

SURGICAL MANAGEMENT OF NONUNIONS

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A nonunion that fails to respond to nonoperative care invariably requires surgery. It is not uncommon for a nonunion in the foot and ankle to be associated with malunion as well. Therefore, surgical management is often the treatment of choice. A successful outcome is dependent on realignment as well as union. It is important to determine why a nonunion developed, as surgical management should be directed at the specific etiology.

A thorough preoperative assessment will provide valuable information. Clinical evaluation is important for assessing the type and degree of deformity, limited or altered range of motion, etc. Selective intraarticular injections, particularly those that are fluoroscopically guided, can often narrow down specific areas of symptoms. Radiographs are obviously important to determine whether or not there is a complete union and to evaluate alignment. The authors often consider long-leg axial and hindfoot alignment views to help evaluate the relationship between the tibia, ankle joint, talus, subtalar joint, and calcaneus. Unfortunately, standard radiographs are sometimes insufficient because of their two-dimensional nature and can be equivocal when evaluating a nonunion. Advanced imaging is beneficial in most cases. Computed tomography (CT) scans and magnetic resonance imaging (MRI) are often helpful in evaluating the extent of a nonunion (Figure 1). Scintigraphy may also be helpful in determining the vascularity and potential to heal.

Surgical procedures for nonunion invariably require bone grafting, complex reconstruction, and an extended period of nonweightbearing. It is important to obtain appropriate physical therapy consultation prior to surgical intervention to ascertain if the patient can tolerate nonweightbearing, especially if premature weightbearing was a contributing factor to nonunion. It is also important to determine the patient's motives prior to surgery. Some patients diagnosed with nonunion may have issues relative to workman's compensation, disability, medicolegal issues, etc. Lastly, it is important to rule out complex regional pain syndrome (CRPS) before proceeding with any type of complex reconstruction or revision. Patients who have sympathetically-maintained pain are at risk for continued problems, regardless of whether or not they go on to a solid union following surgery.



Figure 1A. Lateral radiograph demonstrating nonunion of the subtalar joint after arthrodesis.



Figure 1B. Computed tomography scan confirming subtalar joint nonunion.

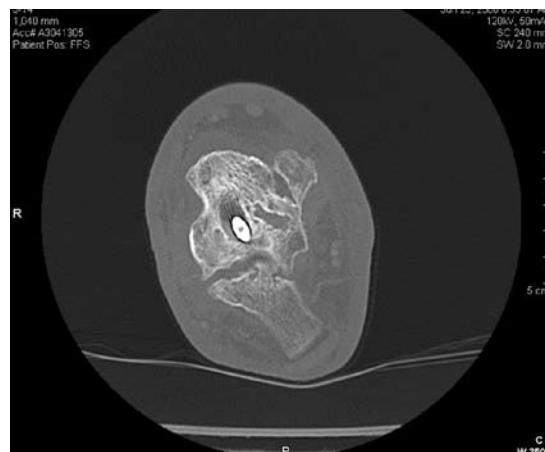


Figure 1C. Axial view showing nonunion.

It is important to determine the reason why nonunion or malunion developed following the patient's index procedure. We have already mentioned premature weightbearing as one possible contributing factor to nonunion or malunion. Additionally, technical issues can sometimes contribute to the development of nonunion. These types of issues may be secondary to inadequate fixation, insufficient bone grafting, inadequate reduction of the deformity, over-correction, inappropriate choices of orthobiologics, bone grafts or bone graft substitutes, etc. Nonunion may also develop because of host factors (diabetes mellitus, etc.). Certain types of pharmaceuticals or vitamin deficiencies can predispose patients to nonunion. It is important to evaluate if the patient will be compliant with treatment recommendations following surgical management. Obviously, noncompliance clearly increases the risk of a poor outcome.

The goals for revisional nonunion surgery include solid arthrodesis or healing of an osteotomy, anatomic alignment, normalized angular relationships on standard radiographs, symptom resolution, and restoration of functional capacity. Surgical approach, debridement and preparation of the nonunion site, bone graft/orthobiologics, supplements, and fixation are important components of revisional nonunion surgery. Surgical approaches for nonunion will vary depending on certain factors including location and degree of deformity, need of structural bone graft to increase length, location of previous incisions, and history of infection. Alternative approaches sometimes need to be utilized to avoid possible complications such as wound dehiscence.

