REARFOOT ARTHRODESIS: The Podiatry Institute Technique

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In 1923, Ryerson introduced the procedure known today as triple arthrodesis. At that time he sought an alternative procedure which would produce satisfying long term results in patients affected by infantile paralysis or similar disabilities. Since that time there has been a divergence of opinion regarding many aspects of triple arthrodesis. However, its indication for the management of painful conditions in the hindfoot has not been disputed. Surgeons agree that single, double or triple joint arthrodesis of the foot have many indications. These include traumatic or degenerative arthritic changes of the joints, malalignment of the foot, such as seen with a valgus or varus foot deformity, or gross instability of the same joints. There are numerous conditions which can result in deformities necessitating rearfoot fusion including tarsal coalitions, congenital vertical talus, systemic arthritis, and neuromuscular diseases such as Charcot-Marie-Tooth disease, cerebral palsy or spina bifida, to name a few.

It is unfortunate that the concept of a rearfoot arthrodesis is often associated with a painful, disabling, apropulsive foot. This has resulted because of the tremendous amount of literature which has emphasized the pitfalls and disadvantages of the procedure in contrast to its major benefits.

Problems associated with triple arthrodesis have included complications of bone healing, such as pseudoarthrosis or nonunion, recurrence of deformity, progressive degenerative joint disease in either proximal or more distal joints, avascular necrosis and alterations of normal bone growth. This has been compounded by complications such as peripheral nerve entrapment, excessive scarring and prolonged edema, muscle atrophy and weakness.

A review of the literature shows a variety of techniques for triple arthrodesis. Most of these have centered on techniques designed to avoid bone healing complications. Few reports have emphasized the importance of rigid internal fixation. Even more important, while much of the literature has emphasized the complications of residual deformity or recurrence of deformity, few have emphasized steps which should be taken to avoid these complications. Consequently triple arthrodesis has often been viewed as a "salvage procedure."

Over the years, The Podiatry Institute has consistently searched for ways to improve both the techniques and the end results of triple arthrodesis, as well as isolated or double joint fusions in the hindfoot. Because of the continuing efforts of The Podiatry Institute faculty, triple arthrodesis has become a very suitable and reliable means of stabilizing the foot, thus providing long-lasting improved function. Any rearfoot fusion entails significant complexity; many factors must be constantly assessed and reassessed preoperatively, intraoperatively, and postoperatively in order to achieve the desired outcome.

This paper will highlight the current techniques of major rearfoot fusions with emphasis on skin incision approaches, joint resection techniques and fixation. It is hoped that these "pearls and techniques" will assist the surgeon in achieving the best possible outcome following a major rearfoot fusion.

CURRENT TECHNIQUE

Perioperative Considerations

Although traditional techniques for major rearfoot fusion have required resection of a major portion of bone, current techniques have found a decreasing need for aggressive resection of the joints in order to successfully accomplish realignment and a solid arthrodesis. When the foot can be manipulated into the desired position of correction, and confirmed on x-rays, many of the faculty have found that resection of the joint via traditional orthopedic techniques can be avoided.

A thorough evaluation of the patient preoperatively is most critical. Clinical assessment should center on an understanding of the muscle tendon balance function around the entire foot and ankle. The ability to place the foot in the desired position of correction is critical prior to surgery. It is not uncommon for many of the faculty to obtain radiographs of the foot in the desired position of correction when mobility exists. In cases where the deformity is rigid in nature, careful surgical planning is necessary to understand which joints will require wedge resection, which joints will require bone grafting to achieve equilibrium of the medial and lateral columns and which joints can be resected by the curettage technique. An in-depth understanding of these principles can only be achieved by additional study (Fig. 1).

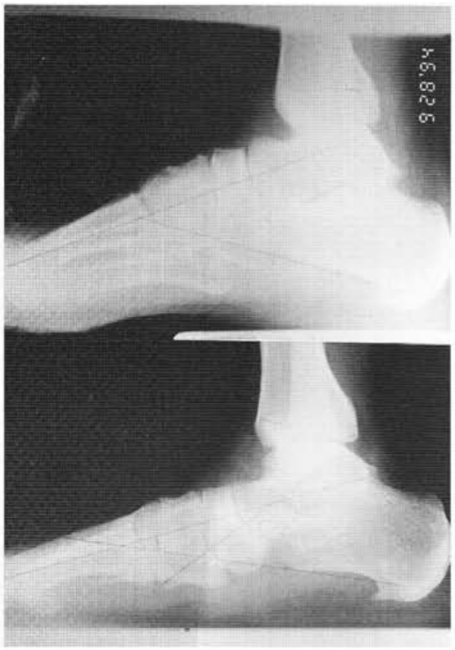

Figure 1. Preoperative weight bearing and neutral position lateral radiographs. Films demonstrate the flexibility of the deformity, suggesting preservation of the joint contour and ability to use the joint curettage technique while performing a rearfoot fusion.

