Chapter 9
Conventional Reconstructive Approaches Following Resection of Head and Neck Cancer

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General Principles of Reconstructive Surgery

In general, reconstruction of the head and neck is challenging. Primarily because the head and neck anatomy is compact and highly functional. Therefore, similar to the hand, you can imagine that disturbing even a relatively small area of anatomy can have a large impact on function and overall form. Reconstructing the head and neck begins with defining the tissue defect. The size, composition of the tissue loss, and complexity of the defect are variable. On the most severe side of the spectrum, oncologic defects can be large, have complex topology, and involve loss of all tissue components, including skin, adipose, muscle, bone, vessels, and nerve. On the other side of the spectrum, defects can involve isolated skin loss and may just require primary closure of the wound. Given the complex and variable nature of reconstruction in general, the approach has been simplified into principles. Therefore, this chapter reviews the principles of reconstructive surgery, how they are applied, and provides a brief review of the many reconstructive options for the head and neck.

The goals of reconstruction at any anatomic site are restoration or maintenance of form, structural integrity, and function [1, 2]. In practice, this means maintaining a cosmetically normal appearance and preserving the many functions of the head and neck, such as facial animation, intelligible speech, mastication, nasal/oral breathing, vision, and protection of the intracranial contents. These goals are intended to maximize the patient's quality of life and minimize the impact of the disease process and medical interventions on morbidity and mortality.

The reconstructive ladder is a principle that prioritizes the simplest reconstructive option first, then moves up the ladder of increasingly complex interventions.

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R. El Assal et al. (eds.), *Early Detection and Treatment of Head & Neck Cancers*, https://doi.org/10.1007/978-3-030-69859-1_9

The reconstructive ladder includes (i) healing by secondary intention, (ii) primary closure, (iii) negative pressure wound therapy, (iv) grafts, (v) local and regional flaps, (vi) tissue expansion, and (vii) free tissue transfer, also referred to as free flaps. This concept is valuable in conceptualizing the options for reconstruction in rank of complexity and risk; however, in practice it is less often employed. Rather, the priority is to choose the surgical option that best addresses the goals of reconstruction as outlined above, even if a more simple option is possible [2].

Special Considerations in Head and Neck Cancer Reconstruction

Reconstruction after head and neck cancer resection comes with some special considerations, relating to both the anatomy and the cancer. In the head and neck specifically, larger margins often significantly affect nearby vital structures. This means that small resections can have a large impact on form and function. Even more so, defects are frequently large, involve multiple tissue types (e.g., bone, vessels, soft tissue, and skin), and have been exposed to radiation as a component of treatment of the primary cancer. Therefore, it is not uncommon to have a large complex radiated wound with loss of both soft tissue and bone.

Radiation therapy commonly precedes resection of head and neck tumors. Radiation exposure increases vessel wall fibrosis and decreases vascular smooth muscle density, practically, this impairs postoperative wound healing and leads to increased risk for wound infections, head and neck fistula formation, postoperative hematomas, and overall all postoperative local complications [3–7]. Moving up the reconstructive ladder, all modalities are negatively impacted by radiation therapy. However, free flaps appear to be the most resilient, since they bring healthy nonradiated tissue into the radiated field [1]. As a result, free flaps offer this as a major benefit in head and neck reconstruction. Although the most reliable option for reconstruction in radiated wounds, free flaps are also negatively affected by radiation. The exact effects of radiation on free flap complications has previously been controversial. However, a recent large metanalysis has shown that preoperative radiation increases the risk of flap failure by 1.82 times and increases the risk of wound infection [8].

Changes in nutritional status in head and neck cancer patients is also an important consideration. These patients often have limited oral intake because of pain with eating or generally feeling unwell. Additionally, having cancer and undergoing radiation and chemotherapy further impairs adequate nutrition. For example, it has been shown that despite sufficient oral intake, patients with head and neck cancer often fail to maintain their nutritional status [9]. This malnutrition leads to decreased muscle and fat mass, decreased strength, poor immune function, and ultimately poor wound healing [10, 11].

Therefore, as previously mentioned, in head and neck cancer reconstruction especially, free flaps are commonly employed. They provide well-vascularized tissue, can provide a large bulk of both bone and soft tissue, and bring healthy non-radiated tissue into the defect.

Head and Neck Reconstruction

There are many surgical options for reconstruction in the head and neck. Selecting the best option depends on the defect location, size, the tissues missing, functional goals, and history of previous surgeries or radiation. The following is an overview of the surgical options for reconstruction of the head and neck, organized by the anatomic site. Specifically, below is an overview of the reconstructive options for the scalp and calvarium, eyelid and periorbital region, midface/maxilla, mandible, and pharynx/esophagus.

Scalp Reconstruction

The scalp includes the soft tissue that covers the cranium and its borders including the face and the neck [10, 11]. The scalp and calvarium physically protect the intracranial contents and are an integral component of maintaining a normal appearance [12]. The goals of scalp and calvarial reconstruction include providing bony continuity to protect the intracranial contents and avoiding exposure of the calvarial bone [2]. Cosmetically, it is important to maintain the hair line and to limit hair loss. Scalp reconstruction typically follows the reconstructive ladder.

Secondary Intention

Healing by secondary intention involves local wound care and leaving the wound to heal without surgical intervention. The advantages of secondary intent are potentially avoiding a more invasive operation and a donor site. This is most efficacious when there is a clean wound bed, on a concave surface, and intact vascularized tissue at the base of the wound, pericranium in the case of the scalp [13]. Unfortunately, this approach significantly delays time to a healed wound and results in alopecia at the wound site.

Primary Closure

Primary closure is the simplest option to achieve a closed wound. If possible, primary closure is preferred since the wound is closed in a single stage and there is no donor site morbidity. Unfortunately, in the scalp, primary closure is typically only possible with tissue defects less than 3 cm [14].

Negative Pressure Wound Therapy

Negative Pressure Wound Therapy (NPWT), also referred to as wound Vacuum-Assisted Closure (wound VAC), can be used to both temporize wounds until definitive reconstruction and speedup healing by secondary intention. It functions by contracting the wound mechanically with suction, optimizing the wound environment by removing excess fluid, and facilitating granulation tissue formation at the microcellular level [15–17]. Contraindications to NPWT include a poor wound bed with necrotic tissue, active infection, and a malignant wound. NWPT has classically been discouraged in malignant wounds thinking that the same mechanism of negative pressure that promotes wound healing would also increase local malignant growth; however, this has been recently brought into question [18].

Skin Grafting

Skin grafting is reliable, quick, and technically simple. The disadvantages of skin grafting on the scalp include contour deformity, donor site morbidity, and hair loss at the defect [13]. Both split-thickness and full-thickness skin grafting are possible in the scalp. However, split thickness tends to have better take, as with other parts of body. In general, for skin grafts to take, there must be a vascularized wound bed that is clean. In the scalp, this means that there is intact periosteum, in the case of full-thickness defects [14]. Radiation can often complicate skin graft take; therefore, more recently, artificial dermal substitutes have been used to reconstruct radiated wounds, in conjunction with skin grafting [13, 19].

Local Flaps

There are many local flaps that may be used for scalp reconstruction. A local flap is defined as utilizing the tissue directly adjacent to the defect as the donor site. Local flap types include advancement, rotation, and transposition flaps. These terms refer to how the donor tissue is moved to cover the defect. There are many named flaps that can be used in the scalp. Describing every example would be beyond the scope of this review. It is worth noting the Orticochea technique, since this was initially described for scalp reconstruction in particular, in 1967 [20]. This flap utilized either three or four large skin flaps to cover the central defect [20, 21]. The advantages of local flaps include good color match and relative ease of harvest. However, in the case of oncologic reconstruction, using local flaps is limited since the tissue adjacent to the wound has often been exposed to radiation in the treatment for the primary cancer.

Regional Flaps

Regional flaps are close in proximity to the tissue defect and are transferred with an intact vascular pedicle. Unfortunately, regional flaps are often limited in the amount of tissue and the reach of the flap. Free tissue transfer is far more versatile and more reliable than pedicled flaps for scalp reconstruction. In head and neck reconstruction, since free tissue transfer is preferred for defects that are large enough to need a regional flap, regional flaps are usually limited to those who are unable to tolerate larger operations or are performed in the context of palliative care [14]. Options for regional flaps for scalp reconstruction include the trapezius flap, latissimus dorsi flap, and the temporoparietal fascia flap [13].

