

My First 100 Consecutive Microvascular Free Flaps: Pearls and Lessons Learned in First Year of Practice

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Background: Microvascular reconstruction for oncologic defects is a challenging and rewarding endeavor, and successful outcomes are dependent on a multitude of factors. This study represents lessons learned from a personal prospective experience with 100 consecutive free flaps.

Methods: All patients' medical records were reviewed for demographics, operative notes, and complications.

Results: Overall 100 flaps were performed in 84 consecutive patients for reconstruction of breast, head and neck, trunk, and extremity defects. Nineteen patients underwent free flap breast reconstruction with 10 patients undergoing bilateral reconstruction and 2 patients receiving a bipedicle flap for reconstruction of a unilateral breast defect. Sixty-five free flaps were performed in 61 patients with 3 patients receiving 2 free flaps for reconstruction of extensive head and neck defects and 1 patient who required a second flap for partial flap loss. Trunk and extremity reconstruction was less common with 2 free flaps performed in each group. Overall, 19 patients (22.6%) developed complications and 14 required a return to the operating room. There were no flap losses in this cohort. Thorough preoperative evaluation and workup, meticulous surgical technique and intraoperative planning, and diligent post-operative monitoring and prompt intervention are critical for flap success.

Conclusions: As a young plastic surgeon embarking in reconstructive plastic surgery at an academic institution, the challenges and dilemmas presented in the first year of practice have been daunting but also represent opportunities for learning and improvement. Skills and knowledge acquired from time, experience, and mentors are invaluable in optimizing outcomes in microvascular free flap reconstruction. (*Plast Reconstr Surg Glob Open* 2013;1:e27; doi:10.1097/GOX.0b013e31829e1007; Published online 22 July 2013.)

The field and art of plastic and reconstructive surgery has witnessed tremendous advances since its inception in ancient times with recon-

struction of nasal defects.¹ Not limited by a specific anatomic location, age, or gender, plastic surgeons do indeed represent the quintessential surgeon who must have the skill, experience, and confidence to address all types of pathology both medical and surgical and have the ability and knowledge to operate on the entire human body. Plastic surgeons are trained to be facile with bony fixation of the craniofacial skeleton and the hand, reconstruction of soft tissue and bony defects, and have equivalent comfort

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reconstructing the abdominal wall as they do in harvesting jejunum.²⁻⁷

Given the breadth of the field, plastic surgeons have not surprisingly always been at the forefront in pioneering and discovering new techniques and developing innovations that have had a profound impact on mankind as a whole.⁸⁻¹¹ The fields of cardiovascular, vascular, and transplant surgery were made possible by Joseph Murray who was awarded the Nobel prize in medicine for his efforts and contributions, not dissimilar to the advent of composite tissue allotransplantation also cultivated by our field.^{12,13} Clearly, the life of a plastic surgeon will be one of lifelong training, exploration, and personal development.

I have had the honor and opportunity to learn from some of the icons and pioneers in the field who have provided invaluable wisdom, guidance, and advice. However, the first year in academic practice was enlightening as I realized how much more there is to learn. Unfortunately, there is no reference, textbook, or article that can hope to cover the full expanse of plastic surgery or the subspecialty of microsurgery. Further, many of the fine nuances that are second nature to seasoned microsurgeons are not referenced. The experience and knowledge gained from each case and interaction with senior surgeons are often only passed through direct communication. The aim of this article is to present an honest, prospective experience with 100 consecutive free flaps and capture pearls learned from my own mistakes and those bestowed upon me by my mentors and professors that can serve as a reference for young plastic surgeons embarking into our field.

METHODS

My first consecutive 100 free flap reconstructions performed at MD Anderson Cancer Center from July 2011 to July 2012 were included for analysis. All patients' medical records were reviewed for demographics, pathology, operative notes, postoperative follow-up, and complications. Institutional Review Board approval was obtained for review of patients' medical records.

