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Microvascular Free Flaps in Oral and Maxillofacial Reconstruction Following Cancer Ablation

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ABSTRACT

Microsurgical free flaps have become the first choice for reconstruction of oral and maxillofacial (OMF) defects after tumor resection. Till recently the pectoralis major myocutaneous flap (PMMC) was considered to be the benchmark for oral and maxillofacial reconstruction. This philosophy is changing fast with rapid advancement in reconstructive microsurgery. Years of innovation in reconstructive microsurgery has given us a reasonably good number of excellent flaps. Tremendous work has been put into producing some exceptionally brilliant research articles, sometimes contradicting each other. This has led to the need for clarity in some areas in this field. This article reviews the most common microvascular free flaps (MFF) namely, radial forearm free flap (RFFF), anterolateral thigh flap (ALT) and free fibula flap (FFF) that are commonly used in oral and maxillofacial reconstruction. Since they can cater to almost all sizeable defects we come across after ablative surgery in the oral and maxillofacial region, they can suitably be titled as the workhorses of oral and maxillofacial reconstruction with regard to free flaps.

Keywords: Free tissue flaps; microsurgery; oral surgical procedures.

INTRODUCTION

With more radical resection for cancer of oral and maxillofacial(OMF) region, it is increasingly difficult to provide surgical reconstruction of hard and soft tissues with an esthetic appearance. The introduction of pectoralis major myocutaneous flap (PMMC) raised the bar in head and neck reconstruction in the 1970s making surgeons confident of operating on previously inoperable defects due to paucity of reconstructive options. However, sizeable defects managed by PMMC and other regional pedicled flaps gave a compromised esthetic and functional result and thus the search was for better options. This search led to induction of microvascular free flaps (MFF) into OMF reconstruction.

A logarithmic leap in OMF reconstruction thus occurred in the late 80s and early 90s with the introduction of MFFs.[1] During its evolution in the past three decades we have seen around twenty different types of free flaps being used in oromandibular reconstruction.[2] But especially the last two decades have seen a rise in the usage and refining of techniques and instruments which has helped tremendously increasing the reliability of MFF with centers reporting as much as 95-100% flap success. At present, the day has dawned in which MFFs are considered as the workhorse and the standard of care for reconstructing large ablative defects of this complex anatomic region.[3]

This article reviews most commonly used MFF to explain their growing impact on OMF reconstructive surgery.

COMMONLY USED MICROVASCULAR FREE FLAPS

RADIAL FOREARM FLAP

The radial forearm free flap (RFFF) was developed in 1978 as a fasciocutaneous flap in the People's Republic of China. Since the introduction of the radial forearm flap by Yang et al in 1981, it has become the most frequently used free flap in head and neck reconstruction.[4]

It is commonly used for tongue, floor of mouth, lip and hard or soft palate reconstruction. Its greatest advantage is the thin and pliable nature of the flap ideal for the restoration of oral mucosal defects after ablative oncologic surgery. Its ease of harvest and long pedicle (about 20 cm) with large caliber vessels makes it popular with beginners (Figure 1.).

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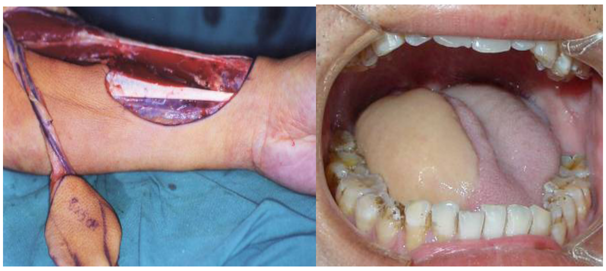

Figure 1. Hemiglossectomy reconstruction with radial forearm flap.

The entire skin in the volar aspect of the forearm can be harvested with the long pedicle permitting microsurgical anastomosis (MA) to the contralateral neck also.[5]Although attempts have been made to harvest a segment of the radius for bony reconstruction, it fell out of favor due to high chances of radius bone fracture. But this is less frequent after pre-plating the radius and cast immobilization of the arm.

