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SPECIAL TOPIC
Reconstructive

Free Your Mind, Not Your Flap

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Summary: The pedicled flap has been a mainstay of soft tissue reconstruction since the earliest days of plastic surgery. Advances in surgical technology and skill have led to an erosion in the use of pedicled flaps in favor of increasingly popular free tissue transfers. Still, regional flaps without microvascular anastomosis remain a valuable reconstructive tool. Although still requiring microsurgical skills, these flaps are of particular benefit in patients with few or poor quality recipient vessels, in those who cannot tolerate antiplatelet therapy, and in those who cannot tolerate the often-extended anesthesia time necessitated by microvascular anastomosis. Furthermore, pedicled flaps may significantly reduce total cost of a reconstruction procedure with similar outcomes. In this case series, we report challenging scenarios where microsurgical approaches may have been typical choices but were instead reconstructed by pedicled options with desired outcomes. Difficult soft tissue defects were successfully reconstructed with a variety of pedicled flaps. Soft tissue transfers to the abdomen, flank, shoulder, and back are presented. None of the reconstructions required microvascular anastomosis. *(Plast Reconstr Surg Glob Open 2022;10:e4384; doi: 10.1097/GOX.0000000000004384; Published online 15 June 2022.)*

INTRODUCTION

The pedicled flap has been a mainstay of soft tissue reconstruction since the earliest days of plastic surgery. In 1597, Gaspare Tagliacozzi published "*De curtorum chirurgia per insitionem*," in which he describes an upper arm flap for nasal reconstruction.[1] The iconic flap went on to become emblematic of reconstructive surgery. However, advances in surgical technology and precision have led to increasingly popular use of free tissue transfers in many complex reconstructions and, consequently, the erosion of pedicled flaps, thereby, effectively shortening the proverbial reconstructive ladder in many of those cases. Still, regional pedicled tissue transfer without microvascular anastomosis should remain a valuable reconstructive tool for a myriad of reasons. Aside from the general lack of thrombotic complications well known in free tissue transfer, pedicled flaps are of particular benefit in patients with few or poor quality recipient vessels, in those who cannot tolerate antiplatelet therapy, and in those who cannot tolerate the often-extended anesthesia time necessitated by microvascular anastomosis. Furthermore, pedicled flaps may significantly reduce the total cost of a reconstruction procedure,[2] likely from all facets of the patient's care. Meta-analyses in upper extremity, back, and breast procedures have noted comparable overall coverage success using pedicled flaps when compared with free flaps.[3–5] Although it is always easier to think of a distant flap to "parachute" in for the task, the elegance and creative design of pedicled options do offer premiums. It is natural that a pedicled flap would command minimized preoperative workup, shortened operative time, and simplified postoperative monitoring, all contributing to economizing precious healthcare resources, which in turn can sometimes conceivably lead to more timely care of the case on hand.

In this case series, we report several challenging scenarios where microsurgical approaches would have been typical choices for many, but were instead reconstructed by regional pedicled options with desired outcomes. With these cases, we would like to reiterate and highlight a time-tested reconstructive principle. Although the brute force of free flaps can always be the last resort, a freer mind outside the box, whenever we can, can restore the reconstructive ladder, especially in those with few or poor recipient vessels, in those who cannot tolerate long and hemodynamically demanding surgeries, in those whose surgeries need to take place at a time and place where

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resources cannot be sufficiently gathered, and in those whose postoperative monitoring does not need to be nearly as intense.

METHODS

A selection of patients with challenging reconstructive needs was identified by the senior authors (L.G. and J.J.P.). These patient charts were reviewed and cases were selected that best demonstrated situations that classically would require free tissue transfer but rather were treated with a pedicled flap. Details of these cases are abstracted for inclusion in this case series.

Takeaways

Question: Is the "reconstructive ladder" still relevant in the era of modern microsurgery?

Findings: This case series demonstrates the versatility of pedicled flaps in reconstructing complex soft tissue and bone defects while avoiding resource intensive microsurgery.

Meaning: Plastic surgeons should remain well-versed in performing locoregional tissue transfer as this remains a valuable and often superior option to free tissue transfer for challenging reconstructive problems.

CASE 1 (L.G.)

