determine if there is any potential protective benefit of ACM usage in patients who receive post-mastectomy radiotherapy. The review will also attempt to identify potential strategies that can be utilised to improve outcome in these patients. The strategies will focus on patient and surgical risk factors, alternative reconstructive options including autologous reconstruction, as well as adjunctive surgical techniques to improve patient outcome.

Keywords: breast reconstruction, radiotherapy, mastectomy, implant, acellular dermal matrix, acellular collagen matrix

INTRODUCTION

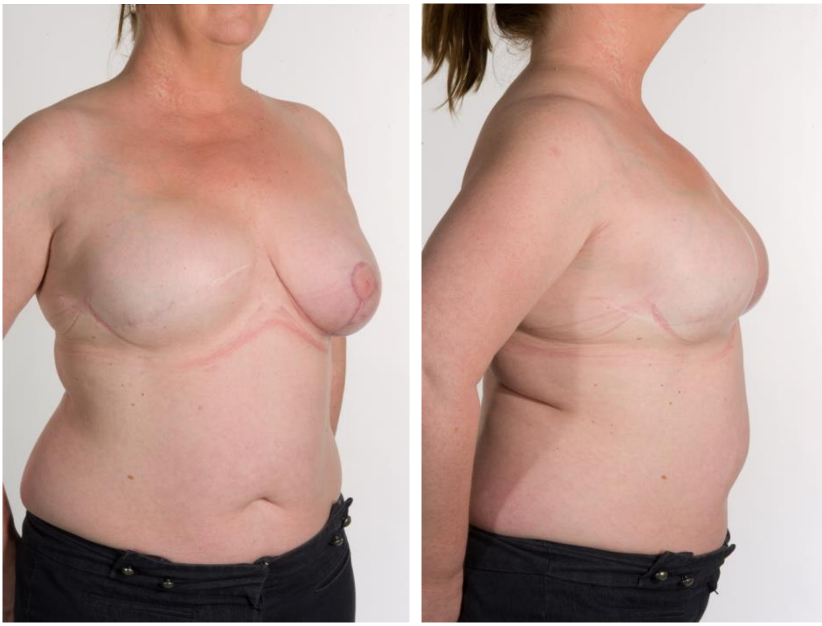
Immediate breast reconstruction [IBR) has been shown to be oncologically safe [1, 2], cost-effective [3], and importantly reduce psychological morbidity [4]. Expander/implant-based breast reconstruction accounts for 65% of all breast reconstruction in the United States [5]. Acellular collagen matrix (ACM), otherwise commonly known as acellular dermal matrix, is being used increasingly [6] in expander/implant-based IBR. ACM provides improved lower pole coverage of the reconstructed breast enabling a one-stage reconstruction with a fixed volume implant or an expander in cases where a larger volume reconstruction is required. ACM improves the aesthetic outcome of expander/implant-based IBR. This is in contrast to the traditional complete submuscular tissue expander reconstruction with disadvantages of limited implant/expander volume, the need for multiple visits for expansion, as well as limited lower pole projection.

Post-mastectomy radiotherapy (PMRT) remains a key adjuvant treatment modality where indicated, and has been shown to improve locoregional control as well as overall survival [7]. The oncological benefit of PMRT is recognized but it is associated with potential side effects including tissue fibrosis, reduction in dermal blood flow, and tissue hypoxia. As a result patients, particularly with implant-based reconstructions, can suffer from complications such as infection, mastectomy flap necrosis, capsular contracture, and explantation. Our aim is to examine the effect of PMRT on the outcome of expander/implant-based IBR with or without the use of ACM. We will attempt to identify strategies that can be utilised to improve outcomes in these patients. The strategies will focus on patient and surgical risk factors, alternative reconstructive options, as well as adjunctive surgical modalities to improve patient outcome.

THE EMERGENCE OF ACELLULAR COLLAGEN MATRIX

Traditional two-stage reconstruction involves submuscular expander insertion at the time of skin-sparing mastectomy. Raising the pectoralis major muscle fibers and the fibers of serratus anterior muscle laterally provides lower pole coverage of the expander. Expansion with saline is performed gradually to achieve the desired reconstructed breast volume. A subsequent operation is performed where the expander is exchanged for a permanent implant. However, it is difficult to create a natural ptotic breast, and the initial implant or expander volumes are limited by the anatomical boundaries.

ACM allows better lower pole coverage of the reconstructed breast, and hence a more natural aesthetic reconstruction. It is sutured on to the lower edge of the pectoralis major muscle and to the inframammmary fold. It acts as a mechanical support, and allows more precise positioning of the expander or implant. Greater intraoperative filling volume is possible using ACM [5]. This in turn enables one-stage IBR, which has the potential to be cost-effective [8]. Human ACM, more commonly utilised in the United States, include AlloDerm, Neoform, DermaMatrix, and FlexHD [9]. They are created by treating human cadaveric skin to remove all cellular and immunogenic components. This leaves a basement membrane and cellular matrix that provides a scaffold. In Europe, human tissue products are not used widely due to regulatory restrictions and hence Porcine (e.g., Strattice) and bovine ACM (e.g., Surgimend and Veritas) are utilised instead [10-12] (Figure 1).



A B

Figure 1. Post-operative images of a patient who underwent implant-based immediate breast reconstruction with ACM on the right with contralateral left breast reduction for symmetry.

CRITERIA FOR ADMINISTRATION OF POST-MASTECTOMY RADIOTHERAPY

Post-mastectomy radiotherapy (PMRT) is beneficial in patients particularly those where the risk of loco-regional recurrence is greater than 20% [13]. Tumour size and nodal status are key factors in determining which patients are offered PMRT. Typically in patients with T3 or T4 disease and those with four or more positive axillary lymph nodes PMRT is indicated [13]. Other important factors in decision to offer PMRT include tumour grade, presence of lymphovascular invasion, age less than 40 years, close margins of less than 1mm, and the presence of significant extracapsular nodal spread [13].

The degree of nodal involvement is important in the decision making to offer PMRT. A meta-analysis of Early Breast Cancer Trialists Collaborative

Group (EBCTCG) showed that for patients with four or more positive axillary nodes, PMRT reduced overall recurrence (RR 0.79) and breast cancer mortality (RR 0.87). For patients with negative axillary nodes, PMRT did not confer benefit with regards to recurrence and survival rates. In the patients with one to three positive axillary nodes, PMRT resulted in recurrence and survival benefits even in the presence of other systemic therapies [14]. However, the question remains as to whether all patients with one to three positive axillary lymph nodes would benefit from PMRT given their relatively lower risk of recurrence. Yao et al. examined the United States National Cancer Data Base, and stated that PMRT is being increasingly utilised in patients with one to three positive axillary lymph nodes; the proportion of patients receiving PMRT in this subgroup increased from 23.9% in 2003 to 36.4% in 2011 [15]. The SUPREMO [Selective Use of Postoperative Radiotherapy After Mastectomy) trial investigates outcome in such patients who have less than four positive axillary lymph nodes and the results of the trial is awaited [16]. A population-based study by the Swedish Western and Southeastern group found that omission of PMRT in patients with one to three positive axillary nodes did not influence survival [17].

Tumour size is another predictor of risk with PMRT improving outcomes in patients with large tumours. Historically, patients with T3 and T4 tumours have been offered PMRT [18]. However, Taghian et al. report that patients with T3N0 tumours treated by mastectomy should not routinely receive PMRT due to the low rate of loco-regional failure [19].

A subset of patients with T1 and T2 tumours with one to three positive nodes may be offered radiotherapy. A recent meta-analysis by Li et al. supports the use of PMRT in this group of patients due to achievement of significant reduction in loco-regional recurrence [20]. A retrospective study from the British Columbia Cancer Agency showed that the risk of loco-regional recurrence at 10 years was 12.7% for T1 or T2 tumours with one to three positive axillary lymph nodes. This study showed that age <45 years, >25% positive lymph nodes, medial tumours, and negative oestrogen receptor status independently increased the risk of loco-regional recurrence [21]. This is corroborated by a study by Jwa et al. who concluded that PMRT may be beneficial for patients with non-luminal breast cancer with one to three positive axillary lymph nodes [22]. A further study by Truong et al. concluded that nodal ratio (positive/excised nodes) of greater than 0.2 was associated with locoregional recurrence rate of >20%, and hence these patients may benefit from PMRT [23]. Study by Trovo et al. also identified pre-menopausal status, oestrogen receptor negative cancer, grade 3 tumours, and the presence of lymphovascular invasions as potential risk factors for loco-regional failure after mastectomy and should therefore prompt consideration for PMRT [24].

Therefore, selection of patients for PMRT requires a careful multidisciplinary approach to optimise oncological outcome in patients, and the above potential predictive factors should be taken into account when deciding which patients should be offered PMRT.

THE EFFECT OF POST-MASTECTOMY RADIOTHERAPY ON IMPLANT-BASED IMMEDIATE BREAST RECONSTRUCTION WITHOUT ACM

A Dutch study [25] reported in 2000 showed that complication rates following IBR with submuscular expanders was 27% in the PMRT group compared to 13% in those without PMRT (median follow-up 30 months). Christante et al. [26] report an explantation rate of 31% in patients who underwent PMRT after immediate expander reconstructions, in contrast to 6% in those who did not receive PMRT.

Another study by Reefy et al. [27] showed that capsular contracture rate was 85% in patients who required PMRT or had previous radiotherapy as opposed to 13% who did not receive radiotherapy. A study [28] from Memorial Sloan-Kettering Cancer center showed that at median follow-up of 86 months, the rate of permanent implant removal or replacement was 29% at 7 years post-radiotherapy. Cordeiro et al. performed a comparison analysis of non-irradiated implanted based reconstruction versus implant-based reconstruction followed by PMRT. With mean follow up time of 56.8 months, implant loss rate was 0.5% in the former as opposed to 9.1% in the latter. Grade III to IV capsular contracture rate was 11.1% and 27.6% respectively. Aesthetic results, as assessed by surgeons, were inferior in patients who received PMRT [29]. A meta-analysis by Barry et al. [30] showed that radiotherapy exposure after implant-based IBR was associated with a 4.2 fold increase (95% CI, 2.4-7.2) in post-operative complications compared to no radiotherapy.

THE EFFECT OF POST-MASTECTOMY RADIOTHERAPY ON IMPLANT-BASED IMMEDIATE BREAST RECONSTRUCTION WITH ACM

In a study by Colwell et al. [31] where ACM was used, complication rates increased to 25.2% in patients who underwent radiotherapy compared to 13.9% without radiotherapy (p = 0.005). Similarly, Clemens et al. [32] from M.D. Anderson reported a complication rate of 43.3% in patients who received radiotherapy compared to 15.6% in those without radiotherapy, where both groups underwent reconstruction using ACM. In particular, mastectomy flap necrosis was seen in 26.7% in the radiotherapy group versus 7.5% in the non-radiotherapy group. Rawlani et al. [9] reported outcomes in ACM-based reconstruction patients receiving radiotherapy (n = 26) versus the no radiotherapy (n = 95). Complication rate was 30.8% in the former group versus 13.7% in the latter group; mastectomy flap necrosis and implant exposure were both high at 15.4% in the radiotherapy group versus 4.2% in the non-radiotherapy group. In a study by Salzberg et al. [33] evaluating the use of one-stage implant-based IBR with ACM, radiotherapy was received by 4.5% of patients where the complication rate was 14.3% versus 3.9% in the non-radiotherapy group. These studies show that radiotherapy seems to be detrimental in patients who undergo implant-based reconstruction using ACM (Figure 2).

Figure 2. Complication following implant-based immediate breast reconstruction with acellular collagen matrix.

Comparison of Outcome in Implant-based Immediate Breast Reconstruction with or without ACM (In Groups not Requiring Adjuvant PMRT)

A Meta-Analysis from Kim et al. [5] reviewed 48 relevant studies comparing complication rates in patients with with human ACM versus submuscular implant/expander reconstruction. AlloDerm was used in the majority of studies. Total complication rate of 15.4% was noted in the ACM group (n = 2037) as opposed to 14% in the submuscular group (n = 12,847). There was a small increase in infection (5.3% vs. 4.7%), flap necrosis (6.9% vs. 4.9%), and seroma rates (4.8% vs. 3.5%) in the ACM group compared to the submuscular group. However, the rates of reconstructive failure were similar at 3.8% in both the ADM and in the submuscular group. ACM is tested to confirm the absence of microbial contamination, but is not sterile [34]. This may account for the higher infection rate in the ACM group. The higher flap necrosis rate may be explained by greater intraoperative filling volume in the ACM group (mean = 264.9ml) versus the submuscular group (mean = 187.1ml). The minor increase in the overall complication rates may be explained by the learning curve of a new surgical technique. This suggestion is corroborated by study from Colwell et al. [31]; complication rate was 21.4% in the surgeons' first year of performing the procedure, but 10.9% in the subsequent years. Studies with longer follow-ups are required, as the mean follow-up time was 13.8 months in the ACM group, compared to 28.3 months in the submuscular group.

Impact of Radiotherapy on Implant-based Immediate Breast Reconstruction with or without ACM

There are comparatively few studies which directly compare the effect of radiotherapy on implant-based IBR with or without ACM. A study by Seth et al. [35] compares the effect of PMRT in the ACM group versus the non-ACM group. They found no significant increase in complication rate with PMRT in the ACM group (n = 74), but significant increase in complication rate was observed in the non-ACM group (n = 49). However, in a study by Parks et al.

[36], which compared ACM (n = 27) versus non-ACM (n = 37) reconstruction, radiation significantly increased the rate of expander loss only in the ACM group. It is worth noting that the evidence for the effect of radiotherapy on ACM versus non-ACM implant reconstructions is based on Level III studies. Additionally, the number of patients included for analysis is small. No definitive conclusion can be drawn at present regarding whether ACM has any protective effects against the detrimental effect against radiation. Further level I direct comparison studies with longer-term follow-up are required.

STRATEGIES TO REDUCE COMPLICATION RATES IN PATIENTS WHO REQUIRE POST-MASTECTOMY RADIOTHERAPY

Predicting which patients require PMRT may enable better pre-operative planning and reduce complication rates. Christante et al. [26] reported that T2 tumours, positive axillary lymph node status, and the number of positive sentinel lymph nodes were independent predictors of PMRT. Therefore, performing upfront sentinel node biopsy prior to reconstruction may provide useful information to assess the likelihood of PMRT. Mannu et al. compared complication rates prior to and after introduction of upfront sentinel node biopsy for patients undergoing mastectomy and IBR. They reported significant reduction in complication rates after introduction of upfront sentinel node biopsy. This was attributed to the fact that prior to the usage of upfront sentinel node biopsy, the proportion of patients receiving unexpected radiotherapy after implant-based reconstructions was higher [37]. Upfront sentinel node biopsy helped identify these patients allowing better planning and avoiding implant-based approaches.

Delayed reconstruction can be an alternate approach in patients who are at high likelihood of receiving PMRT, and indeed Michigan Breast Reconstruction Outcome study showed that immediate reconstruction confers two-fold increased odds for complications compared to delayed reconstruction [38]. This finding is supported by Sullivan et al. who reported higher complication rate and capsular contractures in immediate tissue expander reconstruction compared to delayed expander reconstruction [39]. A survey of breast surgeons in the United Kingdom and United states showed that when PMRT was planned, the surgeon’s preference was for delayed or delayed-immediate breast reconstruction [40, 41]. However, this is counter-balanced against the desire of the patient who may wish to pursue an immediate type of reconstruction. Delayed reconstruction more frequently results in the need for recruitment of autologous tissue with associated donor site morbidities. Furthermore, delayed reconstruction using expander/implant solely is likely to result in inferior aesthetic outcome due to loss of the skin envelope following a mastectomy. Importantly this latter technique is not advised in patients who have received PMRT.

Another approach when PMRT is expected is to consider the delayed-immediate breast reconstruction [42]. In this approach skin-sparing mastectomy is performed with a submuscular expander/implant with an ACM, enabling skin-preservation. The use of an ACM in this setting allows for achievement of the desired volume circumventing the need for multiple expansions, which can potentially delay PMRT. Rozen et al. recommends full expansion of the expander prior to radiotherapy with an aim of maximising the amount of regional tissue available for future reconstructive procedure [43]. Once radiotherapy is complete, the definitive delayed reconstruction can be performed.

Nava et al. compared outcome in three groups [44]; patients receiving PMRT on permanent implant versus tissue expander, and patients who did not require radiotherapy. Reconstructive failure rate was 40% in the tissue expander group, compared to 6.4% in the permanent implant group, and 2.3% in the control group. However, the underlying pathophysiology as to why permanent implants tolerate radiotherapy better than expanders in this study remains unclear.

There is evidence to support the use of polyurethane implants in patients who are likely to need or have already received PMRT [45]. Ideally following radiotherapy, in the setting of an implant/expander reconstruction, one considers revisional surgery for complications such as capsular contracture by transfer of autologous tissue from another site. In patients where this is not feasible or who have strong desire to avoid donor site morbidity, the use of polyurethane implants can be considered. The timing of exchange or revision of expander to permanent implant after PMRT can impact outcome. A study by Peled et al. [46] showed that delaying the expander-implant exchange to greater than 6 months after radiotherapy resulted in a significant reduction in post-operative complication rates compared to less than 6 months (7.7% versus 22.4%; $p = 0.036$).

An alternative approach may be to pursue autologous IBR, but some patients may not have sufficient tissue for fully autologous reconstruction, and evidences suggest that radiotherapy has detrimental effects [30] on autologous reconstructions such as fat necrosis, which may be a complication of less significance as compared to loss of an implant reconstruction. An online risk calculator tool such as the Breast Reconstruction Risk Assessment Score (http://www.BRAscore.org) may aid in perception of risks for different types of breast reconstruction for the patients and clinicians involved. This assessment tool takes account of radiotherapy status [47]. Other surgical approaches have been reported as alternatives to ACM. One such technique is the autologous dermal sling-based IBR [48]. The inferior dermal sling consists of a de-epithelised skin flap created from the lower pole of the breast when using a Wise pattern approach. This provides lower pole support in a similar fashion to ACM. This approach is suitable only in patients with an appropriate degree of ptosis where skin-reducing mastectomies are considered. Another technique is the use of dermal autografts. Lynch et al. [49] performed wide excision of the pre-existing abdominal scars to provide the lower pole coverage instead of ACM. The techniques of inferior dermal sling and dermal autografts are cost effective, but further research is required to determine outcomes in the setting of radiotherapy.

Further considerations include the site of skin sparing mastectomy incision with the inframammary incision reported to have a higher rate of wound breakdown and implant loss following radiotherapy. The authors attribute this to the inframammary position having a higher rate of moist desquamation due to its dependent position. Furthermore, tissue coverage at the inframammary position is less compared to peri-areolar based incision [50].

Ribuffo et al. describe protective effects of lipofilling after expander based IBR and PMRT. This is followed by exchange of the expander to an implant after at least 3 months from the completion of fat grafting. They have reported encouraging early results with reduced explantation rates in patients who were treated in this manner [51]. Serra-Renom et al. similarly utilise fat grafting after PMRT in patients who received expander implant breast reconstruction. They reported low capsular contracture rates at follow up time of 12 months [52]. Furthermore, Panettiere et al. reported lipofilling in 61 consecutive patients who underwent implant-based breast reconstruction followed by PMRT. Improvements in aesthetic outcome, explantation rates, and capsular contracture rates were reported in those treated with lipofilling [53].

It is important to examine general surgical and patient risk factors specific to implant-based IBR. A meticulous surgical approach and addressing modifiable potential risk factors is likely to minimise risk of complications in this potentially high risk patient group who may additionally require PMRT. A published guideline from the Association of Breast Surgery and the British Association of Plastic, Reconstructive, and Aesthetic Surgeons advise a cautious approach in patients undergoing an implant-based ADM IBR with body mass index >30, simultaneous axillary lymph node dissection, PMRT, smoking, and mastectomy weight >600 gram [54]. Surgical site infection in patients with implant-based IBR may lead to subsequent implant loss. Barr et al. have produced a peri-operative ‘theatre implant checklist’ for surgical site infection prevention in implant-based breast surgery. This checklist is based on current review of literature and considers important aspects such as peri-operative antibiotics usage, alcohol-based skin preparation, laminar air flow, minimal theatre traffic, irrigation of implant pocket, double gloving, and conductive warming [55].

Another strategy may be to consider neoadjuvant chemotherapy (NACT). In general, patients who are likely require PMRT have larger tumours with axillary nodal metastases. These patients would also be obligate candidates for chemotherapy. Historically, these patients would have undergone mastectomy, adjuvant chemotherapy, followed by PMRT. Instead, these patients could potentially undergo NACT, followed by mastectomy depending upon tumour response to NACT. Analysis of the NSABP B-18 and B-27 NACT trials showed low rate of loco-regional failure in patients who achieve complete pathological response (cPR). Potentially those patients achieving cPR post-NACT who then requiring a mastectomy could potentially be spared PMRT. The NSABP B-51 trial is currently recruiting patients with an aim of answering this question [56].

DISCUSSION

This review highlights the detrimental effect of radiotherapy on implant-based IBR with or without ACM. Currently there is lack of evidence to show that ACM has any protective effect against radiotherapy. However, the use of ACM is advocated in general, especially when the likelihood of PMRT is low. It is worth noting that most studies were centre or surgeon-specific. Few multicentre studies have been published; a Danish study examined outcome from 9 different centres [57], and the Michigan Breast Reconstruction

Outcome Study project involved 23 surgeons from 12 institutions [38]. In the future, more multicentre studies with longer-term follow-ups are required. Currently in the United Kingdom, the National Implant Breast Reconstruction Audit (iBRA) is collecting data on all type of implant reconstruction performed with over 1700 patients recruited (http://www.ibrastudy.com).

The aesthetic outcome in implant-based IBR deteriorates with time, particularly without ACM use [58]. Studies show that IBR with ACM results in superior aesthetic outcome and reduced rates of capsular contracture, compared to IBR without ACM [59].

Potential strategies to improve patient outcome in implant based breast reconstruction
Consider risk factors to help select appropriate patients • As outlined in the ABS and BAPRAS guideline for ADM assisted breast reconstruction • The Breast Reconstruction Risk Assessment score (http://www.BRAscore.org)
Anticipate need for PMRT based on pre-operative tumour characteristics (utilise upfront sentinel lymph node biopsy)
If PMRT anticipated, consider -ACM implant/expander reconstruction; also consider polyurethane implant -Autologous immediate reconstruction -Delayed-immediate reconstruction with skin envelope preservation -Delayed reconstruction -Neoadjuvant chemotherapy
Minimise potential risks during surgery -'Theatre implant checklist' -Scar placement for skin sparing mastectomy
Consider adjunctive procedure post-radiotherapy -Lipofilling procedure -If revisional surgery is required, ideally tissue transfer is indicated -In patients who decline tissue transfer, consider revisional surgery with polyurethane implant

Figure 3. Potential strategies to improve patient outcome in immediate implant-based reconstruction in setting of post-mastectomy radiotherapy

With development of surgical technology, ACM has resulted in improvement of implant-based IBR aesthetically and in terms of enabling direct to implant one-stage IBR with its associated advantages. However, similar problems are faced with regards to PMRT and its associated detrimental effects. This chapter has highlighted potential strategies currently described in the literature in order to improve patient outcome (Figure 3).

References

[1] Eriksen C, Frisell J, Wickman M, Lidbrink E, Krawiec K, Sandelin K. Immediate reconstruction with implants in women with invasive breast cancer does not affect oncological safety in a matched cohort study. *Breast Cancer Res Treat.* 2011 Jun;127(2):439-46. PubMed PMID: 21409394. Epub 2011/03/17. eng.

[2] Romics L, Jr., Stallard S, Weiler-Mithoff E. Borkimelo (skin-sparing) mastectomia es azonnali emlorekonstrukcio onkologiai biztonsagossaga a recidivaarany, recidivalokalizacio es a rekonstrukcios technika fuggvenyeben. hun. *Orv Hetil*. 2013 Feb 3;154(5):163-71. PubMed PMID: 23395741. Epub 2013/02/12. [Oncologic safety of skin-sparing mastectomy followed by immediate breast reconstruction: rate and localization of recurrences, and impact of reconstruction techniques].

[3] Palit TK, Miltenburg DM, Brunicardi FC. Cost analysis of breast conservation surgery compared with modified radical mastectomy with and without reconstruction. *Am J Surg*. 2000 Jun;179(6):441-5. PubMed PMID: 11004327. Epub 2000/09/27. eng.

[4] Al-Ghazal SK, Fallowfield L, Blamey RW. Comparison of psychological aspects and patient satisfaction following breast conserving surgery, simple mastectomy and breast reconstruction. *European journal of cancer*. 2000 Oct;36(15):1938-43. PubMed PMID: 11000574. Epub 2000/09/23. eng.

[5] Kim JY, Davila AA, Persing S, Connor CM, Jovanovic B, Khan SA, et al. A meta-analysis of human acellular dermis and submuscular tissue expander breast reconstruction. *Plastic and reconstructive surgery*. 2012 Jan;129(1):28-41. PubMed PMID: 22186498. Epub 2011/12/22. eng.

[6] Pannucci CJ, Antony AK, Wilkins EG. The impact of acellular dermal matrix on tissue expander/implant loss in breast reconstruction: an analysis of the TOPS database. *Plast Reconstr Surg*. 2013 Mar 15. PubMed PMID: 23508050. Epub 2013/03/20. Eng.

[7] Dragun AE, Huang B, Gupta S, Crew JB, Tucker TC. One decade later: trends and disparities in the application of post-mastectomy

radiotherapy since the release of the American Society of Clinical Oncology clinical practice guidelines. *Int J Radiat Oncol Biol Phys.* 2012 Aug 1;83(5):e591-6. PubMed PMID: 22768990. Epub 2012/07/10. eng.

[8] Johnson RK, Wright CK, Gandhi A, Charny MC, Barr L. Cost minimisation analysis of using acellular dermal matrix (Strattice) for breast reconstruction compared with standard techniques. European journal of surgical oncology: *the journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology.* 2013 Mar;39(3):242-7. PubMed PMID: 23266307. Epub 2012/12/26. eng.

[9] Rawlani V, Buck DW, 2nd, Johnson SA, Heyer KS, Kim JY. Tissue expander breast reconstruction using prehydrated human acellular dermis. *Ann Plast Surg.* 2011 Jun;66(6):593-7. PubMed PMID: 21233698. Epub 2011/01/15. eng.

[10] Apte A, Walsh M, Chandrasekharan S, Chakravorty A. Single-stage immediate breast reconstruction with acellular dermal matrix: Experience gained and lessons learnt from patient reported outcome measures. European journal of surgical oncology: *The journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology.* 2016 Jan;42(1):39-44. PubMed PMID: 26651226.

[11] Ohkuma R, Buretta KJ, Mohan R, Rosson GD, Rad AN. Initial experience with the use of foetal/neonatal bovine acellular dermal collagen matrix (SurgiMend) for tissue-expander breast reconstruction. Journal of plastic, reconstructive and aesthetic surgery: *JPRAS.* 2013 Sep;66(9):1195-201. PubMed PMID: 23768943.

[12] Mofid MM, Meininger MS, Lacey MS. Veritas(R) bovine pericardium for immediate breast reconstruction: a xenograft alternative to acellular dermal matrix products. *European journal of plastic surgery.* 2012 Oct;35(10):717-22. PubMed PMID: 23002328. Pubmed Central PMCID: 3443340.

[13] Vilarino-Varela M, Chin YS, Makris A. Current indications for post-mastectomy radiation. *International seminars in surgical oncology: ISSO.* 2009;6:5. PubMed PMID: 19203387. Pubmed Central PMCID: 2647547.

[14] Ebctcg, McGale P, Taylor C, Correa C, Cutter D, Duane F, et al. Effect of radiotherapy after mastectomy and axillary surgery on 10-year recurrence and 20-year breast cancer mortality: meta-analysis of

individual patient data for 8135 women in 22 randomised trials. *Lancet.* 2014 Jun 21;383(9935):2127-35. PubMed PMID: 24656685.

[15] Yao K, Liederbach E, Lutfi W, Wang CH, Hou N, Karrison T, et al. Increased utilization of postmastectomy radiotherapy in the United States from 2003 to 2011 in patients with one to three tumor positive nodes. *Journal of surgical oncology.* 2015 Dec;112(8):809-14. PubMed PMID: 26486998.

[16] Kunkler IH, Canney P, van Tienhoven G, Russell NS, Group MESTM. Elucidating the role of chest wall irradiation in 'intermediate-risk' breast cancer: the MRC/EORTC SUPREMO trial. *Clinical oncology.* 2008 Feb;20(1):31-4. PubMed PMID: 18345543.

[17] Nordenskjold AE, Fohlin H, Albertsson P, Arnesson LG, Chamalidou C, Einbeigi Z, et al. No clear effect of postoperative radiotherapy on survival of breast cancer patients with one to three positive nodes: a population-based study. Annals of oncology: official journal of the European Society for Medical Oncology/*ESMO.* 2015 Jun;26(6):1149-54. PubMed PMID: 25839671.

[18] Recht A, Edge SB, Solin LJ, Robinson DS, Estabrook A, Fine RE, et al. Postmastectomy radiotherapy: clinical practice guidelines of the American Society of Clinical Oncology. *Journal of clinical oncology: Official journal of the American Society of Clinical Oncology.* 2001 Mar 1;19(5):1539-69. PubMed PMID: 11230499.

[19] Taghian AG, Jeong JH, Mamounas EP, Parda DS, Deutsch M, Costantino JP, et al. Low locoregional recurrence rate among node-negative breast cancer patients with tumors 5 cm or larger treated by mastectomy, with or without adjuvant systemic therapy and without radiotherapy: results from five national surgical adjuvant breast and bowel project randomized clinical trials. Journal of clinical oncology: *Official journal of the American Society of Clinical Oncology.* 2006 Aug 20;24(24):3927-32. PubMed PMID: 16921044.

[20] Li Y, Moran MS, Huo Q, Yang Q, Haffty BG. Post-mastectomy radiotherapy for breast cancer patients with t1-t2 and 1-3 positive lymph nodes: a meta-analysis. *PLoS One.* 2013;8(12):e81765. PubMed PMID: 24312582. Pubmed Central PMCID: 3849378.

[21] Truong PT, Olivotto IA, Kader HA, Panades M, Speers CH, Berthelet E. Selecting breast cancer patients with T1-T2 tumors and one to three positive axillary nodes at high postmastectomy locoregional recurrence risk for adjuvant radiotherapy. *Int J Radiat Oncol Biol Phys*. 2005 Apr 1;61(5):1337-47. PubMed PMID: 15817335.

