

Original Article - Prospective Study

Long-term follow-up of tibial bone graft for correction of alveolar cleft

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ABSTRACT

Aims: The aim of this prospective study was to evaluate the quality and stability of autogenous tibial bone graft for the correction of alveolar bone defects in cleft patients in a long-term study as well as to evaluate the postoperative morbidity and risk of complications. **Materials and Methods:** A total of 47 patients with 55 donor sites were involved in this study. The first author performed all the procedures from 2003 to 2011. Medial and lateral approaches were used to harvest the bone with standardized surgical technique. Evaluation in both donor and recipient sites was done by clinical examination, postoperative pain and recovery, and radiographic examination by Panoramic and occlusal X-rays and lateral X-ray for the tibia. Moreover, the donor site was assessed for functionality and mobility based on the Lysholm score. Finally, the patient's experience was evaluated subjectively utilizing a visual analog scale. **Results:** The surgical outcome was satisfied in all except two cases with total graft resorption for unknown reasons. Regarding the postoperative patient experience we found that patients experienced pain in the recipient site more than they did at the donor site at 24-hour and two-week follow-ups. **Conclusion:** We conclude that the proximal tibia is a safe site from which cancellous bone graft can be harvested to repair the alveolus as it carries less early and late morbidity. Thus, we suggest that the tibia is an excellent choice as a donor site for alveolar bone grafting in children and adult with cleft lip and palate with satisfactory long-term stability.

Key words: Alveolar bone defect, cleft lip and palate, Saudi Arabia, tibial bone graft

INTRODUCTION

Cleft lip and palate is a congenital deformity caused by abnormal facial developments during the gestation period. These deformities have adverse physical and psychological defects, which can last from birth through adulthood and require some long-term coordinated treatment. Iliac crest bone graft is considered the gold standard for alveolar cleft defect repair.

When reviewing the literature we found that tibial bone graft was not common earlier among oral and maxillofacial surgeons. However, it was common among orthopedic surgeons.^[1] It gained popularity among the maxillofacial surgeons for grafting in orthognathic, cleft, and preprosthetic surgeries, years later.^[2-4]

Facial reconstruction in cleft patients using tibial bone graft was first done by Drachter in 1914, and since then, relatively few authors have reported the tibia as a donor site for secondary alveolar cleft grafts.^[1] Most of these studies either compare the complication rate with that of the iliac crest, or describe variations in the technique to reduce morbidity.^[5-10] Ilankovan *et al.*^[5] and Chen *et al.*^[10] reported that roughly 25 ml of cancellous bone could be harvested in adults without major complications.

Tibial bone graft had been used mainly in adults; most surgeons did not prefer to use it in young patients to avoid any disturbances to the epiphyseal cartilage that may subsequently affect growth. Therefore, Besly and Ward Booth^[6] modified the technique for harvesting tibial bone in adults to make it suitable to be used in

children; they mentioned that the proximal tibia is small and the epiphyseal cartilage is growing, which means that access must be minimized and located more inferiorly to avoid possible interference with the growth center.

The advantages of harvesting tibial cancellous bone are short operating time, minimal scarring, minimal postoperative discomfort, early mobility, and a short stay in hospital. However, the amount of bone harvested is limited to 25 cc, and in some cases, patients must be informed about the possibility that bone may be taken from both legs. Besides intraoperative discomfort occurring while operating under local anesthesia, certain complications follow tibial bone grafting. Complications such as bone fracture and gait disturbance are reported in the literature to range from 1.3% to 3.8%.^[7,10] Rates of proximal tibial fractures after grafting range from none to 2.7%, and patients are usually advised to avoid engaging in sports for at least 3 months.^[9] Long-term follow-up of potential damage to the growth center after proximal tibial grafting in patients with clefts has not been reported.^[5,8] All these advantages make tibia a donor site favorable for harvesting bone for small defect.

MATERIALS AND METHODS

Patients

Over an 8-year period 2003 to 2011, bone was harvested from the proximal tibia in 55 consecutive instances in 47 cases at the Department of Oral and Maxillofacial Surgery, King Abdul-Aziz University Hospital, Jeddah, Saudi Arabia. Exclusion criteria for this bone harvesting procedure were as follows:

1. Poor general health,
2. Disorders of bone tissue metabolism (e.g., osteoporosis),
3. Complaints involving the region of the donor site (e.g., injuries or previous surgery),
4. All patients with a follow-up less than 1 year.