A 57-year-old woman presented with intractable shoulder pain following a shoulder arthrodesis performed 10 years prior. The patient had developed chronic infection of the joint, resulting in pseudoarthrosis. Multiple attempts at revising this fusion were made using bone grafts with even encasing latissimus muscle coverage. Thus, it was felt that transfer of vascularized bone was required to achieve successful fusion. Because of her previous surgeries, no adequate recipient vessel was available for free vascularized osseous tissue transfer, and thus a pedicled scapular flap was designed based on the angular branch of the circumflex scapular artery. To that end, a CT angiogram was performed that demonstrated a patent subscapular artery system. (**See figure 1, Supplemental Digital Content 1,** which shows a CT angiogram demonstrating patient subscapular artery system. **http://links.lww.com/PRSGO/C60**.) A 2.5×6.5 cm osteofascial flap from the scapular tip was harvested based on the angular branch and rotated cephalad to the shoulder, where it was inset along the fusion site (Fig. 1A, B). Upon recovering from this procedure, the patient experienced significant relief of her chronic joint pain with radiographic evidence of successful fusion.

CASE 2 (L.G.)

A 73-year-old man presented with a recurrent large undifferentiated sarcoma of the right lateral abdominal wall and thorax. He had previously undergone radical resection of a sarcoma 3 years prior at the same site requiring reconstruction with a combination of a bipedicled TRAM flap that covered the bulk of the flank defect and contralateral pedicled latissimus musculocutaneous flap that covered the posterior medial portion of the resection defect (Fig. 2A, B). After the recurrence was removed, an even larger defect spanned from the eighth rib superiorly to just inferior to the iliac crest. The abdominal wall was initially stabilized with a polypropylene mesh. A total thigh flap was then designed to provide coverage. The entire anterior thigh was raised, including the pertinent portion of the vastus lateralis and its perforators. The flap extended medially to the sartorius and inferiorly to the knee. The descending branch of the lateral femoral circumflex artery was identified and skeletonized to its origin. The flap was rotated nearly 180 degrees, tunneled under the rectus femoris and sartorius and inset at the defect site. The donor site, after adjacent tissue advancement, was then covered with a split-thickness skin graft (Fig. 3A–D). At 2-months follow-up, the patient has recovered well with no flap issues and complete healing of the skin grafted flap donor site and no noticeable functional deficit.

CASE 3 (L.G.)

A 56-year-old woman developed osteomyelitis of the tibia with subsequent nonunion after initial distal open tibia fracture. After debridement of the nonviable tibia, she was left with a 7-cm distal tibia defect with tenuous soft tissue coverage (Fig. 4). Traditionally, one may consider a free fibula transfer in this scenario. However, given

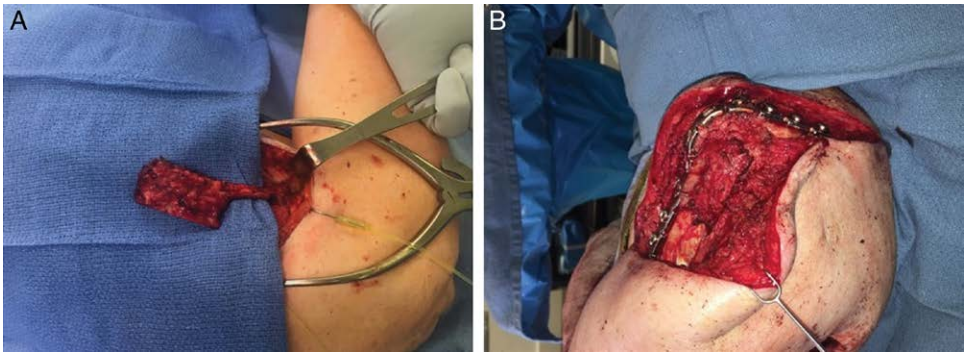

Fig. 1. Pedicled scapula tip flap for shoulder arthrodesis. A, Isolated scapula tip flap on angular branch pedicle. B, Pedicled scapula tip flap after inset to shoulder fusion site.

