CHAPTER **39**

SUBTALAR JOINT DISTRACTION BONE BLOCK ARTHRODESIS

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There are many causes for subtalar joint pathology. These include degenerative joint disease, talar fractures, calcaneal fractures, subtalar joint dislocations, congenital hindfoot deformities, and acquired deformities such as pes valgo planus as a result of chronic posterior tibial tendon dysfunction. In addition, rheumatoid arthritis, psoriatic arthritis and other inflammatory arthritides can cause pathology in this joint. This paper will outline pathologies which result from calcaneal fractures and particular attention will be placed on repair of malunion using subtalar joint distraction bone block arthrodesis.

Calcaneal fractures compose 60-75% of all tarsal bone injuries of the foot. Of these 75% are intra-articular fractures in adults and 25% in children.[1] Various methods of treatment have been used, consisting of closed reduction with or without percutaneous pinning and open reduction and internal fixation.

This condition can be quite debilitating and costly to society. Regardless of the method of therapy, 54% of the patients with calcaneal fractures return to preinjury levels. In a six series study, 5-16% of all calcaneal fractures required subtalar joint arthrodesis because of persistent disability and pain.[2] In a study of 120 displaced intra-articular calcaneal fractures, Sanders et. al,[3] reported that 14% needed subtalar joint arthrodesis. It is generally accepted that the treatment of choice for a symptomatic subtalar joint is arthrodesis.

MECHANISM OF ACTION OF CALCANEAL INTRA-ARTICULAR JOINT DEPRESSION FRACTURE

The general mechanism of calcaneal joint depression fracture injury involves a fall from a height. At impact, the foot is flat against the ground and as axial loading forces continue, the lateral process of the talus drives through the anterior 1/3 of the body of the calcaneus. This divides the calcaneus into an anterior sustentacular fragment and a posterior tuber fragment, known as the primary fracture line. As the injury proceeds, particularly in a pronated foot, the forces of the body coming through the talus, continue to impact the calcaneus, causing a secondary fracture line which runs horizontally exiting posterior to the posterior facet. Frequently another line runs anteriorly exiting at the level of the calcaneal cuboid joint. This impact then allows the body of the calcaneus to widen causing the posterior facet to rotate anteriorly and distally causing it to sink within the body of the calcaneus. Significant trauma and hematoma is created from this sudden impact and significant bleeding and edema is noted. It is not unusual to see many fracture blisters as a result of the contusion to the osseous and soft tissues.

Neglected or poorly treated calcaneal fractures and even those adequately treated with open reduction internal fixation can result in multiple morbidities. This may include all or some of the following:

1. Shortening of the effected extremity
2. Widening of the body of the calcaneus creating impingement to the peroneals and creating difficulty with shoe gear.
3. Varus or valgus deformity of the heel
4. Lateral calcaneal body – fibular impingement
5. Incongruous joint surfaces
6. Degenerative joint disease of the calcaneal cuboid and talonavicular joints.
7. Tibial talar impingement
8. Chronic neuritic pains as a result of sural and/or tibial nerve injury
9. Shortening of the triceps surae resulting in a weakened toe-off phase of gait
10. Chronic plantar fat pad pain

CLINICAL EVALUATION

Patient's status post calcaneal fractures present with multiple forefoot, hindfoot and ankle complaints. The degree and type of injury will help determine the origin of the pain. Patients will often complain of pain on the lateral aspect of the ankle and foot and point to the area lateral to the sinus tarsi. A diagnostic local anesthetic nerve block injected into the lateral wall of the calcaneus will help

delineate whether the impingement pain is due to peroneal and/or rubbing between the body of the calcaneus and fibula. Patients who have relief of subtalar joint pain but continue with ankle pain probably have tibial talar impingement as a result of the more debilitating joint depression, malunion fractures. This causes the talar declination angle to decrease as the talus is forced to rock posteriorly and sinks into the body of the calcaneus. This is clinically evidenced as pain on the distal aspect of the tibia during toe-off phase of gait. Often a local anesthetic block can be used to differentiate paresthesias from injury to the sural and/or tibial nerves. Patients may also be placed in cam walkers, various braces, including a double upright brace to create stability in various planes. Relief of symptoms can help predict success of planned arthrodesis.

RADIOGRAPHIC AND ANCILLARY DIAGNOSTIC STUDIES

Three weightbearing views of the foot and ankle and an axial of the subtalar joint are very important to attain. CT scans, MRI, radiographic reconstructions are also useful. However for the most definitive osseous evaluation of osseous tissues, CT scan in the transverse and coronal planes are still the best. MRI will give an excellent evaluation of soft tissues, ligamentous and tendonous structures.

Roentgenographically, in a calcaneal joint depression fracture a negative Bohler's angle, a decreased calcaneal inclination angle, decreased talar declination angle and decreased hindfoot height are noted. Hindfoot height is determined by adding the calcaneal and talar heights and measured from the superior dome of the talus to the weightbearing surface (Figure 1). The heel will generally fall into varus and equinus as the mechanism of action causes medial and superior shift of the tuber fragment.

When evaluating for the potential of a distraction bone block arthrodesis, a lateral weightbearing view of the foot and ankle is reviewed. This same measurement is compared on the contralateral foot. When there is a difference of 8mm, consideration should be given to distraction bone block arthrodesis or distal displacement calcaneal osteotomy. The calcaneal inclination angle should be 20 degrees and Bohler's angle should be in the range of 30 degrees. The talar declination should bisect the 1st metatarsal on the lateral view.

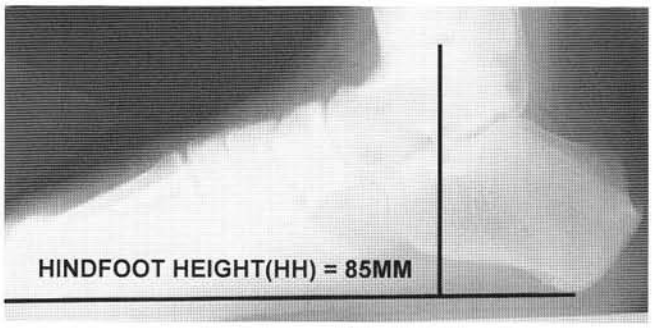
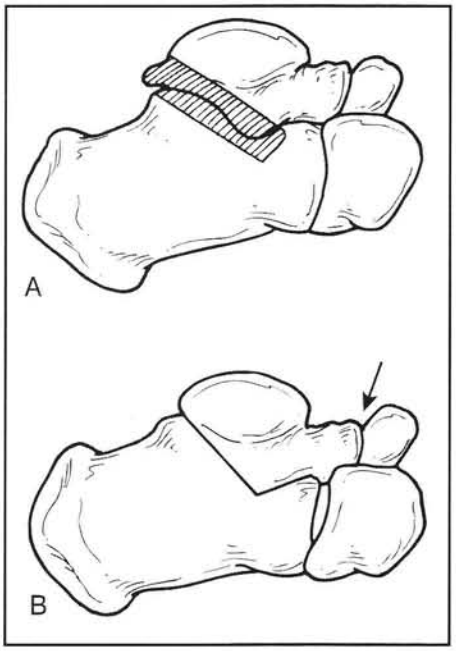


Figure 1. Lateral weightbearing x-ray. The hindfoot height(HH) is measured by measuring from the superior aspect of the talar dome to the weightbearing transverse plane of the foot.

