

# BONE GRAFT MATERIALS AND PERIOPERATIVE MANAGEMENT

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Bone grafts have been used for a wide variety of indications for many years. The use of bone grafting in foot and ankle surgery has expanded over the past ten years. This paper will refine indications for the use of bone grafts, identify proper selection criteria for bone graft materials, and also identify management techniques which will improve the chances of success.

### INDICATIONS FOR GRAFTING

Bone grafts are used in foot and ankle surgery for a variety of indications. Opening-wedge osteotomies such as the Evans calcaneal osteotomy, or the Cotton osteotomy, are common indications. In these situations, the bone graft material must be strong enough to withstand the compression generated by the opening wedge. The bone graft material is placed into a highly osteogenic site in these situations. Therefore, autogenous bone is not necessarily required. An opening-wedge osteotomy is an example of a bone graft functioning as a replacement material. Other indications where the bone graft functions as replacement would include packing of bone cysts or lengthening of metatarsals. In the case of packing a bone cyst, if the site is highly osteogenic (such as a calcaneus), then the use of freeze-dried bone is a very acceptable material choice.

In addition to replacement, a bone graft can be used for augmentation. The best example of this is for facilitation of fusion, or for repair of a nonunion. In these cases, the bone graft material is used to enhance the procedure. An example of this would be an autogenous graft placed across the anterior talo-tibial surface in an ankle fusion. Another example would be an autogenous bone graft either placed around or interposed within a nonunion repair site.

In the author's review of three-hundred bone grafts, the most common surgical indication was for a reconstructive osteotomy such as the Evans calcaneal osteotomy. The second most common indication was use in conjunction with an arthrodesis.

### MATERIAL SELECTION

There are a variety of bone graft materials from which to choose. They can be broken down into autogenous bone, allogeneic bone, and bone graft substitutes such as hydroxyapatite.

#### Autogenous Bone

Autogenous bone is the preferable material in that it is osteoconductive, osteoinductive, and also provides viable cells. There is also no risk of disease transmission or immunologic incompatibility, since the material is retrieved from the patient's own body. Since autogenous bone has such outstanding properties, it should be used in those situations where the maximum amount of biologic potential is required, such as nonunion repair and some arthrodesis repairs.

The primary disadvantage of autogenous bone is the need to create a second surgical site for procurement of the graft. There are a variety of donor sites that are available, including the iliac crest, tibial metaphyseal regions, fibula, calcaneus, and a variety of other sources. The iliac crest is a very common site for retrieving larger autogenous bone grafts. It has the advantage of being able to provide tri-cortical pieces of bone with an ideal cortico-cancellous mix. The tibial metaphyseal regions can be windowed, and significant cancellous bone procured from these sites. The fibula can also be used as a cortico-cancellous donor site, although in most patients, the fibula has a very large component of cortical bone and not very much cancellous bone. The calcaneus is an ideal site for procurement of small grafts in that it provides very nice cortico-cancellous bone in small amounts.<sup>1</sup>

Once bone is procured from a donor site, the donor site can be either packed with a bone graft substitute, or managed with a drain or topical thrombin in order to prevent hematoma formation. In addition, the donor site needs to be protected until the area has fully consolidated. Once the bone graft has been procured, it should be transplanted

rapidly into the patient. The longer the bone remains exposed to air, the lower the number of viable osteogenic cells that will actually be transplanted with the graft.

### **Allogeneic Bone**

Allogeneic bone is an excellent material with many uses in podiatric surgery. In particular, the use of allogeneic bone in highly osteogenic sites can be remarkably effective. A perfect example of this is the Evans calcaneal osteotomy. In this situation, a bone graft is implanted into the highly vascular anterior aspect of the calcaneus. There is less of a need for transplanting osteogenic cells since the area is highly vascular and will be replacing the allogeneic bone with new bone relatively rapidly.

Allogeneic bone is procured from patients who donated their organs. There is a very complex selection criteria utilized for insuring that disease transmission risk is minimized. These criteria do vary from one lab to another. In addition, bone can be obtained which is procured under sterile conditions and then freeze dried, or bone can be procured that is secondarily sterilized with ethylene oxide or gamma radiation. The initial step is the selection criteria which involves multiple blood tests, a comprehensive history, and usually an autopsy to determine the exact cause of death, if it is not known. Patients who died of infectious diseases or malignancy are excluded.