In these cases, curettage resection of the joint is preferred. In cases where the deformity is rigid and/or there has been significant adaptation of the joints, then wedge resection techniques will be necessary alone or in combination with bone grafting. Typical examples include traumatic arthritis of the subtalar joint following prior joint compression calcaneal fracture, severe rigid pes valgo planus deformity secondary to longstanding coalition or severe tri-planar pes cavo varus or pes plano valgus deformities. Even in these conditions, a combination of joint curettage techniques and joint resection with or without wedging and/or bone grafting is preferred (Fig. 2).

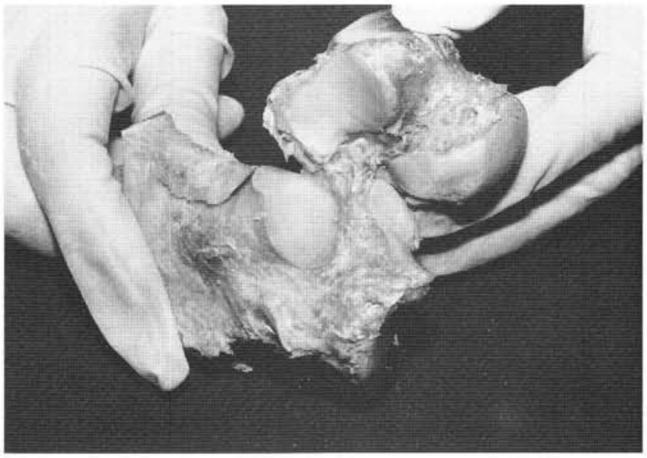

Figure 2. Cadaveric specimen demonstrating the configuration of the subtalar joint complex. Note the extensive curvatures. Also note the configuration of the talar head.

Surgical Incisional Approach

The faculty's approach to major rearfoot arthrodesis procedures typically employs two incisions. This is in contradistinction to the single curvilinear incisional approach popularized by the orthopedic community. The faculty have not found the one incision approach (Modified Ollier) to be effective in providing adequate exposure for joint resection and internal fixation.

The lateral incision typically runs from the tip of the fibular malleolus to the base of the fourth and fifth metatarsal cuboid articulation. The incision can be extended slightly posteriorly and may curve if exposure to the peroneal tendons is desired. It is important that the incision is not placed too inferiorly along the lateral border of the foot, as this will invariably lead to excessive trauma to the lateral dorsal cutaneous nerve and lesser saphenous vein. An incision placed too high or employing excessive dorsal curvature will increase the likelihood of surgical trauma to the intermediate dorsal cutaneous nerve. A postsurgical nerve entrapment may then ensue. The incision is deepened through the subcutaneous tissues to the level of the deep fascia. The deep fascia is a thin layer covering the extensor digitorum brevis muscle and blending with the deep fascia covering the peroneal tendons.

The deep fascia is incised in an inverted T manner. The vertical arm of the T incision is typically directly over the proximal portion of the sinus tarsi. The transverse portion of the T incision runs inferiorly and longitudinally, superior to the course of the peroneal tendons and extends from the anterior edge of the posterior facet of the subtalar joint and courses distally over the calcaneocuboid joint to the base of the fourth and fifth metatarsals. The extensor digitorum brevis muscle is reflected dorsally and distally. The bifurcate ligament is released. The contents of the sinus tarsi are usually evacuated.

An arthrotomy of the posterior subtalar joint is performed and the capsular tissues reflected. It is important to preserve the anatomy of the anterior talofibular ligament to avoid inadvertent anterior subluxation of the talus when performing major rearfoot fusions. A Crego elevator is used to free the capsular and ligamentous tissues around the lateral and posterior side of the subtalar joint. In most cases the calcaneofibular ligament is identified and transected. It may be tagged for later repair if so desired. Finally, as the periosteum, deep fascia and capsular tissues are reflected, one will encounter the lateral aspect of the talonavicular joint complex. The middle and anterior facets of the subtalar joint are readily visualized deep within the sinus tarsi.

Similar dissection technique is performed laterally and inferiorly to provide exposure of the calcaneocuboid joint. The short plantar ligament is usually preserved to help avoid bone healing complications of the calcaneocuboid joint in the initial phases of weight bearing postoperatively (Fig. 3A).

