Proximal Tibia Bone Harvest: Review of Technique, Complications, and Use in Maxillofacial Surgery

James B. Mazock, MS, DDS[1]/Sterling R. Schow, DMD[2]/R. Gilbert Triplett, DDS, PhD[3]

Autologous bone grafts for alveolar ridge augmentation are the gold standard for restoring atrophic residual ridges in preprosthetic surgery. Many indications, donor sites, and techniques have been reported. The purpose of this article is to review the anatomy, surgical technique, and potential complications associated with proximal tibia bone harvest. A consecutive series of 44 patients who underwent proximal tibia bone graft harvest between 2000 and 2003 was studied by retrospective chart review. Five major and 7 minor complications were observed; overall morbidity was low. A significant amount of corticocancellous bone may be harvested from the proximal tibia with minimal morbidity.
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Autologous corticocancellous bone is considered the gold standard material for alveolar ridge augmentation in preparation for implant placement. Various indications, donor sites, and techniques for obtaining autologous bone have been reported.[1–4] Well-accepted donor sites include the anterior and posterior ilium, calvarium, mandible, maxilla, and the proximal tibia.

The harvesting of bone from any site cannot be accomplished without some morbidity. In addition to the need for an additional surgical site, pain, gait disturbances, sensory deficits, and other serious complications have been associated with bone graft procurement.

The quantity of bone needed to complete the procedure often dictates the donor area. Autologous bone harvest from the lateral proximal tibia has been described in the orthopedic literature and used for treatment of lower extremity non-unions. In 1992, Catone and coworkers[5] described the maxillofacial applications of lateral proximal tibia bone harvest. They concluded that there was an overall lack of morbidity and that favorable quality and quantity of bone were available from the lateral proximal tibia. O'Keefe and associates[6] reported on 230 harvests of cancellous bone from the proximal tibia in orthopedic trauma patients and found satisfactory volume, ease of surgical access, and low morbidity. Recently, Marchena and colleagues[7] presented a prospective study with 10 patients who underwent unilateral proximal tibia harvest under intravenous sedation in a day surgery setting. They gathered a mean of 11.3 mL of compressed cancellous bone from each proximal tibia with minimal postoperative discomfort and gait disturbances and no wound complications. The average time for return of normal ambulation was 9 to 10 days.

[1]Chief Resident, Department of Oral and Maxillofacial Surgery, Baylor College of Dentistry, Dallas, Texas.
[2]Professor and Residency Director, Department of Oral and Maxillofacial Surgery, Baylor College of Dentistry, Dallas, Texas.
[3]Regents Professor and Chair, Department of Oral and Maxillofacial Surgery, Baylor College of Dentistry, Dallas, Texas.

Correspondence to: Dr Sterling R. Schow, Department of Oral and Maxillofacial Surgery, Baylor College of Dentistry, PO Box 660677, Dallas, TX 75266-0677. Fax: +214 828 8382. E-mail: srschow@tambcd.edu

Unfortunately, only a few articles that focus specifically on the surgical approach to the proximal tibia and its use as a donor for autologous grafts are available.[5–9] As a result, the proximal tibia may not always be considered as a donor site despite easy accessibility and the availability of high-quality bone.

The purpose of this article is to review the anatomy, surgical procedure, and potential complications of bone harvest from the lateral proximal tibia. A summary of the authors' experience in a consecutive series of patients with a proximal tibia donor site for autologous corticocancellous bone for edentulous alveolar ridge augmentation in preparation for implant placement is reported.

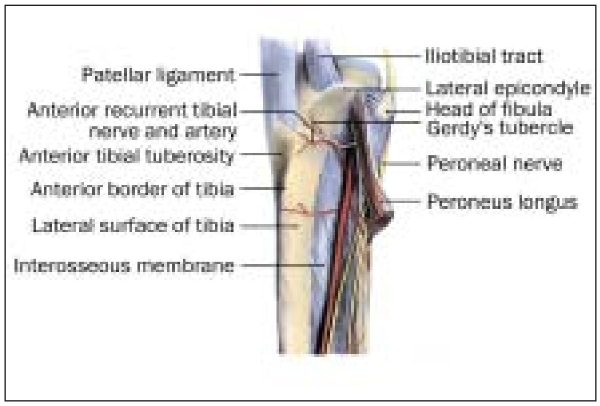

Fig 1 Diagrammatic representation of the left proximal tibia and associated vasculature. The incision location over Gerdy's tubercle is indicated.

