A Retrospective Review of 522 Distal Tibial Bone Graft Harvests

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Abstract

This study evaluated 522 patients from 2005 to 2015 who underwent a distal medial tibia bone graft harvest. The purpose of this study was to evaluate the amount of autogenous bone graft collected from the distal tibia and postoperative complications at the donor site. Patients were evaluated for a total of 24 months. Serial radiographs were used to evaluate healing at the distal tibia harvest site and grafted bone at the receiving site. There were no major complications at the donor site other than one distal fracture through the harvest site, which healed uneventfully. There were 21 instances of complications that occurred out of the 522 bone grafts obtained. The most common complication was superficial dehiscence, which occurred on 10 occasions. A 10 point visual analog scale was used which showed an average of 1.4 out of 10 pain during the first week after operation and was reduced to 0.06 out of 10 at 24 months.

In conclusion the distal aspect of the tibia is a safe and reliable source for harvesting bone grafts. The procedure is not technically challenging and can be done relatively quickly in the OR in an average of 10 to 12 minutes. There was a complication rate of 4.0 percent, which was not statically significant. Complications include 10 cases of superficial dehiscence and six cases of superficial dehiscence with cellulitis. There were four cases of saphenous neuritis, which resolved uneventfully. One case of distal fracture was noted through the harvest site, which also healed uneventfully following appropriate immobilization. Statistical analysis was performed on the portion of the population with complications.

Keywords: Distal Tibia; Bone Graft; Autogenous Bone Graft; Autograft; Tibial Bone Graft

Introduction

Autograft is considered to be the gold standard in bone grafting because it possesses all the three characteristics necessary for new bone deposition and maturation. It’s osteoconductive properties serve as a scaffold for vascular ingrowth by creeping substitution [1]. The increased surface area allows for cell adhesion and tissue maturation. Autograft is also osteoinductive, containing macromolecules such as bone morphogenic proteins that stimulate bone formation [2]. The osteogenic precursor cells within an autograft can differentiate into osteoblasts and simulate bone regeneration [2]. This type of bone graft is immunogenic, therefore incorporates well into the

receiving site without rejection [2]. The combination of these properties provides a superior structural support and promotes the bone healing required for various orthopedic procedures. These procedures can include reconstructive surgery, acute comminuted fractures, non-unions, limb salvage surgery, reconstruction of failed arthroplasties, and the correction of significant bone loss associated with joint replacement or bone tumors. There are other types of bone grafts that can be used in these procedures such as allografts, xenografts, and synthetic grafts [3]. However, these grafts have their shortcomings that make them not as reliable of a source. For example, allografts are slower to be replaced by host bone, can cause an immune response and come with the risk of disease transmission [3]. Most bone substitutes are osteoconductive, but often lack osteogenic and osteoinductive properties, making them less reliable as compared to autograft [4]. Autograft does come with the risk of donor site morbidity though. Our data shows this morbidity is low and should not outweigh the advantages gained by the use of autogenous bone graft obtained from the distal tibia.

**Materials and Methods**

Between the years 2005 and 2015, 522 patients went through an ipsilateral distal tibia bone graft harvesting to augment healing in varieties of fore foot and rear foot surgeries. The same surgeon performed all procedures for consistency of techniques. The postoperative protocol was uniform for all distal tibia grafting sites. The time of postoperative non-weight bearing was dictated by the primary surgery, as the distal tibia bone grafting did not add to the amount of offloading required. The inclusion criteria were: an elective reconstructive surgery, trauma with a large defect, neurovascular qualifications, lack of active osteomyelitis, or active soft tissue infection. The exclusion criteria were: active osteomyelitis, soft tissue infection, neurovascular impairment, active Charcot neuroarthropathy, ankle implant and open growth plates.

The patients were followed at 48 hours, two weeks, six months, and 24 months post operatively. The age, laterality, pain, amount of graft, time to heal, complication rate and type was recorded (Table 1).

