Autologous Distal Medial Tibia Bone Graft Harvest: Results in 522 Patients

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INTRODUCTION

Autograft is considered to be the gold standard in bone grafting because it possesses all 3 characteristics necessary for new bone deposition and maturation. Its 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 osteogenetic precursor cells within an autograft can differentiate into osteoblasts and simulate bone regeneration (2). This type of bone graft is immunogenic, and 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 as 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). Bone substitutes are osteoconductive, but not osteoinductive, making them not as reliable compared to autograft (4). Autograft has the risk of donor site morbidity, where as the above mentioned alternatives do not have this complication. Our data show this morbidity is low and should not outweigh the advantages gained by the autogenous distal tibia bone graft.

MATERIALS AND METHODS

Between 2005 and 2015, a total of 522 patients went through an ipsilateral distal tibia bone graft harvesting procedure to augment healing in varieties of forefoot and rearfoot surgeries. The same surgeon performed all procedures for consistency of technique. The postoperative protocol was uniform for all distal tibia grafting sites. The time of postoperative non-weightbearing was dictated by the primary surgery, as the distal tibia bone grafting did not add to the amount of offloading required. The inclusion criteria was an elective reconstructive surgery, trauma with a large defect, neurovascular qualifications, lack of active osteomyelitis or active soft tissue infection. The exclusion criteria was active osteomyelitis, soft tissue infection, neurovascular impairment, active Charcot neuroarthropathy, ankle implant and open growth plates. The patients were followed at 48 hours, 2 weeks, 6 months, and 24 months postoperatively. The age, laterality, pain, amount of graft, time to heal, complication rate, and type was recorded (Table 1). The pain at the harvest site was recorded separately from the primary surgical site using a visual analog pain scale ranging from 0 to 10 (where 0 = no pain and 10 = representing severe pain) (Figure 1).

Table 1. Characteristics recorded on the patient population for distal tibia bone grafts

Characteristic	Distal Tibia Harvest Site Mean (SD) or n (%)
Age (years)	55.6 (14.4)
Leg	
Right	260/522 (49.8)
Left	262/522 (51.2)
Pain	
48 hours	1.4 (1.2)
2 weeks	1.0 (0.8)
6 months	0.4 (0.6)
24 months	0.06 (0.3)
Amount of graft	7.5 (3.0)
Time to heal	5.3 (1.4)
Complications—yes	21/522 (4.0)
Complication type	
Superficial dehiscence	10/21 (47.6)
Superficial cellulitis/dehiscence	6/21 (28.6)
Saphenous neuritis	4/21 (19.1)
Fracture through harvest site	1 (4.8)

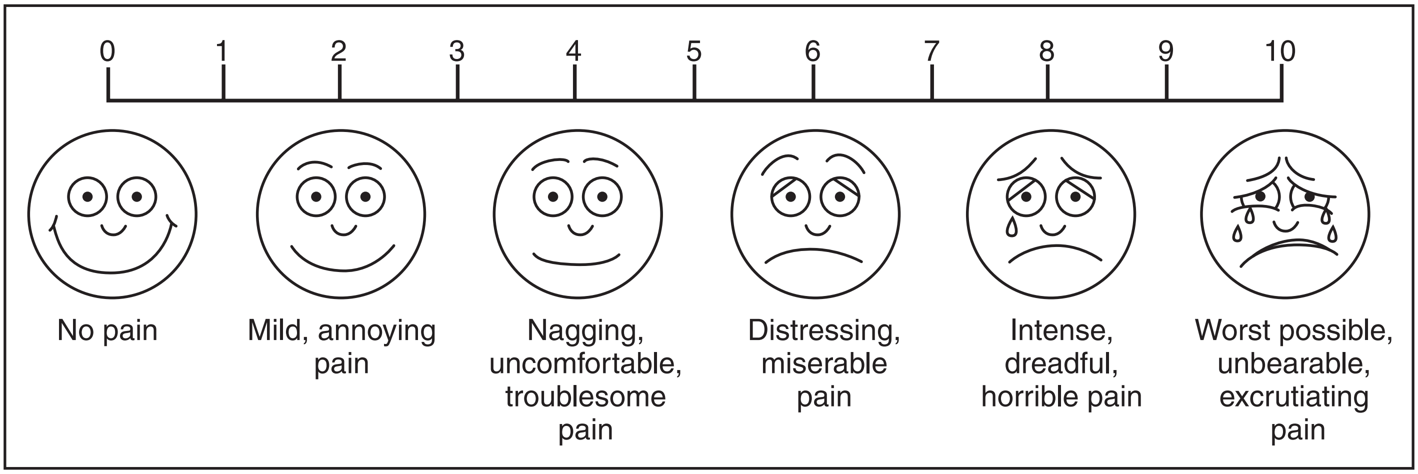

Figure 1. Visual analog scale shown to patients to rate the pain located at the graft harvest site.

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 intra-operatively. Statistical analysis was completed to reveal associations between time to heal, age, and amount of graft. Complication rates were also analyzed to find correlations between age and amount of graft. This was accomplished by dividing the age into quartiles to reveal if a certain quartile range of age was correlated with more complications or an increase in time to heal. 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 versus 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

The position of the patient on the operating table was determined based on the type of primary procedure. A proximal to distal linear incision placed over the anteromedial aspect of the medial surface of the tibia, just above the medial malleolus. If more cortical bone was needed, then the bone window was placed slightly above the metaphyseal-diaphyseal junction (Figure 2A). However, if mainly cancellous bone was needed the bone window was placed over the metaphyseal-diaphyseal junction (Figure 2B).