Other advantages are the presence of large diameter superficial veins (cephalic or basilica) and deep venous system (the venae comitantes).[6] Studies have shown that the smaller venae comitantes give reliable venous outflow but due to their smaller caliber, MA is difficult compared to the cephalic vein.

There still is a debate regarding which is the dominant venous system. An elegant by Ichinose et al.,[7] used Doppler to demonstrate the venae comitantes to be dominant. They theorized that interruption of small superficial venous channels draining into cephalic vein during flap harvest would force venous drainage more into the deep system. The author uses a more clinical way of judgement. After flap harvest, the artery is anastomosed first and venous return noted from both the superficial and deep systems. Whichever has a faster outflow is used for MA.

It can also be harvested with two skin paddles and if necessary the palmaris longus tendon can be harvested to sling the flap to aid in oral competence during lower lip reconstruction. It is versatile in that it also may be transferred as a sensory flap incorporating the medial or lateral antebrachial cutaneous nerve,[8,9] or a composite bone flap using vascularized radius.[10-12] It also may include vascularized tendon[13] and brachioradialis muscle.[14]

The major disadvantages of RFFF is the donor site morbidity especially in cases of paratendon damage during flap harvest causing tenting and painful donor site which can be reduced by suprafascial dissection and minimizing paratenton exposure.[5] Other disadvantages are the need to sacrifice a major artery of the forearm, the radial artery, which decreased sensation in the region supplied by antebrachial cutaneous nerve, hand stiffness, pain and large donor site scar.[15]

ANTEROLATERAL THIGH FLAP

The ALT was first described by Song et al in 1984,[16] is supplied by perforating vessels arising from the descending branch of the lateral circumflex femoral artery, which arises from the profunda femoral trunk. (Figure 2.)

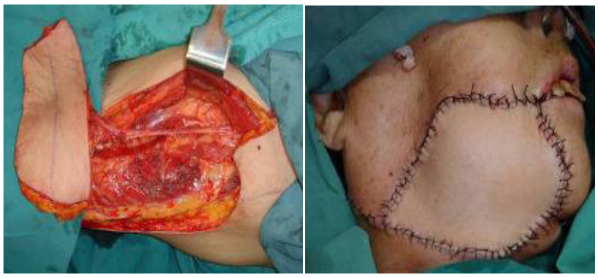

Figure 2. Anterolateral thigh perforator flap for through-and-through cheek and mandibular defect reconstruction.

It enjoys many advantages including low donor site morbidity, simultaneous harvest, large volume of skin and soft tissue available, a long pedicle, acceptability of site for the scar, ability to harvest as subcutaneous, fasciocutaneous, musculocutaneous or adipofacial flap thus giving multiple applications for this flap.[17-21]

The major problems with the ALT flap are the variations in the anatomy of the vascular pedicle, the difficult dissection technique, and the high incidence of hairy skin, especially in male. These led initially to a lack of popularity of this flap. Despite of these disadvantages, the application of this skin flap has become increasingly widespread.[22-24]

Flap reliability, functional outcome and surgical technique should be the main factors influencing the selection of ALT flap. Total glossectomy defects have to be reconstructed with flaps that make up bulk. Function of tongue is important; with the technical limitations we have at present we are only able to replace the missing bulk. We still have not reached a stage in which we can give a dynamic tongue for a patient, which moves with swallowing andmastication, and provides us with sensation of taste. Techniques have been reported,[25] which aim to address this complex issue. This is the goal we should aim for in the future. Sensory nerve neurorrhaphy for reconstruction of tongue [26]is a direction we should look more into.

At present we try to get around the problem of a static tongue by adding some bulk and volume to the reconstruction so that the upper surface of the neo tongue will contact the palate during swallowing thus helping deglutition. This philosophy of compensating for lack of function of tongue by adding bulk to the flap is based on the knowledge that wider and thicker flaps significantly improve swallowing and function when reconstructing large tongue defects which arerelatively immobile.[27] Thus flaps that can bring in bulk like ALT are ideal for total or near total glossectomy defects. Itshould be kept in mind that up to 70% of defects of tongue is best reconstructed with a pliable thin flap like RFFF butbeyond this it is better to add bulk to the reconstruction as the remaining stump of tongue will no longer help much inmovement.