ANATOMY

A significant portion of the proximal tibia lies just beneath the subcutaneous tissue, facilitating ready identification of the bony landmarks. The proximal tibia has 2 flat surfaces, condyles or plateaus. It is these plateaus that articulate with the femoral condyles. The condyles are separated in the midline by the intercondylar eminence and are flanked by the medial and lateral condylar tubercles. Anterior and posterior to the condylar tubercles are the attachments for the cruciate ligaments and menisci. The tibial condyles can be palpated on the medial and lateral aspects of the knee[10] (Fig 1).

The patella is a sesamoid bone—it is wider on the proximal aspect and tapers distally. The patella contains small articular facets on its posterior surface. The patellar tendon is has 3 layers; it connects the quadriceps muscle to the tibia, providing extension at the knee joint. It should be avoided when the incision is made. The tibial tubercle arises from the insertion of the patellar tendon.

The *pes anserinus* is a term used to describe the confluence of the conjoined tendon composed of the sartorius, gracilis, and semitendinosus muscles along the medial tibia.[11] The *pes anserinus* serve as flexors and secondary internal rotators on the tibia, protecting against rotary as well as valgus stress. Their counterpart on the lateral surface is the insertion of the biceps femoris into the fibular head, lateral tibia, and posterior capsule.

The iliotibial tract is the posterior third of the iliotibial band and inserts via Kaplan's fibers into the lateral epicondyle of the femur and, midway between the lateral condyle and the tibial tubercle, to an oval prominence, Gerdy's tubercle.[11] Pierre Nicholas Gerdy is credited with the description of several anatomic structures, including Gerdy's tubercle.[12] In addition, Gerdy's tubercle serves as a secondary insertion of the tensor fascia lata. The tensor fascia lata is an important structure; it helps provide flexion and rotation to the thigh. It originates from the anterior superior iliac spine.

Gerdy's tubercle serves as a landmark for the harvest of corticocancellous bone from the lateral proximal tibia. Identification of the patella, patellar tendon, tibial tuberosity, fibular head, and Gerdy's tubercle is necessary to avoid the articulations on the tibial plateau and fibula. The incision should be placed over Gerdy's tubercle (Fig 2).

Extending deep and lateral to the patellar tendon are branches of the lateral and inferior genicular arteries. The anterior tibial artery gives off the fibular and anterior recurrent tibial arteries. Bleeding from these vessels has not presented a problem and is easily controlled with electrocoagulation and local measures.

The peroneal nerve, a division of the sciatic nerve, is composed of fibers from L4 to S2. At the level of the fibular neck, the short common peroneal nerve divides into 2 sensory branches. One sensory branch, the lateral sural cutaneous nerve, supplies the skin along the lateral knee and proximal tibia. The other sensory branch, the peroneal anastomotic branch, joins the tibial anastomotic branch and forms the sural nerve, serving the skin over the posteriolateral calf, lateral malleolus, foot, and fourth and fifth toes. The superficial peroneal nerve can also be found in the proximal tibia. It travels distally between the peroneus longus and extensor digitorum longus muscles in the intermuscular septum. It provides motor function to the peroneus longus and peroneus brevis and provides sensory function to the skin on the anterior and lateral aspects of the distal tibia and dorsum of the foot.

The tibial nerve is composed of fibers from L4 to S3 and is the larger of the 2 divisions of the sciatic

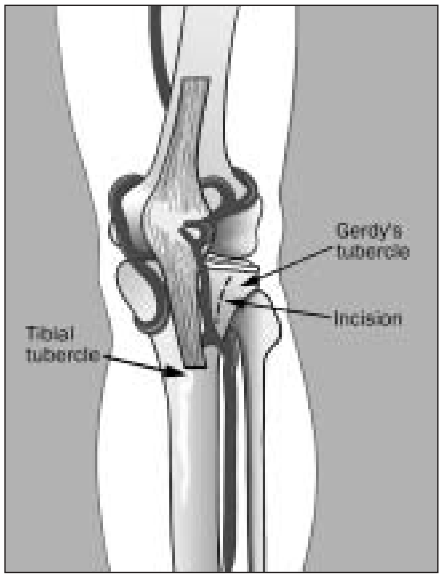

Fig 2 Lateral anatomic illustration of the left tibia showing soft tissue relationships.

