ISOLATED SUBTALAR JOINT ARTHRODESIS REFINEMENTS IN FIXATION TECHNIQUE

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Although triple arthrodesis continues to be the time-honored fusion technique in the rearfoot, isolated subtalar joint arthrodesis has recently gained in popularity and acceptance. Once thought of as a primary or salvage procedure following calcaneal fractures, it is now considered a primary procedure for a number of disorders including, but not limited to, isolated joint arthrosis, instability, valgus or varus deformity of the hindfoot, and talocalcaneal coalition.

The primary technique to accomplish isolated arthrodesis of the subtalar joint has included extensive use of bone grafting, with limited emphasis on the technique of fixation. Few articles have emphasized the importance of minimizing the amount of bone resection to avoid the complications associated with loss of height of the rearfoot complex when performing this procedure. The common complications associated with a significant loss of height include difficulty with wearing normal shoes due to shoe counter irritation, accelerated degenerative changes of the midtarsal joint, and a host of problems involving the peroneal tendons (tenosynovitis, tendinitis, incarceration), and on occasion irritation of the sural nerve itself.

In 1993, the senior author published a detailed description of the curettage technique for major rearfoot fusions including isolated arthrodesis of the subtalar joint. This technique has gained in popularity and acceptance and is currently performed by many of the Podiatry Institute faculty. The curettage technique allows for more accurate positioning of the joint being fused, and avoids some of the common complicating sequelae that occur with more traditional joint resection techniques (osteotome or saw resection). In addition, it allows the surgeon to take advantage of the normal anatomic landmarks which assist in identifying the most appropriate position for fusion. Ultimately, it is the position of fusion that will determine optimum postoperative function.

In 1990, the senior author published an article on refinements in technique when performing subtalar joint arthrodesis. In addition to the emphasis placed on the technique of joint resection and positioning, the author introduced the use of a Steinmann pin driven into the calcaneus at the anterior or leading edge of the lateral process. Its purpose was to prevent the downward migration of the talus in a pronatory direction, thus functioning as an internal arthroereisis. The device assists with maintenance of proper position throughout the procedure and helps to deter and prevent pronation (loss of position) postoperatively with inadvertent weight bearing. The senior author continues to employ this technique in certain situations where one point of fixation is felt to be inadequate and a second point of fixation is not readily achieved.

Although the Steinmann pin technique described previously has proven to be advantageous, it has not addressed other concerns the senior author has had and experienced when performing isolated subtalar joint fusions. Regardless of the type of screw fixation employed (fully-threaded or partially-threaded large cortical or cancellous screws; cannulated or non-cannulated), there can be significant motion around a single point of fixation, especially when performing the curettage technique of joint resection. Although a large 6.5 or 7.3 partially-threaded cancellous screw seemingly imparts rigid internal compression fixation of the joint, one can usually pronate and supinate the subtalar joint around this one point of fixation. In some cases, the amount of movement of the joint is quite dramatic, in other cases it is minimal. The amount of motion present can be readily determined intraoperatively by simply holding the heel of the foot in the palm of one's hand and performing the motions of supination and pronation. Changes in position between the talus and calcaneus will be easily visualized and appreciated as the sinus tarsi opening increases and decreases in size. Once one has observed and appreciated this movement, one should begin to question its significance and impact, if any, on the outcome of the procedure.

In addition to the intraoperative observations described above, the senior author has experienced cases where clinical fusion of the subtalar joint lagged behind the apparent radiographic fusion. In some cases this raised significant concern in the mind of the senior author of a delayed union or potentially a nonunion. In fact the senior author has experienced an occasional nonunion, not only of his own cases, but of other experienced surgeons as well. While this rare postoperative complication might easily be attributed to biological factors, the authors wished to study further whether a more optimal fixation technique could be devised and easily implemented with little modification of current technique. The search for an improved technique of fixation for isolated subtalar joint arthrodesis has been further stimulated by the desire to rehabilitate the extremity as soon as possible to avoid other potential complications such as thromboembolic diseases (DVT or PE) and cast disease.

HISTORICAL REVIEW

A review of the literature on the subject of isolated subtalar joint arthrodesis reveals few articles emphasizing the technique of optimal fixation of the joint. Some of the literature fails to mention the technique of fixation altogether. In some cases the insertion of a cortico-cancellous graft wedged into the fusion site has been described without additional fixation. In other cases the fixation modalities have ranged from one or two isolated Steinmann pins or staples to one large cancellous or cortical bone screw.

The authors have been able to identify only one article suggesting more than one fixation device to stabilize the subtalar joint when performing an isolated talocalcaneal arthrodesis. In 1988, Carr et al. described the use of two 6.5 mm fully-threaded cancellous screws inserted through two stab incisions in the posterior inferior aspect of the heel to fixate the calcaneus to the talus. They indicated that two screws provided more rigid fixation and helped prevent rotary movements around the axis of the subtalar joint. Interestingly, Carr et al. did not cite or discuss any previous complications they had encountered with alternative fixation methods. Their 16 cases all involved previous calcaneal fractures. Fusions were done for the late complication of these fractures via a distraction bone block technique with tricortical posterior iliac crest grafts.

CURRENT TECHNIQUE

The authors' current technique for isolated subtalar joint arthrodesis employs two linear incisions: one lateral and one medial. The lateral incision runs from the inferior aspect of the fibular malleolus to the calcaneocuboid joint. The medial incision runs from the anterior aspect of the medial malleolus to the level of the talonavicular joint. Laterally, the sural nerve and lateral dorsal cutaneous nerve along with the lesser saphenous vein are retracted inferiorly; medially the saphenous nerve and veins are retracted dorsally.

The subtalar joint is exposed through a linear arthrotomy which parallels the skin incision and peroneal tendons just superior to the tendons. The contents of the sinus tarsi are excised completely and all of the ligaments between the talus and calcaneus within the sinus tarsi released. A Crego elevator is used to free the capsular and ligamentous tissue around the lateral and posterior aspect of the subtalar joint. If necessary the calcaneofibular ligament is released. The entire posterior and middle facets should be visualized as well as the lateral process of the talus.

Medially, the head and neck of the talus are exposed through a longitudinal linear incision which again parallels the skin incision. An ankle arthrotomy is accomplished through this incision. The talonavicular joint should be visualized in order to accomplish the fixation technique described in the following. If necessary, an ankle arthroplasty and/or talonavicular joint arthroplasty or synovectomy can be performed through this incision.

