Strategies for Avoiding Complications with Vascularized Bone Flaps in Head and Neck Microvascular Reconstruction

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ABSTRACT

Effective osseous reconstruction of the head and neck after congenital, traumatic, and particularly ablative oncologic procedures is a relatively recent innovation. Whereas pioneers led with individual donor sites, it is only in the past 20 years that most centers have developed teams comfortable with use of the four common donor sites for free flaps: iliac crest, fibula, radius, and scapula. Calvarium, though much less frequently used, is a useful donor site for specific reconstructive challenges. Less commonly used sites such as femur, humerus, and rib have not proved universally reliable. This article aims to illustrate some refinements and pitfalls in vascularized osseous reconstruction of the head and neck using the well-recognized flaps, including calvarium, in a variety of pathologic conditions, recipient-site defects, and comorbidities. Strategies for error avoidance will be emphasized. The authors hope that this will support the concept of a reconstructive “toolbox” for this complex area.

KEYWORDS: Error avoidance, microsurgery, head and neck, osseous free flaps

Osseous reconstruction of the head and neck, most frequently reconstruction of the jaws, orbits, and nasal complex, is a demanding process.¹ Posttraumatic and congenital defects have often been managed with nonvascularized bone grafting, synthetics, and, more recently, bioresorbables in some instances augmented with bone morphogenetic proteins or osseous distraction techniques.

Ablative oncologic defects, which are often followed by postoperative radiation treatment, mandate vascularized osseous reconstruction for optimal outcome. The defects of osteoradionecrosis mandate

composite vascularized reconstruction whether or not supplemental hyperbaric oxygen is used. It must be noted that the evidence to date shows that bisphosphonate-related osteonecrosis of the jaws does not benefit from this type of surgical intervention.

Successful microvascular reconstruction was initially a great relief for the reconstructive surgeon, and the temptation to stick with what works in difficult situations is a powerful (and not unreasonable) one. For this reason, different centers have had a tendency to promote one osseous reconstruction over another during the past

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20 years. This approach supports high free tissue transfer success rates.²

This article aims to show that each of the vascularized osseous reconstructions used in the head and neck has a legitimate place in the reconstructive surgeons repertoire and that balancing the appropriate flap to the appropriate defect and, overwhelmingly, the right patient and situation will allow many of the concerns about the complications associated with vascularized osseous reconstruction of the head and neck to be eased.

GENERAL CONSIDERATIONS IN AVOIDING COMPLICATIONS WITH FREE OSSEOUS TISSUE TRANSFER

An excellent account is given by Mehrara and Cordeiro³ with regard to complications in general during microvascular reconstruction of the head and neck.

Whereas in elective practice, it is wise to optimize patients (or even decline to treat if this is not possible), many patients undergoing osseous head and neck reconstruction will present as a result of advanced malignant disease and cannot be delayed.

Rapid correction of comorbidities where possible, smoking cessation without the use of nicotine replacement therapy,⁴⁻⁸ and controlled alcohol reduction including the use of inpatient benzodiazepine substitution will reduce but not eliminate the risks of unwanted events.

Assessment of cardiorespiratory function and where possible its optimization is essential as failure of delivery of blood-borne oxygen will defeat the most able technical reconstruction.

History of predisposition to coagulopathy should be fully investigated. The unexpected findings of protein S or protein C deficiency can result in the failure of an otherwise perfect reconstruction.

Personal experience shows that virtually all head and neck cancer patients present in a relatively dehydrated state; this is usually corrected in the early perioperative stage. Effective preoperative nutritional correction by enteral supplementation is advisable but difficult due to time constraints.

PERIOPERATIVE CONSIDERATIONS

For most teams performing this type of surgery on a weekly basis, perioperative considerations form part of a standard operative procedure. Avoidance of pressure necrosis at sites of entry of catheters, tubes, and cannulas, maintenance of core and peripheral temperature, and experienced expert anesthesia are prerequisites.

Prophylaxis of deep venous thrombosis is mildly controversial. The flap is probably at greatest risk from hematoma yet these patients, because of their primary

disease, are considered to be at high risk. In fact, the evidence that they are hypercoagulable is scant.⁹ The high incidence of systemic complications and absence of flap survival benefit from the use of low-molecular-weight dextrans has been reported and their use discouraged.¹⁰ Despite this, our practice has been for the past 10 years to use low-molecular-weight heparin¹¹ with no adverse effect on incidence of hematoma or flap failure.