Bone was harvested unilaterally in 39 patients and bilaterally in 8 patients. The patient group comprised 35 females and 12 males, ranging in age from 9 to 22 years. In 55 instances, the harvested bone was used exclusively as an augmentation material for alveolar bone defects as a result of clefts.

We follow the procedure of Amin Kalaaji *et al.*^[6] according to which indications for bone grafting are stabilization of the maxillary arch; facilitation of eruption of the canine, and the lateral incisor; provision of bony support to the teeth adjacent to the cleft; raising the alar base of the nose and facilitation of closure of an oronasal fistula [Table 1].

Table 1: Distribution of patients based on indication for surgery

Indication	No. of patients
Stabilization of the maxilla and bony support to adjacent teeth	40
Facilitation of eruption of lateral incisors	9
Facilitation of eruption of canines	23
Augmentation of alar base	14
Closure of oronasal fistula	16
Insertion of dental implant	7
Bone support for orthodontic movement into the site	8

Surgical procedure

Bone was harvested as an in-patient procedure under general anesthesia, after adequate preparation, from both the medial and lateral condyles of the proximal tibia.

The patient was positioned supine with the knee flexed to about 45°. The landmarks were the patella, the patellar ligament extending to the tibial tuberosity, the medial and lateral condyles, Gerdy's tubercle (with the lateral approach), and the head of the tibia, which critically identifies the approximate level of the epiphyseal cartilage.

Local anesthesia: A total of 2-4 ml of 2% lidocaine with 1:1,000,000 epinephrine was injected subcutaneously, and deep into the periosteum.

Medial approach

The tibial tuberosity was located and lines perpendicular and parallel to the long axis of the tibia were drawn, intersecting at the center of the tuberosity. A point 15 mm medial to the vertical line and 15 mm superior to the horizontal line was marked; this point represented the desired location for the center of osteotomy.^[11] A 2-3 cm incision was made directly on the medial aspect over the proximal tibia. Branches of the medial, superior, and inferior genicular arteries, which passed under the cover of the patellar ligament as well as branches of the lateral inferior genicular fibular, and anterior recurrent tibial arteries and branches of the anterior tibial arteries, could be encountered during the incision. Bleeding from these vessels was minimal and easily controlled using electrocautery [Figure 1a].

The lateral approach

It is important to locate Gerdy's tubercle, which is a ridge on the lateral anterior aspect of the tibia approximately 2-3 cm below the articulating surface. The iliotibial tract attaches to the top portion of Gerdy's tubercle. Inferior of the ridge of Gerdy's tubercle is the anterior tibialis muscle. This ridge is located on the lateral side of the tibia, two-thirds of the way between the head of the fibula and the midline of the tibial shaft, both of which are readily palpable.

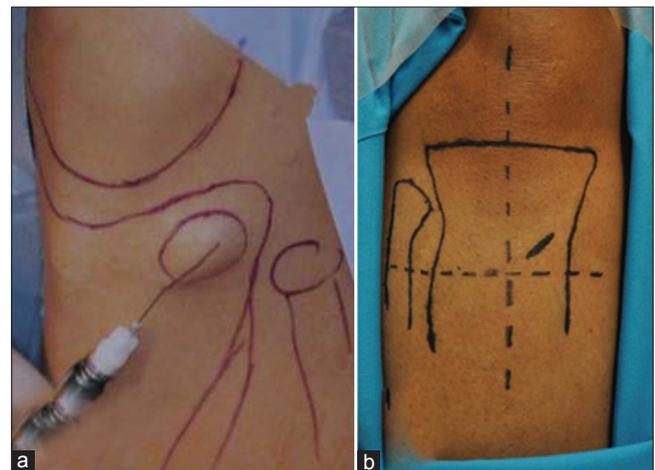


Figure 1: Landmarks and references to approach and to harvest the proximal tibia. (a) Lateral approach. (b) Medial approach

A 2-3 cm incision was made directly over Gerdy's tubercle through skin and incision was angled with its cephalad limit just above and medial to the origin of the tibialis anterior muscle and its caudal extent lateral to the patellar ligament.