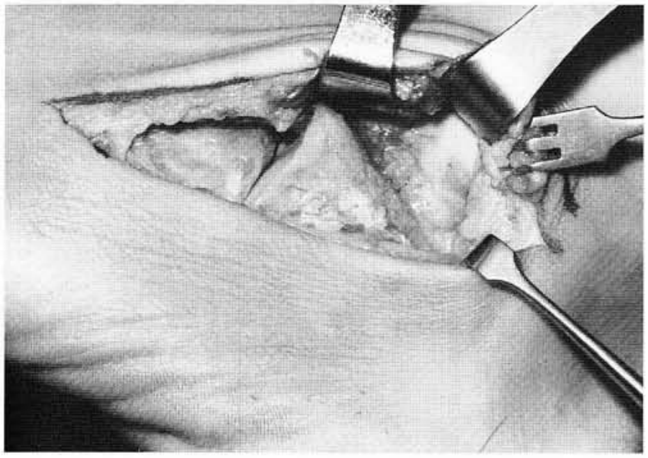

Figure 3A. Lateral incisional approach for major rearfoot fusion. Visualized is the lateral process of the talus which is fused to the calcaneus as a result of a tarsal coalition. The calcaneocuboid joint is also visualized. Note the subcapsular and subperiosteal dissection providing excellent exposure of the lateral tarsal bones.

The medial incision is similar in nature and runs from the tip of the medial malleolus to the level of the medial cuneiform. It tends to be linear in nature, although some faculty prefer to curve the incision dorsally; in some cases the incision is modified to follow the course of the tibialis posterior tendon if a surgical repair of this tendon is planned. The greater saphenous vein and nerve are usually encountered. The inferior tributaries of the greater saphenous vein are ligated and the neurovascular bundle retracted dorsally. This is to facilitate venous drainage postoperatively.

The deep fascia, periosteum and capsular tissues are incised from the anterior aspect of the ankle joint to the level of the medial cuneiform. The tibialis anterior is visualized and preserved. In some cases, portions of the tendon insertion will also be transected. An ankle arthrotomy is performed. Subcapsular and subperiosteal dissection are completed exposing the head and neck of the talus, the talonavicular joint itself, as well as the naviculocuneiform joint when performing a triple arthrodesis or medial column fusion. The incision can be extended distally in cases where naviculocuneiform arthrodesis will also be performed (Fig. 3B).

The medial and lateral incisions are generally connected over the dorsal aspect of the talus. The dorsal tissues can be retracted with the use of a ribbon retractor or a large one inch Penrose drain.

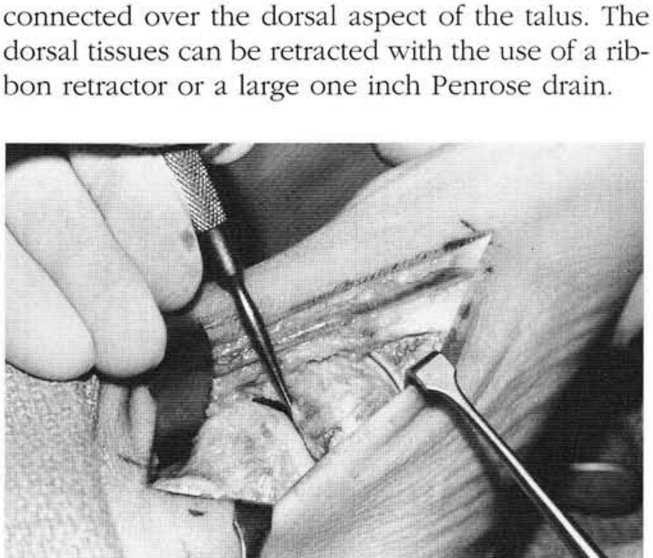

Figure 3B. Medial incisional approach for major rearfoot fusion. Freer elevator within the talonavicular joint complex. Note retraction of saphenous vein dorsally. A portion of the medial cuneiform is visualized.

Joint Resection Techniques

In order to perform joint curettage technique, each of the joints must be distracted to provide complete visualization of the articular surfaces. Thus, it is important to be sure that there are no ligamentous structures binding the joint together and thus preventing adequate distraction (except to the plantar ligament of the calcaneocuboid joint). There are a number of devices available to facilitate the distraction of these joints. These include the use of a baby laminar spreader (baby Inge retractor), a variety of spinal disc distractors, as well as the Synthes miniature distractor. Steinmann pins driven parallel to each other on opposite sides of the joint are used to help facilitate the distraction. Good distraction and separation of the joint is the most important aspect facilitating the curettage joint resection techniques (Figs. 4A, 4B).

