TITLE: Revascularized Tissue Transfers in Head and Neck Surgery
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History

The origins of microvascular surgery can be traced back to Alexis Carrel in the early 1900's. He described reproducible methods of suturing vessels together with excellent patency rates. Applying these applications to humans was limited by adequate magnification and instrumentation to perform the necessary micro-anatomoses. With the development of the operating microscope in the 1950's, Jacobsen and Suarez began performing the first microvascular anastomoses in the animal model. The first successful human free tissue transfer in the head and neck was accomplished in 1957 by Som and Seidenberg who reconstructed an esophagus with a free jejunal segment. Due to the popularization of regional flaps in head and neck reconstruction in the 1960's, further advances in microvascular surgery were delayed. Microvascular surgery was reintroduced in 1972 with Daniels and Taylor performing the first human microvascular transfer of a superficial groin flap. It was these authors were also are credited to use the of term "free flap". In 1974, Baker and Panje performed the first free tissue transfer for head and neck reconstruction after excision of an oral cavity malignancy. Osteocutaneous free flaps were developed and revised in the 1980's and by 1987, osseointegrated implants in revascularized bone for dental restoration was described. "Sensate" radial forearm reconstruction for oral cavity reconstruction was championed by Urken in 1990. Today, free tissue transfers have become an accepted tool in head and neck reconstruction and the standard for reconstruction of many defects within the head and neck.

Advantages and Disadvantages of Free Tissue Transfer

Revascularized tissue transfers in the head and neck have several advantages over other forms of reconstruction. First, there is a wide variety of available tissue types at various donor sites to match a particular surgical defect. The reconstruction can be precisely tailored to match the needs of the defect, ultimately providing the best possible functional and aesthetic result. For example, in oropharyngeal reconstruction, thin sensate fasciocutaneous flaps are preferred over bulky anesthetic flaps that may impair with residual tongue, soft palate, or pharyngeal constrictor muscle function. Pedicled flaps are often less than perfect when the defect requires the extremes of massive bulk or thin, pliable tissue. Free flaps are not limited by these constraints. Indeed, free flaps can provide a much wider range of skin characteristics that can match the host site well. Second, microvascular transfer makes much more efficient use of harvested tissue as nearly all is used directly in the reconstruction. Pedicled flaps require a less efficient use of tissue as entire muscles are defunctionalized in order to safely transfer enough tissue to fill the defect. Third, free tissue transfer allows for immediate reconstruction after tumor resection when tissue planes have already been dissected, recipient vessels are known to be available, and anatomic relationships are not distorted by fibrosis and contracture. Tumor extirpation and flap harvest can be performed with a two-team approach which may decrease operating room time. Fourth, as many head and neck defects are exposed to inhospitable environments (i.e. exposed to saliva, nasal secretions, and tissues previously exposed to radiation and surgery), well perfused free flaps are suited to these conditions. This excellent perfusion significantly improves wound healing and serves to protect against wound breakdown and osteoradionecrosis when post-operative radiotherapy or brachytherapy is utilized. Free flap reconstruction also affords the ability for water-tight closures in skull base defects to prevent CSF leaks. In addition, because revascularized tissue transfers maintain their independent blood supply, they are not as subject to resorption, providing for greater long-term stability and cosmesis to the reconstruction. Resorption, which plagues non-vascularized bony transfers, is virtually eliminated with free flap reconstruction. Fifth, large tumors, particularly along the skull base, can be resected with oncologically sound margins. The extent of resection for control of margins at all sites can be pushed further, irrespective of the magnitude of the surgical defect. Finally, there is potential for functional neurosensory and motor innervation from recipient nerves as well as the ability for primary placement of osseointegrated implants for improved oromandibular function.