RESULTS

Patients

One hundred free flaps were performed in 84 patients (average age, 58.1; range, 21–83) (Table 1). Sixty-one patients underwent head and neck reconstruction with 3 patients receiving a double flap and 1 patient who required a second flap. Nineteen pa-

Table 1. Patient Demographics

Total No. Patients	84
Gender	
Male	51 (60.7%)
Female	33 (39.3%)
Flap distribution	
Head and neck reconstruction	61 (72.6%)
Breast reconstruction	19 (22.6%)
Extremity reconstruction	2 (2.4%)
Torso reconstruction	2 (2.4%)
Smoking history	47 (56.0%)
Head and neck reconstruction	42 (89.4%)
Breast reconstruction	1 (2.1%)
Extremity reconstruction	2 (4.3%)
Torso reconstruction	2 (4.3%)
Radiation treatment	
Preoperative radiation	17 (20.2%)
Postoperative radiation	37 (44.0%)

tients underwent reconstruction for breast cancer (bilateral: 10 patients, unilateral: 7 patients, bipedicle: 2 patients), 2 patients for trunk reconstruction, and 2 for extremity reconstruction.

General Microsurgical Pearls

Preoperative Evaluation and Patient Selection Patients should be questioned specifically regarding any history for blood clots and thromboses. Women should be questioned about their gynecological history and any previous miscarriages or spontaneous abortions that may indicate a hypercoagulable state.^{14,15} A thorough vascular examination, including an Allen's test for the upper extremity and palpation of the dorsalis pedis and posterior tibial vessels, should be performed if flaps are harvested from the forearm or lower leg or if the flap is to be transferred to the extremity. If there are concerns or equivocal findings, an angiogram should be obtained. The recipient arteries, such as the facial artery for head and neck reconstruction, should also be palpated. Although there are studies providing guidance for perforator location, Doppler verification of perforators can be a helpful adjunct in the preoperative planning and design of the flap.

Microvascular Anastomosis Minimizing trauma to the intima is imperative during preparation of the vessels, handling, and suturing. Sutures should be placed precisely making certain the needle passes through the full thickness of the vessel into the lumen. Once the needle has passed through, it should be released to avoid inadvertent trauma.

Although vasospasm can prevent flow initially, a low index of suspicion should prevail if flow remains sluggish. Rather than attributing flow issues to vasospasm, the anastomosis should be interrogated and revised. There should be a low threshold for exploration in any flap that had complications with

the initial anastomosis.¹⁶ Resecting damaged vessels and replacing the segment with a vein graft should also be considered in the setting of poor flow after repeated revisions of the anastomosis and no evidence for an obvious technical error.

Postoperative Management

Serial Clinical Examination Despite the number of new monitoring devices available on the market, clinical examination including color, turgor, and capillary refill remains the gold standard.^{17,18} An arterial and venous Doppler signal should also be verified. Within the limitations of resident work hours, nurses must also be educated, and ideally, serial examinations should be performed by the same individual. Implantable Dopplers can be beneficial for buried flaps; however, a monitoring segment or skin paddle is often preferable.^{19–21} Of critical importance, however, is a change in any of these parameters. Any change in clinical examination should be explored promptly and definitively.²² At the first suspicion of a vascular complication, the appropriate services should be mobilized to minimize any delays in exploration. A negative exploration is far preferable to a lost free flap.

Head and Neck Reconstruction

Of the 61 patients undergoing head and neck reconstruction, 44 were smokers (72.1%), and the majority were male ($n = 51$, 83.6%). The anterolateral thigh (ALT) flap ($n = 32$, 49.2%) was the most commonly performed flap. Mandible reconstruction was performed using soft tissue for 5 posterior defects and 14 free fibula osteocutaneous flaps for segmental defects. Three patients required a double free flap for an extensive defect. One patient undergoing scalp reconstruction developed partial loss of a latissimus muscle flap and required a free vastus lateralis flap (Table 2).

Case Reports and Pearls

Case Report 1 Patient is a 60-year-old man who underwent an extensive scalp resection for squamous cell carcinoma and reconstruction with a free latissimus dorsi muscle flap. The patient developed necrosis of the distal extent of the muscle with exposed calvaria and titanium requiring a second free flap.

