Free Flap Reconstruction of the Maxilla

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Abstract

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Tumors of the maxilla and midface are some of the most difficult to manage, not only in terms of treatment but also in terms of achieving acceptable orofacial reconstruction. Today, free flaps dominate the reconstructive field. Many patients can achieve successful reconstruction after free flap transfer with a return of intelligible speech, a regular diet, and acceptable cosmesis. Herein, the authors review free flap reconstruction of the maxilla, with a focus on the classifications of defects, when obturators are appropriate, types and sources of free flaps, and complications for which to beware.

Tumors of the maxilla and midface are some of the most difficult to manage, not only in terms of treatment but also in terms of achieving acceptable orofacial reconstruction.¹ Historically, maxillofacial prosthodontics have dominated the reconstruction of midface and maxillary defects, but trends have shifted over the past couple of decades toward reconstruction with autologous free tissue transfer.¹ Today, free flaps dominate the reconstructive field, and many reconstructions using free flaps have been successful with return of function, quality of life, and cosmetic satisfaction. Herein, we review free flap reconstruction of the maxilla, with a focus on the classifications of defects, when obturators are appropriate, types and sources of free flaps, and complications for which to beware.

Types of Defects

Classifications

At least 15 individual classification systems have been proposed in the past 50 years to describe missing components of the midface, and there remains no consensus on which system is best and should be routinely used.² Classification schemes have evolved to mirror reconstructive methods; while initially reconstructive methods were primarily prosthetic based, now methods based on bony free tissue transfer

predominate.² A recent systematic review of maxillectomy classification schemes proposed that there are six criteria an ideal classification system would employ to satisfy both surgical and prosthodontist needs.³ An ideal classification scheme would describe: (1) dental status; (2) oroantral/nasal communication status; (3) soft palate and other contiguous structure involvement; (4) superior-inferior extent; (5) anterior-posterior extent; and (6) medial-lateral extent.³ No classification scheme currently exists, however, that, based on the needed proposed criteria, sufficiently describes maxillectomy defects.³

Some terms are frequently used to describe maxillectomy defects, and it is worth clarifying their specific meanings. A *limited maxillectomy* includes the removal of one wall of the antrum; a *subtotal maxillectomy* refers to the removal of at least two walls including the palate and excluding the orbital floor; and a *total maxillectomy* includes the complete removal of the maxilla, usually including orbital exenteration.⁴

Brown and Shaw proposed a classification scheme that is commonly used today. In their scheme, defects are described based on their vertical extent, horizontal extent, and whether they involve the orbit or nasal passageway.¹ First, based on their vertical extent, defects are given a numeral I–VI. Class I defects describe a limited maxillectomy not causing an oronasal fistula. Class II describes a larger maxillectomy with an

oronasal fistula but not involving the orbit. Class III extends farther to involve the orbital adnexae but with orbital retention. Class IV necessitates orbital enucleation or exenteration. Class V is an orbitomaxillary defect without extension through the palate to the oral cavity, and class VI is a nasomaxillary defect, not involving the orbit or oral cavity.¹ Second, the horizontal extent of the defect is assigned a letter, A–D. Type A defects include the palate only, without extension to the dental alveolus. Type B defects are unilateral, less than or equal to half the palate and involving the alveolus. Type C defects are bilateral and anterior, and type D defects include removal of more than half the palate.¹

This classification scheme satisfies a majority of the proposed ideal criteria for a successful classification scheme. Its vertical component presents defects of increasing complexity and requiring more extensive reconstruction the higher the assigned numeral, and its horizontal component describes palatal defects requiring increasingly complex rehabilitation. Class I defects, for example, can typically be reconstructed with a fasciocutaneous free flap such as from the radial forearm. Class II defects can have good results with an obturator or reconstruction with a combination of osteocutaneous free flap and pedicled temporalis or temporoparietal fascia flap to close the oronasal fistula. Class III and IV defects are so extensive that no single prosthetic or free flap is sufficient for rehabilitation. Rather, a combination should be employed. The authors suggest that an iliac crest free flap or scapular free flap both provide adequate bone and soft tissue for reconstruction of the palate, maxilla, and orbital rim, though a fibula with multiple osteotomies has also been used. Further, latissimus dorsi has been used to obliterate the orbitomaxillary cavity. Class V defects require free flap coverage of the cavity with subsequent prosthetic rehabilitation, and class VI defects may not require any reconstruction. If the nasal bones are involved, however, the authors suggest using an osteocutaneous radial forearm flap.¹