The periosteum was reflected, which sometimes required some effort because it was bound rather tenaciously to the underlying bone [Figure 1-b].

Bone harvesting

There are two ways for harvesting the bone from the tibia:

Trephination technique

After bone is exposed only sufficiently to allow a single penetration of the cortex using a serrated cutting-end trephine 5 mm internal diameter with a 27 mm depth stop,^[12] several cores of cancellous bone are harvested in a fan-like pattern. If required further bone can be removed with a curette.

Bone window technique

The bony window is created either by full circumferential window or a window that is left joined medially to the periosteum or to the insertion of the adductors (pes anserinus). It depends on the amount and the type of bone that is needed; if cortical bone is needed then has to be done conventionally by taking out the entire window [Figure 2]. If not then we leave part of the window attached. Spongiosa is then taken from the interior of the head of the tibia through the bony window with bone curettes. After bone harvesting, the bony lid can be repositioned free of the defect before being fixed with a single knot suture.

The surgeon should stand at or above knee level so that the natural direction of entry is downward and across the tibia.

Wound closure

The wound was closed with two deep resorbable sutures to approximate the periosteum, and completed with skin sutures.

The recipient site was closed using a resorbable suture without tension [Figures 3A and B].

Postsurgical Management

A skin pressure dressing was applied for the first 24 hours. After the skin pressure dressing was removed, the wound was checked weekly up to complete recovery, with the healing process recorded in the patient's record. The patient was prescribed the antibiotic, from the day of the operation to the third postoperative day. Postoperative care included analgesia with paracetamol or nonsteroidal analgesics. The leg that was operated on was preferably immobilized and elevated for the first 24 hours after the operation; average physiological exercise of the operated leg was expressly allowed thereafter. After 1 week, running and cycling could be resumed. However, the patient was asked to refrain from any excessive strain, such as skiing or mountaineering, for 6 weeks.

Methods of Investigation

The study comprised of analysis of all 47 patients' records between 2003 and 2011. All 47 patients had required repair of cleft lip and palate. Bone grafting was performed at two stages:

1. Mixed dentition stage in 41 patients
2. Permanent dentition stage in 6 patients.

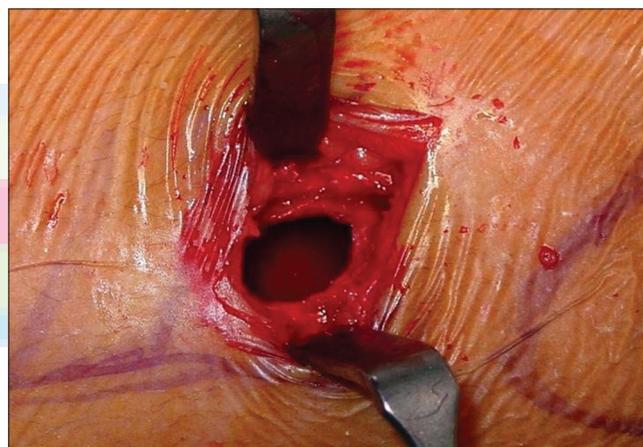


Figure 2: Intraoperative picture after harvesting tibial bone and evaluation of the osteotomy site before closure