The principle disadvantages in revascularized tissue transfer are the technical demands required by the technique and the prolonged anesthesia time. Additional expertise and equipment is required intraoperatively, as well as perioperatively with specialized intensive post operative care by nurses and physicians. Although free flap transfer can add an additional 4 hours to an already lengthy procedure, studies have shown that length of hospitalization and medical complications are not increased in free flap reconstruction patients. While the increased operating room time and microvascular technique does increase the absolute cost of the primary procedure, total costs to the patient are decreased as there are fewer wound complications, shorter lengths of stay, and lack of secondary reconstructions. Even in experienced hands, one can expect a 5 to 10 percent flap failure rate, usually due to thrombosis. Such failure would require a second operative procedure causing additional donor site morbidity. Pedicled flaps have a lower flap failure rate, thus decreasing the potential risk for reoperation. Donor site morbidity is another risk of free tissue transfers. Pathologic fractures, prolonged pain, and poorly aesthetic donor sites can occur when free flaps are employed. Finally, free tissue transfer may be impossible when recipient vessels are unavailable due to previous surgery, irradiation, severe atherosclerosis, or collagen vascular disease.

Preoperative Planning

Perhaps more so than any other surgical procedure, preoperative planning is crucial for successful revascularized tissue transfers. Patient selection, anesthetic selection, donor-site selection, timing of the procedure, and attention to the preparatory aspects of the procedure are key factors in influencing successful outcome. The viability of the transferred tissue is generally attributed to the technical aspects of the procedure (vessel anastomosis, flap transfer timing, and flap tailoring), however, errors in patient and donor selection can also result in flap failure.

Successful free tissue transfer begins with proper patient selection. There are a number of patient characteristics which can additively increase the likelihood of failure. Age is sometimes considered one such factor but, in reality, is not a significant issue. To the extent that increased age is associated with increased arterial atherosclerotic disease and increased venous vascular fragility, it may be an issue. However, many persons of advanced age have excellent vascular anatomy. Instead, at the other end of the spectrum, pediatric patients may have a small vessel size, which may make anastomosis difficult, as vessels less than one millimeter in diameter are hard to anastomose with consistent reliability.

Diabetes and other systemic illness such as hypercholesterolemia can increase the likelihood of microvascular disease and muscular artery atherosclerosis. In addition, poorly controlled diabetes often impairs wound healing. Microvascular disease delays healing and neovascularization between the flap and surrounding tissues. It also increases the likelihood of infection with potential flap loss. Atherosclerosis is most problematic when using lower extremity vasculature such as with fibula flaps and the uncommonly utilized dorsalis pedis free flap. Atherosclerotic disease is less problematic with upper extremity, truncal, and visceral vasculature. Within the head and neck, the facial artery is the peripheral branch of the external carotid system which is most susceptible to atherosclerotic plaques. Still, this vessel is frequently used as a recipient vessel for anastomosis because of its close proximity and good vessel caliber.

Decreased flap perfusion, hypercoagulation, and impaired wound healing have been noted in smokers. Thus, smoking should be discontinued for at least one week prior to surgery and forbidden in the postoperative period. Obesity may also decrease the success of free tissue transfer as the increased adipose tissue makes dissection of the vascular pedicle more difficult and interferes with the microvascular anastomosis, insetting, and flap tailoring after transfer.

Collagen vascular disease is another relative contraindication to free flap transfer. These diseases can compromise the cardiovascular system, particularly in individuals with an active vasculitic process. These individuals have a much higher incidence of anastomotic thrombosis and thus may not be candidates for free tissue transfer.

Coagulopathies are another relative contraindication. Most are secondary to coumadin therapy for those who have a history of cerebrovascular disease, deep vein thrombosis, or mechanical heart valves. As such, most can be modulated with cessation of the coumadin, and the use of replacement blood products such as fresh frozen plasma. However, patients with a history of ethanol-induced hepatic insufficiency will often have a less easily controlled coagulopathy and the risk for severe intraoperative bleeding, postoperative hematoma, and consequent risks to the vascular anastomosis are greater. The only absolute contraindication for free tissue transfer is a hypercoagulable state. In these persons (i.e. polycythemia, sickle cell disease), the risk of anastomotic thrombosis is too great to justify the use of free tissue transfer.