The subtalar joint is distracted and the posterior facet visualized. The articular cartilage is removed using rongeurs, curettes, osteotomes and power burrs if necessary. Only the cartilage is removed, thus preserving the subchondral bone plate and the normal architectural configuration of the joint. Special attention should be given to the periphery of the joint where exostoses or a small rim of cartilage may remain, which will hinder joint apposition. Joint visualization is facilitated by the use of special laminar distractors or special disc distractors used in spinal surgery. The AO/ASIF mini-distractor has also proven to be a very useful tool for distracting the joint and facilitating visualization of the entire posterior and middle facets.

Once the posterior facet has been resected, attention is directed to the middle facet where a similar technique of cartilage removal may be performed if desired by the surgeon. The authors do not routinely perform resection of the middle facet, unless it hinders the ability to oppose the posterior joint surfaces.

The subtalar joint is now placed in its desired position; this is most commonly neutral, rectus, or slight pronation or valgus if desired. A Steinmann pin may be inserted laterally to maintain position, or temporary fixation may be achieved through the use of another technique.

Recommended Fixation

Large cancellous screws ranging in size from 6.5 mm to 7.5 mm are recommended for fixation of the subtalar joint depending on the preference of the surgeon. The Podiatry Institute faculty typically uses either the Synthes (Paoli, Pennsylvania) standard 6.5 mm partially-threaded cancellous screw system or the 7.3 mm cannulated system. The Zimmer (Warsaw, Indiana) 7.5 mm partially-threaded cannulated cancellous screw system is also very effective, and comparable to the cannulated Synthes system in design (self-tapping, self-cutting thread pattern), material, and technique with the exception of missing a counter-sink (Figs. 1-3B).

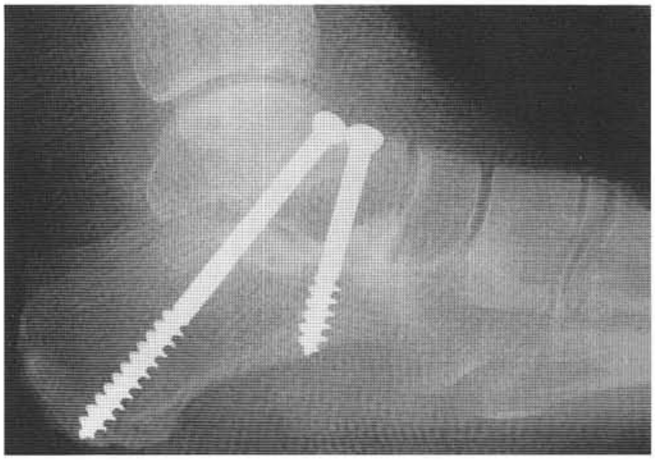

Figure 1. Postoperative lateral radiograph following isolated subtalar joint arthrodesis via a curettage technique using two large cancellous screws for fixation.

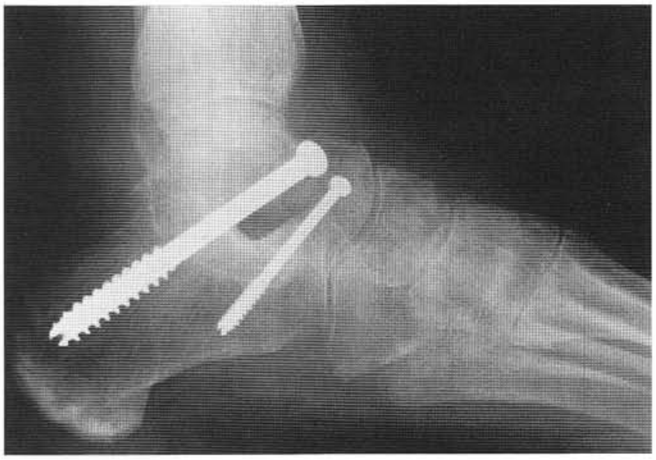

Figure 2. Similar technique as in Figure 1, but one large cancellous screw, and one 4.0 mm cancellous screw were used.

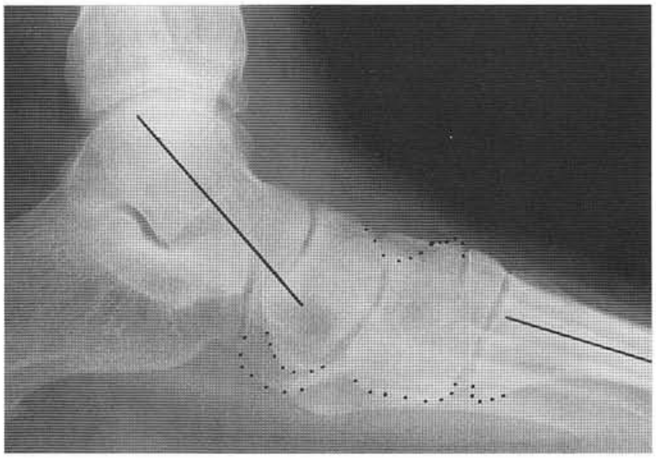

Figure 3A. Preoperative lateral radiograph.

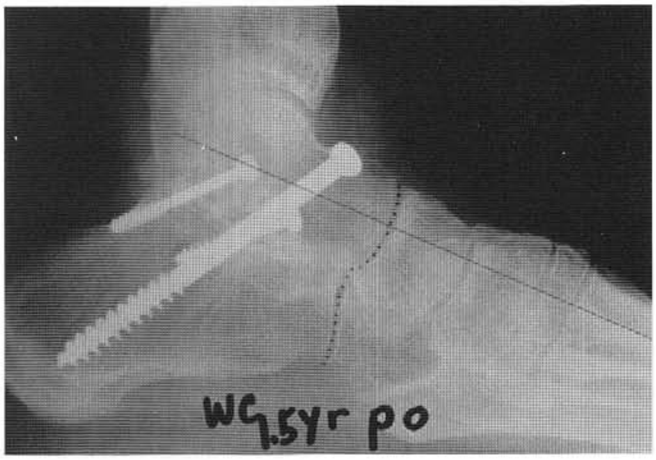

Figure 3B. Postoperative lateral radiograph following subtalar joint arthrodesis with one large cancellous screw and two 4.0 mm cancellous screws placed through the lateral process of the talus. Inadequate rigid internal compression fixation was achieved with a single large cancellous screw intraoperatively.