The trapezius flap (Fig. 9.1) was first described by Mathes and Nahai in 1979 [22]. The trapezius muscle can be harvested either just as the muscle alone or with a skin paddle. The trapezius muscle and the overlying skin in that area receive their blood supply from the superficial and deep descending branches of the transverse cervical artery [23]. The main advantages of the trapezius flap include the reliable anatomy and robust perfusion [23, 24]. Unfortunately, however, this flap has limited reach and inset into a more distally located defect can be difficult [13].

The latissimus dorsi flap (Fig. 9.2) was first described by Tansini in 1906 for breast reconstruction [25]. The latissimus muscle is broad and can provide good muscle bulk. The muscle can be harvested alone or can be raised with an overlying skin paddle. The trapezius muscle receives its blood supply from the thoracodorsal artery. The primary advantages include the large volume of available muscle and a long pedicle. The main disadvantage includes the need for lateral decubitus positioning intraoperatively for flap harvest [26]. The donor site morbidity associated with harvesting a major muscle is also a concern. Given its reliability, this flap is often saved as a last resort, after free tissue transfer has failed [26].

The temporoparietal flap system (Fig. 9.3) will be described in detail below (section "Temporalis System"), for its use in maxillary reconstruction. However, briefly, it is particularly useful in scalp reconstruction because of its long pedicle and the ability to harvest it with bone, muscle, fascia, and skin.

Tissue Expansion

Tissue expansion is an option in scalp reconstruction, in general. It works by inducing biologic and mechanical creep to increase the amount of skin available [13, 27]. However, there is a high rate of complications when used in the scalp, a recent large systematic review cited an overall complications rate of 27.3%. This high complication rate is made even worse in radiated fields or unstable wounds [28]. As a result, tissue expansion is not commonly used in oncologic scalp reconstruction [13].

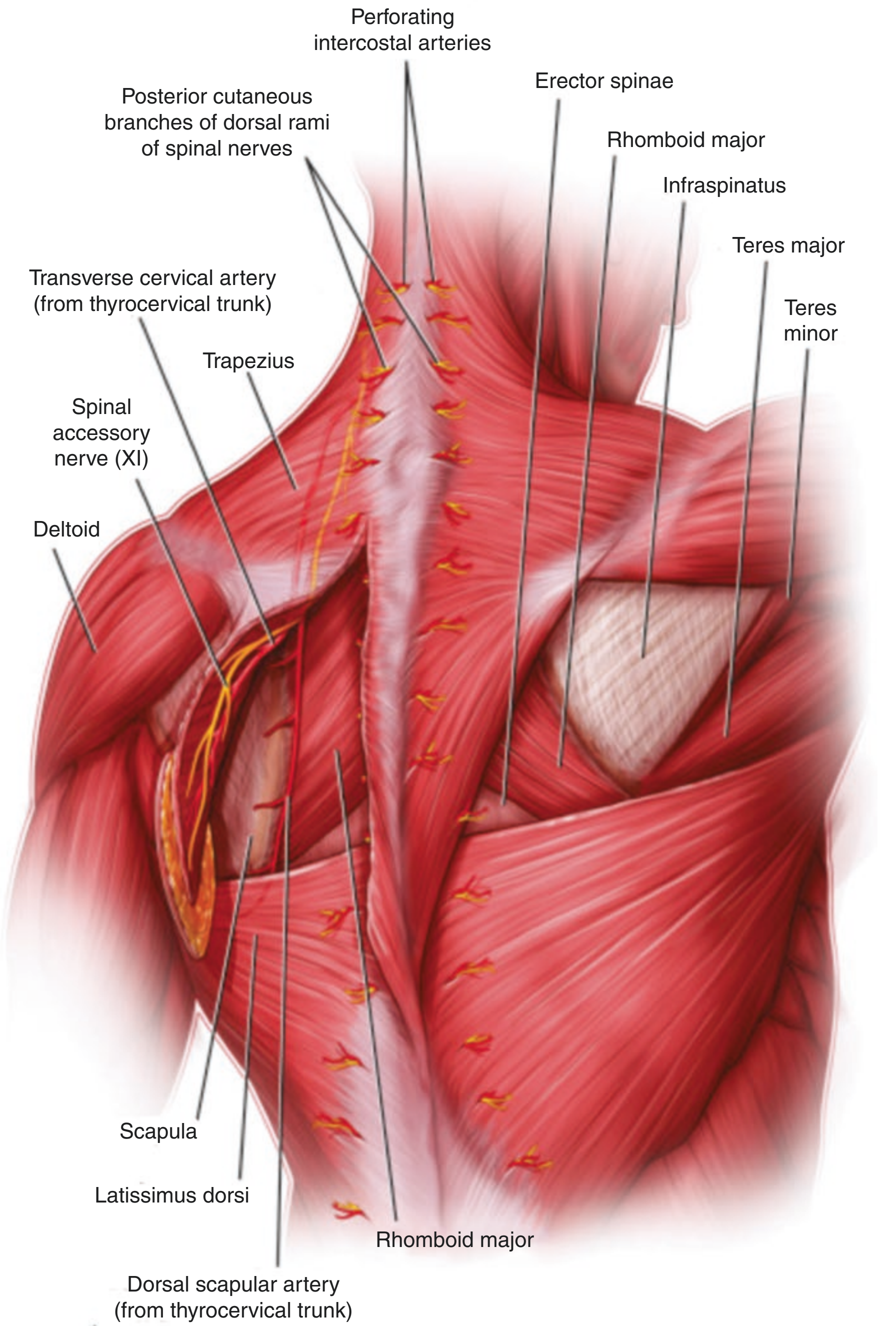

Fig. 9.1 Trapezius flap. (Reprinted by copyright permissions from [99])