SURGICAL TREATMENT OF CALCANEAL MALUNION

In cases where there is minimal change in height of the calcaneus, in situ subtalar joint arthrodesis may be in the patient's best interest. It should be noted that all efforts should be made to minimize shortening of the subtalar joint since most often 4-6mm of cartilage and affected subchondral bone may be removed. The curettage technique with subchondral drilling can be used to minimize shortening. Packing of the joint with autogenous bone grafting can help improve osseous healing and diminish shortening. One of the problems with resecting too much bone from the subtalar joint is that, as the bone is resected, the body of the talus shifts posteriorly creating tension on the ligamentous and capsular structures about the talonavicular and calcaneocuboid joints which can result in incongruous joints, pain and long-term degenerative joint disease (Figure 2).



Figures 2A, B. Resection of the opposing subtalar joint surfaces causes retrograde shifting of the talus on the calcaneus thereby, creating tension and incongruency in the talonavicular and calcaneocuboid joints. (Adapted from: Fellman J, Zollinger H. Surgical fusion of the subtalar joint – changing concepts in changing times. *Orthop Ihrf Grenzgeb* 1996; 134:4, 341-345.)

In those patients where there is obvious shortening of the hindfoot height with obvious decrease in the talar declination angle and impingement is noted at the anterior distal tibial talar junction, distraction arthrodesis will be in the patient's best interest.

Stephens and Sanders *1966*[4] described a classification system of three types of malunions (Figure 3).

1. Type I – Lateral wall bulge and far lateral subtalar joint arthrosis.
   This type of pathology is treated with lateral wall decompression as described by Braly, 1985,[5] and may be combined with a resection of the distal fibular malleolus allowing the patient to ambulate as early as 2-3 days post-operatively (Figure 4). If the peroneal tendons are mobilized and relocated and/or lengthened, then the patient is placed in a BK cast for 6 weeks nonweightbearing followed by progressive weightbearing.
2. Type II - Lateral wall bulge and significant subtalar joint arthrosis.
   These patients are usually treated with lateral wall decompression, peroneal tendon decompression and subtalar joint arthrodesis. If the talus is found to be in dorsiflexion a femoral distractor can be used to help avoid varus malposition of the fusion site. It should be noted that while distracting the subtalar joint for arthrodesis and/or bone block procedures, the subtalar joint can be placed in a varus attitude which will result in a varus heel after healing. This can be prevented by being sure that the medial side is distracted via a femoral distractor and/or various laminar spreaders.
3. Type III - Lateral wall bulge, significant subtalar joint arthrosis and varus angulation of the heel. With this injury the lateral wall is decompressed, tibial talar impingement is corrected by distraction arthrodesis. A Dwyer osteotomy is used to correct varus or valgus within the body of the calcaneus. A tricortical autogenous cortical cancellous bone graft can be contoured as a trapezoidal graft used to help correct varus without the use of an osteotomy (Figure 5). In cases where the calcaneus has shortened, a linear sliding calcaneal osteotomy and tendoachilles lengthening as reported by Huang, et. al,[6] can be used (Figure 6). Note that significant tension can be placed on the skin as the calcaneus is lengthened which can cause morbidity with skin healing. Romash,[7] treated decreased talar declination angle, heel varus, and also heel height by using a "reconstructive

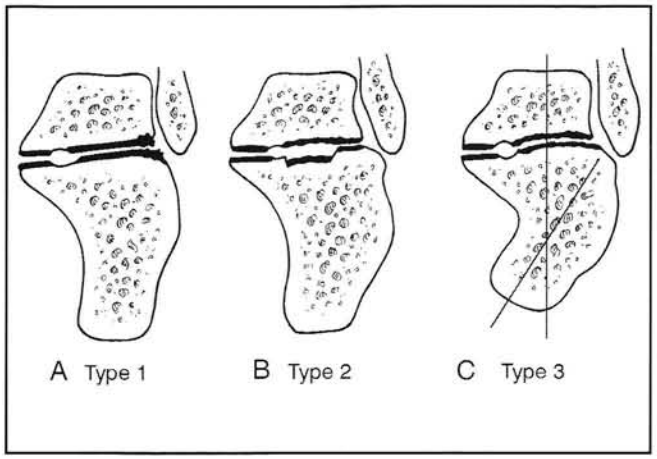


Figure 3. Classification of calcaneal malunions. (A) Type I: lateral wall bulge and far lateral subtalar arthrosis. (B) Type II: significant subtalar arthrosis. Type III: varus angulation and subtalar arthrosis. (Adapted from Stephens HM, Sanders R. Calcaneal malunions: results of a prognostic computed tomography classification system. *Foot Ankle Int* 1996; 17:7:395-401.)

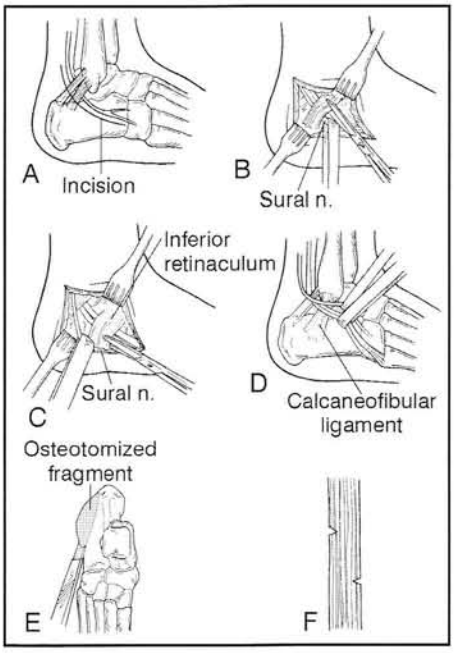


Figure 4. Lateral wall decompression. (A) Incision just inferior to peroneal tendons. (B) Sural nerve decompression. (C) Inferior retinaculum incised and peroneal tenolysis. (D) Calcaneofibular ligament cut to expose lateral calcaneus. (E) Lateral calcaneal osteotomy. (F) Z-lengthening of peroneal tendons for anterior dislocation. (Adapted from Braly WG, Bishop JO, Tullos HS. Lateral decompression for malunited os calcis fracture. *Foot Ankle* 1985; 6:90-6.)

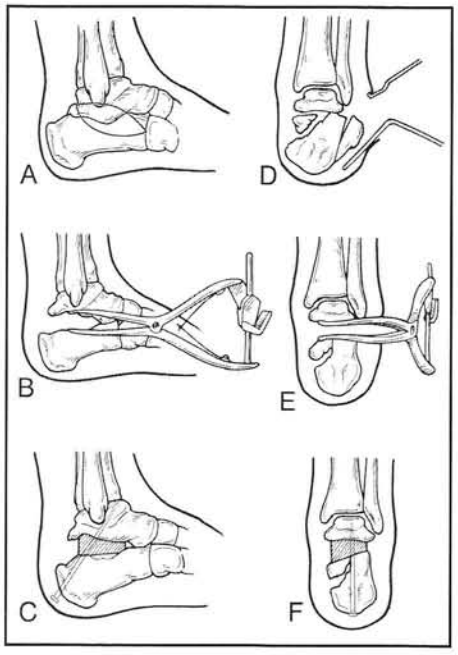


Figure 5. Lateral view. (A) Skin incision. (B) Subtalar distraction with a laminar spreader. (C) Subtalar distraction with an anterior wedge bone graft and a cannulated screw. The postoperative hindfoot height is increased and talonavicular joint subluxation reduced. (D-F) axial views. (D) The calcaneus is in varus. The lateral cortex is exposed after a subperiosteal skin flap and then resected. (E) The subtalar joint is distracted with a laminar spreader. The coronal axes were adjusted into a mild valgus position after a complete medial subtalar capsulotomy to allow more distraction on the medial subtalar joint. (F) The valgus position is maintained with a wedge bone graft and fixed with a cannulated screw. The postoperative hindfoot axis is neutral to mild valgus. (Adapted from: Chen YJ, Huang TJ, Hsu KY, Hsu Rww. Chen CW. Subtalar distraction realignment arthrodesis with wedge bone grafting and lateral decompression for calcaneal malunion. The Journal of Trauma: Injury, Infection, and Critical Care. 1998; 45:4,729-37.)