[22]Jwa E, Shin KH, Lim HW, Jung SY, Lee S, Kang HS, et al. Identification of Risk Factors for Locoregional Recurrence in Breast Cancer Patients with Nodal Stage N0 and N1: Who Could Benefit from Post-Mastectomy Radiotherapy? *PLoS One*. 2015;10(12):e0145463. PubMed PMID: 26691445. Pubmed Central PMCID: 4686923.

[23]Truong PT, Woodward WA, Thames HD, Ragaz J, Olivotto IA, Buchholz TA. The ratio of positive to excised nodes identifies high-risk subsets and reduces inter-institutional differences in locoregional recurrence risk estimates in breast cancer patients with 1-3 positive nodes: an analysis of prospective data from British Columbia and the M. D. Anderson Cancer Center. *Int J Radiat Oncol Biol Phys*. 2007 May 1;68(1):59-65. PubMed PMID: 17321065.

[24]Trovo M, Durofil E, Polesel J, Roncadin M, Perin T, Mileto M, et al. Locoregional failure in early-stage breast cancer patients treated with radical mastectomy and adjuvant systemic therapy: which patients benefit from postmastectomy irradiation? *Int J Radiat Oncol Biol Phys*. 2012 Jun 1;83(2):e153-7. PubMed PMID: 22386375.

[25]Contant CM, van Geel AN, van der Holt B, Griep C, Tjong Joe Wai R, Wiggers T. Morbidity of immediate breast reconstruction (IBR) after mastectomy by a subpectorally placed silicone prosthesis: the adverse effect of radiotherapy. European journal of surgical oncology: *The journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology*. 2000 Jun;26(4):344-50. PubMed PMID: 10873353. Epub 2000/06/30. eng.

[26]Christante D, Pommier SJ, Diggs BS, Samuelson BT, Truong A, Marquez C, et al. Using complications associated with postmastectomy radiation and immediate breast reconstruction to improve surgical decision making. *Arch Surg*. 2010 Sep;145(9):873-8. PubMed PMID: 20855758. Epub 2010/09/22. eng.

[27]Reefy S, Patani N, Anderson A, Burgoyne G, Osman H, Mokbel K. Oncological outcome and patient satisfaction with skin-sparing mastectomy and immediate breast reconstruction: a prospective observational study. *BMC cancer*. 2010;10:171. PubMed PMID: 20429922. Pubmed Central PMCID: 2873394. Epub 2010/05/01. eng.

[28]Ho A, Cordeiro P, Disa J, Mehrara B, Wright J, Van Zee KJ, et al. Long-term outcomes in breast cancer patients undergoing immediate 2-stage expander/implant reconstruction and postmastectomy

radiation. *Cancer*. 2012 May 1;118(9):2552-9. PubMed PMID: 21918963. Epub 2011/09/16. eng.

[29] Cordeiro PG, Albornoz CR, McCormick B, Hu Q, Van Zee K. The impact of postmastectomy radiotherapy on two-stage implant breast reconstruction: an analysis of long-term surgical outcomes, aesthetic results, and satisfaction over 13 years. *Plastic and reconstructive surgery*. 2014 Oct;134(4):588-95. PubMed PMID: 25357021.

[30] Barry M, Kell MR. Radiotherapy and breast reconstruction: a meta-analysis. *Breast Cancer Res Treat*. 2011 May;127(1):15-22. PubMed PMID: 21336948. Epub 2011/02/22. eng.

[31] Colwell AS, Damjanovic B, Zahedi B, Medford-Davis L, Hertl C, Austen WG, Jr. Retrospective review of 331 consecutive immediate single-stage implant reconstructions with acellular dermal matrix: indications, complications, trends, and costs. *Plastic and reconstructive surgery*. 2011 Dec;128(6):1170-8. PubMed PMID: 22094736. Epub 2011/11/19. eng.

[32] Clemens MW, Kronowitz SJ. Acellular dermal matrix in irradiated tissue expander/implant-based breast reconstruction: evidence-based review. *Plastic and reconstructive surgery*. 2012 Nov;130(5 Suppl 2):27S-34S. PubMed PMID: 23096982. Epub 2012/11/01. eng.

[33] Salzberg CA, Ashikari AY, Koch RM, Chabner-Thompson E. An 8-year experience of direct-to-implant immediate breast reconstruction using human acellular dermal matrix (AlloDerm). *Plastic and reconstructive surgery*. 2011 Feb;127(2):514-24. PubMed PMID: 21285756. Epub 2011/02/03. eng.

[34] Liu AS, Kao HK, Reish RG, Hergrueter CA, May JW, Jr., Guo L. Postoperative complications in prosthesis-based breast reconstruction using acellular dermal matrix. *Plastic and reconstructive surgery*. 2011 May;127(5):1755-62. PubMed PMID: 21228744. Epub 2011/01/14. eng.

[35] Seth AK, Hirsch EM, Fine NA, Kim JY. Utility of acellular dermis-assisted breast reconstruction in the setting of radiation: a comparative analysis. *Plastic and reconstructive surgery*. 2012 Oct;130(4):750-8. PubMed PMID: 23018687. Epub 2012/09/29. eng.

[36] Parks JW, Hammond SE, Walsh WA, Adams RL, Chandler RG, Luce EA. Human acellular dermis versus no acellular dermis in tissue expansion breast reconstruction. *Plastic and reconstructive surgery*. 2012 Oct;130(4):739-46. PubMed PMID: 23018685. Epub 2012/09/29. eng.

[37]Mannu GS, Navi A, Morgan A, Mirza SM, Down SK, Farooq N, et al. Sentinel lymph node biopsy before mastectomy and immediate breast reconstruction may predict post-mastectomy radiotherapy, reduce delayed complications and improve the choice of reconstruction. *International journal of surgery.* 2012;10(5):259-64. PubMed PMID: 22525383.

[38]Alderman AK, Wilkins EG, Kim HM, Lowery JC. Complications in postmastectomy breast reconstruction: two-year results of the Michigan Breast Reconstruction Outcome Study. *Plastic and reconstructive surgery.* 2002 Jun;109(7):2265-74. PubMed PMID: 12045548. Epub 2002/06/05. eng.

[39]Sullivan SR, Fletcher DR, Isom CD, Isik FF. True incidence of all complications following immediate and delayed breast reconstruction. *Plastic and reconstructive surgery.* 2008 Jul;122(1):19-28. PubMed PMID: 18594356. Epub 2008/07/03. eng.

[40]Lee M, Reinertsen E, McClure E, Liu S, Kruper L, Tanna N, et al. Surgeon motivations behind the timing of breast reconstruction in patients requiring postmastectomy radiation therapy. Journal of plastic, reconstructive and aesthetic surgery: *JPRAS.* 2015 Nov;68(11):1536-42. PubMed PMID: 26277336. Pubmed Central PMCID: 4659387.

[41]Duxbury PJ, Gandhi A, Kirwan CC, Jain Y, Harvey JR. Current attitudes to breast reconstruction surgery for women at risk of post-mastectomy radiotherapy: A survey of UK breast surgeons. *Breast.* 2015 Aug;24(4):502-12. PubMed PMID: 26021276.

[42]Kronowitz SJ, Robb GL. Radiation therapy and breast reconstruction: a critical review of the literature. *Plastic and reconstructive surgery.* 2009 Aug;124(2):395-408. PubMed PMID: 19644254. Epub 2009/08/01. eng.

[43]Rozen WM, Ashton MW. Radiotherapy and breast reconstruction: oncology, cosmesis and complications. *Gland surgery.* 2012 Aug;1(2):119-27. PubMed PMID: 25083434. Pubmed Central PMCID: 4115692.

[44]Nava MB, Pennati AE, Lozza L, Spano A, Zambetti M, Catanuto G. Outcome of different timings of radiotherapy in implant-based breast reconstructions. *Plastic and reconstructive surgery.* 2011 Aug;128(2):353-9. PubMed PMID: 21788827. Epub 2011/07/27. eng.

[45]Pompei S, Arelli F, Labardi L, Marcasciano F, Caravelli G, Cesarini C, et al. Breast reconstruction with polyurethane implants:

preliminary report. *European journal of plastic surgery.* 2012;35(6):441-7.

[46]Peled AW, Foster RD, Esserman LJ, Park CC, Hwang ES, Fowble B. Increasing the time to expander-implant exchange after postmastectomy radiation therapy reduces expander-implant failure. *Plastic and reconstructive surgery.* 2012 Sep;130(3):503-9. PubMed PMID: 22929235. Epub 2012/08/30. eng.

[47]Kim JY, Mlodinow AS, Khavanin N, Hume KM, Simmons CJ, Weiss MJ, et al. Individualized Risk of Surgical Complications: An Application of the Breast Reconstruction Risk Assessment Score. *Plastic and reconstructive surgery Global open.* 2015 May;3(5):e405. PubMed PMID: 26090295. Pubmed Central PMCID: 4457268.

[48]Goyal A, Wu JM, Chandran VP, Reed MW. Outcome after autologous dermal sling-assisted immediate breast reconstruction. *Br J Surg.* 2011 Sep;98(9):1267-72. PubMed PMID: 21560123. Epub 2011/05/12. eng.

[49]Lynch MP, Chung MT, Rinker BD. A Comparison of Dermal Autograft and Acellular Dermal Matrix in Tissue Expander Breast Reconstruction: Long-term Aesthetic Outcomes and Capsular Contracture. *Ann Plast Surg.* 2015 Jun;74 Suppl 4:S214-7. PubMed PMID: 25389715.

[50]Peled AW, Foster RD, Ligh C, Esserman LJ, Fowble B, Sbitany H. Impact of total skin-sparing mastectomy incision type on reconstructive complications following radiation therapy. *Plastic and reconstructive surgery*. 2014 Aug;134(2):169-75. PubMed PMID: 24732652.

[51]Ribuffo D, Atzeni M, Guerra M, Bucher S, Politi C, Deidda M, et al. Treatment of irradiated expanders: protective lipofilling allows immediate prosthetic breast reconstruction in the setting of postoperative radiotherapy. *Aesthetic plastic surgery.* 2013 Dec; 37(6):1146-52. PubMed PMID: 24114295.

[52]Serra-Renom JM, Munoz-Olmo JL, Serra-Mestre JM. Fat grafting in postmastectomy breast reconstruction with expanders and prostheses in patients who have received radiotherapy: formation of new subcutaneous tissue. *Plastic and reconstructive surgery.* 2010 Jan;125(1):12-8. PubMed PMID: 20048576.

[53]Panettiere P, Marchetti L, Accorsi D. The serial free fat transfer in irradiated prosthetic breast reconstructions. *Aesthetic plastic surgery.* 2009 Sep;33(5):695-700. PubMed PMID: 19484176.

[54]Martin L, O'Donoghue JM, Horgan K, Thrush S, Johnson R, Gandhi A, et al. Acellular dermal matrix (ADM) assisted breast reconstruction procedures: joint guidelines from the Association of Breast Surgery and the British Association of Plastic, Reconstructive and Aesthetic Surgeons. European journal of surgical oncology: *The journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology*. 2013 May;39(5):425-9. PubMed PMID: 23321393.
[55]Barr SP, Topps AR, Barnes NL, Henderson J, Hignett S, Teasdale RL, et al. Infection prevention in breast implant surgery - A review of the surgical evidence, guidelines and a checklist. European journal of surgical oncology: *the journal of the European Society of Surgical Oncology and the British Association of Surgical Oncology*. 2016 May;42(5):591-603. PubMed PMID: 27005885.
[56]Chapman CH, Jagsi R. Postmastectomy Radiotherapy After Neoadjuvant Chemotherapy: A Review of the Evidence. *Oncology (Williston Park). 2*015 Sep;29(9):657-66. PubMed PMID: 26384802.
[57]Hvilsom GB, Friis S, Frederiksen K, Steding-Jessen M, Henriksen TF, Lipworth L, et al. The clinical course of immediate breast implant reconstruction after breast cancer. *Acta Oncol.* 2011 Oct;50(7):1045-52. PubMed PMID: 21604960. Epub 2011/05/25. eng.
[58]Clough KB, O'Donoghue JM, Fitoussi AD, Nos C, Falcou MC. Prospective evaluation of late cosmetic results following breast reconstruction: I. Implant reconstruction. *Plastic and reconstructive surgery*. 2001 Jun;107(7):1702-9. PubMed PMID: 11391188.
[59]Ibrahim AM, Koolen PG, Ganor O, Markarian MK, Tobias AM, Lee BT, et al. Does acellular dermal matrix really improve aesthetic outcome in tissue expander/implant-based breast reconstruction? *Aesthetic plastic surgery*. 2015 Jun;39(3):359-68. PubMed PMID: 25894022.

BIOGRAPHICAL SKETCHES

Baek Kim

Department of Oncoplastic Breast Surgery, St. James's University Hospital, Leeds

Education: University of Cambridge

Research and Professional Experience:

- MD, Doctor of Medicine, University of Leeds. I was awarded an MD for my research thesis titled 'Xenobiotic transporter expression in breast cancer patients treated with neoadjuvant systemic therapy: implications for therapy'
- FRCS in General Surgery, the Royal College of Surgeons of England.

Professional Appointments: Specialist Registrar in General Surgery, Yorkshire deanery

Honors: FRCS MD MA

Publications Last 3 Years:

'Notch inhibition stops chemotherapy-induced activity of Multi-drug Resistance associated Protein-1 in breast cancer'. B Kim, SL Stephen, SM Bell, AM Hanby, K Horgan, SL Perry, J Richardson, EA Roundhill, EMA Valleley, ET Verghese, BJ Williams, TA Hughes, JL Thorne. BMC cancer. 2015 Sep 11; 15.

Comment on 'Causes of false-negative sentinel node biopsy in patients with breast cancer (British Journal of Surgery 2013; 100(6): 775-783)' B Kim, ET Verghese, K Horgan. British Journal of Surgery 2013 Sep;100(10): 1398-9.

'Cytokeratin-19 based one-step nucleic acid amplification (OSNA) should not replace histopathology for sentinel lymph node assessment in breast cancer: a meta-analysis'. JP Tiernan, ET Verghese, A Nair, S Pathak, *B Kim*, J White, H Thygesen, K Horgan, AM Hanby. British Journal of Surgery 2014 Mar; 101(4):298-306.

'Evaluation of the usage and influence of groin ultrasound in primary and secondary healthcare settings'. B Kim, P Robinson, H Modi, H Gupta, K Horgan, R Achuthan. Hernia 2015 Jun; 19(3); 367-71.

'Variation in the management of ductal carcinoma in situ: Results of the Mammary Fold National Practice Survey'. L Ashken, C Ives, *B Kim*, S Potter, T Rattay, D Remoundos, B Zeidan and K Williams. European Journal of Surgical Oncology 2016 Jun 1. pii: S0748-7983(16)30175-5.

'Serial MRI scans help in assessing early response to neoadjuvant chemotherapy and tailoring breast cancer treatment'. H Fatayer, N Sharma, D Manuel, *B Kim*, A Keding, T Perren, G Velikova, M Lansdown, A Shaaban, B Dall. European Journal of Surgical Oncology 2016 Apr 20. pii: S0748-7983(16)30033-6.

'Diagnostic accuracy of faecal calprotectin in patients with suspected colorectal cancer'. J Turvill, A Aghashoseini, N Sivarajasingham, K Abbas, K Lasithiotakis, M Choudhry, K Polyzois, D Volanaki, F Langlands, *B Kim*, J Roos, H Andrew, S Mellen, D Turnock, A Jones. British Journal of General Practice 2016 Jun 6. pii: bjgpjul-2016-66-648-turvill-fl-p.

Rajgopal Achuthan

Department of Oncoplastic Breast Surgery, St. James's University Hospital, Leeds

Education: MBBS, University of Delhi, India

Research and Professional Experience:

- PhD, Doctor of Philosophy, University of Leeds.
- FRCS in General Surgery, The Royal College of Surgeons, Glasgow.

Professional Appointments: Consultant Oncoplastic Breast and General Surgeon, St. James's University Hospital, Leeds

Honors: MS (Surgery), FRCS, PhD

Publications Last 3 Years:

'An observational study on the expression levels of MDM2 and MDMX proteins, and associated effects on P53 in a series of human liposarcomas'. N Touqan, CP Diggle, ET Verghese, S Perry, K Horgan, W Merchant, R Anwar, AF Markham, IM Carr IM, R Achuthan. BMC Clin Pathol. 2013 Dec 13;13(1):32.

'The role of magnetic resonance imaging in preoperative planning for patients undergoing therapeutic mammoplasty'. G Hicks, Turton P, S Rajan, A Nunn, N Sharma, Achuthan R. ISRN Oncol. 2013 Dec 17;2013:260260.

'Evaluation of the usage and influence of groin ultrasound in primary and secondary healthcare settings'. B Kim, P Robinson, H Modi, H Gupta, K Horgan, R Achuthan. Hernia 2015 Jun; 19(3); 367-71. BMC Clin Pathol. 2013 Dec 13;13(1):32.

'Management of breast cancer in an Asian man with post-traumatic stress disorder: a case report'. F Patel, R Achuthan, L Hyklova, AM Hanby, V Speirs. J Med Case Rep. 2016 Mar 29;10(1):77.

In: Breast Reconstruction
Editor: Janice Rivera
ISBN: 978-1-53610-245-1

Chapter 3

DIEP FLAP BREAST RECONSTRUCTION: TECHNICAL TIPS TO OPTIMIZE OUTCOMES AND AVOID COMPLICATIONS

Koichi Tomita* and Kenji Yano
Department of Plastic and Reconstructive Surgery, Graduate School of Medicine, Osaka University, Osaka, Japan

ABSTRACT

Progress in microsurgery techniques has popularized the use of the perforator flap, which enables minimal invasion into the donor site without sacrificing muscle. In breast reconstruction as well, one procedure that has become increasingly common is the transplantation of subcutaneous fat from the lower abdomen as a deep inferior epigastric perforator (DIEP) flap to the affected area. Recent developments in 3D imaging are also quite significant, allowing for 3D photography and 3D printing to be done even at the individual patient level. We have also come to rely more heavily on 3D imaging technology for breast reconstruction employing DIEP flaps, and have reported on its utility. In the present chapter, we focus on our experiences thus far, and present tips for safe maneuvering of DIEP flaps, as well as the implementation status of 3D imaging technology and its utility with regard to breast reconstruction using DIEP flaps.

* Corresponding author's E-mail: ktomita9@hotmail.co.jp.

Keywords: DIEP flap, breast reconstruction, 3-dimensional imaging, 3-dimensional printing

INTRODUCTION

In recent years, a dramatic increase in the number of breast cancer patients has led to a concomitant and daily increase in the needs and awareness surrounding breast reconstruction. Currently, breast reconstruction methods can be divided into the following three categories: 1) transplantation of self tissue to the affected breast (following full or partial mastectomy); 2) use of a breast prosthesis (following full mastectomy); and 3) use of remaining breast tissue to 'clean up' the breast form (following partial mastectomy). Each method has its own set of pros and cons, and decisions concerning the application of any of these are made through conversations between the patient and physician as they consider patient preference, illness, and social background factors. The biggest advantage of breast reconstruction using self tissue such as subcutaneous abdominal fat is that it allows physicians to recreate soft breasts with a natural texture. However, for many years, this technique necessitated sacrificing muscle from the donor site. With the recent emergence of the concept of the perforator flap, this problem may have been resolved, at least from the standpoint of functional sacrifice [1].

Developments in 3D imaging technology have been substantial in recent years, and 3D photography and 3D printing have progressed to the point of being used at the individual level. Along with those developments, this technology is being applied in a variety of medical fields. Plastic surgery, where most surgeries are performed on the surface of the body, is one field that likely benefits from these developments substantially, and many attempts have been made to incorporate 3D imaging technology into treatments of various plastic surgery-related conditions [2, 3]. In recent years, we have become more heavily reliant on the use of 3D imaging technology for breast reconstruction using deep inferior epigastric perforator (DIEP) flaps [4, 5], and have reported on its utility [6]. In the present chapter, we focus on our experiences thus far, and provide tips on the safe maneuver of DIEP flaps. We also describe how we incorporate 3D imaging technology for DIEP flap breast reconstruction and report on the utility of this technology.

ANATOMY

Abdominal fat tissue is nourished by the superior epigastric vessels, the superficial and deep inferior epigastric vessels, and intercostal vessels. After branching off from the external iliac vessels, the deep inferior epigastric vessel (the feeding vessel of the DIEP flap) typically runs inward and upward, and from roughly 3-5 cm caudal of the arcuate line, courses cranially along the underside of the rectus abdominis muscle. Following this, many bifurcations occur in the vessels running through the muscle, yielding medial and lateral branches; notably, not all vessel types bifurcate. In addition, prior to bifurcating into medial/lateral branches, some will branch medially; this medial branch does not pass through the muscle, but directly enters the skin flap near the umbilicus (Figure 1). From blood vessels that pass through the muscles, several thick perforator branches thread through the anterior sheath of the rectus abdominis muscle to reach the adipose tissue, where they radiate out to nourish subcutaneous fat tissue. Most perforator branches are localized to the periphery of the umbilicus, and reportedly, an average of 6 perforator branches on each side with a diameter of 0.5 mm or larger, as well as 1-3 branches with diameters of 1 mm or larger, are found [7].

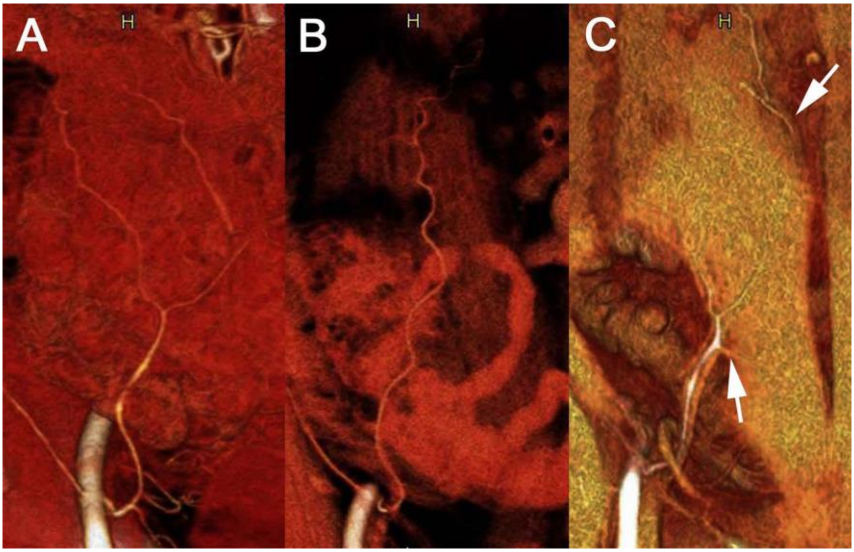


Figure 1. Variations in blood flow of the deep inferior epigastric vessels (all on the right side).
(A) Vessel types that can be divided into medial and lateral branches.

(B) Vessel type that does not make large bifurcations, but rather remains one vessel.
(C) Prior to bifurcating into medial/lateral branches, this type will branch medially. That branch does not pass through the muscle, but directly enters the skin flap (arrow).

PREOPERATIVE PREPARATION

1. Selection of Applicable Cases

The color Doppler method is used to confirm the presence of perforator branches of a certain diameter in the lower abdomen around the umbilicus [8]. If none are found, then either a free or pedicled rectus abdominis musculocutaneous flap is selected. In addition, the patient must have enough subcutaneous abdominal fat to repair the defective tissue. While we do not exclude outright any young women who wish to become pregnant in the future, we do feel they should avoid this procedure, if at all possible.

2. Preoperative Blood Vessel Evaluation and Selection of Perforator Branches

Of utmost importance is confirmation of the paths of the deep inferior epigastric vessels as well as the perforator branches. Previously, these were both evaluated only through color Doppler, but with the emergence of multidetector computed tomography (MDCT), all patients who can tolerate contrast agent now undergo a preoperative abdominal MDCT. This first evaluates the intramuscular route of the deep inferior epigastric vessels through 3D CT imaging, and then branch types mentioned above are categorized.

Perforator branches are then mapped, and those that could be included in the flap are selected in advance (Figure 2). Selection criteria involve, first and foremost, perforator branch thickness; as a rule, we select the thickest vessel (regardless of whether it is on the right or left side). If several vessels fulfill the selection criteria, we turn to other criteria such as the least intramuscular penetration (and thus greater ease of detachment), a strong network with the superficial inferior epigastric vessels, or a vessel on the side with no scars. If we are unsatisfied with the thickness of the perforator branch, we may consider including a total of 2 or 3 branches. However, in addition to the criteria mentioned above, those are selected in a combination that would minimize muscle sacrifice. In general, if perforator branches that originate from the medial and lateral branches are both included in the same flap, the muscular body between them must be cut, leading to more muscle damage. On the other hand, if perforator branches on the same side are selected, muscle damage is minimized, but the intercostal nerves that cut across between the branches must be cut and then rejoined. In addition, if too many perforator branches from the caudal end are included, the length of the vascular pedicle is shortened.

3. Preoperative Evaluation of Required Tissue Amount and Decisions Concerning the Use of Bipedicled DIEP Flaps

One disadvantage of using DIEP flaps is that the blood flow volume is lower than that of the rectus abdominis musculocutaneous flaps (RAMFs), which limits where it can be grafted [9]. Therefore, if a large amount of tissue is required for the transplant, a bipedicled DIEP flap should be considered [10]. At our institution, we simplify the surgical plan by pre-determining the necessary tissue volume as well as that of the flap that can be harvested using 3D imaging data and abdominal fat thickness, respectively [6].

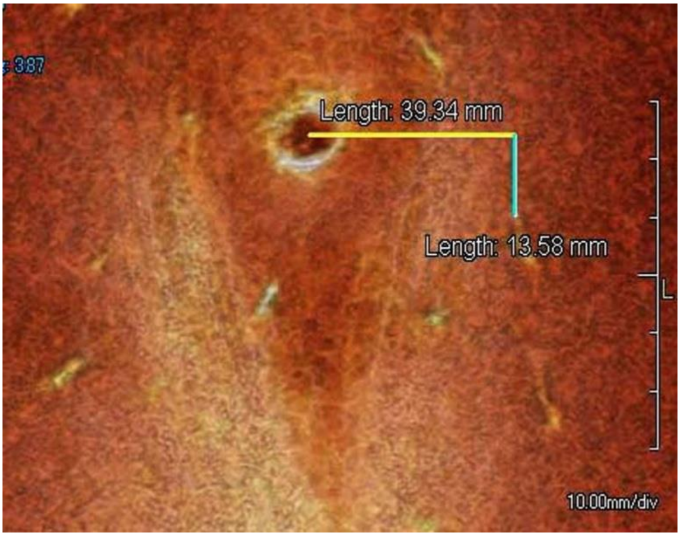


Figure 2. 3D CT mapping of perforator branches. Measurements were taken to determine the distance from the umbilicus (landmark).

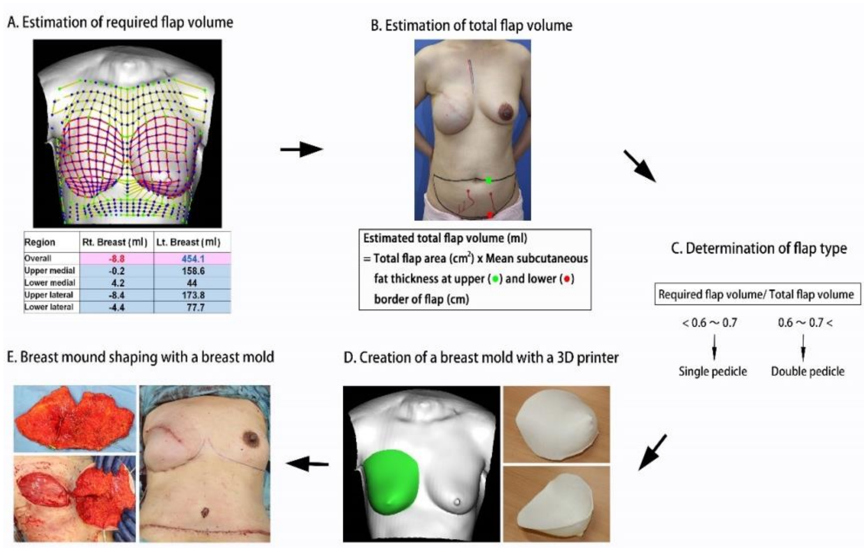


Figure 3. Use of 3D imaging for breast reconstruction using a DIEP flap (Reprinted from ref. 6).

To predetermine the necessary tissue volume, preoperative measurements of both breasts are first made using image analysis software (Breast Rugle®, Medic Engineering, Kyoto) (Figure 3A). For one-stage immediate reconstruction, the volume of the opposite (healthy) side is considered the necessary amount of tissue volume. For two-stage immediate reconstruction and delayed reconstruction, the difference in breast volume between the healthy and affected sides is considered the necessary tissue volume. Because we calculate both the volume of mammary gland tissue to be extracted and that of remaining breast skin tissue for one-stage immediate reconstruction, the necessary tissue volume may be slightly exaggerated in the evaluation. However, in our experience, the amount of error is not to the level that would affect the decision concerning whether a bipedicled DIEP flap would be required or not, and perioperative correction is possible by measuring the excised tissue.

The measurement of extractable flap volume is somewhat affected by the flap extraction method, but we have found that this can be estimated by the following equation: (Total flap volume, ml) = (mean subcutaneous fat thickness (cm) after excluding the skin thickness at the center of the rectus abdominis) x (total flap area (cm^2) as calculated by the imaging software) (Figure 3B). It also depends on the thickness, number, and location of the perforator branches, but if the estimate of necessary tissue volume exceeds 60-70% of the estimated total flap volume, then we plan for a bipedicled DIEP flap (Figure 3C). However, if the numbers are borderline and difficult to determine, then perforator branches on both sides are preserved. After the flap is maneuvered epifascially, a perforator branch on one side is clipped, and perioperative determination is done with indocyanine green fluorescent imaging [11]. Even in these cases, a preoperative estimate of the percentage of the total required flap tissue is extremely useful for perioperative determination of whether or not an additional blood vessel is required.

TIPS ON MANEUVERING THE FLAP

In addition to the perforator branch that was selected through the MDCT perforator branch mapping, all viable perforator branches should be marked preoperatively on the abdominal skin using a color Doppler device and Doppler blood flow meter, as this makes perioperative identification of the targeted perforator branch relatively easy. With regard to flap design, the upper end of the umbilicus should represent the cranial margin for a transverse flap, and the caudal end should have a convex boat-shaped design. Below we describe how to maneuver a transverse flap.

Figure 4. Preoperative condition of patient who underwent mastectomy on the right side.