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Mean (SD) or n (%)</th>
</tr>
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<tbody>
<tr>
<td>Age (years)</td>
<td>55.6 (14.4)</td>
</tr>
<tr>
<td><strong>Leg</strong></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>260/522 (49.8)</td>
</tr>
<tr>
<td>Left</td>
<td>262/522 (50.2)</td>
</tr>
<tr>
<td><strong>Pain</strong></td>
<td></td>
</tr>
<tr>
<td>48 hours</td>
<td>1.4 (1.2)</td>
</tr>
<tr>
<td>2 weeks</td>
<td>1.0 (0.8)</td>
</tr>
<tr>
<td>6 months</td>
<td>0.4 (0.6)</td>
</tr>
<tr>
<td>24 months</td>
<td>0.06 (0.3)</td>
</tr>
<tr>
<td>Amount of graft</td>
<td>7.5 (3.0)</td>
</tr>
<tr>
<td>Time to heal</td>
<td>5.3 (1.4)</td>
</tr>
<tr>
<td>Complications-yes</td>
<td>21/522 (4.0)</td>
</tr>
<tr>
<td><strong>Complication type</strong></td>
<td></td>
</tr>
<tr>
<td>Superficial dehiscence</td>
<td>10/21 (47.6)</td>
</tr>
<tr>
<td>Superficial cellulitis</td>
<td>6/21 (28.6)</td>
</tr>
<tr>
<td>Saphenous neuritis</td>
<td>4/21 (19.0)</td>
</tr>
<tr>
<td>Distal fracture through the harvest site</td>
<td>1/21 (4.8)</td>
</tr>
</tbody>
</table>

**Table 1:** Patient characteristics.
The pain at the harvest site was recorded separately from the primary surgical site using the visual analog pain scale. The scale is numbered from zero to 10, with zero representing no pain and 10 representing severe pain.

The time to heal was recorded and determined by serial radiographs. This was established when the new trabecular bone pattern crossed more than 50% of the original defect on radiograph. An empty syringe was used to measure the amount of cancellous graft taken intraoperatively. The amount of graft was divided at the median of 6 ml to see if more or less graft had an effect on time to heal or complications. The harvest site void was back filled with various bone substitutes such as demineralized bone matrix, calcium phosphate, and calcium sulfate. The size, amount, and type of graft needed (cortical with cancellous vs. cancellous only) dictated how the grafting was approached as described below. The procedures were of lower extremity surgery and included various fusions, non-union fractures, and bone voids (secondary to traumas, implant removal or bone infections).

**Technique**

A linear incision of 4-6 cm is placed over the anteromedial aspect of the distal tibia (Figure 1).

![Figure 1: Incision Placement for proximal tibia bone graft.](image)

Dissection is carried down to the periosteum and meticulous retraction of neurovascular vitals structures is carried out (Figure 2). The periosteum is then incised and retracted.

Once the cortex of the tibia is exposed, four drill holes are made using a 2.0 mm drill bit to score out the corners of a rectangular or diamond shaped bone window (Figure 3a). This window should be made approximately 4cm proximal to the ankle joint (Figure 3b). The drill holes are unicortical and function to prevent stress fracture. Fluoroscopy can be utilized to ensure proper placement of drill holes.
Utilizing a small oscillating saw, the four drill holes are then connected and a cortical window is created (Figure 4).

**Figure 3b:** Ideal location for cortical window.
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Figure 4: Sagittal saw is utilized to connect drill holes to create cortical window.

The cortical window is then removed and can be used as a structural graft, or it is only temporarily removed to gain access to cancellous bone then later returned (Figure 5).

A 3 or 4 mm round curette is used to harvest the desired quantity of cancellous bone (Figure 6). During the harvest, care should be taken to not use the cortical borders as a lever against the curette as this could result in increased stress and fracturing of the tibia. The most viable cancellous bone will be found in the metaphyseal region.
After achieving the desired amount of the bone graft, the void is backfilled with synthetic or allogenic bone graft (Figure 7). The removed cortical window is then replaced, or if utilized as a structural graft, then a cortical allograft is cut to size and placed to fill the cortical void.

