TITLE: The Fibula Osteocutaneous Free Flap for Mandibular Reconstruction
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Introduction/History

The Fibula Osteocutaneous Free Flap (FOFF) is a free tissue transfer of the fibula bone, its vascular pedicle, and soft tissue/skin from the leg (donor site) to another site in the body (recipient site). It has been used as a graft in multiple different reconstructive surgeries. As a microvascular procedure, the FOFF requires harvesting the blood vessels that supply the tissue at the donor site (leg), removing the supplying artery/veins intact with the graft, and re-anastamosing them to a new blood supply at the recipient site. The FOFF was first described by Taylor et al in 1975 for the purposes of reconstructing the lower extremity. Hidalgo described the use of the FOFF for mandibular reconstruction for the first time in 1989. Today, it is the most popular flap used for reconstruction of the mandible.

Relevant Anatomy

The FOFF derives its arterial blood supply from the peroneal artery, which is harvested along with the fibula bone to serve as its vascular pedicle. Two paired veins running with the peroneal artery, commonly referred to as the vena comitantes, are also harvested as the venous supply. Depending on the soft tissue deficit at the recipient site, a variable amount of soft tissue and skin can be harvested along with the fibula bone. Part of the flexor hallicus longus or soleus muscle may be harvested as well skin. The amount of soft tissue available for harvest will depend on the sept-cutaneous perforators branching from the peroneal artery to supply the skin over the lateral compartment of the leg. The anastomosis site for the flap is variable. Most commonly, the facial artery is used in an end-to-end anastamosis. Alternatively, any branch of the external carotid that is healthy can be used. Even the external carotid itself can serve as the anastamosis site, but this requires and end-to-side technique which is less desirable. Nearby veins in the face are used for the venous anastamosis.

Indications

Mandibular defects often result in abnormal speech, mastication, and cosmesis. The goal of a reconstructive operation should be to restore speech to be understandable, reconstruct a functional jaw that allows for a dental implant/normal diet, and restore facial aesthetics. Four different types of osteocutaneous free flaps exist for mandible reconstruction. They are the parascapular free flap, anterior iliac crest free flap, radial forearm free flap, and the FOFF. The FOFF is indicated for mandibular reconstruction secondary to traumatic injury, inflammatory/infectious destruction (ex: osteomyelitis or osteoradionecrosis), invasion by neoplasm (benign or malignant), and congenital abnormalities. It is also indicated for large mandibular deficits requiring more than 10cm of bone.

Advantages

The FOFF allows for free tissue transfer in a one-stage procedure using a single donor site. The associated skin paddle can be up to 25cm long and 5cm thick. In addition, the FOFF offers several advantages over the other free flaps. Up to 25-30cm of bone can be harvested for reconstruction of the mandible (depending on the patient). By comparison, a maximum of 10-15cm can be harvested in the three other free flaps previously mentioned. The blood supply to the fibula bone is both intraosseous and segmental, allowing the surgeon to perform osteotomies on the bone in order to reshape it. Since the donor site (in the leg) is far away from the recipient site (in the head), two different surgical teams can work simultaneously with the patient in the supine position. This reduces the operative time by several hours. Like the mandible, the fibula bone is bicortical, providing a favorable site to hold screws for plating. Finally, the peroneal artery is easily monitored by doppler in the post-operative period because it remains large as it parallels the fibula bone.

Limitations

The FOFF has a number of limitations. First, its vascular pedicle length is usually around 5cm if the whole length of the fibula is harvested. This is comparatively less than the other flaps (10cm pedicles). This limitation can impact the ability of the surgeon to find an adequate arterial anastamosis site for the reconstruction. If a smaller length of fibula bone is needed for reconstruction, however, the vascular pedicle can be extended to be comparable to the length obtain with the other free flaps. Second, the FOFF is limited by the presence of peripheral vascular disease. Significant atherosclerosis in the lower extremity may result in flap failure or significant donor site morbidity. The FOFF is affected more severely by this factor than the parascapular and radial forearm free flaps. Third, the FOFF leaves a long scar in a conspicuous place. Scars from other flaps can be more easily hidden under clothing. Forth, a limited number of osteotomies can be made on the bone before risking graft compromise. Controversy exists over the number that can be made safely, but a general guideline is limiting osteotomies to 2 or less.