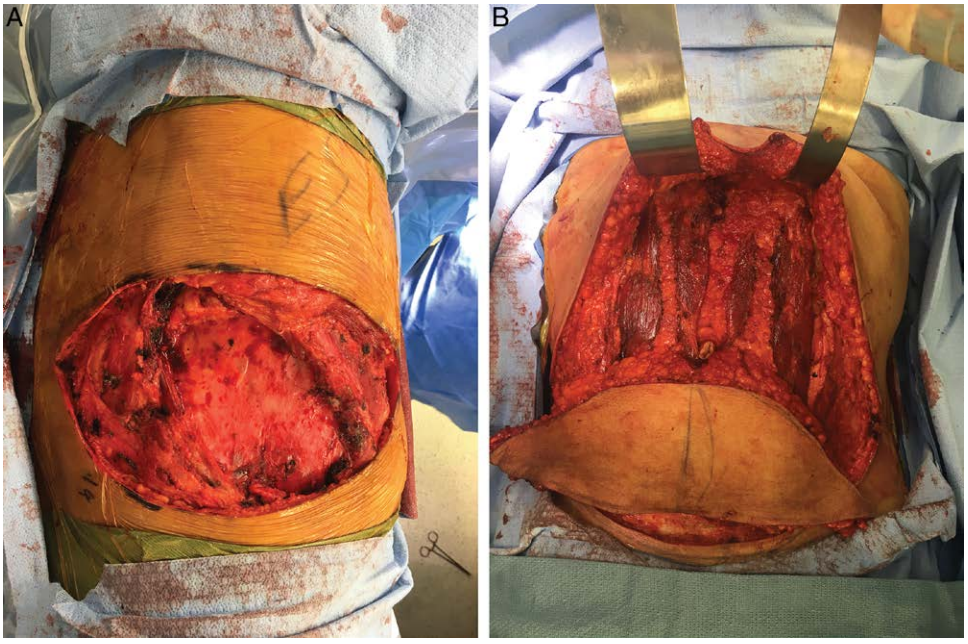

Fig. 2. TRAM reconstruction of flank defect. A, Defect following resection of flank sarcoma. B, Isolated bipedicled TRAM flap before rotation and inset.

the proximity of the defect to the donor osseous tissue, a pedicled osteocutaneous fibula flap was designed in a retrograde fashion off the distal communication between the posterior tibial and peroneal vessels. The fibula was then harvested in standard fashion except that the peroneal artery was ligated at its takeoff from the tibioperoneal

Fig. 3. Total thigh flap for recurrent flank defect. A, Marked total thigh flap. B, Isolated total thigh flap before rotation and inset. C, Total thigh inset into defect with split-thickness skin grafting to donor site. D, Two month follow-up with excellent healing of flap and donor site.

Fig. 4. Seven-centimeter tibia defect with antibiotic spacer in place.

trunk, thus establishing retrograde flow to the harvested flap. The fibula was then carefully divided into three parts. The distal third of the fibula (now with the most robust blood supply in this retrograde design) was telescoped into the medullary canals of the proximal and distal tibia. The slightly shorter but still vascularized middle third and the proximal third (now used as a bone graft) fibula segments were cerclage wired together along the sides of the first strut underneath a reconstruction plate that spanned across the defect (Fig. 5A–C). At 12- and

Fig. 5. Reverse pedicled osteocutaneous fibula flap for mid-tibia defect. A, Markings for reverse pedicled fibula flap. B, Elevated reverse fibula flap before transfer. C, After fibula bone flap inset with skin paddle shown before inset.

16-month follow-ups, the patient had good bony union, was able to fully bear weight, and had acceptable soft tissue contour. (**See figure 2, Supplemental Digital Content 2,** which shows (a) 1-year follow-up X-ray demonstrating bony integration of fibula flap and (b) 16-months follow-up photograph with complete wound healing and intact weight bearing through affected leg. **http://links.lww.com/PRSGO/C61**.)

CASE 4 (L.G.)

A 31-year-old man presented with extensive dog bite injuries resulting in complete soft tissue degloving of his nose and penis. Although the underlying corpora and the glans remained intact, the penile shaft had effectively no soft tissue envelope with exposed urethral perforations that would require buccal graft urethroplasty (Fig. 6). Given the functional deficit, the patient elected to undergo penile reconstruction first while deferring nasal reconstruction. Generally one considers free radial forearm flap coverage for extensive penile injuries or phalloplasty.[6,7] For this patient, however, it was likely that his nasal reconstruction would also require a free flap that may also be best served by a radial forearm flap. After the patient declined to have both of his forearms utilized as donor sites, a regional soft tissue option for penile reconstruction was devised. A thin subcutaneous tunnel was created in the suprapubic abdominal wall to allow for the penis to be covered in this soft tissue. The penis, after graft urethroplasty, was secured in place, and the flap was allowed to mature for approximately 1 month. At this point, the abdominal wall flap was divided with the now covered penis raised. Only a small full-thickness skin graft was needed to cover the residual dorsal penile shaft, and the abdominal donor site was closed primarily (Fig. 7A–C). The two-staged procedures were each performed with a minimal inpatient stay totaling 3 days. At 1 year follow-up, the patient is very pleased with the durability and cosmesis of his reconstructed penile shaft, and did not desire any revisions (Fig. 8).

