Autologous Bone Graft in Foot and Ankle Surgery

Christopher P. Miller, MD[a], Christopher P. Chiodo, MD[b,*]

KEYWORDS

• Autologous bone graft • Iliac crest • Proximal tibia • Calcaneus
• Reamer-Irrigator-Aspirator (RIA) • Bone healing

KEY POINTS

- Autologous graft is the gold standard choice for bone graft and may be harvested safely and quickly with the proper tools and techniques.
- Autologous graft is the only graft option that is osteogenic, osteoinductive, and osteoconductive.
- The quantity of bone graft required and the patient positioning for the primary surgery dictates the harvest site and technique.
- The graft may be harvested from several sites including the iliac crest, proximal tibia, and calcaneus and from within the intramedullary canal using a reaming device.
- Autograft is associated with donor site pain and morbidity; however, this complication is usually limited in foot and ankle surgery, as the primary surgeries rarely require large quantities of bone graft.

INTRODUCTION

Bone graft is a common adjunct procedure in orthopedic surgery used for fusions, fracture repair, and the reconstruction of skeletal defects in the foot and ankle. Autologous graft, or autograft, involves the transport of bone from a donor site to another location in the same patient. It is considered by many to be the gold standard of bone grafting, as it is provides all biologic factors required for functional graft. Further, autograft is 100% histocompatible with no risk of disease transmission.[1–7]

Autograft bone is osteogenic, providing osteoblasts and osteocytes and precursors that will form bone. Autograft bone is also osteoinductive, bringing growth factors and matrix proteins as well as signaling molecules that will facilitate bone growth. Finally, it

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[a] Carl J. Shapiro Department of Orthopaedics, Beth Israel Deaconess Medical Center, Boston, MA, USA; [b] Department of Orthopedic Surgery, Brigham and Women's Hospital, Boston, MA, USA
* Corresponding author.
E-mail address: cchiodo@partners.org

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is osteoconductive, providing a mineral and collagen scaffold for native cells and bone healing to occur in an ordered predictable fashion.

Historically, the common autograft harvest site was the iliac crest. Early complication rates were reported to be as high as 20% to 39% for minor and 2.5% to 10% for major complications.[8–11] Combined with the lack of anatomic proximity, concerns about complications led foot and ankle surgeons to search for alternative harvest sites. These alternative sites included the proximal and distal tibia, the calcaneus, and the intramedullary canal of the tibia and femur.

Commercially available bone graft substitutes have also been developed. Although these substitutes eliminate the risk and potential morbidity associated with graft harvest, no such product is proven to be superior to autologous graft. Additionally, one other concern lies in the significant expenses when using synthetic graft options.

GRAFT COMPOSITION AND QUALITY

Cancellous autograft is the most commonly used autograft in foot and ankle surgery. This type of autograft has a high surface area and contains osteogenic cells. The lattice of trabecular bone provides access for revascularization from the native bone and rapid incorporation of the graft.[6] Cancellous graft lacks structural stability and is, therefore, not appropriate when used in isolation to sustain compressive loads. However, this lack of structure also makes it an ideal choice when filling small defects. Because of the osteogenic properties and porosity of the cancellous bone, cancellous autograft is also highly angiogenic and readily revascularized into the host bone.[6]

In contrast to cancellous bone graft, pure cortical graft offers excellent initial stability. However, this comes at the cost of slower revascularization and incorporation into the host bone because of the minimal osteogenic potential in the cortex. These types of grafts are less frequently used in the foot and ankle, usually as a composite graft to achieve early stability and with the expectation that bone healing and union may initially occur elsewhere at first. An example would be an ankle fusion that required a cortical bone graft strut for bone loss caused by asymmetric ankle arthritis.

Cortico-cancellous graft allows for a compromise between structurally weak but osteogenic cancellous graft and stable but biologically inaccessible cortical graft. These grafts are most commonly harvested from the iliac crest and may have up to 3 cortices intact depending on surgical technique.

Vascularized bone graft is much less commonly used in foot and ankle procedures. A vascularized graft is most often considered when there is concern about the quality of the native bone blood supply, as with osteonecrosis or the case of a chronic, atrophic nonunion. Because of the special nature of these grafts, they require the expertise of a microvascular-trained surgeon. In the appropriate patient, they can bring needed structure, biology, and blood flow to a biologically compromised region.[12,13]

One critical consideration lies in the graft quality. Donor sites are not equal with regard to osteogenic cellularity. In the senior author's histologic study comparing samples of bone graft harvested from the iliac crest and proximal tibia, only the iliac crest grafts contained active hematopoietic marrow (**Fig. 1**).[14] In contrast, the tibial grafts contained quiescent fat and little hematopoietic marrow. Similarly, Hyer and colleagues[15] found that marrow aspirate collected from the iliac crest had a higher concentration of mesenchymal stem osteoprogenitor cells than aspirates from the distal tibia or the calcaneus.

These findings have implications regarding bone graft and its cellular contributions to healing. Clinically, these findings support the use of hematopoietic iliac crest graft or aspirate, at least in patients at high risk for nonunion. Meanwhile, the finding that tibial