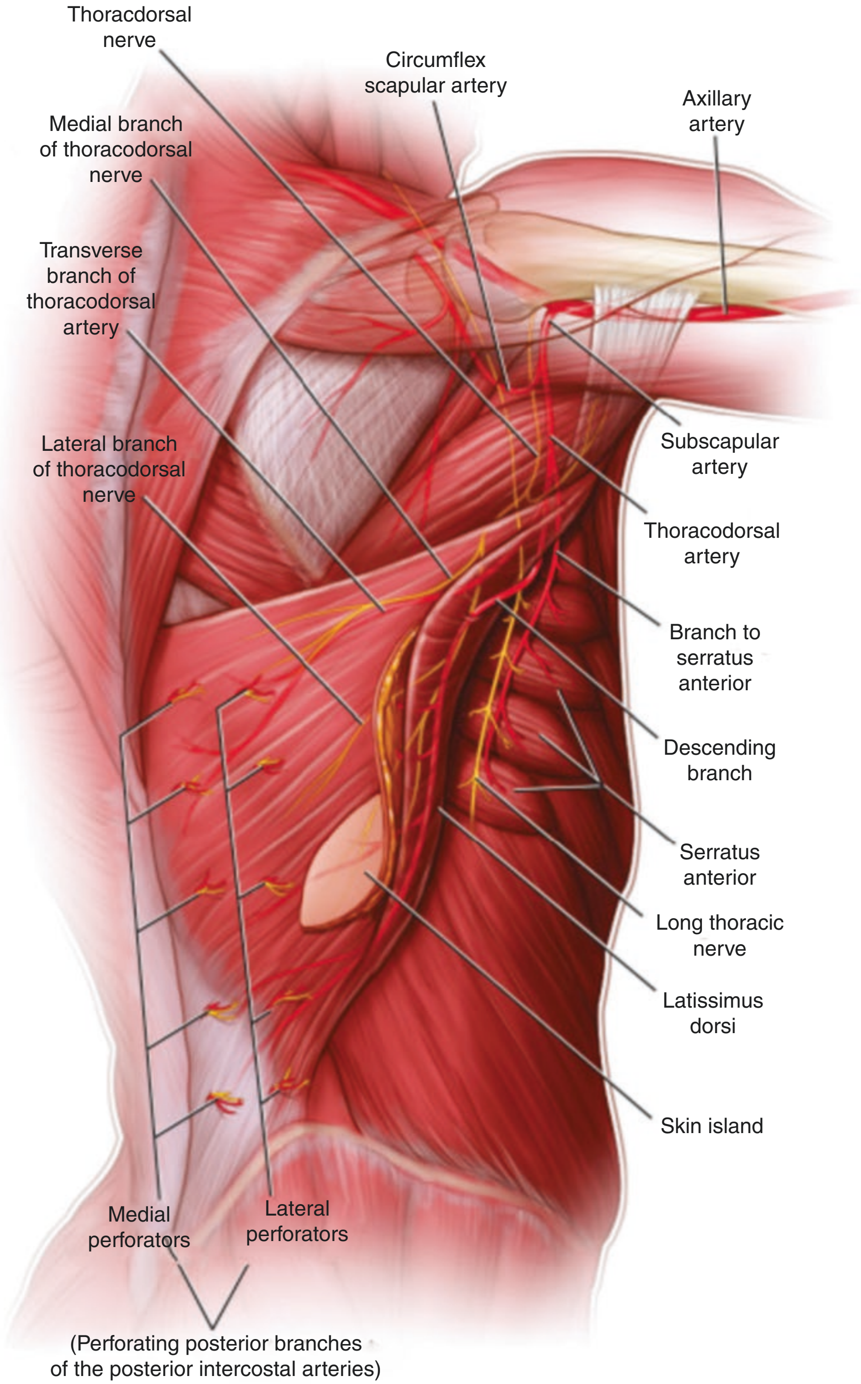

Fig. 9.2 Latissimus dorsi flap. (Reprinted by copyright permissions from [99])

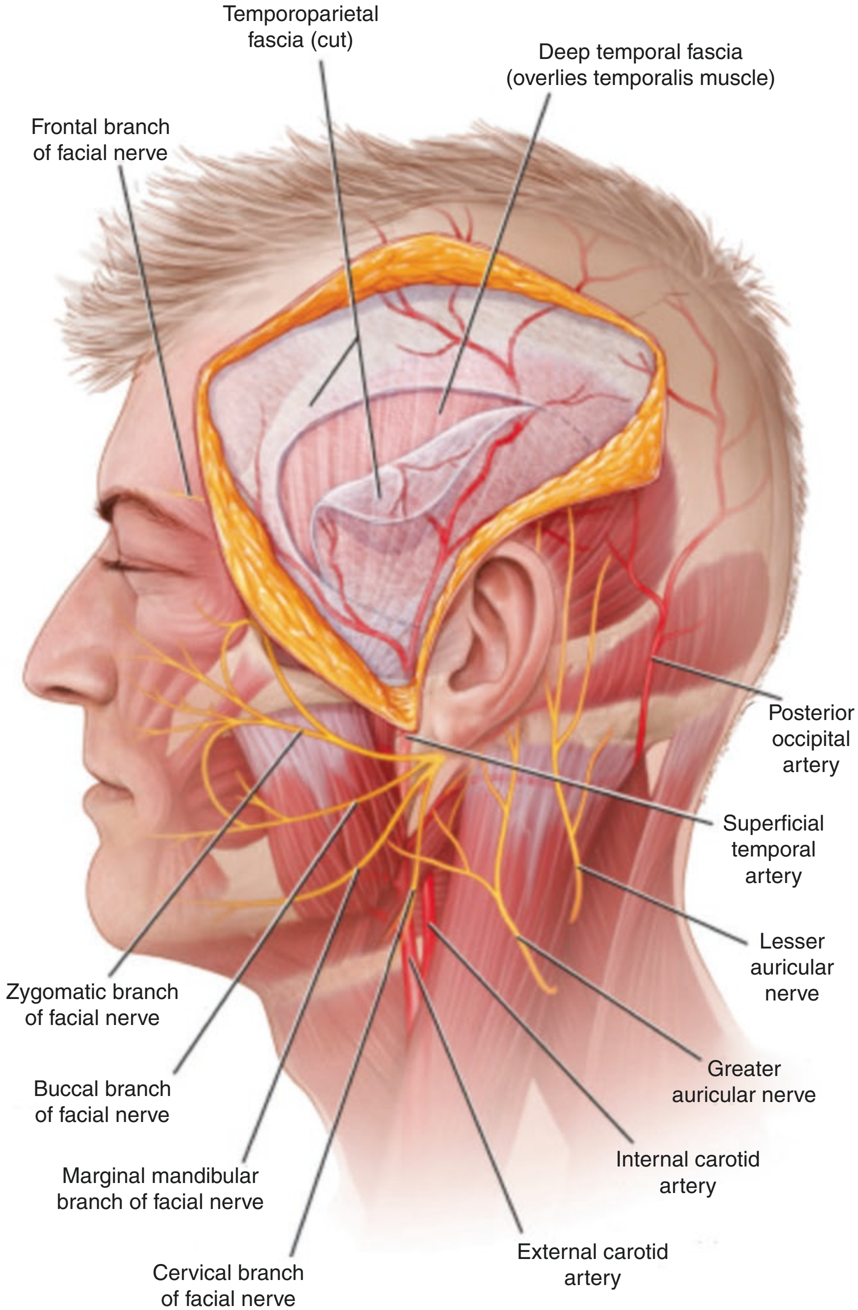

Fig. 9.3 Temporoparietal flap system. (Reprinted by copyright permissions from [99])

Free Tissue Transfer

Free tissue transfer, or free flaps, provide a highly versatile and reliable option for coverage of the scalp. It has the capacity to provide a large amount of healthy tissue that is taken from outside the radiated field. Unfortunately, free flaps are not typically cosmetically appealing because of color mismatch, poor contour, and alopecia of the flap. In the scalp, the superficial temporal artery is the workhorse recipient vessel. The choice of flap depends on the defect characteristics and surgeon's preference. Some of the most commonly used flaps for scalp reconstruction include latissimus dorsi, anterolateral thigh, radial forearm, and rectus abdominus [13, 29, 30].

The anterolateral thigh flap (Fig. 9.4) was first described by Song et al. in 1984 [31]. It provides skin, fascia, and adipose tissue. Furthermore, this flap can be harvested with the vastus lateralis muscle, if greater soft tissue bulk is required [29]. The ALT flap receives is blood supply from of the descending branch of the lateral circumflex femoral artery. The main advantages include good soft tissue bulk, versatility in practice, and a low donor site morbidity [32]. The main disadvantages are that the ALT is a relatively thick flap compared to muscle flaps, resulting in a poor cosmetic appearance of the reconstruction [32].

The latissimus dorsi flap can also be harvested as a free flap. This greatly increases its versatility. The latissimus dorsi flap was reviewed above as a pedicled/regional flap in section "Regional Flaps".

The radial forearm flap is a thin, pliable, and reliable free flap for head and neck reconstruction. It will be reviewed in section "Radial Forearm Free Flap".

The rectus abdominus flap provides substantial soft tissue bulk and affords reliable anatomy. This flap has been reviewed in section "Rectus Abdominis Free Flap".

Calvarial Reconstruction

The calvarium protects the intracranial contents and provides an esthetically pleasing contour. Options for calvarial reconstruction include both alloplastic and autologous materials. Alloplastic options, include titanium mesh, methyl methacrylate, calcium hydroxyapatite, and polyether ether ketone [33]. Alloplastic materials tend to be easy to manipulate, structurally strong, do not resorb, and have the added benefit of avoiding a donor site [34]. The disadvantage of these materials is the risk for infection and exposure of the implant [33, 34]. Autologous options include split calvarial grafts, rib grafts, and iliac bone graft [35, 36]. Autologous bone osteointegrates into the apposed bone and revascularizes, and hence provides durable coverage with a low chance of infection and graft loss [33]. The disadvantage of