Patients who have undergone previous head and neck surgery and in particular those who have undergone surgery and radiotherapy present an especially demanding challenge. Vascular imaging prior to operation will provide essential information in relation to available feeding and draining vessels. Preoperative treatment with hyperbaric oxygen therapy, although controversial,¹² remains our practice.

Maintenance of the spatial relationships of the mandibular remnants after segmental resection is important to ensure optimal function and allow accurate reconstruction. Use of the occlusion, where possible, is the simplest way of achieving this. A brief period of maxillomandibular fixation prior to resection can allow accurate contouring of rigid fixation. In complicated cases, preoperative fabrication of a three-dimensional stereolithographic model can allow accurate extracorporeal contouring of the fixation system and show the dimensions required for the bone flap. In the edentulous patient, or patient without an adequate occlusion, the placement of an external fixator prior to resection helps to maintain the spatial relationship of the bone ends and demonstrates the amount of bone required for reconstruction.

THE FLAPS

The flaps will be considered in alphabetical order—calvarium, deep circumflex iliac, fibula, radial, and scapula—relating each to comorbidities, recipient-site inset, donor-site defect, anastomosis, ergonomics, and patient preference. Surgeon preference, although clearly important, is an individual matter to be balanced honestly against these others and will not be considered.

Calvarium

Both outer table and full-thickness vascularized calvarial bone have been described in head and neck reconstruction.¹³⁻¹⁵ In the earlier series, an emphasis lay on the microvascular supply from the temporalis muscle dominant supply (deep temporal vessels and middle temporal—a branch of the superficial temporal). More recently, recognition of the distinctive temporo-parietal fascia and its dominant vascular supply from the superficial temporal vessels and its relationship to the pericranium has allowed the safe elevation of both

Figure 1 Example of the free temporoparietal fascia cranial bone composite flap.

pedicled and free temporoparietal/pericranial/calvarial flaps¹⁶ (Figs. 1 and 2).

COMORBIDITIES

The temporal vessels are rarely affected by peripheral vascular disease or the microvascular sequelae of diabetes; however, previous surgery in the neck or parotid region may have involved the superficial temporal vessels. Doppler or duplex tracing of the vessels provides reassurance. Ipsilateral head and neck radiotherapy is a relative contraindication.

RECIPIENT-SITE INSETTING

An advantage to this relatively thin strip of cortical bone is that it can be cut from the inner aspect retaining the pericranium to create a multiangled, three-dimensional osseous shape. The dense outer table takes screws for internal semirigid fixation. The principle consideration is the relatively short pedicle length and the orientation and access to recipient vessels. The bone of this flap is only a few millimeters thick and though useful for orbital and midface defects is totally unsuited to segmental defects of the mandible—the most common indication for osseous reconstruction. The inclusion of skin with the flap though feasible in terms of microvasculature generally leaves a poor-quality donor-site defect.

Figure 2 The donor site of the free temporoparietal fascia cranial bone composite flap.

DONOR-SITE DEFECT

If the bone and fascia only flap is used, the only significant defect is an indentation in the skull. If this is likely to present an aesthetic problem to the patient, obturation with a bone cement or synthetic replacement is comparatively simple. Full-thickness harvesting (whether intended or not) can be compensated for with careful hemostasis, dural repair (if indicated), and a titanium mesh internally fixed to healthy surrounding calvarium. It is usually easy to avoid accidental full-thickness harvesting if a curved osteotome (curve directed outwards) is used to complete the harvest. The major risk then is the bone suddenly springing off the skull and ending up on the floor!

ANASTOMOSIS

These are relatively small vessels but should present no particular problems to those using conventional microscopic magnification. The major issues arise with avoiding tension and access to appropriately sized recipient vessels. As with most free flap reconstructions, preoperative planning as to flap and pedicle orientation, length of pedicle, and size and proximity of feeding and draining vessels will prevent an otherwise perfect operation from becoming a stressful and exasperating event. Vein grafting with its attendant reduction in flap survival is required if recipient vessels are unsuitable at operation, and this is much better avoided by adequate preoperative planning.

ERGONOMICS

The possibility of simultaneous two-team operating is very low with this flap, and the need to proceed sequentially means that for many of the more common defects, a distant and conveniently more bulky osseous donor site is preferred.

PATIENT PREFERENCE

As long as the donor-site defect is limited to the outer table of calvarium, the postoperative sequelae are minimal. There is a small risk to the temporal branch of the facial nerve when narrowing the temporoparietal fascia and enclosed vascular pedicle in the region of the zygomatic arch, but this is a relatively uncommon problem. The slight hollowing of the temporal region is rarely noticed, and the skull defect can be easily recon-toured using a synthetic bone substitute.