First, the skin around the perimeter of the umbilicus is cut down to the fascia in the shape of a ring. After isolating the umbilicus, the skin for the entire flap is dissected. For the caudal end of the flap, the deep fascia is reached by going down perpendicularly. However, in that process, it is important to not damage the superficial inferior epigastric vessels. From these vessels, a thick vein is selected, followed to some extent to the proximal part, and then included in the flap. This can be used after flap transplantation if veins become problematic. For the cranial end of the flap, the superficial fascia is peeled back about 2-3 cm in the cranial direction, and this will lead to the deep fascia. By doing this, any mismatch in thickness between the cranial and caudal ends of the flap can be resolved when the harvested flaps are sewn together. It also enables the transplantation of more tissue than required.

Following this, the flap is peeled back and elevated laterally along the fascia. In this process, a more controlled peeling is possible with the use of a needle-shaped scalpel electrode. Once the lateral border of the anterior sheath of the rectus abdominis muscle is reached, careful peeling is done using dissecting scissors, and the perforator branches that were marked preoperatively are identified and preserved. An incision is made in the anterior sheath roughly 1 cm caudal and 3-5 mm lateral of the targeted perforator branch. From that point, the presence of the perforator branch underneath the anterior sheath is confirmed. In this way, initial confirmation of the presence of perforator branches farther under the anterior sheath makes it possible to avoid damaging perforator branches in cases where the perforator branch is attached as it runs along the anterior sheath.

After dissecting the anterior sheath along muscle fibers and opening it up roughly 5 cm, the muscle is divided longitudinally along the muscle fibers in a retrograde fashion from the arterial flow, exposing the blood vessel that will form the pedicle. In thin muscle branches, it is best to stay as far from the vascular pedicle as possible while using bipolar cautery to carefully clot and dissect. Thicker branches should be handled with a microclip, as the peeling is performed until the blood vessel reaches the underside of the muscle body. Motor branches of the intercostal nerve that run transversely should be preserved as much as possible. If the intercostal nerve must be dissected because it is between perforator branches, postoperative muscular atrophy can be prevented by re-stitching the nerve following the flap harvest. When peeling back the blood vessels, it is important to envision this process as a “peeling the surrounding tissue away from the blood vessel, i.e., leaving only the blood vessel in place”, rather than tugging on the blood vessel to peel it away from the surrounding tissue. This will minimize any mechanical damage to the perforator branch. In cases for which the perforator branch is threaded through tendinous intersections, it is impossible to just isolate the perforator branch safely, so rather than trying to achieve the impossible, they are maneuvered along with the tendinous intersections.

After confirming separation of the blood vessel from the muscle body, a new 5-cm incision is made on the anterior sheath, from the lateral margin of the rectus abdominis in the caudal direction, and then the presence of the deep inferior epigastric vessels that insert into the underside of the muscle body from the lateral side of the muscle body is confirmed. This is then peeled back in the cranial direction and connected with the blood vessel that was peeled back earlier. During this process, it is very important to avoid damaging the thick intercostal nerve running transversely from the lateral side. The peeling is also conducted in the caudal direction until the bifurcation of the external iliac vessels is reached.

After the entire flap is peeled back to the fascia, the region of transplantable flap with stable blood flow is determined through subjective evaluation such as flap color or blood color, as well as objective evaluations such as perioperative ICG fluorescent angiography [11]. Any regions with insufficient blood flow are excised.

BREAST MOUND FORMATION BY CREATING A BREAST MOLD THROUGH 3D PRINTING

Using the aforementioned imaging software, it is possible to create a mold image of the breast on the opposite side, using 3D data obtained preoperatively. After this, the data that are transformed to a mirror image can be printed on a 3D printer. This enables the creation of a breast mold on the affected side, which can be gas sterilized and used perioperatively (Figure 3D). Following anastomosis/de-epithelialization of the flap, it is inserted into the mold, with careful attention being paid to the vascular pedicle (for one-stage immediate reconstruction accompanying nipple/areola resection, a part of the de-epithelialization is done later). First, after determining the most appropriate flap placement that will avoid placing tension on the vascular pedicle, any part of the flap that does not fit in the mold is resected (Figure 3E). In the event that the cranial side of the flap is thicker, adipose tissue from under the superficial fascia is removed and adjustments are made. When adjusting the amount of flap, one must remember that the chest wall protrudes out slightly in the front, rather than being flat. Using a measuring spoon as an analogy, the whole spoon leveled off would be excessive; it is important to have not quite a full measuring spoon. In addition, as the breast molds are created according to the form of the body surface, the volume of breast skin is not taken into consideration. As a result, immediately after surgery, the reconstructed breast is slightly bigger than that on the healthy side, but as the flap tends to shrink postoperatively by about 5-10% [12], we feel that this works out quite nicely. In patients with high breast projection, breast mound construction is performed using several absorbable sutures to stabilize the flap on the caudal side. This work can be done prior to the anastomosis, but we opt to perform these procedures afterwards, primarily because it allows for some time to observe the condition of the anastomosis, and because it enables easier de-epithelialization of the flap.

Postoperative Maintenance

For 24 hours after surgery, a Doppler blood flow meter and the Doppler method should be used to monitor the flap blood flow every 4 hours. For 1 week after that, blood flow should be checked roughly three times a day. The patient should become ambulatory the day after surgery, and activity levels should be increased gradually thereafter. The abdominal suction drain should be removed between postoperative day 7 and 10, after which the patient can be discharged.

Representative Case

A 42-year-old female underwent mastectomy and sentinel node biopsy at another institution for cancer in her right breast, and was referred to our institution for delayed reconstruction (Figure 4). First, we inserted a subcutaneous tissue expander and performed mastopexy of the opposite breast, followed by reconstruction using a DIEP flap 4 months later. While the preoperative 3D analysis estimated that roughly 525 ml of tissue would be required, the total estimated flap volume was roughly 810 ml (roughly 65%). As such, we planned for a bipedicled DIEP flap that included one perforator branch from the right side medial row as well as 2 perforator branches from the left side medial and lateral rows (Figure 5A). Following mastopexy of the healthy side, a breast mold was created based on 3D data obtained after the breast form had stabilized. The lateral branch of the deep inferior epigastric vessels on the right side was anastomosed to the main trunk of the deep inferior epigastric vessels on the left (Figure 5B), and the right deep inferior epigastric vessels were anastomosed to the internal mammary vessels. After de-epithelialization, the flap was inserted into the breast mold, and excess flap tissue was excised (of the total 805 g of flap tissue, 560 g transplanted) and the breast mound constructed (Figure 5C). After inserting the flap into the subcutaneous pocket in the anterior chest, an inframammary fold was created using Nava's technique [13] (Figure 5D). Postoperatively, the flap showed complete engraftment, and the patient had a soft and symmetrical breast (Figure 6).

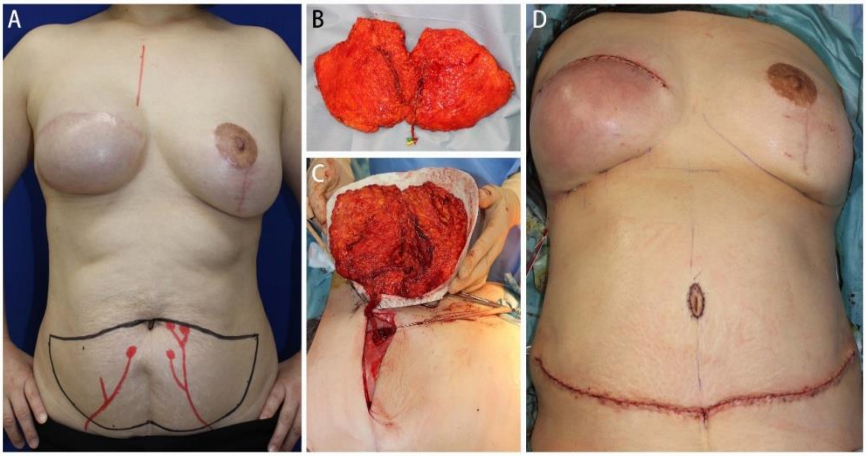


Figure 5. Perioperative findings.
(A) Following subcutaneous insertion and expansion of the tissue expander, and then mastopexy of the other breast, we planned a bipedicled DIEP flap that included one perforator branch on the right side medial row and two perforator branches from the left side medial and lateral rows.
(B) Anastomosis of the lateral branch of the right deep inferior epigastric vessel and the main trunk of the left deep inferior epigastric vessel.
(C) The flap was inserted into the breast mold. Excess flap tissue was excised and the breast mound was formed.
(D) After inserting the flap into the anterior chest subcutaneous pocket, we used Nava's technique to create an inframammary fold.

Figure 6. Postoperative status at 10 months. A sufficient amount of tissue was transplanted, allowing for reconstruction of a soft and symmetrical breast.

CONCLUSION

We have documented some of our recent experiences and innovations with breast reconstruction using DIEP flaps. From the perspective that DIEP flaps minimize muscle sacrifice, allowing for transplant of tissue with a relatively large volume and area, we feel that this technique is an extremely useful option for breast reconstruction. In addition, with recent progress in vascular anatomy studies, as well as the prevalence of MDCT and 3D imaging technologies, increasingly safe and accurate preoperative plans and simulations are now possible. We anticipate even more developments in this standard procedure that uses self tissue for breast reconstruction following mastectomy.

REFERENCES

[1] Blondeel N., Vanderstraeten G.G., Monstrey S.J., Van Landuyt K., Tonnard P., Lysens R., Boeckx W.D., Matton G., (1997). The donor site morbidity of free DIEP flaps and free TRAM flaps for breast reconstruction. *Br J Plast Surg* 50, 322-330.

[2] Nishimoto S., Sotsuka Y., Kawai K., Fujita K., Kakibuchi M., (2014). Three-dimensional mock-up model for chondral framework in auricular reconstruction, built with a personal three-dimensional printer. *Plast Reconstr Surg* 134, 180e-181e.

[3] Sotsuka Y., Nishimoto S., (2014). Making three-dimensional mandible models using a personal three-dimensional printer. *J Plast Reconstr Aesthet Surg* 67, 576-578.

[4] Koshima I., Soeda S., (1989). Inferior epigastric artery skin flaps without rectus abdominis muscle. *Br J Plast Surg* 42, 645-648.

[5] Blondeel P.N., (1999). One hundred free DIEP flap breast reconstructions: a personal experience. *Br J Plast Surg* 52, 104-111.

[6] Tomita K., Yano K., Hata Y., Nishibayashi A., Hosokawa K., (2015). DIEP Flap Breast Reconstruction Using 3-dimensional Surface Imaging and a Printed Mold. *Plast Reconstr Surg Glob Open* 3, e316.

[7] Itoh Y., Arai K., (1993). The deep inferior epigastric artery free skin flap: anatomic study and clinical application. *Plast Reconstr Surg* 91, 853-863; discussion 864.

[8] Yano K., Hosokawa K., Nakai K., Kubo T., Hattori R., (2003). Monitoring by means of color Doppler sonography after buried free DIEP flap transfer. *Plast Reconstr Surg* 112, 1177.

[9] Kroll S.S., (2000). Fat necrosis in free transverse rectus abdominis myocutaneous and deep inferior epigastric perforator flaps. *Plast Reconstr Surg* 106, 576-583.

[10] Blondeel P.N., Boeckx W.D., (1994). Refinements in free flap breast reconstruction: the free bilateral deep inferior epigastric perforator flap anastomosed to the internal mammary artery. *Br J Plast Surg* 47, 495-501.

[11] Losken A., Zenn M.R., Hammel J.A., Walsh M.W., Carlson G.W., (2012). Assessment of zonal perfusion using intraoperative angiography during abdominal flap breast reconstruction. *Plast Reconstr Surg* 129, 618e-624e.

[12] Blondeel P.N., Hijjawi J., Depypere H., Roche N., Van Landuyt K., (2009). Shaping the breast in aesthetic and reconstructive breast surgery:

an easy three-step principle. Part II--Breast reconstruction after total mastectomy. *Plast Reconstr Surg* 123, 794-805.

[13] Nava M., Quattrone P., Riggio E., (1998). Focus on the breast fascial system: a new approach for inframammary fold reconstruction. *Plast Reconstr Surg* 102, 1034-1045.

BIOGRAPHICAL SKETCH

Koichi Tomita

Department of Plastic and Reconstructive Surgery
Graduate School of Medicine, Osaka University

Education:

Osaka University, Medical School M.D., 2000

Osaka University, Graduate School of Medicine Ph.D., 2007

Research and Professional Experience:

Dr. Tomita's research has concentrated in the area of reconstructive microsurgery, including breast reconstruction, facial nerve reconstruction, and head and neck reconstruction. Clinical research areas of interest include breast reconstruction using 3-dimensional imaging and facial nerve reconstruction using multiple motor sources. Basic research areas of interests includes improvement of peripheral nerve regeneration using adipose-derived stem cells and in vivo molding of soft tissue using an absorbable mold.

Professional Appointments:

Since 2007 Assistant Professor, Osaka University

2009-2011 Research fellow, Blond McIndoe Research Laboratories, University of Manchester

Honors:

2009-2011 Uehara memorial foundation research fellowship

2013, 2014 President's incentive award, Osaka University

Publications Last 3 Years:

[1] Nishibayashi A, Tomita K, Kiya K, Yano K, Hosokawa K. Differentiated adipose-derived stem cells promote the recovery of nociceptor function in rats. *Neuroreport*, in press

[2] Tomita K, Nishibayashi A, Yano K, Hosokawa K. Differential reanimation of the upper and lower face using two interpositional nerve

grafts in total facial nerve reconstruction. *Plastic and Reconstructive Surgery Global Open*, 3(10) e544, 2015

[3] Tomita K, Nishibayashi A, Yano K, Hosokawa K. Adipose-derived stem cells protect against endoneurial cell death: Cell therapy for nerve autografts. *Microsurgery*, 35(6) 474-80, 2015

[4] Tomita K, Yano K, Nishibayashi A, Hosokawa K. Effects of subcutaneous versus submuscular tissue expander placement on breast capsule formation. *Plastic and Reconstructive Surgery Global Open*, 3(6) e432, 2015

[5] Tomita K, Yokoi-Fukai M, Ishihara T, Morita K, Hosokawa K. Use of translocated deep inferior epigastric vessels for free flap reconstruction of gluteal defect. *Plastic and Reconstructive Surgery Global Open*, 3 (6) e433, 2015

[6] Nishibayashi A, Hata Y, Hori Y, Tomita K, Matsuda K, Yano K, Hosokawa K. Angiosarcoma on untreated facial capillary malformations. *ePlasty*, 15:e34, 2015

[7] Matsuda K, Tomita K, Fukai M, Kubo T, Hayashi A, Shibata M, Hosokawa K. Vein/arterial grafts harvested within the incision for a free groin flap. *Plastic and Reconstructive Surgery Global Open*, 3(6) e407, 2015

[8] Matsuda K, Kubo T, Fukai M, Kikuchi M, Hikasa H, Nakajima Y, Tomita K, Hosokawa K, Shibata M. Free perivascular tissue flap transfer. *Journal of Plastic, Reconstructive and Aesthetic Surgery*, 68(7) 973-8, 2015

[9] Tomita K, Yano K, Hata Y, Nishibayashi A, and Hosokawa K. DIEP Flap Breast Reconstruction Using 3-Dimensional Surface Imaging and a Printed Mold. *Plastic and Reconstructive Surgery Global Open*, 3(3) e316, 2015

[10] Tomita K, Yano K, Sugio Y, Ishihara T, Nishibayashi A, Matsuda K, Hosokawa K. Breast reconstruction following breast-conserving surgery with a subcutaneous tissue expander and latissimus dorsi flap. *Plastic and Reconstructive Surgery Global Open*, 2(10) e231, 2014

[11] Hata Y, Osuga K, Uehara S, Yano K, Kikuchi M, Tomita K, Matsuda K, Kubo T, Fujiwara T, Hosokawa K. Topological analysis for arteriovenous malformations via computed tomography angiography: Part 2: Practical application. *Plastic and Reconstructive Surgery Global Open*, 2(9) e207, 2014

[12] Hata Y, Osuga K, Kubo T, Matsuda K, Tomita K, Kikuchi M, Fujiwara T, Yano K, Hosokawa K. Topological analysis for arteriovenous

malformations via computed tomography angiography: Part 1: Mathematical concepts, Yuki Hata, et al., Plastic and Reconstructive Surgery Global Open, 2(8) e205, 2014

[13] Tanigawa T, Kanazawa S, Ichibori R, Fujiwara T, Magome T, Shingaki K, Miyata S, Hata Y, Tomita K, Matsuda K, Kubo T, Tohyama M, Yano K, Hosokawa K. (+)-Catechin protects dermal fibloblasts against oxidative stress-induced apoptosis. *BMC Complementary and Alternative Medicine*, 14:133, 2014

[14] Ichibori R, Fujiwara T, Tanigawa T, Kanazawa S, Shingaki K, Torii K, Tomita K, Yano K, Osaka Twin Research Group, Sakai Y, Hosokawa K. Objective assessment of facial skin aging and the associated environmental factors in Japanese monozygotic twins. *Journal of Cosmetic Dermatology*, 13(2):158-63, 2014

[15] Imagawa Y, Tomita K, Kitahara K, Yano K, Hosokawa K. Repair of symptomatic perineal hernia with a titanium mesh. *Hernia*, 18(4):587-90, 2014

[16] Tashima H, Fujikawa M, Izumi K, Matsuda K, Tomita K, Hosokawa K. Anatomic evaluation of the internal mammary vessels using multidetector CT angiography images in 100 Asian patients. *ePlasty* 14:e9, 2014

[17] Izumi K, Fujikawa M, Tashima H, Saito T, Sotsuka Y, Tomita K, Hosokawa K. Immediate reconstruction using free medial circumflex demoral artery perforator flaps after breast-conserving surgery. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 66(11):1528-33, 2013

[18] Tomita K, Nishibayashi A, Yano K, Hosokawa K. Differentiated adipose-derived stem cells promote reinnervation of rat skin flaps. *Plastic and Reconstructive Surgery Global Open* 1(3):e22, 2013

[19] Tomita K, Yano K, Nishibayashi A, Fukai M, Miyasaka M, Hosokawa K. The role of latissimus dorsi myocutaneous flap in secondary breast reconstruction after breast-conserving surgery. *ePlasty* 13:e28, 2013

[20] Tomita K, Madura T, Sakai Y, Yano K, Terenghi G, Hosokawa K. Glial differentiation of human adipose-derived stem cells: Implications for cell-based transplantation therapy. *Neuroscience* 236(16):55-65, 2013

[21] Nishibayashi A, Tomita K, Yano K, Hosokawa K. Correction of complex chest wall deformity in Poland's syndrome using a modified Nuss procedure. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 66(2):e53-e55, 2013

In: Breast Reconstruction
Editor: Janice Rivera
ISBN: 978-1-53610-245-1

Chapter 4

WHAT COMES AFTER A FREE FLAP FAILURE FOR BREAST RECONSTRUCTION?

Lucian Fodor[1,*], Raluca Sobec[1], Laura Sita-Alb[1] and Dragos Zamfirescu[2]

[1]Plastic and Reconstructive Surgery Unit, Emergency Hospital, Cluj Napoca, Romania
[2]Zetta Clinic, Bucharest, Romania

ABSTRACT

Free flaps for breast reconstruction are among the most used procedures nowadays. Most common free flap procedures are DIEP, SGAP, IGAP, FCI and gracilis. The success rates in experienced centers range between 93-97%. Failure of a free flap can have many causes and the result can be a disaster for the patient, with loss of the new breast and donor area scars or other complications. When a salvage procedure fails, the question raised is what to do next.

Choosing an implant or expander-based procedure can be a good choice for these patients. Choosing a second free flap can be a risky procedure, taking into consideration the psychological effect of another failure. When the gluteal area or thigh is used as a donor site, the other

[*] Corresponding author: lucifodor@outlook.com.

one can be used for harvesting. If DIEP was used, this donor area cannot be used again, and other locations should be selected.

The cause of the failure should be carefully evaluated. When prothrombotic systemic disease is ruled out and the quality of recipient vessels are suitable for anastomosis, a second free flap can be used.

Keywords: breast reconstruction, free flap, implants, failure, obesity

INTRODUCTION

There are many possibilities for breast reconstruction (BR), including breast silicone implants or expanders, or flaps, or a combination of these. Pedicled flaps, such as the transverse rectus abdominis muscle (TRAM) was widely used a few decades ago. With developing microsurgical techniques, free flaps are more often used nowadays, and perforator free flaps are used more frequently. Among the most used are the deep inferior epigastric perforator (DIEP), the gluteal artery perforator (GAP) flap, and the fasciocutaneous infragluteal (FCI) flap.

Replacing tissue with tissue-like is of great importance in BR. The chances of long-term complications are reduced for vascular free flaps compared with implants [1-3]. Success rates in breast reconstruction exceed 93-97% in experienced centers. There is no doubt that requests for BR are increasing yearly.

Patients with a family history of breast cancer or have BRCA mutations are interested in prophylactic mastectomy on the contralateral side [4-6]. Autologous tissue BR has the advantage of offering better symmetry, especially in cases with breast ptosis. The DIEP flap is the workhorse for free flap BR and its use also improves the abdominal aspect. While most free flap BR are successful in most centers, a total failure is disappointing both for the surgeon and for the patient. When failure occurs, some authors [7] prefer reconstruction with a prosthetic device which has a higher chance of success. In bilateral cases, using a free flap for the contralateral side offers an easier opportunity for tailoring the flap and a better match with the prosthetic side.

In a retrospective study conducted on 2306 free flaps for BR, obesity, hypertension or prolonged operation were associated with flap failure [8]. A hidden patient hypercoagulability predisposition can lead to multiple free flap failures [9]. A hematological workup can reveal anomalies of protein S activity, Factor VIII, plasminogen activator inhibitor or antiphosphatidyl antibodies. These tests are not done routinely before any free flap procedure. However, when a complication is encountered, all these parameters needs to be evaluated.

A review of the morbidity of BR in obese patients was performed by Fisher et al. [10]. In a study on 15937 BR performed between 2005 and 2010, obesity was present in 27.1%. Grade III obesity was encountered in 4%. It is interesting that the author did not find a difference in first month complications between autologous and implant-based procedures [10]. However, obese patients have a greater perioperative risk and more medical complications. In a study by Garvey et al. on 990 BR in obese patients, 548 had free flaps and 442 had implant-based BR [11]. In this study, the authors found a higher failure rate in the implant-based group (15.8%) than in the free flaps group (1.5%).

Efforts to analyze several parameters for free flaps have been made by experienced surgeons in order to prevent complications and elaborate a strategy for reconstruction. Damen et al. [12] evaluated 406 consecutive free flaps (164 used for unilateral and 121 for bilateral BR). The most common recipient vessels for free flap BR are the internal mammary ones [13, 14]. For the DIEP flap, many authors use a single perforator and consider it sufficient for perfusion. Damen et al. [12] is in favor of using a single perforator when the vein diameter is greater than 1.5mm. Nahabedian et al. [15] considers a single perforator flap safe if the diameter is greater than 1.5mm and the flap weight is less than 750gr. Several recommendations have been described by experienced surgeons to reduce complication rates. Blondeel [16] prefers a single or two perforators located at the musculocutaneous junction. The larger the perforator, the greater the chance for flap survival. When a large perforator is present, it is preferred to two small perforators [17].

The best solution to overcome a failed BR has not been established and authors' opinions vary. Rao et al. [7] reported a 3.5% failure rate on 342 free flaps where reconstruction with tissue expanders and implants was performed. An average of 2.25 additional procedures were necessary in these cases to achieve the final result. In a study on 688 patients, Hamdi et al. [18] reported 14 patients who required tertiary BR. Eight patients had a second free flap, and two required another reconstruction due to failure. A failed solution cannot be solved with the same way of thinking. Identifying the cause of failure as precisely as possible can lead the surgeon to choose the best next solution. According to Hamdi et al. [18], a second free flap can be offered as a solution for a failed one. When an abdominal area was used, other donor areas, such as the buttock or thigh, are good options.

Figure 1A. The mastectomy area in a young female with no abdominal fat deposits.

Figure 1B. The donor area for FCI flap - thehe left side was used.

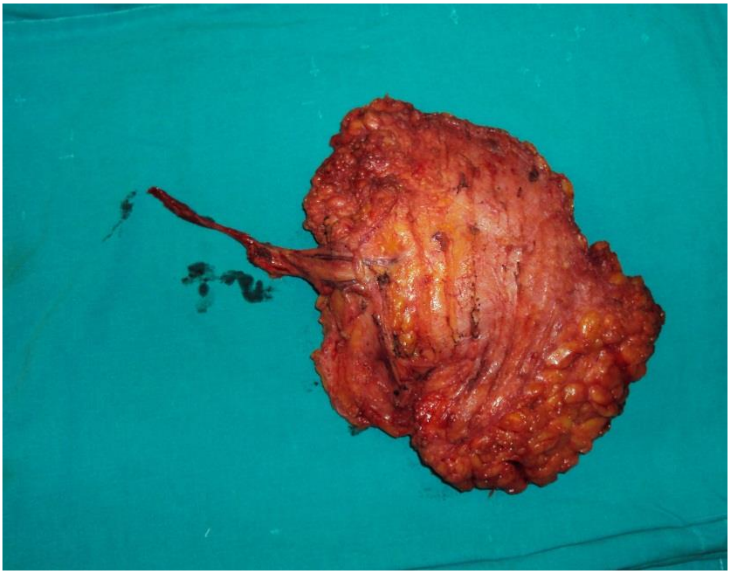


Figure 1C. The flap.

Figure 1D. The flap became congestive on the second day after surgery. A salvage procedure was tried but was only partial successful.

Figure 1E. A few weeks after surgery with a partial flap loss.

Figure 1F. Six months after - the remaining flap became fibrotic and was removed.

Figure 1G. A second free flap was used from the contralateral buttock - 18 months after reconstruction.

Figure 1H. The donor area 18 months after surgery.

According to Mohan et al. [19], DIEP is the first choice for BR in a failed or unsatisfactory implant reconstruction. Implant-based BR is a useful and very common method. Unfortunately, there are cases with unsatisfactory results or long-term complications after implant- or expander-based procedures [20, 21]. The most common late complication is by far capsular contracture [22]. The free flap BR has the advantage of having good long-standing results and fewer revisions compared with other methods.

In a retrospective analyses of 902 free flaps for BR, Baumeister et al. [23] identified 13 patients who had a second free flap after a primary failure. After analyzing possible causes of the failure, the re-operative strategy was changed. For most, more proximal recipient vessels or different recipient vessels were used. A different flap type was used in these cases and success was achieved in 11 of 13 patients. Reconsideration of a second free flap procedure should be done after carefully analyzing the cause of the failure, using a sensitive approach to the patient, and changing the surgical strategy [23]. Massenburg et al. [8] used a contralateral latissimus dorsi (LD) flap for secondary or tertiary reconstructions.

Some authors are in favor of a second tissue transfer after a primary failure [24], while other authors are in favor of this strategy even though it concerns other regions of the body. In a large number of free flap cases (3361) performed in the head and neck, after careful analysis of the outcome of the failed free flap, Wei et al. [25] performed a second free flap and found it reliable for most patients.

Choosing the best solution after a free flap failure is not a simple task, based solely on the surgeon's preference (Figures 1A-H). If the patient is very anxious, we suggest an implant-based solution. In cases with hypercoagulability, such as anticardiolipin antibodies and free flap failure, we suggest an implant only or an implant combined with a LD pedicle flap.

REFERENCES

[1] Claro F, Jr., Figueiredo JC, Zampar AG, Pinto-Neto AM. Applicability and safety of autologous fat for reconstruction of the breast. *The British journal of surgery*. 2012;99(6):768-80. Epub 2012/04/11.

[2] Hvilsom GB, Holmich LR, Steding-Jessen M, Frederiksen K, Henriksen TF, Lipworth L, et al. Delayed breast implant reconstruction: a 10-year prospective study. *Journal of plastic, reconstructive and aesthetic surgery:* JPRAS. 2011;64(11):1466-74. Epub 2011/08/26.

[3] McCarthy CM, Mehrara BJ, Riedel E, Davidge K, Hinson A, Disa JJ, et al. Predicting complications following expander/implant breast reconstruction: an outcomes analysis based on preoperative clinical risk. *Plastic and reconstructive surgery*. 2008;121(6):1886-92. Epub 2008/06/04.

[4] Hartmann LC, Schaid DJ, Woods JE, Crotty TP, Myers JL, Arnold PG, et al. Efficacy of bilateral prophylactic mastectomy in women with a family history of breast cancer. *The New England journal of medicine*. 1999;340(2):77-84. Epub 1999/01/14.

[5] Herrinton LJ, Barlow WE, Yu O, Geiger AM, Elmore JG, Barton MB, et al. Efficacy of prophylactic mastectomy in women with unilateral breast cancer: a cancer research network project. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology*. 2005;23(19):4275-86. Epub 2005/03/30.

[6] Rebbeck TR, Friebel T, Lynch HT, Neuhausen SL, van 't Veer L, Garber JE, et al. Bilateral prophylactic mastectomy reduces breast cancer risk in BRCA1 and BRCA2 mutation carriers: the PROSE Study Group. *Journal of clinical oncology : official journal of the American Society of Clinical Oncology*. 2004;22(6):1055-62. Epub 2004/02/26.

[7] Rao SS, Parikh PM, Goldstein JA, Nahabedian MY. Unilateral failures in bilateral microvascular breast reconstruction. *Plastic and reconstructive surgery*. 2010;126(1):17-25. Epub 2010/07/03.

[8] Massenburg BB, Sanati-Mehrizy P, Ingargiola MJ, Rosa JH, Taub PJ. Flap Failure and Wound Complications in Autologous Breast Reconstruction: A National Perspective. *Aesthetic plastic surgery*. 2015;39(6):902-9. Epub 2015/10/22.

[9] Davison SP, Kessler CM, Al-Attar A. Microvascular free flap failure caused by unrecognized hypercoagulability. *Plastic and reconstructive surgery*. 2009;124(2):490-5. Epub 2009/08/01.

[10] Fischer JP, Cleveland EC, Nelson JA, Kovach SJ, Serletti JM, Wu LC, et al. Breast reconstruction in the morbidly obese patient: assessment of 30-day complications using the 2005 to 2010 National Surgical Quality Improvement Program data sets. *Plastic and reconstructive surgery*. 2013;132(4):750-61. Epub 2013/10/01.

[11] Garvey PB, Villa MT, Rozanski AT, Liu J, Robb GL, Beahm EK. The advantages of free abdominal-based flaps over implants for breast reconstruction in obese patients. *Plastic and reconstructive surgery*. 2012;130(5):991-1000. Epub 2012/10/26.