Another commonly used classification system is that by Cordeiro and Santamaria.^{5,6} In their system, defects are classified as types I–IV based on their extent, with subtypes a and b further delineating the horizontal palatal extent of defects. Type I defects include partial maxillectomy defects, often with resection of the anterior or medial maxillary wall, but in which the palate and orbital floor are left intact. Type II defects, or subtotal maxillectomy defects, include resection of the palate but leave the orbital floor intact. Type IIa specify resection of less than half the transverse palate, while in type IIb defects more than half the transverse palate is missing. Type III defects describe a total maxillectomy. Type IIIa includes defects of both the palate and orbital floor but retention of orbital contents, while type IIIb includes palatal defects and orbital exenteration. Finally, type IV defects are orbitomaxillectomies in which the palate is intact but orbital exenteration has occurred.

Reconstruction

There are many options available to reconstructive surgeons. Many local and pedicled flaps have been described for midface

and maxillary reconstruction; the deltopectoral flap and pectoralis major myocutaneous flaps, for example, have been successfully transferred to the oral cavity, midface, and maxillary cavities.^{7,8} Further, pedicled flaps can be relatively easily harvested. Pedicled flaps, however, are limited by their source vessels, carry the risk of tip necrosis, and do not always provide appropriate tissue types or bulks needed for optimal reconstruction. Thus, autologous free tissue transfer with both classic free flaps and, more recently, perforator free flaps has become a mainstay of midface and maxillary reconstruction.⁹ Not all defects require tissue reconstruction, however, and surgeons should not overlook the advantages of prostheses and obturators in functional rehabilitation.

Prosthesis

Historically, maxillectomy defects were reconstructed with a skin graft to restore a mucosal barrier followed by use of an obturator.¹⁰ Today, some defects are still amenable and, arguably, best treated with an obturator, while others are better reconstructed with a free flap. Limited maxillectomy defects that include a palatal defect but do not include the orbital floor, cranial base, cheek, or mandible are very amenable to obturator rehabilitation (►Fig. 1).¹⁰ An example of an anterior palatal squamous cell carcinoma leading to an anterior lip and palate defect after resection with obturator reconstruction is shown in ►Fig. 1. Although some orbitomaxillary defects can have good initial outcomes with obturator rehabilitation, they can later develop persistent crusting and pain with the need for obturator revisions, which can be cumbersome.¹¹

Obturators have many benefits. First, they can be a cheaper reconstructive option with acceptable functional outcomes that obviate the need for more extensive surgical reconstruction. An obturator may also be a beneficial option for patients who are poor surgical candidates. Next, in theory, obturators can allow for easier clinical monitoring for cancer recurrence, as the obturator can be removed and surgical margins directly viewed. No clinical evidence has ever demonstrated earlier identification of recurrence in patients with obturators as compared to patients reconstructed with free flaps, however.¹¹ If using an obturator, depending on the size and location of the defect, surgeons should consider: (1) removing the inferior turbinate to allow more space to accommodate the prosthesis, (2) performing a coronoidectomy to prevent the obturator from getting dislodged during mandibular function, or (3) skin grafting inside the defect to create a scar band to aid in retention.

Obturators have drawbacks. First, they are subject to wear and tear over time, require daily maintenance, and may require frequent visits for adjustments. Also, a level of manual dexterity is required to insert, remove, and clean an obturator, and this can be challenging for older patients with failing dexterity.¹¹ Next, studies have shown that patients with defects involving more than a third of the soft palate or more than a fourth of the hard palate have poorer outcomes with obturators than those with smaller defects.¹² Further, while some smaller defects may be amenable to skin grafting with an obturator, an important

