Secondary Soft Tissue Reconstruction

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Abbreviations

ALT	Anterolateral thigh
CNS	Central nervous system
CT	Computerized tomography
LCFA	Lateral circumflex femoral artery
MRA	Magnetic resonance angiography

Soft Tissue Analysis

First step of reconstruction is always the assessment of the defect and its relationship to the face as an aesthetic unit. Face and neck can be generally divided into six anatomical entities: skin and soft tissue, intraoral, mandible, midface, cranial base, and scalp. Available reconstructive options include healing by primary closure, secondary intention, skin grafts, local flaps, pedicled flaps, and free tissue transfer. Selection of the reconstructive modality to use is made based on anatomical, physiological nature of the defects (size, location, function) and the patient's condition. For large and complex facial and neck defects, free tissue transfer has proven to be the best aesthetic and functional reconstructive option. Major factor that allows wide use of free tissue transfer in reconstruction is the advancement in microvascular surgery. In past decades, an ample amount of experience regarding each flap's potential in reconstruction has been accumulated, including flap size, pedicle length, and vessel diameter and associated donor morbidities.

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Small *cutaneous and soft tissue* defects can be repaired by primary closure and local tissue flaps. Local flaps such as nasolabial, paramedian forehead, and dorsonasal can be employed. Using local tissue flaps gives the advantage of maintaining similar skin color, texture, and thickness, and scars can be easily hidden in wrinkles and shadows. Skin grafts either partial or full thickness can also be used for larger wounds. Disadvantage of skin grafting includes discoloration, less than ideal contour, and graft contracture. Pedicled flaps such as the pectoralis major flaps, latissimus dorsi flaps, and trapezius flaps are more appropriately used in the neck region. Limited by the length of the pedicles, they should not be used in mid- and upper face defects, and instead, free tissue transfer can be utilized.

Intraoral area serves the function of conduit for food, airflow, and speech and contains important structures including, tongue, pharynx, larynx, and esophagus. Majority of small defects can be repaired primarily without causing anatomical constrictions that may affect speech and articulation. For partial glossectomy, the radial forearm free flap has emerged as the standard for most surgeons because it provides desired bulk and contour for reconstruction. However, in total glossectomy, the more bulky anterolateral thigh (ALT) flap and rectus abdominis are able to provide more volume to compensate for the lack of motor function by assisting the propulsion of food into the pharynx during swallowing. Radial and ALT flaps have emerged as the workhorses for intraoral, pharyngeal, and hypopharyngeal reconstruction. Their thin and pliable tissues can be easily contoured, making the radial and ALT flaps good candidates for reconstruction of tubular structures. Conversely, the jejunal free flap is the flap of choice for circumferential cervical esophageal reconstruction. Even though the jejunal flap is technically challenging due to its low tolerance to ischemia, its exceptional motility, low stricture, and fistula formation rates make it the best candidate for cervical esophageal reconstruction.

Mandible can be divided into symphysis, parasymphysis, body, angle, ascending ramus, and condyle. An understanding

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of the physiological demands of each segment of the mandible and adequate selection of reconstruction is key to ensure a long-lasting repair. Use of nonvascularized bone graft requires a well-vascularized recipient bed and a watertight mucosal coverage to prevent the erosion by saliva. Nonvascularized bone usage should be limited to small defects (less than 5 cm) and avoided in previously irradiated fields where vascularized bone graft should be used instead. Fibular free flap has become the dominant candidate in reconstruction of tissue losses with associated with mandibular defects. Fibular free flaps are long, thin, and durable which allow multiple osteotomies in order to form the ideal contour for mandibular reconstructions. Other donor sites for reconstruction include scapula osteocutaneous free flap, iliac crest, and radial forearm; however, all of them have inferior bony components compared to fibular free flaps and may not tolerate multiple osteotomies. Only concern before the use of a fibula flap is in patients with severe peripheral vascular disease, which may compromise both the donor site and the flap repair. Lastly, the anterior mandible is subjected to the highest amount of stress, and the use of metal plates for the reconstruction of this area is not recommended due to its high failure rate. Conversely, the lateral and posterior mandible are the less stressed areas, therefore, prosthetic plates are acceptable options for reconstruction.

