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Review

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Management after flap failure: a narrative review

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Abstract

Autologous free tissue transfer for breast reconstruction is a well-established and reliable form of reconstruction for women undergoing mastectomies. These surgeries are performed with high rates of success; however, the consequences of flap failure can be devastating to patients and surgeons. Breast reconstruction decision making following flap loss is a uniquely individualized process, based on considerations of safety, patient goals and preferences, as well as the surgeon's skillset. The first priority following flap failure is to provide thoughtful patient counseling and support through this difficult time. The aims of reconstruction salvage after flap loss are to excise unhealthy tissue and restore a breast mound of normal anatomical shape. We present an algorithm as a possible approach to managing flap failures. We also review the management of breast reconstruction following free flap failure, including the role of hematologic investigation, anticoagulation recommendations and secondary or tertiary reconstruction with both prosthetic and autologous techniques.

Keywords: Microsurgery, breast reconstruction, flap failure

INTRODUCTION

Autologous free tissue transfer for breast reconstruction is a well-established and reliable form of reconstruction for women undergoing mastectomies. Free tissue flaps provide a versatile and natural reconstructive option, with greater longevity of results and evidence of improved patient-reported quality of life compared to implant-based reconstruction[1,2]. Free flap breast reconstructions are performed with high

rates of success, estimated at > 96% in high-volume centers[3-9]; however, the consequences of flap failure can still be devastating to patients and surgeons[10]. Specific patient and non-patient related factors have been identified that can PREDISPOSE PATIENTS to a greater risk for flap failures. Patient factors include hypercoagulable conditions, prior radiotherapy, and obesity[11,12]. Beyond patient factors, flap failures can also be IMPACTED by flap and perforator choices, and technical problems in all phases of the procedure including the flap harvest, microvascular anastomoses, flap inset and postoperative incidents.

Breast reconstruction decision making following flap loss is a uniquely individualized process, contingent upon considerations of safety, patient goals and preferences, as well as the surgeon's skillset. The aims of reconstruction salvage after flap loss are to excise unhealthy tissue and restore a breast mound of normal anatomical shape[13]. There are well-described management algorithms for other types of failed microvascular reconstruction, such as for lower extremity[14] or head and neck reconstructions[15], but there is a paucity of information on this topic in breast reconstruction. We present an algorithm as a possible approach to managing flap failures [Figure 1]. We also review the management of breast reconstruction following free flap failure, including the role of hematologic investigation, anticoagulation recommendations and secondary or tertiary reconstruction with both prosthetic and autologous techniques.

PATIENT COUNSELING IN THE SETTING OF FLAP FAILURE

However difficult the conversation may be, clear and thoughtful patient communication is imperative in the event of a flap failure. Complications from surgery have a significant impact on quality of life, including mental health conditions[16]. This can be particularly devastating to women undergoing secondary autologous reconstruction after failed alloplastic reconstruction, as there are potential feelings of losing the breast twice[17]. Having a complete preoperative discussion to set realistic expectations is the first step. This is true for not only complete flap loss, but the range of breast complications as well as those that involve the donor site. Informing patients of the likelihood of adverse events is necessary while also discussing individual factors that place them at higher risk, such as obesity or hypercoagulability. It can be helpful to discuss flap loss rates reported in the literature and, if available, failure rates at the specific treating institution. It is also beneficial to educate patients on the secondary (or tertiary) options for reconstruction, such as implant-based, and additional autologous reconstruction options. While knowledge of the possibility of flap failure can cause some concern for patients, most are placed at ease knowing that alternate options exist in the unlikely event of flap failure and that they will be supported and guided through each step of the process. In patients who do not wish to undergo further reconstructive surgery, the option of an aesthetic flat closure should be offered[18]. In fact, Lineaweaver *et al.* found that nearly half of patients opted to forgo further breast reconstruction following their flap failure[19].

Higgins *et al.* interviewed women who experienced complete flap loss for breast reconstruction to better understand the psychosocial detriment of this outcome[10]. Not surprisingly, women expressed difficulty with body image and coping with emotions after flap loss. Another notable theme that emerged, however, was the impact the relationship with the surgeon had on the patient's overall experience. The study showed that women who reported a strong relationship with their surgeon also reported easier acceptance and coping with their flap loss. Similarly, patients who felt unsupported or dismissed by their surgeon expressed greater emotional distress and questioning after flap loss[10]. Many women suggested increasing emotional support resources in the setting of flap failure, including social workers and psychiatrists. Given that a multidisciplinary approach results in better outcomes in breast reconstruction[20] a similar holistic approach to the management of the patient who has experienced a flap loss may be beneficial. Li *et al.* found that with dedicated nursing attention, surgical breast cancer patients reported lower depression scores and greater satisfaction postoperatively[21]. Even with ancillary support, the surgeon is ultimately responsible for the