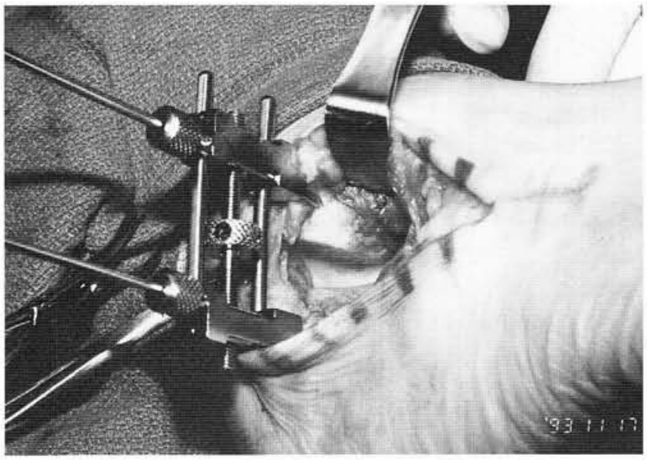

Figure 4A. Distraction of the posterior facet of the subtalar joint utilizing the Synthes mini-distractor. This is visualized through a lateral incision of a right foot.

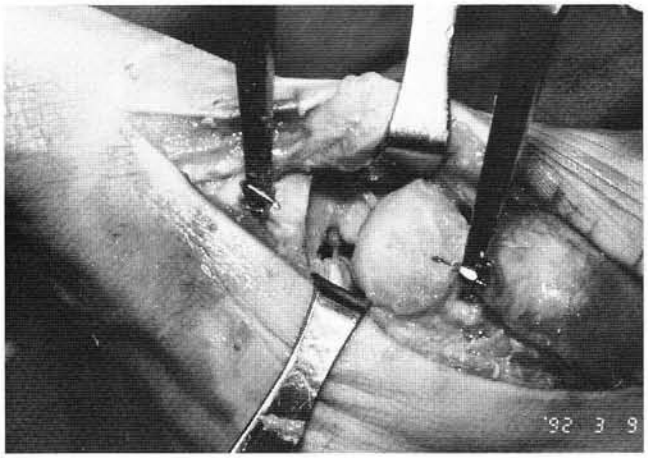

Figure 4B. Distraction of the talonavicular joint complex. Note two Kirschner wires parallel to the joint. They are distracted by use of a special disc distractor.

The cartilage is then removed. The subtalar and calcaneocuboid joints are easily resected by the use of small straight and curved osteotomes as well as closed or open ring bone curettes. All of the cartilage is removed to the level of the subchondral bone plate. One will know that the subchondral bone plate has been reached by the quality and feel of the surface when scraping with a curette. Failure to remove all of the cartilage from the adjacent articular surfaces will clearly increase the likelihood of a postoperative bone healing complication. The talonavicular joint complex is most easily resected by the use of straight and angled, closed and open bone curettes. In some cases, the use of a small power bur will help facilitate cartilage removal. A variety of small needle-nosed and other type of rongeurs may also be helpful.

Each of the joint surfaces is fenestrated with a series of 1.5 mm drill holes. It is not uncommon for the faculty to drill as many as 25-30 holes in each of the surfaces. The resultant "bone paste" is left within the fusion site to facilitate arthrodesis. In some cases, drilling of the articular surfaces is deferred until placement of the fixation devices. Before the fixation devices are tightened and secured, they are loosened and backed out, the joints distracted, the subchondral bone surfaces drilled, the joints replaced back in anatomic position and final fixation achieved (Fig. 5).

The traditional approach to resection of the joint has been by the use of osteotomes or power instrumentation. In lieu of a resection of large wedges and resection of bone, many of the faculty will typically resect the joint employing of

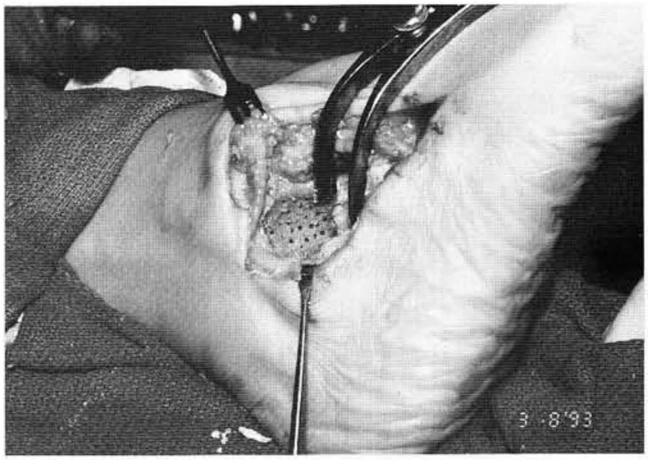

Figure 5. Visualization of the underside of the talus constituting the posterior facet of the subtalar joint. Curettage technique has been utilized to remove cartilage. Extensive subchondral drilling has been completed.

