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Harvesting of Autogenous Cancellous Bone Graft from the Proximal Tibial Metaphysis

A Review of 230 Cases

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Summary: A study was undertaken to review the results of donor site morbidity of cancellous bone grafts obtained from the proximal tibial metaphysis. Two hundred six patients who underwent 230 proximal tibial bone graft harvestings were reviewed. Patients with lower-extremity fractures or nonunions who required cancellous bone grafts and would be non–weight-bearing for at least 6 weeks were selected to undergo the procedure. Minimum length of follow-up was 4 months, with an average length of follow up of 20.4 months. The proximal tibial metaphysis was found to supply an adequate amount of graft for all procedures involved, with a complication rate related to graft donor site of 1.3%. This compares favorably to a previously published report on bone grafts taken primarily from the iliac crest. The postoperative appearance of the proximal tibia may be permanently altered by the procedure, but weight-bearing after 6 weeks appears safe. The proximal tibial metaphysis is a useful site for obtaining cancellous bone graft and is associated with a low morbidity. **Key Words:** Bone graft—Tibial metaphysis.

Through the course of the 20th century, bone grafting has become a common orthopedic procedure, of which an estimated 200,000 are performed annually in the United States (5). As reported in an excellent history of bone grafting before 1955 by Chase and Herndon (6), early experience with autogenous grafting by Von Walther in 1820 (17), and homogenous grafting by MacEwen in 1878 (12), stimulated the experimental work of Ollier (16), Axhausen (2), and others, leading to an increased interest in this procedure at the turn of the century. Largely due to the clinical work of authors such as Lexer (11), Albee (1), and others, the number of reported bone graft procedures increased from 246 cases in the 20 years preceding 1910, to numbers in the thousands in the following decade (6).

Subsequent experimental work has focused on the biology of incorporation of transplanted bone (8). For 30 years, it has been recognized that, although cortical bone grafts supply superior structural properties, cancellous bone graft exhibits increased speed of revascularization, more complete repair, and greater mechanical strength (5,8). Moreover, although banked allografts are available, they are considered to be inferior to fresh autogenous bone, due to inconsistencies in their incorporation (8,10).

A recent review of a large number of bone graft harvestings, taken primarily from the iliac crest, showed a low but significant morbidity associated with this procedure (18). Although most orthopedic

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surgeons probably think first of the iliac crest as a graft donor site, the proximal tibia is also an excellent source of cancellous bone. To date, no study has reported the results of a large number of autogenous cancellous bone graft harvestings from this site.

MATERIALS AND METHODS

A retrospective review was undertaken, which included all patients receiving proximal tibial bone grafts by the orthopedic trauma service at Allegheny General Hospital between January 1985 and December 1989. Minimum length of follow-up for inclusion in this study was 4 months and clinical resolution of the donor site. All patients were reviewed personally by an author.

Information was collected regarding donor site, recipient site, and complications relating to the graft donor site. Knee wounds and knee or proximal tibial injuries were also noted. Moreover, the presence or absence of an established infection, or a traumatic wound on the operative field, which might increase the risk of subsequent donor site infection, was recorded. Both hospital and outpatient charts were reviewed so that information on both early and late complications was available.

Patients who were to be non–weight-bearing for at least 6 weeks were selected to undergo proximal tibial graft harvestings. In the event of an ipsilateral traumatic knee wound, significant knee injury, or proximal tibial fracture, bone graft was usually harvested from elsewhere. Patients with bilateral injuries generally had graft obtained from both proximal tibias. If this was impossible because of a knee or proximal tibial injury, and/or one proximal tibia did not supply adequate graft material for both fractures, a second site was used.

OPERATIVE TECHNIQUE

Although the optimal position for harvesting a proximal tibial bone graft is with the patient supine and a roll under the ipsilateral hip to elevate the anterolateral tibia, patient positioning is ultimately determined by the graft recipient site. In the case of a posterolateral bone graft to the tibia, for example, the patient can be positioned prone with the knee flexed (Fig. 1A).

A 3-cm incision is centered over Gerdy's tubercle (Fig. 1B). A 1-cm osteotome is then placed perpendicular to the crest of the tubercle and driven 45° cephalad (Fig. 1C), removing a 1 cm^2 window of bone, incorporating the crest of the tubercle (Fig. 1D). The crest is important because it represents a simple anatomic marker for avoiding the articular surface of the tibia, while maintaining access to the best metaphyseal bone. Once this corticocancellous window is removed, the entire metaphysis of the proximal tibia is available (Fig. 1E). A curette can then be used to remove as much cancellous bone as needed for grafting.