[12] Damen TH, Morritt AN, Zhong T, Ahmad J, Hofer SO. Improving outcomes in microsurgical breast reconstruction: lessons learnt from 406 consecutive DIEP/TRAM flaps performed by a single surgeon. *Journal of plastic, reconstructive and aesthetic surgery : JPRAS.* 2013;66(8):1032-8. Epub 2013/05/07.
[13] Lorenzetti F, Kuokkanen H, von Smitten K, Asko-Seljavaara S. Intraoperative evaluation of blood flow in the internal mammary or thoracodorsal artery as a recipient vessel for a free TRAM flap. *Annals of plastic surgery*. 2001;46(6):590-3. Epub 2001/06/19.
[14] Saint-Cyr M, Youssef A, Bae HW, Robb GL, Chang DW. Changing trends in recipient vessel selection for microvascular autologous breast reconstruction: an analysis of 1483 consecutive cases. *Plastic and reconstructive surgery*. 2007;119(7):1993-2000. Epub 2007/05/24.
[15] Nahabedian MY, Momen B, Galdino G, Manson PN. Breast Reconstruction with the free TRAM or DIEP flap: patient selection, choice of flap, and outcome. *Plastic and reconstructive surgery*. 2002;110(2):466-75; discussion 76-7. Epub 2002/07/27.
[16] Blondeel PN. One hundred free DIEP flap breast reconstructions: a personal experience. *British journal of plastic surgery*. 1999;52(2):104-11. Epub 1999/08/06.
[17] Chevray PM. Breast reconstruction with superficial inferior epigastric artery flaps: a prospective comparison with TRAM and DIEP flaps. *Plastic and reconstructive surgery*. 2004;114(5):1077-83; discussion 84-5. Epub 2004/10/01.
[18] Hamdi M, Andrades P, Thiessen F, Stillaert F, Roche N, Van Landuyt K, et al. Is a second free flap still an option in a failed free flap breast reconstruction? *Plastic and reconstructive surgery*. 2010;126(2):375-84. Epub 2010/08/04.
[19] Mohan AT, Al-Ajam Y, Mosahebi A. Trends in tertiary breast reconstruction: literature review and single centre experience. *Breast.* 2013;22(2):173-8. Epub 2012/07/17.
[20] Visser NJ, Damen TH, Timman R, Hofer SO, Mureau MA. Surgical results, aesthetic outcome, and patient satisfaction after microsurgical autologous breast reconstruction following failed implant reconstruction. *Plastic and reconstructive surgery*. 2010;126(1):26-36. Epub 2010/07/03.
[21] Hamdi M, Blondeel P, Van Landuyt K, Tondu T, Monstrey S. Bilateral autogenous breast reconstruction using perforator free flaps: a single

center's experience. *Plastic and reconstructive surgery*. 2004;114(1):83-9; discussion 90-2. Epub 2004/06/29.

[22] Levine SM, Lester ME, Fontenot B, Allen RJ, Sr. Perforator flap breast reconstruction after unsatisfactory implant reconstruction. *Annals of plastic surgery*. 2011;66(5):513-7. Epub 2011/02/09.

[23] Baumeister S, Follmar KE, Zenn MR, Erdmann D, Levin LS. Strategy for reoperative free flaps after failure of a first flap. *Plastic and reconstructive surgery*. 2008;122(3):962-71. Epub 2008/09/04.

[24] Bui DT, Cordeiro PG, Hu QY, Disa JJ, Pusic A, Mehrara BJ. Free flap reexploration: indications, treatment, and outcomes in 1193 free flaps. *Plastic and reconstructive surgery*. 2007;119(7):2092-100. Epub 2007/05/24.

[25] Wei FC, Demirkan F, Chen HC, Chuang DC, Chen SH, Lin CH, et al. The outcome of failed free flaps in head and neck and extremity reconstruction: what is next in the reconstructive ladder? *Plastic and reconstructive surgery*. 2001;108(5):1154-60; discussion 61-2. Epub 2001/10/18.

In: Breast Reconstruction
Editor: Janice Rivera ISBN: 978-1-53610-245-1

Chapter 5

DEALING WITH COMPLICATIONS AFTER FREE FLAP BREAST RECONSTRUCTION

Raluca Sobec**, Ioana Tichil and Lucian Fodor
Plastic and Reconstructive Surgery Unit, Emergency County Hospital,
Cluj Napoca, Romania

ABSTRACT

Breast reconstruction using free flaps is a procedure often performed by plastic surgeons. Like any other procedure, it is not without complications, which may occur whether it is an immediate or delayed, unilateral or bilateral reconstruction, with or without pre- or post-operative radiotherapy, in obese or smoking patients. Both the clinical setting and the surgeon's experience are closely related to the rate of these complications. Complications may imply hematomas, infections, vascular impairment, partial or total flap loss, wound dehiscence, hypertrophic scars or donor site complications. More specific to the use of microsurgical techniques are vascular complications: arterial or venous thrombosis and venous congestion.

How do we avoid complications and, if despite all methods of prevention, complications arise, how do we deal with them? The most severe and feared are vascular complications. If they occur, a challenging decision must be made: do we "watch and wait", use conservative methods to prevent impairment, or return the patient to the operating room. Timing of this decision by balancing clinical and objective findings

* Corresponding author: Email: ralucasobec@yahoo.com.

will be the focus of this chapter. For instance, hematomas can lead to external vascular obstruction, and unrecognized or delayed recognition of vascular thrombosis will lead to partial or even total flap loss. Sometimes, partial flap loss is more challenging to deal with in the long-term than total flap loss.

What we intend to highlight in this chapter are: risk factors leading to higher rates of complications, early signs of complications, ways to monitor postoperative patients, and a systematic approach to treatment.

Keywords: free flap, breast reconstruction, complication, flap failure

INTRODUCTION

Although breast reconstruction is an ever-expanding field and the overall number of procedures has increased, still less than half of mastectomy patients undergo reconstruction [1]. Breast reconstruction can be performed either as an immediate or a delayed procedure. Currently, the most common is implant-based because of the short operating time, quick recovery and no donor site complications [2]. On the other hand, autologous breast reconstruction, despite the greater risks involved, provides higher levels of patient satisfaction due to the natural shape and consistency of the reconstructed breast, along with long-lasting esthetic results [1]. A wide range of complications associated with this procedure has been reported, with rates varying across different studies. Early complications occur within 30 days [1] of the procedure, such as edema, hematoma, vascular complications, infection and wound dehiscence, whereas delayed complications occur after 30 days, such as hypertrophic scarring and donor site complications. Avoiding complications is primarily a process of thorough patient selection based on an extensive knowledge of the risk factors involved and choosing the optimal reconstructive procedure, well-timed within the clinical setting.

DEALING WITH RISK FACTORS: ANALYSES AND PROPHYLAXIS

A wide range of free flaps can be used for autologous breast reconstruction, yet the most frequently employed are the abdominal-based ones, such as the deep inferior epigastric perforators (DIEP) flap, the muscle-sparing transverse rectus abdominis muscle (TRAM) flap, and the TRAM flap. Risk factors implicated in performing these procedures have been extensively researched and varying data have been reported. Risk factors can be either patient- or procedure-related.

Patient-Related Risk Factors

Radiation

Pre- and post-operative radiation therapy has been implicated in vessel damage and impaired wound healing. To date, several reports have quantified the impact of radiation therapy on free flap breast reconstruction. In a cohort study involving 199 patients, Fracol et al. reported an increase in intraoperative vascular complications (14% vs 7%) as well as wound infections (4% vs 0.5%), but no significant difference in postoperative thrombosis, flap loss, mastectomy flap necrosis, hematoma, seroma, fat necrosis or wound healing in irradiated vs non-irradiated sites [3]. Kelly et al. suggested that immediate free flap breast reconstruction can be considered even when post-mastectomy radiation therapy is involved [4]. Mirzakeigi et al. raised concerns of volume loss and fat necrosis, but did not advise against immediate reconstruction [5].

Chemotherapy

While it has not been implicated in flap loss and microvascular impairment, chemotherapy has been known to increase overall complications, such as wound healing and fat necrosis. Timing of chemotherapy does not significantly affect outcome [6].

Smoking

Smoking causes nicotine-induced vasospasm, tissue hypoxia due to elevated carbon monoxide, and increased platelet aggregation leading to hypercoagulability status which can cause flap vascularity impairment and donor site morbidity. Cessation of smoking must occur at least four weeks prior to surgery [7]. Smokers have twice the chance of developing donor site complications after DIEP flap harvesting for breast reconstruction compared to non-smokers [8].

Obesity/BMI

A BMI of over 30 independently increases the overall risk of complications due to prolonged intraoperative time, technical difficulties, and associated comorbidities [6]. Some surgeons advise their patients with a BMI of over 30 to lose weight before breast reconstruction surgery with free flaps [9].

Age

Increasing age is usually associated with other medical comorbidities, implicated in overall poorer surgical outcomes. However, complication rates, including vascular thrombosis following autologous breast reconstruction, do not appear to be significantly higher, leading to the conclusion that age is not an independent risk factor and elderly patients, if fit, can benefit from free flap breast reconstruction [10].

Medical Comorbidities

Diabetes and hypertension impact blood vessels structurally and functionally, leading to a higher possibility of both minor and major complications. Good control of glycemic and blood pressure values is mandatory.

Mastectomy Type

Skin-sparing mastectomies (SSM) and nipple-sparing mastectomies (NSM) present the obvious advantage of retaining the original skin envelope and use the free flap to recreate the volume and shape of the breast with good final overall esthetic results. However, they provide difficult access to the internal mammary vessels, which may lead to unforeseen vascular complications. On the other hand, in the case of both SSM and NSM, an implant-based type of reconstruction is usually preferred. This may sometimes lead to unsatisfactory results and salvage procedures, including reconstruction with autologous tissue, may be required to correct them. In a recently published study, Roostaeian et al. found that capsular contracture was incriminated in 62% of cases of implant removal. Accompanying high rates of radiation therapy also lead to recipient vessel scarring 5.23 times more often. This led them to conclude that major complications are more likely to occur when performing salvage reconstruction. However, the procedure can be safely performed with additional preoperative planning with success rates similar to primary flap-based reconstructions [2].

Prior Abdominal Surgery

Abdominal scars raise the question of viable perforators. Adequate preoperative assessment using computed tomography angiography is most useful. Intraoperative bipedicled perforator flaps or supercharging across scars can allow the usage of large volumes of tissue crossing the midline. However, when in doubt, muscle-sparing TRAM flaps are recommended [11].

Nulliparity

Santanelli et al. recently related nulliparity to several perfusion-related complications (PRC), including fat necrosis and partial flap loss, due to a weaker pattern of perforators, as well as smaller angiosomes. Their recommendation for PRC risk reduction is the use of medial row perforators combined with crystalloid/colloid fluid infusion [12].

PROCEDURE-RELATED RISK FACTORS

VTE Prophylaxis

Venous thromboembolism prophylaxis can be achieved based on accurate risk assessment by physical measures, using compression stockings, intermittent calf compression, and low molecular weight heparin on the day prior to surgery. The use of anticoagulants is a much-debated topic. The recent reduced operative times and complication rates, as well as the employment of perforator flaps, has led to faster mobilization, which has made for fewer combined antithrombotic regimens. Recent studies highlight the risk that multiple antithrombotics increase the hematoma reoperation rate [13].

Anesthetic Management

Anesthetic management should aim to provide a high cardiac output with a systolic blood pressure over 100mmHg, low peripheral vascular resistance, normothermia, excellent analgesia and good urine output, as well as mild hemodilution Hematocrit: 30-35% [14], and ensure good flap perfusion. Optimal intraoperative fluid management should adequately provide all of the above. However, overzealous fluid administration targeting supranormal blood pressure values is not recommended, for it will result in interstitial edema which could compromise blood flow and gas exchange at flap microcirculation levels [13]. On the other hand, fluid under-resuscitation may place the patient at risk for postoperative flap thrombosis [15]. It is also recommended that vasoconstrictive drugs should be avoided.

Timing of Reconstruction

There is a consensus in the literature that immediate reconstruction lowers the overall number of procedures, hospital stays, and medical system costs, thereby providing the patient with the best possible outcome and limiting complication rates. It has been agreed that reconstruction can be safely performed even when radiotherapy is involved [3-5]. When performing delayed reconstruction, however, we must rely on mastectomy skin flaps which are mostly scarred, contracted and far less compliant, as well as face higher rates of vascular complications [16].

Free Flap Choice

Generally, for free flap breast reconstruction, abdominal-based flaps, such as DIEP and TRAM flaps, are preferred. They have proved to be safe and reliable with well-documented donor site morbidity. Lately, with the progression of microsurgical techniques and postoperative monitoring, DIEP flaps have become the reconstructive method of choice, due to the lower risk of abdominal bulge and hernia when compared with free TRAM flaps [9]. Another abdominal flap which was described for breast reconstruction is the superficial inferior epigastric artery (SIEA) flap. Although less common and mostly reserved for patients who either require a small-sized breast reconstruction or have insufficient abdominal tissue or extensive abdominal scarring, free flaps from the thigh or buttock can also be used. Such flaps are the superior gluteal artery perforator (SGAP), the inferior gluteal artery perforator (IGAP), the fasciocutaneous infragluteal (FCI), the transverse upper gracilis (TUG), and the profunda artery perforator (PAP) flaps. However, fairly recent employment of these flaps has not led to extensive literature documenting complications and outcomes, compared to abdominal-based free flap breast reconstruction.

Intraoperative Management

Technical issues resulting in arterial thrombosis or venous insufficiency have been known to be dominant factors in overall flap failure rates. Most notably, operative time has been proved to be an independent risk factor for flap loss [17]. Operative time can be prolonged for various reasons: combined mastectomy and reconstructive procedures, especially if bilateral, high complexity and technical difficulty in secondary procedures due to extensive scarring impacting both flap harvest and anastomoses, and/or surgeon inexperience with microsurgery. Ways to minimize operative time include having experienced surgeons perform the procedure, two teams working simultaneously, good preoperative mapping of perforators used for safe and expedited flap harvest, use of microvascular anastomotic coupler for venous anastomoses, and the employment of mechanical sutures for subcutaneous wound closure. Ultimately, ischemia time is an important consideration when discussing microvascular complications, as well as a good predictor of flap outcome [17]. Morris et al. studied changes in flaps submitted to 4, 6, and 8h of ischemia and noticed a significant extent of necrosis when compared with controls, leading them to conclude that an ischemia time no longer than 2h is desirable [18]. Prolonged ischemia time has also been associated with microvascular thrombosis and venous congestion in flaps with adequate perforators. It has been hypothesized that metabolic and structural changes occur within blood vessels during ischemia, and reperfusion further traumatizes the anastomosis site [19].

The internal mammary vessels are frequently used as recipient vessels for free flap breast reconstruction. There are studies showing the presence of tachycardia related to internal mammary vessels anastomoses [20]. Some studies did not find higher complication rates in patients who developed the internal mammary artery tachycardia syndrome [20], but others noticed an increased incidence of complications, such as vascular impairment, venous thrombosis or wound healing related problems [21].

Blood Loss and Transfusions

Anemia and hypovolemia have been known to complicate procedure outcome, patient morbidity and overall recovery. Currently, it is largely accepted that blood transfusions after free flap breast surgery should be administered based on clinical signs of hypovolemia and hemoglobin levels less than 7g/dl. This is most likely to occur in cases of bilateral reconstruction and preoperative anemia. However, blood transfusions are regarded with much skepticism, due to possible involvement of increased microvascular complication rates. The bottom line is that intraoperative efforts must be made to limit blood loss, and adequate perioperative fluid resuscitation must be conducted in order to efficiently avoid hypovolemia.

DEALING WITH COMPLICATIONS

Postoperative Monitoring

The first 72 hours after free flap breast reconstructions are when microvascular complications arise; therefore, close monitoring is mandatory, hourly during the first 24 hours and three-hourly for the next two days. It is well established that early detection and prompt reoperation of perfusion problems can increase flap salvage. Surgeons and their Residents, as well as trained specialized nursing staff, must conduct clinical observation. The color, consistency, temperature and capillary refill of the flap need to be recorded, along with continuous drain monitoring. Recently, objective tools have been used to increase diagnostic accuracy, such as implantable and surface Doppler monitoring, quantitative fluorescence, near-infrared spectrophotometry, visible light spectroscopy, thermography, transcutaneous oxygen measurements, and microanalysis [22]. However, to date no one method has been found to be ideal and various factors may interfere in clinical findings, so that objective measurements must be balanced along with the surgeon's experience when making the decision to take the patient back to the operating room. Such early complications requiring early detection and timely intervention are:

Edema

Postoperative edema that was not present intraoperatively could have many causes, such as an inflammatory byproduct of flap manipulation or a sign of fluid overload, or an early sign of perfusion problems [14, 19]. It must be carefully monitored and interpreted along with other clinical findings, such as flap color, temperature and capillary refill. If prolonged flap edema produces harmful pressure on the anastomosis site leading to microvascular complications, this can by eased by selective removal of sutures and prompt revision of the fluid chart.

Hematoma

Whether it appears from a flap bleeding source or from an anterior thoracic wall bleeding source, being in the microsurgical anastomosis neighborhood, before or after drains removal, makes a hematoma a serious threat for the proper arterial inflow and venous outflow of the flap. Any compression of the flap's pedicle may lead to partial or total loss of the flap. There are studies highlighting surgical management of a hematoma as high as 13%, not only to remove the hematoma, but also to correct the secondary complications: venous congestion or flap thrombosis [13].

Hematoma in the reconstructed breast is not an often seen complication, usually ranging from 2.89-4.4% [9, 23, 24]. A higher incidence of breast hematoma was encountered after double free flap breast reconstruction [24].

Microvascular Complications

Microvascular complications are probably the worst and the most frightening complications for the Plastic Surgeon. These kinds of complications are the easiest way to lose a flap, and a high percentage are due to the surgeon's microsurgical skills. When referring to microvascular complications, we include arterial and venous thrombosis and also venous congestion.

Tamoxifen, a selective estrogen-receptor modulator frequently used in breast cancer patients, was debated for a long time regarding its possible prothrombotic effect on free flap breast reconstruction. Some authors considered tamoxifen to be a thrombotic risk factor, others considered that the prothrombotic effect would be minimized by stopping the tamoxifen two weeks prior to free flap breast reconstruction surgery [25], and others did not consider it as affecting in any way the thrombotic complications of the flap [26]. We prefer to reduce as much as possible any thrombotic risks, so we tell our patients to withhold the tamoxifen for two weeks before free flap breast reconstruction surgery.

Arterial Thrombosis

Clinical aspects of arterial thrombosis include a pale and cold flap, absent capillary refill, or absent Doppler signal at the perforator site. Arterial thrombosis may appear intraoperatively, immediate or late postoperatively. No matter when it happens, it is an emergency and needs re-exploration of the anastomosis in an attempt to save the flap. If the flap cannot be saved after re-exploration of the anastomosis, it needs to be removed.

It is also known that intraoperative microanastomotic technical problems are associated with higher delayed arterial thrombosis [27]. Arterial thrombosis can lead to partial or even total flap loss. In a study on 169 free flap breast reconstruction with DIEP flaps (125 cases) and SIEA (44 cases), Coroneos et al. concluded that higher rates of arterial thrombosis were met in SIEA flap breast reconstruction compared with DIEP flap [28]. Lower SIEA free flap success rates were found in other studies, too, compared with DIEP free flaps, with total necrosis of the flaps as high as 12% [29].

Venous Congestion

Venous congestion occurs intraoperatively in 3.3% of DIEP flaps and 1% of TRAM flaps [30]. Lower incidences are related to secondary venous anastomosis (frequently superficial inferior epigastric vein to cephalic vein) [29]. During abdominal-based flap dissection, the superficial venous system is interrupted, and it is up to the deep venous system to provide adequate drainage. Venous insufficiency is not a routine issue on the ipsilateral side, but problems may arise concerning the contralateral side because of restricted drainage across the midline [23]. If noticed intraoperatively, venous congestion must be addressed. Solutions vary from simple to complex. In the case of DIEP flaps, most used is the second DIE vena comitante which can be anastomosed to the second internal mammary vein. It is not advisable to use the distal stump of the IM vein because it may have valves. If this does not provide sufficient relief, the superficial inferior epigastric vein (SIEV) usually preserved during flap dissection can either be anastomosed to the main pedicle or to the cephalic, circumflex scapular or toracodorsal vein, according to the surgeon's preference. If neither vein can be used, the contralateral DIE venous system or the cephalic end of the ipsilateral DIE vein can be considered as options. If no additional procedures offer sufficient relief, flap reduction must be considered [22].

Authors have reported a reduction of venous congestion incidence by primarily performing two venous anastomoses; however, this has not become routine practice [31]. If no venous congestion is noted intraoperatively but it occurs postoperatively, it requires urgent exploration of the venous anastomosis and, if viable, performing a secondary anastomosis to relieve outflow is advised. In selected cases of mild venous congestion, conservative measures may apply, such as leach therapy or the topical use of nitroglycerine [32].

Venous Thrombosis

Venous thrombosis occurs more often than arterial thrombosis with reported rates as high as 10% [33] and has higher salvage rates [34]. Clinical findings are similar to venous congestion: edema, bluish discoloration, accelerated capillary refill. Urgent exploration of the venous anastomoses must be conducted. Early detection has been reported with the use of an implantable Doppler probe and venous flow coupler [35].

Infection

As in any other infection, the clinical signs are edema, erythema and local warmth, induration, possibly the presence of pus. Treatment ranges from oral antibiotics to intravenous antibiotics, depending on the severity of the infection. Sometimes surgical debridement might be necessary. Fortunately, low incidences of flap infection are encountered [23]. Compared with bilateral free flap breast reconstruction, the incidence of infections seems to be higher in unilateral free flap breast reconstruction [24].

Wound Dehiscence

Wound dehiscence is secondary to local infection or marginal necrosis, with or without partial flap loss. Surgical debridement is usually necessary, followed by secondary wound closure. In small wound dehiscence, conservative management might be sufficient for a good result. In case of wound dehiscence secondary to local infection, antibiotic treatment must be added.

PERFUSION-RELATED COMPLICATIONS

Fat Necrosis

Fat necrosis is a well-established perfusion-related complication that has been known to occur in up to 19.1% of cases [36]. There is general consensus that, if it occurs, fat necrosis should be managed conservatively, and any contour defects can be addressed at a later date by using fat grafting. Preventing such complications, however, has been the focus of much research. Recently, Lee et al. suggested that preoperative volumetric planning using computerized tomographic angiography can aid in decreasing perfusion-related complications [36].

Flap Failure

Current flap failure rates reported by specialized centers range from 0.5% to 2.5% [9, 23], with partial flap failure rates higher than total flap failure. Leading causes are venous congestion and thrombosis [9, 23, 37]. Flap failure is a major setback in patient care with a negative impact on the patient's psychological status. Therefore, adequate counseling and support must be provided. Also, it adds to overall costs, increases hospital stay, and raises the need for a further procedure. For all these reasons, strenuous efforts must be made to identify the cause of flap failure, as such cases can provide valuable lessons. The questions are: was it failure to plan, failure to execute, failure to monitor, or the association of multiple risk factors.

Accurately identifying the cause can improve future conduct and influence further reconstructive decisions. For instance, cases of essential thrombocytosis or thrombophilia [23, 38] have been diagnosed post flap failure and this has guided the decision of further performing an implant-based breast reconstruction instead of another free flap. Both partial and total flap loss must be managed with early debridement in order to prevent infection and salvage as much viable tissue as possible. In the case of primary reconstruction post skin-sparing mastectomy, skin flaps can provide sufficient wound coverage for primary closure and allow for delayed reconstruction. Other options would be to consider another free flap from the thigh or buttock and attempt a primary reconstruction, or to perform an implant-based reconstruction with a *latissimus dorsi* (LD) flap. On the other hand, for delayed reconstructions in case of flap failure, there is not enough skin to primarily close the wound after debridement and, in order to avoid using a skin graft, another free flap reconstruction should be considered, as well as an LD flap.

Donor Site Complications

These generally include seroma, hematoma formation, infection, delayed wound healing and scarring. More specific to the use of abdominal-based free flaps for breast reconstruction are mesh complications, hernia and abdominal bulge. Morbidity associated with thigh and buttock based flaps is related to long-term contour defects that may represent a challenge in correcting. In this regard, least impairing, in our opinion, is the FCI flap when small to medium volumes are employed for breast reconstruction in patients with insufficient abdominal tissue, leading to high levels of patient satisfaction.

Recently, Mirzabeigi et al. reviewed an under-reported complication of abdominal-based free flaps: chronic wound healing. In a study reviewing 1218 patients, they found 13.7% cases of delayed wound healing, which was related to abdominal wall sequelae, such as hernia. Risk factors for delayed wound healing at 30 days leading to chronic abdominal wounds were found to be obesity, smoking, bilateral reconstruction, preoperative chemotherapy, and the use of abdominal mesh. Their recommendation in dealing with this complication was to perform early postoperative debridement and primary wound closure in order to improve patient outcomes [39].

Scarring

Body image is very important when talking about self-esteem. Scars are part of a patient's life after any surgery. When talking about scars after breast reconstruction, we need to deal with scars at the place of reconstruction and at the donor site. Studies show that patients usually prefer donor site scars for breast reconstruction in a body area that they do not see [40, 41]. For example, the LD flap scar was preferred over the DIEP flap scar [41]; even better, the SGAP scar was preferred over the DIEP flap scar [40].

On the other hand, when talking about post breast reconstruction scars, more than half the patients prefer the scar after immediate DIEP flap reconstruction, compared with LD, expander/implant or delayed DIEP flap reconstruction [40].

Like any other scars, these scars might transform into hypertrophic or, even worse, keloid scars. The methods of treatment for these pathologic scars vary from surgical treatment to intralesional corticosteroid injections, laser therapy, silicone sheet, radiotherapy or a combination of these methods.

Other Complications

Other rare complications have been encountered when dealing with free flap breast reconstruction methods. Internal mammary artery tachycardia syndrome was described in those patients in whom the anastomosis of the flap's pedicle was performed at the internal mammary vessels. This tachycardia syndrome was more frequent in cases of anastomosis to the internal mammary vessels compared to the thoracodorsal vessels (58% vs 23%) [20]. A case of cardiac tamponade followed by cardiac arrest was reported, secondary to left internal mammary vessels isolation for microsurgical anastomosis for breast reconstruction [42].

CONCLUSION

When an acute thrombotic event is identified early in the first few hours after surgery, we are in favor of trying a salvage procedure. However, when late onset of thrombosis is identified or unrecognized, in our experience all efforts at salvage are in vain and only put the patient under stress.

REFERENCES

[1] Duraes, E. F., Schwarz, G., Durand, P., Moreira-Gonzalez, A., Duraes, L. C., de Sousa, J. B., Djohan, R. S., Zins, J. and Bernard, S. L. (2015). Complications Following Abdominal-Based Free Flap Breast Reconstruction: Is a 30 days Complication Rate Representative? *Aesthetic Plast Surg.*, *39*(5), 694-9.

[2] Roostaeian, J., Yoon, A. P., Ordon, S., Gold, C., Crisera, C., Festekjian, J., Da Lio, A. and Lipa, J. E. (2016). Impact of Prior Tissue Expander/Implant on Postmastectomy Free Flap Breast Reconstruction. *Plastic and reconstructive surgery.*, *137*(4), 1083-91.

[3] Fracol, M. E., Basta, M. N., Nelson, J. A., Fischer, J. P., Wu, L. C., Serletti, J. M. and Fosnot, J. (2016). Bilateral Free Flap Breast Reconstruction After Unilateral Radiation: Comparing Intraoperative Vascular Complications and Postoperative Outcomes in Radiated Versus Nonradiated Breasts. *Annals of plastic surgery.*, *76*(3), 311-4.

[4] Kelley, B. P., Ahmed, R., Kidwell, K. M., Kozlow, J. H., Chung, K. C. and Momoh, A. O. (2014). A systematic review of morbidity associated with autologous breast reconstruction before and after exposure to radiotherapy: are current practices ideal? *Ann Surg Oncol.*, *21*(5), 1732-8.

[5] Mirzabeigi, M. N., Smartt, J. M., Nelson, J. A., Fosnot, J., Serletti, J. M. and Wu, L. C. (2013). An assessment of the risks and benefits of immediate autologous breast reconstruction in patients undergoing

postmastectomy radiation therapy. *Annals of plastic surgery.*, *71*(2), 149-55.

[6] Voineskos, S. H., Frank, S. G. and Cordeiro, P. G. (2015). Breast reconstruction following conservative mastectomies: predictors of complications and outcomes. *Gland Surg.*, *4*(6), 484-96.

[7] Chang, D. W., Reece, G. P., Wang, B., Robb, G. L., Miller, M. J., Evans, G. R., Langstein, H. N. and Kroll, S. S. (2000). Effect of smoking on complications in patients undergoing free TRAM flap breast reconstruction. *Plastic and reconstructive surgery.*, *105*(7), 2374-80.

[8] Klasson, S., Nyman, J., Svensson, H. and Velander, P. (2016). Smoking increases donor site complications in breast reconstruction with DIEP flap. *Journal of plastic surgery and hand surgery*, 1-5.

[9] Seidenstuecker, K., van Waes, C., Munder, B. I., Claes, K. E., Witzel, C., Roche, N., Stillaert, F., Mahajan, A. L., Andree, C. and Blondeel, P. N. (2016). DIEAP flap for safe definitive autologous breast reconstruction. *Breast.*, *26*, 59-66.

[10] Song, D., Slater, K., Papsdorf, M., Van Laeken, N., Zhong, T., Hazen, A., Vidal, D. and Macadam, S. A. (2016). Autologous Breast Reconstruction in Women Older Than 65 Years Versus Women Younger Than 65 Years: A Multi-Center Analysis. *Annals of plastic surgery.*, *76*(2), 155-63.

[11] Nykiel, M., Hunter, C. and Lee, G. K. (2015). Algorithmic approach to the design and harvest of abdominal flaps for microvascular breast reconstruction in patients with abdominal scars. *Annals of plastic surgery.*, *74* Suppl 1, S33-40.

[12] Santanelli, F., Longo, B., Cagli, B., Pugliese, P., Sorotos, M. and Paolini, G. (2015). Predictive and protective factors for partial necrosis in DIEP flap breast reconstruction: does nulliparity bias flap viability? *Annals of plastic surgery.*, *74*(1), 47-51.

[13] Halle, M., Docherty Skogh, A. C., Friberg, A. and Edsander-Nord, A. (2016). Breast free flap complications related to haematoma formation - do the risks of multiple antithrombotics outweigh the benefits today? *Journal of plastic surgery and hand surgery*, 1-5.

[14] Booi, D. I. (2011). Perioperative fluid overload increases anastomosis thrombosis in the free TRAM flap used for breast reconstruction. *European journal of plastic surgery.*, *34*(2), 81-6.