Fig. 1 Patient with a squamous cell carcinoma of the anterior palate and upper lip who underwent composite resection and obturator reconstruction. (A) Squamous cell carcinoma in vivo. (B) Composite resection of malignancy. (C) Anterior maxillary and upper lip defects after carcinoma excision. (D–F) Palatal obturator to reconstruct the anterior maxillary defect. (G) Obturator in place; the upper lip defect was reconstructed with a skin graft. (H) Immediate external appearance after reconstruction.

consideration is whether the patient will undergo post-operative radiotherapy (RT). Vascularized flaps from free tissue transfer are more robust in the face of RT and less prone to wound breakdown.¹¹ Thus, obturators are more suited to patients with smaller defects, defects that do not

involve the orbit or facial skin, patients with good dexterity, without visual impairment, without trismus, and who do not require postoperative RT.¹² If a patient does not meet these criteria, then he or she may be better suited to free flap reconstruction.

Free Flap Sources

Many free flaps have been proposed and successfully applied to midface reconstruction. An important consideration for free flap reconstruction of the midface, different from reconstruction of other areas, is the location of recipient vessels; they are often not immediately located in the reconstructive bed, so flaps with a longer pedicle may be necessary.⁹ Fasciocutaneous free flaps allow soft tissue reconstruction of defects with varying amounts of tissue bulk. The radial forearm fasciocutaneous free flap (RFFF) is a workhorse of many head and neck reconstructions; it can be relatively easily harvested, has a reliable and long pedicle, can be harvested synchronously with head and neck ablation, and often provides good skin color match for head and neck reconstruction. It carries donor site morbidity, however, with the risk of tendon exposure, and the harvest site requires a split-thickness skin graft for closure.⁹ The free latissimus dorsi myocutaneous flap provides greater tissue bulk than the RFFF and allows for primary closure of the donor site. Often, however, it requires intraoperative patient repositioning, which can be cumbersome, prevent synchronous harvest, and prolong operative times. The rectus abdominis myocutaneous free flap is another option for soft tissue reconstruction, allowing appropriate tissue bulk with a pliable flap. However, it carries the risk of abdominal weakness and hernia formation.⁹ Both fasciocutaneous flaps and myocutaneous flap can be extremely advantageous in some circumstances, but they do not allow for bony reconstruction and subsequent dental implant placement.

Osteocutaneous free flaps can restore soft tissue components in addition to missing bone of the palate, orbital rim, or the maxillofacial buttresses. Sources of free osteocutaneous tissue include the fibular free flap, thoracodorsal artery composite flap with scapular tip, traditional scapular flap (off the circumflex scapular artery), radial forearm osteocutaneous flap, and iliac crest free flap, also known as the deep circumflex iliac artery flap.^{11,13} An example of deep circumflex iliac artery osteocutaneous flap for left maxillectomy reconstruction is shown in ►Fig. 2. The fibular flap also provides excellent bony stock but often requires multiple osteotomies to fit the contour of the maxilla. It has become a staple of mandible reconstruction, but its use for the maxilla is more limited.¹⁴

The fibular flap can be harvested with a skin paddle, but that skin paddle is less mobile than those harvested with other flaps. The radial forearm osteocutaneous flap is useful for smaller reconstructions, but the bony component of the flap is not sufficient for total maxillectomy defects, and occasionally it is not sufficient to allow later dental implantation. The thoracodorsal artery composite flap with scapular tip allows for harvest of a substantial amount of bone, multiple separate skin paddles, and a long pedicle of 14 cm to allow for complex maxillofacial reconstructions.¹³ In fact, the subscapular system of flaps allows for harvest of two skin paddles, two separate bone grafts, and one muscle paddle all on a single pedicle.¹⁴

Bony reconstruction of palatal defects can allow for dental implants to improve oral rehabilitation after surgery.