The first or primary screw is inserted through the neck of the talus crossing the posterior facet of the subtalar joint into the middle of the body of the calcaneus. This screw is located more midline than the secondary screw and is just distal to the anterior edge of the dorsal articular surface of the talus. In essence, it is in the same location as has been advocated for years when performing either isolated subtalar joint fusions or fusion of the joint as part of a triple arthrodesis. If preferred, the screw may be inserted just medial to midline of the talar neck.

The second screw may be of equal diameter to the primary screw or slightly smaller. In most cases the senior author has chosen to use two larger screws when possible. The size and configuration of the head and neck of the talus will influence the size of the secondary screw. In some cases the talar neck may be shorter than usual or lack width, in which case, a smaller screw is preferred. The decision as to which size screw to be employed should be made intraoperatively based upon the stability of the fixation achieved with the first screw and the anatomic configuration of the head and neck of the talus.

The second screw is inserted through the head and neck of the talus just proximal to the talonavicular joint. The screw traverses in a plantar and lateral direction and exits just proximal to the calcaneocuboid joint. The surgeon must use caution when inserting this screw as it is possible to accidentally enter the calcaneocuboid joint itself, an obviously undesirable situation. When aligning the screw for insertion, it is helpful to depict a direction which initially parallels the midtarsal joint complex and then to change the direction slightly so that the screw is coming slightly proximal as it traverses from dorsal-medial to plantar-lateral. If a cannulated screw system is used, the guide pin is inserted, and intraoperative radiographs obtained to confirm proper placement and orientation prior to insertion of the screw (Figs. 4A-4C).

Once the intraoperative radiographs confirm proper orientation of the guide pins, the screws are inserted using standard AO/ASIF technique. The more proximal, or primary compression screw is inserted first. It is important to visually confirm that the originally intended position of the subtalar joint has not been lost during insertion of the screw. The distal screw is inserted next. Again, the position of the subtalar joint should be confirmed after

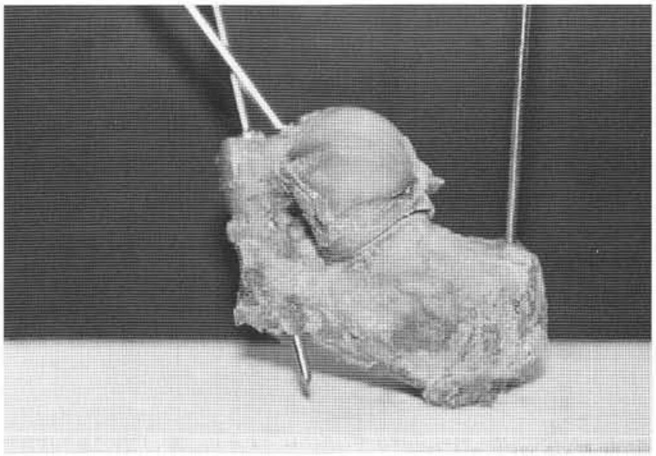

Figure 4A. Lateral view of cadaveric specimen demonstrating placement of the guide pins and screws using a two screw fixation technique for isolated subtalar joint arthrodesis.

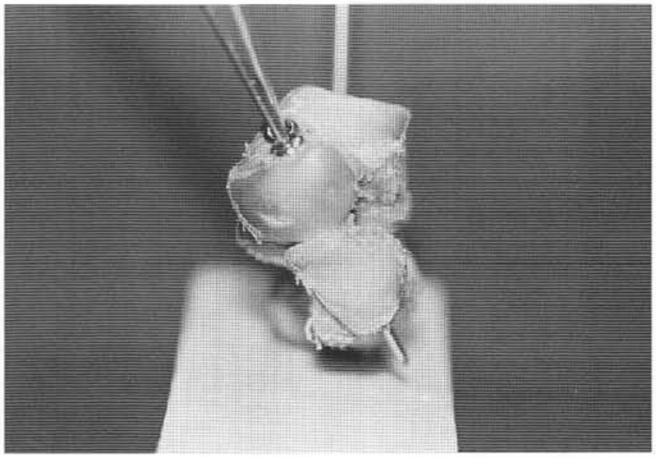

Figure 4B. Anterior view.

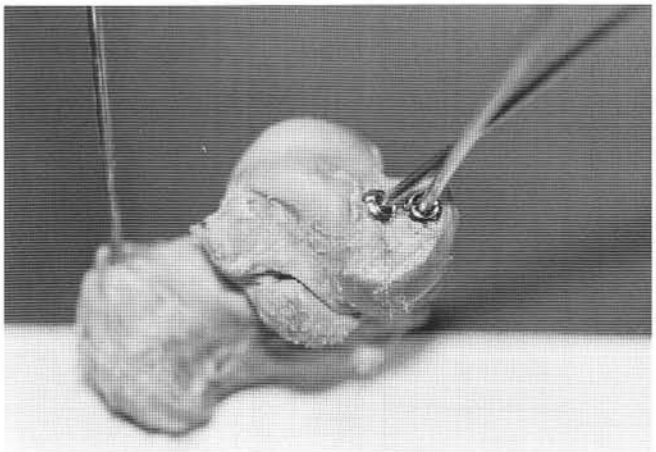

Figure 4C. Medial view.

insertion of the second screw. Additional intraoperative radiographs may be obtained (Figs. 5A, 5B).

The wounds are closed in a standard fashion. A small surgical drain system is used if there is any significant bleeding noted upon release of the tourniquet. A dry sterile compression bandage is applied, along with a Jones compression cast or splints.

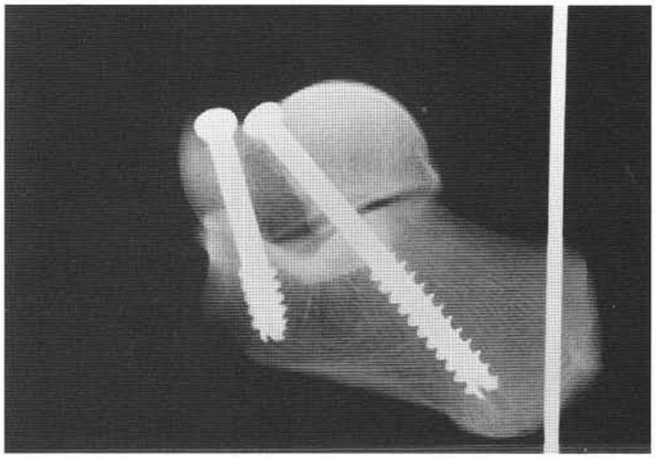

Figure 5A. Lateral radiograph of the specimen shown in Figure 4.

Figure 5B. Dorsoplantar radiograph of specimen shown in Figure 4.