A linear incision 4-6 cm was placed over the anteromedial aspect of the medial surface of the tibia, just proximal to the medial malleolus. The incision was deepened to the level of the periosteum. The periosteum was then incised and

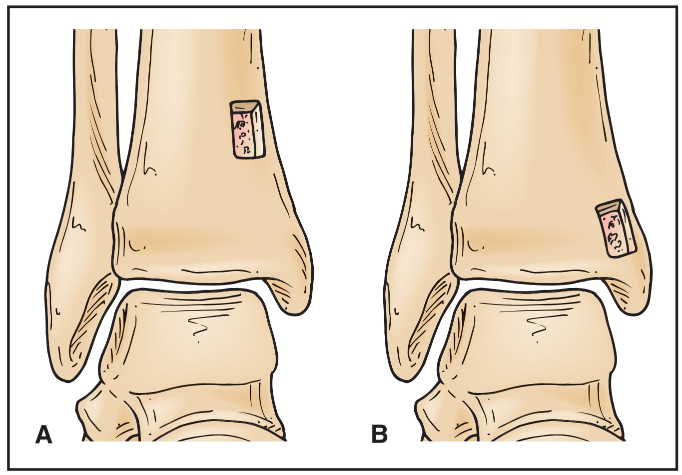

Figure 2. A. Bone window placed above the metaphyseal-diaphyseal junction. B. Bone window placed at the metaphyseal-diaphyseal junction.

elevated. A 0.045 inch Kirschner wire or a 1.5 mm drill was used to score out 4 corners of a rectangular-shaped bone window. This is done to help prevent stress fracture. Using a small oscillating saw the 4 corners were connected and a window was created with care to prevent thermal necrosis. The cuts were created as to bevel the edges inward and create window borders that would prevent migration of the cortical window. The cortical window with its attached cancellous bone was then harvested. A 3 or 4 mm curved curette was used to harvest the cancellous bone as needed. During the harvest, care was taken to not use the cortical window borders as a lever arm to harvest. This could result in fracturing the tibia. Care was also taken to prevent harvesting bone distally or penetrating the lateral wall of the distal tibia, as this would violate the ankle joint and or syndesmotic ligament. Performing this under fluoroscopy was advised for better visualization and to prevent any osseous damage. After achieving the desired amount of the bone graft, the void was filled with any source of the synthetic bone graft. The removed cortical window was then replaced if not used. The periosteum and subcutaneous tissues were sutured with absorbable suture materials. The skin was closed using absorbable suture in a subcuticular fashion. The surgical site was then dressed with a mild compressive dressing. The postoperative weightbearing status was determined based on the primary procedure.

The same surgeon harvested all distal tibia grafts as described above, 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 diameter trephine from Wright Medical to extract distal tibia metaphyseal bone (5). Another trephine technique was described by Donley and Richardson to obtain graft from the distal tibia (6). Brown described a technique using the Acumed system 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

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 on the scale of 1 to 10. The average pain at 2 weeks was 1.0 on the scale of 1 to 10. The average pain score was 0.4 and 0.04 at 6 months and 24 months, respectively. 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 cases. Of those, 10 patients developed superficial dehiscence, 6 patients had superficial dehiscence with cellulitis, and 4 patients with saphenous neuritis (Table 1). One patient had a distal fracture through the harvest site after a postoperative fall. All patients with complications healed uneventfully with the use of offloading and appropriate treatment.

Although the population of patients with complications was not statistically significant (21 patients 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 and an analysis was done to see if a 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 the 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, the iliac crest has been considered the gold standard graft material in some specialties (2). This can be possibly 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 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). Although the mean graft volume of iliac crest is approximately 55.12 ml, a graft of this volume is not often required in foot and ankle surgery (10). Other sites, which are in the scope of podiatric practice, may be more suitable and come with lower complication rates.

Our study supports our hypothesis that distal tibia grafting does not have high rates of complications. Only 21 patients of 522 developed complications, and this was not statistically significant. The complications that did develop were mostly 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 nonsteroidal anti-inflammatory drugs. The case of harvest site fracture occurred during a postoperative fall and healed without event with appropriate offloading for 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 to help harvest graft.

Other complications can be reduced by taking precautions during the surgical procedure. For example, the bone cuts were made with care to not cause thermal necrosis, and 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. Graft site dehiscence was the most common complication seen in our population. 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 a score of 1.4 on a scale of 1 to 10 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 overall complication rate was not statistically significant in our study with only 21 of 522 patients experiencing symptoms. This is 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%. 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. Ten patients (8.7%) had 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 4 cases of graft site stress fracture, all of which healed an 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 1 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 nonunions 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 that ipsilateral ankle motion was not affected by the bone graft procedure (16).

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 showed with the harvesting technique described above, the use of this autologous bone graft is a safe, effective, and reliable source of obtaining cancellous bone. It is important to note the procedure does not add to precious operative time and can be completed 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 enough graft material needed for most foot and ankle surgery.

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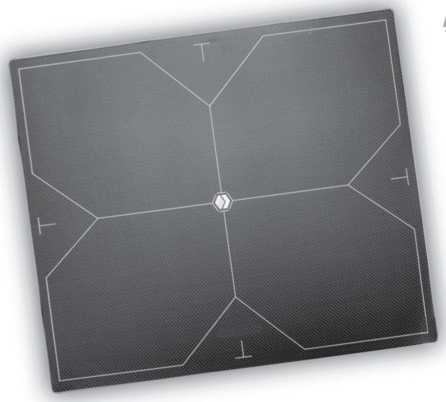

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