Major components of the *midface* include the nose, orbits, maxilla, palate, and paranasal sinuses. Challenge of reconstructing the midfacial defects relates to its three-dimensional nature and its location at the center of the face. Important considerations during reconstruction also include the creation of a barrier between the CNS and aerodigestive tract as well as elimination of dead space. Vascularized bone flaps from iliac crest, scapula, and fibula have been used to establish the bony support required for adequate reconstruction in combination with osteo-integrated devices or prosthesis. Muscle flaps such as the rectus abdominis and radial forearm or anterolateral thigh can be used to fill the dead space after total maxillectomy and orbital exenteration.

Main concern with the repair of *cranial base* defects is to reestablish the barrier between CNS and the external environment. Temporoparietal fascial flaps or pericranial flaps in combination with calvarial bone grafts can be used for small-size defects. Rectus abdominis, radial forearm, and anterolateral thigh are all options for larger defects that cannot be reached by local flaps. Choices depend on the required flap volume to fulfill the dead space.

Local rotational or advancement flaps are the main modalities for closure of small- and moderate-size *scalp defects*. Tissue expanders and pedicled flaps such as the trapezius and latissimus dorsi flaps are options if larger defects are encountered. However, both options are less than ideal. Former requires multiple procedures and is at increased risk for infection. Latter is restricted by its pedicle length and ability to reach the defect without compromising the blood flow. Latissimus dorsi muscle free flaps combined with skin graft or parascapular fasciocutaneous free flap are both good options to cover large areas for scalp defects. Bony defects are generally reconstructed with autologous split-thickness calvarial grafts or titanium meshes and then adequately covered with soft tissue.

Surgical Techniques

Historically pedicled flaps were used for soft tissue reconstruction of head and neck defects. Commonly used flaps included pectoralis major musculocutaneous flap, lateral forehead flap, and deltopectoral flap. Tissue expanders are another option for reconstruction and were first described in 1957 by Neumann. This technique creates a local supply of skin and subcutaneous tissue, as saline is sequentially injected via a port. Tissue expanders are a functional technique that offers acceptable cosmetic results; however, very large defects (>100 cm^2) have a higher rate of failure.

Since the development of microsurgery and free tissue transfer, microsurgery free flaps are considered the standard of care for head and neck secondary soft tissue reconstruction. Free flaps offer significantly more tissue and volume that can be brought into the head and neck for reconstruction. The free flap technique has improved over time in terms of tissue selection, surgical technique, and outcomes. Excellent success rates (91–99 %) have been reported by numerous institutions solidifying the role of free flaps and microsurgery.

Surgical Principles

Similar surgical principles apply to a variety of free flaps that can be used to reconstruct soft tissue defects of the head and neck. After soft tissue analysis has been performed, at least one artery and vein are carefully mobilized for microsurgical anastomosis. Two major sources of recipient arteries of the head and neck are the branches of the external carotid artery and thyrocervical trunk. Four pairs of arteries are usually preferred: superficial temporal, facial, superior thyroid, and transverse cervical vessels. Choices of recipient vessels are based on the length and size of the pedicles and the proximity to the defect in order to ensure a tension-free anastomosis. Ipsilateral vessels should always be considered first, but are not necessarily a requirement. Use of flaps with long pedicles allows anastomosis to be performed on more distant vessels and contralateral vessels without compromising the blood flow. Previous dissection and irradiation impose challenges on surgeons; however, careful preoperative planning and careful dissection allows one to find good recipient vessels for tissue transferring. In order to preserve all available vessels for reconstruction, it is of utmost importance to have a clear plan during the primary surgery for tumor resection.