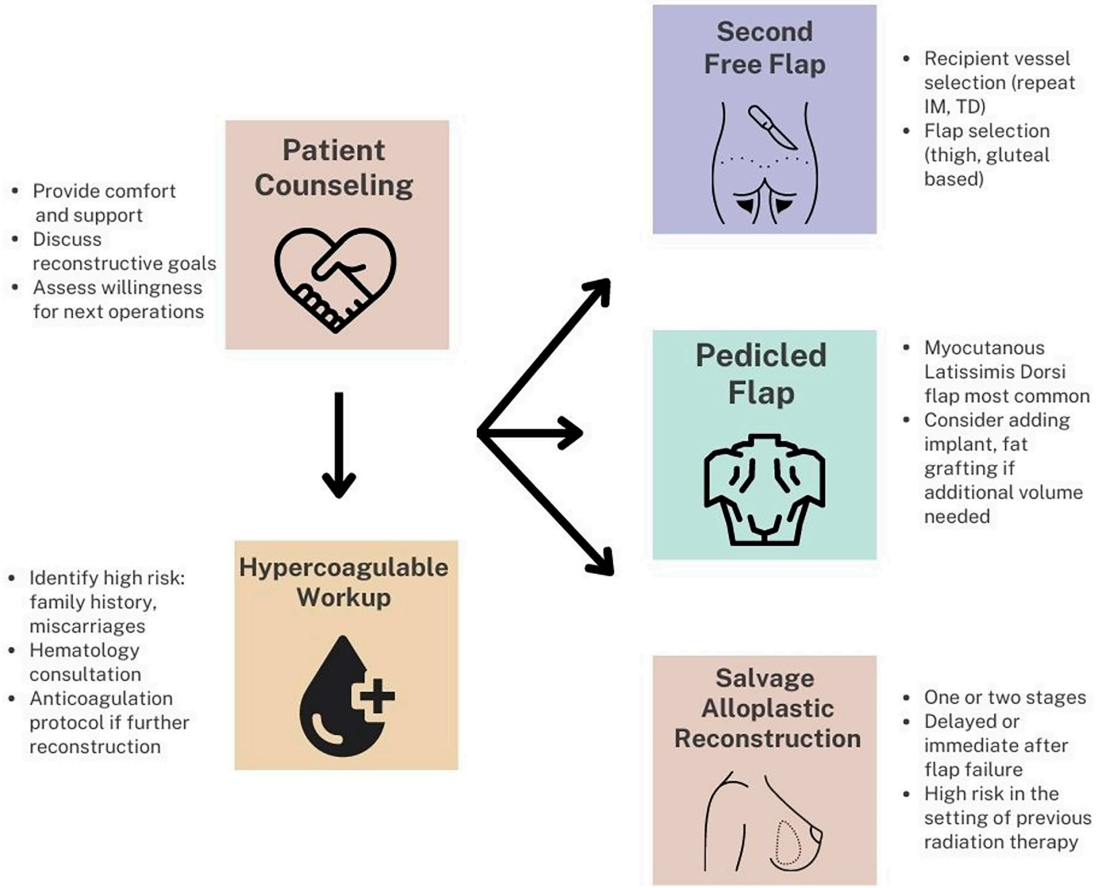

Figure 1. Algorithm for management after flap failure.

management of the patient and has the most influential impact on helping patients through this difficult time.

HEMATOLOGICAL INVESTIGATION

A hematology workup should be considered if risk factors for clotting are identified during the preoperative evaluation, or if unexplained clotting resulting in failure is encountered postoperatively. While free flap transfer can be successfully performed in patients with underlying thrombophilias, hypercoagulability has traditionally been described as a relative contraindication to free tissue transfer. A recent systematic review performed by Kotamarti *et al.* found an 18.4% thrombosis rate with a pooled 12.2% flap failure rate in breast reconstruction patients concerning patients with hypercoagulability[22]. Many patients with hereditary or acquired thrombophilia experience their first complication in the setting of surgery[23]. Additionally, when thrombosis is discovered postoperatively in these patients, the salvage rate is near zero[23,24].

Thrombophilia is reported to have a prevalence rate of 5 to 27% of the population, with even higher prevalence in oncologic patients and patients undergoing lower extremity reconstruction[22,25,26]. Hypercoagubility disorders can be hereditary or acquired. Hereditary disorders include factor V Leiden, prothrombin G20210A mutation, methylenetetrahydrofolate reductase (MTHFR) mutations, protein C deficiency, protein S deficiency, antithrombin III deficiency, and elevated factor VIII. Acquired conditions

include antiphospholipid syndrome (anticardiolipin, lupus anticoagulant), and some forms of hyperhomocysteinemia. Hypercoagulable states pose a challenge in autologous free flap reconstruction because they are frequently undetected preoperatively and are often only brought on by a precipitating event, such as a microvascular procedure[25,27].

Free flap thrombosis more commonly occurs in the postoperative period than intraoperatively in patients with known hypercoagulability disorders[22]. Multiple studies have also demonstrated that flap salvage rates are significantly higher if flap thrombosis and re-exploration occur early in the postoperative period[28-31]. Wang *et al.* found that the failure rate approaches 100% when flap thrombosis occurs on postoperative days 4 and 5 in hypercoagulable patients[28]. For these reasons, it is imperative to screen patients for hypercoagulable disorders preoperatively to minimize the risk of postoperative flap thromboses that are difficult to salvage. Perioperative risk assessment can significantly reduce the occurrence of flap thrombosis[32]. During the initial preoperative consultation, it is important to obtain a thorough history by asking questions regarding (1) personal history of blood clots, including deep vein thrombosis or pulmonary embolism; (2) personal history of miscarriages; (3) personal history of strokes at a young age; and (4) family history of clotting or previously diagnosed coagulation disorders[28,32]. If hypercoagulability is suspected based on history, referral to hematology for further workup is warranted. Patients who were referred to a hematologist have shown a higher flap success rate compared to patients who did not, as administration of an appropriate perioperative anticoagulation regimen can mitigate risk[28]. For instance, Kalmar *et al.* discovered that a platelet count of > 250 K/mcL ($P = 0.004$) is associated with a higher rate of flap failure[33]. The authors suggest there may be a role for personalized anticoagulation protocols for thrombocytosis with agents specifically targeting platelets, such as aspirin, ticlodipine, and dipyramidole[33]. Genetic testing should also be considered, especially in patients with a family history of clotting episodes. It is recommended that a formal hypercoagulable workup be performed at a minimum of 4-6 weeks after a traumatic event such as surgery, as coagulation factors remain elevated during this time, specifically thrombin, that will alter the results of the testing[13,34]. After a patient is confirmed to have a hypercoagulable disorder, surgeons can collaborate with hematologists to determine a perioperative anticoagulation regimen, especially if salvage free-tissue transfer is to be attempted. Literature is sparse on success and failure rates for breast reconstruction of an attempted second flap after an initial failure in a patient with a known hypercoagulable condition. In a series described by Hamdi *et al.*, two patients with hypercoagulable conditions underwent a second free flap with a successful free tissue transfer with appropriate anticoagulation[17].

ANTICOAGULATION REGIMEN

In patients without hypercoagulable disorders, prophylactic antithrombotic therapy is used to minimize the risk of venous thromboembolic events but can also decrease the incidence of microvascular thrombosis after free flap surgery[25]. There is no consensus on anticoagulation protocols and relevant studies are generally lacking. For example, at the authors' institution, it is typical to administer subcutaneous heparin 5,000 units preoperatively, aspirin 300 mg rectal suppository at the end of the case, followed by Lovenox 40 mg QD starting postoperative day 0 and aspirin 325 mg starting on the first postoperative for 30 days for patients without increased risk of thrombosis. Liu *et al.* reported a regimen of intraoperative heparin bolus of 2,000 units intravenously followed by five days of heparin infusion at 500 unit/hour in patients who are at risk of hypercoagulability[35]. Wang *et al.* presented four different anticoagulation protocols based on surgeon preference at a single institution[28]. It is apparent that prophylactic antithrombotic regimen has varied through the decades amongst different institutions and surgeons.