Implants should be delayed at least 6 months after initial reconstruction, however, to allow for complete bony healing and soft tissue contraction.¹⁵ Surgeons should consider soft tissue bulk of osteocutaneous flaps when they expect patients will undergo dental implantation, as bulky flaps may require additional procedures for debulking prior to implantation. Miles and Gilbert noted in their review of scapular tip reconstructions of maxillectomy defects that the skin paddle was thin enough that no patients in their cohort required debulking prior to dental implantation.¹³

Perforator free flaps allow surgeons to harvest large areas of skin and subcutaneous tissue, supplied by vessels perforating the underlying muscle, without harvesting denervated muscle. In so doing, surgeons can minimize postoperative pain, muscle weakness, and the risk of hernia formation after muscle harvest. Surgeons can also better predict flap bulk by not including denervated muscle in a flap that will significantly atrophy over time.⁹ The anterolateral thigh (ALT) flap, for example, can be harvested as a perforator flap for midface reconstruction. It provides significant tissue bulk and a long pedicle (10–15 cm), allows for primary closure of the donor site, and can be sensate.⁹ Further, when two separate perforators are harvested, then the ALT can provide two separate skin flaps allowing for intraoral and skin reconstruction. Other perforator flaps include the deep inferior epigastric perforator flap, the anteromedial thigh perforator flap, the gluteal artery perforator flap, the thoracodorsal artery perforator flap, peroneal artery perforator flap, submental perforator flap, and others.⁹ The iliac crest osteocutaneous flap commonly includes abdominal muscle, often making it too bulky for head and neck reconstruction, but its perforator equivalent, the deep circumflex iliac artery perforator flap, provides thinner, more pliable tissue that is better suited to head and neck reconstruction and, additionally, allows for bony harvest (►Fig. 1).⁹

Pedicle Considerations

The pedicle is an important preoperative consideration in maxillary free flap reconstruction. For total maxillectomy defects, the superficial temporal vessels can often be reliably reached.¹⁵ The superficial temporal artery can be more tenuous and smaller caliber than other arterial options in the neck, however. For other defects, anastomosis in the neck may be more ideal, but the flap will typically need a longer pedicle. For anterior defects, the pedicle can be tunneled subcutaneously beneath the skin. For posterior defects in which the pedicle is above the palate, it can be tunneled through the mylohyoid muscle, medial to the mandible but lateral to the pharynx.¹⁵ Transoral dissection of the facial vessels has also been described and can provide appropriate arterial and venous recipient vessels that are closer to the flap site.¹⁰

Patient-Specific Modeling

Over the past decade, significant advances have been made in preoperative planning and, specifically, the use of 3D modelling. For complex maxillary reconstructions, preoperative 3D planning can allow for more precise intraoperative bone cuts and improved orientation of the pedicle. Together, these

Fig. 2 Patient with a neoplasm of the left maxilla excised and reconstructed with a deep circumflex iliac artery osteocutaneous free flap. (A) Preoperative clinical appearance. (B) Preoperative neoplasm appearance on panorex. (C) Intraoperative Weber-Ferguson incision with exposure of mass and subsequent maxillectomy. (D) Excised neoplasm. (E) Outline of harvest site for deep circumflex iliac artery osteocutaneous free flap. The external obliques have been split to expose the internal obliques. (F) Harvested flap with muscle and bony components. (G) Flap inset to recreate the left palate, alveolar ridge, and face of the maxilla. (H) Appearance of the face after flap inset.

can improve overall intraoperative efficiency, shorten operative times, and, potentially, further minimize risks to patients.¹¹ These benefits should be weighed against the potential for increased costs and a delay to surgery to allow for prefabricated models to be created.

Reconstructive Algorithms

Cordeiro and Chen proposed that the goals of reconstruction of midface defects include closing the midface wound, obliterating the maxillary defect, supporting the orbit or filling in the orbital defect, maintaining a barrier between the nasal cavity and anterior cranial fossa, restoring facial shape, and restoring the palate.⁶ All walls of the maxilla do not necessarily require reconstruction to accomplish these proposed goals, however, and their classification schema of maxillectomy defects also guides their reconstruction.⁶ Type I defects can be reconstructed with a small fasciocutaneous flap, often the RFFF. Type IIa defects are amenable to either fasciocutaneous free flap reconstruction that restores bulk or skin grafting with an obturator. Type IIb defects mandate osteocutaneous free flap reconstruction, however, and type III and IV defects often require multiple flaps for optimal reconstruction.⁶