Fig. 6. Penile skin and urethral defect before urethral reconstruction.

CASE 5 (J.J.P.)

A 74-year-old woman presented with a large wound of the right parascapular region after undergoing excision of a basal cell carcinoma and adjuvant radiation therapy 6 years ago. The wound extended from the spine medially to the lateral scapula border and from the scapular spine to its tip vertically. After debridement of all affected tissue, including a large central ulceration, there was exposed scapula and rib at the wound base, which measured 24×30 cm. Therefore, a latissimus dorsi flap was designed in a V-Y fashion that extended inferiorly to the iliac crest. (**See figure 3, Supplemental Digital Content 3**, which shows a shoulder wound following SCC excision and radiation therapy before debridement and coverage with V-Y flap marked. **http://links.lww.com/PRSGO/C62**.) At 2-month follow-up, the patient has excellent healing of the flap with a small area of superficial sloughing at the inferior tip. (**See figure 4, Supplemental Digital Content 4,** which shows the elevation of large latissimus VY flap with proposed advancement. **http://links.lww.com/PRSGO/C63**.) (**See figure 5, Supplemental Digital Content 5,** which displays a 2-month follow-up showing excellent healing of flap with small area of distal tip skin necrosis. **http://links.lww.com/PRSGO/C64**.) This reconstruction pushed the boundary of V-Y advancement with the underlying axial latissimus muscle perforators.

CASE 6 (J.J.P.)

An 80-year-old woman presented with an extensive squamous cell carcinoma of the left upper lip, cheek, anterior maxilla, and alveolus. After completing neoadjuvant radiation therapy, she required unilateral anterior maxillectomy, including the left floor of the nose. Soft tissue reconstruction required coverage of the maxillary sinus, roof of the mouth, floor of the nose, and cheek (Fig. 9). A pedicled submental flap was designed with tissue expansion and prelamination to meet the three-dimensional reconstructive needs. A full-thickness skin graft was applied to the undersurface of the flap over the expander that would be inset as the oral lining. After 5 weeks of tissue expansion, the prelaminated flap (including the underlying platysma) was tunneled under the lower face soft tissue, rotated, and inset into the maxillary defect (Fig. 10A, B). This was allowed to heal for 4 weeks, after which an Abbe flap was transposed to the upper lip vermilion, recreating the lip. At 5 months follow-up, the patient returned with complete healing of the flap and adequate oral competence. (**See figure 6, Supplemental Digital Content 6,** which shows a maxilla defect before

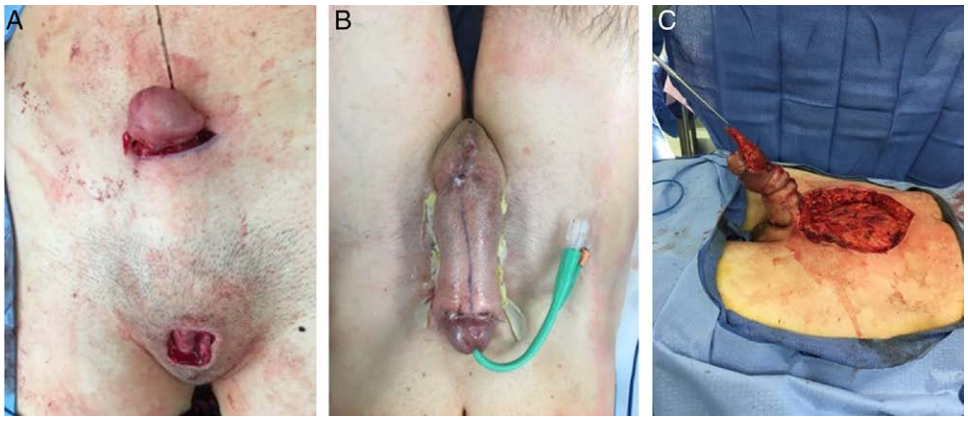

Fig. 7. Buried abdominal wall flap for penile reconstruction. A, Penis after placement within abdominal wall flap. B, Six weeks before elevation of flap. C, After elevation of penis and flap.