RESULTS

From January 1985 through December 1989, 332 bone grafts were harvested by the orthopedic trauma service. Two hundred thirty-four bone grafts were obtained from the proximal tibia, 72 from the anterior iliac crest, 16 from the posterior iliac crest, and 10 from other extremity sites. Of the 210 patients who had grafts harvested from the proximal tibia, two died from causes unrelated to their orthopedic surgery and two were lost to follow-up after hospital discharge. Follow-up is therefore available on 206 patients who underwent 230 proximal tibial bone graft harvestings, representing 98% of the procedures performed during the time period studied. Average length of follow-up was 20.4 months with a range from 4 to 65 months. Proximal tibial bone grafts were harvested in 213 cases of acute fracture, 55 of which involved an open wound on the field either as an open fracture grade II or III or as a major laceration. They were used in 17 cases of nonunion, three of which were infected with the wound exposed to the donor site.

The recipient sites were 168 acute femoral diaphyseal fractures that underwent plate osteosynthesis, six femoral nonunions, 27 supracondylar, and 10 subtrochanteric femoral fractures that were plated. Ten tibial nonunions, four acute tibial fractures, one talar nonunion, and eight other foot and ankle procedures also used proximal tibial metaphyseal bone.

There were 24 cases of bilateral lower extremity injuries requiring bone grafts. In 14 of these, both proximal tibias were used to supply bone graft, while in the remainder only one proximal tibia was available because of either wounds or fractures to the other. In four of these cases, one proximal tibia supplied adequate graft to augment two fractures, and in the remaining six, the proximal tibia was used in combination with another site.