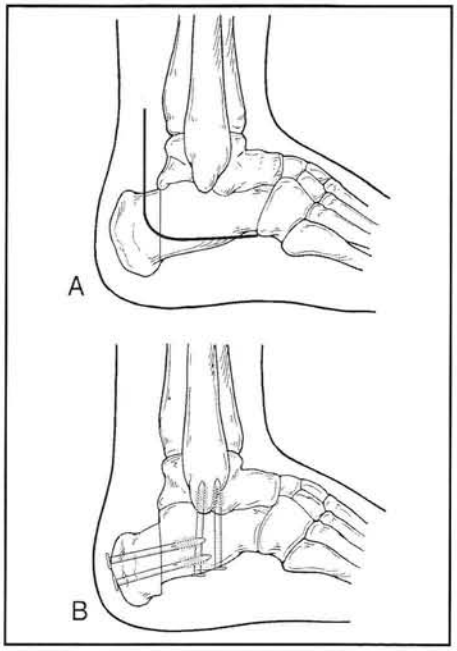


Figure 6. (A) Wide L-shaped skin incision (dotted line) facilitates lateral wall osteotomy decompression and Achilles tendon lengthening when necessary. The vertical osteotomy is performed just posterior to the talus. (B) Distal shift of tuberosity fragment (approximately 10 mm) fixed with cancellous screws as is the subtalar fusion. (Adapted from: Huang PJ, Fu YC, Cheng YM, Lin ST. Subtalar arthrodesis for late sequelae of calcaneal fractures: in situ versus fusion with sliding corrective osteotomy. *Foot Ank Int* 1999; 20:3,166-170.)

osteotomy." The procedure involves creating a lateral sinus tarsi incision. The sinus tarsi is cleared of its contents. The subtalar joint is mobilized and a laminar spreader is used to create separation. The articular surfaces of the joint are prepared for fusion. The primary fracture line of the injury is identified and a Steinman pin is placed in line with it using fluoroscopy (axial view). An osteotomy is then created in the fracture line which separates the calcaneus into the tuberosity fragment and a sustentacular fragment. The tuberosity fragment is shifted inferiorly and medially in relationship to the sustentacular fragment. This position is then held with appropriate Kirshner wires and then small screws are used to fixate the body of the tuber to the sustentaculum fragment. A 6.5mm or 7.0mm screw is used to maintain the length of the newly acquired position directed from the inferior apex of the calcaneus into the talus. The superior void created by the shift is filled with iliac crest bone and occasionally a bone block is necessary to maintain stability (Figure 7). The wound is closed in layers. Note that like the Huang distraction arthrodesis described earlier, morbidity can be associated with tension created on the incision line.

DISCUSSION

Multiple authors have reported excellent healing outcomes with subtalar joint fusions with and without distraction arthrodeses. As early as 1958, Lindsay and Dewar[8] noted that 27% of their patients complained of ankle pain and 20 % lacked ankle dorsiflexion to neutral. They attributed these findings to multiple factors such as cartilage damage, shortened Achilles tendon post injury, etc. They concluded that changes of the ankle did not correlate with symptoms. However, they noted that in severe crush injuries the talus

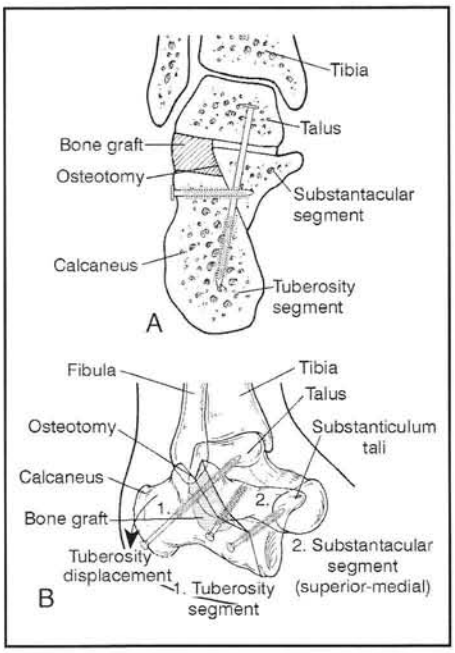


Figure 7. Distraction arthrodesis. (A) Fixation of final construct in coronal plane. (B) Final construct with screw placed through calcaneus. (Adapted from: Romash MM. Reconstructive osteotomy of the calcaneus with subtalar arthrodesis for malunited calcaneal fractures. Clin Orthop 1993; 290:157-67.)

was dorsiflexed. In 1988, Carr et. al.[9] correlated ankle pain with old calcaneal fractures and felt this deformity could be corrected. Up to this point in the literature, no one had appreciated the value of attempting to realign calcaneal malunions to re-establish anatomic function. Carr et. al. are to be commended for this visionary thinking. They reported on 13 of 16 distraction subtalar joint bone block arthrodeses with a follow-up of 22 months. They reported a 81% satisfaction rate. Of 8 patients followed for more than one year, two required valgus osteotomies for malunions and one required bone grafting and screw removal for a nonunion. Myerson and Quill,[10] in 29 patients which were a combined series of in situ arthrodeses and distraction bone arthrodeses, obtained good results in 18, fair in 5, poor in 6. Of the fair and poor results, 3 were related to hindfoot problems which included varus malunion and lateral pain. Three were related to midtarsal joint pain, heel pad pain and nerve problems or alcoholism. Stephens and Sanders, 1996, reported excellent results in 88% of their malunions (23/26) after lateral decompression, correction of heel varus, and subtalar fusion. Amendola and Lammens[11] performed interpositionl bone block arthrodesis in 15 patients. Eleven of 15 were satisfied with the procedure. They had 4 failures secondary to transverse tarsal joint arthritis , one overcorrection into varus and another with reflex sympathetic dystrophy. There was 100% union rate and heel height was improved from an average preoperatively of 84.6 mm to 90.6 mm. postoperatively. Talar declination angle improved from 11.4 degrees preoperatively to 14.7 degrees postoperatively. Eight of 9 patients had improved anterior ankle pain. Bednarz et. al.[12] reviewed 29 feet in 28 patients with a 33 month follow up period. Their AOFAS score improved from 25 preoperatively to 75 postoperatively. Hindfoot height improved an average of 8 mm., 9 degrees of lateral talocalcaneal angle, and 11 degrees in lateral talar declination angle. Satisfaction rate was 95%. Complications included 4 nonunions, 2 varus malunions, 1 metatarsal fracture, and 1 medial plantar nerve paresthesia. For calcaneal malunions, failed open reductions and internal fixations or severely comminuted fractures, Phemister[13] reported union rate of 96%. He reported a nonunion rate of 5% of in situ arthrodeses and 15% nonunions with distraction bone block arthrodeses. This resulted in 10% re-operation rate. Despite high satisfaction (86%), 15% of non-workers compensation and 48% of workman compensation patients were unable to return to work. Thermann et al.,[14] reported on 40 in situ subtalar joint arthrodeses with a five year follow-up. Fifty five percent of these patients were pain free and 83% wore normal shoes but 60% had Grade I arthritis of the ankle. Similar results have been reported by Fellman and Zolinger,[15] and Burton et. al.[16]