Postoperative Management

A dressing change is performed within the first 5 to 7 days and a short-leg non-weight-bearing synthetic cast applied for the first 5 to 6 weeks postoperative. At this time, the cast is removed or converted to a posterior splint. Physical therapy is then instituted, consisting primarily of hydrotherapy with tepid (not warm or hot) water and range of motion exercises to help resolve postoperative edema and avoid cast disease. A compression wrap is used as an adjunct if necessary. In some cases, a surgical shoe is used in place of a posterior splint but only in very reliable patients.

Serial radiographs are obtained at 4 to 5 week intervals to assess bone healing and monitor for any potential complications. Subtle changes in alignment or resorption or radiolucency around the screws themselves suggest an impending bone healing complication. These changes suggest that the patient should be immobilized in another cast, and physical therapy discontinued. If bone consolidation appears solid at 8 to 10 weeks, then progressive weight bearing is instituted. Patients are usually full weight bearing by 10 to 12 weeks.

It should be emphasized that although early range of motion exercises are implemented, patients are usually non-weight bearing for a minimum of 8 weeks. When weight bearing is instituted, shoes which protect the ankle against inversion injuries are recommended.

In less compliant patients, and in those who have significant risk factors for a bone healing complication (underlying neuromuscular disease, chronic tobacco consumption, peripheral neuropathy, diabetes, etc.) cast immobilization for 8 to 12 weeks is more appropriate. An accelerated after care plan is only employed in those patients with a high degree of reliability and compliance.

The screws are left in place indefinitely. To date the senior author has not had to remove any of the screws inserted using this technique. Although the author's experience with this technique is still quite limited (approximately 12 cases to date), it appears to be quite satisfactory.

DISCUSSION

To date, the senior author has employed the technique described above in approximately 12 cases without complication. There are however, several observations deserving discussion.

The technique is intended for cases of isolated subtalar joint arthrodesis. It is not necessary or desirable to employ this technique when performing a triple arthrodesis. Single screw fixation of the subtalar joint is more than adequate in such situations. Fusion of the talonavicular and, to a lesser degree, calcaneocuboid joint provides additional stability to the subtalar joint, which precludes the necessity of a second point of fixation. Furthermore, two screw fixation of the subtalar joint, when performing a triple arthrodesis will make fixation of the talonavicular joint using similar fixation quite difficult if not almost impossible (Figs. 6A, 6B).

The senior author's preference is to use two large cancellous screws of identical size (diameter) when possible. However, in some cases the architecture and configuration of the head and neck of the talus does not lend itself well to accepting two large screws. In these cases the secondary screw will necessarily be smaller in size. The author has used 4.5 mm cortical screws and 4.0 mm cancellous screws successfully in such cases.

Some surgeons are likely to fear placing two large screws into such a small confined area. There may be a fear of potential stress risers leading to overt longitudinal fractures of the head, neck and possibly the body of the talus. One way to overcome this concern would be to insert the primary compression screw from the posterior inferior aspect of the calcaneus. This would then eliminate the potential stress riser created from this screw altogether. The secondary screw, however, should still be inserted through the dorsal surface of the head and neck of the talus. Insertion of this secondary screw from an inferior calcaneal approach would seemingly be very difficult and impractical.

Cannulated screws are very useful when employing this technique. They allow for confirmation of placement and orientation of both screws prior to their insertion. Subtle changes and adjustments are easily made based after viewing the intraoperative radiographs or fluoroscopic imaging. In addition, the guide pins help to avoid changes in the final position of the screws that sometimes occurs with standard non-cannulated screw systems.

An alternative for the second screw would be a smaller screw (4.0 mm cancellous screw) inserted through the anterolateral surface of the lateral process of the talus. This is in the area of attachment of the anterior talofibular ligament. The configuration of the talus, however, does not lend itself to use of a larger screw. A 4.0 mm standard

Figure 6A. Dorsoplantar postoperative radiograph following triple arthrodesis via a curettage technique. Note the presence of one large screw in the subtalar joint which provides excellent rigid internal compression fixation. Fixation of the midtarsal joint complex will prevent motion from occurring at the subtalar joint level.

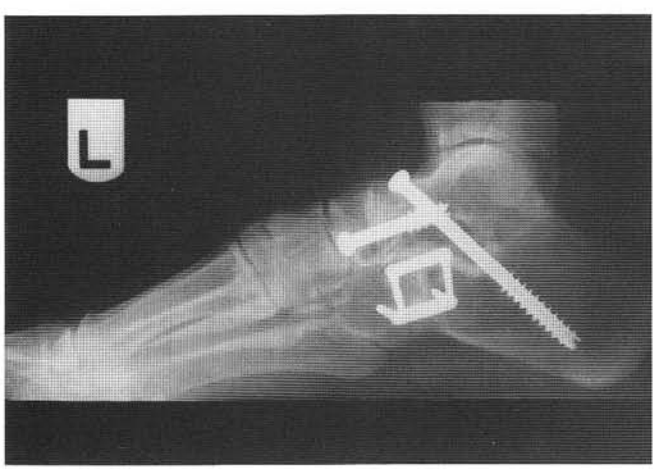

Figure 6B. Lateral postoperative radiograph.

or cannulated cancellous screw has functioned well with this approach. The senior author has used this approach on several cases, however, feels it is inferior in both its rigidity and compression when compared to the technique described earlier. It does serve well as an anti-rotation device, and thus does provide additional stability over a single screw technique.

CADAVERIC MODEL

The authors obtained two cadaveric specimens of the subtalar joint to further study and demonstrate the efficacy of single versus double screw fixation of the subtalar joint. All of the periarticular structures were removed with the exception of the medial ligaments of the posterior and middle facet and the deepest ligaments of the sinus tarsi region. This simulated the surgical technique described previously with respect to release of the ligamentous structures within the sinus tarsi, as well as the lateral and posterior structures.

The specimens were fixed to a wood block using a large Steinmann pin keeping the position of the calcaneus constant throughout the exercise. Dorsoplantar and lateral radiographs were obtained of the specimen prior to fixation in neutral, pronated and supinated positions (Figs. 7A-9B).

The subtalar joint was then fixated in neutral position with a large cannulated cancellous bone screw using standard technique (Fig. 10). The articular surfaces were preserved. The cartilage was not removed as is done in surgery. The screw was inserted through the head and neck of the talus, exiting at the plantar lateral aspect of the calcaneal tuberosity. The authors felt this was a common location and direction of placement when performing isolated subtalar joint arthrodesis. The quality of screw purchase paralleled what is typically experienced in surgery, and excellent rigid internal compression fixation was achieved with the joint in a neutral or rectus position.