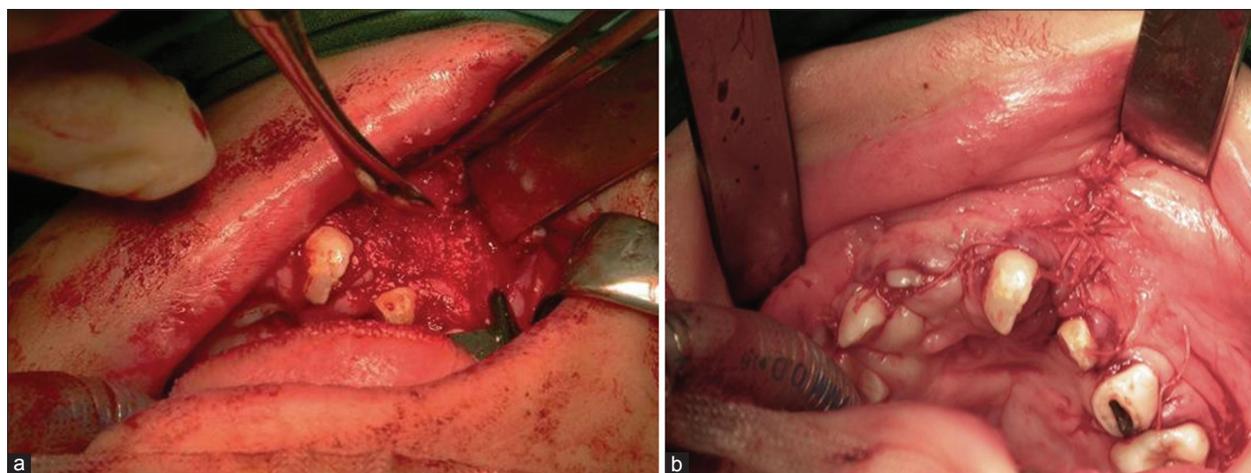


Figure 3: (a) Autogenous tibial graft placed and packed in the cleft site, (b) postoperative picture, showing the flap placed back and sutured with multiple interrupted sutures



Figure 4: Postoperative radiographs of the tibia showing the cortical perforation and its relation to the epiphysis

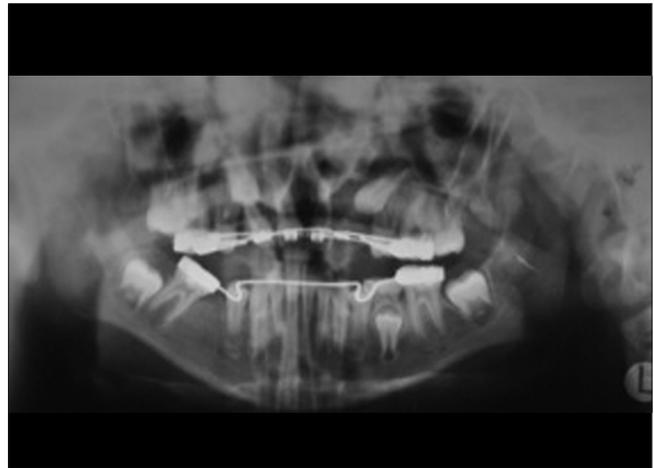


Figure 5: Here is an example, showing the eruption of the canine through the grafted bone; 2 weeks postoperative

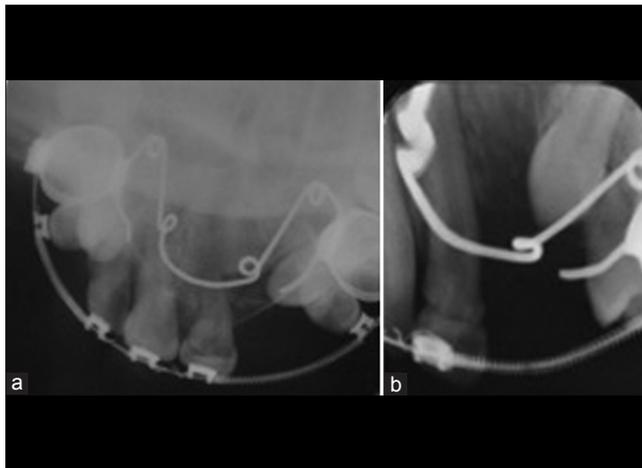


Figure 6: (a) Occlusal X-ray; 6 months postoperative, (b) preapical X-ray; 6 months postoperative



Figure 7: Panoramic X-ray showing complete eruption of the canine

The recipient and donor sites were examined clinically and radiographically in all patients. The authors performed the following examinations:

Donor site

The donor site was assessed for functionality and mobility based on the Lysholm score,^[13] which is a well-validated functional scale designed for knee surgeries. Scoring was out of 100 points; higher the score, better the result. Simultaneously, the patient's subjective experiences were evaluated with standardized questionnaires. A staff member not involved in the treatment scheme performed the interviews and evaluation of results. Postoperative pain was measured using standardized questions on a visual analog scale (VAS).

Postoperative lateral radiographs of the proximal tibia were taken to assess the accuracy of the surface landmarks for locating the harvest site inferior to the cartilaginous epiphysis [Figure 4]. Finally the dimension of the scar was measured in millimeters.