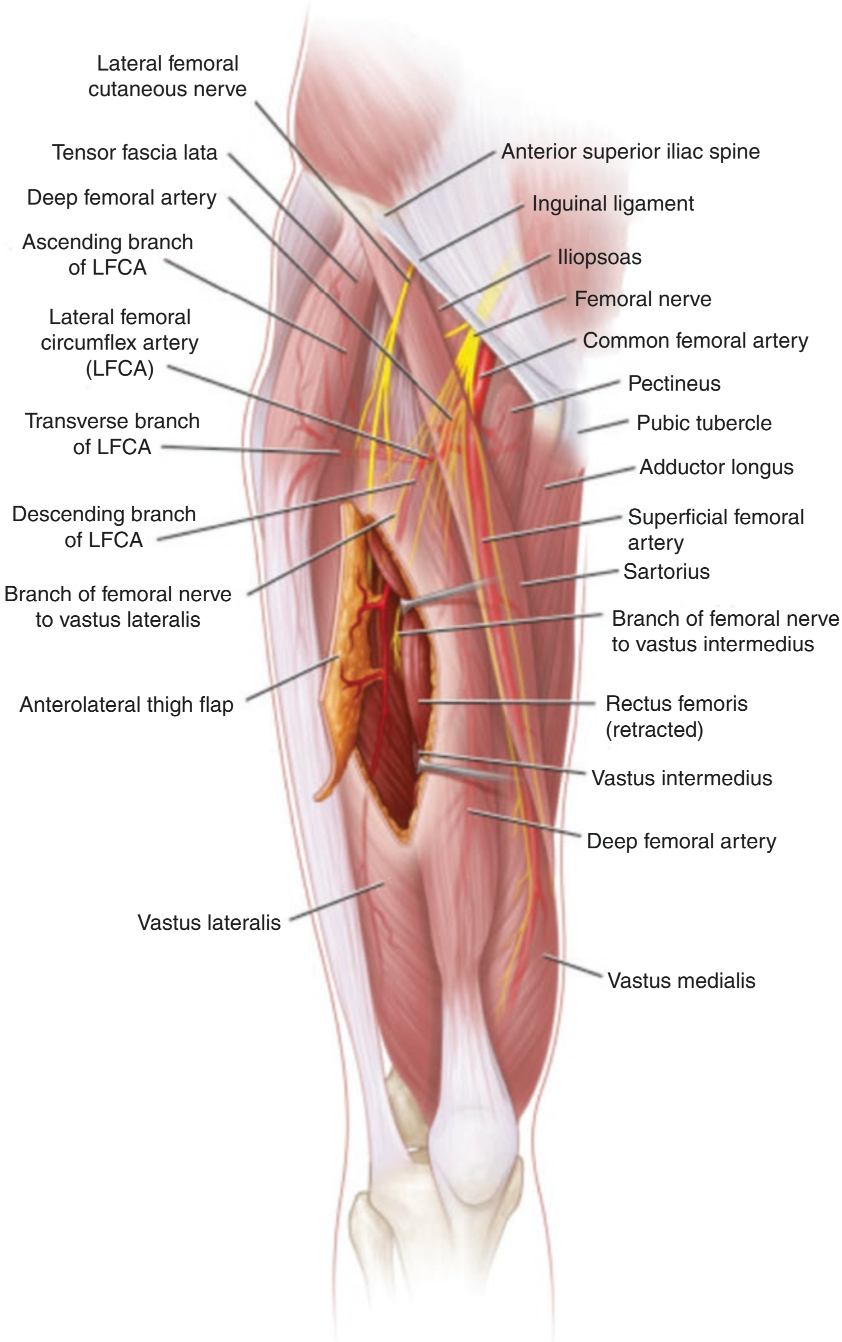

Fig. 9.4 Anterolateral thigh flap. (Reprinted by copyright permissions from [99])

autologous bone are the obligate donor site and the relatively small amount of bone available. In general, autologous reconstruction is preferred over alloplastic reconstruction, for the reasons listed above.

Eyelid and Periorbital Reconstruction

The upper and lower eyelids are exceptionally delicate structures. The goals of eyelid reconstruction are to cover the globe, preserve the tear film, maintain an unobstructed visual field, maintain good closing mechanics, and to restore a normal appearing eye [37]. Therefore, using donor skin of adequate size, similar color and pliability, and minimal donor site morbidity is even more important. Eyelid and periorbital reconstruction tend to follow the reconstructive ladder, with some caveats.

Secondary intention is best for small superficial lesions that located near the medial canthus. The nearby nasal bones resist scar contracture. In contrast, central and lateral eyelid defects carry a high risk of cicatricial ectropion with healing by secondary intent [38]. Moreover, healing by secondary intention in the periorbital area is very rarely done, since significant contour deformity and contracture often result [39].

Primary closure can be attempted for small lesions that do not involve the eyelid margin. Both upper and lower lid defects that involve less than 25–30% of the eyelid margin can be directly closed [37].

Skin grafting is possible for both the upper and lower eyelid. In particular, this is suited for defects of anterior lamella [37]. First choice of donor site is full-thickness graft taken from the contralateral upper eyelid [40]. Full-thickness skin grafts are preferred, to limit contracture.

Full-thickness defects larger than one-third the eyelid margin are repaired with rotation flaps, semicircular flaps, or pedicled flaps [38]. Flap choice is determined by the lid component tissue missing and these reconstructions are truly elegant. Full-thickness defects of the upper lid can be repaired with a modified Tenzel semicircular flap or a Cutler-Beard procedure [38]. Both these options rely on moving components of the lower lid to fill defects in the upper lid. The paramedian forehead flap can also be used for very severe defects. For the lower lid, the Tripier flap uses pedicled skin from the upper lid to reconstruct lower lid defects [37]. The Hughes flap (tarsoconjunctival pedicle flap) takes pedicled conjunctiva, tarsus, and skin from the upper lid to fill large full-thickness lower lid defects [38]. Notably, though, the Hughes flap requires division of the conjunctival pedicle at a later date [41]. The Mustarde flap is a large rotation flap that moves skin from the cheek to cover the lower lid [42].

Generally, free flaps are not used for eyelid reconstruction, since the eyelids are relatively small structures and the priority is good tissue match, which is best obtained from the local anatomy [37, 38].

Midface, Maxilla, and Mandibular Reconstruction

The midface is the central third of the face and includes the maxilla, which is structurally integral to the entire face. In fact, the maxilla is often referred as “keystone” of the midface [43]. It provides the occlusal plane, houses the maxillary dentition, supports the skull base, supports the orbital contents, and serves as the attachment for muscles of mastication and facial expression [44, 45]. There are a number of maxillary defect classification systems, but no unified system is routinely used [46–49]. The lack of a unified classification is likely a result of the complexity of maxillary reconstruction [50]. Although, different classification systems can be employed to direct maxillary reconstruction, the same general principles of reconstruction can be applied. Including replacing like-with-like, restoring structural support, and maintaining a cosmetic appearance. The goals of maxillary reconstruction, in particular, are to achieve separation of the oral and nasal cavities, support the orbital contents, provide functional dentition, and maintain facial contour [44, 45]. With any oncologic reconstruction, but with maxillary defects in particular, there is concern that the reconstruction may interfere with surveillance for recurrent disease. The maxilla especially so, since the defect can be deep, and the margin of resection would be obscured by the reconstruction. However, it appears that free flap and bone reconstruction are not independently associated with worse outcomes in head and neck reconstruction in general [51].

Historically, large maxillary defects were treated with prosthetic devices. The advent of free tissue transfer greatly decreased the use of prosthetics, since free tissue transfer has resulted in better satisfaction scores than prosthetic devices [52, 53]. Prosthetic obturation remains a good option for those who cannot tolerate or have a contraindication to a reconstructive procedure [54].

Midface and maxillary oncologic resections will result in loss of soft tissue, bone, or both. Loss of soft tissue and bone can be replaced with local, regional, and free flaps. The reconstructive ladder in maxillary reconstruction can be applied, but is in general less helpful. Specifically, because maxillary defects are not amenable to healing by secondary intent, primary closure, and skin grafting is less of a viable option given the concern for contracture at the recipient site [50]. Therefore, the reconstructive ladder in maxillary reconstruction usually starts with local flaps. Loss of bone specifically, can be replaced with bone grafts or free vascularized bone flaps. Small bone defects that do not compromise the structural architecture of the midface can be obliterated with soft tissue. However, if the structural support of the midface is compromised (e.g., resection of the orbital floor, nasal sidewall, or a tooth bearing segment of the maxilla), rigid reconstruction is needed to provide structural support and bone stock for osteointegrated dental implants [50]. Additionally, if multiple components are missing, composite flaps can be used.