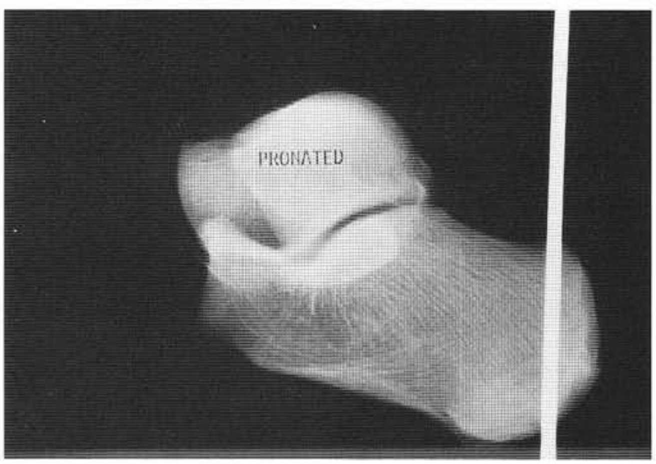

Figure 7A. Lateral radiograph of cadaveric specimen demonstrating maximally pronated attitude of the subtalar joint prior to fixation.

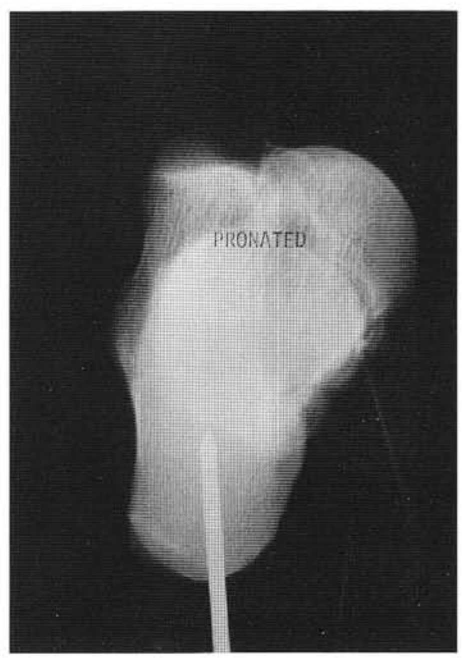

Figure 7B. Dorsoplantar radiograph demonstrating pronated attitude.

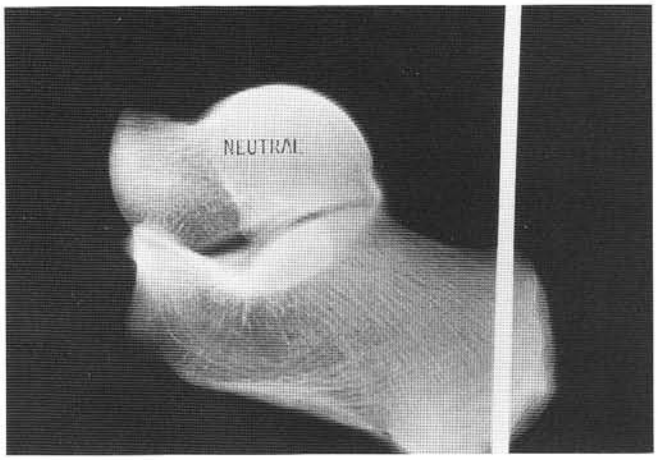

Figure 8A. Lateral radiograph of cadaveric specimen demonstrating neutral or rectus position of the subtalar joint prior to fixation.

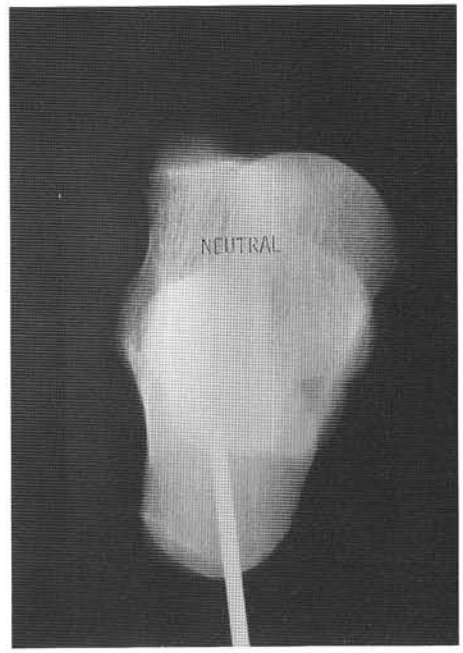

Figure 8B. Dorsoplantar radiograph demonstrating neutral or rectus position.

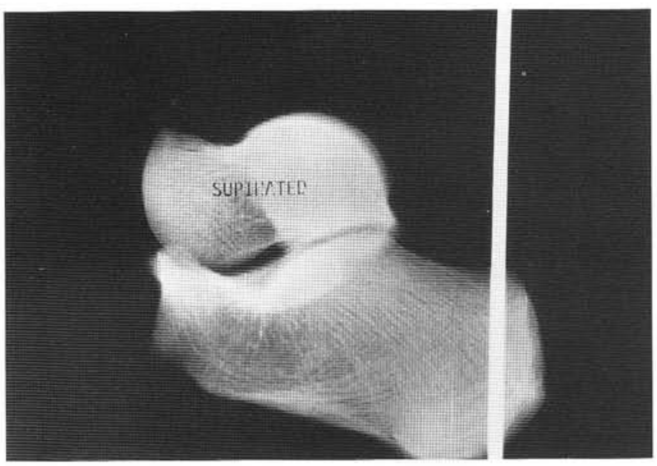

Figure 9A. Lateral radiograph of cadaveric specimen demonstrating maximally supinated attitude of the subtalar joint prior to fixation.

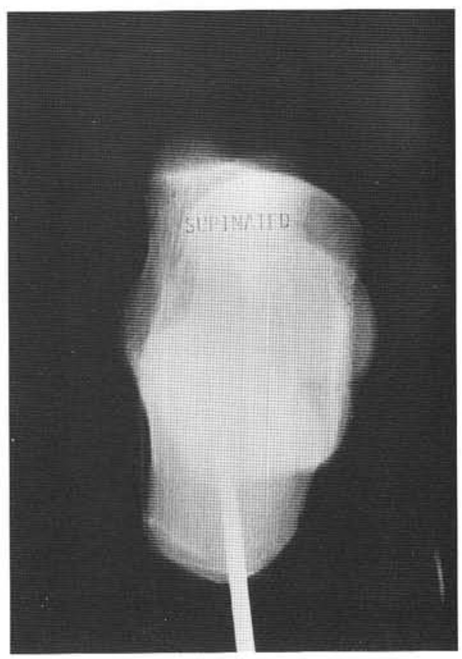

Figure 9B. Dorsoplantar radiograph demonstrating maximally supinated attitude.