Impact of Comorbidities. Although the patient refrained from smoking preoperatively, I failed to emphasize the importance of stopping smoking as the patient resumed smoking that may have compromised the perfusion to the distal extent of the muscle. In general, the distal 5 cm of the latissimus

Table 2. Head and Neck Reconstruction: Defects and Free Flap Distribution

	Number (%)
Defect type ($n = 64$)	
Maxilla	7 (10.9%)
Mandible	18 (28.1%)*
Tongue	6 (9.4%)
Parotid	15 (23.4%)
Pharyngoesophageal	7 (10.9%)
Intraoral mucosal	3 (4.7%)
Scalp	3 (4.7%)†
Facial	4 (6.3%)
Orbital exenteration	1 (1.6%)
Free flap ($n = 65$)	
Anterolateral thigh	32 (49.2%)
Free fibula osteocutaneous	14 (21.5%)
Radial forearm free flap	11 (16.9%)
Latissimus dorsi muscle flap	3 (4.6%)
Ulnar artery perforator flap	1 (1.5%)
Tensor fascia lata myocutaneous flap	1 (1.5%)
Lateral arm flap	1 (1.5%)
Vastus lateralis muscle flap	1 (1.5%)
Freestyle fasciocutaneous flap	1 (1.5%)

*One patient underwent a through-and-through posterior mandibulectomy reconstruction requiring 2 free flaps to reconstruct.

†One patient had a scalp defect requiring a second free flap after partial loss of the original flap.

muscle is also less reliable because it is often supplied predominantly by intercostal and lumbar perforators (Fig. 1). Traction during harvest may have also compromised the viability of the distal flap. Repositioning of the original flap to place well-perfused muscle over the area of greatest concern would have avoided this complication and potentially the use of vein grafts would have allowed more appropriate positioning over the hardware and denuded calvaria.

Case Report 2 Patient is a 65-year-old woman who underwent reconstruction of a composite mandible and hemiglossectomy defect with a free fibula osteocutaneous flap and freestyle perforator flap. She developed venous congestion/thrombosis of the fibula flap and was taken back for salvage with Fogarty catheter thrombectomy, thrombolysis, and heparinization. The return to the operating room occurred efficiently, and the entire venous pedicle was thrombosed. The flap was salvaged, and the patient ultimately healed without evidence of a leak or fistula.

Microvascular Anastomosis. As critical to the precise technical demands of performing the anastomosis is making certain the vessels are aligned without a kink or twist. The pedicle should be positioned to account for closure and turning of the neck, and postoperative swelling may compress or kink the pedicle. In this case, there were 2 sets of anastomoses, and I overlooked the curvature and position of the fibula

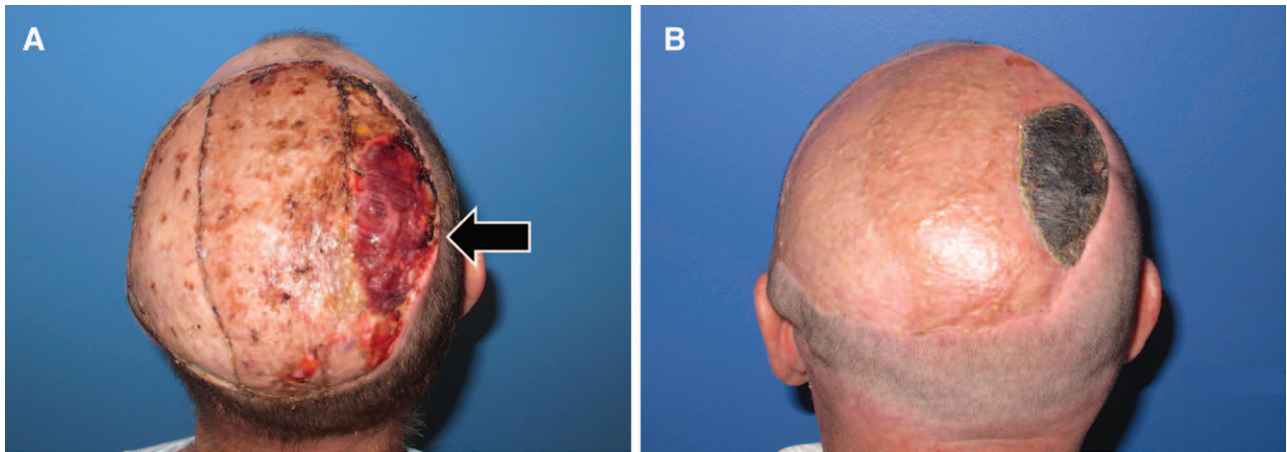


Fig. 1. Distal end of latissimus dorsi flap with initial skin graft loss and subsequent demarcation and necrosis of muscle. Black arrow marks muscle ischemia with subsequent necrosis.

pedicle (Fig. 2). Before closure, the pedicle should always be reexamined to make certain there is compression or kink upon inset, drains are not adjacent to the vessels, and the anastomoses are patent.