Donor site considerations include functional and aesthetic needs, degree of bulk required, the need for carotid coverage, the surface area of the defect requiring coverage, the need for and external vs. internal lining, and the need for bone. Each site has inherent advantages and disadvantages with regard to the length and size of the vascular pedicle, the specific texture, bulkiness, hair-bearing characteristics, color match, and potential for sensory or motor reinnervation. Donor sites also differ in the level of difficulty encountered in harvesting, insetting, and contouring, as well as the cosmetic and functional disability. Ideal donor sites should allow scars to lie in hidden areas easily concealed by clothing and should not cause prolonged pain or limit early ambulation. In addition, ideal sites provide a constant vascular pedicle with good diameter vessels, allow rapid flap dissection, and be reasonably distant from the defect to allow a two-team approach for tumor resection and flap harvest. One must be sure that no previous trauma or surgery has been performed in the proposed donor site area. A history of radiation to the donor site area or intravenous drug use in the area also needs to be questioned. Informed consent is important as the potential for morbidity exists, including the need for a wide range of salvage operations and a preconceived alternative flap plan, if necessary. Finally, photos should be taken to clearly document the extensiveness of the disease process and need for repair.

Intraoperative Management

The detail of the microvascular technique will not be covered in this text but selected important principles will be mentioned. The operating microscope needs to be checked prior to the case to ensure it is in working order. All necessary instruments, including the proper suture materials, should be readily available. The operating room nurse should have warm physiosol, 1% lidocaine without epinephrine, heparin, and papavarine available for immediate irrigation. No systemic pressor agents (i.e. dopamine or phenylephrine) should be used by anesthesia.

The use of various anticoagulants and vascular expanders is employed by some to reduce the probability of vascular thrombosis. Some have been shown to produce an advantage in experimental models. The three most commonly used substances include heparin, aspirin, and low molecular weight dextran (a volume expander). Heparin (5000 units) may be given during the last quarter of the venous anastomosis and continued as a low continuous rate of infusion to achieve a PTT of approximately 1.5 times normal value. Aspirin is often given at 5 to 10 grains per day (per rectal or per NGT). Low molecular weight dextran is usually given at a low rate of infusion (20-30 cc/hr) either continuously or as a serial infusion (i.e. 12 hours on and 12 hours off).

Patency of an anastomosis can be tested in various ways. Venous patency is easily evident when the vessel is translucent. Direct observation of expansive pulsation is a reliable indicator of vessel patency, whereas longitudinal pulsation usually indicates a partial or complete obstruction. The Doppler ultrasound can be also used as an indicator of vessel patency. The chances of thrombosis are greatest at the site of anastomosis 15-20 minutes following closure. Therefore, it is customary to observe the anastomosis and test its patency during this period of time. If partial obstruction occurs, gently squeezing the vessel with forceps or massaging the vessel may break up the thrombus. A complete thrombus necessitates resection of the damaged segment and reanastomosis.

Vascular thrombosis is most commonly due to technical error in suture placement, pedicle kinking, or the use of a vessel with a damaged intimal layer. Thrombosis at the venous anastomosis accounts for 9 of 10 thromboses and is more likely due to the slower venous flow and relative stasis of blood at this site. After the first 20 minutes, the next critical period is within the first 3 postoperative days as 90% of vascular thromboses occur during this time. After this time, vascular thrombosis is rare but can be associated with the late development of a hematoma, infection, or fistula. Although neovascularization may occur quickly in thin flaps, thicker flaps may take several weeks before they are independent of their anastomosed blood supply.

Postoperative Management and Care

Proper care after surgery requires nursing and surgical personnel who understand the principles of free tissue transfer. Thus, it is common sense to avoid any pressure in the vicinity of the pedicle or flap. An anastogram at the bedside can illustrate the sites of anastomosis to those not present during the procedure. Supplemental oxygen and cool humidified air should be considered carefully as these can cool a superficial flap and inhibit its blood flow. Strict orders to keep the head in neutral position will limit the tension placed on the anastomosis. Hemodynamics and blood volume should be monitored closely. Although there is little scientific evidence supporting the ideal hematocrit in free flap patients, the consensus among experienced surgeons is somewhere between 27-29, with 30 an appropriate goal. Close surveillance for hematoma formation is necessary to avoid vascular compression and blood pressure needs to be maintained appropriately for tissue perfusion. As stated previously, systemic pressure agents should be strictly avoided in managing blood pressure fluctuations in these patients. Doppler flow measurements of the vascular pedicle should be performed regularly to ensure it patency.