reconstruction. **http://links.lww.com/PRSGO/C65**.) (**See figure 7, Supplemental Digital Content 7,** which shows a 5-month follow-up after pedicled submental flap reconstruction and Abbe flap lip revision. **http://links.lww.com/PRSGO/C66**.)

DISCUSSION

Improved trauma systems and advances in cancer care have led to improved survival of severely affected patients and, thus, increasingly complex soft tissue reconstructive needs.[8,9] Similarly, there have been remarkable advances in microsurgical technology, training, and skill that have made the free flap ever more accessible and attainable as a reconstructive option.[10,11] Microsurgical technique has allowed for the coverage of previously nonsalvageable defects. However, the increase in focus on training in microsurgical reconstruction and perhaps over-reliance on it may have unintentionally eroded experience in designing complex locoregional tissue flaps. As we have demonstrated, free tissue transfer is at times not feasible or may be a less ideal reconstructive option. A central tenet of reconstructive surgery is to select the most appropriate option, considering all patient circumstances. This may call for a microsurgical option in one situation, while a locoregional flap may be superior in a different but similar defect. Maintaining a degree of creativity and a detailed knowledge of vascular anatomy, including the precise location of the vessel pivot point, the length of the vascular pedicle, and the reach of a reliable skin paddle, one can push the boundaries of the traditionally described pedicled flaps to reach and cover soft tissue defects that seemingly would be reconstructed only by free flaps.

Many have described techniques of vascularized bone transfer to achieve arthrodesis and bone healing. The

Fig. 8. One-year follow up with excellent flap healing.

Fig. 9. Maxilla defect following excision of invasive squamous cell carcinoma.

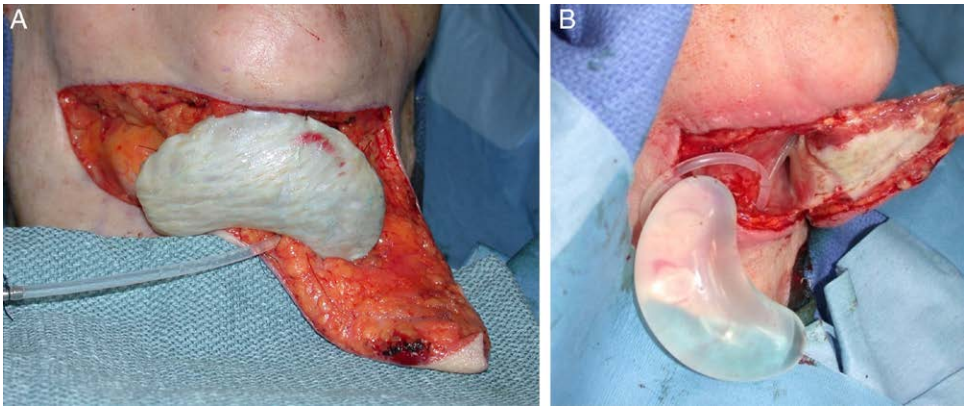

Fig. 10. Prelaminated, expanded submental flap for midface reconstruction. A, Following flap elevation with tissue expander and full-thickness skin graft before placement. B, Following tissue expansion and flap prelamination just before rotation and inset.