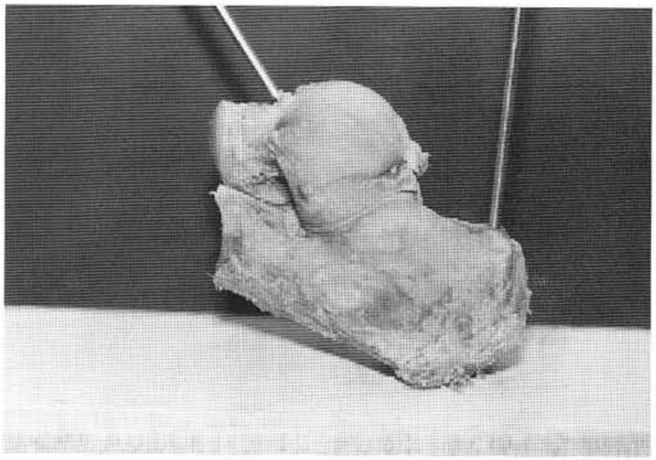

Figure 10. Cadaveric specimen with guide pin and cannulated screw in place and tightened. The joint is in neutral or rectus position. The screw is not seen due to the angle of the photo and the countersinking process.

Lateral and dorsoplantar radiographs were obtained, and neutral position of the joint confirmed. The specimen was then maximally pronated and supinated. Rotation around the single screw was readily appreciated. Lateral and dorsoplantar radiographs were again obtained and demonstrated the change in position. The amount of movement which was observed with a single point of fixation was quite impressive and consistent with what the authors have observed on numerous occasions in surgery when performing arthrodesis of the subtalar joint with a single point of fixation (Figs. 11A-11C,12A-12C).

The exercise was repeated with a second specimen with a slight change in position of the screw. The point of entry of the screw remained the same, but the screw was directed to exit in the middle of the body of the calcaneus rather than the more plantar attitude in the first specimen. The specimen was then maximally pronated and supinated and the same radiograph views obtained. Again, rigid compression fixation was readily achieved and the quality of screw purchase felt to be excellent (Figs. 13A-13C).

Interestingly, the specimen easily supinated around the single screw (Figs. 14A-14C). Pronation around the screw, however, was much less compared to what was observed with the first specimen. Complete release of all the remaining ligaments resulted in a slight increase in rotary movement in the direction of pronation. The significance of this will require further study. Subtle changes in the direction and location of the screw may have some affect on the overall stability and rigidity with a single screw technique when performing isolated subtalar joint arthrodesis.

When a second screw of equal diameter was inserted, no movement around the fixation devices could be discerned clinically or radiographically. Radiographs of the specimens demonstrated no change in the relationship between the talus and calcaneus as expected.

SUMMARY

The authors have described a combination approach to fixation of isolated subtalar joint arthrodeses. The method of two screw fixation is designed to provide enhanced rigidity and compression. It allows for early postoperative rehabilitation and potentially earlier weight bearing while minimizing the risk of a bone healing complication. The technique prevents any rotary movements which could result in a change in the position of fusion with final bone healing. Assuming proper technique is employed, the potential for complications appears minimal based upon the authors' experience.

It is hoped that this paper will stimulate foot and ankle surgeons to carefully reevaluate the potential risks of single screw fixation when performing an isolated subtalar joint fusion. The authors intend to report on the final outcomes of a much larger series of cases within the next two years.

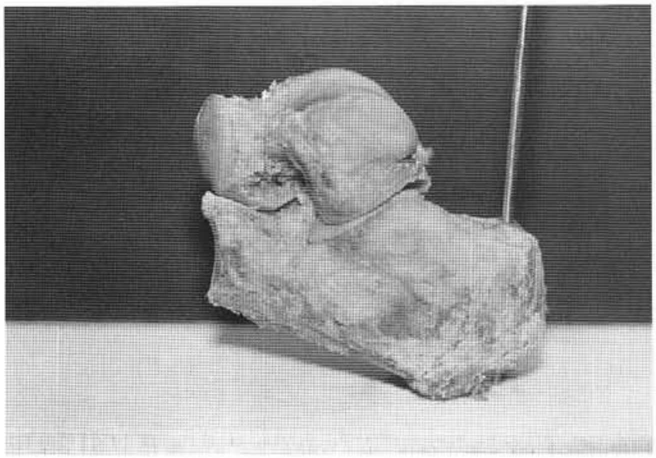

Figure 11A. Cadaveric specimen after manipulation in the direction of supination. Note the significant change in position of the talus with respect to the calcaneus in spite of the single large cancellous screw in place.

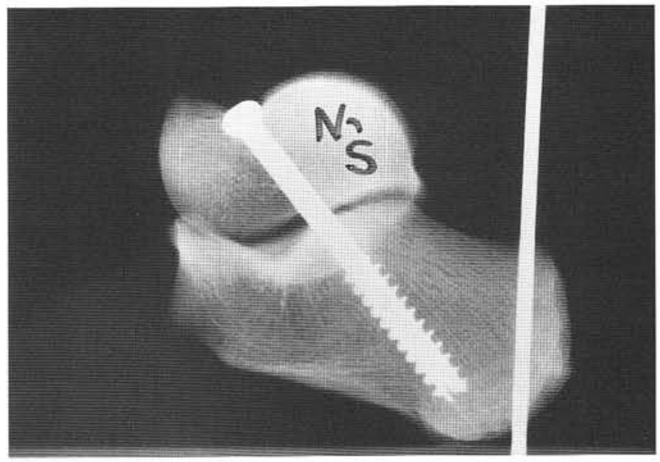

Figure 11B. Lateral view following manipulation of the joint of the direction of supination with the screw tightened.

