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Review Article: Bone Grafting Surgery: Proximal Tibia as Donor Site

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ABSTRACT

Proximal Tibia is the second most common site for cancellous bone harvest after Iliac Crest. It is an excellent bone graft donor site especially when the same limb is undergoing the primary operation. The amount of graft and the quality probably are comparable to that taken from iliac crest and complications are by far less common and less serious. It seems that Proximal Tibia is a suitable donor site for bone graft harvest and orthopedic surgeons must keep this site in mind when this surgery is necessary.

1. Introduction

Iliac crest, proximal tibia, and fibula are the most common sites, from which bone graft is taken. Among them, Iliac crest cancellous bone graft is the standard, to which all other materials are compared [1] and the iliac crest is the most common donor site for bone grafting in orthopedics [2] and the choice in oral and maxillofacial surgery [3]. However, iliac crest bone graft harvest has been infamous for the high rate of complications, occurring in up to 49% of patients [1-5], more common in the spine, orthopedic, and oral surgery [1, 3]. Thus, attention has been paid more and more to alternative sites. The proximal tibia is another common source of cortical, cancellous, and corticocancellous bone graft harvest. This narrative review attempts to assess the literature on all aspects of bone graft removal from the proximal tibia. PubMed, Embase, Web of Science, and Google scholar were reviewed and any related articles, including the references of these papers, were assessed for important points, from 1985 to the present.

2. Body

Albee has been credited with using different sources of bone graft, ilium, tibia, fibula, cranium, and metatarsal bones [2], but the first documented use of proximal

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tibia as a graft is of Drachter, who used this bone for cleft closure in the maxilla in 1914 [6]. The proximal tibia is an excellent source of graft especially when the same limb is undergoing the primary surgery, but it has been used in several sites of surgery from foot and ankle [7-9] to upper extremity [10, 11] and oral and maxillofacial [9]. Proximal tibia has been the center of attention in oral surgery much more than the orthopedic ones. As taking large cortical grafts may lead to fracture of tibia with weight-bearing, proximal tibia is considered mostly when the cancellous bone is needed.

Grossly, a cancellous bone from the proximal tibia looks different from that of the iliac crest, being more porous and containing more fat. A histologic study showed the iliac cancellous bone superiority upon proximal tibia [12], but the study conducted by Takemoto et al. failed to report a significant difference in the mRNA levels of different types of bone morphogenetic proteins among proximal tibia, iliac crest, and proximal humerus [13]. Regarding the amount of graft that can be taken from these two sites, no significant difference in the volume of cancellous bone harvested between the proximal tibia and anterior iliac crest was shown [14] and even more cancellous bone has been harvested from the proximal tibia in some instances [15, 16]. However, cadaver studies showed the reverse: less bone could be harvested from the proximal tibia than the anterior iliac crest [17, 18]. Another study compared "corticocancellous" graft from the iliac crest with "cancellous" graft from proximal tibia in cadavers and they were equal [19]. At the same time, this may not be a fair comparison; the amount of graft taken from the proximal tibia is completely dependant on the size of the osteotomy and the window created; the larger the osteotomy, the bigger will be the amount of graft harvested [20]. At least theoretically, a larger osteotomy will increase the chance of fracture and complications, while the iliac crest can be easily accessed via a larger osteotomy. On the other hand, the clinical experience of most surgeons will not support the "measured" amount of bone graft from the proximal tibia, probably because of the limitations with window size and the fear of joint penetration and fracture, and the fact that movement of the curette against the spongy cancellous bone may compress the cancellous bone along the cortex, misleading the surgeon to a conclusion that the space is empty [21].

Bone harvest from proximal tibia may be performed from the medial or lateral sides and with many techniques, while no difference has been reported about the quantity of the graft taken [11, 13]. Although harvest has involved the lateral side traditionally, especially in orthopedic surgeries [22], the medial side has been suggested as safer [11]. However, to the best of our knowledge, a comparison has not been performed. In-office harvest has been reported from the lateral side under local anesthesia and sedation, without significant complications [23]. On the other hand, a retrospective review on 79 patients who had undergone bone harvest from the medial side under local anesthesia encountered two major complications: one wound delayed healing and one case of "stress fracture" that healed with immobilization. Also, 7% of the patients reported dysesthesia for about six months in the area of graft harvest [24]. It is unclear whether the type of anesthesia has had any effects on these outcomes.

The size of the window created for graft removal (osteotomy) has been investigated. Obviously, the larger the window, the greater will be the amount of graft, but this can not be taken easy, as at least theoretically, the larger window will lead to an increased risk of fracture. Despite this, the "safe maximum size" of osteotomy has not been determined. Most authors have suggested a 1 cm^2 or between 1 and 2 cm^2 window, but a cadaveric study suggested that even with a 25 mm^2 window, catastrophic failure of the tibia is unlikely [20].