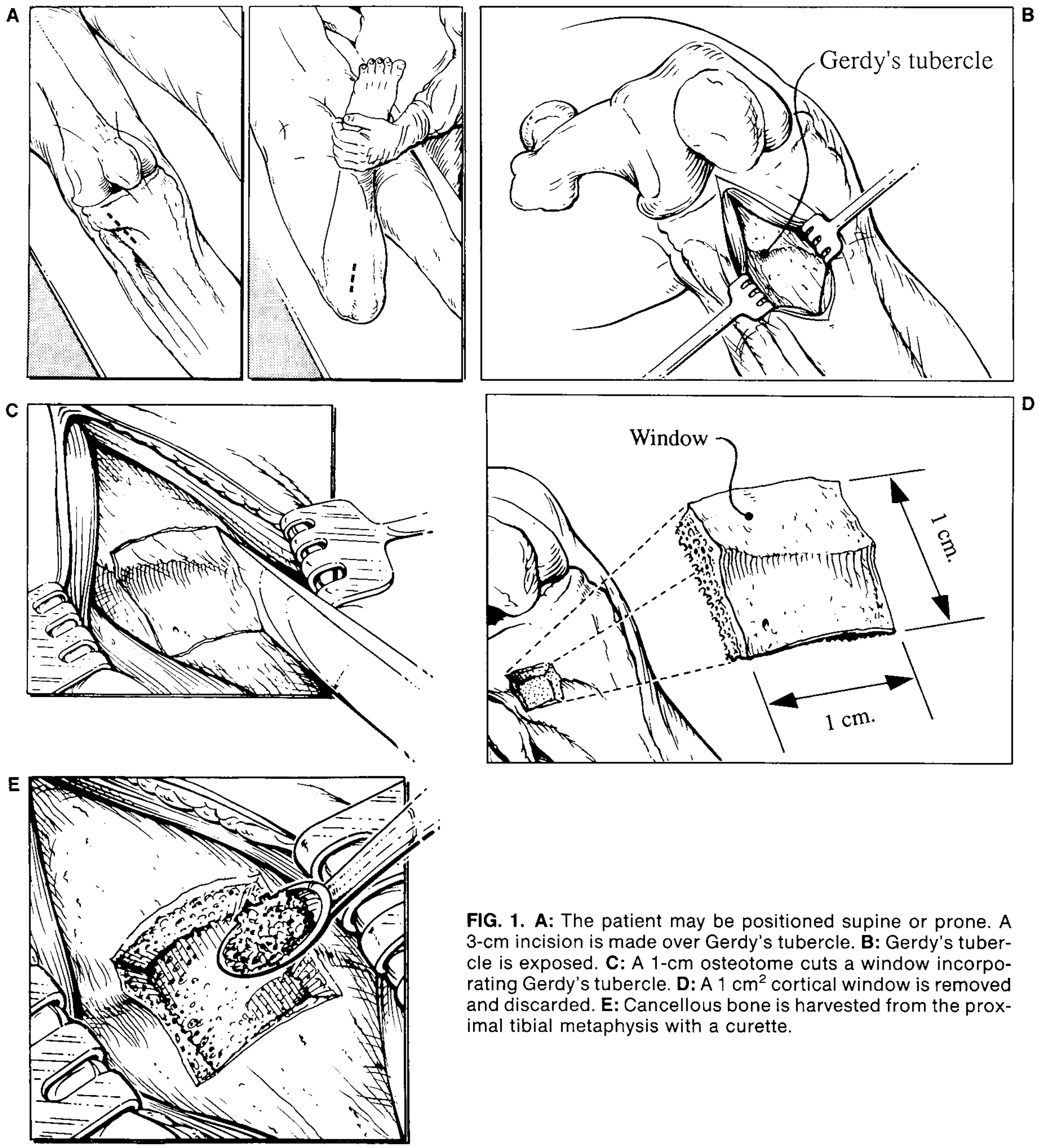

FIG. 1. A: The patient may be positioned supine or prone. A 3-cm incision is made over Gerdy's tubercle. **B:** Gerdy's tubercle is exposed. **C:** A 1-cm osteotome cuts a window incorporating Gerdy's tubercle. **D:** A 1 cm^2 cortical window is removed and discarded. **E:** Cancellous bone is harvested from the proximal tibial metaphysis with a curette.

Patients with 227 of 230 proximal tibial bone graft harvestings had no complications related to their graft site and reported no long-term discomfort related to the procedure. Cosmesis was not a concern. No patients complained of pain with kneeling. There were no cases of sensory loss, or fracture of the proximal tibia once weight-bearing was commenced. Despite the fact that 55 of these procedures were performed with an open wound on the operative field, there were no cases of deep infection.

There were three complications of the proximal tibia graft donor sites, none of which constituted a long-term problem for the patient involved. One patient was noted to have an undisplaced fracture of the tibial eminence on postoperative radiographs after the graft was obtained. The patient was maintained on the usual non–weight-bearing protocol, with the addition of a knee immobilizer, and the fracture healed without incident.

Two patients, both of whom had closed fractures with no open wound on the operative field, had wound complications. One drained a hematoma from the proximal tibial wound for 4 days and subsequently healed without difficulty. The other developed a superficial wound infection at the proximal tibial incision, requiring local care for 3 weeks, before healing. All three patients have done well following the resolution of their complication, and have had no residual discomfort related to the graft site.

In all cases one donor site was adequate for one fracture. In four cases one donor site provided adequate cancellous bone for two recipient sites. We are routinely able to fill a 4-ounce bowl with cancellous bone.

DISCUSSION

The overall complication rate in this study is 1.3%, which compares favorably with Younger and Chapman's report on morbidity of graft donor sites, where the overall major complication rate was reported to be 8.6% with a minor complication rate of 20.6%. That study included all types of bone graft procedures, and was weighed heavily toward iliac crest grafts (89.5%), many of which were obtained during the course of spinal surgery (53.4%). The major complication rate related specifically to iliac crest donor sites was 9.2% with a minor complication rate of 20.7%. Twenty-six extremity sites were reviewed, of which only eight (3.3%) were from the proximal tibia, yielding a major complication rate of 3.8% and a minor complication rate of 19.2% (18). The proximal tibial donor sites were not separately reviewed, and direct comparison between the studies is therefore not possible.

Our service consists primarily of high-energy, blunt, polytrauma patients, many of whom undergo plate osteosynthesis with bone grafting for femoral diaphyseal fractures. We have also used the proximal tibia for a variety of other acute fractures as well as reconstructive procedures. Adequate bone graft was obtained for at least one fracture in all cases. In four cases, one donor site provided sufficient cancellous graft to augment two recipient sites. Contrary to popular belief, the proximal tibia provides a large volume of cancellous graft material.

Younger and Chapman distinguished between grafts taken via the surgical incision and grafts taken through a separate incision, citing significant differences in the complication rates of the two (18). Because a similar difference was not noted in this study, it has been the practice of the authors to include Gerdy's tubercle in the surgical incision if it is nearby. Otherwise, the graft has been obtained through a separate, 3-cm incision over the tubercle.