nerve. It originates just proximal to the popliteal fossa. It travels through the popliteal fossa and supplies the plantaris, the soleus, the popliteus, and both heads of the gastrocnemius.[11] Injuries to the tibial nerve are severely disabling because of the large sensory deficit on the plantar surface of the foot. Neurologic injury to these areas has not been commonly reported and is easily avoided by proper placement of the incision and meticulous attention to dissection in the appropriate plane (Fig 2).

The few articles that have estimated the amount of cancellous bone available from the proximal tibia report that 25 to 50 mm^3 of bone can be obtained. The amount of bone retrieved is based on the volume needed at the recipient site. Gerdy's tubercle and the area of access to the tibial head are illustrated in Fig 2.

SURGICAL TECHNIQUE

Utilizing standard anesthesia techniques, the patient is sedated. The use of preoperative intravenous antibiotics is encouraged to establish a blood level prior to surgical insult. A small pelvic roll or sandbag may be placed under the ipsilateral hip to provide some medial rotation (varus) to the anterolateral tibia. In addition, a folded pillow may be placed on the medial surface of the tibia with the knee in slight flexion. This allows the anterolateral tibia to be adequately positioned. All other pressure points on the patient's knees and feet must be carefully padded.

The proximal tibia is prepared, and the area is draped to create a sterile field (Fig 3a). A significant portion of the proximal tibia lies just beneath the subcutaneous tissue, facilitating identification of the bony landmarks. The tibial condyles are palpated on the medial and lateral aspects of the knee. Slightly lateral and caudal to the lateral condyle, the fibular head is palpated, identified, and marked with a surgical marker. The patella, patellar tendon, and its insertion into the anterior tibial tuberosity are palpated and marked. The midpoint of a line from the fibular head to the anterior tibial tuberosity approximates the location of Gerdy's tubercle, which is palpated and marked (Fig 3b). Appropriate identification of these landmarks is essential to avoid violation of the regional vasculature and the articular surface of the tibial plateau. In addition, identification of these landmarks helps the surgeon avoid the articulation of the fibula to the tibia, which is also located at this level. The incision is placed over Gerdy's tubercle.

After preparation of the field, sounding of Gerdy's tubercle with a 25-gauge needle and infiltration of local anesthesia is accomplished. A straight-line incision, 2 to 3 cm in length, directed obliquely from superolaterally to inferomedially through skin and subcutaneous tissue is made directly over Gerdy's tubercle. This places the incision just above and medial to the origin of the anterior tibialis muscle and lateral to the patellar tendon. The incision is continued through skin and subcutaneous tissue to the iliotibial tract of the fascia lata, down to periosteum. Although an uncommon complication, if the initial incision is misplaced, areas of bleeding can arise from the belly of the anterior tibialis muscle, the genicular arteries, or the recurrent anterior tibial artery. Electrocoagulation should be utilized to manage any hemorrhage encountered prior to proceeding.

Prior to incising the periosteum, the surrounding tissues may be mobilized in all directions with blunt dissection. Using small rake retractors for exposure, the periosteum is sharply incised and retracted to expose Gerdy's tubercle (Fig 3c). Drill holes are made through cortical bone using a no. 701 bur in a 1.5 × 1.5-cm square over Gerdy's tubercle. When the holes are connected, the angle of the bur faces inward on the osteotomy to facilitate removal of the osseous window.[5] The location of the window is illustrated in Fig 3c. Using an osteotome, the cuts are refined and the osseous window is delivered. The osseous window is stored in sterile saline and utilized as a veneer, pulverized, or retained and replaced at the conclusion of the harvest. Using a superiorly based U flap to create an osteoperiosteal