Secondary sterilization can be performed, as well as other types of procedures, to neutralize the risk of virus transmission while still maintaining the viability of the bone morphogenetic protein. For most podiatric procedures, it is less critical to preserve the bone morphogenetic protein. If the bone is going to be transplanted into a highly osteogenic site, then the bone morphogenetic protein has less critical importance. These secondary treatments to the bone graft do affect the mechanical stability of the graft. Again, in general this is not a significant issue for those indications where allogeneic bone is commonly used.

In terms of the healing properties, allogeneic bone heals more slowly than autogenous bone, as would be expected since one does not transfer a viable osteogenic tissue when performing an allogeneic graft. Nonetheless, in the author's experience with opening-wedge calcaneal osteotomies, allogeneic bone does heal quite rapidly in a highly osteogenic environment. In addition, avoiding the

procurement of an iliac crest autogenous graft eliminates a significant degree of possible morbidity to the patient. Therefore, one could argue that the use of allogeneic bone is preferable in procedures such as Evans calcaneal osteotomies.

### **Bone Graft Substitutes**

There are few bone graft substitutes that are available. Nonetheless, it is important to be familiar with the available alternatives. The best example of this is hydroxyapatite. Hydroxyapatite comes in the form of coral, which is prepared in a sterile and uniform manner. This is an ideal material to be used for the packing of defects in cancellous-rich beds. It suffices to occupy space and function in an osteoconductive manner while preventing disease transmission. Therefore, it is important to recognize that there are some other choices available in addition to autogenous and allogeneic bone.

## **PERIOPERATIVE MANAGEMENT**

There are a number of considerations that go into managing bone grafts. Many practitioners prefer to use perioperative antibiotics when utilizing a bone graft. Although this could not be considered the standard of care, in many cases it is a wise decision to use one preoperative dose of a first generation cephalosporin, and one or two postoperative doses, in order to reduce the risk of infection. The question is not so much that the risk of infection is greater when using a bone graft, as it is that if an infection does occur with a bone graft, then the morbidity is substantially greater than there might be otherwise.

Another important consideration is the use of appropriate instrumentation with the graft. When manipulating an autogenous graft, it is important not to burn the bone with a dull saw blade. Instrumentation should be sharp, and the area should be well-hydrated during cutting. It may also be useful to radius the corners of the area where the autogenous graft is being procured, to help prevent stress risers. This is more important in cortical areas such as the tibia.

Hemostasis is also vitally important and is best achieved through careful dissection techniques. However, a closed suction drain or topical thrombin can also be useful, particularly in an autogenous donor site from a rich cancellous bed.

The donor site can also be packed with hydroxyapatite or allogeneic bone to have more rapid osteoconduction and also to achieve hemostasis.

Stability of the bone graft is a critical consideration. The graft must have a stable environment in order to establish vascular patterns at the graft-host interface. This is even more important when using an allogeneic graft, due to the somewhat longer period required for healing. The author's general practice has not been to use fixation with Evans calcaneal osteotomies or Cotton osteotomies, as these areas are under compression and are generally quite stable. A nonunion repair of a first metatarsal however, requires very stable fixation in order to have the best chance of healing successfully. Clearly, one of the lessons that was learned from the author's study of three-hundred bone grafts was that a stable mechanical environment is one of the key factors for success.

### **POSTOPERATIVE MANAGEMENT**

Protection of the graft during the healing phase is paramount. Generally this is done with a cast, for enough time to insure adequate healing of the graft. The author takes a conservative approach when it comes to casting for the Evans calcaneal osteotomy, and recommends casting for 10 to 12 weeks, with the first 8 weeks in a non-weight-bearing position. A first metatarsal nonunion requires an even longer period of protection, consisting of casting as well as a variety of specialized shoes or inserts to unload the first metatarsal.

### **SUMMARY**

Bone grafting is an important part of reconstructive foot and ankle surgery. In order to assure success, the surgeon must know the range of materials available, and be able to determine which choice best suits a particular indication. A well-vascularized host bed, and stable fixation, are particularly important keys to success. Allogeneic grafts can be very useful when placed into a highly osteogenic environment. Autogenous bone grafts are most useful for nonunion repair and facilitation of arthrodesis.

### **REFERENCE**

1. Mahan KT: Calcaneal donor bone grafts. *J Am Podiatr Med Assoc* 84(1):1-9, 1994.