Keep in mind that reoperation and simultaneous double flaps may be needed to fully reconstruct the defect, and unnecessary sacrifice of vessels may lead to much difficulty during the reconstructive part of the surgery. Interpositional grafts and sequential linked flaps are usually considered as less than ideal options when access to recipient vessels are limited, because of their association with increased failure rates and flap necrosis. Same concepts can be applied when choosing recipient veins. Branches of internal jugular vein and smaller-sized external jugular veins are available options.

Next, the resection site is covered with moist gauze while the flap is prepared. After the flap is harvested, it is inserted with the deepest or the most difficult to reach location first. Tension-free repair is paramount, and the neck should be passively rotated through its range of motion bilaterally to avoid pedicle complications. Arterial anastomosis is generally performed prior to venous anastomosis, because it allows for evaluation of the venous system. A drain is placed in dependent areas to prevent fluid collections per a surgeon's discretion.

Free Flap Selection

There are numerous options for flaps used in head and neck reconstructions, and the selection depends on the soft tissue deficit analysis, individual anatomic considerations, and surgeon preference (see Table 25.1). In this chapter, we will discuss soft tissue, bone, and visceral free flaps.

Soft Tissue Flaps: Anterolateral Thigh Flap (ALT) and Radial Forearm

Two commonly used soft tissue flaps are the radial forearm and anterolateral thigh flap (ALT). Radial forearm flap is one of the most frequently used flaps, and its main advantage is its reliability. It generates a thin, malleable flap with a long pedicle (Fig. 25.1). Its use is limited by the small amount of soft tissue it produces and donor-site morbidity; however, these complications can be limited with a suprafascial technique. Liu et al. compared 53 radial forearms to 21 ALT flaps for head and neck reconstruction and found equivalent survival rates between the flaps. Although, radial forearm flaps had significantly more complications such as numbness and weakness and less patient satisfaction.

ALT flap provides an excellent volume of tissue, and it can be harvested in several variations including subcutaneous, fasciocutaneous, musculocutaneous, or adipofascial. The availability of skin, fascia, and muscle allows for excellent versatility based on the type and quantity of tissue required. ALT flap is generally supplied by the descending branch of the lateral circumflex femoral artery (LCFA) system. However, anatomic variations of the pedicle are seen with the absence of a lateral branch and a replacement with a medial or oblique branch. ALT have utility in a variety of head and neck reconstructions including oral cavity, laryngopharyngeal, skull base, and parotid defects. (See Fig. 25.2.)

Bone Flap

Fibula osteoseptocutaneous flap is ideal when vascularized bone is required, as in cases of mandibular reconstruction. (See Fig. 25.3.) It is a single flap with a bone and soft tissue component. The flap pedicle is supplied by the peroneal artery. The fibula functions well for contouring and can undergo multiple osteotomies. Another advantage is its large size and ability to support dental implantation. Double-barreling of the fibula can help restore mandibular height, especially in the anterior segment. If additional soft tissue is required, a double free flap technique combing the fibula osteoseptocutaneous with the ALT flap is useful. Most common morbidity is great toe flexion contracture or weakness, and less likely lower extremity compartment syndrome or ischemia can develop.

Table 25.1 Description of most commonly used free tissue flaps in the head and neck

Flap type	Characteristics[a]	Pedicle size	Common applications
Anterolateral thigh flap	Length: 5–30 cm Width: 4–22 cm Height: 0.2–1 cm	Length: 7–15 cm Diameter: 1.8–2.4 mm	Intraoral, pharyngeal, and hypopharyngeal reconstruction
Radial forearm flap	Length: 5–30 cm Width: 5–14 cm Height: 0.8–1.2 cm	Length: 15–20 cm Diameter: 2.0–3.0 mm	Intraoral, pharyngeal, and hypopharyngeal reconstruction
Fibula osteocutaneous flap	Length: 12–28 cm Width: 4–12 cm Height: 1–3 cm	Length: 5–12 cm Diameter: 1.2–2.2 mm	Mandibular reconstruction
Visceral (jejuna) flap	Length: 5–30 cm Lumen: 2.5–4.5 cm	Length: 4–7 cm Diameter: 1.0–2.5 mm	Pharyngoesophageal reconstruction