Pharmacotherapy has become routine is free tissue transfers. As discussed earlier, aspirin is initiated after surgery using 5-10 grains daily for 2-3 weeks in order to inhibit platelet and endothelial cyclooxygenase. Dextran is used for its viscosity lowering properties and inhibition of rouleaux formation. Heparin is continued as part of most postoperative protocols for at least the first 3 postoperative days. Antibiotics are given as usual for head neck procedures and delirium tremens prophylaxis should be administered for at risk individuals.

As the majority of free tissue transfer fail secondary to vascular anastomosis problems, early detection and timely repair can often salvage the flap. Although many different methods exist for early detection of vascular thrombosis, the current standard is clinical evaluation. This is accomplished by visually inspecting the flap color, turgor and capillary refill, dopplering the pedicle frequently during the first 3 days, and performing the prick test daily. A healthy flap will be pink, warm, minimally edematous, and will have a capillary refill time of 1-3 seconds. The prick test will produce 1-3 drops of bright red blood. Venous anastomosis thrombosis, implicated in over 90% of flap failures, is clinically evident with a dark blue congested appearance of the cutaneous portion of the transferred tissue and often with concurrent hematoma within the operative site. This occurs as thrombosis of the venous outflow causes a high-pressure buildup within the flap, and consequent diffuse bleeding from the flap soft tissue. This is usually obvious clinically and recognition is followed by immediate return to the operating room for exploration, thrombectomy, and revision anastomosis. Using established techniques, over 50% of those flaps developing venous thrombosis can be salvaged. If the anastomosis cannot be salvaged, heparinization and the use of medicinal leeches can occasionally buy enough time for peripheral revascularization to occur so as to result in partial or total flap salvage. However, these later measures never replace exploration unless there is some reason the patient is unfit to return to the operating room. Arterial anastomosis thrombosis is uncommon but produces a pale, cold flap with no bleeding after pricking. Treatment is immediate return to the operating room with reanastomosis.

Because early detection of flap compromise allows for earlier intervention and higher chances for successful salvage, numerous adjuncts to clinical assessment have been devised. Temperature measurements have demonstrated good reliability, however, thin skin flaps and those placed intraorally have negligible temperature drops, especially with venous thrombosis. In addition, fluctuations in surface, peripheral, or core temperature can provide misleading data about the viability of the flap. Technetium scanning within the first week after surgery can be valuable for evaluating the perfusion of composite bone grafts, however its use after the first week is unreliable. Single-photon emission computed tomography (SPECT) may be a useful indicator of flap viability, however few centers have such technology. Infrared spectroscopy to noninvasively monitor the concentrations of oxy- and deoxy-hemoglobin in the flap is available at some centers, however is ex[pensive to use and results are variable. Transcutaneous and intravascular devices which measure oxygen tension, pH, and carbon dioxide levels have met with great enthusiasm however may not live up to its lofty goals. The laser Doppler flowmeter also holds promise, however it is not applicable to deep flaps in the oropharynx. Therefore, as there is no perfect objective device that accurately indicates flap failure consistently, clinical assessment remains the standard.

Reconstructive Planning

A basic goal in reconstructing of head and neck defects is to maximize cosmesis and function while minimizing the complexity and risk involved. Free tissue transfer is not only expensive and difficult to perform, but the donor site morbidity and more complex postoperative care make it an option that must be considered carefully. Therefore, for each surgical defect, one must consider all reconstructive options. In many instances, a non-free flap reconstruction should be employed. There are many forms of reconstruction available and only after carefully weighing the potential added advantage of free tissue transfer as compared to more simplistic methods, should it be employed. Options that should be considered in each patient include 1) healing by secondary intent, 2) primary closure, 3) skin grafts, 4) local flaps, 5) myocutaneous flaps, and finally 6) free flaps.