The goals of mandibular reconstruction include (i) providing structural support of the soft tissues of the oral cavity and lower face, (ii) achieve proper occlusion, (iii) supply bone stock for dental implants, (iv) restore sensation when able, and (v) achieve tongue palate contact for swallowing and speech [55]. Mandibular defects are classified based on location, size, and degree of soft tissue loss. Mandibular reconstruction is distinct from maxillary reconstruction in that prosthetics are never an option [55]. Additionally, although nonvascularized bone grafts have been used in mandibular reconstruction, in a radiated field there is a greater risk of reabsorption of the graft and nonunion [56]. As a result, vascularized bone free flaps have become the standard of care in mandibular reconstruction [55]. The most commonly used donor sites for mandibular reconstruction include the fibula, iliac crest, and the scapula [57].

A review of the options for reconstruction of the midface, maxilla, and mandible follows.

Local Flaps

Local flaps can be used for small defects that do not require bone reconstruction.

Buccal Fat Pad

The buccal fat pad (Fig. 9.5) was first described for head and neck reconstruction by Egyedi in 1977, where he used to tissue to close oral-antral and oro-nasal fistulae [58]. It provides specialized fat that is located between the buccinator muscle and

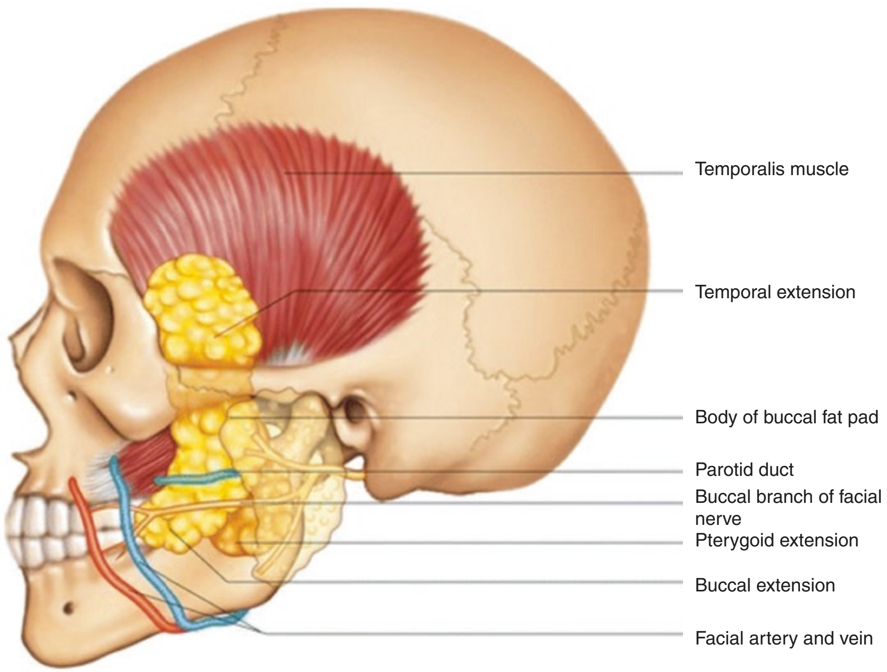

Fig. 9.5 Buccal fat pad. (Reprinted by copyright permissions from [100])

the mandibular ramus [59]. The fat pad is easily accessed and has a rich blood supply from the branches from the maxillary artery, superficial temporal artery, and facial artery [60]. It can be harvested as a pedicled flap to cover small oral defects. In general, it can be used to fill palatal defects up to 4 cm in diameter [60]. However, the size of the buccal fat pad is highly variable and changes with age [59]. Because of the limited reach of the flap, it is best suited for small maxillary defects that do not pass midline [60]. Buccal fat can also be used in combination with other reconstructive techniques to provide extra tissue volume.

Palatal Mucoperiosteal Island Flap

The palatal mucoperiosteal island flap was first described for reconstruction of intra-oral defects by Gullane and Arena in 1977 [61]. It utilizes the soft tissue over the hard palate, raised on a pedicle, and can then be rotated to cover adjacent defects. The blood supply is robust, and includes supplying vessels from the greater and lesser palatine arteries, ascending branch of the facial artery, and palatine branch of the ascending pharyngeal artery [61]. The main advantage of this flap is the large amount of soft tissue available from a local flap, which is approximately 15 cm^2 [62]. The main disadvantages are the short reach of the tissue, limiting the extent of the defects that it can fill, and the lack of bony tissue availability for osseus reconstruction. Notably, in contrast to most flaps, the donor site defect is typically left open, to heal by secondary intention/granulation [62].

Regional Flaps

There are a limited number of regional flaps available for maxillary reconstruction. These include the submental island flap, temporalis flap, and vascularized calvarial bone flap. Unfortunately, regional flaps in the head and neck are often limited by the length of the vascular pedicle and can be insufficient in reconstructing complex and broad defects [50]. For example, deltopectoral, latissimus dorsi, sternomastoid, and trapezius pedicled muscle flaps have been described; however, these were either unreliable, did not provide significant reach, or were too bulky for most defects [43]. Additionally, in oncologic reconstruction, many of these flaps will likely be radiated as part of the treatment for the primary tumor.

Temporalis System

The temporalis muscle flap was described as early as 1961, for reconstruction of a radical mastoidectomy [63]. Since then the flap has been widely applied and further described to include more than just the muscle. This flap system includes the temporalis muscle, temporoparietal galea, coronoid process, and underlying calvarial bone [64, 65]. Flaps using these structures are based of the superficial temporal artery. It can be taken as a pedicled or free flap and as a muscle, fascial, or composite flap. The temporalperietal galea or muscle flap can be used to obliterate oral and orbital defects, reconstruct the upper lip, and in the case of maxillary reconstruction needing bone stock for dental implants, the temporoparietal system can be harvested with calvarial bone as a vascularized bone flap [64]. Advantages of this flap system include reliable anatomy, tissue bulk, and the ability to take vascularized bone [64, 66]. Disadvantages include an unsightly donor site and possible involvement in the radiated field.

Submental Island Flap

The submental island flap was first described by Martin et al. in 1991 for orofacial defects, as an alternative to previously used cervical flaps [67]. The blood supply is the submental artery. Advantages include good color match to the face and a large amount of soft tissue available, originally described as 7 × 18 cm of tissue [67]. As such, it has been used for coverage of range of midface and lower face defects. Unfortunately, if level I lymph nodes are involved, this is a relative contraindication to using this flap [50].

Free Tissue Transfer

There are many options for maxillary reconstruction with free tissue transfer. As mentioned, if appropriate, free tissue transfer is an excellent option. Free tissue transfer enables bringing healthy nonradiated tissue into a poorly healing, likely radiated field. Additionally, it can provide reconstruction for complex defects missing multiple tissue types, and usually be performed in a single stage. Additionally, free flap reconstruction after oral and oropharyngeal cancer can improve patients' quality of life, in part by restoring their ability to speak and swallow [68].

Radial Forearm Free Flap

The radial forearm free flap (Fig. 9.6) was developed Goufan, Baoqui, and Yuzhi in 1978 [69]. It provides a large amount of soft tissue from the forearm. If bone reconstruction is needed, a segment of vascularized radius can also be harvested. Alternatively, autologous bone can be taken as a graft from the iliac crest, calvarium, or rib, which would save the radius as a donor site [46]. The blood supply is the radial artery. Since its development, because of its reliability, it has become widely used in head and neck reconstruction, to the point of being known as a workhorse flap [70]. The advantages of the forearm flap include a thin pliable flap with a long vascular pedicle. Disadvantages include a poorly appearing donor site, which may require a skin graft to close if a large amount of tissue is harvested [71].