[a]Size of individual components (bone, muscle, skin) may vary depending on reconstructive requirement

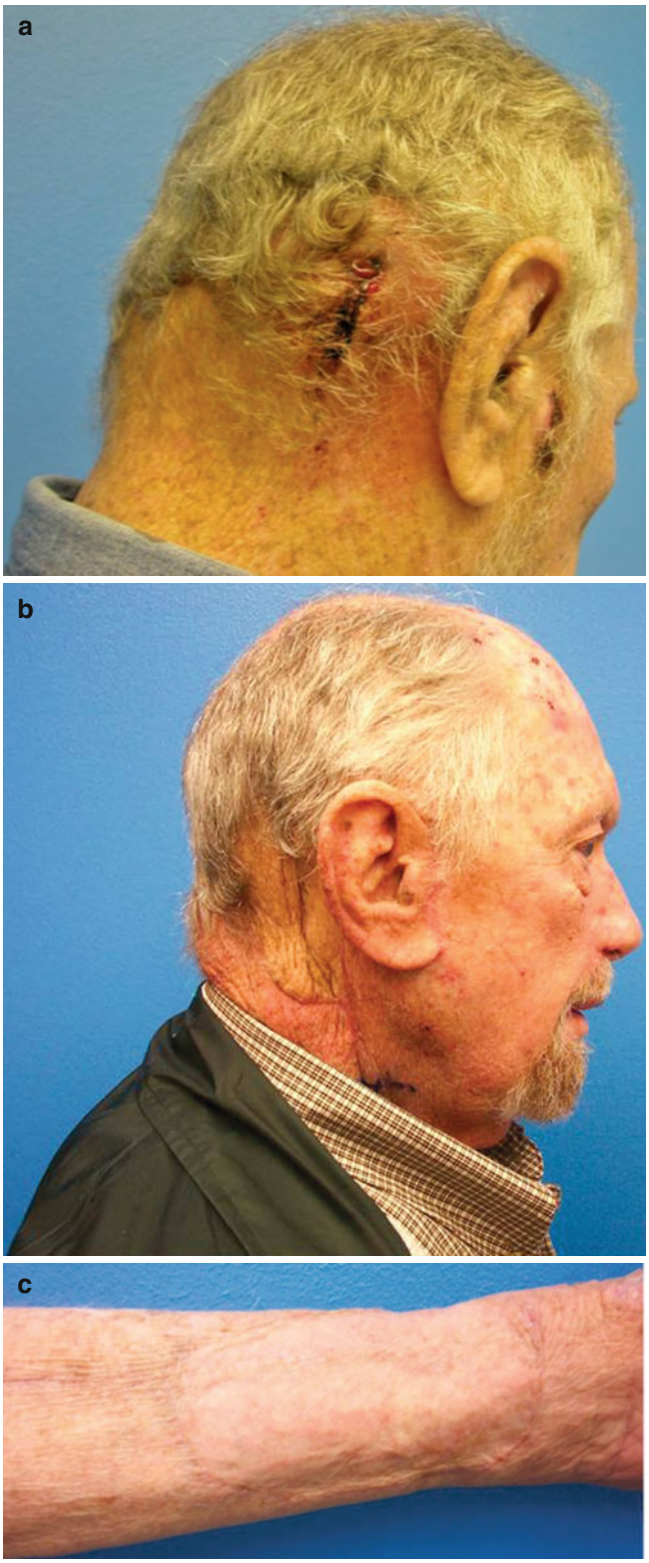

Fig. 25.1 A 58-year-old male with biopsy-proven squamous cell carcinoma of the right posterior scalp (**a**). Defect reconstructed using a radial forearm fasciocutaneous free flap with results for defect (**b**) and donor site (**c**) at 4 months post-op (Courtesy of Dr. Christopher J. Salgado)

Visceral (Jejunal) Flap

Jejunum free flaps can be used with complex pharyngoesophageal defects. This flap allows for the reconstruction of partial or circumferential defects of the cervical esophagus. It is technically demanding and susceptible to ischemic injury. The jejunum free flap provides good results with return of the swallowing function; however, significant complications are not uncommon. Ikeguchi et al. reviewed various institutions' operative experience and found the rate of anastomotic leakage ranged from 0 to 35 %, necrosis/loss of jejunal graft 0–10 %, and mortality 0–17 %.