[15] Nelson, J. A., Fischer, J. P., Grover, R., Mirzabeigi, M. N., Nelson, P., Wes, A. M., Au, A., Serletti, J. M. and Wu, L. C. (2015). Intraoperative perfusion management impacts postoperative outcomes: an analysis of

682 autologous breast reconstruction patients. *Journal of plastic*, *reconstructive and aesthetic surgery: JPRAS.*, *68*(2), 175-83.

[16] Masoomi, H., Clark, E. G., Paydar, K. Z., Evans, G. R., Nguyen, A., Kobayashi, M. R. and Wirth, G. A. (2014). Predictive risk factors of free flap thrombosis in breast reconstruction surgery. *Microsurgery.*, *34*(8), 589-94.

[17] Wong, A. K., Joanna Nguyen, T., Peric, M., Shahabi, A., Vidar, E. N., Hwang, B. H., Niknam Leilabadi, S., Chan, L. S. and Urata, M. M. (2015). Analysis of risk factors associated with microvascular free flap failure using a multi-institutional database. *Microsurgery.*, *35*(1), 6-12.

[18] Morris, S. F., Pang, C. Y., Zhong, A., Boyd, B. and Forrest, C. R. (1993). Assessment of ischemia-induced reperfusion injury in the pig latissimus dorsi myocutaneous flap model. *Plastic and reconstructive surgery.*, *92*(6), 1162-72.

[19] Marre, D. and Hontanilla, B. (2013). Increments in ischaemia time induces microvascular complications in the DIEP flap for breast reconstruction. *Journal of plastic*, *reconstructive and aesthetic surgery: JPRAS.*, *66*(1), 80-6.

[20] Sachanandani, N. S., Kale, S. S., Skolnick, G. B., Barbour, J. R. and Myckatyn, T. M. (2015). Tachycardia in breast reconstructive microsurgery: Affirmation of the IMA tachycardia syndrome. *Journal of plastic*, *reconstructive and aesthetic surgery: JPRAS.*, *68*(6), 787-91.

[21] Fischer, J. P., Nelson, J. A., Mirzabeigi, M. N., Serletti, J. M. and Kanchwala, S. (2012). Perioperative hemodynamics in free flap breast reconstruction: incidence, predictors, and management of tachycardia. *Annals of plastic surgery.*, *69*(4), 356-60.

[22] Ozturk, C. N., Ozturk, C., Ledinh, W., Bozkurt, M., Schwarz, G., O'Rourke, C. and Djohan, R. (2015). Variables affecting postoperative tissue perfusion monitoring in free flap breast reconstruction. *Microsurgery.*, *35*(2), 123-8.

[23] Damen, T. H., Morritt, A. N., Zhong, T., Ahmad, J. and Hofer, S. O. (2013). Improving outcomes in microsurgical breast reconstruction: lessons learnt from 406 consecutive DIEP/TRAM flaps performed by a single surgeon. *Journal of plastic*, *reconstructive and aesthetic surgery : JPRAS.*, *66*(8), 1032-8.

[24] Wormald, J. C., Wade, R. G. and Figus, A. (2014). The increased risk of adverse outcomes in bilateral deep inferior epigastric artery perforator flap breast reconstruction compared to unilateral reconstruction: a

systematic review and meta-analysis. *Journal of plastic*, *reconstructive and aesthetic surgery: JPRAS.*, *67*(2), 143-56.

[25] Mirzabeigi, M. N., Nelson, J. A., Fischer, J. P., Kovach, S. J., Serletti, J. M., Wu, L. C. and Kanchwala, S. (2015). Tamoxifen (selective estrogen-receptor modulators) and aromatase inhibitors as potential perioperative thrombotic risk factors in free flap breast reconstruction. *Plastic and reconstructive surgery.*, *135*(4), 670e-9e.

[26] Salibian, A. A., Bokarius, A. V., Gu, J., Lee, Y., Wirth, G. A., Paydar, K. Z., Kobayashi, M. R. and Evans, G. R. (2016). The Effects of Perioperative Tamoxifen Therapy on Microvascular Flap Complications in Transverse Rectus Abdominis Myocutaneous/Deep Inferior Epigastric Perforator Flap Breast Reconstruction. *Annals of plastic surgery*.

[27] Fosnot, J., Jandali, S., Low, D. W., Kovach, S. J., 3rd, Wu, L. C. and Serletti, J. M. (2011). Closer to an understanding of fate: the role of vascular complications in free flap breast reconstruction. *Plastic and reconstructive surgery.*, *128*(4), 835-43.

[28] Coroneos, C. J., Heller, A. M., Voineskos, S. H. and Avram, R. (2015). SIEA versus DIEP Arterial Complications: A Cohort Study. *Plastic and reconstructive surgery.*, *135*(5), 802e-7e.

[29] Acosta, R., Smit, J. M., Audolfsson, T., Darcy, C. M., Enajat, M., Kildal, M. and Liss, A. G. (2011). A clinical review of 9 years of free perforator flap breast reconstructions: an analysis of 675 flaps and the influence of new techniques on clinical practice. *Journal of reconstructive microsurgery.*, *27*(2), 91-8.

[30] Kim, D. Y., Lee, T. J., Kim, E. K., Yun, J. and Eom, J. S. (2015). Intraoperative venous congestion in free transverse rectus abdominis musculocutaneous and deep inferior epigastric artery perforator flaps during breast reconstruction: A systematic review. *Plast Surg (Oakv).*, *23*(4), 255-9.

[31] Enajat, M., Rozen, W. M., Whitaker, I. S., Smit, J. M. and Acosta, R. (2010). A single center comparison of one versus two venous anastomoses in 564 consecutive DIEP flaps: investigating the effect on venous congestion and flap survival. *Microsurgery.*, *30*(3), 185-91.

[32] Gdalevitch, P., Van Laeken, N., Bahng, S., Ho, A., Bovill, E., Lennox, P., Brasher, P. and Macadam, S. (2015). Effects of nitroglycerin ointment on mastectomy flap necrosis in immediate breast reconstruction: a randomized controlled trial. *Plastic and reconstructive surgery.*, *135*(6), 1530-9.

[33] Nahabedian, M. Y., Momen, B., Galdino, G. and Manson, P. N. (2002). Breast Reconstruction with the free TRAM or DIEP flap: patient selection, choice of flap, and outcome. *Plastic and reconstructive surgery.*, *110*(2), 466-75, discussion 76-7.

[34] Bui, D. T., Cordeiro, P. G., Hu, Q. Y., Disa, J. J., Pusic, A. and Mehrara, B. J. (2007). Free flap reexploration: indications, treatment, and outcomes in 1193 free flaps. *Plastic and reconstructive surgery.*, *119*(7), 2092-100.

[35] Um, G. T., Chang, J., Louie, O., Colohan, S. M., Said, H. K., Neligan, P. C. and Mathes, D. W. (2014). Implantable Cook-Swartz Doppler probe versus Synovis Flow Coupler for the post-operative monitoring of free flap breast reconstruction. *Journal of plastic, reconstructive and aesthetic surgery: JPRAS.*, *67*(7), 960-6.

[36] Lee, K. T. and Mun, G. H. (2016). Volumetric Planning Using Computed Tomographic Angiography Improves Clinical Outcomes in DIEP Flap Breast Reconstruction. *Plastic and reconstructive surgery.*, *137*(5), 771e-80e.

[37] Massenburg, B. B., Sanati-Mehrizy, P., Ingargiola, M. J., Rosa, J. H. and Taub, P. J. (2015). Flap Failure and Wound Complications in Autologous Breast Reconstruction: A National Perspective. *Aesthetic Plast Surg.*, *39*(6), 902-9.

[38] Senchenkov, A., Lemaine, V. and Tran, N. V. (2015). Management of perioperative microvascular thrombotic complications - The use of multiagent anticoagulation algorithm in 395 consecutive free flaps. *Journal of plastic, reconstructive and aesthetic surgery: JPRAS.*, *68*(9), 1293-303.

[39] Mirzabeigi, M. N., Wilson, A. J., Fischer, J. P., Basta, M., Kanchwala, S., Kovach, S. J., Serletti, J. M. and Wu, L. C. (2015). Predicting and managing donor-site wound complications in abdominally based free flap breast reconstruction: improved outcomes with early reoperative closure. *Plastic and reconstructive surgery.*, *135*(1), 14-23.

[40] Joyce, C. W., Murphy, S., Kelly, J. L. and Morrison, C. M. (2015). Scar Wars: Preferences in Breast Surgery. *Archives of plastic surgery.*, *42*(5), 596-600.

[41] Lindegren, A., Halle, M., Docherty Skogh, A. C. and Edsander-Nord, A. (2012). Postmastectomy breast reconstruction in the irradiated breast: a comparative study of DIEP and latissimus dorsi flap outcome. *Plastic and reconstructive surgery.*, *130*(1), 10-8.

[42] Pratt, G. F., Faris, J. G., Lethbridge, M. and Teh, L. G. (2009). Breast reconstruction with a free DIEP (TRAM) flap complicated by cardiac tamponade and arrest: a case report. *Journal of plastic*, *reconstructive and aesthetic surgery: JPRAS.*, *62*(3), e73-5.

In: Breast Reconstruction
Editor: Janice Rivera
ISBN: 978-1-53610-245-1

Chapter 6

MANAGING COMPLICATIONS IN FREE-FLAP BREAST RECONSTRUCTION

Gordon K. Lee[1], Jarom N. Gilstrap[1] and Jennifer E. Cheesborough[2]
[1]Plastic Surgery at Stanford University,
Stanford, CA, US
[2]Northwestern University,
Evanston, IL, US

ABSTRACT

Breast cancer treatment remains on the forefront of healthcare in the United States, affecting nearly one in eight women in their lifetime [1]. With increasing awareness and policy changes, such as the Women's Health and Cancer Rights Act of 1998 [2], breast reconstruction rates have continuously climbed over the last two decades, a nearly 35% increase since 2000 [3]. Breast reconstruction with free autologous tissue, gaining widespread popularity in the 1990's, can provide a natural, aesthetic breast shape while avoiding many of the pitfalls associated with implant-based reconstruction [4-6]. The number of available donor sites and flap types has also increased dramatically in recent years. Today, autologous tissue constitutes close to 20% of breast reconstruction [7].

CONSIDERATIONS FOR FREE-FLAP RECONSTRUCTION

There is no one "best" method for breast reconstruction, as evidenced by the variety of methods seen in practice today. However, there may be a "perfect" method for an individual patient. Appreciating several factors when deciding on the method of reconstruction is critical. Among these are:

- *Patient factors*- obesity and other comorbid conditions, bleeding disorders, tobacco use, available donor tissue, lifestyle, previous surgery, recreational and occupational activities, preference, and need for adjuvant therapy.
- *Surgeon/Facility factors*- Surgeon training/background and comfort with microsurgical practices, availability of operating room equipment, personnel and adequate post-operative monitoring.
- *Mastectomy and incision type*- Traditional modified radical mastectomy, skin-sparing mastectomy, nipple-sparing mastectomy (including incision for approach) and surgical technique of extirpative surgeon.

TIMING

The timing of reconstruction plays a role in outcomes. Immediate autologous reconstruction is usually reserved for patients with early stage cancer who do not require post-operative radiation. Several studies have demonstrated the benefits of reconstruction for the breast cancer patient's body image and quality of life [8, 9]. Delayed reconstruction is usually recommended for patients who will require radiation, although this remains controversial. Delayed reconstruction is also indicated for those patients who underwent mastectomy at a center that does not have a plastic surgeon available for immediate reconstruction, those who have lost their implant-based reconstruction due to infection, and for patients who elected to postpone their reconstruction in order to begin adjuvant therapy. Compared with the aesthetic results obtained from immediate reconstructions in which the majority of the breast skin is maintained, delayed reconstructions yield modest results [10-12]. More recently, a delayed-immediate approach has been developed for individuals with intermediate disease whose radiotherapy needs are undetermined prior to mastectomy and lymph node assessment [13].

RISK FACTORS

Several factors have been linked to increased risk of complication in free tissue-based reconstruction. Factors include: Smoking [14], obesity [15-18], diabetes [19], breast size, bleeding disorders, and previous abdominal surgery [20, 21].

COMPLICATIONS AND MANAGEMENT

Understanding the diagnosis and management options of free flap complications is vital to patient care. Complications will be divided into three categories and discussed in depth:

Complications Related to Reconstructed Breast

Anastomotic failure, total free flap loss, partial flap loss [22-24], fat necrosis [25], mastectomy flap necrosis, hematoma, seroma, infection, pneumothorax

Complications Related to Donor Site

Hematoma, seroma, delayed wound healing, dehiscence, abdominal skin flap necrosis, numbness/altered sensation, abdominal wall weakness, hernia [26, 27]

Complications Related to Prolonged Surgical Time

Myocardial infarction, cerebrovascular accident, venous thromboembolism, pressure ulcers, compressive neuropathies

COMPLICATIONS RELATED TO THE RECONSTRUCTED BREAST

Anastomotic Failure

Creation of a patent microsurgical anastomosis is a skill requiring practice and refinement, however, even the most experienced microsurgeon will occasionally experience problems with a vessel requiring revision. A published failure rate of 3-5% means that if one does enough free flaps, one will eventually fail (Figure 1).

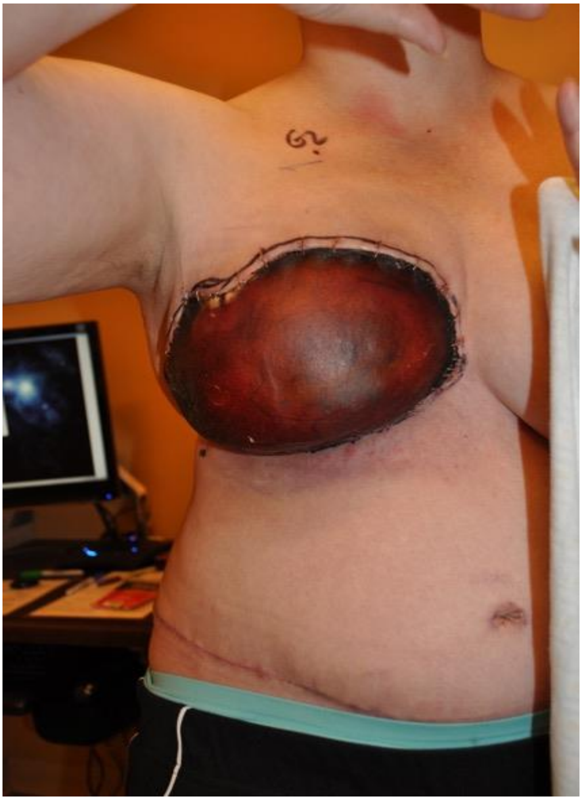


Figure 1. Total flap loss.

Diagnosis

Anastomotic failure can be either arterial or venous in origin and can be subdivided into complete occlusion or insufficient flow. Arterial occlusion is diagnosed clinically as a pale, cool flap with poor turgor (Figure 2), whereas a venous problem will manifest as a swollen, purple flap with rapid capillary refill and brisk, dark bleeding (Figure 3). Timing is key and early recognition of vascular compromise is vital to flap salvage (Figures 4 and 5). These issues can be identified in the operating room or may not be apparent until the post-operative period. Thrombosis typically occurs within the first 48 hours in 80% of patients. Monitoring the free flap during the postoperative phase is critical to ensuring flap survival in the event of anastomotic failure. When recognized early and managed promptly, compromised flaps have a 75% salvage rate when taken back to the operating room. Thus, all personnel responsible for flap monitoring must be knowledgeable about the appearance and evaluation of the healthy and compromised flap.

Figure 2. Arterial insufficiency presents as a pale flap with poor turgor and slow capillary refill. Be cognizant of the donor site skin tone as well when examining the flap.

Figure 3. Venous congestion presents as a purple, swollen flap with brisk capillary refill and dark red bleeding.

Figure 4. Venous congestion requires emergent return to the operating room for exploration. If intervened upon early in the course, the flap is potentially salvageable.

Figure 5. Later in the course the flap will demarcate as partial or complete flap loss.

The most important variable to flap salvage is early identification and early action. Studies have demonstrated that venous thrombosis alone is more common than either arterial or combined arterial and venous thrombosis [24]. While physical examination is the gold standard, many methods and technologies are available to aid in the diagnosis of anastomotic failure. Intraoperatively, one can look for visible pulse, Doppler signal, Flicker test (Figure 6), milking the vessel, laser flowmetry, indocyanine green angiography (Figure 7), etc. Similar modalities for flap monitoring are available in the post-operative period. In fact, a healthy debate continues regarding modalities of post-operative monitoring with such devices as the implantable doppler, Vioptix, etc. (Figure 8). However, clinical examination remains the gold standard.

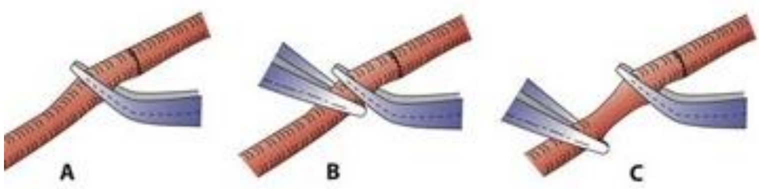


Figure 6A. This test is somewhat traumatic. Occlude the vessel with forceps distal to the anastomosis (A). Place another forceps just distal to the first (B). Milk the vessel for several millimeters away from the anastomosis (C). Occlude the emptied vessel, and release the proximal forceps.

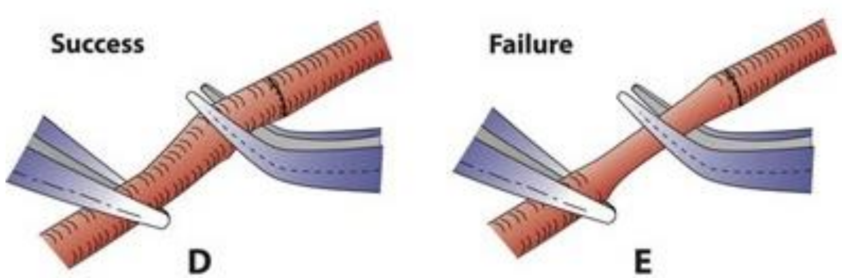


Figure 6B. You should see rapid filling from proximal to distal (D). If you don't see rapid filling, then there is anastomotic failure (E).

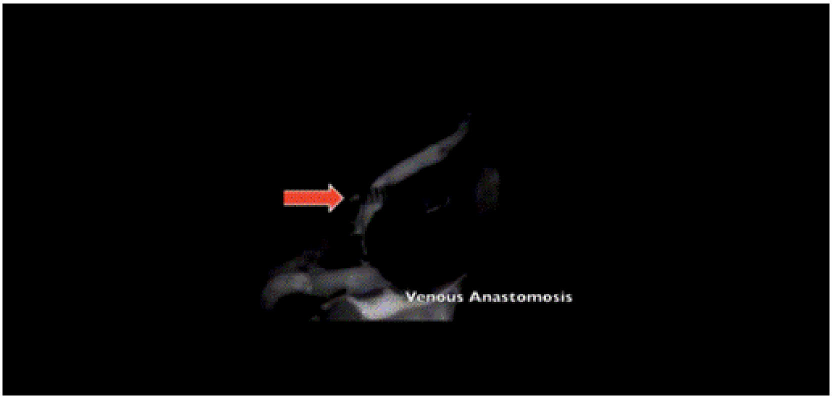


Figure 7. ICG angiography- patent couple venous anastomosis (red arrow). The patent arterial anastomosis can also be seen at the bottom of the photograph.

Figure 8. Vioptix System relies on tissue oxygen perfusion and is available for monitoring through smart devices.

Management

Re-operative exploration of the compromised or potentially compromised flap is required. Removing sutures to relieve pressure on the flap caused by skin closure can be performed, but even in the case of clinical improvement after this maneuver, exploration is still essential. One should visualize the anastomosis and perform exercises to determine where the problem may lie. Technical errors (back wall stitch, narrowing, intimal damage, twisting, kinking of the vessels) are the most common reasons for anastomotic failure (Diagram 1). These are solved by takedown and revision of the problematic anastomosis or anastomoses. Thrombectomy, heparin flush and tissue plasminogen activator (tPA) flush may also be useful, depending on the situation encountered. One should always perform an examination of the lumen and remove any damaged portions of the vessel. A step-wise approach to evaluation of the vessels is outlined below.

1. Look for kinking of the vessels: Kinking can often be identified on re-exploration, however the vessel may kink only when the flap is inset. Vessel 'lie' should be meticulously observed. Sometimes a small stay stitch will help prevent kinking or twisting. Occasionally, the vessels need to be shortened due to excess length of one or both of the vessels (usually the artery is longer). A vessel that is too long may have folded in the excess portions, requiring an adjustment in placement of the vessel or flap inset. A vessel that is too short may kink at an anchor point. Oftentimes, further dissection of the recipient vessel or anchor point is all that is required. Occasionally an interposition vein graft is required. Kinking may also be prevented by using gel-foam or local tissue to pad a gentle curve of the vessels.
2. Look for twisting of the vessels: A vessel may be twisted unknowingly prior to anastomosis and go unnoticed while the vessel is flaccid. When the vessel clamps are removed and flow is re-established, this problem may become more apparent. A twisted vessel typical requires revision of the anastomosis. Marking the orientation of the donor and recipient vessels prior to anastomosis may aid in identifying and preventing any twisting.
3. Look for excess vessel traction. Stretch should not be an issue, as an anastomosis should never be performed under tension. However, shifting of the flap on inset can cause tension on the vessels. Undue tension can cause fracture of the endothelial lining and ultimately vessel thrombosis. If tension is the culprit for flap compromise, the

anastomosis may need to be taken-down, examined for intimal damage and revised. An interposition vein graft can be used to achieve additional pedicle length necessary for proper flap inset. Adjusting the flap orientation, further vessel dissection to achieve additional pedicle length or placement of an interposition vein graft will help to reduce tension on the vascular pedicle.

4. Look for any areas of vasospasm: Vasospasm is the subject of much debate. It can be caused by intrinsic factors triggered by rigorous dissection and vessel handling. Extrinsic factors may also be present, such as administration of sympathomimetics. The best approach is warming, gentle vessel dilation, sympathectomy by adventitial stripping and use of vasodilatory agents. Multiple classes of agents have been studied and used for this effect, including phosphodiesterase inhibitors (papavarine, phentophylline, amrinone), local anesthetics (lidocaine), calcium channel blockers (nicardipine, verapamil, nifedipine, magnesium sulfate), direct vasodilators (sodium nitroprusside, prostaglandin E1, nitroglycerine, hydralazine) and alpha antagonists (phentolamine, chlorpromazine) [28]. Recent animal studies suggest that topical magnesium sulfate may be most effective in its spasmolytic effects [29].
5. Look for signs of external compression. Hematoma is the most common reason for external compression compromising flap blood flow and requires immediate evacuation (Figure 9). Surrounding pressure must be prevented (hemostasis) and often times, the anastomosis will require revision. Additionally, ‘leaking’ anastomoses may trigger intraluminal activation of the clotting cascade, exacerbating the problem. One must be aware of the vessel lie in regards to adjacent structures such as the ribs and pectoralis major when utilizing the internal mammary vessels as recipients. A tight overlying skin closure may also provide external compression and flap compromise. At the time of initial closure/flap inset, some amount of flap swelling should be expected and planned for. Finally, the surgeon must be aware of other types of sabotage in the way of external compression (abdominal binders, surgical bras, heating pads, patient lying on the flap, etc.). The weight of the flap itself is not typically a site of external compression.

Figure 9. Large, expanding hematoma. Note as well the congested appearance of the flap. Oftentimes, a hematoma may cause compression of the venous drainage and lead to congestion of the flap.

If an early thrombus is present, one must address the underlying issues as illustrated above. Unexplained thrombosis is an ominous sign. If no other factors can be identified, one can only redo the anastomosis and hope. The “No Reflow Phenomenon” [30-32] is related to tissue reperfusion injury at the level of the capillaries and often times is not a salvageable event.

Hypercoagulable states are the subject of much debate. Patients with cancer are often hypercoagulable at baseline. Additionally patients may be on medications that increase risk of venous thromboembolism (tamoxifen, oral contraceptives, etc). Still other patients may have a native hypercoagulable state due to Factor V Leiden or lupus anticoagulant, for example. Others clues to hypercoagulability (unexplained miscarriages, family or personal history of VTE) should be elicited pre-operatively.

Patent anastomosis, but clinical flow insufficiency, may become apparent. More often this is venous in origin leading to a turgid, hyperemic flap. A patent anastomosis but venous insufficiency should be super-charged whenever possible. In the case of a TRAM flap, use of the SIEV coupled to the retrograde IMV, thoracodorsal or thoracoacromial system can provide a useful bailout (Figure 10). Arterial insufficiency is harder to diagnose and often times only manifests weeks later in the form of fat necrosis. Debate remains regarding actual flow rates to flap size/volume.

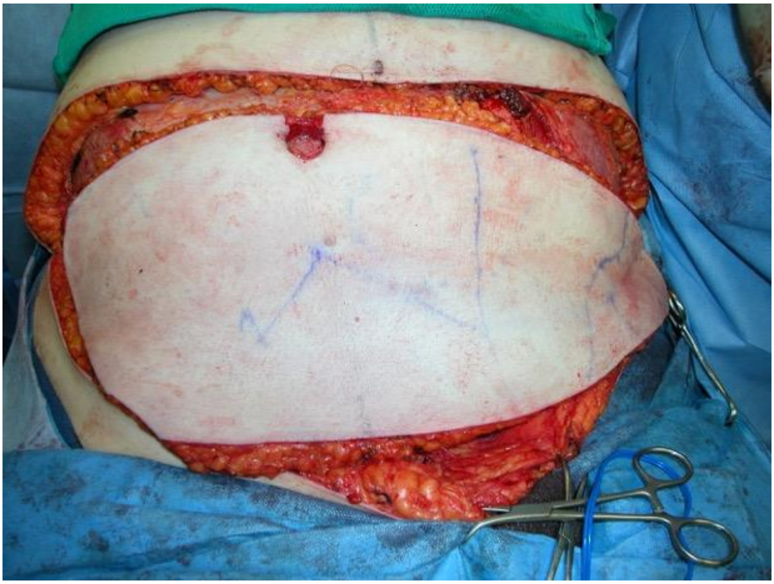


Figure 10. This flap has been raised on the deep inferior epigastric system, however, note the congested appearance. This flap required supercharging with the superficial inferior epigastric vein.

A clot indicates activation of the coagulation cascade. For this purpose, the surgeon may need to perform a thrombectomy (typically using a size 2 or 3 Fogarty catheter) and heparinize the flap, in addition to revising the anastomosis. In late thromboses, thrombolytic therapy (tPA, streptokinase, urokinase, etc.) may also be considered. If used, thrombolytics should be restricted to flow through the flap by allowing drainage through an unused venous outflow tract, rather than systemic administration.

When a free flap ‘goes down,’ and salvage is unsuccessful, there are four options:

1. Perform a second free flap, if the patient is medically stable.
2. Perform a pedicled flap: May be possible to perform a pedicled latissimus flap or TRAM flap, under the right circumstances.
3. Implant-based reconstruction: Placement of tissue expanders, if possible
4. Delayed reconstruction: Close incisions.

It is imperative that informed consent includes the possibility flap failure and secondary options and that this be discussed with the patient pre-operatively.

Total Free Flap Loss

Diagnosis

Total flap loss represents vascular compromise (Figure 11). This may be an unrecognized flow problem at the level pedicle or it may be at the capillary level, as in the case of the no-reflow phenomenon. The problem will often be readily apparent in the first several postoperative days, but may present later.

Figure 11. Total flap loss.

Management

Integral to the treatment of flap loss is identification of etiology for failure. The only thing worse than a total flap loss is a second total flap loss. Care should include timely debridement and immediate or delayed reconstruction. The decision for reconstruction should again be approached with the patient and appropriate options discussed. Discussion may include consideration of a second free flap or placement of a tissue expander with or without a pedicled latissimus dorsi flap for additional soft tissue coverage.

Partial Flap Loss

Diagnosis

Partial flap loss may be very apparent with areas of demarcated skin or may be more insidious in nature, in the form of fat necrosis (Figure 12 and 13). Both of these entities represent insufficient flow. This is different than mastectomy flap necrosis, which is principally dependent on patient factors and technique of the extirpative surgeon. Partial flap loss may be due to non-occlusive clots at the level of the anastomosis, emboli originating at the anastomosis, insufficient flow volume to flap size (zone 4 necrosis, for example) or any other insult to the intrinsic blood flow of the flap (such as prolonged ischemia time leading to reperfusion injury). In many cases, as with any anastomosis failure, the primary cause is technical error. In regard to flow size to flap volume, the advent of free abdominal tissue transfer based on the deep inferior epigastric artery has improved outcomes. While technically a Mathes and Nahai type III muscle [33], the rectus abdominis muscle does show a dominance of the inferior epigastric artery, leading to much less distal flap loss and fat necrosis than the superior epigastric-based pedicled TRAM. However, some degree of flow discrepancy may occur and the answer to specific flap mass to flow rate has yet to be elucidated. At this point, flap size to pedicle size and flow relies on clinical judgment and acumen of the operating surgeon and a sound understanding of Taylor's angiosome theory [34]. The evolution of intraoperative indocyanine green angiography has, minimized flap loss when utilized. Evidence shows that on-table ICG angiography allows the surgeon to preemptively debride portions of the flap that show insufficient flow, thus precluding any need for later debridement [35-39].

Figure 12. Partial flap necrosis.

Figure 13. Fat necrosis.

Management

The management of partial flap loss is an evolving field. Management of partial flap loss is primarily to allow the flap to demarcate, debride necrotic portions and revise as necessary (Figure 14). Adjunct techniques to supplement for the loss of tissue would include fat grafting, local tissue rearrangement, and/or prosthetic implants. It is not absolutely necessary to remove every bit of fat necrosis, rather only that which is palpable and clinically relevant.

Figure 14A. Spotty areas of superficial skin necrosis.

Figure 14B. These areas are debrided and allowed to heal by secondary intention.

Figure 14C. Although additional scarring is present, this patient went on to have a good result with excellent symmetry and breast shape.

Fat Necrosis

Diagnosis

Fat necrosis is caused by saponification of dead or damaged fat tissue after trauma or ischemia to the breast (Figure 13). At a microscopic level, the initial change is disruption of fat cells where vacuoles with the remnants of necrotic fat cells are formed. Lipid-laden macrophages, multinucleated giant cells, and acute inflammatory cells then engulf them. Fibrosis develops during the reparative phase peripherally enclosing an area of necrotic fat and cellular debris. Eventually, fibrosis may replace the area of degenerated fat with a scar, or loculated and degenerated fat may persist for years within the scar tissue. Clinically, fat necrosis presents as a firm lump or lumps and can be associated with pain or discomfort and erythema. It can be seen in the breast after needle biopsy, lumpectomy, radiotherapy or other trauma. In the setting of breast reconstruction, fat necrosis may represent insufficient flow to portions of the transferred flap or tissue trauma.

