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An Overview of Regional Tissue Transfer for Head and Neck Reconstruction

Moubayed SP[1], Mourad M[1]*, Lee T[2] and Ducic Y[3]

[1]Department of Otolaryngology-Head and Neck Surgery, New York, NY, USA

[2]Department of Otolaryngology-Head and Neck Surgery, Richmond, VA, USA

[3]Otolaryngology and Facial Plastic Surgery Associates, Fort Worth, TX, USA

***Corresponding author:** Moustafa Mourad, Department of Otolaryngology and Head & Neck Surgery, New York Eye and Ear Infirmary of Mt. Sinai, 310 E 14th Street, New York 10003, USA, Tel: (212) 979 4000; Email: mousmourad@gmail.com

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INTRODUCTION

Defects in the head and neck most commonly result from cancer resection, although they may be caused by congenital diseases or trauma as well. Head and neck reconstruction should adhere to the principles of the reconstructive ladder, which entails choosing the simplest option to reconstruct a specific defect before moving on to the next rung [1]. The sequence of reconstruction from simplest to most complex is the following: secondary intention, primary intention, delayed primary closure, skin grafting, tissue expansion, local tissue transfer and free tissue transfer. Grafts are distinguished from flaps (local tissue and free tissue transfer) in the sense that flaps possess an intrinsic vascular supply, but grafts require secondary neovascularization from the recipient bed [2]. Flaps are commonly classified in terms of vascularity, composition, or method of transfer [3].

There are multiple ways to look at vascularity. The first is to determine whether a flap has an axial or a random pattern blood supply. An axial flap has an anatomically recognized arterio-venous system running along its long axis, whereas a random pattern flap does not possess such a system [4]. Another commonly used scheme to classify the vascularity of flaps is the classification of Mathes and Nahai, which was described for muscle flaps [5]:

- Type I: One dominant vascular pedicle.
- Type II: Dominant vascular pedicles and minor pedicles.
- Type III: Two dominant pedicles.
- Type IV: Segmental vascular pedicles.
- Type V: One dominant vascular pedicle and secondary segmental vascular pedicles.

Another type of flap, perforator flaps, was later added. A perforator is defined as a vessel that has its origin in one of the axial vessels of the body and that passes through certain structural elements of the body, besides interstitial connective tissue and fat, before reaching the subcutaneous fat layer [6].

The composition of flaps is a very important concept to understand when classifying them, as a principle of reconstruction is to replace like with like, and composition significantly affects thickness of any given flap. Flaps may be cutaneous, fasciocutaneous, fascial, musculocutaneous, muscular, osseous, osteocutaneous, or enteric. Cutaneous may be replaced with the term *mucosal* when appropriate.

Method of transfer is classified as local, regional, or free. A local flap originates directly next to the defect, or may be separated by a very small bridge of tissue [3]. A regional flap is located at a significant distance from the defect, and this entails that regional flaps usually possess an axial blood supply [3]. The flap remains connected to its axial blood supply, and is dependent on the arc of rotation to reach the defect [3]. Free flaps are transferred using microvascular surgery from a region to another [3].

Finally, geometric configuration (rhombic, bilobed, V–Y, Z-plasties, or W-plasties) and the method of transfer (rotation, transposition, advancement, interpolation, and island flaps) are also sometimes used to classify flaps [3].

There has been a recent resurgence in the use of regional flaps for head and neck reconstruction [7]. We will present a comprehensive overview of the most common regional flaps used for head and neck reconstruction in 2015. For each flap, we will present the composition, the vascular supply, the indications, donor site closure, size and reach, as well as advantages and disadvantages.