When it comes to patients who have already experienced a thrombotic event or patients who are likely to have an underlying hypercoagulable condition, the use of therapeutic anticoagulation remains controversial. A retrospective review by Senchenkov *et al.* described an algorithm of anticoagulation for patients both with and without a history of hypercoagulability[25]. They concluded that in patients without hypercoagulable history, additional anticoagulation beyond routine VTE prophylaxis is not indicated. Based on available data in the cardiovascular literature, Senchenkov *et al.* recommend that in patients with a hypercoagulable history, a heparin bolus prior to flap ischemia, ex-vivo irrigation of the flap with heparinized saline prior to anastomosis, and systemic anticoagulation should be considered[25]. Additionally, in the setting of recurrent flap thrombosis, heparin drip, intraoperative ASA, Plavix via nasogastric tube, and dextran-40 infusion should be considered[25].

The use of thrombolytic agents after free flap failure can be considered, but their efficacy has not been well established. Thrombolytic agents used in free flap salvage include streptokinase, urokinase, and tissue-plasminogen activator (tPA)[29,36,37]. tPA is the most commonly used agent and is generally injected via the arterial pedicle at a concentration of 1 mg/mL[37]. Urokinase is generally infused in an anterograde manner through the arterial pedicle at a concentration of 5,000 units/mL. Streptokinase can be injected into the arterial pedicle at 7,500 to 250,000 units diluted in 10-30 cc of normal saline[37]. Thrombolytics should be used with caution and only as a last resort due to their associated complications, including bleeding events and allergic reactions. With this in mind, they can be injected just proximal to the arterial anastomosis to increase their bioavailability at the site of the thrombus. Some have also reported taking down the venous anastomosis to avoid the systemic spread of the thrombolytic agent, though the risk of complications from systemic spread of the doses used in flap salvage is not entirely clear[37].

SALVAGE FREE FLAP: RECIPIENT VESSEL SELECTION

A significant challenge facing the reconstructive surgeon following the failure of free flaps for breast reconstruction is the availability of recipient vessels in the chest. There is no consensus on the optimal timing of secondary free flap reconstruction following the failure of the initial flap, though some surgeons advocate for immediate free flap reconstruction at the time of debridement of the original flap as the mammary arteries and veins may still be salvageable. Hamdi *et al.* advocate for color Duplex imaging to assess the internal mammary system following free flap failure if considering another flap[17]. If the anterograde system is thrombosed, the retrograde system should be interrogated as it is a robust and reliable recipient vessel option for secondary free flap reconstruction[38,39]. Alternative vessel choices can be based on the subscapular system, which comes off of the axillary vessels, namely the thoracodorsal or serratus vessels[40] [Figure 2]. To identify the thoracodorsal and serratus vessels, the lateral pectoralis border is first found. Within the axillary fat, the lateral thoracic vein is found and can be followed proximally to the axillary vein. Carefully dissecting bluntly through the axillary fat posterior to the origin of the lateral thoracic vein reveals the proximal thoracodorsal vessels. The serratus branch can be found two to three cm from the origin of the thoracodorsal artery, supplying the serratus muscle[40]. The thoracodorsal artery must be ligated distally to avoid a caliber mismatch of secondary flap pedicle[41]. Moran *et al.* conducted a prospective cohort study and found no significant outcome differences between the internal mammary and thoracodorsal vessels as recipient sites for autologous breast reconstruction, concluding that both are safe options with acceptable results[42].

Other less common venous outflow options have been described, such as the cephalic and external jugular veins[43]. Additionally, if the failure is not due to thrombosis of the pedicle and the anastomosis remains patient, the initial flap artery and vein can be used for secondary flap salvage recipient vessels[44,45]. The thoracoacromial vessels have also been described for recipient vessels for autologous breast reconstruction,

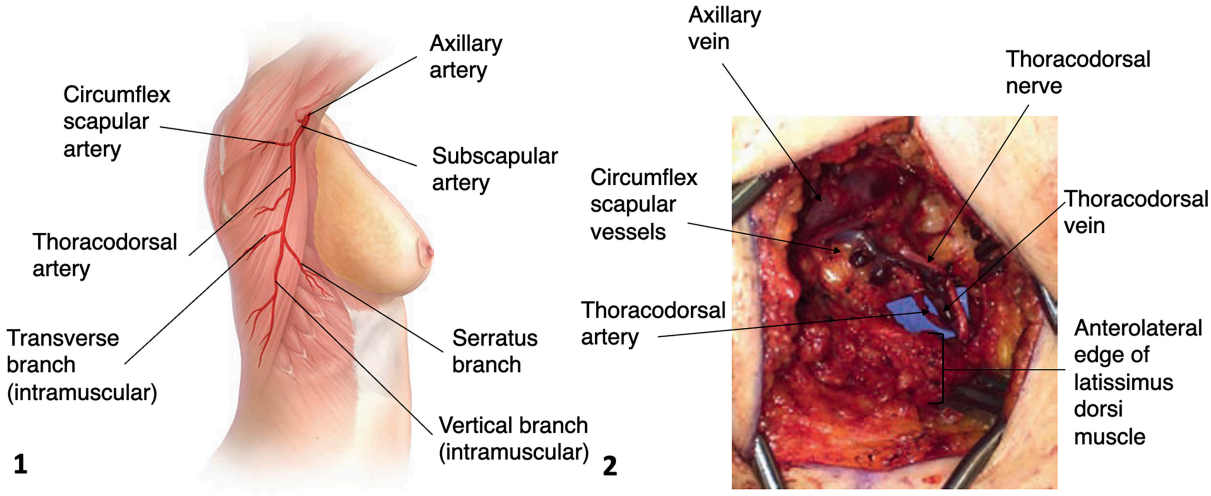

Figure 2. Illustration of the thoracodorsal vessels arising from the subscapular system (Image 1). Exposure of the thoracodorsal artery, vein, and nerve prior to their entry into the latissimus dorsi muscle. The nerve should be dissected free to prevent any kinking of the vessels after anastomosis (Image 2). Reproduced with permission from TA Kung, AO Momoh, Ch 24: Recipient Vessel Exposure--Internal Mammary and Thoracodorsal, Operative Techniques in Breast Surgery, Trunk Reconstruction and Body Contouring. Publication Date: June 3, 2019. Wolters Kluwer.

with the added benefit of not sacrificing any rib and possibly less pain[46]. Yamamoto *et al.* compared thoracoacromial vessels to the internal mammary vessels for breast reconstruction found a significantly smaller size artery (1.70 ± 0.26 mm) and vein (1.64 ± 0.24 mm) compared to the internal mammary artery (2.27 ± 0.31 mm) and vein (2.33 ± 0.29 mm) ($P < 0.001$)[46]. Even less commonly, contralateral internal mammary vessels as recipient options have been described[47,48].