Multilevel Thrombectomy. Navigating the Fogarty catheter, the entire length of the pedicle is challenging and can potentially lead to inadvertent trauma to the intima. On recommendation from the assisting fellow, the thrombectomy was performed not only from the cut end of the pedicle vein but also a number of ligated venous branches were opened and used as entry points for sequentially smaller catheters which allowed for a complete thrombectomy of the pedicle to the level of the perforators.

Case Report 3 Patient is a 77-year-old man, with recurrent squamous cell carcinoma of the buccal mucosa treated previously with resection and 2 rounds of radiation, who developed mandibular osteoradionecrosis with a pathological fracture,

orocutaneous fistula, and recurrent disease. The patient underwent a through-and-through posterior mandibulectomy requiring a free ALT and tensor fasciae latae flap. The patient developed hyperemia of the ALT flap used to resurface the external defect, and on exploration, all anastomoses were patent. However, upon reinset of the flap, the flap again became hyperemic suggesting that compression was occurring at the level of the perforator. During the initial operation, the flap was bulky, and I failed to recognize the need to harvest the skin paddle larger to accommodate the inset and postoperative swelling. Additionally, I was hesitant to thin the flap for fear of damaging the perforator and compromising perfusion to the entire skin paddle.

Thinning of Bulky Flaps. If there are no alternate appropriate donor sites for a thinner flap, a bulkier flap can still be utilized but will need to be thinned or harvested larger than the size of the defect to account for the inset and swelling. A senior surgeon

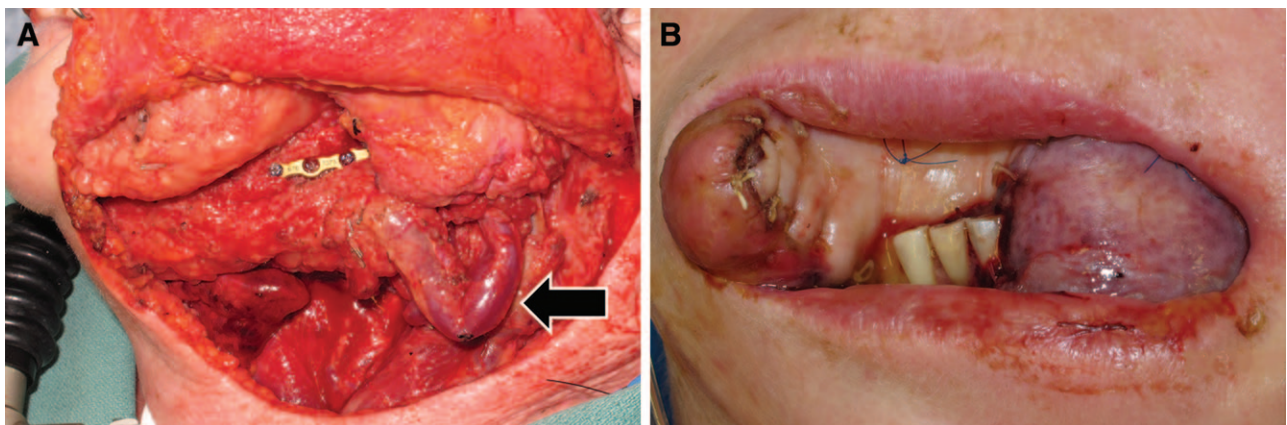


Fig. 2. A, Venous pedicle of free fibula osteocutaneous flap and curvature to anastomosis with common facial vein. Black arrow marks kink in peroneal artery venae comitantes and source of pedicle thrombosis. B, Venous congestion of free fibula osteocutaneous flap skin paddle. Free perforator flap reconstruction of hemiglossectomy defect is viable.

was recruited and demonstrated that thinning of the flap should proceed cautiously and radially away from the perforator to avoid damage to the perforator and the arcade of microvessels arising from the perforator. Following the thinning process, the flap was easily inset without any resultant hyperemia.