SMOKING AND OTHER RISK FACTORS IN NONUNION

Increased morbidity and complications with these fractures, can be expected in patients with metabolic problems such as diabetes mellitus and neuropathy, poor vascularity, and more traumatic wound injuries, etc. It is also known that smoking can deter osseous healing as the carbon monoxide from the cigarette competes with the oxygen needed in the microcirculation necessary for appropriate bone healing. Easley, et al.,[17] in a series of 148 isolated subtalar joint arthrodeses found a union rate of 92% in nonsmokers vs 73% in smokers. They also found that the rate of union was significantly decreased by the presence of more than 2mm of avascular bone at the failed previous subtalar joint arthrodesis. They also found that the use of a structural allograft and performance of the subtalar arthrodesis adjacent to the site of a previous ankle arthrodesis were also suggested risk factors. When patients with the above discussed risk factors were removed, the overall union rate was found to be 96% (73/76).

CASE PRESENTATION

On 5/6/01, a 44-year-old Caucasian male suffered a crush injury to his right foot and ankle after falling off his roof. He was diagnosed with a comminuted calcaneal fracture and casted for three months. He returned to work 9/01, but continued with pain that worsened with time. On 1/02, he returned to his doctor and underwent physical therapy without success. Pain continued and on 2/02 underwent a subtalar fusion with bone graft from the ipsilateral hip. This was followed by non weightbearing cast for 6 weeks, then a walking brace and subsequently physical therapy. Eight months later disability and pain continued. He then sought consultation with a podiatric physician who treated him in conservative fashion with orthotics, etc. Failing conservative therapy he was referred to me for surgical evaluation.

On 1/6/03, examination revealed moderate edema about the entire hindfoot and ankle (Figures 8A, 8B). Pain was illicited on palpation of the entire hindfoot and ankle. Moderate pain was noted with attempted STJ range of motion. Ankle dorsiflexion was likewise painful at the anterior tibial talar joint. Social history revealed a 20+ pack year nicotine abuse. Neurological examination revealed paresthesias from the tarsal tunnel to the inferior calcaneal fat pad and decreased light touch on the lateral aspect of the foot. During stance, the patient did not apply much pressure to the right foot. Gait evaluation revealed a very slow midstance to midstance gait. Patient could not toe raise on the right foot. Bilateral weightbearing lateral x-rays of the foot and ankle revealed a hindfoot height of 77 mm. right and 85 mm. on the left. Talar declination angle on the right was 15 degrees and 30 degrees on the left (Figures 9A, 9B). Radiographic analysis revealed radiolucency and subchondral sclerosis of the subtalar joint (Figure 10), widening and shortening of the calcaneus (Figure 11). A three phase Technetium 99 bone scan on 12/2/02, revealed increased uptake in the delayed stage (Figure 12).

A local anesthetic block into the right sinus tarsi and lateral aspect of the calcaneal body reduced subtalar joint and peroneal/lateral wall pain, but ankle pain continued.

The following diagnoses were made: 1) Joint depression fracture 2) Post-traumatic degenerative joint disease subtalar joint 3) Rule out DJD fibulocalcaneal junction 4) Impingement and chronic tenosynovitis peroneal tendons 5) Neuritis medial calcaneal branch 6) Hypoesthesia sural nerve 7) Rule out hypertrophic nonunion subtalar joint.

Recommendations: 1) CT scan of the subtalar and midtarsal joints 2) Consider internal or external compression

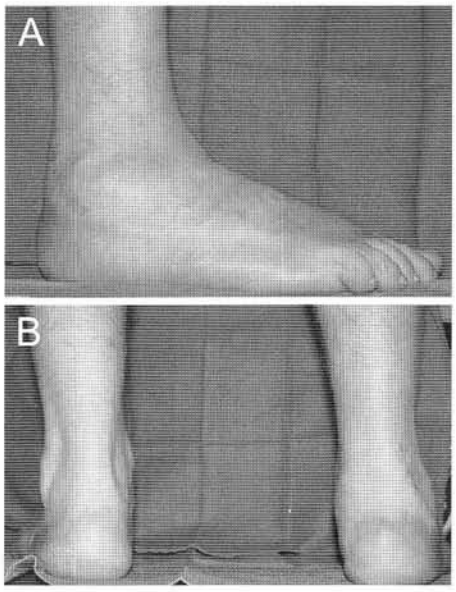


Figure 8A. Note moderate edema of the entire hindfoot and ankle. Figure 8B. Comparative evaluation of normal left ankle and injured right ankle from posterior view.

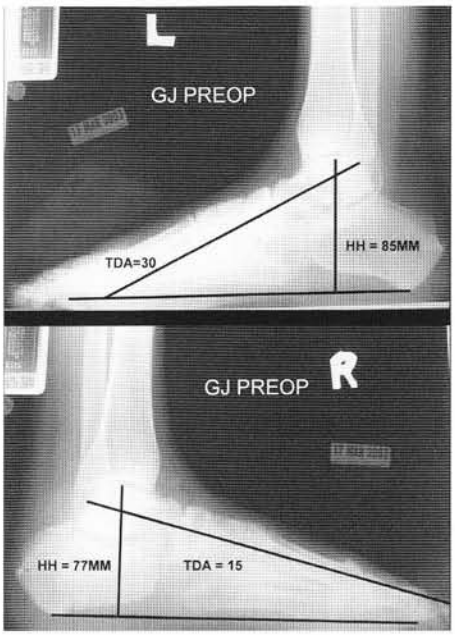


Figure 9A. Standing weightbearing lateral of the left foot and ankle reveals hindfoot height of 85mm and talar declination angle of 30 degrees. 9B. Weightbearing lateral of right injured extremity hindfoot height equals 77mm, talar declination angle equals 15 degrees.

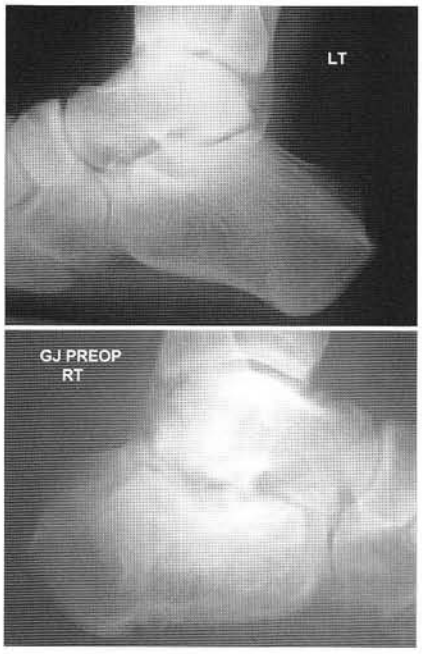


Figure 10. Lateral x-ray, right foot (right side) reveals radiolucency of subtalar joint and subchondral sclerosis consistent with nonunion of subtalar joint. Compare to normal left foot.

fixation subtalar joint with external bone stimulation and non weightbearing 3) Consider subtalar joint distraction bone block arthrodesis with autogenous/allogeneic tricortical iliac crest bone to regain height of the hindfoot and implantation of an internal bone stimulator 4) Consider triple arthrodesis 5) Anti-inflammatory/pain medicines.