reciprocal planing technique described by E. D. McGlamry. This is particularly true when dealing with both the talonavicular and calcaneocuboid articulations. A large saw blade with coarse-edged teeth is recommended. In some cases, the saw blades can be doubled. When resecting the talonavicular joint, it is important that one appreciates the extensive convexity of the talar head and concavity of the navicular. If resection is begun at the more proximal edge of the navicular, then excessive bone will have been resected from the talar head. Consequently, it is recommended that the talonavicular joint be placed in its desired position, and the joint resection begun by moving several millimeters distally onto the main body of the navicular bone. The first pass of the saw blade is likely to remove only the peripheral edge of the articular surface of the navicular and, at the same time, a small portion of the talar head. A failure to appreciate this concept is likely to result in excessive shortening of the medial column of the foot.

In cases where abduction of the midfoot is desired, a wedge resection of bone may be performed as an alternative to reciprocal planing of the calcaneocuboid articulation. Likewise, when increased adduction of the mid foot is desired, the joint can be resected and a bone graft inserted.

In cases of rigid subtalar joint deformity (tarsal coalition or prior calcaneal fracture), an osteotome may be necessary to pry the joint open or to fracture through the middle and/or anterior facet areas. While joint curettage technique can still be utilized in these cases, it is not uncommon to have to insert some type of cortical cancellous bone graft to facilitate repositioning of the subtalar joint.

Fixation Techniques

Over the years, refinements in the technique of fixation have also been made. The principles of rigid internal compression fixation continue to guide these refinements. Advancements in the fixation materials and design have further facilitated the fixation of large joints of the rearfoot and ankle.

The preferred technique of fixation of the subtalar joint continues to be the use of a large cancellous bone screw through the neck of the talus and into the body of the calcaneus, crossing the posterior facet of the subtalar joint. The Synthes and Zimmer large cannulated screw systems are especially popular for fixation of this joint (7.3 mm and 7.5 mm). The typical screw length is 85 to 100 mm. Long thread pattern (32 mm) screws are usually employed. The necessity of a second point of fixation is not universally agreed upon among the faculty. All faculty would agree that one can expect primary consolidation of the fusion site without loss of position, presuming the patient maintains strict non-weight bearing for the first 8 to 10 weeks. Some faculty prefer the use of two points of fixation to avoid potential disturbance or loss of correction of the subtalar joint position. This can be accomplished by the use of a small Steinmann pin, large or small cancellous bone screw, or a large bone staple as a second point of fixation and stabilization.

In situations where the skin and overlying soft tissues are compromised, thus making insertion of the screw through the neck of the talus a difficult endeavor, the author recommends insertion of the screw from the plantar lateral aspect of the calcaneus up into the neck of the talus. Again, a cannulated screw system is most efficient when employing this technique. In some cases it may be desirable to expose the neck of the talus through a very small surgical incision, insert the appropriate guide wire through the neck of the talus, across the subtalar joint and out the posterolateral aspect of the calcaneus. The final screw fixation can then be done through a plantar lateral approach over the guide pin. Some orthopedic surgeons have advocated insertion of the screw from this direction, suggesting that the quality of the talus provides for increased holding power of the cancellous screw threads. To date, the author is unaware of any scientific data to support this idea. It does, however, have value and application in select cases.

The preferred technique for fixation of the talonavicular joint continues to be one large cancellous screw. This is typically a 6.5-7.5 mm diameter long thread screw measuring 60 mm ± 5 mm. The screw is directed through the navicular tuberosity into the head, neck and body of the talus. It may be inserted either medial or lateral to the subtalar joint screw or laterally, depending on the surgeon's preference. Excellent rigid internal compression fixation is consistently achieved with this technique.

In cases where the bones are exceptionally large, the author prefers the use of two 6.5 mm cancellous screws. In cases where rigid internal compression fixation cannot be achieved, the use of one or two large bone staples is preferred by the faculty; either two staples are inserted from the medial side or one staple from the medial side and one from the lateral side. When utilizing large cancellous screw fixation, it is important that the screw is countersunk so that the head is flush with the distal articular surface of the navicular. Failure to provide adequate countersinking may result in fracture of the navicular bone altogether, or pain with manipulation of the naviculocuneiform articulation. It is not uncommon to remove a small portion of bone from the most medial aspect of the cuneiform in order to achieve proper placement of this screw (Fig. 6).