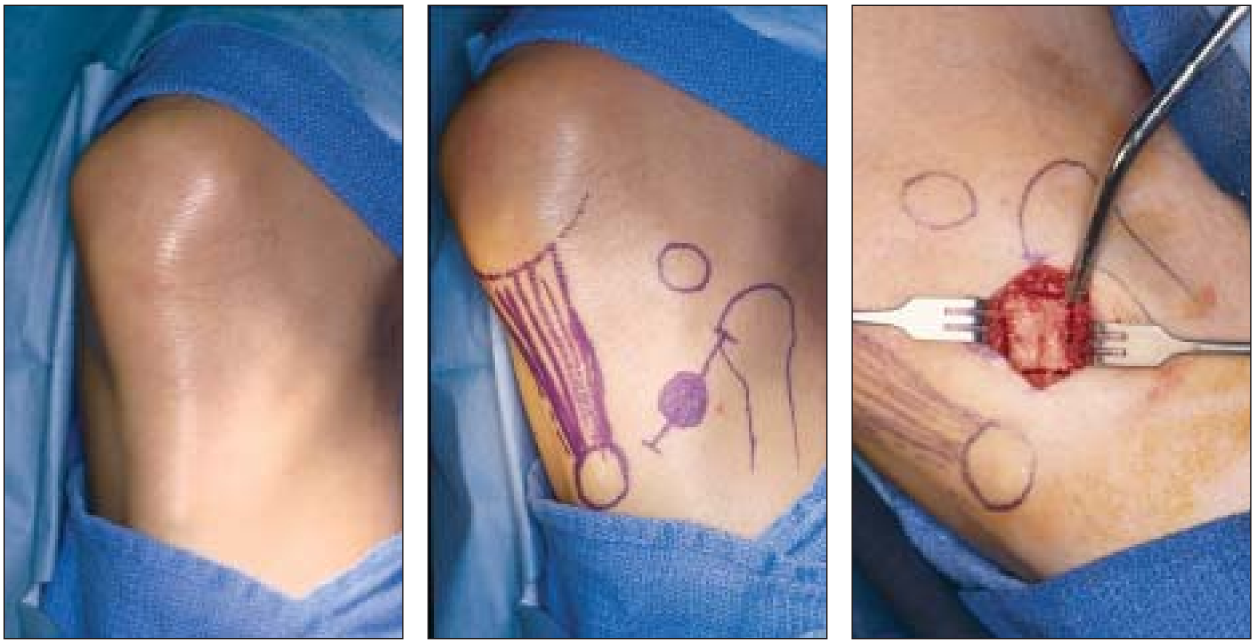

Fig 3a The left knee. The tibia is positioned, prepared, and draped for proximal harvest from a lateral approach.

Fig 3b The left knee, marked for proximal tibia harvest from a lateral approach.

Fig 3c The cortical window is outlined on Gerdy's tubercle to gain access to cancellous bone in the proximal tibia. The site is sufficiently distal to articular surfaces.

flap or "trapdoor" has also been described with excellent results.[5]

After elevation and removal of the cortical window, cancellous bone is obtained using a variety of methods. Gouges, trephines, and straight and curved curettes have been used successfully to remove particulate cancellous bone.

Hand-driven trephines (Biomet/W. Lorenz Surgical, Jacksonville, FL) have been used by the authors with excellent results. Once the cancellous bone is exposed, the appropriate trephine is introduced (Fig 4). With rotational forces applied by hand, the trephine is advanced to a length of 5 cm or until the inner surface of the medial cortex is reached. Anthropologic studies of the proximal tibia[13] have shown the average width of the proximal tibia at the level of the epicondyles to be approximately 7.5 cm. The trephine can be redirected in multiple directions to obtain additional cancellous bone. The use of power-driven trephines may lead to perforation of the medial cortex and is therefore not recommended. The cancellous bone obtained is slightly compacted by the method described and is very easy to manipulate. Curettes and gouges are used to remove additional cancellous bone if necessary. Care must be taken to avoid removal of bone cephalic to the tibial plateau. Although uncommon, undermining the tibial plateau has been reported to result in its fracture or collapse.[6]

After collection of the cancellous bone, the bony margins are smoothed with a rasp, and the area is irrigated with sterile saline. Microfibrillar collagen can be fluffed into the wound and carefully packed into the bleeding cancellous margins for hemostasis. If platelet-rich plasma (PRP) is utilized to supplement the bone graft, platelet-poor plasma (PPP) may be added to the donor site defect for hemostasis. Interrupted 3-0 polylactic acid sutures are placed to reapproximate the periosteal layer. If a periosteal window approach was utilized, it can be repositioned and the periosteum closed as stated. The 4-0 polylactic acid sutures are also used to approximate the subcutaneous layer and 5-0 Prolene (Ethicon, Somerville, NJ) or a similar suture is placed to reapproximate skin margins (Fig 5). The placement of a drain is not routine.