A frank discussion was held with the patient identifying that surgical intervention may reduce some or none of his complaints and that he may not be able to return to the standing job he loved at the Nissan car factory in Smyrna, Tennessee. He was also cautioned with respect to cessation of smoking to improve percentage of osseous and tissue healing.

Following consultation with his primary podiatric physician and family the patient decided to undergo surgery and on the 3/19/03 the following procedures were performed:

1. Bone block distraction arthrodesis of the right subtalar joint with autogenous tricortical iliac crest bone graft from the contra-lateral hip.
2. Implantation of EBI single-lead implantable bone stimulator, right foot.
3. Repair of nonunion right subtalar joint.

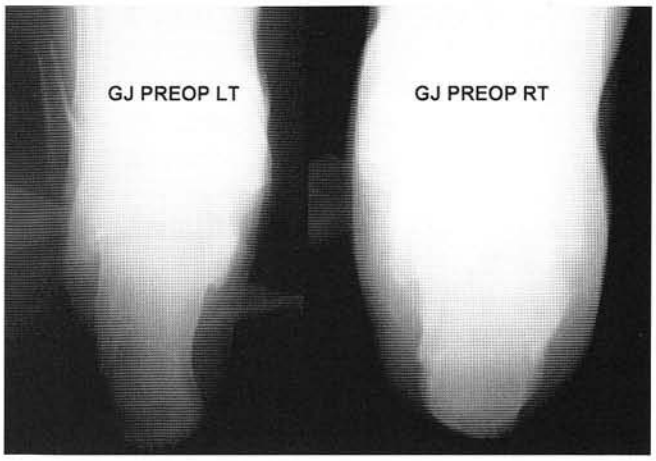


Figure 11. Axial view of calcaneus reveals widening and shortening of the right calcaneus (right side).

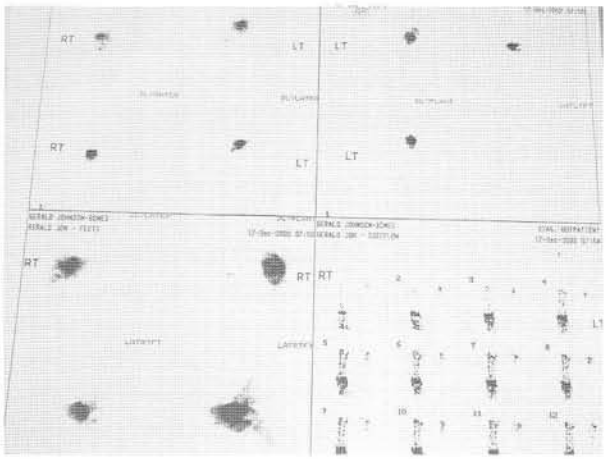


Figure 12. Three phase Technetium 99 bone scan reveals increased uptake in the delayed stage.

BONE BLOCK DISTRACTION ARTHRODESIS, RIGHT SUBTALAR JOINT, WITH ILIAC CREST BONE GRAFT.

With the patient in the left lateral decubitus position, the right limb was exsanguinated and pneumatic thigh tourniquet was elevated to 350mmHg.

Attention was then directed to the lateral aspect of the right hindfoot, where an 8cm modified Ollier incision was created from the tip of the fibula out to the level of the calcaneocuboid joint (Figure 13). Dissection was carried into the subcutaneous tissues, with care taken to avoid all critical neurovascular structures and bovie and ligate those vessels deemed necessary to maintain adequate surgical

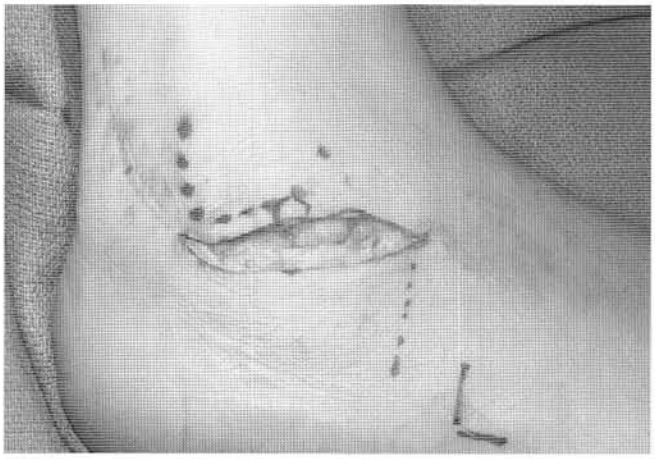


Figure 13. Ollier incision used to gain access to the subtalar joint.

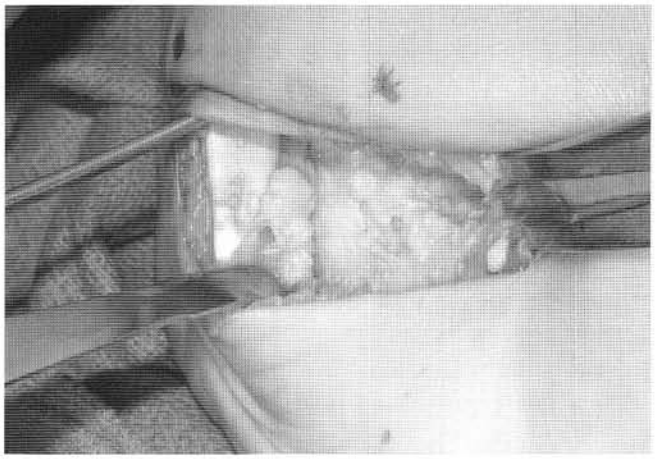


Figure 14. Peroneal tendons are retracted and lateral wall of calcaneus is inspected. Mild to moderate blow-out of lateral wall is noted.