Postoperative Care

Basic surgical principles should be followed in postoperative care, including pain and blood pressure control. It is also important to avoid compression of the flap by any medical tubing such as tracheostomy or oxygen tubes. The flap should be exposed and examined frequently. Hourly monitoring is performed immediately postoperatively; however, the duration of hourly monitoring depends on surgeon and institutional policy. Clinical examination is paramount; however, additional monitoring techniques such as Doppler can be employed. Complications and surgical re-exploration are seen in 5–25 % of cases, with a majority of cases ending with successful flap salvage. Venous thrombosis is the most common complication identified at re-exploration. Nonthrombotic vascular events are also common with causes including inappropriate flap inlay, external pedicle compression, and vasospasm. Adequate flap monitoring should include assessment of both tissue and vascular supply integrity. Flap tissue is assessed by its color (pink, not pale or cyanotic), temperature (warm, not cool), and by the tissue turgor (not flat or tense). Vascular anastomosis is evaluated by Doppler monitoring (pulsatile signals present) and capillary refill (normal $\leq$2 s). Lastly, infection should be treated with antibiotics and debridement of devitalized tissue as indicated.

Special Considerations

Large tissue defects in the head and neck may require the use of multiple techniques for adequate coverage. One important technique, although technically demanding, is the use of *double free flaps*. Use of the fibula osteoseptocutaneous flap in conjunction with ALT flap can be used for reconstruction of extensive oromandibular defects with concomitant extensive soft tissue/skin requirements. The ALT flap's primary

Fig. 25.2 A 10-year-old child with congenital absence of the mandible, both hands, and the right lower extremity below the knee presented after multiple failed mandibular reconstructive procedures. She underwent reconstruction of the mandible using a free fibula osteoseptocutaneous flap. It was found that the skin paddle of the fibula was insufficient to provide stable coverage of the lower facial skin, and the patient suffered from chronic skin breakdown with exposure of the reconstruction plate (**a**). A free anterolateral thigh flap was used to resurface the unstable area. The flap was 18 × 10 cm in size and raised on two musculocutaneous perforators from the thigh affected by the congenital failure of formation (**b**, **c**). The donor site was closed directly and the postoperative course was uneventful. Two years after the soft tissue reconstruction, the patient underwent distraction osteogenesis of the previous fibula bone flap. The ALT flap provided stable coverage of the reconstructed mandible throughout the distraction process (**d**) (Courtesy of Dr. Christopher J. Salgado)

advantage as a secondary flap is the obliteration of dead space, especially in patients expected to complete adjuvant radiotherapy, with minimal donor-site morbidity. Other commonly used flap combinations include the following: the fibula osteoseptocutaneous and radial forearm fasciocutaneous flap or fibula osteoseptocutaneous and rectus abdominis myocutaneous flap.

Depending on the type of reconstruction and the extent of the facial defect, most patients require some form of preoperative radiography. Adequate assessment of recipient vessels correlates with increased reconstructive success. Plain films of the face are historically important to evaluate for fractures and for those reasons more commonly used in

