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Literature Review for Iliaca, Scapula, and Fibula Free Flap as A Modality in Mandibular Ameloblastoma Reconstruction

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ABSTRACT

Introduction: Mandibular reconstruction is complex as there are multiple goals for the final outcome, with a main focus of returning form and function as close to baseline as possible. It may be challenging for ameloblastoma treatment which is focused on surgical resection with a wide margin of normal tissue because of its high propensity for regional invasion. Free vascularized bone flaps are widely recognized as the optimal reconstruction for this case and have been widely developed from the iliaca, scapula, or fibula.

Methods: Using the PubMed and Google Scholar databases, we searched for reported cases of ameloblastoma published in the English-language literature.

Results: We were able to retrieve 47 acceptable literatures and perform a comprehensive literature review, particularly those using microvascular composite free flaps, then compared iliaca, scapula, and fibula free flaps to identify optimal flap choice for mandibular reconstruction. In addition, we present an additional case of ameloblastoma affecting the anterior mandible in a 26-year-old male patient.

Conclusion: Microsurgical techniques are now considered safe and reliable in reconstruction of the jaws by reestablishing the continuity and normal anatomy, aiding to restore the normal function of swallowing, mastication, and speech production. In our experience, free osteocutaneous fibula flap technique is a further confirmation of its potential in the reconstruction of hard and soft tissue in maxillofacial surgery.

Keywords

Fibula Free-Flap, Illiaca Free-Flap, Scapula Free-Flap, Mandibular Reconstruction, Ameloblastoma

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INTRODUCTION

Ameloblastoma presents clinically as a slow-growing relatively painless tumor. It constitutes about 14% of all jaw tumors and cysts, and it is the most prevalent odontogenic tumors in developing countries1. Due to naivety and limited healthcare facilities, ameloblastoma patients in developing countries often present with massively grown lesions before seeking care.[1,2]

Ameloblastoma has no established preventive measures although majority of patients are between ages 30 and 60 years. Ameloblastoma is an aggressive odontogenic tumour that forms from odontogenic epithelium within a mature fibrous stroma devoid of odontogenic ectomesenchyme with unlimited growth capacity.[3]

Due to its locally aggressive growth characteristics, ameloblastoma can rapidly become a massive and expansile tumour causing tooth mobility, tooth displacement, and a grotesque facial appearance if the patient

delays getting treatment. Treatment of ameloblastoma is focused on surgical resection with a wide margin of normal tissue because of its high propensity for loco-regional invasion which often time needs a mandibular resection.[4]

The mandible frames the lower third of the face and represents an integral component of mastication, deglutition, phonation, and oral competence. This structure also represents a major component of the human form, capable of suggesting either strength or weakness of character. The effect of mandibular resection can thus prove devastating to the psychological and physical welfare of the patient. In the pursuit of perfect restoration of defective mandibles, reconstructive surgeons have made numerous technical advances over the past several decades.[5]

Today, free vascularized bone flaps are considered the treatment of choice in mandibular reconstruction for extensive bone defects over 6cm resulting from trauma, infection, or tumour resections.[6,7,8] Since 1989, when Hidalgo first used the free vascularized fibula flap as a new method for reconstruction of the mandible, it has become an effective and safe procedure, giving excellent results both functionally and aesthetically.[9,10]

With the various free flap options now available, reconstructions of composite mandibular defects have been able to achieve significant improvements in both functional and aesthetic results. The unique features of each flap have been well characterized in the literature. The quality of each type of bone is distinct, as is the quality of the accompanying skin portion. Moreover, double free flaps should be considered for patients in whom defects are extensive or recipient vessels are not readily available. Common reconstruction options are the fibula, iliac crest, tip scapular and lateral scapula border free flap.[11,12,13]

The present study reviewed mandibular reconstructions, particularly those using microvascular composite free flaps, and compared iliaca, scapula, and fibula free osseous and osteocutaneous flaps to identify optimal flap choice for mandibular reconstruction.