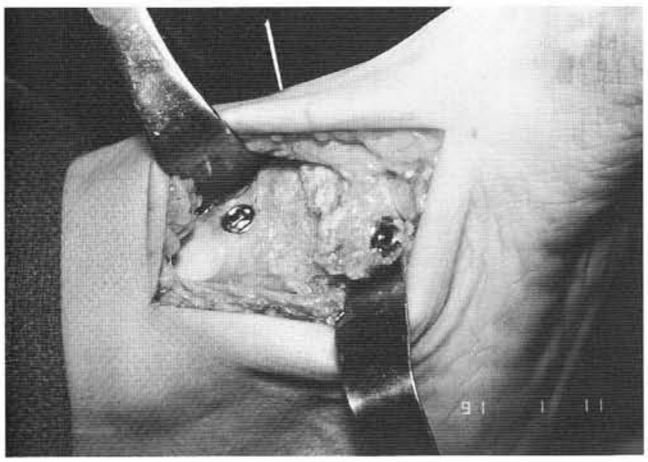

Figure 6. Final appearance following compression arthrodesis of the subtalar joint and talonavicular joint. Note the extent of countersinking to avoid prominence of the screw heads, and prevent stress risers.

The calcaneocuboid joint is fixated with either one or two large bone staples, or one large cancellous screw. The use of a large cancellous screw is somewhat more difficult and tenuous than with the other two joints. There are two alternatives for fixation of this joint. The screw can enter the distal articular surface of the cuboid or can be inserted proximally through the distal dorsal beak of the calcaneus if the osseous architecture so permits. The screw length is typically 55 mm ± 5 mm. The architecture of the joint as well as the configuration of the cuboid and calcaneus does not lend itself as well to the use of large cancellous screws as the other two joints. Consequently, staple fixation is often employed.

When utilizing staple fixation, the author prefers to achieve compression at the fusion site prior to the insertion of the staples. This is readily accomplished by using the Synthes Mini Distractor. The large Steinmann pins are inserted parallel to the joint surface on the inferior lateral side of the calcaneus and cuboid. The joint is then placed in its desired position and the device tightened. When the desired compression has been achieved, the staples are inserted. The author uses large serrated bone staples with a small profile to the top portion of the staple. The Richards staple set and the HowMedica Ellison staple set have been ideal for this purpose. Two 2.0 mm holes are pre-drilled prior to insertion of the staples. This helps prevent shifting of the fusion site as the staples are driven in, especially in cases where one or both of the bones are dense and hard in nature (Figs. 7A, 7B).

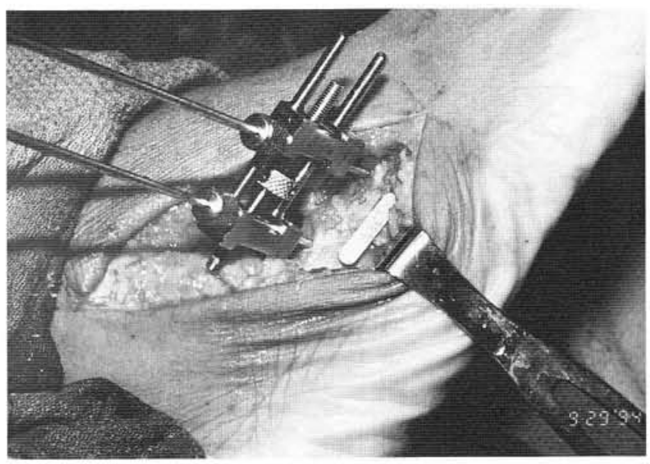

Figure 7A. Calcaneocuboid articulation under compression utilizing the Synthes mini-distractor. One large staple has been inserted on the inferior lateral aspect of the joint.

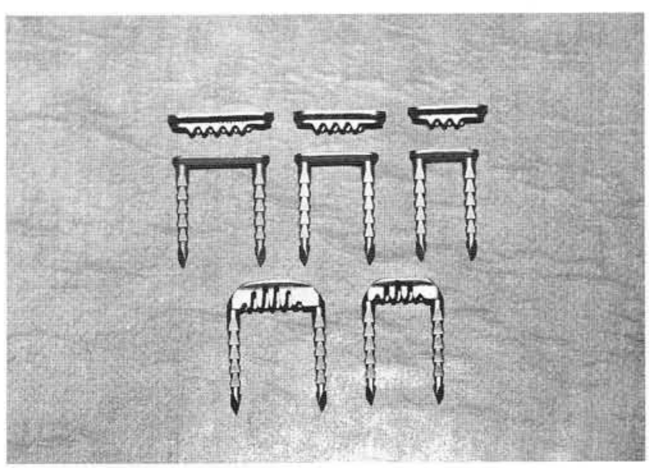

Figure 7B. Configuration of different staples available for use with major rearfoot fusions.

Although the staples do not impart compression or stability themselves, they are very capable of maintaining compression which has been achieved with the Synthes compression device. The author recommends that the staples be inserted at 90 degrees to each other; one from a lateral to medial direction and the other from a dorsal to plantar direction. In cases where the bones are large, three staples may be preferred.