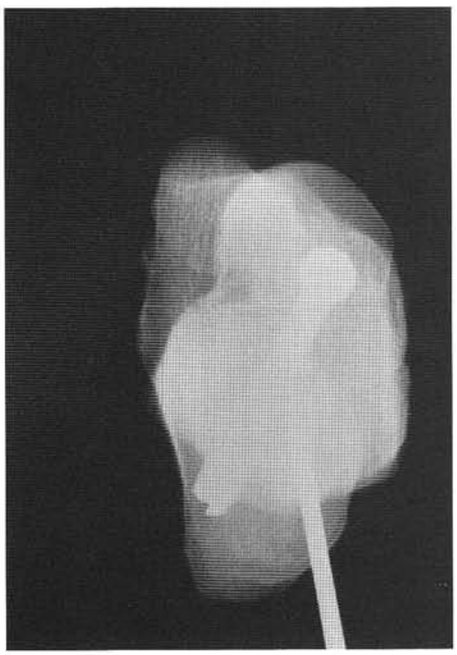

Figure 11C. Dorsoplantar view.

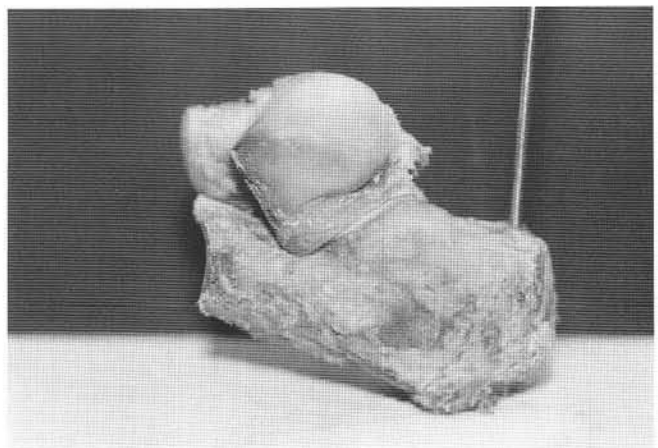

Figure 12A. Cadaveric specimen after manipulation in the direction of pronation. Note the significant change in position of the talus with respect to the calcaneus in spite of the single large cancellous screw in place.

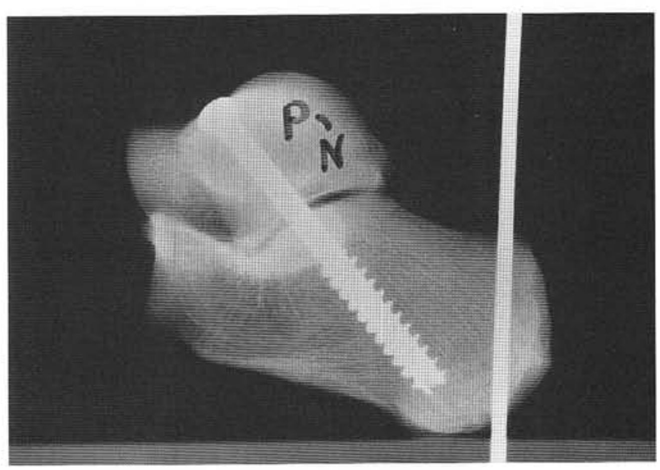

Figure 12B. Dorsoplantar view.

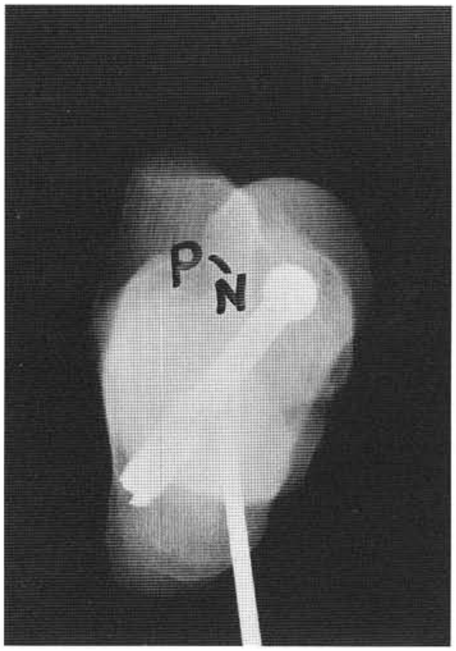

Figure 12C. Lateral view.

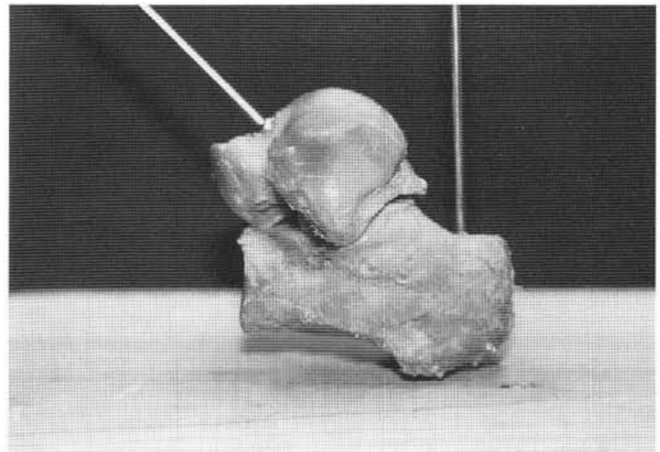

Figure 13A. Second cadaveric specimen in neutral with a single large cancellous screw which is placed in a more central position within the body of the calcaneus.

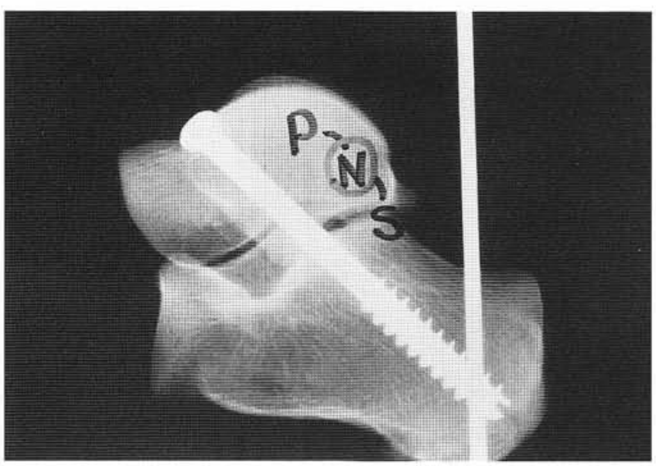

Figure 13B. Lateral view.