METHODS

Literature search in PubMed and Google Scholar databases was performed for this review using the search terms ‘ameloblastoma’, ‘reconstruction’, and ‘free flap’. The inclusion criteria were all types of articles published in PubMed and related only to humans. The exclusion criteria were articles for which full text was not available, were not in English, or were grey literature.

We were able to retrieve 47 acceptable literatures and perform a comprehensive literature review, particularly those using microvascular composite free flaps, then compared iliaca, scapula, and fibula free flaps to identify optimal flap choice for mandibular reconstruction. In addition, we present an additional case of ameloblastoma affecting the anterior mandible in a 26-year-old male patient

RESULTS

A 26-year-old patient presented to the Regional Hospital Reconstructive and Aesthetic outpatient ward with a massive mass on his mandible that had been increasing in size for three months prior (Figure 1). Patient had history of recurrent trauma to the mandible. The patient also presented with difficulty in speech and mastication.

During the biopsy, a tumor mass was found that spanned from the left down to the right mandibular angle and had a distinct boundary with thin and fragile walls which later Anatomic pathology examination result showed an ameloblastoma with granular cell components. The Patient was later referred to a Tertiary Hospital for further Mandibular Reconstruction and undergone microvascular free flap (Figure 2). A free vascularized Fibula Osteocutaneous Free Flap based on the peroneal artery was elevated in the left fibula region. The vascularised fibula bone flap was elevated including these branches and a small muscle cuff of flexor hallucis longus. The flap was then transferred to the orbital defect and fixed using titanium mini-plates.

Figure 1. Intraoperative Fibula Osteocutaneous Free Flap surgery.

For soft-tissue coverage, a pedicled flap was procured from the fibula region to fill a large mandibullary defect. The flap was set into the defect and obliterated the alveolar defect (Figure 2). The postoperative course was uneventful. The flap was successful and the patient achieved satisfactory to good facial aesthetics. Four months after the surgery, the patient ate a normal diet and his speech was intelligible. Donor-site morbidity was minimal with an inconspicuous scar, minimal pain and no sensory disturbance in the calve (Figure 2). However, dental implantation believed is needed to achieve a better mastication and overall aesthetic and reconstructive outcome.

Figure 2. A. Postoperative Fibula Osteocutaneous Free Flap surgery. B. 4 months post op

DISCUSSION

The current treatment modality for ameloblastoma is segmental resection of the mandible. Resection with safety margins and prompt reconstruction during the same procedure dan result in a low recurrence rate, good oral function, and high quality of life.[9,10,14]

To restore components of the defect and enable osseointegration, the optimal flap for an oromandibular defect must provide adequate bone whose length, thickness, and width should resemble the mandibula. Suitable donor vessels allow anastomoses to large vessels in the neck, and osseointegrated dental implants can be placed simultaneously or later. Other crucial considerations of ideal free flap selection are restore buccal mucosa or overlying skin with necessary bulk. tolerable scarring in the donor area, no functional deficit, aesthetic appearance, and efficient surgical operation.[4,8,9]

The fibula, scapula, and iliac crest free flaps are the most widely used bone-containing free flaps. These three flaps each have advantages and disadvantages, and choosing the right flap is an important step in the surgical process.[15]

Table 1. Summary of Iliaca, Scapula, and Fiula Free- Flap in Mandibular Reconstruction