Figure 7: Backfilling of graft site with allograft bone.

In larger graft sites a small locking plate is sometimes used to maintain position and prevent extraction of graft site.

Layered closure is then carried out of the periosteum, subcutaneous tissue, and skin. The surgical site is then dressed with nonadherent and a mild compressive dressing. The postoperative weight bearing status is determined based on the primary procedure.

This was the technique that was carried out for all 522 tibial bone grafts in this study, however there are other methods described in the literature. These include various techniques utilizing trephines to help remove a core of distal tibia metaphyseal bone. For example, Raikin and Brislin described a technique utilizing a 9 mm in diameter trephine to extract distal tibia metaphyseal bone [5]. Another trephination technique was described by Donley and Richardson to obtain graft from the distal tibia [6]. Brown also described a technique for obtaining morselized cancellous graft from the distal tibia [7]. The surgeon's previous training, level of comfort, and experience all contribute to the rate of success using the various methods.

Results

The average age of the population studied was 55.6 years old. There were 260 right and 262 left distal tibias in which bone grafts were harvested. The average pain at 48 hours was 1.4 out of 10. The average pain at 2 weeks was 1.0 out of 10. At 6 months the average pain was 0.4 out of 10, and 0.04 out of 10 pain at 24 months. The amount of graft taken ranged from 4 ml to 15 ml with an average of 7.5 ml.

and the cortical window was approximately 1 cm x 2 cm in maximal dimensions. Based on serial radiographs, the time to heal varied from 3 months to 16 months with an average of 5.3 months.

There were 21 complications noted out of 522. Of those, 10 patients developed superficial dehiscence, 6 patients with superficial dehiscence, and 4 patients with saphenous neuritis (Table 1). There was one patient with distal fracture through the harvest site status post fall injury after surgery. All patients with complications healed uneventfully with the use of offloading and appropriate treatment.

Though the population of patients with complications was not statistically significant (only 21 patients out of 522), further analysis was done within this population to look for correlations. Age did not have an effect on time to heal. The graft amount was divided at the mean of 6 ml. Analysis was done to see if graft amount greater or less than 6 ml had any correlation with time to heal or complication rate. We found an increase in time to heal was statistically significant with greater than 6 ml of graft harvested. However, the graft amount had no correlation with rate of complication.

Discussion

There are many sites for autologous bone graft that the surgeon may choose from. Some of the most common sites include the iliac crest, distal tibia, and calcaneus [1-4]. Of these, iliac crest has been considered the gold standard graft material in some specialties [2]. This can be due to the graft composition and amount that can be grafted, but this site comes with its own set of complications [8]. Silber, et al. reported 134 out of 187 total patients had symptoms following anterior iliac crest bone graft harvest. He reported complications with ambulation in 50.7%, extended antibiotic usage with 7.5%, persistent drainage in 3.7%, wound dehiscence in 2.2%, and incision and drainage in 1.5%. Also, 11.2% of patients chronically used pain medication [9]. Though the mean graft volume of iliac crest is about 55.12 ml, a graft of this volume is not often required in foot and ankle surgery [10]. Our study supports our hypothesis that distal tibia grafting does not have high rates of complications. Only 21 patients out of 522 developed complications, which is not statistically significant. Most complications were minor. There were incidents of saphenous neuritis, superficial dehiscence with and without cellulitis and one with distal fracture through the harvest site. The cases of saphenous neuritis resolved with the treatment of non-steroidal anti-inflammatories. The case of harvest site fracture occurred during a postoperative fall and healed with appropriate offloading in 6 months. The risk of fracture is fortunately an unusual complication and can be minimized by avoiding harvesting excessive quantities of bone, by avoiding placement of the bone harvest too close to the ankle joint, and avoiding using the surrounding tibial window as a level arm at the time of graft harvest.