SALVAGE FREE FLAP: SECONDARY FLAP SELECTION

As the DIEP flap remains the gold standard for autologous breast reconstruction, in the scenario of a failed initial free flap reconstruction, secondary free flap options require alternative donor sites. These include the thigh (myocutaneous gracilis flaps, profunda artery perforator flap, lateral thigh flap) and trunk (lumbar artery perforator flap, superior and inferior gluteal artery perforator flaps).

A myocutaneous gracilis flap (either transverse, diagonal, or vertical skin paddle orientation) is a reliable option with high patient satisfaction for secondary free flap salvage[49]. As this flap does not require perforator dissection, it can be performed expeditiously if attempting in the setting of an immediate flap loss. The profunda artery perforator (PAP) flap is another medial thigh-based flap with similar advantages to the myocutaneous gracilis flap but a muscle-sparing alternative[50] [Figure 3]. The lateral thigh perforator (LTP) flap, renovated for breast reconstruction by Robert Allen, Sr. is a secondary option for patients with the "saddlebag" deformity[51,52]. Based on the ascending lateral circumflex femoral artery, dissection is relatively simple due to the septocutaneous location of the perforators between the tensor fascia lata (TFL) and the gluteus medius (GM) muscles[53]. The LTP has a short pedicle, often necessitating vein grafting in salvage cases. The lumbar artery perforator (LAP) flap perforasome includes the soft tissues commonly referred to as the "love handle" region[54]. Like the LTP flap, this also has a short pedicle. Gluteal artery perforator flaps (superior and inferior)[55] are additional trunk-based options for alternative flap options. Historically, the SGAP and IGAP flaps were preferred second-line options, though now mostly replaced by

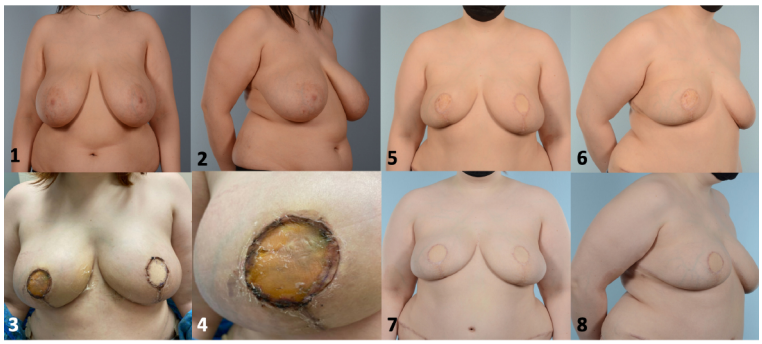

Figure 3. Patient with a genetic predisposition for breast cancer (Images 1 and 2) who underwent bilateral skin- sparing mastectomies and immediate reconstruction with a left DIEP flap and a right SIEA flap. Three weeks postoperatively, she presented with a discoloration of the right flap skin paddle, brisk capillary refill, and firmness at the inferolateral quadrant of the breast (Images 3 and 4). While not frankly necrotic, the entire breast ultimately was very firm (Images 5 and 6). The right SIEA flap was debrided and replaced with a PAP flap using a more proximal portion of the same antegrade internal mammary vessels (Images 7 and 8).

medial thigh-based flaps due to reliable anatomy, availability of donor site tissue, ease of harvest, and lower complication rates[53,56].

Though typically utilized in a pedicled fashion, a contralateral latissimus dorsi myocutaneous free flap can be performed in the setting of tertiary reconstruction[57]. This has a reliable anatomy with generally adequate donor site tissue, especially if a large area of skin is needed. An additional consideration for this option would be if the ipsilateral thoracodorsal dorsal pedicle was previously sacrificed during an axillary lymph node dissection. While this may not be the first choice for a free flap tertiary salvage breast reconstruction, a contralateral free latissimus is an option if needed.

Non-abdominally based flaps may not provide enough tissue in the setting of a DIEP flap failure. Challenges with alternative flaps include less volume with a smaller skin paddle and an inability to restore the breast footprint or skin envelope, especially when working to match a relatively large contralateral breast (native or reconstructed)[58]. With smaller flaps, a dependable solution is to combine two flaps for single breast reconstruction in a "stacked" fashion[39]. When recipient vessels are limited due to previous thrombosis after flap failure, flaps can be stacked using the "daisy-chain" technique: anastomosing one flap to a branch of the pedicle of the other flap[59].

Performing a second free flap after an initial failure can be a reasonable option shown to be effective in the literature. Hamdi *et al.* retrospectively reviewed their series of repeat free flap breast reconstruction after an initial free flap failure[17]. In this series, 688 patients experienced 14 failures of autologous reconstruction requiring salvage. Of these 14, eight patients underwent nine microvascular breast reconstructions, with two of these nine experienced failures of the second flap. This information is useful when discussing options with patients after free flap failures. Baumeister *et al.* similarly retrospectively reviewed 902 free flaps, identifying 13 patients who underwent a second flap surgery[60]. Microsurgical free tissue transfers were successful in 11 of the 13 patients. The authors outline their approach in the setting of a failed flap which includes a reconsideration of the need for autologous tissue, sensitive patient counseling, thorough analysis of the cause of failure, and change in microsurgical strategy[60].

PEDICLED FLAP OPTIONS

Pedicled flaps are an alternative option to performing free flaps for salvage in clinical situations where vascularized tissue is required, such as in the setting of radiation. Implant reconstructions in the setting of

prior radiation result in increased rates of major complications such as implant extrusion, capsular contracture, and reconstruction failure compared to similar reconstructions in non-irradiated breasts[61]. As such, many reconstructive surgeons opt to use autologous reconstruction in these patients. The latissimus dorsi flap (LD)[62] is the most common pedicled flap option for autologous tissue salvage following free flap failure, as it does not require microsurgery and has a reliable anatomy with a versatile skin paddle that results in a high reconstructive success rate[13,63] [Figure 4]. Though first described for postmastectomy reconstruction by D'Este in 1912[63], it was popularized in the late 1970s as a method of autologous breast reconstruction. The latissimus dorsi flap allows for the harvest of a large skin paddle, useful in situations where there was a loss of skin from the prior failed free flap.

Aesthetic results are often excellent, and the LD flap permits the use of healthy, non-radiated tissue to cover an implant if one is needed to achieve a size match[64]. If greater volume is required, an implant or tissue expander can be placed under the flap, in one or two stages, either above or below the pectoralis muscle[65]. In appropriate candidates, autologous fat grafting at the initial time of the LD flap can provide significant volume enhancement as needed[66,67]. This is known as the Latissimus Dorsi and Immediate Fat Transfer (LIFT) procedure, where upwards of 500 cc of fat can be added for increased volume. When considering this option, ensure the thoracodorsal pedicle has not been injured from previous interventions, such as an axillary lymph node dissection or radiation[68]. A recent retrospective review of 248 patients by Wattoo *et al.* showed long-term overall patient satisfaction from latissimus flap reconstruction[69]. While minor complication rates were high in the short term (seroma 58% and wound infection 13%), chronic complications were low (shoulder stiffness 1.9%, pain 11.5%), highlighting the utility of this procedure. These results are consistent with another retrospective review of 277 patients by Yezhelyev *et al.*, with higher short-term complications (seroma 19.5%), but overall low risk in the long term[70].