Characteristic	Types of Free - Flaps		
	Iliaca	Scapula	Fibula
Perforator artery	Deep Circumflex Iliac Artery (DCIA)[25]	Lateral: Circumflex Scapular Artery (CSA)[28] Tip: Thoracodorsal artery[34]	Peroneal artery (PA)[9]
Quality and quantity	Abundant of vertical and horizontal height[22]	A variety of 3-dimensional shapes able to be harvested[38]	Provide implantation rehabilitation of secondary teeth[40]
Length of Bone	Large concave segment[47]	Variable (8-14.5 cm)[37]	Up to 25 cm[8]
Length of Soft Tissue	Sufficient[14]	Variable[33]	Plentiful[17]
Soft-tissue skin paddle	Potential for two skin paddles[16]	Large skin paddle[36]	Potential for two skin paddles, flexible skin island[45]
Possibility of osteotomy	Limited[17]	Possible[35]	Multiple osteotomies is possible[24]
Optimal reconstruction site	Mandible Lateral and Angle[60]	Mandible body and angle[38]	Various mandible regions[18]
Surgery experience	One team possible[60]	Two team often with resection, makes more crowded and slower[15]	Two team approach, the fastest duration and lowest in blood lost[15]
Dental implant	Easy dental rehabilitation with osseointegrated implants[17,60]	Possible[15,61]	Possible[15,28]
Complication	Donor site morbidity and hernia[25]	Donor site morbidity[15]	Minor complication[63]

Iliaca

Bone and skin paddle are based in the deep circumflex iliac artery (DCIA) and deep circumflex iliac vein (DCIV). These vessels arise from the external iliac vessels16. The external iliac artery and femoral artery meet at the inguinal ligament, and these blood arteries provide the inflow necessary for the DCIA flap. The saphenous vein or a tributary receives the vein that supplies the DCIA before it drains into the femoral vein. The deep circumflex iliac artery (DCIA) bone flap provides a large concave segment of bone suitable for reconstruction of mandible. DCIA transferred sufficient soft tissue with localized blood flow, with greater success in patients previously treated with surgery or radiation.[17,18]

The vascular pedicle of the internal oblique muscle is represented by the ascending branch of the DCIV. The skin paddle is obliquely oriented, with its major axis running along the iliac crest. The blood supply to the iliac crest bone is derived from the DCIV coursing along the inner aspect of the iliac crest in a groove between the iliacus and transversus abdominis muscles. This is located approximately 2 cm from the top of the crest.[19,20] The DCIV are now recommended as nutrient pedicle vessels, particularly for the restoration of large bone defects such as the mandible.[20]

This flap has special benefits. When the internal oblique muscle is included into the flap, it first enables the simultaneous harvesting of a significant amount of bone and soft tissue. Its natural curvature is already anatomically contoured for ipsilateral reconstruction, the abundance of vertical and horizontal height of bone available for mandibular contour and osseointegration and including sufficient skin and soft tissue component for reconstruction for composite or compound defects.[21]

The micro-vascularized iliac crest flap has unique qualities that cannot be found in any other type of flap. First, DCIA vessels are rarely affected by atherosclerosis and are usually of sufficient caliber for carrying microvascular anastomosis in the cervical region. Second, the DCIA flap offers a large quantity of high-quality bone. Third, the DCIA flap ensures easy dental rehabilitation with osseointegrated implants.[16]

It has a good cosmetic appearance of the donor site compared with the other free flaps, which are used for mandibular reconstruction.[21] Additionally, the iliac bone is ideal for placing dental implants, and the muscle component used for resurfacing the nasal and oral lining typically goes through re-epithelialization within a few weeks.[22-24]

The vascularized iliac crest free flap was first described by Taylor et al. in 1979 and it has been widely used for the reconstruction of composite head and neck defects.[22] However, recent years have seen a decline in popularity of this reconstructive resource, and it is rarely selected for head and neck reconstruction by the vast majority of reconstructive surgeons. The main reasons for the decrease in use of this flap include the relatively short pedicle length (8–10 cm), increased harvest time, and donor site morbidity.[25,26] Especially in obese patients when the flap is excessively thick and dissection is more challenging. Vein grafts are frequently required to reach the recipient neck vessels because of the short pedicle caused by the deep circumflex iliac artery system, and this microvascular operation is associated with an increase in complications such as risk of hernia.[23,25-27] The iliac flap experienced a significantly higher rate of loss compared to both the scapula and fibula flaps. In a 2015 review by Markiewicz, which assessed 1221 patients with 1262 mandibular free flaps, the overall flap survival rate was 94.8%. Their study identified the DCIA flap as having the highest odds ratio (OR) for flap loss among all flaps, with an OR of 1.73 relative to other flaps and an OR of 7.4 compared to the radial forearm flap.[28]

Scapula

Lateral

The scapula free flap is known for its robust blood supply and is often considered in cases where a large skin paddle is required. The length of the vascularized scapula used for reconstruction varied from 8 to 14.5 cm, with a mean length of 10 cm. The scapular bone grafts would be sculpted to fit the mandibular defects by strategically located osteotomies.[29]

The circumflex scapular artery serves as the flap's vessel once it passes through the triangular area, which is where the flap's apex is located. Since flap dissection moves from medial to lateral, the trapezius and infraspinatus muscles are crucial landmarks that are recognized early in the dissection. Just above the substantial muscular fascia of the back, in the areolar fascial layer, the flap is elevated.[29,30,31] However, the harvest of this flap is technically challenging and can lead to shoulder stiffness and pain in the donor site.[32,33] During the harvest procedure, the patient is placed in lateral decubitus position. This position allows a two-team approach for simultaneous tumour resection and flap harvesting.[34]

A solid graft is provided that can replace a relatively long bone defect, of up to about 13 cm in length. Soft-tissue bulk is not excessive and donor site morbidity and deformity are acceptable. As the scapular skin island and bone have separate vascular pedicles, three-dimensional manoeuvrability of the flap relative to the bone significantly facilitates simpler reconstruction of the oral cavity without remnant dead space.[32,34]

Tip

Another donor in scapula free flap is the scapular tip free flap (STFF). It is based on the angular branch of the thoracodorsal artery. The unique shape of the scapular tip offers advantages in certain clinical situations. The scapular tip is ideal for the mandibular angle defect. The natural angular shape of the tip can be positioned to match various defects of the body and angle of the mandible while eliminating the need for osteotomies.[35]

Recently, it has regained popularity as a versatile osseous flap that is useful for midface reconstruction.[36] The STFF can be harvested as a stand-alone osseous flap or as part of a complex chimeric

osseous/soft tissue free flap. The vascular pattern of the subscapular system provides unparalleled versatility and freedom between the soft tissue and bone.[37]

Specific advantages of the scapular tip as a donor flap have been neatly summarized by Chepeha et al.[36] These include: (1) a long pedicle, (2) independently mobile tissue components, and (3) a variety of 3-dimensional shapes able to be harvested. Furthermore, the reduced amount of atherosclerotic disease affecting the subscapular vascular system, as compared to lower limb and iliac crest systems, may be important especially in the elderly patients with cancer35. The scapular flap is based on the posterior cutaneous branch of the inferior scapular artery that has a very strong, lengthy, and reliable vascular pedicle. The skin is thin and does not need defatting. The morphology of the mandible angle and the scapular tip are also similar. Therefore, provide relatively good aesthetic outcomes compared to other free flaps in head and neck reconstruction.[36,38,39]

While the fibula is easier for bone shaping due to the arcuate artery property, the scapula is not [21,35,36]. However, the main disadvantage of scapular free- flap raising is the fact that the 2-team approach is sometimes not possible, and intraoperative position changes are time-consuming. Even though 2-team work can be performed by placing the patients in a tilted decubital position, flap raising is still cumbersome because of the proximity between the 2 operation teams. In contrast, fibular flap raising allows a 2-team approach by default.[40-43] Another disadvantage of scapular flap is the scar, which is located on the back of the scapula.

Fibula

The fibula is a non-weight bearing bone in the lower leg. One can expect to harvest up to 25 cm of bone in length, with an average width dimension of 1–3 cm.[9,10] The peroneal artery and venae are located near to the fibula, which makes it possible to harvest it from a single, substantial pedicle. This donor is among the most helpful when osseous reconstruction is necessary due to the length of the bone, the steady blood supply, and the relative simplicity of harvest.[9,10,41]

There are four to eight perforators to the bone at the level of the middle and distal third of the fibula, where these distal vessels are more likely septocutaneous, while the proximal perforators are usually musculocutaneous traversing through the soleus or flexor hallucis longus. Multiple osteotomies are possible due to the segmental blood supply.[9,19,29,40]

The distal end of the fibula forms the lateral malleolus where the bone articulates medially with the talus. The distal six centimetres of the fibula are preserved to avoid disruption of the ankle joint. The skin island can be identified on an axis that is just posterior to the bone's axis.[44,45] The fibular free flap has been widely discussed in the literature because of some of the advantages it provides: a good bone stock suitable for dental implants, a long vascular pedicle, a thin pliable fascia-cutaneous paddle for soft tissue coverage, and the ability for multiple osteotomies.[47,48]

The fibula flaps are quicker to harvest with less blood loss, enough length of fibular bone segment for any length of mandibular defect, and adequate pedicle length.[49] Disadvantages of fibula are the straightness of the bone, necessitating osteotomies for curvature, which add time to the operation and low profile of the fibular bone relative to the height of the native mandible in dentulous patients. Because of the straight shape of the fibular bone, fibular flap is more suitable for anterior mandibular defect.[48,49]

Fibular free flaps were first introduced by Taylor et al for reconstruction of a large traumatic tibial bone defects and was later used for mandibular reconstruction by Hidalgo in 1989.[9,24] Fibular free flaps allow for a 2-team approach and subsequently shorter intraoperative time, low donor-site morbidity, ability to perform multiple osteotomies without compromising bone viability, and the length of the fibula9. There are several studies showing excellent results with a 90% to 97% flap success rate and a superior functional and aesthetic outcome.[50,51,52] Minor complications, such as ossification of vascular pedicle of the fibula around the periosteum and partial or complete skin graft necrosis of the donor site range from 4% to 18%.[53,54] Free fibular flaps have also demonstrated 80% to 97% success rate with osteointegrated dental implants.[50,52,55,56].

The fibular osteocutaneous free flap is favored for its versatility and ease of harvest. It provides extensive soft tissue coverage, and if needed, a double-barrel flap can be used for larger defects, though it increases morbidity and scarring.[57,58,59] We have combined various notes to gather comprehensive information regarding the considerations necessary for choosing the desired flap between the iliac, scapula, and fibula options. The study by Wilkman et al. (2019) [15] was the first to clinically compare the iliac, scapula, and fibula flaps using case reports. Their findings revealed that the iliac flap group had the highest rate of flap loss ($p = 0.001$). The fibula flap was the quickest for reconstruction ($p = 0.001$) and resulted in the lowest perioperative blood loss ($p = 0.013$). While there were no significant differences in early or late complications among the flaps, donor site complications were more severe in the iliac group. Osteotomies and dental implants were successfully performed across all flap types with similar outcomes.[15]

Markiewicz et al. (2015) performed a meta-analysis and determined that survival rates should not influence the choice of donor site for mandibular reconstruction, as the success rate for free flap reconstruction of the mandible is high regardless of the flap type or algorithm used.[61]

CONCLUSION

When choosing a free-transfer flap for a mandibular reconstruction, the surgeon must take into consideration the size of the skin paddle required, the blood supply of the flap, and the potential morbidity of the donor site. The review of this study suggest that free flap reconstruction of the mandible is highly successful. Our experience and the review of literature suggest that, the fibular osteocutaneous free flap is a versatile option that offers a good balance of these factors, scapula, and iliaca flaps may also be considered based on the specific needs of the patient. We conclude that understanding these three distinct alternatives enables the selection of the most suitable flap for each patient's specific maxillofacial reconstruction needs. However, it is important to exercise caution when opting for the illiaca free- flap.

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