Contraindications

Contraindications to the procedure include a history of peripheral vascular disease, unfavorable imaging of the lower extremity, venous insufficiency, need for independent

positioning of the soft tissue relative to the bone, and anomalous lower extremity vasculature (particularly Class III vasculature of the leg, see below)

Pre-operative Work -Up

Preoperative work-up for the FOFF requires some form of imaging to assess the lower extremity arterial vasculature. Initially, controversy existed about the need for imaging. It was proposed that only patients with abnormal physical exams should receive imaging for a pre-operative evaluation. Many congenital vasculature anomalies, however, are not detectable by physical exam alone. Imaging must rule out atherosclerotic lesions and congenital anomalous vasculature that would result in significant donor site morbidity or graft compromise. Conventional angiography is considered the gold standard but it is expensive, invasive, and results in significant patient irradiation. CT angiography has good sensitivity and specificity, but also subjects the patient to radiation. MRA avoids radiation and is less expensive than conventional angiography, but is not available at every center. Duplex doppler is accurate and allows mapping of cutanous perforator vessels, but is highly operator dependent.

Variability in Lower Extremity Vasculature

Leg vasculature is divided into three classes. In class I, the popliteal artery branches below the knee joint. The vast majority of individuals (over 90%) fall into class IA. In these patients, the popliteal artery bifurcates into the anterior and posterior tibial artery below the knee joint. The anterior tibial artery penetrates the interosseous membrane to enter the anterior compartment of the leg while the posterior tibial artery remains in the posterior compartment of the leg. The peroneal artery in class IA branches from the posterior tibial artery and supplies the fibula bone as well as soft tissue over the lateral compartment via branching septocutaneous perforators. Class IB differs from class IA in that the popliteal artery trifurcates into anterior tibial, peroneal, and posterior tibial arteries in the same location below the knee joint. In Class IC, the peroneal artery branches from the anterior rather than the posterior tibial artery.

Class II vasculature involves branching of the popliteal artery more proximal in the leg, typically at the level of or above the knee joint. Class III vasculature describes individuals in which one or both of the tibial arteries is hypoplastic. As a result, the peroneal artery is large and provides blood supply to the foot in place of the hypoplastic artery. In class IIIA, the posterior tibial artery is hypoplastic. The anterior tibial artery is hypoplastic in class IIIB. Both anterior and posterior tibial arteries are hypoplastic in Class IIIC (also known as arteria peronia magna). In this class, the peroneal artery is the sole blood supply to the foot.

Donor Site Morbidity

Morbidity of the donor site is typically mild with the FOFF. In addition, any problems/complications tend to resolve with time (typically around 3 months). Residual pain, leg weakness, temporary foot drop, and edema may occur. Ankle weakness or instability occasionally occurs but the risk of this complication is minimized by leaving the distal 4-10cm of the fibula intact. The donor site may require a skin graft if the amount of skin and soft tissue harvested with the graft is significant. By comparison, other osteocutaneous flaps have donor site morbidities that worsen with time. In particular, the iliac crest flap donor site is prone to

secondary herniations. Parascapular flap patients may experience difficulties with arm abduction.

Outcomes

Outcomes with the FOFF have generally been good. Hidalgo published a follow- up study in 2002 tracking the outcomes of patients who received FOFF for mandible reconstruction in the late 1980's and early 1990's. The study examined outcomes of facial aesthetics, diet, speech, bone resorption of the graft (measured by X-ray), and donor site morbidity. The mean follow-up time was 11 years. During the time period examined, 82 patients underwent FOFF for mandibular reconstruction. 34 patients were still alive at the time of the study and 20 participated. 15 patients underwent radiation therapy (2 pre-operatively, 13 post-operatively). 55% of patients had an excellent aesthetic outcome. 20% had a good outcome and 25% had fair/poor results. Hidalgo noted that these outcomes were similar to the facial aesthetic evaluations in the immediate post-operative period and had remained stable over the follow-up period. 70% of patients reported eating a regular diet while 30% required a soft diet. Speech was generally good with 85% of patients exhibiting speech that was easily intelligible. The other 15% of patients had speech that was intelligible with effort, but these patients all underwent partial glossectomy during their FOFF procedure. Hidalgo measured bone resorption of the reconstructed mandible by taking X rays of the jaw at three different places: the midbody, midramus, and symphysis. The height of the reconstructed mandible was measured and compared to the immediate post-operative X-rays taken at the same locations. The mean midbody height was 92% of that in the post-operative period. The midramus and symphyis heights were 93% and 92% respectively. Long-term donor site morbidity was found to be minimal. No patients suffered any significant long-term disabilities as a result of the procedure. Three patients out of the twenty described occasional leg weakness, but only one of them was limited in activity. One patient even reported being able to run a marathon.

Conclusion

The FOFF is a free tissue transfer procedure utilizing microvascular techniques that can be used to the reconstruction of the mandible. It is particularly useful for reconstructing large bony defects of the jaw bone. The pre-operative workup requires imaging to assess the lower extremity vasculature. Donor site morbidity is low and long-term outcomes have been relatively good.

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