Mucosal Flaps

Nasoseptal

The nasoseptal flap was described in 2006 [8], and has revolutionized endoscopic skull base reconstruction by reducing cerebrospinal leak rates from 50% to below 10% [9]. It is a mucoperichondrial flap based on the posterior septal artery, a branch of the sphenopalatine artery [9]. The main indication is anterior skull base defects [9], and its size may reach 25 cm^2 [8]. The donor site is left to granulate in, with crusting or perforation occurring in the postoperative

period. To avoid septal perforation, whenever possible, it is best to preserve septal cartilage or the septal mucosa on the non-harvested site along the anterior septum. Posterior septal perforation is generally asymptomatic while the anterior septal perforation can cause nasal obstruction and crusting. The nasoseptal flap may reach the anterior and middle skull base [8]. Advantages are ease of harvest, consistent vascularity, long pedicle, and size and shape customization [9]. The main disadvantages are hyposmia/anosmia, crusting, nasal obstruction, and septal perforation [9].

Palatal island

Initially described by Millard in 1962 for cleft palate [10], it gained a resurgence with expansion of its use to oncological defects by Gullane and Arena in 1977 [11]. It is composed of mucosa, submucosa, and periosteum, and is based on the greater palatine artery, which is a branch of the internal maxillary artery [12]. The donor site is left to mucosalize without added morbidity and with sensory ingrowth [12]. Its main application is soft and hard palate defects, and may provide up to 10 cm^2 of coverage [12]. The advantages are the multiple layers available for reconstruction, ease of harvest, and absence of contracture due to the underlying bone [12]. The disadvantage is the limited arc of rotation, that may be improved by removing the hamulus [12]. Contraindications are a defect larger than the remaining palate, absence of the internal maxillary artery, prior palatal surgery, and prior radiation, due to increased risk of radionecrosis [12].

Facial artery musculomucosal (FAMM) flap

The FAMM flap was described by Pribaz in 1992 when attempting to perform a mucosal nasolabial flap [13]. Since then, it has gained widespread popularity. It is based on the facial/angular artery, and may be inferiorly or superiorly based. It is composed of buccinator muscle and buccal mucosa. The inferiorly based FAMM flap is primarily indicated for floor of mouth, tongue, and retromolar trigone defects, and the superiorly based flap is mainly used for palate defects [7]. The whole buccal mucosa may be harvested, and the donor site is either closed primarily or skin grafted. A buccal fat pad flap can also be insetted into the defect and left to mucosalize [7]. A flap up to 36 cm^2 may be harvested, and care must be taken not to injure Stensen's duct and to stay 1cm away from the oral commissure [7]. The main advantages are the ability to reconstruct mucosal defects with mucosa [7]. The principal disadvantage is the requirement of a second stage surgery to divide the pedicle, although a modification circumventing this disadvantage has been described, and the necessity to protect the pedicle from dentate patients by using a bite block [14].

Buccinator

A buccinator myomucosal flap was described by Bozola in 1989 [15], posteriorly based on the buccal artery [15]. Care must be taken not to injure Stensen's duct during harvest, and to stay 1cm away from the oral commissure [16]. The indications are defects of soft palate, retromolar trigone,

posterior floor of mouth, and lateral pharyngeal wall [16]. However, the size is limited to 28 cm^2 [16]. The donor site is usually closed primarily. Due to this limited size, this is an interesting flap to use when previous neck dissection or hypoplastic facial artery precludes the use of a FAMM flap. The pedicle must also be protected in dentate patients.

Fascial Flaps

Temporoparietal fascial flap (TPFF)

The TPFF has been described since the 1800s [16]. It is composed of the temporoparietal fascia, which is a continuation of the superficial musculoaponeurotic system above the zygomatic arch [16]. It is based on the parietal branch of the superficial temporal artery, as the frontal branch must be ligated close to its origin to protect the temporal branch of the facial nerve [16]. Common indications are auricular reconstruction, orbitomaxillary defects, and skull base reconstruction [16]. It is usually harvested without skin, allowing primary closure of the donor site with an incision that is hidden in the hair-bearing scalp [16]. Advantages are ease of harvest and reliability. The most common complication is alopecia [16]. Size can reach up to 81 cm^2 [17]. This flap may also be used as a microvascular free flap.