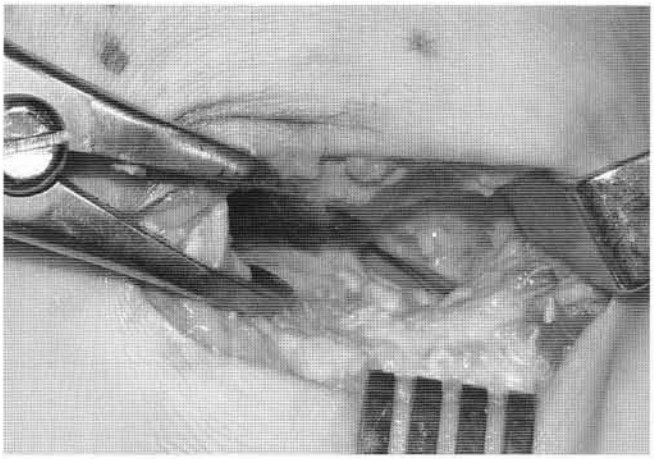


Figure 15. Laminar spreader holding subtalar joint open identifying posterior and middle facets

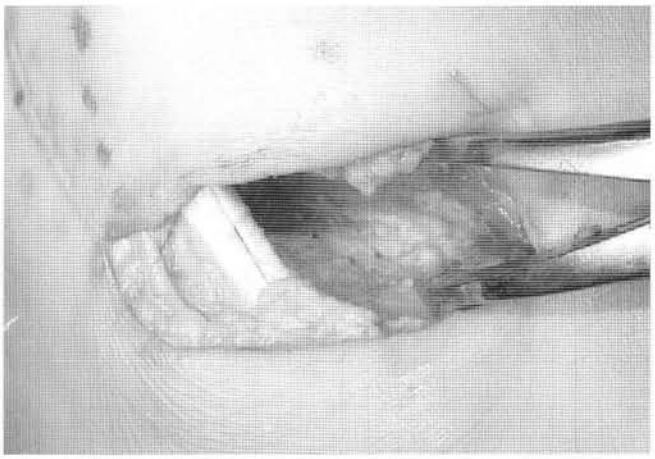


Figure 16. Articular surfaces have been resected and multiple small subchondral drill holes are placed through the subchondral plate.

hemostasis. Sharp dissection was carried down until the natural separation between the subcutaneous and deep fascial layers was appreciated. This fascial plane was utilized to reflect the subcutaneous tissues dorsally and plantarly off the extensor retinaculum. An L-shaped incision was created from the leading surface of the talar body adjacent to the lateral talar process onto the calcaneocuboid joint. Subperiosteal dissection was performed, elevating the ligaments and muscle belly off of the calcaneocuboid joint with care taken to preserve the dorsal calcaneocuboid and bifurcate ligaments. The lateral aspect of the subtalar joint capsule was exposed and the peroneals were retracted posteriorly The lateral ligaments of the subtalar joint were then incised to allow for further access to the joint. Moderate lateral wall blow-out was seen, however, there appeared to be no direct impingement of the peroneal tendons or any calcaneofibular impingement (Figure 14). There was significant fibrous tissue in the subtalar joint. This was removed utilizing a rongeur and key elevator. The Hoke's tonsil was well as the intertarsal ligaments on the medial aspect of the sinus tarsi were removed, allowing for exposure to the middle facet of the subtalar joint (Figure 15). Utilizing power sagittal saw, the adjacent surfaces of the calcaneus and talus were decorticated and debrided of fibrous and cartilaginous tissues and the remaining subchondral bone plate was fenestrated with a drill bit. Cartilage was still evident in the medial and posterior aspects of the joint. No evidence of the graft was apparent from the prior surgery.

After good healthy cancellous bleeding surfaces were obtained in both the posterior facet and middle facets of the subtalar joint, a sagittal saw was utilized to create planar surfaces to allow for better congruous fit of the bone graft (Figure 16). A lamina spreader was placed at the medial side of the subtalar joint through the lateral incision and the subtalar joint was distracted. This

was viewed under image intensification. This allowed decompression of the anterior ankle joint and restoration of the height of the hindfoot.

Next, attention was directed to the iliac crest bone graft that was procured earlier. This was denuded of all fibrous tissue and cut or reshaped utilizing a sagittal saw to allow for the exact measurements following distraction. The graft was approximately 13mm in dorsal to plantar depth. Utilizing a rotary bur, the dorsal and plantar cortices of the iliac crest graft were fenestrated to allow for bony ingrowth. This provided areas of healthy cancellous bone without destroying the structural nature of the graft (Figure 17). The graft was then gently tapped into the posterior aspect of the subtalar joint and advanced medially to reduce heel varus (Figure 18). Image intensifier was utilized to confirm placement of the graft and overall alignment, which was found to be good. Clinical examination showed the heel to be slightly valgus relative to the position to the leg (Figure 19).

Two small 1 cm stab incisions were placed side by side in the inferior aspect of the calcaneus. Two calcaneotalar guide wires were placed in a retrograde fashion. The first pin was positioned laterally in the heel perpendicularly through the graft and into the posterior aspect of the facet of the talar body. The second pin was placed in the medial position into the medial aspect of the head and heck of the talus. Two 7.3mm cannulated screws were placed over the guide wires and secured (Figure 20). Both screws had excellent purchase.

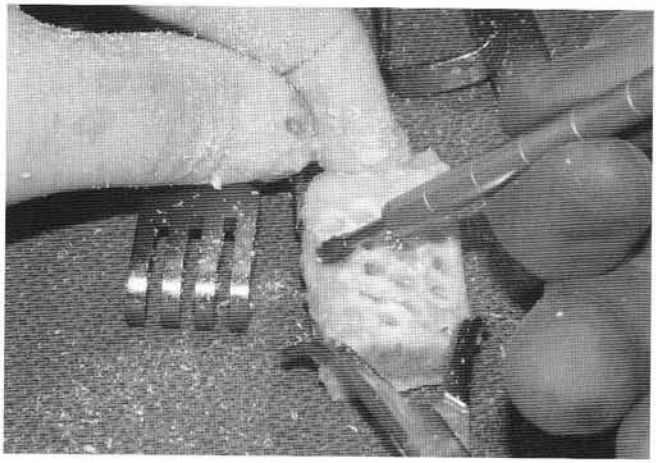


Figure 17. Tricortical bone graft being prepared for insertion. Note multiple drill holes placed in graft for easier incorporation.

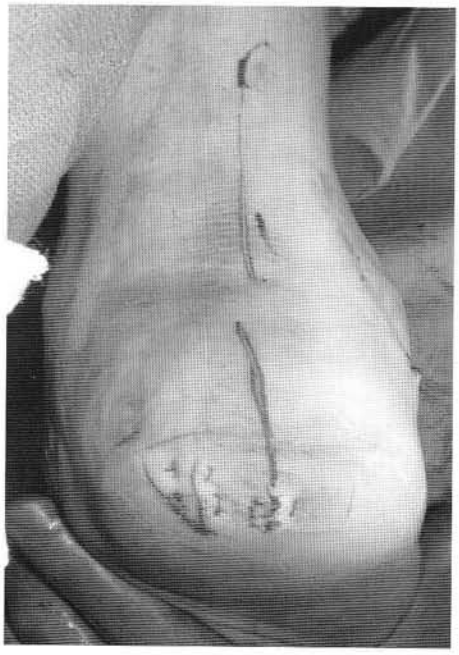


Figure 19. Calcaneus in 5-6 degrees of valgus position.

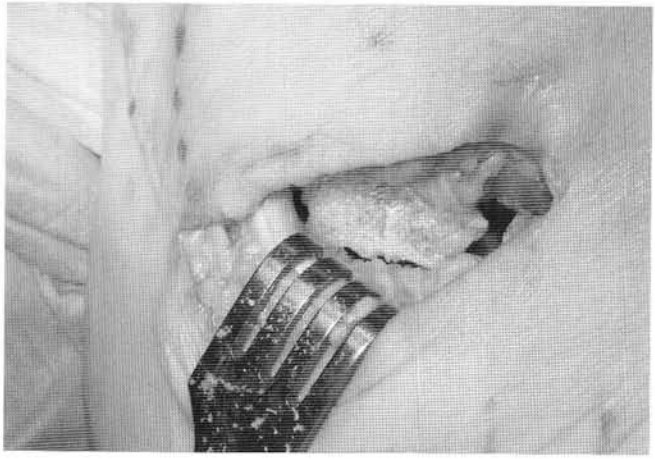


Figure 18. Bone graft in place maintaining length and slightly everted position of the subtalar joint.