The most common complications after bone harvest from proximal tibia have been superficial wound infection (1.3%), superficial hematoma (1.3-15%), and immediate postoperative pain (20%) [25, 26]. The pain has subsided in around two years in most cases, but 4% of the patients reported long-term persistent mild pain [27]. The pain was reported to be significantly less severe in the proximal tibia donor site than the iliac crest [15, 16].

Gait disturbance, described as a major complication of proximal tibia bone graft harvest, is a rare complication. It is not reported in most series and occurred in two of 63 patients reported by Frohberg et al. [28], which persisted "well beyond the three weeks". Regarding Chen et al. experience on 40 patients, 2.5% showed gait disturbance, but it was resolved by three months in all patients [29].

Fractures at the donor site have been reported as a very rare but serious complication, 10 patients in total, mostly by craniomaxillofacial surgeons and after activities, such as playing tennis, one to six weeks and even three months after the procedure, or a fall from staircase two weeks after the operation [30-32]. However, it has been reported without trauma [33]. Fractures of the tibial plateau have been reported twice [33, 34], both in the postoperative follow-up and without specific trauma. Also, a plateau fracture has been reported as an intraoperative complication [35]. Reattachment of the cortical cap has

been advocated to decrease the chance of fracture [36]. A fracture of tibial eminence was reported as one of the three complications in 230 bone graft harvests from the proximal tibia [26]. It was nondisplaced and healed by immobilization, but open reduction and internal fixation sometimes have been necessary for shaft fracture [30]. One case of joint perforation has been reported as an intraoperative complication that healed uneventfully despite prolonged knee pain [28] and as mentioned previously a case of stress fracture of the tibial condyle has been reported [24].

Biomechanical studies have shown that the tibia is stable during full weight-bearing after the harvest of considerable amounts of cancellous bone graft [17, 20]. Although protection for six to twelve months has been suggested to prevent fractures of the tibia after graft removal [37], this seems to be about cases, in which large cortical grafts have been harvested from the shaft and this is usually performed only in children. In most cases, immediate weight-bearing after surgery is allowed, but still, some other authors preferred four to six weeks of non-weight-bearing after this procedure as a routine [25, 30, 31, 33]. If the window crosses the midline, protected weight-bearing for six to twelve weeks has been advocated, and as a general, recommendation sharp angels in the window should be avoided to prevent a stress riser [25]. Also, avoidance of strenuous physical activity and contact sports for three months has been encouraged after this procedure [32, 38]. A negative correlation between the maximal compressive strength of proximal tibia and the volume of bone harvested has been shown, which may imply that a larger amount of bone harvested will lead to a higher risk of fracture in the tibia plateau [39]. Although it is a general agreement that some amount of cancellous bone would remain intact to prevent complications, there is no consensus that what this amount should be. At least 2 cm of subchondral bone preservation has been advocated by some researchers [11, 17].

Peroneal nerve [25], tibial recurrent vessels and nerves [7, 25], and Saphenous vein [25] are theoretically at risk when the graft is harvested from the proximal tibia, and "nerve injury" has been mentioned as a "documented complication" of this procedure [7, 25]; however, we could not find a single case in the series mentioned above and some others that we reviewed, including the provided references for "documented" nerve injury. Transient sensory dysesthesia in three of the five medial proximal tibia harvest that resolved with weight-bearing [9] has been interpreted as "temporary nerve injury" by others, who recommended taking care to avoid and preserve the inferior patella and Saphenous nerve [7], and at the same time, dysesthesia and paresthesia have been mentioned frequently as a complication in this procedure. When an incision is made, "nerve injury" is inevitable, but this generally is not considered a serious complication.

"Taking care" to avoid physis has been advocated as a rule when removing cancellous bone graft from the proximal tibia in a child [37]. At the same time, bone graft harvest from proximal tibia has been suggested as contraindicated in children with open physis [25], obviously because of the possibility of growth disturbances. Also, a technique for harvest in children has been described and performed without complications except for one case of hematoma and consequent temporary knee stiffness [40]. The report is related to 15 patients with a mean age of about 10 years and their criteria for avoiding the physis are not clear. The surgeon(s) used "postoperative radiograms" to ensure not damaging the growth plate. The article does not provide any follow-up about the growth of the patients, and in concordance with others [38], we found that such follow-up is missing in the literature. It seems that maxillofacial surgeons have used proximal tibia in children more frequently since this article has been published [6].

3. Conclusion

Proximal tibia is an excellent source of bone graft harvest and complications are by far less common than the iliac crest. The quality and quantity of bone harvested are comparable in these sites.

Ethical Considerations

Compliance with ethical guidelines

This article is a review paper with no ethical considerations to be considered.

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

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