Pericranial

The pericranial flap is composed of pericranium, and is used frequently in anterior skull base reconstruction, initially open, and now endoscopic, with the flap brought in the endoscopic field through a small nasionectomy [18]. It is based on the supraorbital and supratrochlear arteries [18]. It causes minimal donor site scarring, and provides extensive potential for coverage up to the level of the sella [18]. The main disadvantage is large external incisions when the flap is not harvested endoscopically [18].

Cutaneous or Fasciocutaneous Flaps

Paramedian forehead flap (PMFF)

The PMFF was initially described in 700 BC in India [12]. It has gained mainstream popularity since the 1930s when the supratrocheal and supraorbital arteries were described as its primary source arteries [12]. It is composed of skin, subcutaneous tissue, and frontalis muscle, and may be thinned as needed [12]. The main indication is nasal reconstruction for large oncological defects [12]. Size may reach up to 30 cm^2 [19]. The main disadvantage is the conspicuous donor site, flap bulk, and the requirement for a multistage procedure [19].

Nasolabial

The nasolabial flap was also described in 600 BC [20], and it can be considered the cutaneous counterpart of the FAMM flap. It can be either superiorly based on the angular artery, and used to reconstruct nasal defects, or inferiorly based on the facial artery, and used for lip defects [20]. The maximal obtainable size has been described as 5x5 cm [20]. It should be harvested

with the underlying facial mimetic musculature in order to capture the axial vessels, although it may be harvested in the subcutaneous plane as a random pattern flap [20]. The donor site is closed primarily. The main disadvantage is a less inconspicuous scar in patients without a deep nasolabial crease. Two-stage surgery is generally required.

Scalping

The anterior scalping flap was described in the 1930s by Converse, and the posterior scalping flap was described by Arena in 1977 [12]. The anterior scalping flap is composed of up to half the forehead skin, and includes skin and subcutaneous tissue over the frontalis muscle, and incorporates galea above the frontalis, in order to protect the innervation and function of that muscle [12]. It is supplied by the supratrocheal, supraorbital, and superficial temporal arteries opposite the side where skin is harvested, leaving a very widely based pedicle [12]. The anterior scalping flap is used for coverage of large nasal and cheek cutaneous defects. It is a good alternative to a PMFF in patients with a narrow forehead or a low hairline, and it can produce a significantly longer flap that the PMFF allowing the flap to be folded on itself [12]. Disadvantages of the anterior scalping flap include an aesthetically unfavorable donor site defect that requires skin grafting, modification of the hairline, and the requirement of a two-stage procedure for pedicle division [12].

The posterior scalping flap has thinner skin, and is based on the superficial temporal, supratrochlear, and supraorbital arteries [12]. Occipital and postauricular arteries are typically transected during the flap harvest. The neck skin overlying the trapezius, splenius capitis, and levator scapulae is elevated, and the flap incorporates the galea over the skull [12]. A delay procedure may help obtain additional length inferiorly [12]. It is mainly used in resurfacing cutaneous nose, cheek, and orbital defects [12]. Disadvantages of the posterior scalping flap include color mismatch due to hyperpigmentation of the neck in patients who spent considerable time in the sun, modification of the posterior hairline, transferring hair-bearing skin that must eventually be addressed, and a significant donor site deformity that must be skin-grafted [12].

Submental island

The submental island flap was described in 1992 by Martin in France and is based on the submental artery branching off the facial artery [21]. It can be used for facial and intraoral defects. The flap includes the platysma and the ipsilateral digastric muscle [21]. A “pinch test” is performed to determine the maximal width obtainable in order to close the donor site primarily [21]. It has the advantages of primary donor site closure, color match, and ease of harvest [21]. Disadvantages is that the flap must be used with caution in the presence of metastatic disease in the neck, and in younger patients where flap size will be limited due to lesser skin laxity [21].