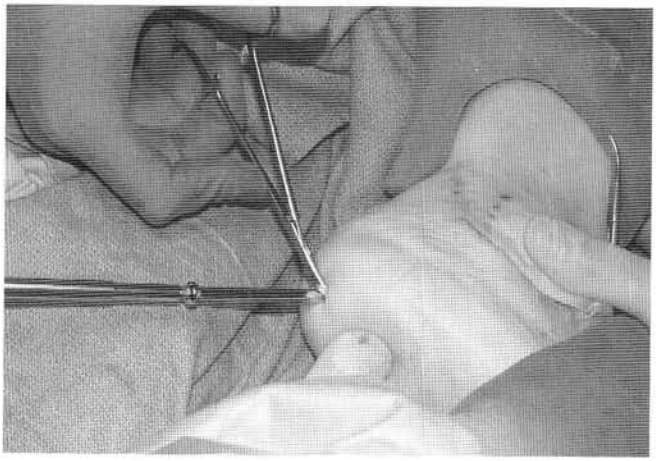


Figure 20. A 7.3 cancellous partially threaded cannulated self tapping bone screw placed over guide wire is being inserted into the talocalcaneal joint.

IMPLANTATION OF EBI IMPLANTABLE BONE STIMULATOR

Attention was directed to the anterior lateral aspect of the right leg, where a 4 cm incision was created to allow for passage of the battery pack (Figure 21). A subcutaneous tunnel was created from this incision, which was located approximately 8cm above the lateral malleolus to the distal incision. The battery pack was then pulled up through the subcutaneous tunnel into the anterior and lateral leg (Figure 22). The single monofilament lead was then woven in and around the area inferior to the bone graft and small defects, as well as anterior to the graft, and was additionally woven through the graft utilizing multiple drill holes. The remainder of the iliac crest graft was then placed into the anterior aspect of the sinus tarsi, around the area of the middle facet. The remaining defects were also packed. The wound was then copiously irrigated with sterile saline. The wounds were then closed in layers over a single TLS drain (Figure 23).

Betadine paint, Steri-strips and moistened saline sponge and a dry sterile dressing were applied to the surgical site, followed by a short leg Jones compression cast, with the ankle in neutral position (Figures 24, 25).

Dressings and cast were changed at 2 weeks and again at 6 weeks. Normally patients are allowed guarded weightbearing after 6 weeks assuming radiographic analysis reveals appropriate healing. Due to compliance reasons, our patient was allowed to bear weight at 12 weeks. He was then converted t o a cam walker slowly advancing his rehabilitation. Repeat x-rays at 18 weeks and at 28 weeks showed continued consolidation of the arthrodesis site (Figure 26). The 28 week lateral weight-bearing x-ray showed a hindfoot height of 81 mm, a 4 mm increase from the preoperative state. Ankle and foot symptomatology improved to the point that by 8 months he returned to full time work at the car factory. The patient stopped smoking on the day of surgery and remained non-smoking upon his return to work.

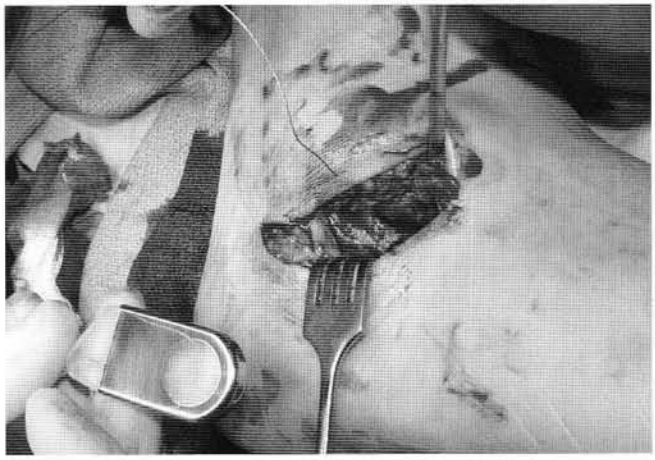


Figure 21. EBI bone stimulator which will be placed into surgical site.

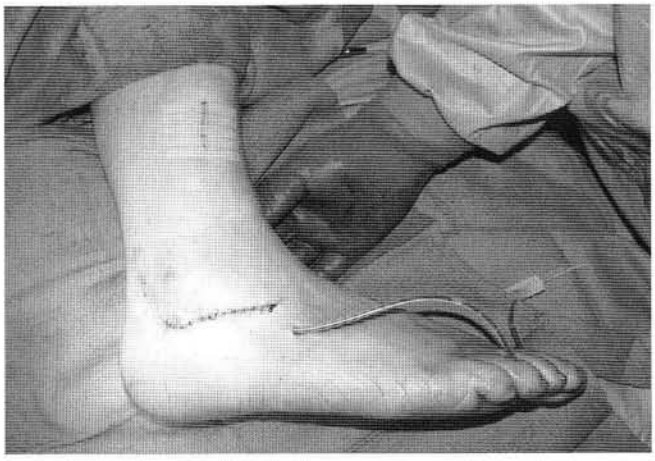


Figure 23. Layer closure after insertion of TLS drain.

Figure 22. Bone stimulator in place. Anode has been placed below subcutaneous tissues on the anterior lateral compartment of the right lower leg.

Figure 24. Postoperative lateral view of foot and ankle showing graft in place stabilized with two 7.3mm screws. Note that the most posterior screw is perpendicular to the subtalar joint and graft and the 2nd screw is placed anterior and serves as a second point of fixation to encourage stability and decrease rotation.

Figure 25. AP of ankle and lower leg showing EBI bone stimulator in place.

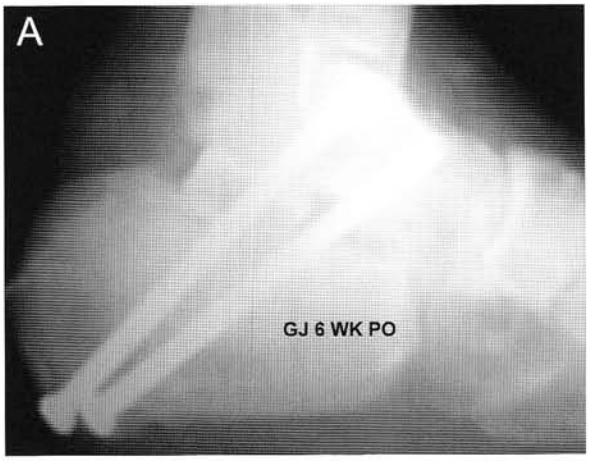


Figure 26A-G. Series of x-rays between 6 weeks and 7 months revealing continued incorporation and healing of the subtalar joint fusion site. Note an increase in hindfoot height of 4 mm from preoperative level. The patient is fully weightbearing and expected to return to work at this point.