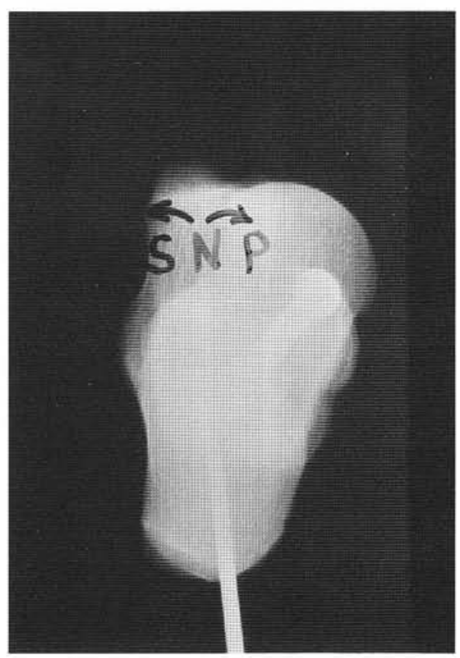

Figure 13C. Dorsoplantar view.

Figure 14A. Second cadaveric specimen after manipulation in the direction of supination. Note the subtle but still significant change in position of the talus with respect to the calcaneus in spite of the single large cancellous screw in place. Significant pronation of the specimen was not seen unless all of the ligaments of the subtalar joint were released. The screw configuration in this specimen may be more stable than the configuration shown in the first specimen.

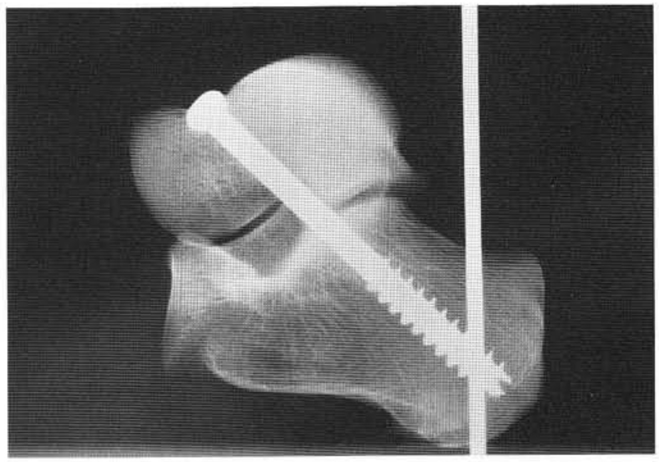

Figure 14B. Lateral radiograph.

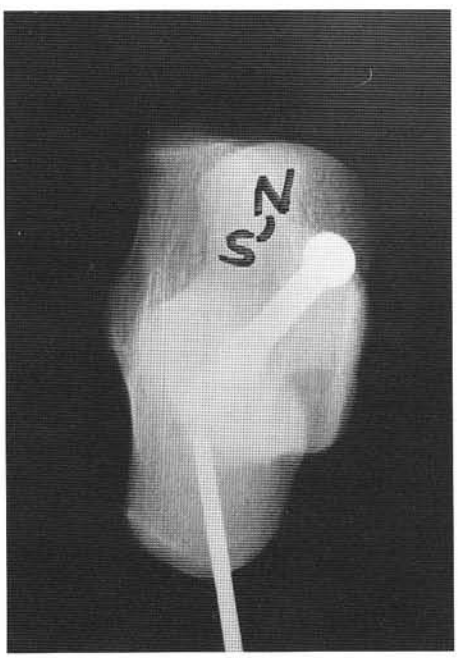

Figure 14C. Dorsoplantar radiograph.

BIBLIOGRAPHY

Amendola A, Lammens P: Subtalar arthrodesis using interposition iliac crest bone graft after calcaneal fracture. *Foot Ankle* 17(10): 608, 1996.

Barrasso J, Wile P, Gage J:Extra-articular subtalar arthrodesis with internal fixation. *J Ped Orthop* 4:555, 1984.

Buch B, Myerson M, Miller S: Primary subtalar arthrodesis for treatment of comminuted calcaneal fractures. *Foot Ankle* 17(2):61, 1996.

Carr J, Hansen S, Benirschke S: Subtalar distraction bone block fusion for late complications of os calcis fractures. *Foot Ankle* 9(2):81, 1988.

Dennyson W, Fulford G: Subtalar arthrodesis by cancellous grafts and metallic internal fixation. *J Bone Joint Surg* 58B:507, 1976.

Dick I: Primary fusion of the posterior subtalar joint in the treatment of fractures of the calcaneum. *J Bone Joint Surg* 35B:375, 1953.

Hall M, Pennal G: Primary subtalar arthrodesis in the treatment of severe fractures of the calcaneum. *J Bone Joint Surg* 42B:336, 1960.

Harris R: Fractures of the os calcis: treatment by early subtalar arthrodesis. *Clin Orthop* 30:100, 1963.

Johanasson J, Harrison J, Greenswood F: Subtalar arthrodesis for traumatic arthritis. *Foot Ankle* 2:294, 1982.

Kalamchi A, Evans J: Posterior subtalar fusion: a preliminary report on a modified Gaille's procedure. *J Bone Joint Surg* 59B:287, 1977.

Kuwada G: Modification of fixation technique for a subtalar joint and triple arthrodesis. *J Am Podiatr Med Assoc* 78(9):482, 1988.

Mann R, Baumgarten M: Subtalar fusion for isolated subtalar disorders. *Clin Orthop* 226:260, 1988.

Noble J, McQuillan W: Early posterior subtalar fusion in the treatment of fractures of the os calcis. *J Bone Joint Surg* 61B:90, 1979.

Romash M: Reconstructive osteotomy of the calcaneus with subtalar arthrodesis from malunited calcaneal fractures. *Clin Orthop* 290:157, 1993.

Ross P, Lyne E: The Grice procedure: indications and evaluation of long-term results. *Clin Orthop* 153:194:1980.

Russotti G, Cass J, Johnson K: Isolated talocalcaneal arthrodesis: a technique using moldable bone graft. *J Bone Joint Surg* 70A: 1472, 1988.

Thomas F. Arthrodesis of the subtalar joint. *J Bone Joint Surg* 49B:93, 1967.

Yu G, Thornton D: Subtalar joint arthrodesis: refinement in technique. In DiNapoli DR, ed. *Reconstructive Surgery of the Foot and Leg, Update '90* Tucker, GA:Podiatry Institute Publishing; 1990: 20-25.

Yu G, Shook J, Sellers C, Judge M: Subtalar joint arthrodesis: a retrospective study. In Camasta CA, Vickers NS, Carter SR, eds. *Reconstructive Surgery of the Foot and Leg, Update '95* Tucker, GA:Podiatry Institute Publishing; 1995: 10-12.