Management

While a new mass in the reconstructed breast may be distressing to the patient, in a post-mastectomy reconstruction, this typically does not represent cancer recurrence. Certainly, in a patient who had partial breast removal (lumpectomy), a new mass warrants a complete cancer work up. Mammography of fat necrosis will often reveal stippled, curvilinear calcifications within the periphery creating the appearance of lucent “bubbles,” with low-density centers. Ultrasound typically reveals a hypoechoic mass with well-defined nodular margins. Management requires patient reassurance and excision/revision versus non-surgical management depending on symptomology and patient wishes. Adjunct techniques to supplement for the loss of volume would include fat grafting, local tissue rearrangement, and/or prosthetic implants. As noted above, only clinically significant fat necrosis need be removed.

Mastectomy Flap Necrosis

Diagnosis

Mastectomy flap necrosis is damaged, poorly perfused breast skin, which presents as an area of demarcating necrosis within the first days to weeks after mastectomy (Figure 15). This is due to patient factors, including smoking/nicotine use, obesity, diabetes, previous breast size and radiation. Mastectomy flap necrosis is also related to surgical technique of the extirpative surgeon, such intraoperative tissue handling and plane of dissection.

Figure 15. Mastectomy flap necrosis.

Management

The management of mastectomy flap necrosis is evolving with the use of ICG angiography, allowing reconstructive surgeons to preemptively excise devascularized skin at the time of initial reconstruction if tumescent is not utilized during mastectomy. Another strategy to address this vexing issue to bury the immediate free flap without performing de-epithelialization and plan to bring the patient back several days later, excise demarcated breast skin, perform de-epithelialization and inset the flap [40]. This technique, however, does require a return trip to the operating room. At this time, the most commonly employed strategy is to try to identify any questionable areas of breast skin intraoperatively and preemptively debride. For postoperative necrosis, recommendations include debridement and revision (Figure 16).

a

b

Figure 16. (Continued)

c

d

e

Figure 16A-E. Mastectomy flap necrosis, requiring serial debridement, wound care and ventual skin grafting.

Hematoma

Diagnosis

As with all operations, hematoma formation is a risk of free flap breast reconstruction. A hematoma will typically present as an expanding mass and overlying ecchymosis (Figure 17). However, in the case of a hematoma in free flap breast reconstruction, there is added concern for flap compromise due to pressure on the pedicle. Evidence shows that hematomas are not prevented by drain placement.

Figure 17. Hematoma.

Management

Hematoma after breast reconstruction mandates prompt diagnosis and evacuation if there is clinical compromise to the flap. Re-exploration should be performed in the operating room in order to thoroughly examine the anastomosis (especially the venous anastomosis) and ensure hemostasis. Hemoglobin should be checked regularly and be kept above 10g/dL and hypovolemia treated with fluid and blood products, rather than sympathomimetics. There is mounting evidence in the head and neck literature demonstrating that the perivascular sympathectomy performed with vessel dissection blunts the effect of sympathomimetic medications, however this has not been studied in the breast reconstruction literature and should be avoided, if possible.

Seroma

Diagnosis

Seromas may present both in the donor site as well as the reconstructed breast site. They typically present later in the clinical course (Figure 18). They typically do not cause external compression and vascular compromise.

Figure 18. Right sided breast seroma.

Management

Seromas may be treated symptomatically with aspiration under sterile conditions and/or closed suction drainage. Occasionally, a seroma may be refractory to serial aspiration and require placement of a drain or use of sclerosing therapy. Sclerosing agents should be avoided in the area of the vascular anastomosis.

Infection

Diagnosis

Infection, as with all surgical procedures, represents a real risk especially if there is prolonged surgical time or the patient experiences intraoperative hypothermia (Figure 19). Complicating the diagnosis, typical signs of infection (such as erythema) can occasionally be mistaken or masked as vascular compromise. For this reason, the operating surgeon should be liberal in obtaining cultures, particularly at the time of re-exploration or revision. As an added risk in the free flap patient, infection can be a trigger for vessel thrombosis. Infection presents as erythema, pain, warmth, purulent drainage, and can cause breast skin or flap necrosis.

Figure 19. Superficial cellulitis.

Management

Evidence regarding prevention of surgical site infection follows the 2006 Surgical Care Improvement Project (SCIP) protocol. Patients should receive preoperative antibiotics. Antibiotics should be re-dosed appropriately intraoperatively and attention should be given to maintain normal body temperature. Abscesses or deep-seated infections should be treated with drainage, debridement and appropriate antibiotic coverage. There is no evidence for prophylactic antibiotics beyond the immediate perioperative period.

Pneumothorax

Diagnosis

Pneumothorax is a possible complication of rib resection and exposure of the internal memory vessels. Classically, this presents at the time of occurrence as a visible rent in the parietal pleura and audible sucking sound. Intraoperatively, irrigation fluid can be introduced into the trough created by rib resection and if bubbles are observed rising through the fluid, it is likely the pleura has been violated. Rarely, pneumothorax can present in the postoperative period with hypoxia, tachycardia and shortness of breath. Workup should include chest and abdominal x-rays.

Management

Optimally, pneumothorax is identified at the time of occurrence. This typically does not require treatment unless a lung injury occurs. The patient is receiving positive pressure ventilation, and use of a closed suction subcutaneous drain in the breast reconstruction pocket is sufficient to remove any residual air and prevent subcutaneous emphysema. Typically, there is no need for placement of a chest tube. A post-operative chest radiograph can be obtained if there is concern for pleural violation. There is no evidence supporting routine postoperative chest radiograph. Should the patient present with a post-operative symptomatic pneumothorax, a chest tube should be placed.

Poor Cosmetic Outcome

Diagnosis

Modern breast reconstruction has in many ways ‘raised the bar’ in terms of patient expectations of cosmetic outcome. More and more patients expect a rapid return to ‘normal’ life with a reconstructed breast indistinguishable from or better than their pre-operative status. Critical to management of cosmetic concerns is establishing patient expectations early with regards to their final outcome. A suboptimal cosmetic outcome may be due to several factors including effacement of the inframammary fold, asymmetry, contour irregularities, skin tone differences (between donor skin and breast skin), fat necrosis, etc.

Management

Cosmetic revision should be addressed primarily with expectant management as much as possible, as the patient will experience a certain amount of settling in the year after surgery. However, revisional surgery including liposuction, fat grafting, etc., may safely be performed six weeks after the initial reconstruction. Further discussion regarding cosmetic revision is beyond the scope of this chapter.

COMPLICATIONS RELATED TO THE DONOR SITE

Abdominally-Based (Free TRAM, ms-TRAM, DIEP, SIEA)

Hernia/Abdominal Wall Weakness

Diagnosis

In an effort to minimize dysfunction of the abdominal wall, advancements have been made in techniques to decrease rectus muscle and fascia injury, leading to advocacy for the DIEP flap [41-43]. In 2006, Garvey, et al., demonstrated a 16% hernia rate in pedicled TRAM versus 1% in the DIEP cohort [44] Several subsequent studies demonstrated conflicting or equivocal results [45, 46]. More recently, in a large multi-center database search including 8246 patient, Fischer et al., demonstrated surgically-repaired abdominal wall hernias in 7% of pedicled TRAM patients, 5.7% in free TRAM patients and 1.8% in DIEP patients (Figure 20 and 21) [27]. Abdominal wall weakness or hernia may be subclinical or asymptomatic and go unnoticed unless found incidentally by CT scan for other reasons. However, symptomatic or clinically apparent abdominal bulges or hernias should be addressed surgically. The primary advantage of the SIEA flap over those based upon the deep inferior epigastric or superior epigastric system is the lack of penetration of the abdominal fascia and muscle thus eliminating the risk of subsequent abdominal wall weakness/bulge or hernia.

Figure 20. Abdominal bulge.

Figure 21. Abdominal bulge.

Management

The average time to hernia repair after abdominally-based breast reconstruction is approximately 1 year [27]. Treatment involves exposure of the rectus fascia with primary closure and mesh reinforcement. The authors recommend that at the time of initial reconstruction, the fascia and abdominal musculature be carefully evaluated as it may be advised to place mesh prophylactically to prevent post-operative hernias and bulges.

Hematoma

Diagnosis

Abdominal hematomas are experienced in a small percentage of the patients undergoing abdominal-based breast reconstruction. They present as expanding masses and ecchymosis as well as increased sanguinous drain output.

Management

Hematomas should be treated with re-exploration to remove the hematoma, irrigate and obtain hemostasis,

Seroma

Diagnosis

Seromas more commonly present in the abdominal donor site, rather than at the site of breast reconstruction. They will typically present several weeks to months after the time of initial surgery. Abdominal seromas are similar to those occurring in cosmetic abdominoplasty and present as fullness which may or may not be ballotable and occasionally uncomfortable. Erythema is a sign of underlying infection.

Management

Decreased seroma formation has been linked with placement of intermittent quilting sutures [47, 48]. Seromas may safely be treated when symptomatic with aspiration under sterile conditions and/or closed suction drainage. Occasionally, a seroma may be refractory to serial aspiration and require use of drains, sclerosing agents or even surgical removal of the seroma cavity.

Wound Dehiscence

Diagnosis

Wound dehiscence or abdominal flap necrosis may occur at the site of abdominal closure and typically occurs centrally, at the site of highest tension (Figure 22 and 23). This is most often due to ischemia from tight closure and will appear pale intraoperatively, followed by a progression to local purpura and finally frank necrosis of the skin and underlying fat with associated wound failure. The risk of this complication is increased when there is a T-junction as may occur at the site of the transposed umbilicus. This may be very discouraging to the patient, who has had an otherwise successful operation.

Figure 22. Abdominal wound failure. Notice the central location, representing the area of most distal perfusion as well as the area of highest tension.

Figure 23. Abdominal wound failure.

Management

Optimal management is avoidance of high-tension closure. Occasionally, paucity of abdominal tissue on an otherwise small-framed patient may dictate a tighter closure than desired. Progressive tension sutures can be used and the wound may be temporarily supported with an incisional negative pressure device (wound vac). The patient should be advised to remain in a flexed position at the waist for several days to weeks to minimize tension on the abdominal closure. Should the patient develop an open wound despite all precautions, the wound should be managed conservatively with moist dressings, debridement as indicated, and healing by secondary intention. A wound vac may also speed wound closure.

Bowel Perforation/Enterocutaneous Fistula

Diagnosis

While no portion of the harvest of an abdominal flap for breast reconstruction should proceed to the intra-abdominal cavity, there is a small risk of bowel perforation with harvest of abdominally-based flaps based upon the deep inferior epigastric system. The patient will present postoperatively with inability to tolerate oral intake and nausea/vomiting. Abdominal radiographs should be obtained and will show subphrenic air and air-fluid levels.

Management

The patient will require exploratory laparotomy with general surgery to identify and repair the enterotomy.

Numbness/Altered Sensation

Diagnosis

Peri-incisional and peri- and infra-umbilical numbness is a common occurrence following abdominal-based breast reconstruction. This altered sensation is due to transection of the local cutaneous nerves or a cutaneous neuropraxia from retraction. Patients may also experience a burning or tingling sensation in a similar distribution associated with nerve regeneration. Occasionally patients may complain of pain or burning in the thigh or groin due to injury of the lateral femoral cutaneous nerve or the ilioinguinal nerve, similar to that seen in abdominoplasty.

Management

Local changes in sensation; numbness, burning, and tingling may be treated expectantly, with return of normal sensation in six months to one year. Patients may be instructed in desensitization techniques to help in the meantime. If the lateral femoral cutaneous nerve or ilioinguinal nerve is injured or tethered by suture, it may require operative intervention depending upon the severity and persistence of symptoms.

Thigh-Based Flaps, Such as Gracilis Flaps

Lymphedema

Diagnosis/Management

While uncommon, lymphedema is a potential and devastating complication in patients undergoing a transversely-oriented upper gracilis (TUG) flap. Care should be taken to avoid carrying the dissection too deeply/anteriorly over the femoral triangle. The best treatment is avoidance. A thorough discussion of treatment modalities for lower extremity lymphedema is beyond the scope of this book.

Seroma

Diagnosis/Management

While perhaps not as prevalent as in abdominal or gluteal-based breast reconstruction, seroma formation represents a potential risk and drains should be placed at the time of surgery. Seromas are treated when symptomatic with aspiration under sterile conditions and/or closed suction drainage. Occasionally, a seroma may be refractory to serial aspiration and sclerosing therapy or seroma cavity excision may be necessary. Additionally, formation of a lymphocele in this area may be considered in the differential for persistent, refractory fluid collections.

Contour Deformity

Diagnosis/Management

Contour deformity of the upper thigh may be of particular concern to the patient (Figure 24). Contour deformities may be addressed with liposuction or lipofilling as indicated. Deformity of the vulva due to excessive tension at the closure is difficult to treat. Placement of the scar below the groin crease minimizes this deformity but leads to a more visible scar. Careful pre-operative discussion regarding these risks is vital.

Figure 24. Medial thigh contour irregularity and scarring following a tranverse upper gracilis (TUG) flap.

Gluteal-Based Flaps

Bleeding

Diagnosis/Management

Special mention of bleeding risks, particularly intraoperative bleeding is central to discussion of gluteal-based flaps. Great care must be taken when approaching the proximal portion of the gluteal artery at its origin from the internal iliac artery, as there is an extensive surrounding venous plexus (ominously referred to as Medusa's Head). Bleeding occurring in this vicinity can be significant and it is often deep and difficult to reach and control.

Nerve Injury

Diagnosis/Management

The sciatic and posterior femoral cutaneous nerves take a course exiting from between the pyriformis and superior gemellus and may be especially prone to irritation or injury while harvesting an inferior gluteal artery perforator flap, as the sciatic nerve travels with the vascular pedicle. Rough handling of this nerve can be a cause of great discomfort with the patient for months after surgery.

Figure 25. Superior gluteal artery perforator (SGAP) donor site. Patients should be counseled regarding scarring and resulting contour irregularity in the donor site.

Buttock Distortion

Diagnosis/Management

While superior gluteal artery flaps are thought to provide a form of buttock-lift, often the change in contour is not in line with a patients' expectations (Figure 25). Particular care must be taken regarding contour irregularity associated with the inferior gluteal artery flap, as it may efface the inferior gluteal crease and pull the buttock down. This deformity is much harder to hide under clothing.

Seroma

Diagnosis/Management

The gluteal donor sites are notorious for seroma formation. Often in order to prevent this, drains are left in place for two to three weeks.

Complications Related to Prolonged Surgical Time

Myocardial infarction: Appropriate preoperative evaluation and optimization are essential to prevention of complications related to prolong surgical time.

Cerebrovascular accident: Appropriate preoperative evaluation and optimization are essential to prevention of complications related to prolong surgical time.

Venous thromboembolism: Preoperative, as well as postoperative chemical and mechanical DVT prophylaxis are critical to the care of the free flap patient.

Pressure ulcers: Pressure ulcer formation can occur within hours [49]. Appropriate padding of all bony prominences is important to preventing this untoward complication.

Compressive neuropathies: Finally, the surgeon must be aware of proper padding and positioning of both arms and legs in order to prevent or minimize this uncomfortable complications.

CONCLUSION

Free flap reconstruction is a common and well-established method for breast reconstruction. Although the flap selection, microsurgical technique and countless other variables may change, the general approach to diagnosing and managing free-flap complications remains the same. Key to this is a logical and algorithmic approach to the early and late problems seen in free-flap reconstruction.

REFERENCES

[1] What are the key statistics about breast cancer? 2016. (Accessed 2/26/16, 2016, at http://www.cancer.org/cancer/breastcancer/detailedguide/breast-cancer-key-statistics).

[2] Congress U. Women's Health and Cancer Rights Act. 1998.

[3] 2015 Reconstructive Plastic Surgery Statistics. 2015. (Accessed 2/25/16, 2016, at http://www.plasticsurgery.org/Documents/news-resources/statistics/2015-statistics/reconstructive-procedure-trends-2015.pdf).

[4] Holmstrom H. The free abdominoplasty flap and its use in breast reconstruction. An experimental study and clinical case report. *Scandinavian journal of plastic and reconstructive surgery* 1979;13:423-27.

[5] Hartrampf CR, Scheflan M, Black PW. Breast reconstruction with a transverse abdominal island flap. *Plastic and reconstructive surgery* 1982;69:216-25.

[6] Grotting JC. The free abdominoplasty flap for immediate breast reconstruction. *Annals of plastic surgery* 1991;27:351-4.

[7] 2014 Reconstructive Breast Procedures. 2014. (Accessed 2/25/16, 2016, at http://www.plasticsurgery.org/Documents/news-resources/statistics/2014-statistics/plastic-surgery-statsitics-full-report.pdf).

[8] Elder EE, Brandberg Y, Bjorklund T, et al. Quality of life and patient satisfaction in breast cancer patients after immediate breast reconstruction: a prospective study. *Breast* (Edinburgh, Scotland) 2005;14:201-8.

[9] Dean C, Chetty U, Forrest AP. Effects of immediate breast reconstruction on psychosocial morbidity after mastectomy. *Lancet* (London, England) 1983;1:459-62.

[10] Kroll SS, Coffey JA, Jr., Winn RJ, Schusterman MA. A comparison of factors affecting aesthetic outcomes of TRAM flap breast reconstructions. *Plastic and reconstructive surgery* 1995;96:860-4.
[11] Kronowitz SJ. Immediate versus delayed reconstruction. *Clinics in plastic surgery* 2007;34:39-50; abstract vi.
[12] Miller MJ, Rock CS, Robb GL. Aesthetic breast reconstruction using a combination of free transverse rectus abdominis musculocutaneous flaps and breast implants. *Annals of plastic surgery* 1996;37:258-64.
[13] Kronowitz SJ. Delayed-immediate breast reconstruction: technical and timing considerations. *Plastic and reconstructive surgery* 2010;125:463-74.
[14] Klasson S, Nyman J, Svensson H, Velander P. Smoking increases donor site complications in breast reconstruction with DIEP flap. *Journal of plastic surgery and hand surgery* 2016:1-5.
[15] Dayicioglu D, Tugertimur B, Munzenmaier K, et al. Outcomes of Breast Reconstruction After Mastectomy Using Deep Inferior Epigastric Perforator Flap After Massive Weight Loss. *Annals of plastic surgery* 2016;76 Suppl 4:S286-9.
[16] Hanwright PJ, Davila AA, Hirsch EM, et al. The differential effect of BMI on prosthetic versus autogenous breast reconstruction: a multivariate analysis of 12,986 patients. *Breast* (Edinburgh, Scotland) 2013;22:938-45.
[17] Lee TJ, Oh TS, Kim EK, et al. Risk factors of mastectomy skin flap necrosis in immediate breast reconstruction using low abdominal flaps. *Journal of plastic surgery and hand surgery* 2016:1-5.
[18] Ochoa O, Chrysopoulo M, Nastala C, Ledoux P, Pisano S. Abdominal wall stability and flap complications after deep inferior epigastric perforator flap breast reconstruction: does body mass index make a difference? Analysis of 418 patients and 639 flaps. *Plastic and reconstructive surgery* 2012;130:21e-33e.
[19] Wang XL, Liu LB, Song FM, Wang QY. Meta-analysis of the safety and factors contributing to complications of MS-TRAM, DIEP, and SIEA flaps for breast reconstruction. *Aesthetic plastic surgery* 2014;38:681-91.
[20] Seidenstuecker K, Munder B, Mahajan AL, Richrath P, Behrendt P, Andree C. Morbidity of microsurgical breast reconstruction in patients with comorbid conditions. *Plastic and reconstructive surgery* 2011;127:1086-92.

[21] Voineskos SH, Frank SG, Cordeiro PG. Breast reconstruction following conservative mastectomies: predictors of complications and outcomes. *Gland surgery* 2015;4:484-96.
[22] Galanis C, Nguyen P, Koh J, Roostaeian J, Festekjian J, Crisera C. Microvascular lifeboats: a stepwise approach to intraoperative venous congestion in DIEP flap breast reconstruction. *Plastic and reconstructive surgery* 2014;134:20-7.
[23] Khansa I, Chao AH, Taghizadeh M, Nagel T, Wang D, Tiwari P. A systematic approach to emergent breast free flap takeback: Clinical outcomes, algorithm, and review of the literature. *Microsurgery* 2013;33:505-13.
[24] Bui DT, Cordeiro PG, Hu QY, Disa JJ, Pusic A, Mehrara BJ. Free flap reexploration: indications, treatment, and outcomes in 1193 free flaps. *Plastic and reconstructive surgery* 2007;119:2092-100.
[25] Lee KT, Lee JE, Nam SJ, Mun GH. Ischaemic time and fat necrosis in breast reconstruction with a free deep inferior epigastric perforator flap. *Journal of plastic, reconstructive and aesthetic surgery: JPRAS* 2013;66:174-81.
[26] Macadam SA, Zhong T, Weichman K, et al. Quality of Life and Patient-Reported Outcomes in Breast Cancer Survivors: A Multicenter Comparison of Four Abdominally Based Autologous Reconstruction Methods. *Plastic and reconstructive surgery* 2016;137:758-71.
[27] Shubinets V, Fox JP, Sarik JR, Kovach SJ, Fischer JP. Surgically Treated Hernia following Abdominally Based Autologous Breast Reconstruction: Prevalence, Outcomes, and Expenditures. *Plastic and reconstructive surgery* 2016;137:749-57.
[28] Vargas CR, Iorio ML, Lee BT. A Systematic Review of Topical Vasodilators for the Treatment of Intraoperative Vasospasm in Reconstructive Microsurgery. *Plastic and reconstructive surgery* 2015;136:411-22.
[29] Hyza P, Streit L, Schwarz D, Kubek T, Vesely J. Vasospasm of the Flap Pedicle: The Effect of 11 of the Most Often Used Vasodilating Drugs. Comparative Study in a Rat Model. *Plastic and reconstructive surgery* 2014;134:574e-84e.
[30] Widgerow AD. Ischemia-reperfusion injury: influencing the microcirculatory and cellular environment. *Annals of plastic surgery* 2014;72:253-60.

[31] Kucukcelebi A, Ozcan M. The beneficial effect of cyclosporin-A on the no-reflow phenomenon in rat skin island flaps. *British journal of plastic surgery* 1992;45:512-4.

[32] Punch J, Rees R, Cashmer B, Wilkins E, Smith DJ, Till GO. Xanthine oxidase: its role in the no-reflow phenomenon. *Surgery* 1992;111:169-76.

[33] Mathes SJ, Nahai F. Classification of the vascular anatomy of muscles: experimental and clinical correlation. *Plastic and reconstructive surgery* 1981;67:177-87.

[34] Taylor GI, Palmer JH. 'Angiosome theory.' British journal of plastic surgery 1992;45:327-8.

[35] Duggal CS, Madni T, Losken A. An outcome analysis of intraoperative angiography for postmastectomy breast reconstruction. *Aesthetic surgery journal / the American Society for Aesthetic Plastic surgery* 2014;34:61-5.

[36] Munabi NC, Olorunnipa OB, Goltsman D, Rohde CH, Ascherman JA. The ability of intra-operative perfusion mapping with laser-assisted indocyanine green angiography to predict mastectomy flap necrosis in breast reconstruction: a prospective trial. *Journal of plastic, reconstructive and aesthetic surgery: JPRAS* 2014;67:449-55.

[37] Quilichini J, Le Masurier P, Guihard T. [Increasing the reliability of SIEA flap using peroperative fluorescent angiography with indocyanine green in breast reconstruction]. *Annales de chirurgie plastique et esthetique* 2010;55:531-8.

[38] Wu C, Kim S, Halvorson EG. Laser-assisted indocyanine green angiography: a critical appraisal. *Annals of plastic surgery* 2013;70:613-9.

[39] Yamaguchi S, De Lorenzi F, Petit JY, et al. The "perfusion map" of the unipedicled TRAM flap to reduce postoperative partial necrosis. *Annals of plastic surgery* 2004;53:205-9.

[40] Liao EC, Labow BI, May JW, Jr. Skin banking closure technique in immediate autologous breast reconstruction. *Plastic and reconstructive surgery* 2007;120:1133-6.

[41] Koshima I, Soeda S. Inferior epigastric artery skin flaps without rectus abdominis muscle. *British journal of plastic surgery* 1989;42:645-8.

[42] Allen RJ, Treece P. Deep inferior epigastric perforator flap for breast reconstruction. *Annals of plastic surgery* 1994;32:32-8.

[43] Rozen WM, Ashton MW. Improving outcomes in autologous breast reconstruction. *Aesthetic plastic surgery* 2009;33:327-35.

[44] Garvey PB, Buchel EW, Pockaj BA, et al. DIEP and pedicled TRAM flaps: a comparison of outcomes. *Plastic and reconstructive surgery* 2006;117:1711-9; discussion 20-1.

[45] Ireton JE, Kluft JA, Ascherman JA. Unilateral and Bilateral Breast Reconstruction with Pedicled TRAM Flaps: An Outcomes Analysis of 188 Consecutive Patients. *Plastic and reconstructive surgery Global open* 2013;1:1-7.

[46] Chun YS, Sinha I, Turko A, Lipsitz S, Pribaz JJ. Outcomes and patient satisfaction following breast reconstruction with bilateral pedicled TRAM flaps in 105 consecutive patients. *Plastic and reconstructive surgery* 2010;125:1-9.

[47] Lee J, Bae Y, Jung JH, et al. Effects of Quilting Suture Interval on Donor Site Seromas After Breast Reconstruction With Latissimus Dorsi Muscle Flap: A Randomized Trial. *Clinical breast cancer* 2016.

[48] Nagarkar P, Lakhiani C, Cheng A, Lee M, Teotia S, Saint-Cyr M. No-drain DIEP Flap Donor-site Closure Using Barbed Progressive Tension Sutures. Plastic and reconstructive surgery *Global open* 2016;4:e672.

[49] Gefen A. How much time does it take to get a pressure ulcer? Integrated evidence from human, animal, and in vitro studies. *Ostomy/wound management* 2008;54:26-8, 30-5.

In: Breast Reconstruction
Editor: Janice Rivera

ISBN: 978-1-53610-245-1

Chapter 7

PATIENT SATISFACTION FOLLOWING AUTOLOGOUS OR HETEROLOGOUS BREAST RECONSTRUCTION

Laura Sita-Alb**, Laura Duta and Lucian Fodor
Plastic and Reconstructive Surgery Unit, Emergency County Hospital, Cluj Napoca, Romania

ABSTRACT

Health cannot be defined anymore just from a physiological point of view; good self-esteem, sexuality and quality of life are essential for a healthy patient. Today, medicine is more and more directed towards the patient, giving them more choices, control and information. To be able to accurately measure health care outcomes, patient satisfaction data cannot be disregarded.

Every year more than 60,000 American patients are subjected to a mastectomy, a surgery that is highly mutilating especially for young women, and from this 20-40% will undergo a breast reconstruction. In front of a large variety of solutions the patient should be aware of her opportunities. Whether or not a candidate for an autologous, prosthetic or autologous and prosthetic breast reconstruction the patients should know what to expect.

What is, indeed, the best technique, an autologous or a heterologous reconstruction? And if is an autologous, which one gives the best results:

* Corresponding author: Laura Sita-Alb, laura.sita.alb@gmail.com.

the abdominal flaps (pedicled or perforator) the latissimus dorsi flap, the gluteal flaps or a combination of flaps with prosthetic reconstruction? In the past years a large number of studies assessing patient satisfaction and quality of life were published, comparing different techniques (autologous versus autologous, autologous versus heterologous, heterologous versus heterologous) in their attempt to improve patient health-care.

Lately there is a unanimous finding that shows that patients are mostly satisfied, and have a higher long-term satisfaction following an abdominal autologous breast reconstruction, when compared to any other reconstruction techniques.

Keywords: patient satisfaction, breast reconstruction, autologous breast reconstruction, prosthesis breast reconstruction, DIEP flap, abdominal flaps

INTRODUCTION

The concept of health, in modern times, cannot just be defined as freedom from pain or physical disease. It involves the overall condition of being sound in body and mind, completed by psychosocial well-being and sexual well-being. A healthy and satisfied patient, as a member of society, sets the grounds for a healthy and happy society. Ergo, modern medicine tends to focus on the patient as an individual, giving the patient a voice with regard to treatment decisions by providing multiple options, the necessary knowledge, information and medical data, including other patients' reported outcomes. In order to accurately measure health care outcomes, patient satisfaction data cannot be disregarded.

Over 296,000 American women were diagnosed with breast cancer in 2013 [1], ranking breast cancer in 1st place in non-skin cancer neoplasms in the American female population [2]. Although early stage diagnosed patients are presented with the choice of conservative treatment, more than 25% undergo mastectomy [3, 4]. This is a mutilating process, harming female femininity, affecting not only the patient's life but their partners and families as well, and is connected to numerous psychosocial disorders [5-10]. Less than 40% of thus traumatized patients will proceed to a breast reconstruction, viewed by many as a way to restore one's self-image, and the final step in breast cancer treatment. Faced with a world of solutions, the patient should be aware of the multiple options available. This is where the doctor's experience and knowledge, along with other patient's experience and reported outcomes, should guide the patient in finding the best solution for herself.

What Do Patients Expect Once Deciding Pro Reconstruction?

The most frequent motive pro reconstruction is a return to normalcy and a feeling of wholeness that a restored breast can generate for its recipients, along with the psychosocial benefits resulting from increased self-esteem and better performance in social circles [11]. For most women, breast reconstruction represents the final step in cancer treatment and healing [11]. That being said, most women do not know what to expect in the aftermath of reconstruction and proceed towards surgery with different expectations than the final outcome. For example, most patients are anxious for nipple reconstruction, unaware of the lack of sensation afterwards, or expect perfect symmetry post-unilateral prosthesis reconstruction [11]. Unfulfilled or unrealistic expectations represent a major source of post-reconstruction dissatisfaction, underlining once more the importance of patient education beforehand. In order to avoid such discomfort, both surgeon and patient should move forward from starting on common ground.

How Can We Quantify the Impact of Breast Reconstruction on a Patient's Quality of Life?

Moving forward, the quality of a surgeon's work should be validated by the positive impact it has on a patient's life. Due to the great pallet of options, how does the surgeon decide the best fit for each case? Most times, the emotional cancer patient can be overwhelmed with information and technical aspects of reconstruction possibilities. Relying on the premise that the surgeon knows best, the patient may end up with unsatisfactory results due to making the wrong decision. As a solution, patients' reported outcomes came to the scene, thereby providing data to create a bridge between surgical knowledge and patient expectations.