End-to-Side Venous Coupling. In the previously operated and radiated neck, there is often a paucity of recipient vessels that may require use of alternate vessels such as the transverse cervical vessels.²³ In the hostile neck, using the external jugular vein is not recommended as the proximal drainage may be compromised from the prior neck dissection, but it may serve as a conduit for vein grafting. While a hand-sewn end-to-side anastomosis can be performed with high success,²⁴ if even a short stump is available on the internal jugular vein (IJV), an end-to-side anastomosis can be performed with a coupler. The IJV will need to be mobilized adequately proximally and distally to allow sufficient laxity to bring the edges of the IJV into the coupling device allowing the anastomosis to be coupled.

Breast Reconstruction

A total of 19 patients (22.6%) underwent free flap breast reconstruction [muscle-sparing transverse rectus abdominus myocutaneous (MS-TRAM): 20, deep inferior epigastric perforator (DIEP): 6, and transverse rectus abdominus myocutaneous (TRAM): 1]. Two patients received a bipedicle flap for reconstruction of a unilateral breast defect to provide adequate volume and skin replacement to achieve an aesthetic reconstruction. One bipedicle flap was a combined free MS-TRAM and DIEP, and the other was a free MS-TRAM and superficial inferior epigastric artery flap.

Case Reports and Pearls

Case Report 1 Patient is a 28-year-old woman with a left-sided invasive ductal carcinoma treated previously with a modified radical mastectomy and radiation and opted to undergo a contralateral prophylactic mastectomy with bilateral reconstruction. The right flap became hyperemic upon transfer from the operating table (Fig. 3). On exploration, a small hematoma was evacuated and all anastomoses were patent; however, the pedicle kinked as it passed over the rib through the pectoralis major muscle.

Venous Congestion and Hematoma. A hematoma can certainly compress the anastomoses; however, if no obvious bleeding is found, the venous anastomosis should be examined to make certain there is no obstruction. Venous congestion can result in a hematoma as the flap attempts to decompress to compensate for inadequate outflow. As heavy flaps can cause compression of the perforator, I often harvest a small

cuff of muscle and fascia around the perforator to minimize the chances of perforator compression.

Pectoralis Major Muscle Trough. Splitting the muscle fibers of the pectoralis muscle to gain access to the internal mammary vessels is customary; however, when patients become mobile, the weight of the flap can cause the muscle to “window shade” across the pedicle. The patient had a very prominent rib, and a larger trough should have been cut into the muscle to prevent kinking the pedicle. Alternatively, I could have positioned the pedicle to pass along the rib rather than over the rib. Creating a trough also has not resulted in any noticeable contour deformity of the reconstructed breast. Although I do not routinely place supporting sutures to anchor the flap to the chest, they can be useful with larger flaps to prevent traction on the pedicle.

Internal Mammary Vessel Dissection. For patients undergoing a left-sided autologous reconstruction, I often isolate the internal mammary vessels toward the second intercostal space which often provides a larger caliber vein that can be the confluence of 2 smaller veins more suitable than either the medial or lateral vein alone. If the flap exhibits superficial dominance, the superficial epigastric vein can be anastomosed in a retrograde fashion as a supercharged flap.²⁵ Additionally, in the previously radiated left side, considerations for alternate outflow vessels such as the external jugular vein or a cephalic turndown should be considered.^{26,27}

Case Report 2 Patient is a 58-year-old woman undergoing delayed reconstruction of the right breast following a modified radical mastectomy and radiation. The friable nature of the internal mammary artery developed a longitudinal tear requiring excision and redo of the anastomosis.

Knot Tying and Needle Handling. When operating on radiated, atherosclerotic, or diseased vessels, it is imperative that sutures should be tied with sufficient tension only to coapt the vessels without strangulation, particularly if the vessels are radiated and more friable. The concept of haptic feedback and avoiding tying sutures with excessive tension is critical as it can tear through the vessel or cause leaks at the needle holes. Additionally, following placement of the needle, care must be taken so that the needle does not tear through the vessel. Such errors may require cutting the recipient vessel more proximally and redoing the entire anastomosis which increases ischemia time and may significantly shorten the recipient vessel making the anastomosis even more challenging.