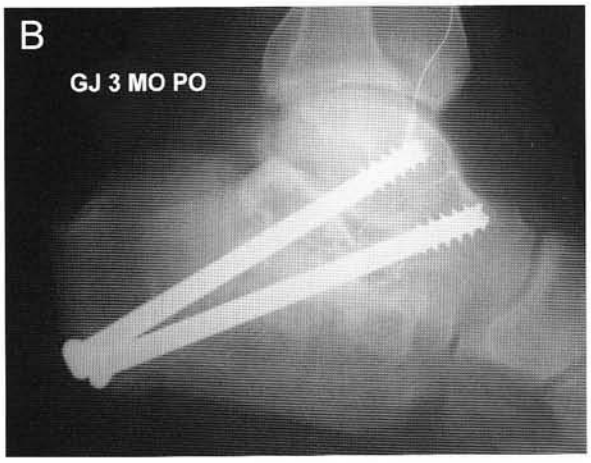


Figure 26B.

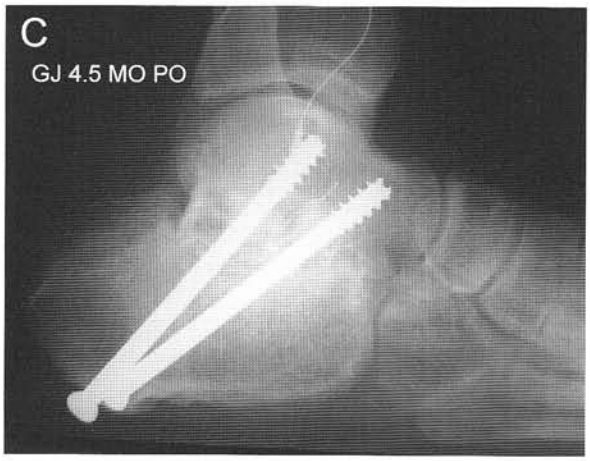


Figure 26C.

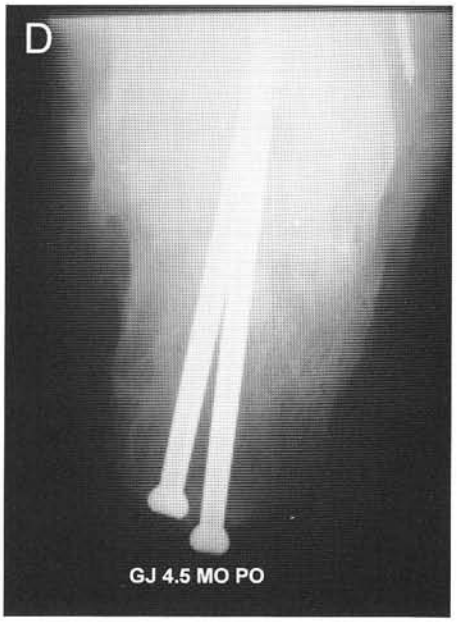


Figure 26D.

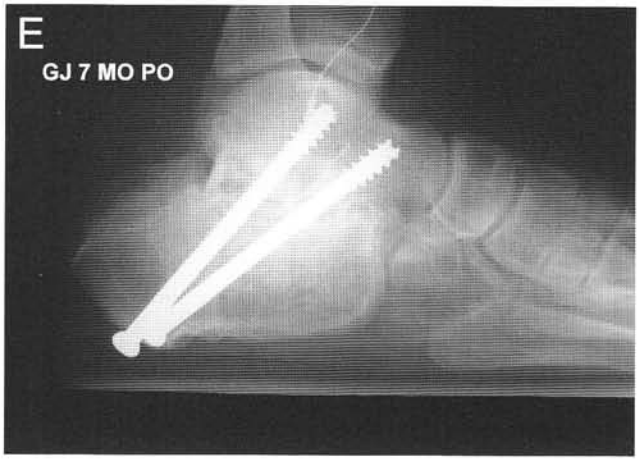


Figure 26E.

Figure 26F.

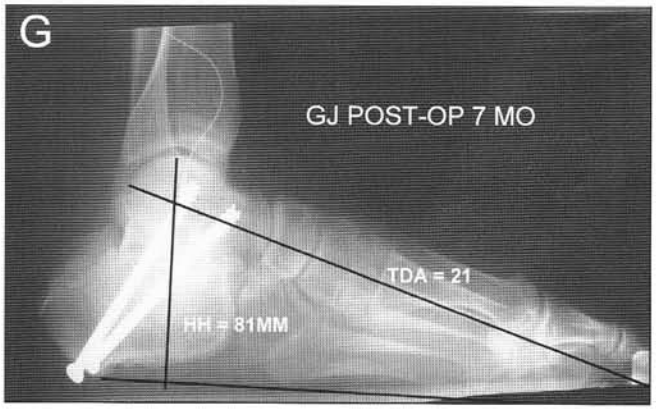


Figure 26G.

SUMMARY

It is a well known fact that severe injuries to the subtalar joint can create malunions, shortening and widening of the calcaneus. Varus or valgus rotation of the tuber of the calcaneus, and irregularities and/or arthritis of the midtarsal joint especially the calcaneo- cuboid joint ensue. Once the talar declination angle decreases, tibial talar impingement can result in ankle pain. This shortening impacts the gastrosoleus complex by shortening and weakening the lever arm of the calcaneus resulting in a weak toe-off.

It is imperative that the hindfoot be realigned and elevation added to the talocalcaneal component in order to anatomically realign osseous structures and relieve stresses on soft tissues. The goal of the distraction arthrodesis for malunion of a calcaneal fracture is to create a functional foot allowing patients to return to a pre-injury function and hopefully full time work. Generally results have been less than satisfying to the majority of patients who wish to return back to work. In 1908, Cotton and Henderson[18] stated that a man who breaks his heel bone is virtually "done" with respect to his industrial future. However with improved methods of evaluation, classification and instrumentation, fracture patterns can be more easily determined making pre-operative planning and intraoperative intervention more successful. Following calcaneal joint depression fractures, we use early operative intervention, to meticulously realign the subtalar joint articular surfaces. We gain height of the calcaneus, diminish width of the body and realign malposition of the tuber.

New information is gleaned frequently relatively to improvements on to best treat these severe calcaneal fracture deformities. One method is distraction calcaneal bone block arthrodeses which has improved outcomes.

REFERENCES

1. Cohen MM in: Banks AS, Downey MS, Martin DE, Miller SJ. McGlamry's Comprehensive Textbook of Foot and Ankle Surgery Vol. II, 3rd Ed. P 1819, Philadelphia;Lippincott Williams & Wilkins; 2001.
2. Robinson JF, Murphy GA. Arthrodesis as salvage for calcaneal malunions. *Foot Ankle Clin N Am* 2002;7:107-20.
3. Sanders R, Fortin P, Walling A. Subtalar arthrodesis following calcaneal fracture. *Orthop Tran* 1991; 5:656.
4. Stephens HM, Sanders R. Calcaneal malunions: results of a prognostic computed tomography classification system. *Foot Ankle Int* 1996;17:395-401.
5. Braly WG, Bishop JO, Tullos HS. Lateral decompression for malunited os calcis fracture. *Foot Ankle* 1985;6:90-6.
6. Huang JF, Fu YC, Cheng YM, Lin SY. Subtalar arthrodesis for late sequelae of calcaneal fractures: fusion in situ versus fusion with sliding corrective osteotomy. *Foot Ankle Int* 1999;20:166-70.
7. