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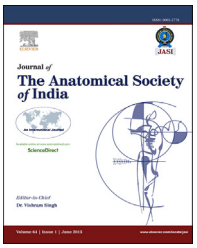

Original Article

Morphometric analysis of fibular graft dimensions for placement of dental implants

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ABSTRACT

Introduction: Surgical resections in the maxilla and mandible due to varied etiologies may lead to significant facial deformities, altered oral functions and subsequent psychological problems, raising the need for advanced reconstruction techniques. The goal of reconstruction being establishment of mandibular continuity with acceptable cosmetic result, establishment of osseous alveolar base for further dental rehabilitation and correction of soft tissue defect.

The present study was aimed for observing the length of the fibular graft with maximum height and width along which the implants with bigger diameter and maximum height can be fitted.

Methods: The study was conducted on thirty dry human fibula bones. The mean length of fibular bone extending from the styloid process to the lateral malleollus was calculated. The mean width at the midpoint was recorded. The mean width of the medial, lateral and posterior surfaces was assessed for compatibility of different standard commercially available dental implant systems.

Results: The study recorded the mean length of the fibula (X–Y) as 35.58 cm, ranging between 32 and 40 cm. Mean length of the bone available for graft (W–Z) is recorded as 16.72 cm. The mean width at the midpoint (A) being 12.83 mm.

Discussion: The maximum width and height of the fibula existed from a point 30 mm proximal to the mid point and 20 mm distal to the mid point and fibular graft if procured between these two points will provide us with maximum width and height. This knowledge would help the maxillofacial surgeons to procure the vascularised graft.

1. Introduction

Major ablative surgeries in head and neck oncology patients lead to significant defects in orofacial region, the latter raising the need for advanced reconstruction techniques. The reconstruction is aimed at restoring function and facial contour resulting in continuous improvement of oral rehabilitation. Various methods of immediate reconstruction are

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implemented by different oral and maxillofacial surgeons from time to time including autogenous non vascular bone graft, allogenic bone graft, autofrozen mandible or reconstruction plates, each having its own merits and demerits. The non vascularised bone grafts completely rely on the recipient bed for revascularization and healing. Vascularised grafts on the other hand provide a good bulk of bone to place implants and satisfactory contour. They have considerably reduced the adverse effects of tumor surgery on the patients' oral function thus revolutionizing the reconstruction in the head and neck region. Lack of vitality as a result of vascular occlusion either arterial or venous might result in graft necrosis, bone resorption and poor bone healing. Though these vascularised bone grafts for mandibular reconstruction can be achieved from radius, metatarsus, thoracic rib and scapula, iliac crest and fibula, fibular graft however has demonstrated high adaptability and reliability for reconstruction. Fibular graft was first used for the reconstruction of lower limb.[1] Later the same was used for the reconstruction of mandible.[2] The primary advantages of the graft being length of the bone (upto 25 cm), trigonal diameter, long vascular pedicle and ability to get osteotomised to provide a favorable facial contour. Implant rehabilitation along with these grafts result in improved facial appearance, function, restoration of speech and mastication.

The present study was aimed for observing the length of the fibular graft with maximum height and width along which the implants with bigger diameter and maximum height can be fitted and give better results both functionally and aesthetically.

2. Materials and methods

The study included 30 dry fibular bones procured from the Department of Anatomy, ESIC Dental College, Rohini, Delhi. The different measurements included:

1. The length of the fibular bone (X–Y) was measured extending from the head at the superior end and the styloid process at the inferior end (Figs. 5 and 6).
2. Two points, W and Z were marked, W at a distance of seven cm distal to the proximal end of the bone, Z at the beginning of the distal third of the bone (Figs. 5 and 6).
3. Mid point of the length W–Z was taken (A). At the regular intervals of 10 mm, points B1,C1,D1,E1 and F1 were marked proximal and points B2,C2,D2,E2,F2 were marked distal to mark A (Figs. 5 and 6).
4. With reference to the mid point (A), surface landmarks p, q, r, s were taken on anterior, medial, posterior borders and medial crest respectively.
5. Corresponding to p, points – p1,p2,p3,p4,p5,p6,p7,p8,p9 were marked at different intervals (B1,C1,D1,E1, B2,C2,D2,E2,F2 respectively) from the mid point A.
6. Corresponding to q, points – q1,q2,q3,q4,q5,q6,q7,q8,q9 were marked at different intervals (B1,C1,D1,E1,B2,C2,-D2,E2,F2 respectively) from the mid point A.
7. Corresponding to r, points – r1,r2,r3,r4,r5,r6,r7,r8,r9 were marked at different intervals (B1,C1,D1,E1,B2,C2,D2,E2,F2 respectively) from the mid point A.

Fig. 1 – Front view photograph, right side hemimandible constructed with vascularised fibular graft.

8. Corresponding to s, other points – s1,s2,s3,s4,s5,s6,s7,s8,s9 were marked at different levels (B1,C1,D1,E1 and B2,C2,D2,E2,F2 respectively) from the mid point A.
9. The four points p,q,r,s were joined with each other and the width of the bone at the mid point A was calculated as (p–q) + (q–r) + (r–s) + (s–p). Similarly the width of the bone was taken at different intervals as follows:

B1 (p1–q1) + (q1–r1) + (r1–s1) + (s1–p1)

C1 (p2–q2) + (q2–r2) + (r2–s2) + (s2–p2)

D1 (p3–q3) + (q3–r3) + (r3–s3) + (s3–p3)

E1 (p4–q4) + (q4–r4) + (r4–s4) + (s4–p4)

B2 (p5–q5) + (q5–r5) + (r5–s5) + (s5–p5)

C2 (p6–q6) + (q6–r6) + (r6–s6) + (s6–p6)

D2 (p7–q7) + (q7–r7) + (r7–s7) + (s7–p7)

E2 (p8–q8) + (q8–r8) + (r8–s8) + (s8–p8)

Fig. 2 – Intraoral view of reconstructed mandible.

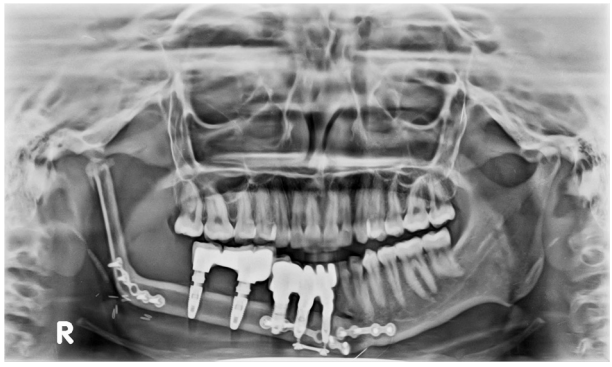

Fig. 3 – Orthopantomogram showing five implants and fixed partial denture.

F2 (p9–q9) + (q9–r9) + (r9–s9) + (s9–p9)

10. Mean of the width taken at all these intervals was recorded (Figs. 5 and 6).
11. After calculating the entire Mean width, Mean width of lateral, medial and posterior surfaces was calculated.
12. Mean width of the lateral surface of the fibula (**P–R**) lying between the anterior and posterior border was calculated.
13. Mean width of the medial surface of the fibula (**P–Q**) lying between anterior and medial borders was recorded.
14. Mean width of the posterior surface between the medial border and medial crest (**Q–S**) and mean width of the posterior surface lying between the medial crest and posterior border (**R–S**) was observed.