A clear adhesive covering (Tegaderm; 3M Healthcare, St Paul, MN) is placed over the wound for protection. The knee is flexed slightly and a Kerlex gauze wrap (Johnson & Johnson, New Brunswick, NJ) is wrapped around the wound for pressure. It should remain in place for 48 to 72 hours.

Postoperatively, the patient is given instructions for ambulation. Normally, the patient is instructed not to put weight on his or her leg on the first postoperative day but to begin weight bearing as tolerated the following morning.

Fig 4 *(Left)* Trephines used to harvest cancellous bone from proximal tibia.

Fig 5 *(Right)* Tibial donor site closure.

The patient is seen at 1 week, and the skin sutures are removed. It is not uncommon to notice ecchymotic areas, which may run the length of the lateral tibia. Dorsalis pedis and posterior tibal pulses are checked as well as the presence or absence of Homan's sign. Postoperative donor site radiographs are not routine.

RECORD REVIEW

Forty-four cases of proximal tibial metaphysis bone harvests were reviewed for incidence and type of complications. The bone procurements were performed from March 2000 to April 2003 under the supervision of the same staff surgeons utilizing the technique described. The procedure was indicated for the treatment of osseous deficiencies of the maxilla and mandible (Table 1). Considerations for choice of donor limb included factors such as previous surgeries, standard or automatic vehicle preferences, and arthritic changes.

All patients underwent unilateral proximal tibia metaphysis harvest under intravenous sedation in the outpatient surgical setting. All patients were allowed to ambulate by the second postoperative day. A total of 17 male and 27 female patients records were reviewed (Table 1). The patients ranged from 19 to 80 years of age, with a mean age of 56 years. The distribution of recipient sites as it relates to age is summarized in Table 1. Seven minor complications (15.9%) and 5 major complications (11.4%) were encountered. The procedure was performed for sinus augmentation in 19 patients, maxillary atrophy in 21 patients, and mandibular atrophy in 8 patients.

One major complication occurred in an obese patient with peripheral vascular disease who suffered a persistent seroma. Conservative therapy consisting of local wound debridement and pressure gauze was unsuccessful, and the patient required surgical debridement and closure. Use of a suction drain was required for 4 days postsurgery. No infection was noted, and the patient recovered uneventfully.

A second major complication was necrosis at the incision site. This patient was a middle-aged African American woman who failed to admit to a history of hypertrophic scarring and Raynaud's phenomenon. Subsequent follow-up appointments led to the discovery of this information. A third major complication occurred when the joint space was entered while excavating bone from the tibial plateau. This patient has chronic joint pain that has never completely resolved.

In the initial trials with the use of trephines to aid in harvesting the lateral proximal tibia, rotary air-driven trephines were used. This resulted in a perforation of the medial cortex. The patient had no untoward effects. Since then, hand-operated trephines have been used with good results and a better tactile sense.

Ecchymotic areas around the donor site were common and are considered a normal consequence of the procedure. One patient reported local paresthesia around the wound. Several reported long-term knee pain, but all resolved within a few weeks.

Table 1 Patient Demographics

Age (y)	n	Maxillary atrophy	Mandibular atrophy	Sinus pneumatization	Major complications
15 to 25					
Male	1	1	1	0	None
Female	0	0	0	0	
26 to 35					
Male	0	0	0	0	None
Female	2	1	1	0	
36 to 45					
Male	2	2	0	1	None
Female	1	1	0	0	
46 to 55					
Male	3	1	0	2	Wound necrosis (1)
Female	9	3	2	5	
56 to 65					
Male	5	2	1	3	Perisistant seroma (1),
Female	11	5	2	4	Joint pain (2)
66 to 75					
Male	5	3	1	1	Transient paresthesia (1)
Female	4	2	0	2	
76 to 85					
Male	1	0	0	1	None
Female	0	0	0	0	
Total	44	21	8	19	5

Only the amount of cancellous bone needed to complete the procedure is harvested. A single donor site is sufficient for a sinus lift procedure. Other studies have cited volumes of uncompressed cancellous bone to be in the range of 25 to 50 mm^3. The volume of the autologous graft can be increased by various additives. These additives include but are not limited to allogenic bone, morsalized tibial cortex, lyophilized allogenic bone, and graft material from additional autogenous sites such as the iliac crest or calvaria.