Recipient site

The recipient site was examined radiographically and clinically:

Imaging studies included anterior occlusal, panoramic and periapical radiographs; T1 within 6 months before the surgery, T2 immediately after the surgery, T3 6 months after the surgery, and T4 more than 1 year after the surgery [Figures 5-7]. This was to evaluate the height of the bone and to observe the eruption of canine through the grafted bone.

Clinical examination was done using a bone caliper to measure the bone width at three points: apical, middle, and coronal [Figures 8a and b].

RESULTS

Fifty-five donor sites were evaluated in 47 patients, all of which were tibia. A total of 39 donor sites were approached medially and 16 donor sites were approached laterally. All patients were discharged on the second day of the intervention. There were no



Figure 8: (a) Bone caliper (b) clinical application of the bone caliper to measure the width of the harvested bone

complications intraoperatively or immediately postoperatively that necessitated longer hospitalization. The mean clinical follow-up period of the 47 patients was 5.5 years.

Regarding the postoperative patient experience we found that patients experienced pain at the cleft site i.e., recipient site more than that at the donor site (tibial bone graft harvesting site) at 24 hours and 2-week follow-up. A summary of the results is demonstrated in [Table 2].

The present data showed that the mean length of the procedure of harvesting bone from the tibia was around 20 minutes. Intraoperative blood loss at the donor site area was insignificant (less than 15 ml). One of the advantages of harvesting from the tibia is that there was always the possibility of working with two teams thereby reducing operating time. The resultant scar was insignificant [Figure 9]. A satisfactory amount of cancellous bone, upto 25cc, was always obtained. No major complaints, growth disturbances or permanent gait restrictions at the donor region were reported at any time following the operation.

One patient reported pain and mobility restrictions in the area of the knee for up to 2 weeks after the operation. Two patients noted pain and gait disturbances for more than 2 weeks. One patient reported temporary paresthesia in the donor region, which was only followed up. Wound infection at the recipient site occurred in three cases, all healed successfully after giving antibiotic and daily irrigation with chlorhexidine mouthwash and normal saline. One patient reported pain persisting for two weeks at the donor site without local signs of infection, but recovered without problems. No bleeding, fracture, and shortening of the limb were recorded. Also no hemorrhage or seromas was recorded. Patients were mobilized the day after surgery and could engage in normal physical activities 1 month after surgery. Delayed wound healing after dehiscence caused an unpleasant scar in one case.

Postoperatively, within the first week, all patients recorded a high Lysholm score; 95% of the patients had a score of 100, and the other 5% had achieved a score of 98.



Figure 9: Insignificant scar formation (3 months postoperative)

Table 2: Summary of the results

Total number of donor sites	55
Total number of patients	47
Mean clinical follow-up period	8 years
Mean length of the procedure	20 min
Blood loss in the donor site	Negligible (less than 15 ml)
Mean postoperative hospital stay	1 day

A satisfactory amount of cancellous bone was always obtained

Table 3: Clinical data related to surgery in the recipient site

Complication	No. of patients
Flap dehiscence	8
Total resorption	2
Wound infection	1
Operation of fistula	2
Success rate	97%

Wound dehiscence was observed in eight cases and infection in one case, which healed successfully after application of a dressing. Total resorption was reported in two cases [Table 3].

DISCUSSION

The proximal tibia offers an excellent source of bone grafting material. Advantages of this approach include the ease of harvest and the low complication rate. Patients can walk the same day with minimal postoperative pain.

Historically Von Eiselsberg^[14] in 1901 and Lexer^[15] in 1908 were the first to use autogenous bone graft for the cleft maxilla by a free bone or pedicled soft tissue and bone of the little finger. Drachter^[16] in 1914 was the first to report the closure of a cleft using tibial bone and periosteum.

According to Cohen *et al.*,^[17] the success or failure of the final outcome of the harvested bone does not depend primarily on the source of the bone graft. However, controversies exist about different donor sites regarding the morbidity, amount of bone required, the viability of autogenous bone, type of bone needed (cortical or cancellous), and expected biological behavior (neovascularization and resorption).^[18]

In the 1970s Boyne and Sands^[19,20] described a technique for secondary bone grafting in cleft patients using cancellous bone grafts from the iliac crest.