Deep Circumflex Iliac Artery

COMORBIDITIES

Previous abdominal surgery on the ipsilateral abdominal wall or presence of a hernia or other weakness is a relative contraindication as is obesity. This is the only osseous free flap used in head and neck reconstruction where

Figure 3 Angiogram of the circumflex iliac vessels showing no atheroma. The same patient had multiple vessel disease in his lower limb vessels (see Fig. 7).

impotence has been described as a complication.¹⁷ The deep circumflex iliac artery (DCIA) and deep circumflex iliac vein (DCIV) are relatively large vessels between 2 to 3 mm and 3 to 5 mm in diameter, and they are rarely involved in atheromatous disease despite this being common in the external iliac artery (Fig. 3).

The major shortcomings of this flap are the relatively short vascular pedicle (maximum 7 cm) and the quality of associated skin, which is often not suitable for head and neck reconstruction. This led to the popularization of the DCIA bone flap with the internal oblique muscle (Fig. 4) supplied by the ascending branch of the deep circumflex iliac artery as a soft tissue component for oral and oropharyngeal reconstruction.¹⁸

RECIPIENT-SITE INSETTING

The DCIA is a bulky flap and requires relative rigidity during inset. Care to avoid twisting the relatively short

Figure 4 The deep circumflex iliac artery flap; note the relatively short vascular pedicle.

Figure 5 A typical insertion of the DCIA and internal oblique into a segmental mandibular defect.

pedicle when orienting the bone and avoiding compression of the bulky muscle of the internal oblique is required. The muscle atrophies over a period of a few months but is difficult to monitor and ischemia especially if followed by radical radiation can result in massive tissue defects. Figure 5 shows the typical use of a DCIA for reconstructing mandibular segmental defects that require height for subsequent dental rehabilitation with implant-borne prosthesis. The vascularized bone is fixed using a titanium reconstruction plate. Lighter 1.3- to 1.5-mm semirigid plates are used when inseting the DCIA in the maxilla (Fig. 6). If osteotomies to create a curvature are required, it is essential to remember that these are made on the lateral aspect creating opening osteotomies, which gives a less satisfactory curve. The real secret to avoiding complications with this site is to ensure an adequate length of feeding and draining vessels are dissected during the neck dissection and ablation. The combination of orientation and relatively short pedicle length can place the anastomosis under tension and often in a location that makes the microvascular component frustrating.

Figure 6 Insetting a DCIA into a high maxillectomy defect. The single most important point in error avoidance is ensuring an adequate length of feeding and draining vessels from the neck.

DONOR-SITE DEFECT

Postoperative hernia and limp are the most commonly quoted complications, and it is often assumed that the hip donor site is more painful than are the other osseous donor sites. A article comparing the two most frequently used osseous donor sites (the fibula and the DCIA) suggests that there is little difference between the two.¹⁹

Careful closure of the muscular layers coupled with mesh reinforcement is commonplace, and a variety of techniques have been described to minimize the risk of postoperative hernia. Most large series of this flap have patients with postoperative abdominal weakness or hernia despite this. Many patients describe a chronic dull ache.

ANASTOMOSIS

As long as there are no problems with pedicle length, there is seldom any technical difficulty for those using microscopic magnification as the artery at origin measures 1.5 to 3 mm in diameter and the venae 3 to 5 mm in diameter.²⁰ The major technical consideration by far is location of recipient-site vessels, which compensates for the relatively short and sometimes difficult to orient flap vessels.

ERGONOMICS

This is a good flap for two-team work as it is perfectly possible to accommodate two sets of surgeons, assistants, scrub staff, and instrument trolleys around the patient to allow two-site operating. This means the flap can be harvested while the ablation is being performed and is cost neutral in terms of theater time providing two teams are available.

PATIENT PREFERENCE

In comparison with the fibula, which has to be regarded as the major rival of the iliac crest, there is a general belief that the iliac crest donor site produces more long-term chronic pain and gait disturbance. This has been challenged by a well-structured study.¹⁹ If it is accepted that there is relatively little difference between the donor-site morbidities, then aspects of greatest importance to the patient will be likelihood of success and potential for rehabilitation with prosthesis. These will usually be implant borne, and the iliac crest gives a greater bulk and depth of bone than does the fibula and provides a much better match in terms of mandibular height for the dentate patient. In the maxilla (Fig. 6), the bone bulk provides good support for the midface, and internal oblique muscle re-creates an excellent palate and attached gingivae.²¹

When considering success and failure, the availability of healthy recipient site vessels is paramount. Cases where the risk/benefit is biased against the DCIA include revision surgery, osteoradionecrosis, and cases where radical neck dissection is required to address the bulk of disease in the neck.

Figure 7 Angiography of the distal limb may reveal atherosclerotic disease, but this can usually be predicted by clinical examination and duplex ultrasound examination.

Fibula

COMORBIDITIES

Previous surgery to the donor site limb forms a relative contraindication for the use of this flap, but the most

Figure 8 A ribbon-like ultrathin fibula, which would be of no use in mandibular reconstruction in the patient it was intended for.

Figure 9 Standard operative skin markings for a fibula osseocutaneous free flap; note the skin paddle is based around the junction of the middle and distal thirds of the points between the head of the fibula and the lateral malleolus.

significant comorbidity is peripheral vascular disease (Figs. 3 and 7). The patient population with head and neck cancer has a high incidence of smoking, and the incidence of atherosclerotic changes in the distal leg can be expected to be high in the very group who could most benefit from this flap. For this reason and the fear of losing a foot, some authors advocate routine preoperative angiography.²² Others, including the authors, rely on clinically palpable foot pulses and duplex ultrasound, which has excluded all at-risk limbs in our series. A preoperative plain radiograph will prevent the error of harvesting a fibula that will not provide adequate bone stock—a rare but avoidable problem (Fig. 8).

The location of skin paddles at the distal end of the lower leg (Fig. 9) and use of the full length of the peroneal vessels ensures a well-vascularized flap and obviates many of the previous criticisms of the fibula (Fig. 10).

RECIPIENT-SITE INSETTING

The combination of relatively flexible skin up to 12×7 cm, long dense bone up to 25 cm, and a wide-bore pedicle makes the fibula a good option in composite defects of the edentulous mandible, osteoradionecrosis, or other cases where the contralateral neck may have to be used for vascular access. It can also be effective as a

Figure 10 A 20-cm segment of fibula with a 7-cm length of skin paddle harvested for side-table customizing.

Figure 11 An alternative is to shape the fibula by osteotomy while it remains perfused on the leg. This is more demanding and probably unnecessary.

reconstruction for moderate and low-level defects of the maxilla. The flap may be contoured while the pedicle remains attached (Fig. 11) or on a side table. Premanipulation of a 2.4-mm reconstruction plate allows exact replication of the previous bony contour in the mandible (Fig. 12). In the maxilla, 1.5-mm plates secure the dense fibula bone to the much thinner maxilla at buttress and piriform rim sites. An essential tactic when cutting the

Figure 12 Mandibular reconstruction with a cut osseocutaneous free fibula and 2.4-mm reconstruction plate.

fibula is to avoid excessive periosteal damage and preserve the vascular pedicle on the medial surface. In doing this, closing osteotomies are achieved with an excellent enveloping blood supply. A monocortically placed screw, even when using a bicortical plating system, avoids the risk of inadvertent vessel damage. Take care not to twist or shear the perforating vessels (which are more at risk at inset than at harvesting) when adjusting the shape and length of the cut bone to the skin paddle.

DONOR-SITE DEFECT

As discussed in the section on the DCIA flap, it has long been held that in the absence of vascular disaster, the donor-site defect associated with the fibula is less than that of the DCIA. Common complaints that are largely unavoidable include altered sensation over the lateral malleolus, some weakness in dorsiflexion of the great toe, and foot and ankle edema. Although objective comparison of gait disturbance¹⁹ suggests that patients with fibula donor sites suffer as greatly as those with iliac crest donor sites, this does not seem to be borne out by subjective reporting.²³ If large skin paddles are harvested, in our experience greater than 4 to 5 cm in width, then skin grafting of the donor site is required. This inevitably delays healing and patient mobilization.

ANASTOMOSIS

The free fibula provides a long pedicle (up to 15 cm) depending on the length of bone required for reconstruction. This usually allows orientation to healthy neck vessels even in the contralateral neck providing the flap is inset appropriately. The vessels are very large and present no anastomotic difficulty unless the venae are particularly voluminous and complex where it may be necessary to reduce the size of the flap vein for an end-to-end anastomosis.

ERGONOMICS

This is the ideal flap for two-team work, and it is possible for the two surgical teams to operate simultaneously with no physical limitations.

PATIENT PREFERENCE

Similar issues arise as those discussed previously for the DCIA. In circumstances where access to healthy vessels is an issue at the recipient site, the fibula has an advantage because of ease of orientation and pedicle length. A major disadvantage is in the height of bone available making the fibula a much less suitable reconstruction for the dentate mandible than is the DCIA. Issues around implant-borne rehabilitation have also been raised, although fixing the flap in the middle zone of the vertical mandible compensates for the reduced implant length. Some authors have suggested that the free fibula should be the flap of first choice in mandibular reconstruction.^{2,24} We would return to the concept of the "right flap for the problem."

Radial

COMORBIDITIES

The radial vessels are rarely significantly affected by peripheral vascular disease, and in the presence of a successful Allen's test and normal duplex there are few contraindications to its harvest. It has been long recognized as a "workhorse" soft tissue free flap for head and neck reconstruction. The introduction of a segment of radius²⁵ created an option for reconstruction of smaller composite defects of the head and neck. Previous surgery or significant rheumatoid disease present relative contraindications, but other than those factors discussed previously in the section on general considerations, this is a safe flap. Its drawbacks come from the bone bulk and the donor-site defect.

RECIPIENT-SITE INSETTING

The segment of bone that is limited to 40% of the radius is a good vertical and horizontal match only for pencil-thin (pipe-stem) atrophic mandibles, an edentulous section of maxilla, and areas of the midface and orbits where thin segments of bone may be required. Care must be taken when inseting the flap to ensure that the screws retaining the segment of radius engage bone safely below the periosteum adjacent to the septocutaneous vessels from the main radial pedicle. Closing osteotomies are possible. This flap does have the advantage of ease of orientation and a long, easy-to-manipulate vascular pedicle, which allows for use of relatively distant vessels (Fig. 13).

DONOR-SITE DEFECT

The defect at the composite radial donor site has been a significant deterrent to using this flap. Fractures of the radius occur in around 25% of cases even after long-term support in external splints²⁶ (Fig. 14). To overcome this when we believe this flap is indicated, for example in a previously operated case with a composite radionecrotic atrophic bone defect (Fig. 15), we prophylactically plate the donor site radius²⁷ (Fig. 16). The soft tissue defect

Figure 13 An example of a sensory innervated, composite radial forearm free flap with additional venous drainage. The length of pedicle is an advantage.

Figure 14 Fracture of the donor-site radius can occur as a late complication even when protracted external splintage has been used.

on the forearm is covered with an ipsilateral full-thickness skin graft from the forearm harvested simultaneously with the flap.²⁸ We have found this superior to other techniques for this donor site.

ANASTOMOSIS

This flap is so regularly used in head and neck reconstruction that anastomosis rarely presents problems. An additional venous drainage can be used although we tend to reserve this for training purposes and rely on the venae for primary drainage of the flap. It is our practice to anastomose both venae usually end-to-side into the internal jugular vein where this is present.

ERGONOMICS

It is technically more difficult to harvest this flap simultaneously with the head and neck resective procedure, due to proximity of the teams. This is only a significant problem when the head and neck defect is on the side of the donor arm and requires substantial physical flexibility and temperamental forbearance on

Figure 15 This dental panoramic tomogram of a patient who has had ongoing necrosis of her mandible secondary to intraosseous lymphoma some 15 years previously. Previous reconstructions consisted of a free fibula osseous flap followed by the contralateral fibula as an osseocutaneous flap. A fracture with mucosal breakdown occurred at the union of the two flaps in the neomandible in a patient with bilaterally operated and irradiated neck.

Figure 16 Prophylactic plating of radial composite free flap donor site.

the part of the operating teams. There are instances, however, where the composite radial forearm free flap is able to be used for a reconstruction that might otherwise be impossible (Fig. 17).

PATIENT PREFERENCE

It is usual practice to harvest the nondominant arm in the absence of contraindications. The patient must understand the need for arm elevation in the early postoperative period and may experience altered sensation in the thenar region and some weakness of grip, pronation, and supination. This can disrupt some basic items of daily living even when the radius is prophylactically plated.

Figure 17 Postoperative radiograph of the patient illustrated in Figure 15. Reconstruction of the anterior mandible and floor of mouth was achieved using a composite radial forearm free flap based on the neomandible remnants (bilateral free fibulas) using customized titanium reconstruction plates.

Prosthetic rehabilitation with conventional or implant-borne prosthesis is possible, but the bone stock of the radius is only suitable for the very atrophic edentulous mandible or maxilla in this respect.

Scapula

COMORBIDITIES

The subscapular system of vessels is rarely involved in atheromatous disease, and the group of flaps that can be harvested from this region are very attractive from the point of view of head and neck reconstruction.^{29,30} Major issues with regard to comorbidity are previous ipsilateral neck or axillary surgery. Damage to the accessory nerve and cervical plexus from the former will exacerbate the recognized shoulder dysfunction at the donor site, and the latter may compromise the vascular supply to the flap. Preexisting injury to or dysfunction of the brachial plexus is a relative contraindication as this is a recognized complication of the positioning for raising the flap (Fig. 18).

RECIPIENT-SITE INSETTING

A major advantage of the scapula is the relative versatility and independence of movement of its component parts allowing osseous reconstruction with bone of reasonable height and just adequate width for implant-borne rehabilitation and large soft tissue components that can be easily orientated for internal or external coverage (Fig. 19). Even greater versatility can be achieved by including the thoracodorsal vessels to the point where the angular branch supplies the angle of the scapula, which can allow two separate pedicles, one for bone and one for soft tissue.³¹ The osseous component is vascularized by periosteal vessels, and fixation with bicortical or monocortical screws is safe provided periosteal stripping is minimized. The

Figure 18 Skin markings for the scapula osseocutaneous flap. Note the position of the patient renders two-team simultaneous operating in the head and neck impossible.

Figure 19 Inset of an osseocutaneous scapula free flap; the good bulk of bone stock coupled with a large flexible skin paddle make this flap an alternative to combination free flaps in some instances.

periosteal supply allows closing osteotomies to be safely made if needed.

DONOR-SITE DEFECT

Shoulder dysfunction is a particular problem with the osseocutaneous scapula flap. It is essential to stay at least 1 cm below the glenoid fossa when harvesting bone to avoid damage to the joint space. Muscles stabilizing the shoulder particularly teres major muscle, which has to be cut during harvest of the flap, are rendered dysfunctional. Reinsertion has been advocated for some time, but results are controversial and may result in additional stiffness and discomfort. This degree of shoulder dysfunction is compounded if the ipsilateral scapula (to the neck dissection) is harvested. Advanced warning of the patient and early active physiotherapy may minimize this problem.

ANASTOMOSIS

The circumflex scapular vessels are wide bore and easy to anastomose (Fig. 20); the main problem is pedicle length, particularly with the more extensive and demanding

Figure 20 The circumflex scapular vessels are wide bore and relatively easy to anastomose.

dissection that is required to harvest the osseous version of the flap. The simplest dissection will yield a pedicle of only 4 to 6 cm although dissection to the origin from the subscapular vessels, though demanding, can yield a length of up to 10 cm.

ERGONOMICS

The major issue with using the scapula osseocutaneous flap for head and neck reconstruction is with the positioning of the patient for harvest. It is impossible to operate simultaneously using two teams, and the operation must proceed sequentially thereby greatly increasing overall operating time.

PATIENT PREFERENCE

The additional length of time in theater is of no significance to most patients, and those who wish the most aesthetic external color match for facial skin may prefer a scapula reconstruction. In those who will not receive radiation treatment, the skin is less hairy than are alternatives. For those whose main concern is shoulder dysfunction, another flap may be more suitable. For patients with extremely complex composite defects, the choice may be between an extensive composite scapula flap and combination flaps where two complimentary free flaps are used. The latter is often our team's preference unless the patient specifies otherwise as despite the addition of a second flap, simultaneous operating allows flap harvest to be cost neutral in terms of time. The disadvantage to the patient is two donor sites with their attendant issues.

DISCUSSION

The simplest flap that is most likely to succeed in your hands (i.e., those you use regularly) and that does the job required for that individual patient in the safest and most efficient manner is the optimum solution to any reconstructive challenge requiring microvascular reconstruction. This article has reviewed the small number of osseous free flaps regularly used for head and neck reconstruction and individually illustrated how best to avoid complications with those techniques. Matching generic techniques for avoiding complications in microvascular surgery with sensible preassessment of both the patient and the potential defect and the benefits and limitations of one of these osseous free flaps should help the surgeon recognize when and which reconstruction is best for any individual patient.

CONCLUSION

The commonly used osseous free flaps for head and neck reconstruction have been briefly outlined with particular reference to avoiding complications. It is hoped that the head and neck reconstructive surgeon will agree that

developing a limited but sufficiently versatile free flap "toolbox" for this challenging surgery is the way forward for our patients.

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