Oral Cavity and Oropharynx Reconstruction

Within the oral cavity, one has thin pliable mucosa covering the buccal surfaces, floor of mouth, lips, and palate. All reconstructive options should be considered for defects involving the oral cavity and often primary closure or skin grafts allow for appropriate function and cosmesis. However, these can result in contracture and reduced mobility and function. In addition, myocutaneous flaps are often too bulky to reconstruct the thin resected surfaces. Therefore, some free flaps such as radial forearm, scapular or parascapular, upper arm, lateral thigh, split jejunum, or gastric flaps may be more appropriate options in selected patients. Of these listed, the radial forearm is used most often.

Radial Forearm Free Flap

The radial forearm flap has its arterial source as the radial artery and its venous outflow from the superficial veins of the forearm and the deep vena commitantes which accompany the artery.

Advantages:
1) Thin skin with long, large vascular pedicle
2) Easy positioning for two team harvest
3) Potential for sensate flap with antebrachial cutaneous nerve
4) Potential for unusual shapes with large donor site
5) Potential for vascularized bone attached to flap
6) Ease of preoperative evaluation

Disadvantages:
1) Possible loss of hand (must ensure ulnar system is patent with Allen's test or Doppler)
2) Donor site defect cosmetically unappealing
3) Donor site usually requires skin graft for closure
4) Must ensure fascia is covering tendons to prevent loss of function
5) Potential for pathologic fractures when bone is taken

Scapular/Parascapular Free Flap

The scapular and parascapular free flaps are both fasciocutaneous flaps which can be harvested independent of bone and have the circumflex scapular artery as their pedicle. The accompanying vena commitantes drain the flap. As the circumflex scapular artery emerges from the triangular space bounded by the teres minor and major muscles and the long head of the triceps, it branches into horizontal and vertical fasciocutaneous branches overlying the scapula. Scapula (horizontally oriented) or parascapular (obliquely oriented) fasciocutaneous or osteofasciocutaneous flaps can be harvested from these two branches.

Advantages:
1) Large skin paddle that is easy to harvest
2) Low donor site morbidity
3) Possibility for including scapula for necessary bony reconstruction

Disadvantages:

1) Thicker skin
2) Difficult positioning for two team harvest

Lateral Arm Free Flap

The upper arm flap has seemingly the best of both worlds as it is easy to harvest with two teams and has little donor site morbidity apart from a vertical scar. The flap is based on the posterior radial collateral artery which branches from the profunda brachia artery. The flap is drained from its vena commitantes which travel with the radial nerve in the spiral groove of the humerus.

Advantages:
1) Low donor site morbidity
2) Easy positioning and two team harvest
3) Potential for sensory innervation from the lower lateral and posterior cutaneous nerves

Disadvantages:
1) Short and small caliber artery (1.8 mm average)
2) Thicker subcutaneous tissue

Gastric Mucosa Free Flap

This flap is seldom used in oropharyngeal reconstruction, however its main advantage lies in its excellent mucosal lining potential. The flap itself is harvested from the greater curve of the stomach and is based on the right gastroepiploic artery and its associated venous drainage. Because of the necessary laparotomy and the potential problems with opening the viscera, the flap is not popular.

Advantages:
1) Mucosal surface
2) Very thin

Disadvantages:
1) Laparotomy

Tongue Reconstruction

The tongue is one of the most specialized tissues within the oral cavity. Reconstructive efforts for the tongue should be focused on preserving what has not been lost and preserving adequate shape, volume, sensation, and motion. The extent of the defect, coupled with the adjacent tissues lost (i.e. floor of mouth) and neural integrity of remaining tongue, should dictate what reconstruction may be appropriate. For mobile tongue defects, most forms of reconstruction are adequate as long as they prevent tethering of the remaining tongue. Free tissue transfers may be useful when it is anticipated that contracture with primary closure or a skin graft will make speech or bolus manipulation difficult. This is particularly true with defects involving over one-third to one-half of the oral tongue. Reconstruction of the entire anterior

2/3's of the tongue may be best accomplished with a tubed or coned fasciocutaneous flap such as the radial forearm.

For reconstruction of the tongue base and for total glossectomy defects, one must consider the patient's pulmonary reserve and ability to tolerate aspiration. The goal with total glossectomy defects is to create an adequate oral mound such that the patient can have some approximation of the flap tissue with the palate. Only in this way will they have the potential for intelligible speech and some ability to move a food bolus into the oropharynx. Once in the oropharynx, the bolus must initiate the pharyngeal phase of swallowing and be transferred into the cervical esophagus without significant aspiration. This requires an intact pharynx and an anteriorly based larynx.