The advantages of grafting cancellous bone over cortical bone for alveolar cleft repair has been confirmed. Cancellous bone is living tissue having growth factors, which incorporates faster than cortical bone, thus remodelling the maxillary segments and allowing teeth eruption. Autogenous bone from the anterior iliac crest is used widely and advocated most frequently. Others sources like^[15,20] cranial,^[21,22] mandibular,^[23,24] and costal^[18,24] have also been reported. Relatively few authors in the last two decades have reported the tibia as a donor site.^[16,25-28] However, it is becoming more popular nowadays.

The complications that usually follow bone graft from the ilium are much higher than the complications associated with the tibial bone graft. These complications, for instance hypoesthesia or anesthesia over the distribution of the lateral femoral cutaneous nerve, developed in 10.3% of cases.^[18] Gait disturbance and pain lasting for 2 weeks to 2 months were also reported. On the other hand, skull as the donor site is not preferred because of the possible serious complication that might happen with it. Hematoma, excessive bleeding, a long scar, and penetration of the inner table of the cranium were reported when using the skull as a donor site.^[29]

When the skull is used the possibility of two teams to operate simultaneously is limited, which makes the operating time longer. Moreover, it might be difficult to explain the choice of the skull to parents when other donor sites are available.^[30]

Risks involving harvesting bone graft from the mandibular symphysis include damage to the roots of the canine and incisor and injury to the mental nerve.^[30] There is also no possibility for two teams to operate simultaneously, resulting in a longer operating time. In addition, less bone is available from the chin, which might restrict its use to small alveolar clefts.^[31]

The main arguments against the use of rib bone and costal cartilage are postoperative chest infections, pneumothorax, wound breakdown, and an unsatisfactory amount of cancellous bone.^[18] The chest donor site can also cause unpleasant long-term discomfort, and with incorrect placement of the incision the scar will be impossible to hide.^[18]

Bone harvesting from the tibia under intravenous sedation has been described as a well-tolerated procedure.^[4,32] In our series the procedures were done under general anesthesia. Such surgeries could be done under local anesthesia without sedation in adult patients. The advantage of not applying sedation or a narcotic lies in the immediate postoperative mobilization and discharge of the patient. Most patients found harvesting bone from the tibia to be a nonstressful procedure. What they did describe was a scraping sensation during bone harvesting, but no pain. Only five patients reported experiencing psychological and physical stress during bone harvesting. Even under sedation, patients reported physical discomfort caused by the scraping and grating during bone harvesting.^[4]

Based on the results of this study, the harvesting of spongy bone from the proximal tibia under general anesthesia can be recommended. The complication rate is very low, and patient tolerance is extremely high. Nonetheless, before bone harvesting under local anesthesia, patients should be made aware of possible intraoperative discomfort as well as postoperative complaints and impairments that may occur and, last but not least, an unlikely complication as that of a fracture may occur. When comparing medial or lateral approaches, we found that the medial approach is favourable for many reasons: firstly, it avoids stripping of the tibialis muscle. Secondly, there is a close proximity of various anatomical structures, including nerves and vessels, in relation to the lateral portion of the tibia. It was consistently found that branches of the recurrent tibial vessels and nerve course through the anterior tibialis and directly in the area of lateral bone harvested.^[11] Moreover, the lateral approach involves entering the anterior compartment of the lower extremity whereas the medial approach does not require entrance into any of the four lower extremity compartments. Finally, the bone is much closer to the skin surface in this area.

CONCLUSION

Based on the results of this study, harvesting bone from the proximal tibia under general anesthesia is highly recommended to repair alveolar bone cleft. The advantages of harvesting bone from the proximal tibia include the following: short operating time; short scar; early ambulation; minimal complication rate; and, from the psychological point of view, an acceptable choice for parents and children, and extremely high patient tolerance. Although fracture may be an unlikely complication.

We conclude that tibia is an excellent choice. Although the final results of the bone grafting procedure to the residual alveolar cleft in patients with cleft lip and palate might be minimally influenced by the choice of the donor site, the tibial donor site harvesting technique carries far less early and late morbidity. Thus we highly recommend tibia as a donor site for alveolar bone grafting in

children and adult with cleft lip and palate with good long-term stability and minimal morbidity.

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