The free ALT flap is reliable and versatile. It can transfer multiple soft tissues with large amounts of skin. Cheng and Tang reported that the maximum dimension of the ALT flap was 40x20 cm. It also can be trimmed to the subdermal fat as thin as 3-5 mm. The body habitus has no obvious impact on the choice of ALT flap, although the incidence of obesity is higherin the Western population. The ALT flap can be thinned in the deep adipofascial layer before transplantation, unlike the PMMC flap which cannot be thinned. Thinning of the ALT flap can be safely performed when a cuff of fascia 1.5 cm from the main perforator is preserved before dividing the pedicle. Some difficulties may be increased in the flap harvest for patients with a larger thigh, but the ALT flap is practicable via thinning it.

A chimeric ALT flap based on two different perforators could also be designed to meet the requirements for the reconstruction of composite defects.[28] ALT flaps have advantages and versatile designing capabilities that make them suitable for the reconstruction of OMF defects in most clinical settings.

Disadvantages of ALT include lack of bone stock, since this is a pure soft tissue flap, difficult intramuscular dissection is necessary since it is a perforator flap, risk of morbidity when wider flaps are harvested with skin grafting and when vastus lateralis is harvested along with the flap.

Even if there is difficulty with the perforators during the dissection, it can be easily converted to a tensor fascia lata flap. This flap is based along the ascending branch of the lateral circumflex femoral artery and an advantage is that a part of the iliac bone also can be harvested along with this flap. But the disadvantage is that the donor site is difficult to be closed primarily and also the pedicle length is shorter than that of the ALT.[29]

FREE FIBULA FLAP

As its adaptation as a technique for manidbular reconstruction in 1989 by Hidalgo,[30] the free fibula flap (FFF) is the first choice for restoration of extensive mandibular bone resection. The pedicle for the fibular free flap is the peroneal artery, a branch off the tibioperoneal trunk. The peroneal artery courses with paired venae comitantes along the entire distance of the fibula; along its medial aspect. The fibula is nourished by both periosteal and endosteal blood supplies.

The advantages of fibula include the length of bone available (around 25-30 cm), which permits multiple osteotomies and provides adequate pedicle length even for maxillary reconstruction. The peroneal artery and vein are usually of good quality and caliber and ideal for microsurgical anastomosis (MA) to the neck vessels. With proper harvesting techniques the donor site morbidity can be kept to a minimum. The remaining flexor halluces longus (FHL) should be sutured to the interosseous membrane and the peroneus muscle to the soleus during closure, after attaining hemostasis of the donor site. During harvest, distally atleast 5cm of fibula should be left to prevent angle instability.

The flap harvesting is technically challenging for the beginner but with experience, can be completed within 1 hour. Again due to the distance from the recipient site, two team approaches can be used thus greatly reducing operative time. The lack of a large skin paddle is a drawback, which limits its use in situations with full thickness cheek defects along with a segmental mandibular defect with floor of mouth involvement. A method to overcome this problem is to use double flaps, like radial forearm free flap (RFFF) for soft tissue cover and fibula for hard tissue reconstruction of mandible and skin paddle of fibula used for the skin defect.[31] Even though this is time consuming and technically difficult, these double flaps give excellent results. But the amount of cheek skin that can be replaced such is limited, also is the technical challenge of using two free flaps. Yet another option is to use a PMMC for facial skin cover, while the segmental defect of the mandible is reconstructed by fibula.[32]

The color of the skin paddle harvested along the fibula is a mismatch for facial defects and is darker than facial skin.Although this small skin paddle can effectively cover intraoral lining defects of buccal mucosa, floor of the mouth and tongue, the thickness of the skin paddle of the fibula is not pliable enough to mimic the suppleness of oral mucosa. The posterior crural septum, which connects the paddle to the peroneal artery, can be used to cover the reconstruction plate when the skin paddle is folded intraorally. This helps to a certain extent to avoid plate exposure in patients with thin soft tissue cover over the plates.