CONVERSION TO ALLOPLASTIC

Alloplastic or implant-based reconstruction is another effective option for salvage, particularly in non-radiated breasts. When contemplating conversion to implant-based reconstruction, the psychological and emotional toll experienced after free flap failure should be considered, especially in women who specifically chose autologous tissue to avoid implants[71,72]. The benefits of conversion to prosthetic reconstruction include a shorter hospital stay and a lower complication rate in the short term [Figure 5][73]. Factors that influence the decision to choose alloplastic reconstruction include the amount and quality of mastectomy skin available, the desired size of the breast and ultimately the patient's wishes. Decisions about implant pocket placement (prepectoral or subpectoral) and use of a biologic mesh (coverage and support with or without acellular dermal matrix) need to be made. A history of radiation must be considered if choosing alloplastic reconstruction.

The timing of initiation of expansion in the outpatient clinic is variable, depending upon surgeon preference and healing of the incision. The timing of adjuvant therapies must also be considered. If initial flap failure occurs in the immediate postoperative setting with several days to weeks of complications, a full course of tissue expansion may not allow for timely receipt of adjuvant radiation or chemotherapy. Expansion can begin as quickly as 10-14 days without an increase in complications[74], though a common protocol is to begin expansion 3-4 weeks after tissue expander placement with exchange to permanent implants 3-6 months from tissue expander placement. Patients can then undergo revisions including fat grafting as needed to achieve optimal aesthetic results.

CONCLUSION/RECOMMENDATIONS

While less common in high-volume centers[75], autologous free tissue transfer failures can be devastating in

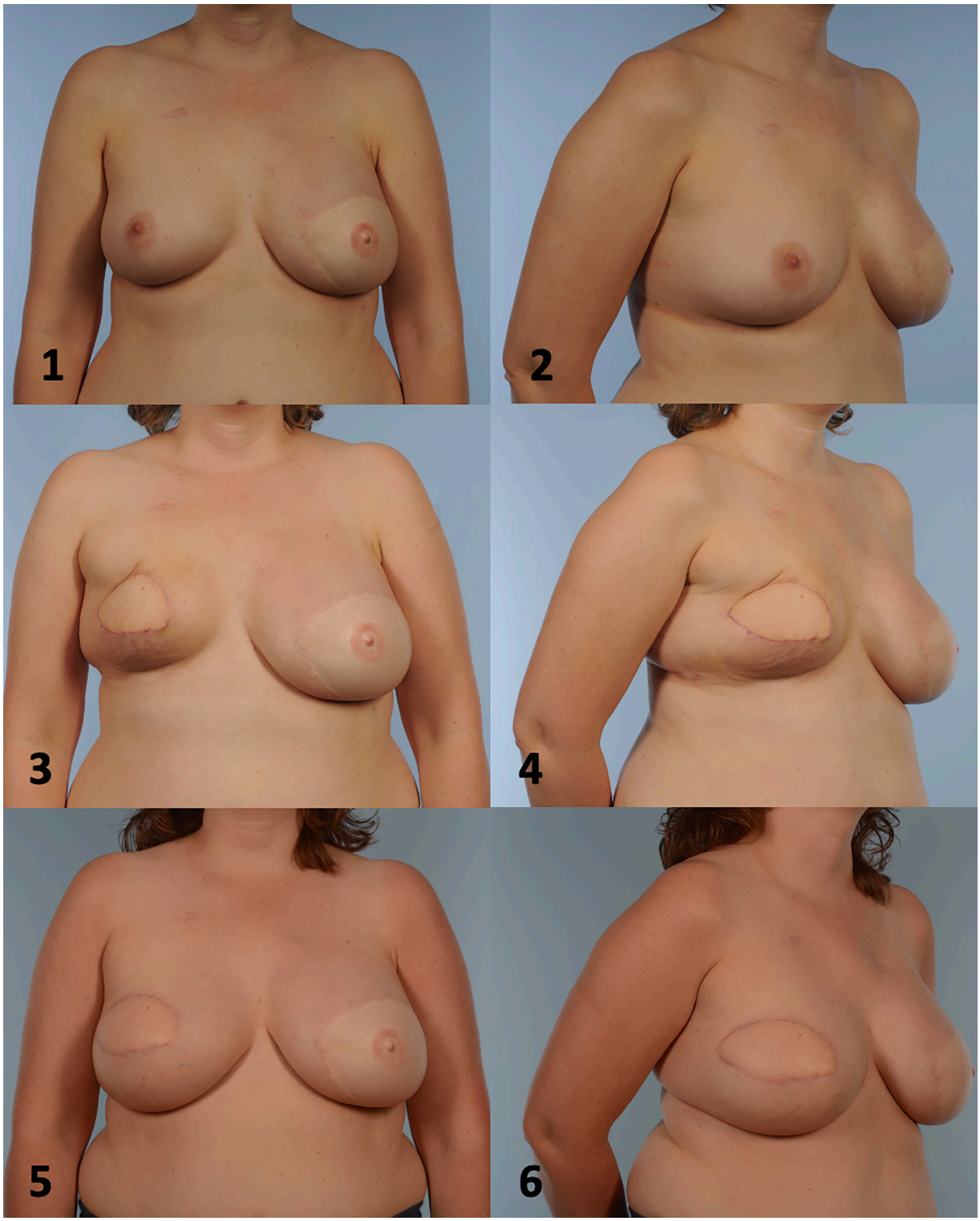

Figure 4. Patient with previous left breast cancer and latissimus dorsi flap reconstruction with new right breast cancer (Images 1 and 2). Salvage reconstruction was performed with right latissimus dorsi flap + tissue expander placement reconstruction (Images 3 and 4). Final postoperative result following implant exchange (Images 5 and 6).