Supraclavicular artery island flap (SCAIF)

The SCAIF was described in 1997 by Pallua [3]. It is a fasciocutaneous flap based off of the

supraclavicular artery, which is a branch of the transverse cervical artery [3]. It is mainly used to defects of the lower face or neck, or for pharyngoesophageal reconstruction [7]. It can reach dimensions of up to 10x22 cm classically with primary closure of the donor site [7]. The main advantages are the color match and ease of harvest, and disadvantages are mainly the thinness of this flap, and its limited use when the transverse cervical artery is not available [3].

Deltopectoral

The deltopectoral flap was popularized by Bakamjian, a Canadian surgeon, in the 1960s [12]. It is composed of the fascia and skin overlying the pectoralis and deltoid muscles, and is based off of perforators of the internal mammary artery from the 2nd and 3rd intercostal spaces, with a 2cm parasternal zone that must remain untouched to avoid disrupting blood supply [12]. The initial indication was pharyngoesophageal reconstruction, although it is also used for cutaneous defects up to the mentum and cheek [12]. Advantages include ease of harvest and color match. The major disadvantages are a two-stage procedure, a skin graft to close the donor site, and the unreliability of the distal portion of the flap when extended over the deltoid [12]. A modification has been described to circumvent the two-stage procedure by using the flap as an island [12].

Musculocutaneous or Muscular Flaps

Temporalis

Initially described as a muscle flap to obliterate orbital defects in 1898, the temporalis muscle flap is now mainly used for facial paralysis rehabilitation [12]. It is composed of temporalis muscle, either partially or in its entirety, and blood supply originates from the deep temporal artery, branching off of the internal maxillary artery [12]. Two general techniques for facial paralysis reanimation have been described using the temporalis muscle. The Gillies approach flips the temporalis over the zygomatic arch, and transfers the muscle from the temporalis fossa into the insertion of the oral commissure [12]. This approach produces significant donor site deformity, and for this reason, an orthodromic technique has been described where the muscle is advanced in the temporalis fossa, the insertion on the coronoid process is detached and reattached onto the oral commissure using a nasolabial incision [22]. This technique produces excellent outcomes in terms of midfacial rehabilitation for facial paralysis. The donor site is closed primarily. The advantages of temporalis flap over a microvascular free tissue transfer for facial paralysis rehabilitation are the avoidance of a two-stage procedure as seen in a cross-facial nerve grafting with delayed free flap reconstruction, and technically much easier with faster recovery. A minor disadvantage is a nasolabial incision that might be more obvious in patients with less pronounced nasolabial folds.

Platysma

Two possibilities for head and neck reconstruction with a platysma flap exist: the superiorly based flap and the posteriorly based flap [23]. The blood supply originates from the submental

artery superiorly, and from the occipital artery posteriorly [23]. The platysma also receives contributions inferiorly from the transverse cervical artery without application for head and neck reconstruction [23]. The external jugular vein must be preserved for venous drainage [23]. The skin paddle must overly the muscle fibers, and must be oriented perpendicularly to muscle fibers [23]. The skin that is not to be used a skin paddle must first be elevated off of the platysma. For the posteriorly based flap, the superior, inferior, and anterior attachments are transsected, leaving the platysma and overlying skin paddle pedicled on the blood supply coursing through the investing fascia above the sternocleidomastoid muscle [23]. For the superiorly based flap, the muscle is transsected anteriorly, posteriorly, and inferiorly [23]. Defects of up to 75 cm^2 can be reconstructed with this flap, although a skin slough rate of up to 60% can occur [23]. The main indication is cutaneous or mucosal defects of the lower one third of the face [23]. Advantages are color match and ease of harvest [23]. Disadvantage is high skin slough rates.