3. Results

1. Mean Length of the bone(X–Y) extending between the head of the fibula (superiorily) and the styloid process (Inferiorily) was recorded as 35.58 cm, ranging between 32 cm and 40 cm (Fig. 6).
2. Mean Length of the bone (W–Z) available for the graft, sparing proximal seven cm and distal one third was observed as 16.72 cm (Figs. 5 and 6).
3. Mean width at the midpoint of W–Z (A) was recorded as 12.83 mm ranging between 11 and 15 mm (Fig. 5).
4. Mean width of the lateral surface (**P–R**) was noted as 12.62 mm (range, 9–16 mm).
5. Mean width of the medial surface lying between anterior and medial borders, (**P–Q**) was recorded as 5.6 mm (range3–8.5 mm).
6. Mean width of the posterior surface, between medial border and medial crest, (**Q–S**) was noted to be 7.25 mm (range 7–11 mm).
7. Mean width of the posterior surface, between medial crest and posterior border, (**R–S**) was observed to be 11.25 mm.

Fig. 4 – Intraoral view showing fixed partial denture.

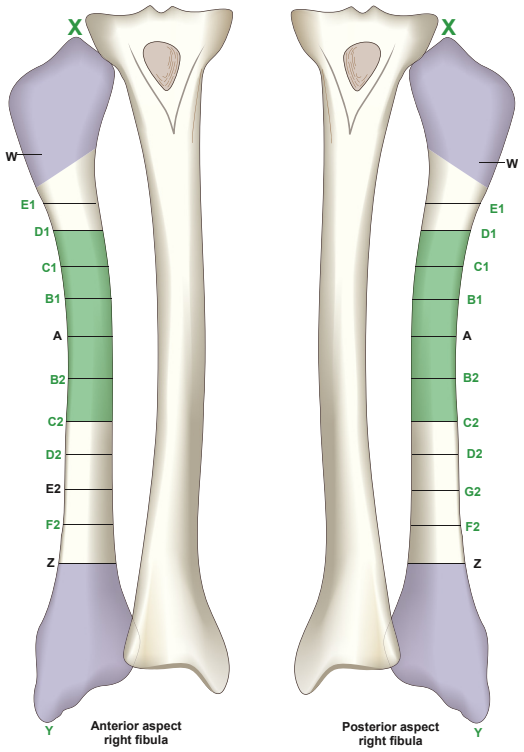

Fig. 5 – Anterior and posterior view of the right fibula showing mid point A, the different intervals B1,C1,D1,E1 (proximal to A), B2, C2, D2, E2, F2 (distal to A) and D1–C2 indicates the length of the bone available for procuring the graft with maximum width and height.

4. Discussion

Segmental mandible defect reconstruction used to be one of the most difficult tasks in maxillofacial surgery. Surgical rehabilitation of patients with orofacial defects pose a common and challenging problem. The surgeon has to balance his

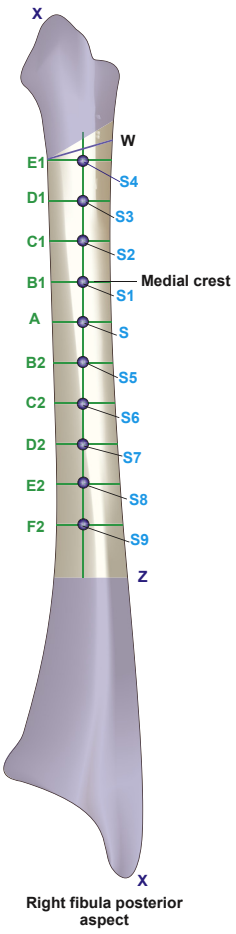

Fig. 6 – Posterior view of right fibula showing the medial crest and the points taken on it. s-Point taken at the medial crest at the mid point A.s1,s2,s3,s4,s5,s6,s7,s8,s9- Points corresponding to s at B1,C1,D1,E1 and B2,C2,D2,E2,F2 respectively.

procedure to achieve best cosmetic appearance with reliable function. In the past few years, microsurgical techniques are considered the gold standard for mandible reconstruction. Various methods of reconstruction have been implemented from time to time, vascular bone grafts involving transfer of osteoid tissue and associated soft tissues from the leg (fibular osteocutaneous free flap), hip (anterior iliac crest free flap), scapula (parascapular free flap) and radius (radial forearm free flap) have revolutionized the reconstruction of composite defects of the oral cavity.