As an alternative, one can use a 3M stabilizer device. When employing this device, the largest size staples should be inserted and multiple staples are recommended. It is not uncommon to insert 4-6 of this type of staple for each joint.

Intraoperative Radiographs

Intraoperatively, once the joint surfaces have been resected and proper position and alignment established, temporary fixation is usually achieved. Intraoperative radiographs are generally obtained to confirm the alignment and position to the foot and to confirm proper placement of guide pins for cannulated screws. Recommended intraoperative radiographs include a dorsoplantar, lateral, and calcaneal axial views of the foot. These are easily obtained in the operating room theater with minimal difficulty or disturbance to the surgical field (Figs. 8, 9A, 9B).

Figure 8. Intraoperative dorsoplantar radiograph to confirm alignment and position of the talonavicular and calcaneocuboid joint complexes. Pins inserted will serve as a guide wire for the final screw fixation.

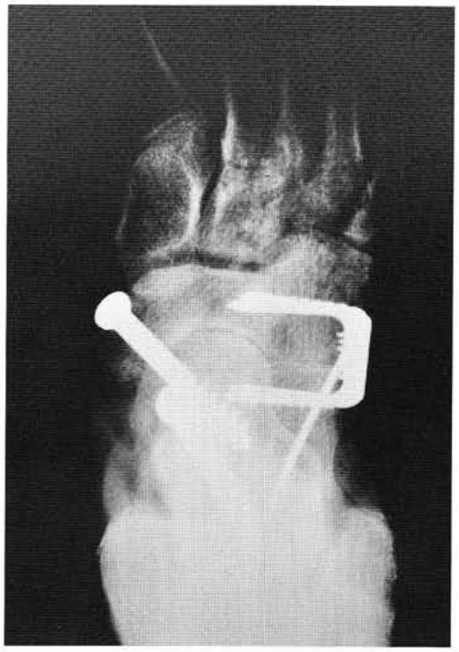

Figure 9A. Intraoperative radiograph following fixation and triple arthrodesis.

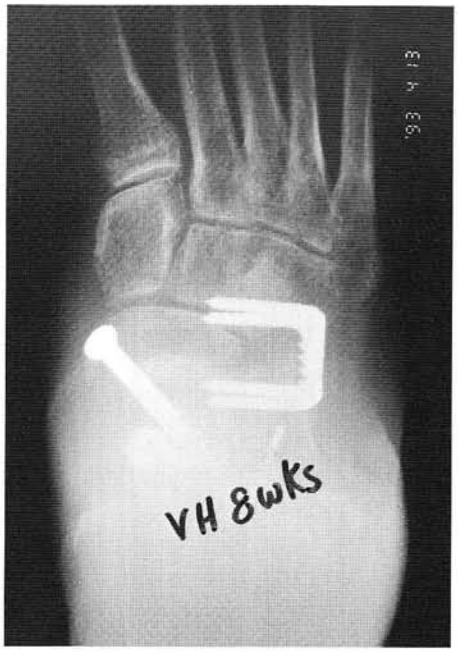

Figure 9B. Note the excellent consolidation of the talonavicular and calcaneocuboid joints eight weeks later in the same patient.

Surgical Hemostasis

A mid-thigh pneumatic tourniquet is used for surgical hemostasis. Hemostasis is further facilitated by the use of local anesthetic with Epinephrine in a concentration of 1:200,000 along the incisional area, as well as other key areas known to be highly vascular. The use of anatomic dissection techniques will further facilitate hemostasis. This becomes most evident when the tourniquet is released prior to closure.

At the time the tourniquet is released, the surgical wounds are packed with varying hemostatic agents. The most common is the use of Surgicel or sponges impregnated with topical thrombin. A sterile ace bandage is then applied for five to ten minutes to allow the vascular structures to reach an equilibrium following release of the tourniquet.

Surgical drains are routinely used. The most common is the use of a large TLS drain system which is inserted beneath the deep fascia, capsular and periosteal tissues. Anatomic layer closure is performed. The skin is typically closed with an intradermal stitch. Steri-Strips are applied for additional wound support.

Patients are maintained in a Jones compression dressing for the first three to seven days. A sterile dressing change is then performed and the patient is placed in a short leg non-weight bearing synthetic cast or splint. At 5 to 8 weeks post-operatively, the cast may be bivalved and converted to a removable splint. Physical therapy modalities and range of motion exercises are prescribed to help resolve edema. Patients are permitted partial weight bearing between 10 and 12 weeks post-operatively, depending upon radiographic healing. Appropriate shoe modifications and orthotic devices are prescribed to further facilitate gait and prevent excessive stress across the more proximal and distal joints. Serial radiographs are obtained to evaluate and assess bone healing and to monitor fixation device migration or loosening (Figs. 10A-12B).