Trapezius

First described in 1972 as a regional flap by Conley, the trapezius flap has evolved into three separate flaps based on different vascular origins: the superior island, the lateral island, and the lower island [12]. The superior island flap is used for posterolateral neck defects that extend no more medial than the midline, and is based on paraspinous perforators along with a contribution from the occipital artery [12]. A skin graft is often required for closure of the donor site [12]. The lateral island flap is based on the transverse cervical artery, and is the least reliable of the three [12]. It is used for external defects of the lateral and anterior neck. Primary closure of the donor site is possible The disadvantage is that the vascular pedicle is often transected following neck dissection, and this flap is not usable [12]. The inferior island flap is used for posterior neck and scalp defects and is supplied by the transverse cervical and dorsal scapular artery [12]. Primary closure of the donor site is achievable. The main disadvantage of this flap is that harvest requires lateral or prone positioning of the patient, and the obvious potential for shoulder morbidity [3]. This flap is therefore seldom used, unless in salvage cases with significant patient comorbidity that preclude the use of microvascular tissue transfer.

Sternocleidomastoid (SCM)

First reported as a flap in 1908, the SCM has been extensively studied since then [12]. Three options are available: a superiorly based island flap, an inferiorly based island flap, and a muscle-only flap [12]. The musculocutaneous flaps are used for mucosal and cutaneous defects in the head and neck, and the muscle-only flap is used for contour restoration following parotidectomy and mandibulectomy [12]. Absence of SCM results in minimal morbidity for the patient. The superiorly based flap is based on the occipital artery, and the inferiorly based flap is based on perforators from the transverse cervical artery [12]. Contributions also exist from the superior thyroid artery and the posterior aurical artery, and the superior thyroid artery may be particularly important in increasing skin viability [12]. The platysma must also be captured for the skin to be viable.

The donor site is usually closed primarily. Disadvantages include donor site contour deformity, inability to use it in the presence of nodal disease, limited size of the musculocutaneous flap, and the unreliability of the skin paddle [12].

Pectoralis major

Arguably the most commonly used regional flap in head and neck reconstruction following oncological defects, the pectoralis major flap has been popularized by Ariyan in the 1970s [12]. One of the major applications is to provide vessel coverage in previously irradiated patients. The major pedicle is the pectoral branch of the thoracoacromial artery, with minor contributiosn from the lateral thoracic, the parasternal perforators off of the internal mammary artery, and the superior thoracic artery [12]. The flap may be muscular or musculocutaneous, and is used for an extremely wide variety of defects in the head and neck as high as the zygomatic arch. Its use has been relegated to salvage surgery with the advent of microvascular free tissue transfer in the 1980s. However, it is an extremely reliable, versatile, and easy to harvest flap, and causes minimal donor site morbidity [12]. The major advantages are rich vascularity, large skin territory, ability to close skin primarily, good arc of rotation, good bulk, and ease of harvest [12]. Bulk could be listed as a disadvantage when thinner tissue is required for reconstruction. Total potential skin territory is over 400 cm^2 [12].

Latissimus dorsi

The pedicled latissimius dorsi flap for head and neck reconstruction was first described in 1978 by Quillen [12]. The flap is based on the thoracodorsal artery, and may be used as a muscular or musculocutaneous flap [12]. One can reach virtually any site of the head and neck by tunneling the flap through the axilla between the pectoralis major and minor muscles [12]. One can also release the lateral attachment of the pectoralis major muscle after the thoracoacromial artery has been identified to minimize the risk of thoracodorsal artery/vein compression while still preserving the pectoralis muscle flap for possible future use. A very large area of skin is available for harvest, and is usually closed primarily [12]. The muscle is usually very thin, and denervation atrophy produces an even thinner muscle. The major disadvantage is the harvest position where the patient must be turned laterally, as well as the difficulty in tunneling the muscle into the neck, and donor site morbidity from loss of latissimus dorsi function.