Subtotal Maxillectomy Defects

Skin islands from soft tissue flaps are sufficient for closure of palatal defects; however, only a very small skin paddle should be used. Large skin paddles can lead to sagging and bulging of the flap which makes denture fitting and swallow rehabilitation more difficult.¹⁵ Further, for large palatal defect, the skin island reconstructing the palate can be secured to the cranial vault to prevent collapse of the roof and allow subsequent obturator fitting.¹⁵ The osteocutaneous radial forearm flap is an ideal option for reconstruction of subtotal maxillectomy defects; it provides adequate bony material to support dental implants, but not too much bone to be unwieldy. It also provides a thin, pliable skin paddle ideal for palatal reconstruction.¹⁵ Of note, the radial bone should be secured to the palate with miniplates, as larger palates carry the risk of devascularizing the radial bone.

Total Maxillectomy Defects

Total maxillectomy defects and bilateral maxillectomy defects require osteocutaneous reconstruction not only for return of function but also for maintenance of facial aesthetics. A fibular free flap in a double-barrel technique can be used for reconstruction of a total maxillectomy defects, either unilateral or bilateral, and can reestablish maxillary height.¹⁶ It provides enough bone to allow dental implants, and the skin paddle can be used for palatal coverage to separate the oral and nasal cavities.¹⁶ It requires multiple osteotomies, however, and in a review of cases of bilateral maxillectomy reconstruction, Joseph et al reported a 30% rate of flap loss requiring revision surgery.¹⁶ Using the Cordeiro classification system, type IIa and III defects will have better outcomes if the molars can be preserved, as they are important to future alignment and fitting of dentures.¹⁵ If they cannot be preserved, then reconstruction with an osteocutaneous free flap with sufficient bone for dental implants is ideal.

Orbitomaxillectomy Defects

Defects involving the orbit and maxilla require reconstitution of the orbital floor to support the eye (or ocular prosthesis) and obliteration of the maxillary cavity. This can be accomplished with multiple methods. In some cases, split-thickness calvarial or other bone can be used to recreate the orbital floor, and a bulky fasciocutaneous free flap can fill in the maxillary space. Alternatively, an osteocutaneous free flap can accomplish both goals with one flap. When there exists a defect involving the palate, maxilla, and orbital floor, then a composite free flap, such as the scapular tip flap, can be harvested with multiple skin paddles, one to line the orbital floor and one to line the oral cavity.

Nasomaxillectomy Defects

Nasomaxillectomy defects require a bulky soft tissue flap to obliterate the maxillary cavity, with or without bone for the palatal defect, then skin to cover the intraoral defect and nasal lining. This can be accomplished with a composite free flap that includes multiple skin paddles, such as the scapular tip flap, or with a combination of free flaps and local or pedicled flaps. Failure to adequately recreate the lining of the oral and nasal cavities increases the chances of fistula formation.¹³

Postoperative Considerations

Flap Complications

Total flap loss is rare but devastating to patients. Flap failure rates are estimated to be around 2 to 5%, and most commonly are due to a thrombotic event of the flap vessels.¹⁷ Venous and arterial thromboses are most likely to occur in the first 72 hours after free tissue transfer, and salvage rates of compromised flaps are estimated at 70 to 80% when the compromise is recognized early, so flap management protocols often include intensive flap checks in the immediate postoperative period that are gradually relaxed over time.¹⁷ Conventional flap checks including physical and handheld Doppler examination of a free flap are typically sufficient, but are less useful in the case of a buried free flap as is often encountered in oromaxillary reconstruction. In a large review of more than 1,000 head and neck free flap transfers by Wax, the implantable Doppler reduced postoperative revision rates from 14 to 7%. In their report, sensitivity of the implanted Doppler was 87%.¹⁸

Cordeiro and Chen reviewed their experience with free flap reconstructions of maxillectomy defects in 100 patients.⁶ Using their classification system described above, they observed that major complications after surgery, such as flap compromise, systemic complications, and death, occurred more often in patients with type III and IV defects than those with type I and II. Minor complications, aesthetic outcomes, and functional outcomes did not significantly vary with the defect classification, however. Miles and Gilbert found that 46% of patients in their cohort suffered some sort of complication, though the majority were minor and easily managed.¹³ They also noted that 41% of patients underwent some sort of revision procedure.¹³