Adequate debridement of a nonunion and preparation of host tissue are critical. The goal of preparation is to expose the subchondral bone such that one can develop a healthy cancellous substrate that will go on to primary union (Figure 2). Revision of a nonunion invariably requires some type of bone grafting to either provide structure or enhance healing. There are a large number of bone graft options such as orthobiologics, bone graft substitutes, that are available (1). Some cases may require autogenous bone grafting (Figures 3-5). Additionally, one should consider supplements that enhance healing such as vitamins and bone growth stimulators. Decisions regarding fixation are important. Fixation must provide a stable construct that will immobilize the joint or osteotomy such that primary union will occur.

Nonunions often have hardware that is retained within the surgical site. This hardware can be broken and difficult to access. The authors will typically try to remove hardware prior to inflating the pneumatic thigh tourniquet. The hardware is usually removed under image intensification through percutaneous incisions whenever possible to avoid wasting tourniquet time. It is important to take time to

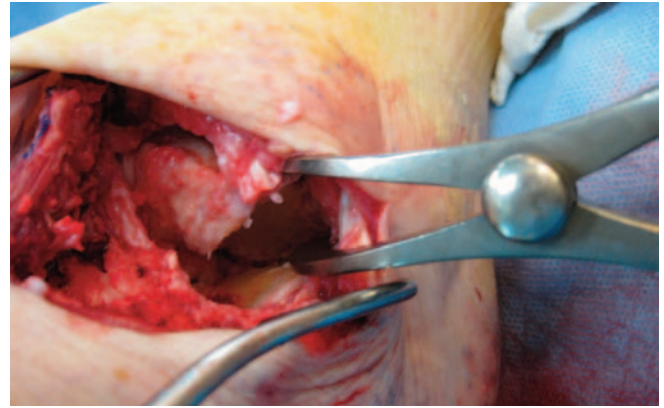


Figure 2A. Preparation of subtalar joint. Developing a healthy cancellous substrate.

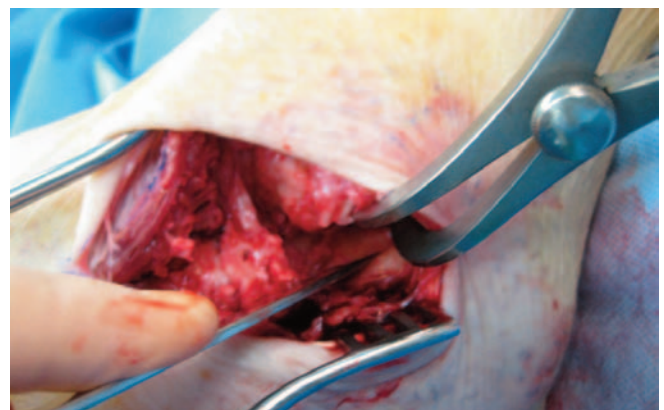


Figure 2B.

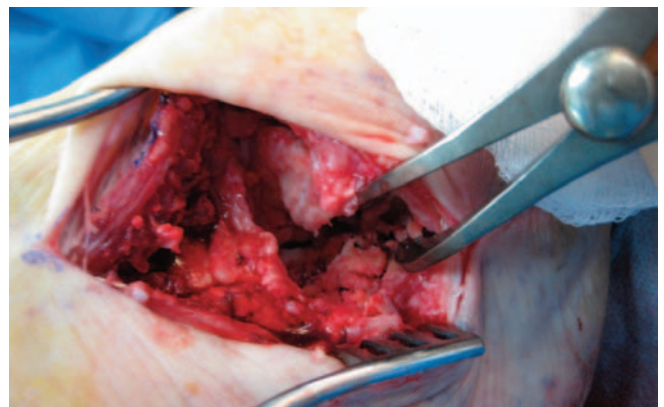


Figure 2C.

position the patient appropriately before surgery begins. This should be done before the patient is prepped and draped. The patient should be positioned such that image intensification and delivery of fixation can be performed in a relatively straight forward manner. We also recommend culturing any suspicious areas of nonunion as there is always a possibility of infection. We try to avoid lengthening procedures or opening wedge techniques that require



Figure 3A. Revision of subtalar joint arthrodesis nonunion with autogenous structural bone graft, screw fixation and implantable bone growth stimulator.