Table 1. Breast-Q reconstruction module [13]

PSYCHOSOCIAL WELL-BEING • body image • self-esteem • confidence • emotional integrity	BREASTS • breast appearance • clothing • bra fit • rippling (implant related)	STAFF PROVIDED SUPPORT • care • emotional support
SEXUAL WELFARE/BODY IMAGE • sexual confidence • sexual attractiveness (with/without clothes) • lack of self-consciousness during intercourse	NIPPLES (NAC) • shape • color • natural aspect • projection	PAIN • during 1st week post-reconstruction
PHYSICAL WELL-BEING CHEST/UPPER BODY • pain • breast area related distress • activity limitation • discomfort-induced sleep problems ABDOMEN/TRUNK (TRAM/DIEP flaps) • abdominal weakness leading to activity impairment • negative physical consequences BACK/SHOULDER (LD flap) • negative physical consequences • arm and shoulder activity impairment	ABDOMEN • appearance • scars • navel position BACK • scar appearance • scar location OUTCOME • overall assessment • met expectations (esthetic appearance) • impact upon life • decision toward surgery CARE • information • medical staff • surgeon • office staff	RECOVERY • during 1st week post-reconstruction COPING • during 1st year post-reconstruction BREAST APPEARANCE • 1 year post-reconstruction PSYCHOSOCIAL WELL-BEING • 1 year post-reconstruction

Starting in 2012, BREAST-Q (Table 1) has been largely embraced by the medical community as a means to quantify and convey patient reported data regarding breast surgery. It is a computer software program developed by Pusic et al. [12], designed to analyse a women's perspective concerning breast surgery by evaluating and quantifying different parameters associated with satisfaction post-breast surgery. The parameters included in the reconstruction module can be reviewed in Table 1 [13].

Other means for analyzing outcomes have been developed, from a panel of specialists evaluating photographs and measuring a set of established parameters [14], to computer program aesthetic assessment of reconstructive results (BCCT.core)[15], all in the attempt to make the best decision for each patient.

TIMING OF RECONSTRUCTION: NO RECONSTRUCTION, IMMEDIATE OR DELAYED RECONSTRUCTION

Reasons for Breast Reconstruction Refusal

The vast majority of patients (60-80%) [16] choose not to undergo breast restoration surgery after mastectomy. The most cited reason for reconstruction refusal is to avoid additional surgery, while other common reasons include low level of education, older patients or patients presenting comorbidities, fear of a reconstructed breast shielding cancer recurrence [17, 18], financial aspects, or the need for chemotherapy [19]. Studies trying to establish the reasons why women refuse to undergo a reconstruction procedure found that 62% of the patients cited a lack of information regarding the reconstruction procedure as an important factor in influencing their decision [20].

Immediate vs Delayed Breast Reconstruction

Whether we perform breast restoration surgery by using alloplastic or autologous material, we can opt for immediate reconstruction (at the same time as the mastectomy) or delayed reconstruction (weeks, years). A consensus is starting to take shape concerning the indications and contraindications for immediate and delayed reconstruction, with minor differences between different centers' protocols.

There is no absolute contraindication for breast reconstruction, but relative contraindications include morbid obesity (BMI≥40 kg/m^2), and current smoking status. Senior citizens can benefit from breast reconstruction without any particular age-related contraindication [21].

Immediate reconstruction is the preferred choice for most patients, as it generates better aesthetic results, hence higher satisfaction rates [22]. The requirement for postoperative radiation therapy can be regarded as a relative contraindication concerning immediate breast reconstruction; in cases of T3 and T4 tumours, positive axillar lymph nodes and inflammatory breast cancer, it is recommended to delay the reconstruction procedures [21].

Delayed reconstruction is generally associated with lower satisfaction rates compared to immediate reconstruction, but long-term results reveal no differences related to the satisfaction levels reported by the two groups [23].

The majority of breast reconstructions worldwide uses alloplastic material. Although immediate reconstructions are preferred and studies reported higher satisfaction with immediate reconstruction than delayed ones [24], there are studies that highlight the incidence of higher complication rates associated with immediate implant-based procedures [25], but no difference in reconstruction failure rates related to the timing of the reconstruction [26].

When radiation therapy is required, opting for a prosthesis-based reconstruction is not advised, because of the multiple complications risks.

For autologous flap reconstructions, immediate reconstruction is associated with the advantage of fewer surgeries and better aesthetic results [27]. In delayed reconstructions, the skin is contracted, with thin and scarred skin flaps. Some studies found higher rates of complications in the delayed group, such as the risk of thrombosis [28], while others did not find statistical discrepancies concerning minor versus major complications related to the timing of autologous (free TRAM) breast restoration [29].

The immediate flap-based breast reconstruction might affect radiation delivery and alter the aesthetic results as well [30]; therefore, the patient should be aware of the possible risks. Recent studies reveal no statistically significant discrepancies when speaking of local recurrences, metastases or patient survival, whether a TRAM flap reconstruction or no reconstruction is done [31].

In an attempt to establish the best moment to proceed to a delayed reconstruction following post-mastectomy radiotherapy, when comparing results and complications, it was found that a 12-month delay after radiotherapy gave less complications, less vascular thrombosis and better results when using a free abdominal flap [32].

Studies reveal that women choosing to undergo a breast reconstruction procedure have a different socioeconomic status than those who refuse breast reconstruction, are wealthier [33], more educated, with greater access to medical services.

A study of more than 54,000 breast reconstructions found that immediate reconstruction enhances breast cancer specific survival [34]. A possible explanation lies in the fact that this type of reconstruction was chosen by younger women, diagnosed at an early stage, without lymph node involvement, and lower chances of receiving radiation therapy.

ALLOPLASTIC BREAST RECONSTRUCTIONS

The great majority of breast reconstruction (BR) worldwide is done with prostheses; over 76,000 implant-based BR (representing 79% of all BR procedures) were reported in 2011 in the United States [35]. Even though recent studies reveal a higher satisfaction rate with autologous reconstructions, up to 70-80% of BR are implant-based [36], although a decreasing pattern is observed mostly in specialized centers.

The explanation for this percentage is mostly due to the fact that free flap autologous reconstructions are done only in specialized centers that cannot support the great amount of reconstructions, and different BR options must be generally approachable. Other possible explanations might be shortened surgery time and hospital admission duration, cultural acceptance regarding implants, better reimbursement from insurance companies [37], and fewer contraindications from an oncological point of view [38].

Implant-based reconstructions are favorable in small breasted women with no or minimum breast ptosis [39] and good skin quality. They are also indicated for bilateral reconstructions [40] and patients diagnosed in early stages, preferably sentinel node-free [41].

Breast reconstruction using a prosthesis can be chosen while doing the mastectomy surgery (immediate), either by placing a tissue expander concomitant with the mastectomy to maintain the skin envelope coverage, followed by a permanent prosthesis (delayed) [42].

Factors that influence outcome and satisfaction in alloplastic breast reconstructions (Tables 2, 3)

Timing of Reconstruction

Regaining consciousness in the early post-surgery aftermath and acknowledging an amputated breast is associated with great physiological distress, this being the reason why immediate restoration of the breast has the benefit of preventing the process [43], by recreating the volume of the breast and also the shape, to the patient's greater satisfaction [44, 45]. There are some limitations, however, such as the need for surgical revision in the years to come [46, 47]. As previously discussed, the timing of the surgery influences the satisfaction. Immediate BR is preferred when possible, as the inframammary fold is preserved, no skin contraction occurs and minimal scars are generated.

On the other hand, patients requiring radiation therapy [48] or possessing large breasts with advanced ptosis might benefit more from a two-stage reconstruction [49] or delayed reconstruction, as the expander will be placed right after or some time after mastectomy, in order to maintain the natural breast envelope proceeded by definitive implant.

Radiotherapy

It is documented that radiotherapy, regardless of the timing of administration, favors complications and implant failure risk [50], as well as lower satisfaction levels regarding surgical results, and a significant impact on the patient's physical, psychosocial and sexual wellbeing [51]. The highest dissatisfaction rates were associated with radiation therapy on immediately implant reconstructed breasts compared to delayed, as the radiation leads to capsular contraction [52]. Long-term felt pain post-radiation and capsular contraction [53] accompanied by the imperative secondary surgical procedures [54, 55] concluded in breast restoration failure [56, 57].

Breast implants nowadays can be chosen based on their content (saline or silicone), form (round or anatomic) and outer shell (textured or non-textured) [38]. With regard to form (round or anatomic), no unanimous opinion has been reached, while pros and cons and complication data have been found to be similar [58].

Although implant-based breast restoration is paired with great satisfaction [59], when considering content, studies indicate that silicone implants are preferred to saline ones by a vast majority of patients [60, 61], due to the more natural feel they generate as they are softer than saline implants.

In response to implant coating, textured shells were adopted as a solution for capsular contraction [62, 63]. Despite some controversy over the years [64, 65], textured implants have also proven their efficiency in keeping the implant in place [66], as well as not having a ripple aspect as seen often after long-term deflation of saline-filled implants [59].

Smoking is a well-known factor to increase surgical complications, more precisely in prosthetic BR. Smoking increases the risks of complications by 2-3 times compared to non-smoking patients, reaching a complication rate of 37.9%. Ex-smokers (up to 1 year after) also have higher complication rates [67].

Other factors, such as *obesity,* have been proven to increase the risk of complications at approximate twice for a BMI>30, compared to normal weighted women. Women with a BMI>25 prefer to undergo an autologous abdominal flap BR. Also *elderly patients*, those over 65 years of age, are prone to develop perioperative complications [26].

Breast restoration using a prosthesis is preferred by women under 40 years of age, compared to women between 40 and 60 years of age who prefer abdominally-based flap reconstructions [2, 68].

Concerning patient-related factors that might influence outcome and satisfaction, it was found that *diabetes* is not an independent complication predictive factor or implant reconstruction failure [50].

Immediately reconstructed breasts using prosthesis only and those combining implants and ADMs (Acellular Dermal Matrix) were equally appreciated by their recipients, with insignificant discrepancies regarding the final result between the two [69]. The combined method of reconstructed breasts lacked the natural sensation when compared to implant-based restoration, but the recipient's overall satisfaction was equal [69].

Limitations

It is known that breast implants should not be retained for a lifetime, that revision surgery and implant change might be needed. The decreased satisfaction with implant BR when compared to autologous abdominal reconstruction could be related to the complications and the possibility of secondary surgery that accompanies this procedure. Mild to severe capsular contracture is reported in numerous studies, with percentage varying between

2% to 83% [70], with increased chances in the irradiated groups [71]; reoperations for implant removal or replacement was found in 30% of cases, with a total reoperation rate of about 45-50% [72].

To conclude, patients with irradiated breasts, with multiple scars, with skin deficit, with poor soft tissue or with severe breast deformities should not undergo an implant-based BR alone. The procedures more suitable in these situations are either an autologous BR or a combination of an autologous flap, such as latissimus dorsi flap, that brings enough soft tissue to cover an implant.

AUTOLOGOUS BREAST RECONSTRUCTION

Restoring the breast from the patient's own tissues using flaps rather than alloplastic material has proven to be the generator of most satisfying results [73, 74], to such an extent that studies trying to objectively quantify the self-recognition (using functional MRI to assess brain activity) of one's DIEP flap reconstructed breast concluded few discrepancies in evaluating the natural and the restored breast [75].

In choosing a flap, the possibilities are numerous. Flaps for breast restoration can be pedicled or free, myocutaneous or cutaneous. Donor sites are also numerous, with the abdomen as the most frequently used.

Factors that influence outcome and satisfaction in autologous breast reconstructions (Table 2)

Table 2. Patient-related factors influencing breast reconstruction outcome, satisfaction and complications

	ALLOPLASTIC	AUTOLOGOUS
RADIATION	• Capsular contracture • Infection • Wound-related complications • Lower satisfaction overall	• Poor cosmesis • Fat necrosis
CHEMOTHERAPY	• No influence (if waiting 6-8 weeks before reconstruction)	• No influence (no waiting needed)
SMOKING	• Skin necrosis • Infection • Reconstructive failure	• Negative influence • Flap necrosis • Fat necrosis • Abdominal hernia

OBESITY	• Reconstructive failure	• Flap complications • Donor site complications
AGE	• No influence	• No influence
MEDICAL COMMORBIDITIES	• Hypertension: pre-op complications; premature prosthesis removal • Diabetes Mellitus: no independent influence	• Hypertension: surgical complications; donor, receptor site complications • Diabetes Mellitus: infection; vascular disease; surgical and post-op complications
PRIOR SURGERY	• Breast conserving treatment: capsular contracture; inferior esthetic outcome • Multiple scars on irradiated tissue: inferior outcome	• Abdominal scars: minor complications

Table 3. Surgical factors influencing alloplastic breast reconstruction outcomes and complications

	ALLOPLASTIC
IMPLANT PROPERTIES	• SHAPE: No influence • CONTENT: silicone greater satisfaction over saline
RECONSTRUCTION TIMING	• Greater satisfaction with immediate reconstruction
SINGLE STAGE BREAST RECONSTRUCTION	• Direct-to-implant: lower aesthetic results
USE OF ADMs, AUTOLOGOUS, FAT GRAFTS	• + ADMs: risk of seroma, reconstructive failure, infection • + AUTOLOGOUS: lower risk of implant related complications • + FAT GRAFTS: improve overall aspect of reconstructed breast; greater satisfaction with outcome; risk of fat necrosis, oil cysts, infection

Timing of Reconstruction

Autologous reconstructions, as the implant-based ones, can be immediate or delayed. Immediate BR, when possible, is preferred in autologous reconstructions also; it results in fewer interventions, good aesthetic results [27], better skin quality, and lower rates of free flap thrombosis [28]. Recent studies show that immediate reconstruction with TRAM flap does not change the rates of local recurrences, metastasis or patient survival when compared to no reconstruction. Furthermore, immediate TRAM flap BR does not interfere with long-term results, even when radiation therapy is necessary after mastectomy [31]. Still, patients are persuaded to first finish their radiotherapy and then proceed to BR, as this associates with better long-term results [76]. For optimum results, the appropriate delay should be at least 12 months.

Radiation Therapy

Even though numerous studies show that the immediate use of flaps does not interfere with cancer spread, recurrence or overall survival, the aesthetic results are altered when radiotherapy is involved.

When trying to compare different autologous flaps that received radiotherapy, no great differences were observed. A study that compared breast restoration using free DIEP flap to pedicled TRAM flap found similar fat necrosis rates in the two groups.

Smoking also interferes with autologous reconstructions results. Using a latissimus dorsi or TRAM pedicled flap in a smoking patient seems to have fewer complications [22]. Smoking was found to increase the incidence of necrosis rates in fat tissue and flaps. The predisposition to wound infection when using free TRAM flaps was also increased [77]. In pedicled TRAM flaps, smoking was found to increase the wound healing period, infections and flap complications. At least 1 month of smoking abstinence is necessary to increase the chances of free flap survival [78].

Other factors, such as *diabetes,* stir continuous debate. Diabetes is cited among the majority of contraindications for free flaps and even pedicle abdominal flaps. Studies that specifically compared results of free flap outcomes in BR did not find any differences in complications and outcomes for type I diabetes, type II diabetes or diabetes-free patients in 896 free TRAM flaps [79]. Another study of 1533 free flaps did not find diabetes to be an independent complication generator in breast reconstruction, but they found that diabetes is a risk factor in extremities free flaps reconstructions [80].

Obesity has also proven to generate up to 2 times more flap complications [81]. However, despite this complication rate, autologous BR is more suited to obese patients, as women with a BMI>25 are more likely to receive abdominally-based flaps [2], and satisfaction rates after this type of BR are similar to normal BMI patients [82]. In prosthesis-based BR in obese patients, decreased esthetic satisfaction was found, but there were no differences in satisfaction when autologous TRAM flaps were used for BR [83].

Choosing the Right Autologous Flap (Table 4)

Latissimus Dorsi (LD) Flap

The first flap described in the literature, more than 100 years ago, for breast reconstruction is the LD flap [84]. Its utility has been recognized, not only as autologous reconstruction, but also in covering implants in autologous and alloplastic reconstruction combined. If harvested with a skin paddle, it has the ability to compensate for skin loss [84-86] but, when used on its own, it offers a small restorative volume as it suffers atrophy, thus the recipient is preferred to be thin or small breasted [87, 88]. LD flap can be used to provide coverage for a prosthesis instead of pectoralis or serratus muscle with superior esthetic outcomes [89]. The introduction of ADMs on a large scale and perfected microvascular techniques facilitating free tissue transfer, accompanied by complications such as pain and seroma at the harvest site [90-94], shoulder girdle impaired mobility [95-97], together with torso contour alteration [88], lead LD flaps in breast surgery to fall from grace.

Long-term surveillance data state the requirement for secondary surgery in 10 years after breast reconstruction using combined LD flap and implant, in more than 50% of patients [98], restricting the use of LD flaps to limited cases. Statistically, over the past years, the use of LD flaps has been decreasing in favor of free flaps or allografts [89, 99]. When compared to acellular dermal matrix for implant cover, complication profiles have been similar, even though LD enjoyed better cosmetic results [100]. When compared to an abdominal flap, patients undergoing LD reconstructions were less satisfied than women receiving TRAM or DIEP flaps [101].

In terms of patient appreciation, long-term surveillance of LD flap use in breast reconstruction suggests great satisfaction from its recipients, data quantified using not only patient reports (BREAST-Q) but medical staff evaluation and computer analysis programs (BCCT.core) as well [87, 102].

All in all, even if cast to the background in favor of other techniques [89], the LD flap is cited among the “workhorse” flaps for breast restoration, with innovative use and perfecting harvest techniques [103] in addition to the ones we know.

Table 4. Surgical factors influencing autologous breast reconstruction outcomes and complications

	AUTOLOGOUS
FLAPS	• Flap options: pTRAM, fTRAM, DIEP, SIEA, TUG, SGAP, IGAP, FCI, PAP, LD • No significant difference in complication incidence in free flaps vs pedicled • pTRAM vs free flaps: fat tissue necrosis; flap loss (total to partial) in obese patients • DIEP vs fTRAM: donor site morbidity, abdominal hernia, partial flap loss • SIEA vs fTRAM and DIEP: small pedicle diameter and length, small flap, risk of fat necrosis and thrombosis • Gluteal and thigh flaps: good option for slender, small breasted patients • High satisfaction with overall outcome and long term results
RECONSTRUCTION TIMING	• Greater satisfaction and better aesthetic outcome in immediate reconstruction
FAT GRAFTS	• Better symmetry and cosmetic outcome

Abdominal Flaps

When choosing to undergo an autologous restoration of the breast, the most common site used in harvesting a flap is the lower abdomen [104]. Rather than implant reconstructed breasts, the autologous tissue offers the possibility of acquiring a more natural appearance and consistency for the restored breast [105]. At the same time, the patient's satisfaction increases when excess abdominal tissue is transferred in the process of autologous reconstruction [106]. Even though postoperative recovery is more demanding, secondary surgery is rarely necessary [2], so the appeal of this kind of reconstruction is explainable to active women of society.

The abdomen offers three major flap possibilities: the TRAM (transverse rectus abdominis musculocutaneous), the DIEP (deep inferior epigastric artery perforator) and the SIEA (superficial inferior epigastric artery).

The TRAM flap was the first to be introduced for breast reconstruction [107] 37 years ago. In time, the TRAM flap has suffered numerous alterations regarding its composition and tailoring as to limit donor-site suffering.

In 1992, the DIEP flap era began in breast reconstruction [108]. Over the years, operative technique refinement and perfecting has led to establishing the DIEP flap as the most elected breast restoration method using autologous tissue [104, 109]. Adding to its appeal is the possibility of solving chronic lymphedema in some cases by incorporating lymph nodes from the inguinal region in the tissue transfer process [110].

However, both TRAM and DIEP flap dissection damage the abdominal wall (TRAM by including muscle and DIEP by injuring the rectus abdominis muscle fascia), thus allowing the possibility of herniation, although post-DIEP herniation occurred in considerably fewer cases than post-TRAM herniation [111-113]. As a solution to the problem, the SIEA flap comes to mind, since it does not involve tampering with the abdominal wall muscular structure, by its adipocutaneous nature [88, 104]. Its limitation, however, lies in inconstant superficial epigastric artery presence and the reduced dimension, often insufficient for reconstructing a breast [109, 112, 114].

When considering patient satisfaction and quality of life, recent studies trying to quantify these parameters using BREAST-Q modules found greater appreciation of autologous abdominal flap breast reconstruction as opposed to prosthesis [115], also when compared to LD autologous reconstruction [101].

At the same time, when comparing pedicle TRAM flaps to free abdominal flaps, patients reported greater appreciation for the pedicle flap in the immediately postoperative period, with equivalent scores of satisfaction as time went by [116]. The offered explanation consists of operation timing, as pedicled flaps were chosen to restore breasts after skin preserving mastectomy followed by immediate reconstruction, whereas patients requiring adjuvant tumor-related treatment benefited from delayed reconstruction resulting in physiological distress that ended after breast reconstruction [116]. Another study comparing the outcomes of pedicle TRAM flaps to free abdominal flaps found that pedicle TRAM was associated with more flap necrosis than free abdominal flaps [117]. Comparison of donor site morbidity between pedicle TRAM and DIEP showed that TRAM patients needed abdominal closure with mesh in 44.2% of cases. Also, the hernia or bulge after pedicle TRAM flap was 21.2% as opposed to 3.1% for the DIEP patients [118].

Quality-of-life 5 years post-autologous breast restoration using the DIEP flap was found to be high among its recipients, even similar to that of the general population [119].

Gluteal and Thigh Flaps

Not all patients are candidates for abdominal flap breast reconstruction, as slender patients with no excess tissue on their lower abdomen are unsuitable for DIEP or TRAM flap breast reconstruction. To fulfill their wish for autologous reconstruction, the gluteal area and the inner thigh have proven to be more than suitable. Depending on the needed breast volume, a superior or inferior gluteal artery perforator (sGAP/iGAP) flap is suitable for slightly larger breasts whereas a transverse upper gracilis myocutaneous (TUG) flap is suitable for medium to small sized breasts [109, 120].

Introduced to the breast reconstruction field approximately 10 years apart, sGAP (1993 [121]) and iGAP (2004 [122]) offer the advantage of better projection to the reconstructed breast when compared to their abdominal alternatives [123]. The vascular pedicle provided by the iGAP is longer than the sGAP one, but can lead to asymmetric gluteal projection and infragluteal crease. Also, skin tone may differ, making them better suited for skin-sparing mastectomy reconstructions [123]. In order to preserve gluteal area symmetry, a double iGAP unilateral breast reconstruction has been described [123]. Concerning disadvantages, slight discomfort in the sitting position has been brought to attention in iGAP reconstruction cases [109].

Another reliable option regarding breast reconstruction when considering younger patients, presenting firmer breasts and less ptosis, is the fasciocutaneous infragluteal (FCI) free flap, which has been shown to offer adequate volume even in slender patients [124].

The TUG flap, used in breast reconstruction since 2004 [125-127], offers a good option for small to medium breasted patients, but requires a minute and laborious dissection to isolate the vascular pedicle, as attention must be paid to the saphenous vein and inguinal lymph nodes in an attempt to avoid lymphorrhea [128] and to the the posterior cutaneous nerve of the thigh to preserve thigh skin physiological sensation. In response to this predicament, the profunda femoris artery perforator flap was described recently [129], its pedicle trajectory allowing the avoidance of lymphatic structures; it also offers a longer pedicle than the TUG flap, with similar characteristics [129].

As microsurgical skills are more and more refined among surgeons, various combinations of free flaps can be used for remarkable cosmetic outcomes, even in bilateral breast reconstruction, offering the surgeon the possibility of molding the flaps to create the desired and suitable shape for every patient opting for autologous breast restoration, regardless of the BMI.

Conclusion

- Breast reconstruction represents an immensely important step towards physical and mental healing in the aftermath of breast cancer.
- Providing patient tailored information, presenting the patient with a wide pallet of options and leading her towards the best personal fit, assisted by patient reported reception of reconstruction, can lead to increased level of satisfaction with the results [130].
- Educating the patient in knowing what to expect in the immediate post-reconstruction period and leading the patient to realistic expectations sets the ground for a satisfying outcome.
- Immediate reconstruction when opposed to delayed reconstruction generates greater levels of satisfaction, but long-term results suggests no difference between the two groups.
- Skin and nipple preserving mastectomies followed by immediate reconstruction are favored.
- In case of alloplastic materials, direct-to-implant reconstruction, covering the implant with ADMs/synthetic meshes, and respecting the integrity of pectoralis and serratus muscles enjoys better reception.
- When comparing the combination of ADMs with implants versus latissimus dorsi flaps with implant, patients reported better aesthetics with the second option.
- Autologous reconstruction is reported to enjoy better long-term satisfaction as no secondary surgery is required in the majority of cases.
- The lower abdomen is the go-to donor site and the DIEP flap the go-to flap for long-term satisfaction.
- In obese patients, implant-based reconstruction was met with lower levels of satisfaction regarding cosmetic outcome in comparison to autologous reconstruction.
- Delayed autologous reconstruction is associated with better outcomes in patients requesting radiotherapy.
- Complications throughout the breast reconstruction process leads to lower overall satisfaction outcomes, especially if associated with requiring secondary intervention.
- Long-term surveillance (more than 5 years) revealed that QOL in patients with DIEP flap reconstructed breasts is similar to general population QOL.

All this being said, there are cases when the esthetic outcome pleases the patient more than the surgeon [131], suggesting the utmost importance of breast restoration treatment for cancer patients, as the esthetic aspect of the matter is not the most appraised one [69].

REFERENCES

[1] American Cancer Society, Breast Cancer Facts and Figures 2013-2014, 2014, http://www.cancer.org/acs/groups/content/@research/documents/document/acspc-042725.pdf.

[2] Ballard, TN; Kim, Y; Cohen, WA; Hamill, JB; Momoh, AO; Pusic, AL; Kim, HM; Wilkins, EG. Sociodemographic predictors of breast reconstruction procedure choice: Analysis of the Mastectomy Reconstruction Outcomes Consortium Study Cohort. *Plastic Surgery International* 2015;2015:150856. doi: 10.1155/2015/150856.

[3] Hartmann, LC; Schaid, DJ; Woods, JE; Crotty, TP; Myers, JL; Arnold, PG; Petty, PM; Sellers, TA; Johnson, JL; McDonnell, SK; Frost, MH; Jenkins, RB. Efficacy of bilateral prophylactic mastectomy in women with a family history of breast cancer. *New England Journal of Medicine* 1999;340(2):77-84.

[4] Deppen, SA; Aldrich, MC; Hartgeetal, DP. Cancer screening: the journey from epidemiology to policy. *Annals of Epidemiology* 2012;22(6):439–445.

[5] Foibar, P; Steward, SL; Chang, S; D'Onofrio, C; Banks, PJ; Bloom, JR. Body image and sexual problems in young women with breast cancer. *Psycho-Oncology* 2006;15(7):579–594.

[6] Rennekerand, R; Cutler, M. Psychological problems of adjustment to cancer of the breast. *Journal of the American Medical Association* 1952;148(10):833–838.

[7] Frost, MH; Schaid, DJ; Sellers, TA; Slezak, JM; Arnold, PG; Woods, JE; Petty, PM; Johnson, JL; Sitta, DL; McDonnell, SK; Rummans, TA; Jenkins, RB; Sloan, JA; Hartmann, LC. Long-term satisfaction and psychological and social function following bilateral prophylactic mastectomy. *Journal of the American Medical Association* 2000;284(3):319–324.

[8] Asken, MJ. PsychoemotionaL aspects of mastectomy: a review of recent literature. *American Journal of Psychiatry* 1975;132(1):56–59.

[9] Roberts, MM; Furnival, IG; Forrest, AP. The morbidity of mastectomy. *British Journal of Surgery* 1972;59(4):301–302.

[10] Maguire, P. The psychological and social sequelae of mastectomy. In:Modern Perspectives in the Psychiatric Aspects of Surgery, J. G. Howells, Ed., pp. 390–421, Brunner/Mazel, New York,NY,USA,1976.

[11] Pusic, AL; Klassen, AF; Snell, L; Cano, SJ; McCarthy, C; Scott, A; Cemal, Y; Rubin, LR; Cordeiro, PG. Measuring and managing patient expectations for breast reconstruction: impact on quality of life and patient satisfaction. *Expert Review of Pharmacoeconomics and Outcomes Research* 2012;12(2):149-58. doi: 10.1586/erp.11.105.

[12] Pusic, AL; Klassen, AF; Scott, AM; Klok, JA; Cordeiro, PG; Cano, SJ. Development of a new patient-reported outcome measure for breast surgery: the BREAST-Q. *Plastic and Reconstructive Surgery* 2009;124(2):345-353.

[13] Breast Q, Users Manual. Version 1.0, 2012.

[14] Mori, H; Umeda, T; Osanai, T; Hata, Y. Esthetic evaluation of immediate breast reconstruction after nipple sparing or skin-sparing mastectomy. *Breast Cancer* 2005;12:299-303.

[15] Preuss, J; Lester, L; Saunders, C. BCCT.core - can a computer program be used for the assessment of aesthetic outcome after breast reconstructive surgery? *The Breast* 2012;21(4):597-600. doi: 10.1016/j.breast.2012.05.012.

[16] American Cancer Society. *Breast Cancer Facts and Figures 2013-2014*. Atlanta: American Cancer Society, Inc. 2013.

[17] Alderman, AK; Jagsi, R. Discussion: Immediate post-mastectomy breast reconstruction followed by radiotherapy: risk factors for complications. *Breast Cancer Research and Treatment* 2010;121:635–637.

[18] Shameem, H; Yip, CH; Fong, E. Immediate breast reconstruction after mastectomy--why do women choose this option? *Asian Pacific Journal of Cancer Prevention* 2008;9:409–412.

[19] Morrow, M; Li, Y; Alderman, AK; Jagsi, R; Hamilton, AS; Graff, JJ; Hawley, ST; Katz, SJ Access to breast reconstruction and patient perspectives on decision making. *JAMA Surgery* 2014;149(10):1015-1021. doi: 10.1001/jamasurg.2014.548.

[20] Héquet, D; Zarca, K; Dolbeault, D; Couturaud, B; Ngô, C; Fourchotte, V; De La Rochefordière, A; Féron, JG; Fitoussi, A; Bélichard, C; Reyal, F; Laki, F; Hajage, D; Sigal, B; Asselain, B; Alran, S; Institut Curie Breast Cancer Group, Roman Rouzier. Reasons of not having breast reconstruction: a historical cohort of 1937 breast cancer patients

undergoing mastectomy. *Springerplus* 2013;2:325. doi: 10.1186/2193-1801-2-325.