All patients in this study reported minimal to moderate pain associated with the donor site, and all were satisfied with the cosmetic result at the donor site. No donor site infections, persistent neuropathy, persistent pain, deep vein thrombophlebitis, or hematoma were noted. No fractures of the proximal tibia or disruptions of the articular surface have been experienced. Only 1 patient has had a sustained gait disturbance beyond the initial postoperative recovery period.

DISCUSSION

There have been reports of morbidity associated with the harvest of the proximal tibia metaphysis in the literature, and the present results compare favorably to those previously described.[5,6,8] The literature is replete with reports related to the iliac crest donor site and its potential major and minor complications.[14,15] For this reason, alternative donor sites should be considered, especially if smaller amounts of donor bone are needed. In selected cases, bone harvest from the proximal tibia is a safe procedure that can be performed on an outpatient basis with minimal morbidity.[5–8]

In all the presented patients, with the exception of the major complications, morbidity was limited to ecchymosis on the donor limb. There was never any evidence of deep vein thrombophlebitis throughout the course of any patient's recovery. The ecchymosis may be related to incomplete closure of the periosteum. Others have reported on the frequency of ecchymosis at the donor site. This has not been reported as a minor complication in this series. It is considered an expected sequela to the procedure that quickly resolves.

For the patient who presented with regional paresthesia, only the area immediately adjacent to the incision was involved, and sensation returned spontaneously by the second postoperative week. The patient who suffered a persistent seroma was obese, with signs of peripheral vascular disease, which may have compromised healing. In addition, after the patient had returned to her normal activities, she sustained a blow to the area while moving furniture.

An additional major complication occurred in a patient who had not provided a history of Raynaud's phenomenon. The patient was noncompliant with postoperative instructions and had repeated bouts of edema in the area. Episodes of Raynaud's are marked by severe pallor accompanied by paresthesia and pain. Eight weeks postoperatively, the patient had made marked improvement and had complete healing of the wound. The dorsalis pedis and posterior tibialis pulses remained strong throughout.

Caution should be used in the harvest of proximal tibia from obese patients, those with known peripheral vascular disease, or those who may have compromised wound healing from systemic disabilities.

OTHER POTENTIAL COMPLICATIONS

Postoperative radiographs of the donor site are obtained routinely. However, when ordering such images, communication with the radiologist should include the history of surgical access to the area to decrease the chance of misdiagnosis. O'Keefe and associates reported on 3 patients who were considered for biopsy of the proximal tibia by surgeons unaware of the patients' previous bone harvest.[6] Besly and Ward-Booth have reported similar findings.[3] The fracture incidence of 2.7% reported by Hughes and Revington was a surprising finding.[8] The case they reported was a fracture that occurred in an area unrelated to the donor site, but sufficient time had elapsed to make differentiation of the donor site radiographically impossible.[8]

Another major complication in the present series occurred with a patient who had persistent joint pain related to surgical entry into the joint space during bone excavation from the area approximating the tibial plateau. This occurred early on in the authors' experience with lateral proximal tibia harvesting and led to protocol alteration and the avoidance of excavation near the plateau.

Additionally, the lack of complications related to deep-vein thrombophlebitis, pulmonary problems, or peritoneal or genitourinary system injury support the use of the proximal tibia as a donor site. Long-term complications are uncommon. The literature has no reports of sustained neurosensory deficit associated with this procedure. Donor site pain does not seem to be a cited concern in the literature but was a finding in this series. Subjective analysis of pain associated with the donor site should be an area of further investigation.