Rectus abdominus and latissimus dorsi musculocutaneous free tissue transfers for total tongue reconstruction offer abundant subcutaneous tissue to create the oral mound. The rectus flap has an added advantage of allowing suspension of the anterior rectus sheath to the mandible to prevent gravitational drop of the oral flap tissues.

Rectus Abdominus Free Flap

The rectus abdominus can be harvested as a muscle flap, a musculocutaneous flap, or a musculoperitoneal flap. It is based on the deep inferior epigastric artery and vena commitantes which join with the external iliac vessels. This flap has musculocutaneous perforators which penetrate the anterior rectus sheath in the periumbilical area such that the skin paddle can be harvested with very little underlying muscle if desired.

Advantages:
1) Easy positioning and harvest
2) Long and large caliber pedicle
3) Donor site can be closed primarily with minimal donor defect
4) Large flap can be obtained

Disadvantages:
1) Often bulky
2) Potential for hernia formation particularly if dissection below arcuate line
3) No sensation potential

Latissimus Dorsi Free Flap

The latissimus dorsi flap is based on the thoracodorsal artery and vein. This large fan-shaped muscle arises from the iliac crest and lumbar vertebrae via the thoracodorsal fascia and inserts on the humerus. There is a possibility for muscular nerve reinnervation which can decrease muscle atrophy.

Advantages:
1) Large flap (20 x 40 cm) with long pedicle
2) Low donor site morbidity

3) Possibility for muscle reinnervation via thoracodorsal nerve

Disadvantages:
1) Difficult positioning and two team harvest
2) Postoperative seroma formation common
3) Often bulky flap

Hypopharynx and Cervical Esophageal Reconstruction

Because pharyngeal and laryngopharyngeal carcinomas often have significant submucosal spread beyond the obvious tumor boundary, the extent of surgical defect can be greater than anticipated preoperatively. Therefore, with the exception of the smallest tumors, a plan for reconstruction of a complete circumferential defect should be considered preoperatively. Typically, if 3 centimeters or more of mucosa remains, primary closure is advocated. If less than 3 centimeters remain, consideration for a pectoralis major regional flap or radial forearm free flap should be considered. For total loss above the thoracic inlet, a tubed pectoralis major flap, radial forearm free flap, scapular free flap, lateral thigh free flap, or free jejunum flap could be considered. If total loss occurs below the thoracic inlet, a gastric pull-up should be a consideration in the reconstruction effort.

Lateral Thigh Free Flap

The lateral thigh flap is supplied by the third perforator of the profunda femoris artery and the accompanying vena commitantes.

Advantages:
1) Large amount of thin, hairless skin
2) Low donor site morbidity
3) Easy positioning and two team harvest
4) Flap may be reinnervated by the lateral femoral cutaneous nerve

Disadvantages
1) Difficult dissection
2) Small variable pedicle

Jejunum Free Flap

The jejunum is a popular method of reconstructing complete defects of the hypopharynx. This flap is based on a portion of the superior mesenteric arterial arcade. This flap is usually harvested by a general or plastic surgeon as it requires a laparotomy. As a flap to reconstruct the pharynx, it seems ideal as it is a mucosal lined muscular tube. For a person with xerostomia, the mucosal surface may aid with lubrication and bolus transit. However, peristalsis of the mucosal segment is typically uncoordinated and can produce retrograde movement of the bolus. In addition, as the flap is lined with serosa, there is no neovascularization potential and it remains permanently dependent of the vascular supply.

Advantages:
1) Tubular
2) Mucosal surface
3) Minimal donor defect

Disadvantages
1) Bowel or pharynx fistulas
2) Need for laparotomy and bowel preparation
3) Short pedicle
4) Lack of neovascularization
5) Reverse peristalsis
6) Poor tracheoesophageal speech
7) Difficult to harvest in obese people

Mandibular Reconstruction

Loss of the anterior mandibular arch results in the loss of chin and lip support, sensory loss, malocclusion, and retrognathia. These result in severe cosmetic deformity and functional deficits, including lack of oral competence and extreme difficulties with eating and speaking. Reconstruction of this portion of the mandible is considered by some as one of the few absolute indications for a free tissue transfer. Other methods of reconstruction such as the use of reconstruction plates and nonvascularized bone grafts result in much poorer functional and cosmetic results, and are associated with much higher rates of failure. Reconstruction with regional bone-containing flaps is much less optimal as all such flaps have a tenuous blood supply to the attached bone. Regional flaps such as the sternocleidomastoid muscle with clavicle, pectoralis major with rib, trapezius with spine of scapula, and latissimus with rib have been utilized but do have a higher likelihood of flap failure. The usual candidates for bone containing free flaps used for mandibular reconstruction include the fibula, iliac crest, scapula, and radius.

Fibula Free Flap

The fibular free flap is based on the peroneal artery and the accompanying vena commitantes. The variability in blood supply is one reason this flap may not be acceptable in certain patients. Aberrations in blood supply to the foot can occur in up to 10% of the population with the peroneal artery being the dominant vessel to the entire foot. In order to verify this is not the case preoperatively, it is necessary to have an imaging study of the lower extremity vasculature (i.e. an angiogram or MRA). Peripheral vascular disease can also affect the normal circulation of the foot thereby necessitating a preoperative imaging study as well.

Advantages:
1) Longest and strongest bone stock
2) Low donor site morbidity
3) Easy positioning and two team harvest
4) Excellent periosteal blood supply allows contouring of bone
4) Easily supports osseointegrated dental implants

Disadvantages
1) Higher incidence of vascular disease and anomalies
2) Limited cutaneous paddle
3) Slight reduction in ankle strength and limited great toe flexion
4) Small chance of chronic ankle pain

Loss of the lateral mandible (posterior to the mental nerve foramen), will result in a concavity of the cheek, mandible rotation to the defect side with cross bite malocclusion, remnant rotation superiorly and medially, and mental nerve loss. These losses are much easier to adjust to than anterior loss. However, in a relatively fit patient with or without dentition, the advantages of reconstruction compared to primary closure without reconstruction can be dramatic. The iliac crest free flap is good consideration for reconstruction of these lateral defects.

Iliac Crest Free Flap

The iliac crest is based on the blood supply from the deep circumflex iliac artery, which arises opposite the deep inferior epigastric artery (the blood supply to the rectus flap). This flap has a thick bone stock and can support osseointegrated bone implants. The bone can be harvested by incorporating the anterior iliac spine which can nicely reconstitute the mandibular angle when this is taken with the resection. Unfortunately, the skin component is often too thick and immobile to allow good intraoral coverage. Thus, the internal oblique muscle component is usually harvested with the flap and draped into the oral cavity and allowed to mucosalize by secondary intent or be skin grafted.

Advantages:
1) Thick bone stock
2) Easy positioning and two team harvest
3) Defect closed primarily
4) Minimal donor deformity

Disadvantages:
1) Bulky soft tissue component
2) Poor reliability of skin paddle
3) Pelvic pain and the risk for hernia formation
4) Decreased postoperative ambulation
5) Possible risk to peritoneum and bowel

The scapular free flap and radial forearm free flap discussed earlier can both incorporate an osseous component thereby allowing for mandibular reconstruction. The scapular osteocutaneous flap which adds the lateral border of the scapular blade contains bone much thinner than iliac crest and fibula and will not support osseointegrated implants. It can be harvested into two independent paddles based on the scapular and parascapular branches which can allow for simultaneous reconstruction of both internal and external soft tissue defects. The radial forearm free flap can also incorporate up to 40% of the radius diameter. This does not allow for dental rehabilitation and pathologic fractures can occur in the remaining radius.

Skull Base Reconstruction

Skull base reconstructions are usually accomplished with bulky, well vascularized flaps such as the rectus or latissimus flaps. These flaps are positioned against the skull base with the flap muscle packed into the orbital, nasal, paranasal, infratemporal, or temporal skull base defects. Thus, the contaminated extracranial space can be separated from the dural repair.