Figure 3B.

structural bone grafts. These procedures often require increased convalescence to allow incorporation. However, there are times when structural grafts are necessary to restore length. It is important to have appropriate technology available since these cases can be rather challenging. Having the latest technology provides more tools with which to address the underlying problem. Industry people intimately familiar with these latest technologies should be readily available for consultation and assistance.

Bone graft selection is important during revisional nonunion surgery. The functional requirement of the bone graft will obviously affect what type of graft is selected. The surgeon should know exactly what is to be accomplished with the use of bone graft i.e., structural bone graft to maintain length versus cancellous graft to provide a combination of osteogenesis and osteoinduction. One must also consider potential complications. There are times when certain patients are not good candidates for an autogenous graft harvested from the ipsilateral iliac crest and it is prudent to consider alternative types of bone grafts in these cases. There may be a situation where an allograft in combination with some type of orthobiologic might be a more realistic alternative. The local environment is also important. The host environment needs to be optimal for bone graft incorporation. It is important to assess the biologic potential of the bone graft. Lastly, the volume of graft that is required will also affect selection of bone graft.

There are several basic principals of bone grafts that are

important to understand. A bone graft cannot manifest biological activity without adequate blood supply. It is imperative to perform a thorough debridement of the nonunion. Furthermore, the goal of debridement is to develop a healthy cancellous substrate that will eventually go on to primary union. Motion during healing impedes incorporation, including micromotion. Therefore, it is important to provide a stiff and rigid fixation construct that eliminates all micromotion. Lastly, biologic response is influenced by load and instability. Therefore, the majority of these revisional nonunion cases will require an extended period of nonweightbearing.

There are perimeter issues that often affect the outcome of patients undergoing revisional surgery for nonunion. Obviously cessation of tobacco use is important in those patients that use nicotine. It has been well documented that smoking adversely affects union rates (2, 3). Patients taking medications that decrease healing should also be thoroughly evaluated. These medications should be discontinued whenever possible. Patients should have optimal nutritional support preoperatively and during the healing phase. Lastly, in patients that are obese or overweight, weight loss is often beneficial.

There are sometimes legal implications in patients undergoing revisional surgery for nonunion. It is important to have empathy for the original treating surgeon. Unfortunately, nonunion is seen in 10-15% of all foot and ankle surgery. Nonunion is something that most physicians will encounter from time to time. It is also important to



Figure 4A. Revision of modified Lapidus arthrodesis nonunion with structural-bone graft and screw/plate fixation.



Figure 4B.



Figure 4C.

evaluate work-related issues, particularly in those patients who are filing workman's compensation claims. These patients tend to have lower success rates following revision. Patients should be counseled about this prior to surgery.

The postoperative course following revisional nonunion surgery invariably requires nonweightbearing. We prefer to maintain patients nonweightbearing until there has been radiographic evidence of consolidation at the host-graft interface. Sometimes this is difficult to ascertain on standard radiographs. Serial CT scans can be used to qualify the fusion mass. Clinically, a lack of warmth and edema indicates

satisfactory healing. Additionally, we will often supplement the surgical procedures with an electrical bone growth stimulator. If we were unable to utilize an implantable stimulator, we will use external stimulation. This can be done with electricity or low intensity ultrasound.

CRPS is not uncommon in these patients with long-term or chronic problems. Patients undergoing multiple surgeries, such as those being treated for nonunion, are at risk for developing sympathetically-maintained pain. Unfortunately, CRPS will compromise outcomes. The surgeon should have a high index of suspicion of CRPS in this patient population and should appreciate the necessity of early intervention. Treatment for CRPS may include physical therapy, pharmacologic agents, and paravertebral nerve blocks. Rehabilitation goals following complex revisional surgery for nonunion will include restoration of motion, increased strength, improved balance, and appropriate stretching.

In summary, surgical management requires appropriate planning to address those factors responsible for nonunion. Although these revisional surgeries are often associated with high risk and extended convalescence, successful outcomes can be rewarding.



Figure 5A. Revision of nonunion with autogenous iliac crest and plate.



Figure 5B.



Figure 5C.

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