Bone Containing Regional Flaps

With the availability of osteocutaneous free flaps for major head and neck reconstruction, pedicled osteocutaneous flaps are rarely used for major oromandibular or palatomaxillary reconstruction. They are sometimes reported for contour reconstruction of sites such as orbital rim. Although a detailed overview of all possibilities is beyond the scope of this chapter, we listed osteocutaneous regional flaps that are possible for minor head and neck:

- Temporoparietal osteofascial flap [24]
- Osteopericranial flap [25]
- Occipitoparietal osteocutaneous [26]

- Submental island osteomyocutaneous [27]
- Supraclavicular osteocutaneous flap [28]
- Deltopectoral acromion flap [12]
- Temporalis-calvarial flap [12]
- Trapezius osteomyocutaneous [12]
- SCM osteomyocutaneous [12]
- Pectoralis major and sternum [12]
- Pectoralis major and rib [12]
- Latissimus dorsi and rib [12]

Table 1

Flap	Composition	Bone?	Artery	Advantages	Disadvantages
Nasoseptal	Mucoperichondrium	No	Posterior septal	Ease of harvest Long pedicle Custmoziable	Hyposmia Nasal obstruction Septal perforation
Palatal island	Mucoperiosteum	No	Greater palatine	Ease of harvest Multiple layers No contracture of donor site	Limited arc of rotation
FAMM flap	Musculomucosal	No	Facial or angular	Ease of harvest Reconstruct mucosal defects with mucosa	Two stages Vulnerable pedicle
Buccinator	Musculomucosal	No	Buccal	Ease of harvest	Limited flap size Vulnerable pedicle
TPFF	Fascia	Yes	Parietal branch of superficial temporal	Ease of harvest Reliability	Alopecia
Pericranial	Pericranium	Yes	Supraorbital, supratrochlear	Ease of harvest Minimal donor site morbidity	External scar
PMFF	Skin, subcutaneous tissue, frontalis	No	Supraorbital, supratrochlear	Ease of harvest	Two stages External scar
Nasolabial	Skin, subcutaneous tissue, muscle	No	Angular	Ease of harvest Primary closure	Two stages External scar
Scalping flap	Skin, subcutaneous tissue, galea	Yes	Superficial temporal, supratrochlear, supraorbital	Ease of harvest	Two stages Requires skin graft Hairline modification
Submental island	Skin, subcutaneous tissue, platysma	Yes	Submental	Ease of harvest Color match Primary closure	Limited use in neck dissection Limited size in younger patients

SCAIF	Skin, subcutaneous tissue, fascia	Yes	Supraclavicular artery	Ease of harvest Color match Primary closure	Limited use in neck dissection Thinness
Deltopectoral	Skin ,subcutaneous tissue, fascia	Yes	Internal mammary perforators	Ease of harvest Color match	Two stages Can require skin graft Unreliable distal tip
Temporalis	Muscle	Yes	Deep temporal	Ease of harvest Avoidance of a two stage free flap	External scar
Platysma	Muscle +- skin	No	Submental artery, occipital artery	Ease of harvest Color match	High skin slough rates
Trapezius	Muscle +- skin	Yes	Paraspinal perforators, transverse cervical, dorsal scapular	Ease of harvest Color match	Requires patient repositioning Two stage Can require skin graft Shoulder morbidity
SCM	Muscle +- skin	Yes	Occipital, superior thyroid, transverse cervical	Ease of harvest Color match	Contour deformity Limited use with neck dissection Limited size skin paddle Unreliable skin paddle
Pectoralis major	Muscle +- skin	Yes	Thoracoacromial	Ease of harvest Reliable Versatile	Bulky Limited reach above zygoma
Latissimus dorsi	Muscle +- skin	Yes	Thoracodorsal	Ease of harvest Reliable Versatile Can reach above zygoma up to vertex	Requires patient repositioning Can be bulky Difficulty in tunneling flap through axilla

CONCLUSION

There is an emergence of several regional options in head and neck reconstruction in the past several years. Virtually any mucosal or cutaneous defect in the head and neck can be potentially reconstructed using a regional option, depending on the thickness desired by the surgeon. The only drawbacks are oromandibular and palatomaxillary bony defects or massive intraoral mucosal defects that are preferentially reconstructed using osseous or osteocutaneous free flaps.

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