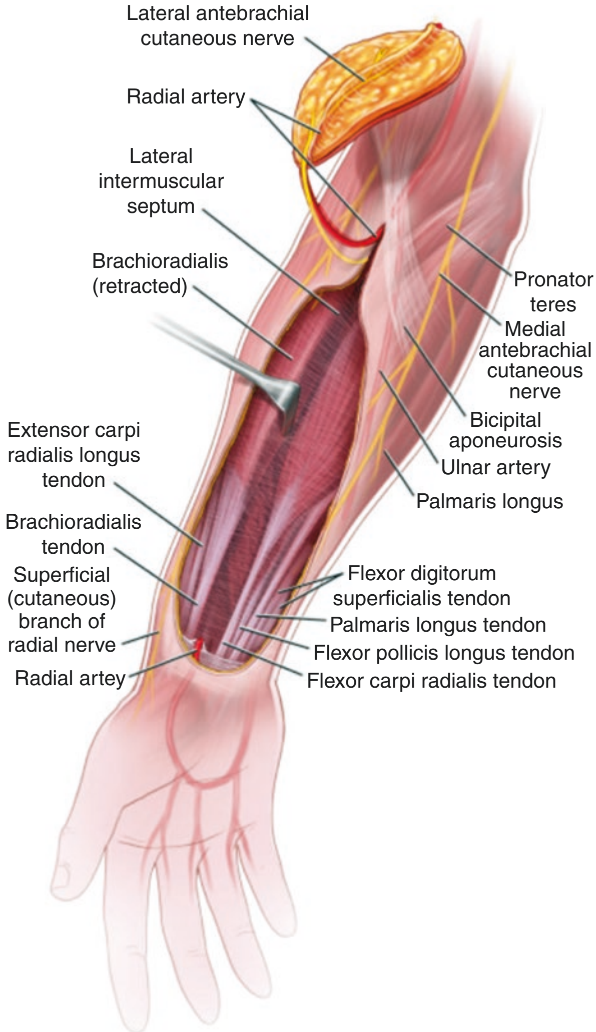

Fig. 9.6 Radial forearm free flap. (Reprinted by copyright permissions from [99])

Rectus Abdominis Free Flap

The rectus abdominus free flap (Fig. 9.7) was first described by Pennington et al. in 1980 [72]. It provides a large amount of muscle and can be taken with an overlying skin paddle. If bone graft is needed, it can be taken from the rib or calvarium [46, 73, 74]. It is based off the inferior epigastric artery. Advantages include a long vascular pedicle and large amount of soft tissue [50]. Disadvantages include abdominal wall donor site and the risk of an abdominal bulge or a hernia [75].

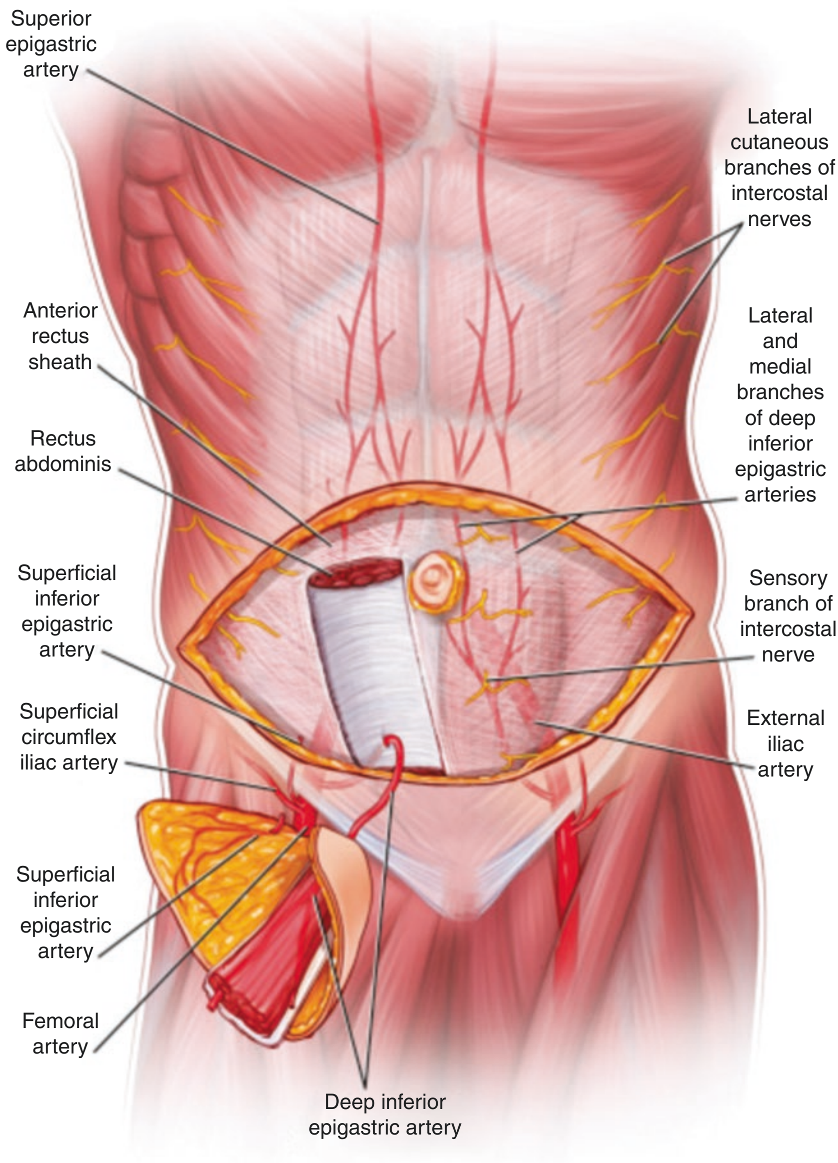

Fig. 9.7 Rectus abdominis free flap. (Reprinted by copyright permissions from [99])

Latissimus Dorsi and the Scapular Free-Flap System

The scapular free flap was first described by dos Santos et al. in 1984 [76]. It can provide vascularized bone, the overlying muscle, and a skin paddle. It is based off either the angular branch from the thoracodorsal artery or the cutaneous scapular artery [76, 77]. The scapular osteocutaneous free flap can also be raised as a bipedicled flap [77]. Meaning that the flap is harvested with two pedicles that allow for two independent vascularized bone segments, which could be useful in special cases. In the case of a total maxillectomy, which requires a large amount of tissue to obliterate the defect, the scapula can be harvested in combination with latissimus dorsi muscle off the same vascular pedicle, providing a customizable flap with a large bulk of muscle and bone [78]. Those who routinely use this flap find it to be highly versatile, have consistent anatomy, and good quality bone and soft tissue for head and neck reconstruction [79]. Disadvantages include difficult intraoperative positioning to harvest the flap for head and neck reconstruction.

Iliac Crest Free Flap

The iliac crest free flap (Fig. 9.8) was first described both experimentally and in a clinic setting by Taylor et al. in 1979 [80, 81]. The flap can be raised with iliac crest as bone stock, the attached internal oblique, and an overlying skin paddle [79]. The blood supply is based off the deep circumflex iliac artery (DCIA). The composite iliac crest internal oblique osteomusculocutaneous free flap is particularly suited to extensive maxillary defects. Advantages include providing a large amount of bone stock that can address the vertical component of the maxillary defect and support placement of osteointegrated implants [82]. Disadvantages include a short vascular pedicle, donor site morbidity, and limited soft tissue pliability [83].

Fibula Free Flap

The free fibula flap (Fig. 9.9) was first described by Taylor et al. in 1975, for lower extremity reconstruction [84]. The free fibula is a highly versatile flap that provides bone and soft tissue. It can be taken with or without a skin paddle. The blood supply is the peroneal artery. Advantages include a generous supply of bone stock that can support dental implants, the option to raise multiple skin paddles, and reliable anatomy [85]. The primary disadvantage of this flap is a relatively short pedicle and the added level of complexity in attempting to change a straight bone into a rigid curved structure [85].