Trunk and Extremity Flap Reconstruction

For trunk reconstruction, 1 patient received a free vertical rectus abdominus myocutaneous flap for a

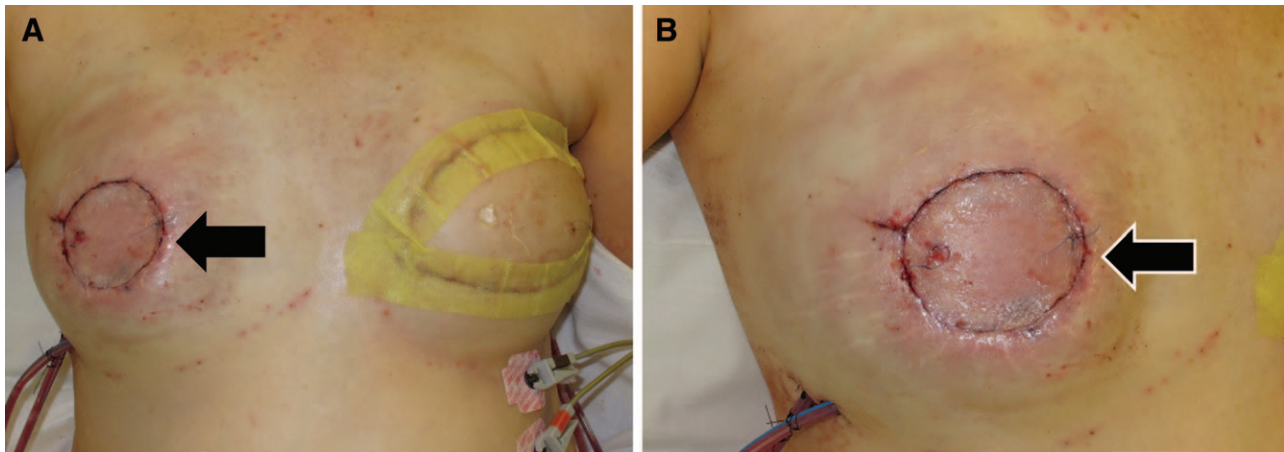


Fig. 3. Hyperemia of right muscle-sparing TRAM flap reconstruction immediately following transfer from operating table to bed suggesting compromised outflow. Note the difference between the right compromised flap and the left flap. Black arrows demonstrate hyperemic flap. Reexploration of flap demonstrated kink of the pedicle over the pectoralis muscle and prominent third rib.

chest and axillary wound, and the second patient underwent a free ALT flap to a sternal defect. One free gracilis and vastus lateralis flap were performed for coverage of previously irradiated forearm defects with exposure of vessels, tendons, and bone.

Case Report Pearls

Case Report 1 Patient is a 64-year-old female hairdresser with recurrent squamous cell carcinoma of the nondominant dorsal forearm who has undergone multiple resections and radiation therapy. A gracilis flap was harvested for coverage of exposed bone and tendons. The initial recipient vein I utilized was sclerosed without any proximal outflow due to the prior surgeries and radiation. An end-to-side anastomosis was performed to the ulnar artery and exploration of the volar side of the forearm was needed to isolate a patent outflow vein.

Zone of Injury. Utilizing vessels outside the zone of injury has been well described in extremity trauma reconstruction.²⁸⁻³¹ Regarding oncologic reconstruction, the basic premise still presides as prior surgery and radiation also create an extensive zone of injury that can preclude the use of recipient vessels in close proximity to the defect. I should have explored the original recipient vein more thoroughly and tested for adequate flow before use. A vein graft may also be necessary to gain access to recipient vessels away from the zone of injury and should certainly be considered in the setting of a thrombosis to augment perfusion or drainage of a failing flap.

Postoperative Management. All patients undergoing extremity free flap reconstruction should be splinted to minimize motion. Flexion, rotation, abduction, or supination can easily cause traction or compression

of the pedicle. Additionally, all extremities should be elevated to prevent congestion, and a dangling protocol should be employed in coordination with nursing and physical therapists.

Complications

Nineteen patients (22.6%) developed complications, and 14 (16.7%) required a return to the operating room (Table 3). Eleven head and neck patients had complications, most commonly an infection and abscess requiring drainage and washout ($n=5$; 5.9%). One patient required a pectoralis major muscle flap coverage of a fistula. One patient with alcoholic liver cirrhosis developed venous congestion secondary to a hematoma requiring evacuation. Three other patients developed complications as described.