Figure 10A. Postoperative radiograph following triple arthrodesis. Note the absence of degenerative arthritic changes of the ankle or more distal joints.

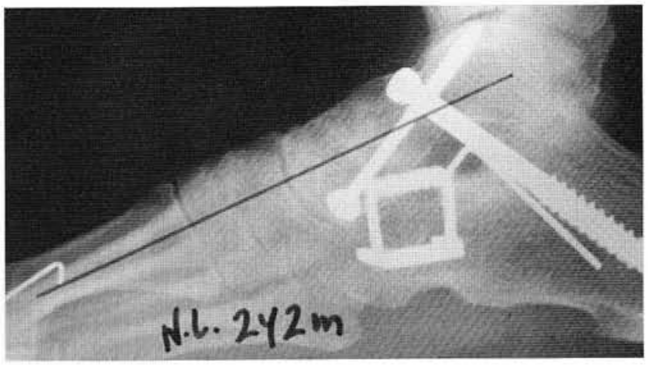

Figure 10B. Postoperative radiograph following triple arthrodesis.

Figure 11A. Clinical appearance of left foot following a triple arthrodesis utilizing curettage technique. Notice the excellent cosmetic appearance of the foot and neutral positioning at the time of fusion.

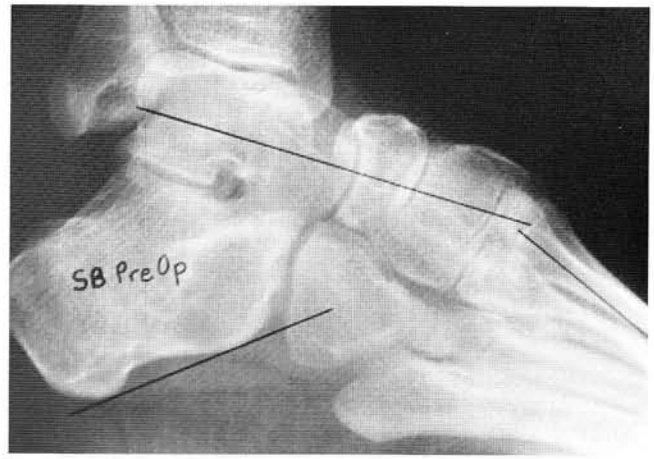

Figure 12A. Preoperative radiograph prior to triple arthrodesis for neurological cavovarus foot deformity.

Figure 11B. AP view of left foot following a triple arthrodesis using curettage technique.

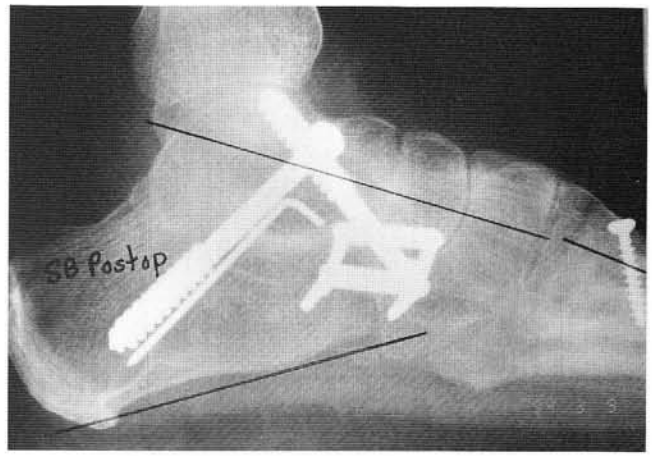

Figure 12B. Postoperative radiograph following triple arthrodesis. Curettage technique was used to realign the subtalar joint and talonavicular joints. A wedge resection was removed from the calcaneocuboid joint. A simultaneous DFWO of the first metatarsal was also performed.

Figure 12C. Preoperative weight bearing and postoperative dorsoplantar x-ray following a triple arthrodesis in the same patient. Note the effects of the wedge resection from the calcaneocuboid joint on restoration of midtarsal joint alignment.

SUMMARY

Over the years, many refinements have been made in the techniques for major rearfoot fusions. These techniques are complemented by the advances in fixation modalities. The combination of meticulous surgical technique, proper joint positioning and an accelerated postoperative recovery management regimen have all contributed to convert what has been formerly perceived as a crippling procedure to a very rewarding procedure to both patients and surgeons. When a major rearfoot arthrodesis is performed for the proper indications, complications are few and minor. As the science of bone healing further advances, additional refinements in surgical technique can be expected, which may allow patients earlier weight bearing and ambulation.

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