One of the best advances in this area is represented by fibular free transfer. Considering the advantages, fibula is considered to be the flap of choice for the microvascular transfer of bone and associated soft tissues by most of the maxillofacial surgeons.[3–9] The fibula osteocutaneous free flap 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).The FOFF is indicated for mandibular reconstruction secondary to traumatic injury, inflammatory/infectious destruction (osteomyelitis or osteoradionecrosis), invasion of neoplasm (benign or malignant), congenital abnormalities, large mandibular defects requiring more than 10 cm. The advantages of such grafts being available length of the bone, trigonal diameter of the bone, associated soft tissues available, and the ability to accept bicortical implants. Fibular flap can harvest a length of 25–30 cm, compared to other flaps (parascapular, iliac crest and radial) harvesting a length of approximately 10 cm. The blood supply being both intraosseus and segmental allows the surgeon to perform osteotomies on the bone to reshapen it depending upon the extent and location of the mandibular defect.[10] This also makes a surgeon to perform multiple osteotomies without jeopardising bone viability. Moreover just like mandible, fibula is a bicortical bone providing a favourable site to hold screws for plating. The bicortical nature also facilitates osseointegration and less resorption.[11] The ability to harvest the flap concurrent with the resection procedure optimizes case flow and minimizes length of the procedure. Post operative donor site morbidity being very low facilitates the insertion of dental implants owing to the fibular similarity to mandibular width and marble like bone structure.

Viewing these advantages, the present study was conducted on dry fibular bones to assess the length of the bone presenting with maximum height and width along which the implants with bigger diameter and maximum height can be fitted. This knowledge would help the maxillofacial surgeon to procure the vascularised graft, in the living from that part of the fibula bearing maximum width and height.

The study involved calculation of the mean length of the fibula (X–Y, 35.58 cm) extending from the fibular head superiorily to the lateral malleollus inferiorily (Figs. 5 and 6), indicating submuscular and subcutaneous course of the flap. The bone was divided into three parts; the proximal seven centimeter of the bone was spared, as it indicates the approximate insertion of peroneal vessels within the intermuscular septum. The distal one third was also spared for maintaining the ankle stability. Two markings W and Z were made, W about 7 cm distal from the fibular head and Z at the beginning of the distal third of the bone (Figs. 5 and 6). Thus the available bone length, W–Z (16.72 cm) was available for the graft sparing the proximal seven cm and distal one third. The mid point of this length was taken as point A (Fig. 5). Within the length W–Z, the different measurements including width, inferolateral and inferomedial height of the bone were taken at the distances of 10 mm proximal (B1,C1,D1,E1,F1) to the mid point (A) and also at the distances of 10 mm (B2,C2,D2,E2,F2) distal to the midpoint (Figs. 5 and 6). It was observed that the maximum height and width for the graft was recorded between A and D1 (proximal to the mid point) and between A to C2 (distal to the mid point).Thus it can be concluded that, the graft should be procured between two points D1–C2, 30 mm proximal and 20 mm distal to the mid point, A (Figs. 5 and 6).

After procuring the graft between these points, placement of graft is also very important for oral and maxillofacial surgeons as limited height of the fibular flap makes implant supported prosthetic replacement difficult. For better acceptability of the graft, the medial surface (between anterior and medial border) along with the part of the posterior surface (between medial border and medial crest) should be placed medially (lingualy) thus providing us with mean height of 12.25 mm, (**P–Q**) + (**Q–S**). The part of the posterior surface

between the medial crest and posterior border should face occlusally (upper border) providing us with a mean width of 11.25 mm (**R–S**). The lateral surface between anterior and posterior border should face laterally (buccaly) thus providing a mean height of 12.62 mm (**P–R**).

The graft if placed in this manner, can achieve maximum height and width for better dental implant placement and prosthetic rehabilitation.

Fibular graft was used for the reconstruction of the mandilble in a nineteen year old girl presenting with Ameloblastoma (Fig. 1). Right sided mandible was constructed with the help of vascularised fibular graft (Fig. 2). Five dental implants were fixed using fibular graft as shown in Orthopantomogram (Figs. 3 and 4). She had an excellent recovery both functionally & aesthetically. The bone healing occurred without any major complication (Fig. 1).

During the implant placement, one of the important concern of the surgeon is approximation of peroneal artery with the facial or external carotid artery. The peroneal artery also termed as fibular artery is harvested along with the fibula to serve as its vascular pedicle. Two paired veins running with the peroneal artery, commonly referred to as the vena comitants are also harvested as venous supply. A variable amount of soft tissue is also harvested (Flexor Hallucis Longus and Soleus). The amount of soft tissue available for the harvest will depend upon the sept-cutaneous perforators branching from the peroneal artery to supply the lateral compartment of leg. The anastomosis site is variable. Most commonly facial artery is used but alternately branch of External Carotid artery can be used.

The peroneal artery, most commonly arising from the posterior tibial artery 2.5 cm distal to the popliteus passes obliquely to the fibula descending along its medial crest either in a fibrous canal between tibialis posterior and flexor hallucis longus or within flexor hallucis longus. Although some authors do not advocate regular assessment of lower limb vasculature, the arteriography must be mandatory while planning the surgery as patients presenting with peripheral vascular disease, venous insufficiency and anamolous lower limb vasculature are contraindication for such type of surgeries.

For a maxillofacial surgeon, proper placement of fibular graft is very important. For better anastomosis between peroneal and facial artery, we should use the right sided fibular graft for fixing the dental implants on left side. This will provide us with maximum width and height of the graft. The graft should be placed in such a manner that anterior border of the bone is directed medially with the inferior end anteriorily and superior end posteriorily. By practicing this,the peroneal artery (harvested along with the fibula to serve as its vascular pedicle) running along the interroseus border also comes to lie medially and it becomes easier for maxillofacial surgeon to perform end to end anastomosis of peroneal artery with facial artery or external carotid artery. The advantage of using peroneal artery during anastomosis is that it can be easily monitored by Doppler in post operative period as it remains large while paralleling the fibular bone.

Apart from vascularised fibular graft, there are other options using alloplastic materials or alloplast & bone graft together. Alloplastic reconstruction following segmental mandibulectomy is a simple way to maintain mandibular segmental relationships partially preserving form and function for many patients.[12] Alloplastic materials, in the form of stainless steel plates (alloy of iron, chromium, nickel) or vitalium (alloy of chromium, cobalt, molybdenum) can be used but these grafts resulted in facial deformity, poor aesthetics, orocutaneous fistula due to lack of vascularity. The fibula provides the longest segment of bone with 20–30 cm available for harvest. Also, the segmental blood supply of the bone permits multiple osteotomy. The bone is also having adequate width & height to allow placement of osseointegrated dental implants. Donor site morbidity with this graft is minimal unless the distal osteotomy site is within 6 cm of the ankle. In addition the location of the graft will allow simultaneous harvest by a second team at the time of tumor resection. Peroneal nerve injury with resultant foot drop or weakness in planter flexion of the great toe can occur as one of the complications which can be avoided with meticulous dissection.

5. Conclusions

The study concluded that the fibular graft should be procured along a distance of fifty mm, which includes thirty mm proximal and twenty mm distal to the midpoint of the bone so that maximum height and width can be achieved for better dental implant placement. Moreover by placing the graft as discussed in the present study, the fibular or peroneal artery is automatically placed on the medial side for better approximation with the facial or external carotid artery. In the follow up period, orthopantamogram should be done routinely to assess bone resorption and every time compared with the immediate postoperative radiograph.

Conflicts of interest

All authors have none to declare.

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