Two breast reconstruction patients (2.3%) developed operative complications, one for a hematoma and the second for venous congestion as described. No patients undergoing trunk or extremity free flap reconstruction developed complications. Donor site complications included 1 hematoma, 2 seromas, and partial skin graft loss in 1 ALT donor site and fibula donor site. Two patients undergoing breast reconstruction developed donor site wound dehiscence.

There were no flap losses in this series.

DISCUSSION

Microvascular free flap reconstruction has undergone tremendous advancements since the techniques were described and pioneered by Alexes Carrell and Joseph Murray. Nowadays, flap success rates are over 95% at high volume institutions; however, salvage of compromised flaps and maximizing flap survival requires experience and recognizing

preventable complications.^{32–34} Many maneuvers performed by senior surgeons are innate and performed by instinct; however, for the novice microsurgeon, explicit identification of impending complications and avoiding complications is certainly worthwhile. Additionally, the education of trainees and nursing staff to recognize an impending flap loss based on clinical examination is invaluable in optimizing outcomes.

Many of the pearls presented seem obvious and intuitive especially for the more experienced surgeon. However, there are countless considerations and pitfalls that can be distracting during the operation, and I overlooked some simple steps that could have prevented a complication. A mental checklist to warn the trainees and being cognizant about potential pitfalls will hopefully prevent and minimize the chances of developing a complication. Additionally, knowledge of an armamentarium of different techniques for preparation of the case both preoperative workup and intraoperative setup is also critical. For instance, marking the pedicle orientation is a simple method to avoid twisting during the anastomosis.³⁵

In the unfortunate setting of a flap take back, correct identification of the underlying etiology, knowing options for salvage, and implementing different techniques to develop novel solutions for unforeseen challenges are paramount for successful salvage. For example, using the Fogarty catheter for a thrombectomy has been well described, but using ligated branches as access points was a novel extension of this technique that allowed complete clearance of the clot from the thrombosed vein.

Over the year, the mental checklist has been beneficial and imparted onto the fellows who hopefully will be able to avoid the mistakes I committed when I began practice. Although I have witnessed a maturation over the past year in terms of confidence and allowing more fellow independence, there was no

significant difference in operative time or ischemia time from the beginning of the year to the end of the year. One explanation is the increased complexity of cases (double free flaps) in the latter half of the year and allowing more fellow autonomy which could have contributed to a consistent operative and ischemia time over the year. I suspect many years are needed to achieve the shorter duration many seasoned surgeons have achieved. Although many surgeons can perform DIEP flaps with ease and high success, I performed predominantly MS-TRAM flaps and 5 of the 6 DIEP flaps performed were after the first 6 months which again confound the data on the length of the operation. This also applies to the dissection of ALT flaps which I typically elevated incorporating a portion of the vastus lateralis early on, but now I am elevating as true perforator flaps. The head and neck flaps were tailored more precisely and 2 of the 3 double free flaps for head and neck reconstruction were performed after 6 months. Overall, there remains significant room for improvement and continued growth.

A final note is that many junior microsurgeons, including myself, have the luxury of having senior colleagues available to assist in challenging circumstances. For those who have this opportunity, it would behoove one to take advantage of the knowledge, expertise, and experience of mentors and colleagues. Whenever possible, I asked senior faculty for their advice and assistance which was educational for me and in the best interest of patient care. Recognizing the need for lifelong learning and avoiding hubris will undoubtedly improve the care of patients and optimize outcomes.

CONCLUSION

Microvascular free flap reconstruction can be performed with high success rates and reliable outcomes. Thorough preoperative assessment and workup, careful intraoperative preparation and meticulous technique, and diligent postoperative monitoring and anticipation of potential pitfalls will optimize outcomes and flap success.

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Table 3. Overall Complications following Free Flap Reconstruction

Total patients	19
Recipient site	
Flap loss	0
Venous congestion/thrombosis	4 (21.1%)
Hematoma	2 (10.5%)
Infection	5 (26.3%)
Partial flap loss	1 (5.3%)
Fistula	1 (5.3%)
Donor site	
Infection	0
Delayed wound healing/dehiscence	2 (10.5%)
Hematoma	1 (5.3%)
Seroma	2 (10.5%)
Skin graft loss	2 (10.5%)

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