Harvesting a cuff of FHL along with the fibula is another way of adding soft tissue bulk in the flap to fill up dead space. The FHL can also be used to line palatal defects with the muscle eventually forming a reasonable color match for the palatal mucoperiosteum over time. Although the soleus need not be harvested for protecting the skin perforator, some authors recommend the same.[33] Experiences in pediatric patients have been encouraging as it is one of the safest flaps to harvest in pediatric population with iliac crest, scapula causing growth disorders later in life.[34] Also since the sural nerve lies in the same donor area as the harvesting site; it is simultaneously possible to harvest the sural nerve in patients who are planned for reconstruction of inferior alveolar nerve.[35]

A clinical example of the fibular free tissue flap being harvested to reconstruct the composite resection is shown in (Figure 3).

Figure 3. Harvest of a fibula composite flap for mandibular reconstruction.

DENTAL REHABILITATION

Although the reconstruction of the mandible with a fibula free tissue transfer (FTT) restores the form and function of the mandible, it does not address the absence of dentition that results in and that leads to significant functional impairment. The use of osseointegrated implants (OIs) has been successful in restoring this function in patients that are able to maintain hygiene and who are reliable with follow-up, which are issues that should be addressed before considering the placement of OIs.[36] Implants can be placed primarily at the time of reconstruction or secondarily at a later date.

The procedure is divided into three phases. First, titanium oxide coated titanium implants are fixed to the mandibular graft, oriented with waxing screws, and covered with a capping temporary screw. After bony union is complete after 4–6 months, the skin flap that surrounds the implants can be replaced with a palatal graft, while healing abutments are used to replace the capping screws. In addition to the use of a palatal mucosal graft, the skin paddle can be thinned or removed and replaced by a skin graft. Finally, the dental prosthesis is affixed to the OI approximately 1 month later.

OTHER FREE FLAP OPTIONS

ILIAC CREST

The initial reports involving transfer of vascularized iliac crest segments in 1978 were based off the superficial circumflex iliac artery. Taylor et al. in 1979 later proved that large amounts of vascularized iliac crest could be harvested when the flap was based off the deep circumflex iliac artery (DCIA).[37] Proponents of the vascularized iliac crest free flap report several beneficial characteristics for mandibular reconstruction including the provision of good, sturdy bone with an intrinsic curvature that is useful in restoring hemi-mandibular defects.[38] Additionally, the cortical bone of the iliac crest allows for dental rehabilitation via osseointegrated dental implants.

There are several disadvantages to this flap that has caused it to fall out of favor in some centers. Major drawbacks include functional donor site morbidities. Major complications such as femoral neuropathy, contour deformity and incisional hernia formation were infrequent unless associated with the inclusion of a skin paddle.[39]

Anatomic studies have proposed that two subsets of patients exist: those with a dominant perforator artery from the deep circumflex iliac vessels and those that lack the dominant perforator.[40] The iliac crest has been criticized because of the poor reliability of the skin paddle and because osteotomies of the donor graft have been shown to decrease the viability of the bone graft.[41] The decreased viability of the skin paddle has been proposed to be a geometric problem, as the skin island naturally lies on the external surface of the graft, but must be rotated underneath the neomandible to form neworal lining which interferes with perfusion and complicates the task of obliterating dead space in reconstruction. The variability of perforator artery anatomy may also contribute to the unreliability of the skin paddle in reconstruction. To ensure viability of the overlying skin paddle,[42] stressed the importance of harvesting an 8 x 2.5 cm^2 external oblique muscle cuff to capturethe major perforators from the DCIA.

Table 1. Comparative analysis of factors pertaining to donor site.

Donor site	Skin area	Bone stock	Soft tissue bulk	Soft tissue pliability	Pedicle length	Morbidity	Location
RFFF	MF	UF	UF	VF	VF	UF	MF
ALT	VF	NR	VF*	VF#	VF	VF	VF
Fibula	MF	VF	MF	UF	VF	MF	VF
Iliac	MF	MF	VF	UF	MF	MF	MF
Scapula	VF	VF	VF	UF	MF	MF	UF
Rectus	VF	NR	VF	VF	VF	MF	VF

(= When harvested as a musculocutaneous flap; # = when harvested as a subcutaneous flap; flaps are rated from best to worst as very favourable (VF); Italic text = Moderately favourable (MF), Unfavourable (UF); Bold text = Not relevant (NR); RFFF= Radial forearm free flap; ALT= Anteriolateral thigh)*