Functional Outcomes

Cordeiro and Chen reviewed their experience with 100 free flap reconstructions of maxillectomy defects and found that of 44 patients who underwent palate resections, postoperative speech achieved “normal” or “near-normal” ratings in 84% of patients.⁶ It was “intelligible” in 14% of patients, while 2% of patients retained unintelligible speech.⁶ A similar review of maxillary reconstructions by Futran found that all patients achieved intelligible speech over the phone.¹⁹ Additionally, all patients who underwent bilateral total maxillectomy reconstruction by Joseph et al had a return of intelligible speech.¹⁶

Similarly, in Cordeiro and Chen’s review of patients who underwent palatal resection, over half achieved a normal diet after surgery, and an additional 21% achieved a soft diet. Six percent of patients could only tolerate a liquid diet, and 2% remained tube dependent.⁶ A similar review of 57 midface free flap reconstructions by Costa et al found that 38% of patients achieved a soft diet, while 62% achieved an unrestricted diet.¹⁰ No patients in their review required a liquid diet or tube feeds. Of note, they preferred iliac crest reconstruction of bony palatal defects affecting more than 50% of the horizontal palate. A third review of palatal reconstruction by Futran and Haller found that 32% of patients at 6 months after surgery remained on a soft diet, while 68% had a regular, unrestricted diet.²⁰ Again, no patients at 6-month follow-up required a liquid diet or tube feeds.²⁰ Other reviews have also found that most, if not all, patients regain an oral diet after maxillary free flap reconstruction, with more than half achieving an unrestricted diet and most others achieving a soft diet.^{13,16,19}

In the Cordeiro and Chen’s study, outcomes after reconstruction of the orbital floor were generally good; 24% of patients had either vertical or horizontal persistent diplopia after surgery, and nearly half of patients had persistent ectropion, but no patients required further surgical interventions.⁶

Quality of Life Outcomes

The Patient Concerns Inventory (PCI) is a survey tool developed to help patients express their concerns; it has been successfully used in head and neck cancer patients, and it suggests that patients of lower socioeconomic status are more likely to: (1) develop oral cancer and (2) have more difficulty coping with the treatment.²¹ The University of Washington Quality of Life (UWQOL) questionnaire is another validated tool to help assess patients’ overall quality of life after head and neck cancer treatment.²¹ Also, the European Organization for Research and Treatment of Cancer (EORTC) Core QOL questionnaire is a validated questionnaire elucidating various facets of oral and pharyngeal function and quality of life after head and neck surgery.¹² These and other tools can potentially improve surgeon–patient communication by helping patients express their biggest concerns and helping surgeons learn what issues matter the most to their patients.

Not surprisingly, studies have reported that satisfactory functioning of the obturator prosthesis, when one is employed in reconstruction, significantly contributes to

improved psychological well-being and quality of life for maxillectomy patients.²² Patients whose reconstruction included an obturator have reported no significant differences in quality of life based on UWQOL and EORTC surveys.¹²

Aesthetic Outcomes

Cordeiro and Chen found that 94% of patients who underwent midface reconstruction achieved an aesthetic outcome rated as “excellent” or “good.”⁶ Not surprisingly, patients who had undergone skin, eyelid, or lip resections had poorer aesthetic outcomes.⁶ Similarly, Futran found that 76% of patients achieved an “excellent” or “good” aesthetic outcome, while 20% achieved a “fair” outcome, and 4% a “poor” outcome.¹⁹

Conclusion

The best treatment of patients with defects of the maxilla and midface is with a multidisciplinary team, including the surgeon, prosthodontist, and speech pathologist, from the start of patient care to help educate patients about all reconstructive options and likely outcomes. Obturators are sufficient for small, palatal defects, but larger maxillectomy defects are better reconstructed with autologous free tissue transfer. Many patients can achieve successful reconstruction with a return of intelligible speech, a regular diet, and acceptable cosmesis. Complications throughout the course of treatment are not uncommon, however, and patients should be educated about the likelihood of needing multiple procedures over time before a final result is achieved.

Conflict of Interest

None.