most discussed source of vascularized bone autograft is the free fibula flap. This workhorse flap has been employed in the reconstruction of humerus defects resulting from trauma, infection, and neoplasm. There are multiple cases described of glenohumeral defects from trauma, infection, and neoplasm, in which a free fibula flap is employed to achieve joint arthrodesis.[12,13] Surgeons have utilized the free fibula transfer to reconstruct a myriad of humeral defects when nonvascularized bone graft or prosthesis would not be sufficient.[14–16] However, there conceivably exist circumstances where a free fibula flap is not an option, as in our shoulder arthrodesis case. Patients with multiple previous surgeries and attempts at wound coverage may have significant disruption of the regional vasculature. The axilla is particularly susceptible to such insult due to its complex anatomy and as a frequent target of radiation and node dissections. The pedicled osteocutaneous scapula flap is thus a valuable tool to provide vascularized bone to the shoulder and even upper arm, where the pivot can likely reach.[17,18] In fact, one may even argue that in a search for local osseous options, any adjacent bony structures could be considered in terms of vascular supply and potential transpositional arc of reach, thus realizing the very essence and potential of the reconstructive principles. Reconstruction of the tibial defect in the lower leg with a pedicled fibula transfer serves to illustrate this very point. This particular approach has been described by the senior author and others for reconstruction of sites around the tibia and the ankle.[19–21] The usual peroneal perforators that support a skin paddle in a classic fibula flap can also be equally reliable in a retrograde configuration, thus providing a versatile reconstructive option. As we show in this series, regional transfer can be performed in a reverse fashion, when feasible, to maximize the mobility of the transferred tissue and even include a skin paddle, if needed, for chimeric flap coverage of complex defects. This approach provides a reliable reconstructive option with an adequate blood supply and sufficient arc of transposition and, at the same time, avoids the need for microvascular anastomosis in the injured region.

This case series demonstrates the ability of a surgeon to stretch the traditional boundaries of regional tissue transfer. Carefully considered tunneling options often allow for extension of the arc of rotation for many pedicled flaps. Large mid-lower flank defects have relatively infrequent presentation. The pedicled TRAM flap is routinely associated with breast reconstruction. However, an un-partitioned bi-pedicle TRAM flap can evidently provide the sufficient coverage as demonstrated by our first reconstructive effort. The pedicled anterolateral thigh flap has been extensively lauded for its versatility in perineal and lower abdominal reconstruction, and authors have demonstrated multiple techniques for extending the reach, size, and rotation of this flap.[22–24] The descending branch of the lateral femoral circumflex artery may be rotated easily to provide flap coverage to the abdomen well beyond umbilical level, flanks, and perineum. Furthermore, perfusion from the lateral femoral circumflex artery perforators is robust, allowing for the flap to encompass nearly the entire anterior thigh and to extend to the level of the knee, thus providing not only a large skin paddle but, more importantly, the reach of flap coverage. In our hands, a carefully designed flap may even reach upper abdominal and sub-xiphoid defects. In the face, careful identification of the vascular pedicles allowed for full rotation and transposition of large flaps seen in this series.

As demonstrated by our submental flap case, and similarly with pre-expanded supraclavicular flaps,[25,26] tissue expansion could be a powerful adjunct tool to not only shape, prelaminate, thin out the flap, and facilitate donor site closure, but also to increase the reach of the pedicled flap and thus its coverage area. Maxilla defects of this size are typically reconstructed with a free fascial flap from the upper or lower extremity,[27–29] which in this elderly patient would not be without adverse consequences. With the current pedicled approach and the added bonus of a staged procedure, the incorporation of surgical delay and prelamination minimized the midface edema and healing complications after initial inset of the flap. In addition, in the head and neck area, regional flaps often provide much better color match than a free flap from a distant donor site.

Our series presents multiple examples of flaps that while well described as free flaps, may also be employed using a preserved pedicle if meticulous planning and dissection is performed. For shoulder reconstruction, the forearm filet flap has been presented as a free tissue transfer option in

multiple case reports.[30,31] Yet the robust vascular supply to the forearm may often be preserved, allowing for its use as a pedicled flap, even in a delayed fashion.[32] Similarly, the free fibula flap is a true workhorse of bone reconstruction, including in the lower extremity.[33,34] Yet with careful planning the fibula may be transposed on its vascular pedicle without the need or risks incumbent with microvascular anastomosis. Although it is always conceptually easier to call in "air support" to tackle the reconstructive needs at hand, well-planned "ground maneuvers" should never be overlooked. After all, a reconstructive ladder should continue to maintain its ordered rungs, sometimes out of necessities of patient protoplasm or other logistical complexities and other times just with a better cost–benefit calculus.

CONCLUSIONS

The advent of modern microsurgical techniques has undoubtedly revolutionized the ability to reconstruct complex defects. Yet, there is a significant financial, emotional, and logistical cost to performing microvascular free tissue transfers.[2,35] It is, therefore, essential to maintain an open and free mind before resorting to the customary free flap.

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