In the present series, patients were routinely allowed to ambulate on the second postoperative day.[5,16] No untoward consequences of this have been experienced. However, further evaluation of the effects of weight bearing is warranted before immediate ambulation can be advocated.[6] The patient is routinely provided with a walker and its use is encouraged to assist in ambulation during the immediate postoperative period. Postoperative ambulation after proximal tibia metaphysis harvest is rapid and less limited than that seen with iliac crest harvest sites.

CONCLUSION

Use of the proximal tibia metaphysis for harvesting of cancellous bone should be considered as an alternative to other sites when moderate amounts of cancellous autologous bone are needed. The advantages in using the proximal tibia can be summarized as a low incidence of overall complication, mild postoperative pain, relative ease of harvest, decreased operative time, early ambulation, and rapid recovery. In addition, the surgery can be performed under intravenous sedation on an ambulatory basis, negating the need for hospitalization that is associated with iliac crest harvests.[7,14,15] The use of autogenous bone in craniofacial applications is the gold standard.[17] The use of the proximal tibia metaphysis as a donor site for cancellous bone for alveolar ridge augmentation or sinus lifting may be considered when autologous grafting for implant site preparation is needed.

REFERENCES

1. Habal MB. Different forms of bone grafts. In: Habal MB, Reddi AH (eds). Bone Grafts and Bone Substitutes. Philadelphia: Saunders, 1992.
2. Shepard GH, Dierberg WJ. Use of the cylinder osteotome for cancellous bone grafting. Plast Reconstr Surg 1987;80: 129–132.
3. Besly W, Ward-Booth P. Technique for harvesting tibial cancellous bone modified for use in children. Br J Oral Maxillofac Surg 1999;37:129–133.
4. Hankovan V, Stronczek M, Telfer L, Peterson J, Stassen LFA, Ward-Booth P. A prospective study of trephined bone grafts of the tibial shaft and iliac crest. Br J Oral Maxillofac Surg 1998;36:434–439.
5. Catone GA, Reimer BL, McNeir D, Ray R. Tibial autogenous cancellous bone as an alternative donor site in maxillofacial surgery: A preliminary report. J Oral Maxillofac Surg 1992;50:1258–1263.
6. O'Keefe RM, Reimer BL, Butterfield SL. Harvesting of autogenous cancellous bone graft from the proximal tibial metaphysis: A review of 230 cases. J Orthop Trauma 1991;5:469–474.

7. Marchena JM, Block MS, Stover JD. Tibial bone harvesting under intravenous sedation: Morbidity and patient experiences. J Oral Maxillofac Surg 2002;60:1151–1154.
8. Hughes CW, Revington PJ. The proximal tibia donor site in cleft alveolar bone grafting: Experience of 75 consecutive cases. J Craniomaxillofac Surg 2002;30:12–16.
9. van Damme PA, Merkx MA. A modification of the tibial bone graft harvesting technique. Int J Oral Maxillofac Surg 1996;25:346–348.
10. Canale ST. Campbell's Operative Orthopaedics, ed 9. St Louis: Mosby, 1998.
11. Matsumoto H, Seedhom B. Tension characteristics of the iliotibial and role of its superficial layer. Clin Orthop 1995;(313):253–255.
12. Beals TC. So who was Gerdy...and how did he get his own tubercle? Am J Orthop 1996;25:750–752.
13. Uehara K, Kadoya Y, Kobayashi A, Ohhashi H, Yamano Y. Optimal tibial component size in total knee replacement—Analysis with computed tomography and intraoperative measurement. Poster presented at the 47th Annual Meeting of the Orthopaedic Research Society, San Francisco, February 2001.
14. Eufinger H, Leppanen H. Iliac crest donor site morbidity following open and closed methods of bone harvest for alveolar cleft osteoplasty. J Craniomaxillofac Surg 2000;28:31–38.
15. Laurie SW, Kaban B, Mulliken JB, Murray JE. Donor site morbidity after harvesting rib and iliac bone. Plast Reconstr Surg 1984;73:933–938.
16. Alt V, Nawab A, Seligson D. Bone grafting from the proximal tibia. Trauma 1999;47:555–557.
17. Marx RE. Reconstruction: Biology of bone grafts. In: Kelly JPW (ed). OMS Knowledge Update, vol 1. Rosemont, IL: American Association of Oral and Maxillofacial Surgeons, 1994:3–17.