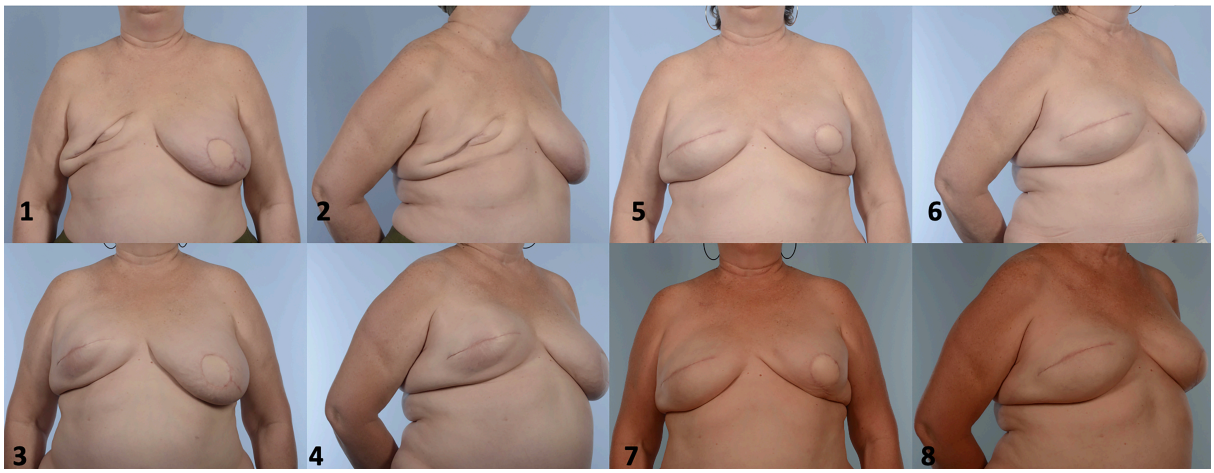

Figure 5. Patient with left breast cancer who underwent bilateral mastectomies and immediate reconstruction with DIEP flaps. The right flap failed (Images 1 and 2). After debridement and a period of healing, the breast was reconstructed with a subpectoral tissue expander (Images 3 and 4). The expander was later exchanged for a 700 cc silicone implant (Images 5 and 6).

breast reconstruction; it is important to have secondary (and tertiary) options available. It is imperative to discuss the risks and benefits of the procedure with patients, including the availability of secondary options in the event of failure. Efforts should be made to build a trusting relationship with patients preoperatively and to provide emotional support postoperatively when failures occur. Second-line options, including free and pedicled flaps, implants, or a combination of both, should be entertained based on the clinical scenario with a balance of safety and achieving the patient's overall reconstructive goals.

DECLARATIONS

Authors' contributions

Substantial contributions to the conception and design of the review paper, including clinical recommendations, literature review, manuscript writing, and figure creation: Myers PL, Tang SYQ, Saad NH, Momoh AO

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Conflicts of interest

All authors declared that there are no conflicts of interest.

Ethical approval and consent to participate

All participants provided written informed consent.

Consent for publication

Written informed consent for publication of patient photographs was obtained, specifically for external not-for-profit educational purposes such as lectures, presentations at professional conferences and publication.

REFERENCES

1. Yueh JH, Slavin SA, Adesiyun T, et al. Patient satisfaction in postmastectomy breast reconstruction: a comparative evaluation of DIEP, TRAM, latissimus flap, and implant techniques. *Plast Reconstr Surg* 2010;125:1585-95. DOI
2. Santosa KB, Qi J, Kim HM, Hamill JB, Wilkins EG, Pusic AL. Long-term patient-reported outcomes in postmastectomy breast reconstruction. *JAMA Surg* 2018;153:891-9. DOI PubMed PMC
3. Bui DT, Cordeiro PG, Hu QY, Disa JJ, Pusic A, Mehrara BJ. Free flap reexploration: indications, treatment, and outcomes in 1193 free flaps. *Plast Reconstr Surg* 2007;119:2092-100. DOI PubMed
4. Carney MJ, Weissler JM, Tecce MG, et al. 5000 free flaps and counting: a 10-year review of a single academic institution's microsurgical development and outcomes. *Plast Reconstr Surg* 2018;141:855-63. DOI
5. Chen KT, Mardini S, Chuang DC, et al. Timing of presentation of the first signs of vascular compromise dictates the salvage outcome of free flap transfers. *Plast Reconstr Surg* 2007;120:187-95. DOI
6. Hanasono MM, Butler CE. Prevention and treatment of thrombosis in microvascular surgery. *J Reconstr Microsurg* 2008;24:305-14. DOI PubMed
7. Hildago DA, Jones CS. The role of emergent exploration in free-tissue transfer: a review of 150 consecutive cases. *Plast Reconstr Surg* 1990;86:492-8; discussion 499-501. DOI
8. 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. DOI
9. Selber JC, Angel Soto-Miranda M, Liu J, Robb G. The survival curve: factors impacting the outcome of free flap take-backs. *Plast Reconstr Surg* 2012;130:105-13. DOI PubMed
10. Higgins KS, Gillis J, Williams JG, LeBlanc M, Bezuhly M, Chorney JM. Women's experiences with flap failure after autologous breast reconstruction: a qualitative analysis. *Ann Plast Surg* 2017;78:521-5. DOI PubMed
11. Fischer JP, Nelson JA, Sieber B, et al. Free tissue transfer in the obese patient: an outcome and cost analysis in 1258 consecutive abdominally based reconstructions. *Plast Reconstr Surg* 2013;131:681e-92e. DOI
12. 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. *J Plast Reconstr Aesthet Surg* 2016;69:894-906. DOI PubMed
13. Mohan AT, Al-Ajam Y, Mosahebi A. Trends in tertiary breast reconstruction: literature review and single centre experience. *Breast* 2013;22:173-8. DOI PubMed
14. Struebing F, Xiong L, Bigdeli AK, et al. Microsurgical strategies after free flap failure in soft tissue reconstruction of the lower extremity: a 17-year single-center experience. *J Pers Med* 2022;12:1563. DOI PubMed PMC
15. Walia A, Lee JJ, Jackson RS, et al. Management of flap failure after head and neck reconstruction: a systematic review and meta-analysis. *Otolaryngol Head Neck Surg* 2022;167:224-35. DOI PubMed PMC
16. Ghoneim MM, O'Hara MW. Depression and postoperative complications: an overview. *BMC Surg* 2016;16:5. DOI PubMed PMC
17. Hamdi M, Andrades P, Thiessen F, et al. Is a second free flap still an option in a failed free flap breast reconstruction? *Plast Reconstr Surg* 2010;126:375-84. DOI
18. Morrison KA, Karp NS. Not just a linear closure: aesthetic flat closure after mastectomy. *Plast Reconstr Surg Glob Open* 2022;10:e4327. DOI PubMed PMC
19. Lineaweaver W, Akdemir O, Schleich A. Management strategies following microsurgical flap failure. *Microsurgery* 2010;30:61-3. DOI PubMed
20. Taylor C, Shewbridge A, Harris J, Green JS. Benefits of multidisciplinary teamwork in the management of breast cancer. *Breast Cancer* 2013;5:79-85. DOI PubMed PMC
21. Li Y, Zhang X, Zhang L, Wang W. Effects of evidence-based nursing on psychological well-being, postoperative complications and quality of life after breast cancer surgery. *Am J Transl Res* 2021;13:5165-73. PubMed
22. Kotamarti VS, Shiah E, Rezak KM, Patel A, Ricci JA. Does anticoagulation improve flap outcomes in hypercoagulable patients? a systematic review. *J Reconstr Microsurg* 2020;36:204-12. DOI PubMed
23. Herrera FA, Lee CK, Kryger G, et al. Microsurgery in the hypercoagulable patient: review of the literature. *J Reconstr Microsurg* 2012;28:305-12. DOI
24. Nelson JA, Chung CU, Bauder AR, Wu LC. Prevention of thrombosis in hypercoagulable patients undergoing microsurgery: a novel anticoagulation protocol. *J Plast Reconstr Aesthet Surg* 2017;70:307-12. DOI PubMed
25. Senchenkov A, Lemaine V, Tran NV. Management of perioperative microvascular thrombotic complications-the use of multiagent anticoagulation algorithm in 395 consecutive free flaps. *J Plast Reconstr Aesthet Surg* 2015;68:1293-303. DOI PubMed
26. Rosendaal FR. Venous thrombosis: a multicausal disease. *Lancet* 1999;353:1167-73. DOI PubMed
27. Pannucci CJ, Kovach SJ, Cuker A. Microsurgery and the hypercoagulable state: a hematologist's perspective. *Plast Reconstr Surg* 2015;136:545e-52e. DOI PubMed
28. Wang TY, Serletti JM, Cuker A, et al. Free tissue transfer in the hypercoagulable patient: a review of 58 flaps. *Plast Reconstr Surg*

2012;129:443-53. DOI
29. Yii NW, Evans GR, Miller MJ, et al. Thrombolytic therapy: what is its role in free flap salvage? *Ann Plast Surg* 2001;46:601-4. DOI
30. Kroll SS, Schusterman MA, Reece GP, et al. Choice of flap and incidence of free flap success. *Plast Reconstr Surg* 1996;98:459-63.
31. Coriddi M, Myers P, Mehrara B, et al. Management of postoperative microvascular compromise and ischemia reperfusion injury in breast reconstruction using autologous tissue transfer: retrospective review of 2103 flaps. *Microsurgery* 2022;42:109-16. DOI PubMed PMC
32. Falkner F, Thomas B, Aman M, et al. The prognostic role of extended preoperative hypercoagulability work-up in high-risk microsurgical free flaps: a single-center retrospective case series of patients with heterozygotic factor V Leiden thrombophilia. *BMC Surg* 2022;22:190. DOI PubMed PMC
33. Kalmar CL, Drolet BC, Kassis S, Thayer WP, Higdon KK, Perdikis G. Breast reconstruction free flap failure: does platelet count matter? *Ann Plast Surg* 2022;89:523-8. DOI PubMed
34. Selby R, Geerts W, Ofosu FA, et al. Hypercoagulability after trauma: hemostatic changes and relationship to venous thromboembolism. *Thromb Res* 2009;124:281-7. DOI
35. Liu FC, Miller TJ, Wan DC, Momeni A. The Impact of coagulopathy on clinical outcomes following microsurgical breast reconstruction. *Plast Reconstr Surg* 2021;148:14e-8e. DOI PubMed
36. Wheatley MJ, Meltzer TR. The role of vascular pedicle thrombectomy in the management of compromised free tissue transfers. *Ann Plast Surg* 1996;36:360-4. DOI PubMed
37. Brouwers K, Kruit AS, Hummelink S, Ulrich DJO. Management of free flap salvage using thrombolytic drugs: a systematic review. *J Plast Reconstr Aesthet Surg* 2020;73:1806-14. DOI PubMed
38. Salgarello M, Visconti G, Barone-Adesi L, Cina A. The retrograde limb of internal mammary vessels as reliable recipient vessels in DIEP flap breast reconstruction: a clinical and radiological study. *Ann Plast Surg* 2015;74:447-53. DOI PubMed
39. Stalder MW, Lam J, Allen RJ, Sadeghi A. Using the retrograde internal mammary system for stacked perforator flap breast reconstruction: 71 breast reconstructions in 53 consecutive patients. *Plast Reconstr Surg* 2016;137:265e-77e. DOI PubMed
40. Fosnot J, Serletti JM. Clinical anatomy and recipient vessel selection in the chest, abdomen, groin, and back. 2nd ed: Elsevier; 2017.
41. Haddock NT, Cho MJ, Gassman A, Teotia SS. Stacked profunda artery perforator flap for breast reconstruction in failed or unavailable deep inferior epigastric perforator flap. *Plast Reconstr Surg* 2019;143:488e-94e. DOI PubMed
42. Moran SL, Nava G, Behnam AB, Serletti JM. An outcome analysis comparing the thoracodorsal and internal mammary vessels as recipient sites for microvascular breast reconstruction: a prospective study of 100 patients. *Plast Reconstr Surg* 2003;111:1876-82. DOI PubMed
43. Casey WJ 3rd, Rebecca AM, Smith AA, Craft RO, Buchel EW. The cephalic and external jugular veins: important alternative recipient vessels in left-sided microvascular breast reconstruction. *Microsurgery* 2007;27:465-9. DOI PubMed
44. Reissis D, Butler DP, Henry FP, Wood SH. Preserving a patent DIEP pedicle to facilitate salvage breast reconstruction with a second free flap: a case report. *Microsurgery* 2018;38:563-6. DOI PubMed
45. Mehrara BJ, Santoro T, Smith A, et al. Alternative venous outflow vessels in microvascular breast reconstruction. *Plast Reconstr Surg* 2003;112:448-55. DOI
46. Yamamoto T, Kageyama T, Sakai H, Fuse Y, Tsukuura R, Yamamoto N. Thoracoacromial artery and vein as main recipient vessels in deep inferior epigastric artery perforator (DIEP) flap transfer for breast reconstruction. *J Surg Oncol* 2021;123:1232-7. DOI PubMed
47. Martins A, Nunes Pombo J, Paias Gouveia C, Gomes Rosa B, Ribeiro G, Pinheiro C. Contralateral internal mammary vessels - a rescue recipient vessels option in breast reconstruction. *Case Reports Plast Surg Hand Surg* 2022;9:84-7. DOI PubMed PMC
48. Satake T, Muto M, Yasuoka Y, et al. Tertiary breast reconstruction using a free contralateral latissimus dorsi myocutaneous flap and contralateral internal mammary recipient vessel anastomosis. *JPRAS Open* 2016;7:44-9. DOI
49. Dayan JH, Allen RJ Jr. Lower extremity free flaps for breast reconstruction. *Plast Reconstr Surg* 2017;140:77S-86S. DOI PubMed
50. Allen RJ, Haddock NT, Ahn CY, Sadeghi A. Breast reconstruction with the profunda artery perforator flap. *Plast Reconstr Surg* 2012;129:16e-23e. DOI PubMed
51. Allen R, Guarda H, Wall F, Dupin C, Glass C. Free flap breast reconstruction: the LSU experience (1984-1996). *J La State Med Soc* 1997;149:388-92. PubMed
52. Tuinder SMH, Beugels J, Lataster A, et al. The lateral thigh perforator flap for autologous breast reconstruction: a prospective analysis of 138 flaps. *Plast Reconstr Surg* 2018;141:257-68. DOI
53. Myers PL, Nelson JA, Allen RJ Jr. Alternative flaps in autologous breast reconstruction. *Gland Surg* 2021;10:444-59. DOI PubMed PMC
54. Weerd L, Elvenes OP, Strandenes E, Weum S. Autologous breast reconstruction with a free lumbar artery perforator flap. *Br J Plast Surg* 2003;56:180-3. DOI PubMed
55. LoTempio MM, Allen RJ. Breast reconstruction with SGAP and IGAP flaps. *Plast Reconstr Surg* 2010;126:393-401. DOI PubMed
56. Murphy DC, Razzano S, Wade RG, Haywood RM, Figus A. Inferior gluteal artery perforator (IGAP) flap versus profunda artery perforator (PAP) flap as an alternative option for free autologous breast reconstruction. *J Plast Reconstr Aesthet Surg* 2022;75:1100-7. DOI PubMed
57. Munhoz AM, Montag E, Arruda EG, et al. The use of contralateral free extended latissimus dorsi myocutaneous flap for a tertiary failed breast reconstruction: is it still an option? *J Plast Reconstr Aesthet Surg* 2016;69:1087-91. DOI
58. Blondeel PN, Hijjawi J, Depypere H, Roche N, Van Landuyt K. Shaping the breast in aesthetic and reconstructive breast surgery: an

easy three-step principle. Part II--breast reconstruction after total mastectomy. *Plast Reconstr Surg* 2009;123:794-805. DOI PubMed

59. Koolen PG, Lee BT, Lin SJ, Erhard HA, Greenspun DT. Bipedicle-conjoined perforator flaps in breast reconstruction. *J Surg Res* 2015;197:256-64. DOI PubMed
60. Baumeister S, Follmar KE, Zenn MR, Erdmann D, Levin LS. Strategy for reoperative free flaps after failure of a first flap. *Plast Reconstr Surg* 2008;122:962-71. DOI PubMed
61. Clemens MW, Kronowitz SJ. Current perspectives on radiation therapy in autologous and prosthetic breast reconstruction. *Gland Surg* 2015;4:222-31. DOI PubMed PMC
62. Schneider WJ, Hill HL Jr, Brown RG. Latissimus dorsi myocutaneous flap for breast reconstruction. *Br J Plast Surg* 1977;30:277-81. DOI PubMed
63. Mushin OP, Myers PL, Langstein HN. Indications and controversies for complete and implant-enhanced latissimus dorsi breast reconstructions. *Clin Plast Surg* 2018;45:75-81. DOI PubMed
64. Disa JJ, Cordeiro PG, Heerdt AH, Petrek JA, Borgen PJ, Hidalgo DA. Skin-sparing mastectomy and immediate autologous tissue reconstruction after whole-breast irradiation. *Plast Reconstr Surg* 2003;111:118-24. DOI PubMed
65. Akyurek M, Dowlatshahi S, Quinlan RM. Two-stage prosthetic breast reconstruction with latissimus flap: prepectoral versus subpectoral approach. *J Plast Reconstr Aesthet Surg* 2020;73:501-6. DOI PubMed
66. Economides JM, Song DH. Latissimus dorsi and immediate fat transfer (LIFT) for complete autologous breast reconstruction. *Plast Reconstr Surg Glob Open* 2018;6:e1656. DOI PubMed PMC
67. Escandón JM, Escandón L, Ahmed A, et al. Breast reconstruction using the latissimus dorsi flap and immediate fat transfer (LIFT): a systematic review and meta-analysis. *J Plast Reconstr Aesthet Surg* 2022;75:4106-16. DOI
68. Mayer HF, Piedra Buena I, Petersen ML. The value of preoperative computed tomography angiography (CT-A) in patients undergoing delayed latissimus dorsi flap breast reconstruction after axillary lymph node dissection or irradiation and suspicion of pedicle injury. *J Plast Reconstr Aesthet Surg* 2020;73:2086-102. DOI PubMed
69. Wattoo G, Nayak S, Khan S, et al. Long-term outcomes of latissimus dorsi flap breast reconstructions: a single-centre observational cohort study with up to 12 years of follow up. *J Plast Reconstr Aesthet Surg* 2021;74:2202-9. DOI
70. Yezhelyev M, Duggal CS, Carlson GW, Losken A. Complications of latissimus dorsi flap breast reconstruction in overweight and obese patients. *Ann Plast Surg* 2013;70:557-62. DOI PubMed
71. Rao SS, Parikh PM, Goldstein JA, Nahabedian MY. Unilateral failures in bilateral microvascular breast reconstruction. *Plast Reconstr Surg* 2010;126:17-25. DOI PubMed
72. Timman R, Gopie JP, Brinkman JN, et al. Most women recover from psychological distress after postoperative complications following implant or DIEP flap breast reconstruction: a prospective long-term follow-up study. *PLoS One* 2017;12:e0174455. DOI PubMed PMC
73. Mak JC, Kwong A. Complications in post-mastectomy immediate breast reconstruction: a ten-year analysis of outcomes. *Clin Breast Cancer* 2020;20:402-7. DOI PubMed
74. Pusic AL, Cordeiro PG. An accelerated approach to tissue expansion for breast reconstruction: experience with intraoperative and rapid postoperative expansion in 370 reconstructions. *Plast Reconstr Surg* 2003;111:1871-5. DOI PubMed
75. Mahmoudi E, Lu Y, Chang SC, et al. Associations of surgeon and hospital volumes with outcome for free tissue transfer by using the national Taiwan population health care data from 2001 to 2012. *Plast Reconstr Surg* 2017;140:455e-65e. DOI PubMed PMC