RECTUS ABDOMINIS FLAP

The perforated rectus abdominis or deep inferior epigastric artery perforated rectus abdominis (DIEAP-ra) free flap[43] is a relatively new procedure developed as a modification of the transverse rectus abdominis muscle (TRAM) flap.[44,45] DIEA-based free flaps have distinct advantages: they allow harvesting larger and thicker skin paddles (mandatory when dealing with total/subtotal glossectomy or extensive maxillofacial defects) than a radial forearm free flap; they have a much more constant and reliable vascular anatomy when matched with the anterolateral thigh; they do not require patient's repositioning during surgery as in latissimus dorsi and parascapular free flaps, thus making the two-team approach feasible.

The classic DIEA myocutaneous free flap can give rise to donor site problems, such as abdominal weakness or herniation, particularly if the anterior fascia is extensively harvested together with the skin paddle.[46] The DIEAP-ra has several advantages over other available flaps in head and neck reconstruction, especially when tissue bulk is required. Because there is no muscle or fascia harvested, donor-site morbidity is greatly reduced. Its greatest advantages, in spite of a more time-consuming and tedious dissection of the perforator vessels, are reduced donor site morbidity and a greater adjustable thickness of the skin paddle, especially in females and obese patients.

SCAPULA

The free scapular/parascapular flap based on the circumflex scapular artery (CSA) and paired venae comitantes was introduced by Gilbert and Teot in 1982.[47] The CSA is one of two terminal branches of the subscapular system. After passing through a muscular triangular space formed by the teres minor, teres major, and long head of the triceps muscles, it divides into a descending branch and a transverse branch that supply the scapular flap and the parascapular flap, respectively. The CSA has periosteal branches, which supply the lateral aspect of the scapula and allows for the harvest of approximately 10–14 cm of bone as an osteocutaneous scapular flap. A composite flap that incorporates the scapular tip, supplied by the angular artery, can be harvested to reconstruct angle defects. The pedicle length, which depends on how proximal the dissection is continued and the inclusion of the subscapular artery, ranges from 11 to 14 cm.[48]

Advantages to the scapular flap include the constant and easily dissected pedicle of good length and caliber, the ability to tolerate multiple osteotomies, and the large quantity of soft tissue that can beharvested. Another favorable characteristic of the subscapular system is the ability to harvest a unique composite flap composed of bone, muscular components, and multiple skin islands. The subscapular artery terminates in the circumflex artery and the thoracodorsal artery. The terminal branches of the circumflex artery include the descendent branch and the transverse branch, which supply the scapular and the parascapular fasciocutaneous flaps, respectively. The thoracodorsal artery supplies the latissimus dorsi muscle and terminates in the angular artery, which supplies the tip of the scapula and a branch to the anterior serratus muscle. This vascular system allows one to harvest, in a single flap, a wide amount of muscle, soft tissue, and bone to reconstruct large three-dimensional defects.

The scapula remains largely underutilized due to the location of the donor site. Patients require intraoperative repositioning for the harvest and inset, which prolongs operative time. Other drawbacks to the use of the scapular free flap for mandibular reconstruction is the quality of bone stock, which may be unsuitable for dental implants except in larger male patients.[49]

CONCLUSIONS

Simplification of flap selection for OMF reconstruction has been a recent trend. Microsurgery being a field requiring intense practical training, the surgeon should not initially venture into harvesting newer flaps which he is not familiar with, but should have the resolve to do so later on when he has mastered the basic skills reasonably well. We consider three flaps- the RFFF, ALT and FFF to have all the components necessary for OMF reconstruction (Table 1). RFFF can be considered for medium size intraoral defects where pliability of the tissue is paramount, FFF can be considered in maxillomandibular defects when we need to reconstruct a long span defect of bone, and ALT can be considered for replacing a large soft tissue defect in the OMF region, especially when there is a skin defect. Mastery in these three flaps can arm the reconstructive surgeon with sufficient options in his arsenal to reconstruct almost all types of OMF defects.

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