References

- 1 Brown JS, Shaw RJ. Reconstruction of the maxilla and midface: introducing a new classification. *Lancet Oncol* 2010;11(10):1001–1008
- 2 Alam D, Ali Y, Klem C, Coventry D. The evolution of complex microsurgical midface reconstruction: a classification scheme and reconstructive algorithm. *Facial Plast Surg Clin North Am* 2016;24(04):593–603
- 3 Bidra AS, Jacob RF, Taylor TD. Classification of maxillectomy defects: a systematic review and criteria necessary for a universal description. *J Prosthet Dent* 2012;107(04):261–270
- 4 Spiro RH, Strong EW, Shah JP. Maxillectomy and its classification. *Head Neck* 1997;19(04):309–314
- 5 Cordeiro PG, Santamaria E. A classification system and algorithm for reconstruction of maxillectomy and midfacial defects. *Plast Reconstr Surg* 2000;105(07):2331–2346, discussion 2347–2348
- 6 Cordeiro PG, Chen CM. A 15-year review of midface reconstruction after total and subtotal maxillectomy: part I. Algorithm and outcomes. *Plast Reconstr Surg* 2012;129(01):124–136
- 7 Ariyan S. The pectoralis major myocutaneous flap. A versatile flap for reconstruction in the head and neck. *Plast Reconstr Surg* 1979;63(01):73–81
- 8 Owens N. A compound neck pedicle designed for the repair of massive facial defects: formation, development and application. *Plast Reconstr Surg* (1946) 1955;15(05):369–389

- 9 Chana JS, Odili J. Perforator flaps in head and neck reconstruction. *Semin Plast Surg* 2010;24(03):237–254
- 10 Costa H, Zenha H, Sequeira H, et al. Microsurgical reconstruction of the maxilla: algorithm and concepts. *J Plast Reconstr Aesthet Surg* 2015;68(05):e89–e104
- 11 Yetzer J, Fernandes R. Reconstruction of orbitomaxillary defects. *J Oral Maxillofac Surg* 2013;71(02):398–409
- 12 Rogers SN, Lowe D, McNally D, Brown JS, Vaughan ED. Health-related quality of life after maxillectomy: a comparison between prosthetic obturation and free flap. *J Oral Maxillofac Surg* 2003;61(02):174–181
- 13 Miles BAM, Gilbert RW. Maxillary reconstruction with the scapular angle osteomyogenous free flap. *Arch Otolaryngol Head Neck Surg* 2011;137(11):1130–1135
- 14 Genden EM. Reconstruction of the mandible and the maxilla: the evolution of surgical technique. *Arch Facial Plast Surg* 2010;12(02):87–90
- 15 Cordeiro PG, Chen CM. A 15-year review of midface reconstruction after total and subtotal maxillectomy: part II. Technical modifications to maximize aesthetic and functional outcomes. *Plast Reconstr Surg* 2012;129(01):139–147
- 16 Joseph ST, Thankappan K, Buggaveeti R, Sharma M, Mathew J, Iyer S. Challenges in the reconstruction of bilateral maxillectomy defects. *J Oral Maxillofac Surg* 2015;73(02):349–356
- 17 Cannady SB, Lamarre E, Wax MK. Microvascular reconstruction: evidence-based procedures. *Facial Plast Surg Clin North Am* 2015;23(03):347–356
- 18 Wax MK. The role of the implantable Doppler probe in free flap surgery. *Laryngoscope* 2014;124(Suppl 1):S1–S12
- 19 Futran ND. Primary reconstruction of the maxilla following maxillectomy with or without sacrifice of the orbit. *J Oral Maxillofac Surg* 2005;63(12):1765–1769
- 20 Futran ND, Haller JR. Considerations for free-flap reconstruction of the hard palate. *Arch Otolaryngol Head Neck Surg* 1999;125(06):665–669
- 21 Allen S, Lowe D, Harris RV, Brown S, Rogers SN. Is social inequality related to different patient concerns in routine oral cancer follow-up clinics? *Eur Arch Otorhinolaryngol* 2017;274(01):451–459
- 22 Kornblith AB, Zlotolow IM, Gooen J, et al. Quality of life of maxillectomy patients using an obturator prosthesis. *Head Neck* 1996;18(04):323–334