Other complications can be reduced by taking precautions during the surgical technique. For example, the bone cuts were made with care to not cause thermal necrosis and angled such to be inverted at the window borders. This allowed for better apposition of the tibia interface once the graft had been extracted and the graft site void was closed. The void itself was filled with bone substitute before the cortical window was placed on top. This helped with preventing hematoma subsequent dehiscence and risk of cellulitis. Grafting site dehiscence was the most common complication seen in our study.

Harvesting the autograft requires an additional surgery at the donor site that can result in its own complications that occasionally outlast the pain of the original surgical procedure. This study showed that the pain level associated with the donor site resulted in low levels of pain with only 1.4 out of 10 pain at 48 hours, which virtually resolved between 2 weeks and 24 months.

Many factors go into choosing the appropriate graft type. Some surgeons may choose allograft solely on its readiness, even though it is inferior to autograft. Distal tibia bone grafting can be extracted and the harvest site closed in an average of 10 minutes. This not only provides superior autograft in a short amount of time but also saves in operating room expenses, as many allografts can be expensive.

The results of our study are consistent with other studies found in the literature. In a retrospective study by the senior author, 77 cases were reviewed of patients who underwent ipsilateral distal tibia grafts for the use of lower extremity surgery. Of all the cases there were
only minor complications encountered at a rate of 3.9 percent. It was concluded that the distal tibia was a reliable source for harvesting bone grafts and can be used in foot and ankle surgeries with the same or even less complications as the other harvesting sites [11]. Raikin and Brislin evaluated 70 cases of ipsilateral distal tibia grafting. They found no major complications. Their study resulted in ten patients (8.7%) having minor complications including initial incisional sensitivity or local numbness, none of which affected function or required additional treatment. Satisfaction rate for the procedure was 100%. They concluded that it is safe and reliable for operative procedures of the foot and ankle [5]. Mendicino, et al. used autologous bone grafts in arthrodesis or for revision of malunions or non-unions. He concluded that the lower extremity provides a good source for obtaining cortical, cortico-cancellous, and cancellous bone for use in foot and ankle surgery [12]. Cho, et al. studied 100 autografts obtained from the distal tibia. They reported on four cases of graft site stress fracture, all of which healed on average of 2.4 months with cast immobilization. They concluded stress fracture through the donor site is a rare complication and can be successfully treated non-operatively [13]. Saltrick, et al. examined 16 patients who underwent distal tibia bone grafting. They had an average follow up of 37 months. They found no donor site complications. They reported one case of residual pain at the donor site, which resolved within 4 months. They concluded the distal tibia metaphyseal area as an excellent source of cortico-cancellous bone for grafting in reconstructive foot and ankle surgery [14]. Torg, et al. reported on the use of distal tibia bone grafts in 20 delayed or non-unions of fifth metatarsal base fractures requiring surgical intervention. There were no tibia fractures or other complications at the donor site with uneventful healing in 95% of the recipient sites [15]. Danziger, et al. reported on 41 cases of arthrodesis in the foot and ankle where bone graft was obtained through a cortical window made just above the medial metaphyseal distal tibia flare. Their average follow-up was 23.3 months. They reported no complications at the donor site based on patient examination and radiographs. They further stated ipsilateral ankle motion was not affected by the bone graft procedure [16].

Conclusion
To our knowledge our study is the largest retrospective analysis of the complications associated with autologous ipsilateral, distal-medial tibia bone grafts for the use of lower extremity surgery. Our results show the utilizing the harvesting technique described above that the use of this autologous bone graft is a safe, effective, and reliable. It is important to note that harvesting autogenous distal tibial bone graft does not significantly add to overall operative time. In our experience we have found it can safely and effectively be done in an average of 10 minutes. Autologous bone graft from the iliac crest has multiple reported complications, which include: donor site pain, blood loss, heterotopic bone formation, pelvic instability, iliac hernia, infection, fracture, and deformity [17]. Allografts can be expensive and come with their own complications including disease transmission and immune response. The use of an autologous distal tibia bone graft avoids these downfalls, is not associated with significant complications, and provides adequate graft material needed for most foot and ankle surgery.

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