[21] Zhong, T; Spithoff, K; Kellett, S; Boyd, K; Brackstone, M; Hanrahan, R; et al. Breast cancer reconstruction surgery (immediate and delayed) across Ontario: Patient indications and appropriate surgical options. Breast Reconstruction Expert Panel, January 5, 2016.

[22] Eric, E; Mihic, N; Krivokuca, D. Breast reconstruction following mastectomy; patient's satisfaction. *Acta Chirugica Belgica* 2009;109:159-166.

[23] Zhong, T; McCarthy, C; Min, S; Zhang, J; Beber, B; Pusic, AL; Hofer SO. Patient satisfaction and health-related quality of life after autologous tissue breast reconstruction: a prospective analysis of early postoperative outcomes. *Cancer* 2012;118(6):1701-1709. doi: 10.1002/cncr.26417.

[24] Fernández-Delgado, J; López-Pedraza, MJ; Blasco, JA; Andradas-Aragones, E; Sánchez-Méndez, JI; Sordo-Miralles, G. Satisfaction with and psychological impact of immediate and deferred breast reconstruction. *Annals of Oncology* 2008;19(8):1430-1434. doi: 10.1093/annonc/mdn153.

[25] Alderman, AK; Wilkins, EG; Kim, HM; Lowery, JC. Complications in postmastectomy breast reconstruction: two-year results of the Michigan Breast Reconstruction Outcome Study. *Plastic and Reconstructive Surgery* 2002;109:2265-2274.

[26] McCarthy, CM; Mehrara, BJ; Riedel, E; Davidge, K; Hinson, A; Disa, JJ; Cordeiro, PG; Pusic, AL. Predicting complications following expander/implant breast reconstruction: an outcomes analysis based on preoperative clinical risk. *Plastic and Reconstructive Surgery* 2008;121:1886-1892. doi: 10.1097/PRS.0b013e31817151c4.

[27] Chevray, PM. Timing of breast reconstruction: immediate versus delayed. *Cancer Journal* 2008;14:223-229.

[28] Masoomi, H; Clark, EG; Paydar, KZ; Evans, GR; Nguyen, A; Kobayashi, MR; Wirth, GA. Predictive risk factors of free flap thrombosis in breast reconstruction surgery. *Microsurgery* 2014;34:589-594. doi: 10.1002/micr.22250.

[29] DeBono, R; Thompson, A; Stevenson, JH. Immediate versus delayed free TRAM breast reconstruction: an analysis of perioperative factors and complications. *British Journal of Plastic Surgery* 2002;55:111-116.

[30] Kronowitz, JS; Robb, LG. Breast reconstruction with post-mstectomy radiation therapy: current issues. *Plastic and Reconstructive Surgery* 2004;114:950-960.

[31] Lee, HH; Hou, MF; Wei, SY; Lin, SD; Luo, KH; Huang, MY; Ou-Yang, F; Huang, CJ. Comparison of long-term outcomes of postmastectomy radiotherapy between breast cancer patients with and without immediate flap reconstruction. *PLoS One* 2016;11(2):e0148318. doi: 10.1371/journal.pone.0148318.

[32] Baumann, DP; Crosby, MA; Selber, JC; Garvey, PB; Sacks, JM; Adelman, DM. Optimal timing of delayed free lower abdominal flap breast reconstruction after postmastectomy radiation therapy. *Plastic and Reconstructive Surgery* 2011;127(3):1100-1106. doi: 10.1097/PRS.0b013e3182043652.

[33] Morrow, M; Scott, SK; Menck, HR; Mustoe, TA; Winchester, DP. Factors influencing the use of breast reconstruction postmastectomy: A National Cancer Database Study. *Journal of the American College of Surgeons* 2001;192(1):1-8.

[34] Bezuhly, M; Temple, C. Sigurdson, LI; Davis, RB; Flowerdew, G; Cook, EF. Immediate postmastectomy reconstruction is associated with improved breast cancer-specific survival: evidence and new challenges from the Surveillance, Epidemiology, and End Results database. *Cancer* 2009;115(20):4648–4654. doi: 10.1002/cncr.24511,

[35] http://www.plasticsurgery.org/Documents/newsresources/statistics/2011 statistics/20011_Stats_Full_Reportpdf.

[36] Gurunluoglu, R; Gurunluoglu, A; Williams, SA; Tebockhorst, S. Current trends in breast reconstruction: survey of American Society of Plastic Surgeons 2010. *Annals of Plastic Surgery* 2013;70:103–110. doi: 10.1097/SAP.0b013e31822ed5ce.

[37] Albornoz, CR; Bach, PB; Mehrara, BJ; Disa, JJ; Pusic, AL; McCarthy, CM; Cordeiro, PG; Matros, E. A paradigm shift in U.S. Breast reconstruction: increasing implant rates. *Plastic and Reconstructive Surgery* 2013;131:15-23. doi: 10.1097/PRS.0b013e3182729cde.

[38] O'Shaughnessy, K. Evolution and update on current devices for prosthetic breast reconstruction. *Gland Surgery* 2015;4(2):97-110. doi: 10.3978/j.issn.2227-684X.2015.03.09.

[39] Roostaeian, J; Pavone, L; Da Lio, A; Lipa, J; Festekjian, J; Crisera, C. Immediate placement of implants in breast reconstruction: patients selection and outcomes. *Plastic and Reconstructive Surgery*, 2011;127:1407-1416. doi: 10.1097/PRS.0b013e318208d0ea.

[40] Baildam, AD. Breast reconstruction state of the art. *Breast* 2006;15 Suppl 2:S27-30.

[41] Spear, SL; Spittler, CJ. Breast reconstruction with implants and expanders. *Plastic and Reconstructive Surgery* 2001;107:177-188.
[42] Salhab, M; Al Sarakbi, W; Joseph, A; Sheards, S; Travers, J; Mokbel, K. Skin-sparing mastectomy and immediate breast reconstruction: patient satisfaction and clinical outcome. *International Journal of Clinical Oncology* 2006;11:51-54.
[43] Ganz, PA. Psychological and social aspects of breast cancer. *Oncology* (Williston Park) 2008;22(6):642-646.
[44] Racano, C; Fania, PL; Motta, GB; Belloni, C; Lazzarini, E; Isoardi, R; Boccù, C; Duodeci, S; D'Agosto, M; Ragni, L. Immediate and delayed two-stage post-mastectomy breast recon-struction with implants. Our experience of general surgeons. *Minerva Chirugica* 2002;57:135-149.
[45] Kim, SW; Lee, HK; Kang, SM; Kang, TH; Yoon, CS; Ko, SS; Hur, MH; Kang, SS; Seul, CH; Gu, JS. Short-term outcomes of immediate breast reconstruction using an implant or tissue expander after mastectomy in breast cancer patients. *Breast Cancer* 2016;23(2):279-285. doi: 10.1007/s12282-014-0570-y.
[46] Robertson, S; Wengström, Y; Eriksen, C; Sandelin, K.. Breast surgeons performing immediate breast reconstruction with implants - assessment of resource-use and patient reported outcome measures. *Breast* 2012;21(4):590-596. doi: 10.1016/j.breast.2012.01.003.
[47] Gibney, J. Use of a permanent tissue expander for breast reconstruction. *Plastic and Reconstructive Surgery* 1989;84:607-620.
[48] Kronowitz, SJ. State of the art and science in postmastectomy breast reconstruction. *Plastic and Reconstructive Surgery* 2015;135:755e-771e. doi: 10.1097/PRS.0000000000001118.
[49] Hodgson, EL; Malata, CM. Implant-based breast reconstruction following mastectomy. *Breast Disease* 2002;16:47-63.
[50] Alderman, A; Gutowski, K; Ahuja, A; Gray, D; Postmastectomy Expander Implant Breast Reconstruction Guideline Work Group. ASPS clinical practice guideline summary on breast reconstruction with expanders and implants. *Plastic and Reconstructive Surgery* 2014;134:648e-655e. doi: 10.1097/PRS.0000000000000541.
[51] Albornoz, CR; Matros, E; McCarthy, CM; Klassen, A; Cano, SJ; Alderman, AK; VanLaeken, N; Lennox, P; Macadam, SA; Disa, JJ; Mehrara, BJ; Cordeiro, PG; Pusic, AL. Implant breast reconstruction and radiation: a multicenter analysis of long-term health-related quality of life and satisfaction. *Annals of Surgical Oncology* 2014;21:2159-2164. doi: 10.1245/s10434-014-3483-2.

[52] Giacalone, PL; Rathat, G; Daures, JP; Benos, P; Azria, D; Rouleau, C. New concept for immediate breast reconstruction for invasive cancers: feasibility, oncological safety and esthetic outcome of postneoadjuvant therapy immediate breast reconstruction versus delayed breast reconstruction: a prospective pilot study. *Breast Cancer Research and Treatment* 2010;122:439-451. doi: 10.1007/s10549-010-0951-7.

[53] Behranwala, KA; Dua, RS; Ross, GM; Ward, A; A'hern, R; Gui, GP. The influence of radiotherapy on capsule formation and aesthetic outcome after immediate breast reconstruction using biodimensional anatomical expander implants. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2006;59:1043-1051.

[54] Losken, A; Carlson, GW; Schoemann, MB; Jones, GE; Culbertson, JH; Hester, TR. Factors that influence the completion of breast reconstruction. *Annals of Plastic Surgery* 2004;52:258-262.

[55] Wong, JS; Ho, AY; Kaelin, CM; Bishop, KL; Silver, B; Gelman, R; Harris, JR; Hergrueter, CA. Incidence of major corrective surgery after post-mastectomy breast reconstruction and radiation therapy. *Breast Journal* 2008;14:49-54. doi: 10.1111/j.1524-4741.2007.00522.x.

[56] Cowen, D; Gross, E; Rouannet, P; Teissier, E; Ellis, S; Resbeut, M; Tallet, A; Cowen, VV; Azria, D; Hannoun-Levi, JM. Immediate post-mastectomy breast reconstruction followed by radiotherapy: risk factors for complications. *Breast Cancer Research and Treatment* 2010;121:627-634. doi: 10.1007/s10549-010-0791-5.

[57] Krueger, EA; Wilkins, EG; Strawderman, M; Cederna, P; Goldfarb, S; Vicini, FA; Pierce, LJ. Complications and patient satisfaction following expander/implant breast reconstruction with and without radiotherapy. *International Journal of Radiation Oncololgy, Biology, Physics* 2001;49:713-21.

[58] Nahabedian, MY. Shaped versus round implants for breast reconstruction: indications and outcomes. *Plastic and Reconstructive Surgery. Global Open* 2014;2:e116. doi: 10.1097/GOX. 000000 0000000068.

[59] Handel, N; Cordray, T; Gutierrez, J; Jensen, JA. A long-term study of outcomes, complications, and patient satisfaction with breast implants. *Plastic and Reconstructive Surgery* 2006;117:757-772.

[60] Macadam, SA; Ho, AL; Cook, EF Jr; Lennox, PA; Pusic, AL. Patient satisfaction and health-related quality of life following breast reconstruction: patient-reported outcomes among saline and silicone

implant recipients. *Plastic and Reconstructive Surgery* 2010;125:761-771. doi: 10.1097/PRS.0b013e3181cb5cf8.

[61] McCarthy, CM; Klassen, AF; Cano, SJ; Scott, A; Vanlaeken, N; Lennox, PA; Alderman, AK; Mehrara, BJ; Disa, JJ; Cordeiro, PG; Pusic, AL. Patient satisfaction with postmastectomy breast reconstruction: a comparison of saline and silicone implants. *Cancer* 2010;116:5584-5591. doi: 10.1002/cncr.25552.

[62] Capozzi, A; Pennisi, VR. Clinical experience with polyurethane-covered gel-filled mammary prostheses. *Plastic and Reconstructive Surgery* 1981;68:512-520.

[63] Herman, S. The Meme implant. *Plastic and Reconstructive Surgery* 1984;73:411-414.

[64] Cohney, BC; Cohney, TB; Hearne, VA. Nineteen years' experience with polyurethane foam-covered mammary prosthesis: a preliminary report. *Annals of Plastic Surgery* 1991;27:27-30.

[65] Dunn, KW; Hall, PN; Khoo, CT. Breast implant materials: sense and safety. *British Journal of Plastic Surgery* 1992;45:315-321.

[66] Calobrace, MB; Hammond, D. Anatomic gel implants: from concept to device. *Plastic and Reconstructive Surgery* 2014;134:4S-9S. doi: 10.1097/PRS.0000000000000608.

[67] Goodwin, SJ; McCarthy, CM; Pusic, AL; Bui, D; Howard, M; Disa, JJ; Cordeiro, PG; Mehrara, BJ. Complications in smokers after postmastectomy tissue expander/implant breast reconstruction. *Annals of Plastic Surgery* 2005;55:16-20.

[68] Albornoz, CR; Bach, PB; Pusic, AL; McCarthy, CM; Mehrara, BJ; Disa, JJ; Cordeiro, PG; Matros, E. The influence of sociodemographic factors and hospital characteristics on the method of breast reconstruction, including microsurgery: a U.S. population-based study. *Plastic and Reconstructive Surgery* 2012;129(5):1071-1079. doi: 10.1097/PRS.0b013e31824a29c5.

[69] Dieterich, M; Angres, J; Stubert, J; Stachs, A; Reimer, T; Gerber, B. Patient-reported outcomes in implant-based breast reconstruction alone or in combination with a titanium-coated polypropylene mesh – a detailed analysis of the BREAST-Q and overview of the literature. *Geburtshilfe und Frauenheilkinde* 2015;75(7):692-701.

[70] Momoh, AO; Ahmed, R; Kelley, BP; Aliu, O; Kidwell, KM; Kozlow, JH; Chung, KC. A systematic review of complications of implant-based breast reconstruction with pre-reconstruction and post-reconstruction

radiation therapy. *Annals of Surgical Oncology* 2014;21(1):118-124. doi:10.1245/s10434-013-3284-z.

[71] Cordiero, PG; Pusic, AL; Disa, JJ; McCormick, B; VanZee, K. Irradiation after immediate tissue expander/implant breast reconstruction: outcomes, complications, aesthetic results, and satisfaction among 156 patients. *Plastic and Reconstructive Surgery* 2004;113:877–881.

[72] Inamed Corporation. Summary of safety and effectiveness data: McGhan silicone filled breast implants. Tech. Rep. PMA P020056, Inamed Corporation, Santa Barbara CA, USA, 2004.

[73] Andrade, WN; Baxter, N; Semple, JL. Clinical determinants of patient satisfaction with breast reconstruction. *Plastic and Reconstructive Surgery* 2001;107:46–54.

[74] Alderman, AK; Wilkins, EG; Lowery, JC; Kim, M; Davis, JA. Determinants of patient satisfaction in postmastectomy breast reconstruction. *Plastic and Reconstructive Surgery* 2000:106:769–776.

[75] Caterson, SA; Fox, SE; Tobias, AM; Lee, BT. Functional MRI to evaluate "Sense of Self" following perforator flap breast reconstruction. *PLoS One* 2012;7(11):e49883. doi: 10.1371/journal.pone.0049883.

[76] Allen, R; Heitland, A. Autogenous augmentation mammaplasty with microsurgical tissue transfer. *Plastic and Reconstructive Surgery* 2003;112:91-100.

[77] Selber, JC; Kurichi, JE; Vega, SJ; Sonnad, SS; Serletti, JM. Risk factors and complications in free TRAM flap breast reconstruction. *Annals of Plastic Surgery* 2006;56:492-497.

[78] Spear, SL; Ducic, I; Cuoco, F; Hannan, C. The effect of smoking on flap and donor-site complications in pedicled TRAM breast reconstruction. *Plastic and Reconstructive Surgery* 2005;116(7):1873-1880.

[79] Miller, RB; Reece, G; Kroll, SS; Chang, D; Langstein, H; Ziogas, A; Robb, G; Evans, GR. Microvascular breast reconstruction in the diabetic patient. *Plastic and Reconstructive Surgery* 2007;119(1):38-48.

[80] Las, DE; de Jong, T; Zuidam, JM; Verweij, NM; Hovius, SE; Mureau, MA. Identification of independent risk factors for flap failure: A retrospective analysis of 1530 free flaps for breast, head and neck and extremity reconstruction. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2016;69(7):894-906. doi: 10.1016/j.bjps.2016.02.001.

[81] Chang, DW; Wang, B; Robb, GL; Reece, GP; Miller, MJ; Evans, GR; Langstein, HN; Kroll, SS. Effect of obesity on flap and donor-site complications in free transverse rectus abdominis myocutaneous flap

breast reconstruction. *Plastic and Reconstructive Surgery* 2000;105:1640-1648.

[82] Sinha, S; Ruskin, O; D'Angelo, A; McCombe, D; Morrison, WA; Webb, A. Are overweight and obese patients who receive autologous free-flap breast reconstruction satisfied with their postoperative outcome? A single-centre study. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2016;69(1):30-36. doi: 10.1016/j.bjps.2015.08.036.

[83] Atisha, DM; Alderman, AK; Kuhn, LE; Wilkins, EG. The impact of obesity on patient satisfaction with breast reconstruction. *Plastic and Reconstructive Surgery* 2008;121:1893-1899. doi: 10.1097/ PRS.0b013e3181715198.

[84] Olivari, N. The latissimus flap. *British Journal of Plastic Surgery* 1976;29:126-128.

[85] McCraw, JB; Dibbell, DG; Carraway, JH. Clinical definition of independent myocutaneous vascular territories. *Plastic and Reconstructive Surgery* 1977;60(3):341–352.

[86] Schneider, WJ; Hill, HL Jr; Brown, RG. Latissimus dorsi myocutaneous flap for breast reconstruction. *British Journal of Plastic Surgery* 1977;30(4):277–281.

[87] Kim, Z; Kang, SG; Roh, JH; Park, JH; Lee, J; Kim, S; Lim, CW; Lee, MH. Skin-sparing mastectomy and immediate latissimus dorsi flap reconstruction: a retrospective analysis of the surgical and patient-reported outcomes. *World Journal of Surgical Oncology* 2012;10:259. doi: 10.1186/1477-7819-10-259.

[88] Schmauss, D; Machens, HG; Harder, Y. Breast reconstruction after mastectomy. *Frontiers in Surgery* 2016;2:71. doi: 10.3389/ fsurg.2015.00071.

[89] Leff, DR; Bottle, A; Mayer, E; Patten, DK; Rao, C; Aylin, P; Hadjiminas, DJ; Athanasiou, T; Darzi, A; Gui, G. Trends in immediate postmastectomy breast reconstruction in the United Kingdom. *Plastic and Reconstructive Surgery. Global Open* 2015;3(9):e507. doi: 10.1097/GOX.0000000000000484.

[90] Clough, KB; Louis-Sylvestre, C; Fitoussi, A; Couturaud, B; Nos, C. Donor site sequelae after autologous breast reconstruction with an extended latissimus dorsi flap. *Plastic and Reconstructive Surgery* 2002;109:1904–1911.

[91] Menke, H; Erkens, M; Olbrisch, RR. Evolving concepts in breast reconstruction with latissimus dorsi flaps: results and follow-up of 121 consecutive patients. *Annals of Plastic Surgery* 2001;47:107–114.

[92] Schwabegger, A; Ninković, M; Brenner, E; Anderl, H. Seroma as a common donor site morbidity after harvesting the latissimus dorsi flap: observations on cause and prevention. *Annals of Plastic Surgery* 1997;38:594–597.

[93] Munhoz, AM; Montag, E; Fels, KW; Arruda, EG; Sturtz, GP; Aldrighi, C; Gemperli, R; Ferreira, MC. Outcome analysis of breast-conservation surgery and immediate latissimus dorsi flap reconstruction in patients with T1 to T2 breast cancer. *Plastic and Reconstructive Surgery* 2005;116:741–752.

[94] Pinsolle, V; Grinfeder, C; Mathoulin-Pelissier, S; Faucher, A. Complications analysis of 266 immediate breast reconstructions. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2006;59:1017–1024.

[95] Thomson, HJ; Potter, S; Greenwood, RJ; Bahl, A; Barker, J; Cawthorn, SJ; Winters, ZE. A prospective longitudinal study of cosmetic outcome in immediate latissimus dorsi breast reconstruction and the influence of radiotherapy. *Annals of Surgical Oncology* 2008;15:1081–1091. doi: 10.1245/s10434-007-9772-2.

[96] Forthomme, B; Heymans, O; Jacquemin, D; Klinkenberg, S; Hoffmann, S; Grandjean, FX; Crielaard, JM; Croisier, JL. Shoulder function after latissimus dorsi transfer in breast reconstruction. *Clinical Physiology and Functional Imaging* 2010;30:406–412. doi: 10.1111/j.1475-097X.2010.00956.x.

[97] Fraulin, FO; Louie, G; Zorrilla, L; Tilley, W. Functional evaluation of the shoulder following latissimus dorsi muscle transfer. *Annals of Plastic Surgery* 1995;35:349–355.

[98] Tarantino, I; Banic, A; Fischer, T. Evaluation of late results in breast reconstruction by latissimus dorsi flap and prosthesis implantation. *Plastic and Reconstructive Surgery* 2006;117(5):1387–1394.

[99] Reefy, S; Patani, N; Anderson, A; Burgoyne, G; Osman, H; Mokbel, K. Oncological outcome and patient satisfaction with skin-sparing mastectomy and immediate breast reconstruction: a prospective observational study. *BMC Cancer* 2010;10:171. doi: 10.1186/1471-2407-10-171.

[100] Lee, J; Bae, Y. Use of latissimus dorsi muscle onlay patch alternative to acellular dermal matrix in implant-based breast reconstruction," *Gland Surgery* 2015;4(3):270-276. doi: 10.3978/j.issn.2227-684X.2015.01.07.

[101] Yueh, JH; Slavin, SA; Adesiyun, T; Nyame, TT; Gautam, S; Morris, DJ; Tobias, AM; Lee, BT. Patient satisfaction in postmastectomy breast reconstruction: a comparative evaluation of DIEP, TRAM, latissimus

flap, and implant techniques. *Plastic and Reconstructive Surgery* 2010;125(6):1585–1595. doi: 10.1097/PRS.0b013e3181cb6351.

[102] Kim, KD; Kim, Z; Kuk, JC; Jeong, J; Choi, KS; Hur, SM. Long-term results of oncoplastic breast surgery with latissimus dorsi flap reconstruction: a pilot study of the objective cosmetic results and patient reported outcome. *Annals of Surgical Treatment and Research* 2016;90(3):117-123. doi: 10.4174/astr.2016.90.3.117.

[103] Lee, MA; Miteff, KG. The scarless latissimus dorsi flap provides effective lower pole prosthetic coverage in breast reconstruction. *Plastic and Reconstructive Surgery. Global Open* 2014;2(5):e147. doi: 10.1097/GOX.0000000000000089.

[104] Pollhammer, MS; Duscher, D; Schmidt, M; Huemer, GM. Recent advances in microvascular autologous breast reconstruction after ablative tumor surgery. *World Journal of Clinical Oncology* 2016;7(1):114-121. doi: 10.5306/wjco.v7.i1.114.

[105] Nahabedian, MY. Achieving ideal breast aesthetics with autologous reconstruction. *Gland Surgery* 2015;4(2):134-144. doi: 10.3978/j.issn.2227-684X.2015.03.03.

[106] Ziswiler-Gietz, J; Makrodimou, M; Harder, Y; Banic, A; Erni, D. Outcome analysis of breast reconstruction with free transverse rectus abdominis musculocutaneous (TRAM) flaps. *Swiss Medical Weekly* 2008;138(7-8):114-120. doi: 2008/07/smw-12069.

[107] Holstrom, H. The free abdominoplasty flap and its use in breast reconstruction: An experimental study and clinical case report. *Scandinavian Journal of Plastic and Reconstructive Surgery* 1979;13:423-7.

[108] Allen, RJ; Treece, P. Deep inferior epigastric perforator flap for breast reconstruction. *Annals of Plastic Surgery* 1994;32:32-8.

[109] Healy, C; Ramakrishnan, V. Autologous microvascular breast reconstruction. *Archives of Plastic Surgery* 2013;40(1):3-10. doi: 10.5999/aps.2013.40.1.3.

[110] Saaristo, AM; Niemi, TS; Viitanen, TP; Tervala, TV; Hartiala, P; Suominen, EA. Microvascular breast reconstruction and lymph node transfer for postmastectomy lymphedema patients. *Annals of Surgery* 2012;255(3):468–473. doi: 10.1097/SLA.0b013e3182426757.

[111] Egeberg, A; Rasmussen, MK; Sørensen, JA. Comparing the donor site morbidity using DIEP, SIEA or MS-TRAM flaps for breast reconstructive surgery: a meta-analysis. *Journal of Plastic,*

Reconstructive and Aesthetic Surgery 2012;65:1474-1480. doi: 10.1016/j.bjps.2012.07.001.

[112] Granzow, JW; Levine, JL; Chiu, ES; Allen, RJ. Breast reconstruction with the deep inferior epigastric perforator flap: history and an update on current technique. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2006;59:571-579. doi: 10.1016/j.bjps.2006.01.004.

[113] Gill, PS; Hunt, JP; Guerra, AB; Dellacroce, FJ; Sullivan, SK; Boraski, J; Metzinger, SE; Dupin, CL; Allen, RJ. A 10-year retrospective review of 758 DIEP flaps for breast reconstruction. *Plastic and Reconstructive Surgery* 2004;113:1153-1160. doi: 10.1097/01. PRS.00001 10328.47206.50.

[114] Hadad, I; Ibrahim, AM; Lin, SJ; Lee, BT. Augmented SIEA flap for microvascular breast reconstruction after prior ligation of bilateral deep inferior epigastric arteries. *Journal of Plastic, Reconstructive and Aesthetic Surgery* 2013;66:845-847. doi: 10.1016/j.bjps.2012.09.010.

[115] Sgarzani, R; Negosanti, L; Morselli, PG; Vietti Michelina, V; Lapalorcia, LM;, Cipriani, R. Patient satisfaction and quality of life in DIEAP flap versus implant breast reconstruction. *Surgery Research and Practice* 2015;2015:405163. doi: 10.1155/2015/405163.

[116] Schwitzer, JA; Miller, HC; Pusic, AL; Matros, E; Mehrara, BJ; McCarthy, CM; Lennox, PA; Van Laeken, N; Disa, JJ. Satisfaction following unilateral breast reconstruction: a comparison of pedicled TRAM and free abdominal flaps. *Plastic and Reconstructive Surgery. Global Open* 2015;3(8):e482. doi: 10.1097/GOX.0000000000000458.

[117] Andrades, P; Fix, RJ; Danilla, S; Howell, RE 3rd; Campbell, WJ; De la Torre, J; Vasconez, LO. Ischemic complications in pedicle, free, and muscle sparing transverse rectus abdominis myocutaneous flaps for breast reconstruction. *Annals of Plastic Surgery* 2008;60:562-567. doi: 10.1097/SAP.0b013e31816fc372.

[118] Knox, AD; Ho, AL; Leung, L; Tashakkor, AY; Lennox, PA; Van Laeken, N; Macadam, SA. Comparison of outcomes following autologous breast reconstruction using the DIEP and pedicled TRAM flaps: a 12-year clinical retrospective study and literature review. *Plastic and Reconstructive Surgery* 2016;138(1):16-28. doi: 10.1097/PRS. 0000000000001747.

[119] Hunsinger, V; Hivelin, M; Derder, M; Klein, D; Velten, M; Lantieri, L. Long-term follow-up of quality of life following DIEP flap breast reconstruction. *Plastic and Reconstructive Surgery* 2016;137(5):1361-1371. doi: 10.1097/PRS.0000000000002047.

[120] Yu, SC; Kleiber, GM; Song, DH. An algorithmic approach to total breast reconstruction with free tissue transfer. *Archives of Plastic Surgery* 2013;40:173-180. doi: 10.5999/aps.2013.40.3.173.
[121] Allen, RJ; Tucker, C Jr. Superior gluteal artery perforator free flap for breast reconstruction. *Plastic and Reconstructive Surgery* 1995;95:1207–1212.
[122] Guerra, AB; Metzinger, SE; Bidros, RS; Gill, PS; Dupin, CL; Allen, RJ. Breast reconstruction with gluteal artery perforator (GAP) flaps: a critical analysis of 142 cases. *Annals of Plastic Surgery* 2004;52:118–125.
[123] Satake, T; Muto, M; Ogawa, M; Shibuya, M; Yasumura, K; Kobayashi, S. Unilateral breast reconstruction using bilateral inferior gluteal artery perforator flaps. *Plastic and Reconstructive Surgery. Global Open* 2015;3(3):e314. doi: 10.1097/GOX.0000000000000287.
[124] Papp, C; Windhofer, C; Michlits, W. Autologous breast augmentation with the deepithelialized fasciocutaneous infragluteal free flap: a 10-year experience. *Annals of Plastic Surgery* 2011;66:587-592. doi: 10.1097/SAP.0b013e3181d376bf.
[125] LoTempio, MM; Allen, RJ. Breast reconstruction with SGAP and IGAP flaps. *Plastic and Reconstructive Surgery* 2010;126:393-401. doi: 10.1097/PRS.0b013e3181de236a.
[126] Schoeller, T; Wechselberger, G. Breast reconstruction by the free transverse gracilis (TUG) flap. *British Journal of Plastic Surgery* 2004;57:481-482.
[127] Wechselberger, G; Schoeller, T. The transverse myocutaneous gracilis free flap: a valuable tissue source in autologous breast reconstruction. *Plastic and Reconstructive Surgery* 2004;114:69-73.
[128] Fattah A, Figus A, Mathur B, et al. The transverse myocutaneous gracilis flap: technical refinements. J Plast Reconstr Aesthet Surg 2010;63:305-13.
[129] Allen, RJ; Haddock, NT; Ahn, CY; Sadeghi, A. Breast reconstruction with the profunda artery perforator flap. *Plastic and Reconstructive Surgery* 2012;129:16e-23e. doi: 10.1097/PRS.0b013e3182363d9f.
[130] Kane, RL. Understanding Health Care Outcomes Research, Jones and Barlett Publisher, Sudbury MA, USA, 2005.

[131] Gerber, B; Krause, A; Kuchenmeister, I; Reimer, T; Makovitzky, J; Kundt, G; Friese, K. Skin sparing mastectomy with autologous immediate reconstruction: oncological risks and aesthetic results. *Zentralblatt fur Gynakologie* 2000;122:476–482.

[132] Hunsinger, V; Hivelin, M; Derder, M; Klein, D; Velten, M; Lantieri, L. Long-term follow-up of quality of life following DIEP flap breast reconstruction. *Plastic and Reconstructive Surgery* 2016;137(5):1361-1371. doi: 10.1097/PRS.0000000000002047.

INDEX

#

A

B

C

D

E

F

G

M

N

O

P

Q

R