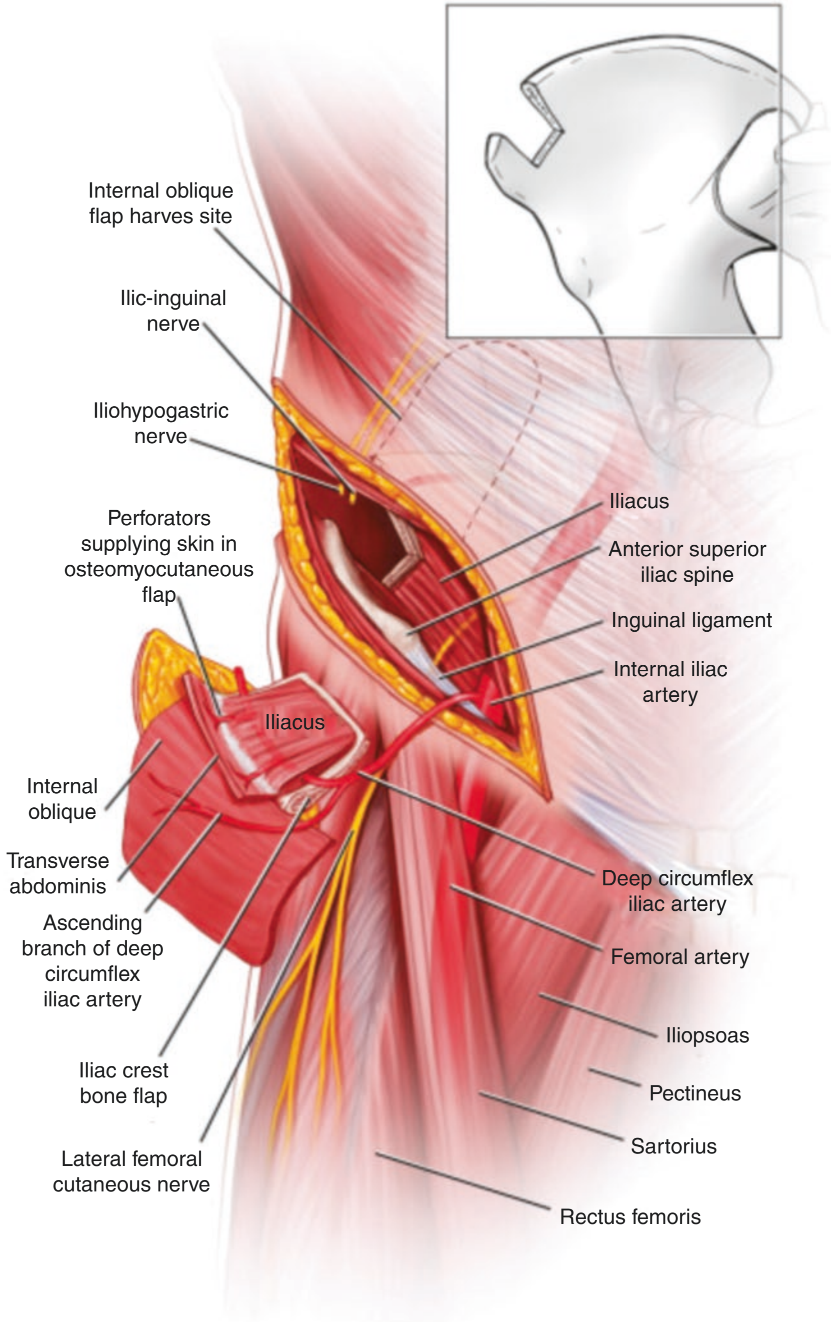

Fig. 9.8 Iliac crest free flap. (Reprinted by copyright permissions from [99])

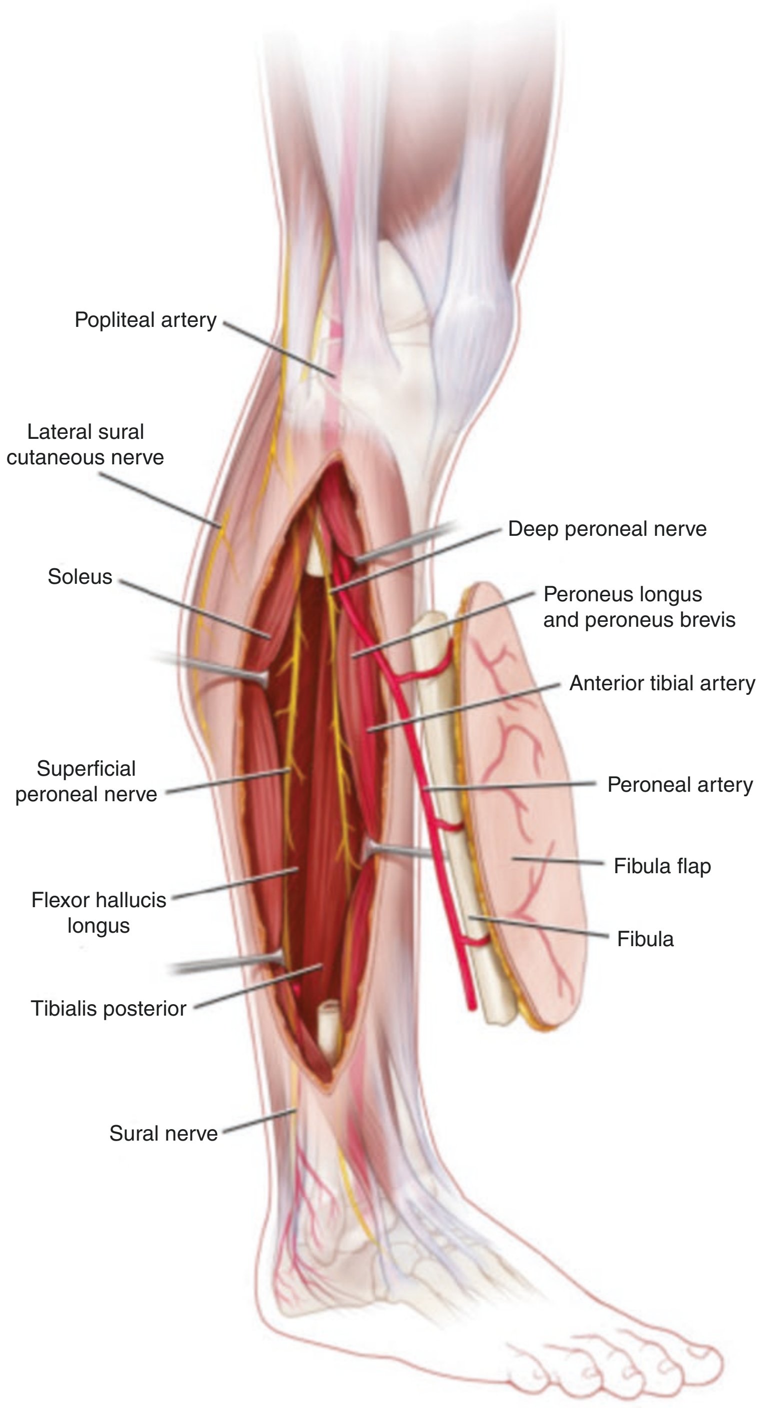

Fig. 9.9 Fibula free flap. (Reprinted by copyright permissions from [99])

Pharyngoesophageal Reconstruction

The pharynx and esophagus are essential components of the aerodigestive system. Dysfunction in these structures impairs speech, ventilation, and oral nutrition intake. Therefore, the goals of pharyngoesophageal reconstruction include restoring speech, normal swallowing, and protecting the airway [86]. Reconstruction of near circumferential or total circumferential defects of the pharynx and esophagus require reconstruction. Pedicled flap options include pectoralis major, supraclavicular artery island, latissimus dorsi, and trapezius pedicled flaps [87]. Free flap options are numerous, such as the anterolateral thigh and radial forearm flap. Additionally, enteric flaps are an option, most commonly the free jejunum flap. Other enteric flaps have been used for pharyngoesophageal reconstruction, but less commonly and typically in special cases.

Pedicled Flaps

Pedicled flaps in pharyngoesophageal reconstruction tend to be reserved as a backup option after free tissue transfer. The pectoralis major flap in particular is highly reliable and considered a workhorse flap for both initial pharyngoesophageal reconstruction and for correcting pharyngocutaneous fistula after reconstruction [87]. The supraclavicular artery island, latissimus dorsi, and trapezius pedicled flaps are also good options; however, these flaps are not nearly as commonly utilized as the pectoralis flap.

Pectoralis Flap

The pectoralis flap (Fig. 9.10) was described as early as 1917 and has been used in head in neck reconstruction since the 1920s [88]. The pectoralis flap can be taken with muscle, rib, and skin. The blood supply originates from the thoracoacromial artery and the perforating branches of the internal mammary artery [88]. Advantages include a single stage reconstruction, reliable pedicle, and providing healthy muscle for radiated and contaminated wounds [89]. Disadvantages include a relatively short reach and a large muscle bulk which can limit ease of creating a tube from of the flap [89, 90].

The trapezius flap and latissimus dorsi flap are already reviewed in this chapter. In pharyngoesophageal reconstruction in particular, the latissimus is a reliable option but tends to provide more tissue thickness than required and tends to be challenging to make into a tube [87].