We have only harvested bone from the proximal tibia in patients who would be non–weight-bearing for 6 weeks. We have seen no fractures through a weakened proximal tibial metaphysis. It may be possible, especially with small graft harvestings, to bear weight immediately postsurgery.

Although the proximal tibia is clearly healed adequately to permit weight-bearing after 6 weeks, the metaphyseal defect at the donor site can remain as a permanently visible radiographic finding. As reported by Daffner, this radiographic finding can be mistakenly felt to represent a giant cell tumor of bone, or other significant abnormality, in the absence of appropriate clinical history (7) (Fig. 2). Anecdotally, the authors are aware of three cases in which patients were considered for surgical biopsy by physicians unfamiliar with their entire clinical history. It is important, therefore, that patients understand that the radiographic changes induced by tibial bone graft harvesting may remain permanently.

McGrath and Watson have described sclerosis and trabeculation on radiographs of distal radius bone graft donor sites 9–12 months after graft harvesting, and have documented the regeneration of cancellous bone in the face of postoperative radiographic lucency (14). Montgomery and Moed's study on canine iliac crests demonstrated the microscopically mature appearing trabecular pattern of cancellous bone 1 year after graft harvesting, although the radiographic appearance of the ilium was not an adequate predictor of donor site regeneration (15). We have not harvested a second graft from the proximal tibial metaphysis, and we have not done any studies to assess regeneration of cancellous bone.

We have found the cancellous bone harvested from the proximal tibial metaphysis to incorporate as well as cancellous bone harvested from other sites (Fig. 3). The bone harvested is soft and easily molded to fill gaps in fractures.

Recently in the orthopedic literature there has

A B

FIG. 2. Anteroposterior **(A)** and lateral **(B)** radiographs of knee in a 23-year-old man 4 months postharvesting of proximal tibial metaphyseal bone graft. Postoperative findings are consistent with giant cell tumor. A biopsy was recommended to the patient.

been a great deal of interest surrounding the use of substances such as interporous hydroxyapatite and tricalcium phosphate as bone graft substitutes (3,4,10,13). Until the use of these or other materials can be perfected, autogenous cancellous bone grafting remains the procedure of choice when augmentation of bone healing is required (5,9).

The proximal tibia provides a useful site from which autogenous cancellous bone graft can be obtained. When harvested via Gerdy's tubercle, the complication rate is low, the amount of graft obtained is adequate, and patient discomfort is minimized.

Note: This is the same clinical example used in a previously-published article. It was our patient, and the same figures are being used with the permission of Dr. Daffner.

A-C

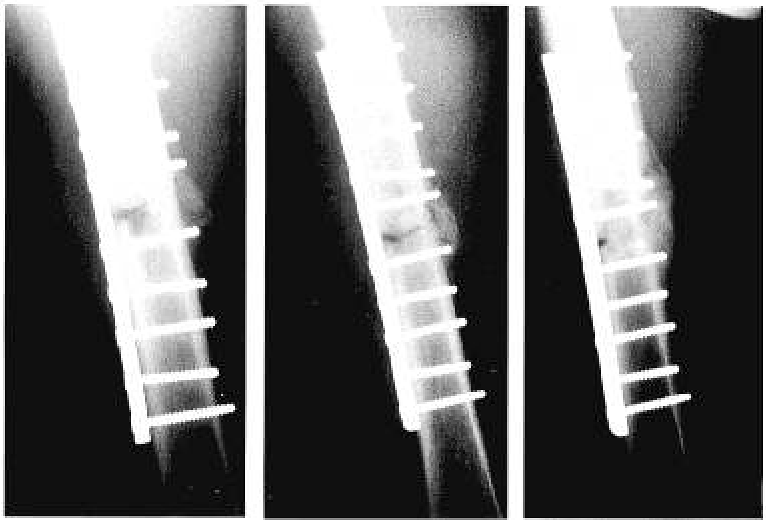

FIG. 3. A: Immediate postoperative radiograph of plated femoral diaphyseal fracture with fresh bone graft from Gerdy's tubercle. **B:** Eight-week postoperative appearance showing early incorporation of bone graft. **C:** Fracture has united by incorporation of bone graft at 12 weeks. Note that the fracture line is still visible.

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