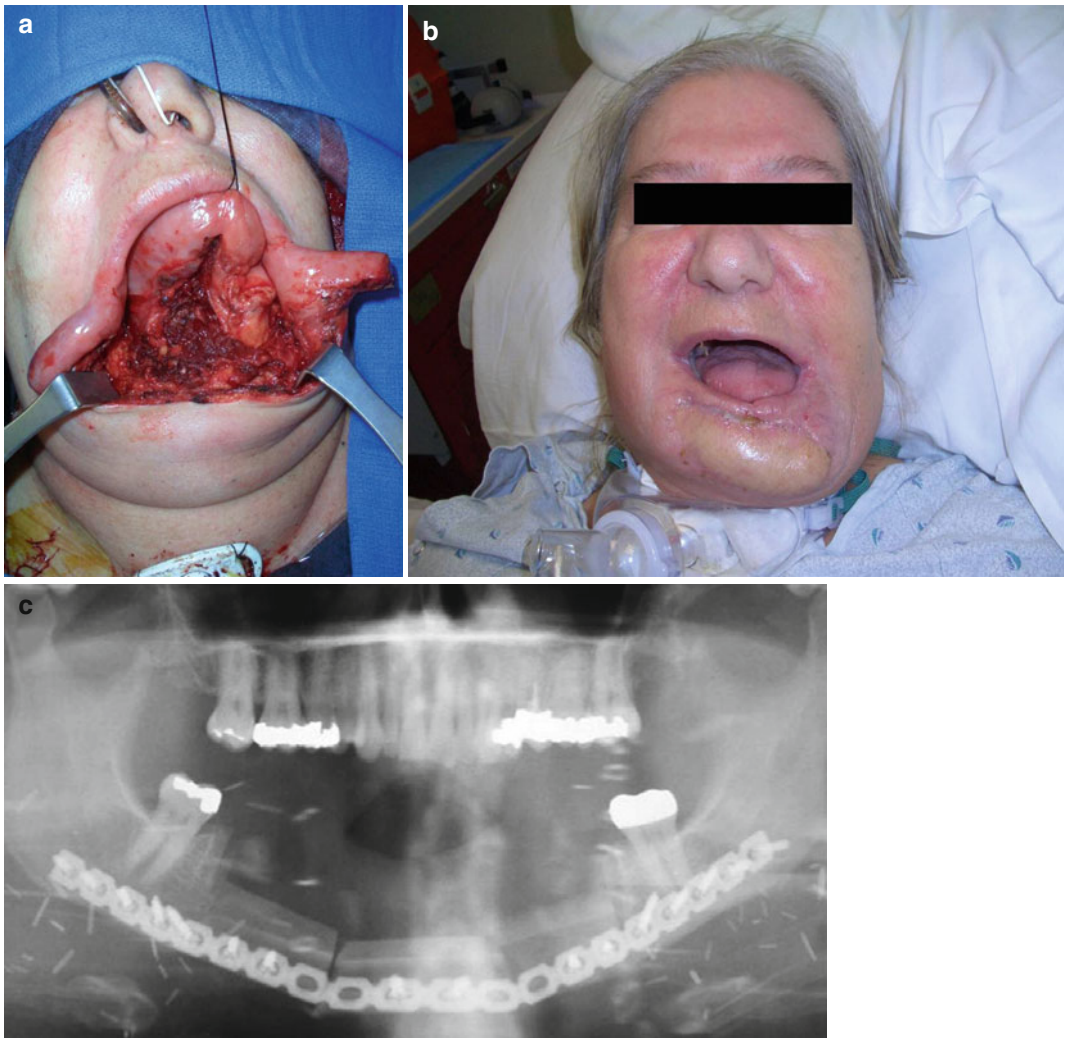

Fig. 25.3 Reconstruction of mandibular and soft tissue defect after resection of a mandibular ameloblastoma (**a**). Plain film demonstrates the bony segment of the fibula osteoseptocutaneous flap used for reconstruction (**b**). Follow-up at 3 months post-op with revision of lower lip (**c**) (Courtesy of Dr. Christopher J. Salgado)

trauma victims. CT angiography allows for visualization and *selection of target vessels* and 3-D reconstruction of adjacent anatomical structures. Other preoperative imaging options include the following: magnetic resonance angiography (MRA), high-resolution ultrasonography, and less commonly used conventional angiography.

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