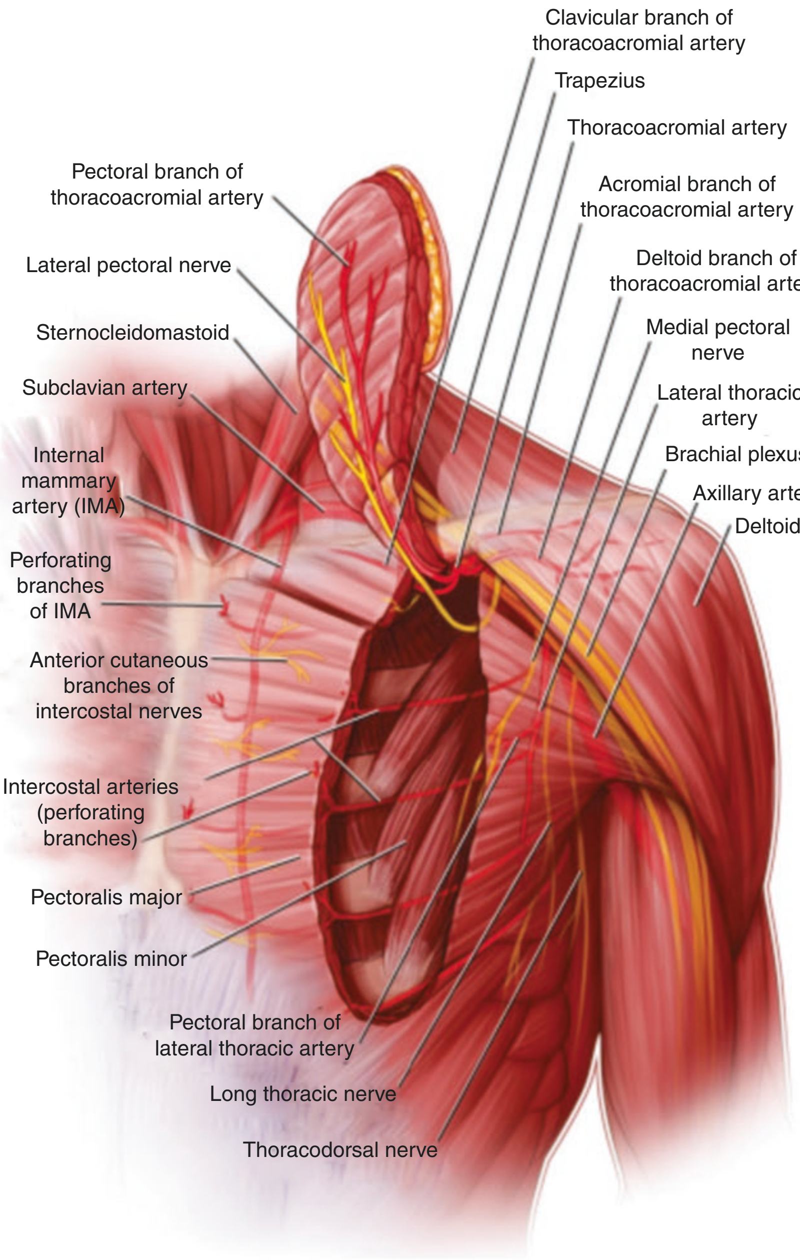

Fig. 9.10 Pectoralis flap. (Reprinted by copyright permissions from [99])

Free Tissue Transfer

Using jejunum as a pedicled flap (Fig. 9.11) for esophageal reconstruction was first reported in the early 1900s [89]. Its use as a free flap was first reported by Seidenbert et al. in 1959, specifically for pharyngoesophageal reconstruction [91]. The jejunal blood supply originates from the superior mesenteric artery. This flap is unique in the types of flaps reported in this chapter, in that it provides small bowel tissue. All other flaps reported here provide a combination of skin, adipose, fascia, muscle, and/or bone. This makes it particularly suited for pharyngoesophageal reconstruction, since you are transferring a functional tubular structure. Other advantages include a lower rate of fistula formation compared to cutaneous reconstruction of the pharynx/esophagus [92]. As a result, the free jejunum has become the first-line

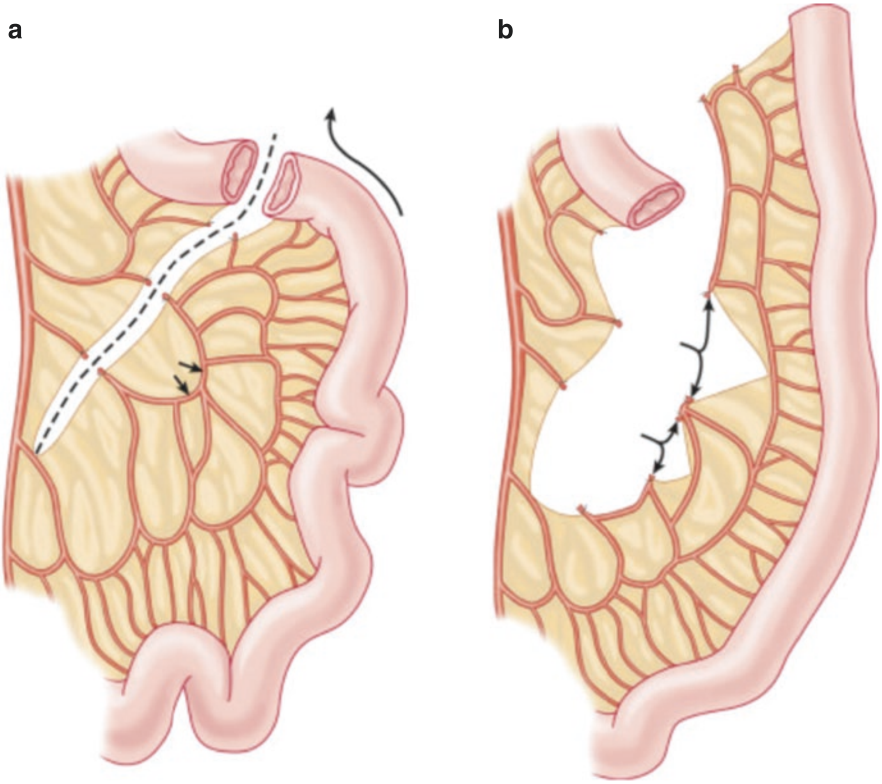

Fig. 9.11 Jejunum as a pedicled flap. (**a**) For esophageal reconstruction, a distance jejunum is better for a pedicled flap. (**b**) To retain the length for supercharging, the third jejunal artery is ligated and divided close to its origin from the superior mesenteric artery. (Reprinted by copyright permissions from [99])

workhorse flap for circumferential pharyngoesophageal reconstruction for many surgeons [92, 93]. Notably, however, there is evidence suggesting that pharyngoesophageal reconstruction with cutaneous flaps, specifically the anterolateral thigh flap, offers better speech and swallowing function [94]. Disadvantages of free jejunal transfer include the need for a laparotomy, abdominal complications, and the relatively high risk of ischemia from the high metabolic demand of jejunum [92].

The radial forearm flap and anterolateral thigh flap have been reviewed elsewhere in this chapter. Notably, in pharyngoesophageal reconstruction, both of these flaps need to be formed into tubes to provide a pharyngoesophageal conduit. Unfortunately, this means that the conduit will involve an additional suture line along the length of the entire conduit. Exposure of a greater length of suture line to saliva presumably is one of the reasons these flaps tend to have higher rates of fistula formation and stricture compared to free Jejunal flaps [89, 95]. It should be noted, however, that there are few studies directly comparing outcomes of free jejunal transfer, anterolateral thigh flap, and radial free forearm flap use for pharyngoesophageal reconstruction [96]. Choice of flap is typically surgeon- and institution-dependent.

Conclusion and Future Prospective

Head and neck reconstruction has progressed significantly. Improvement in outcomes has been largely affected by advancements in cancer therapy as well as the advent of microsurgery and the subsequent capacity for free tissue transfer. Another relatively recent advancement in head and neck reconstruction is the use of virtual surgical planning and rapid prototype modeling. Virtual surgical planning relies on 3D imaging data obtained from computed tomography scans to build models of the relevant anatomy for intraoperative use, surgical cutting guides to direct tumor extirpation as well as the bony reconstruction, and even mold or 3D print custom hardware [97]. Virtual surgical planning as a tool offers improved precision and reliability in head and neck reconstruction. It will likely become more widely used as acquisition costs and logistic challenges are limited [98]. The most immediate future advancements in head and neck reconstruction will likely be based in the application of virtual surgical planning.

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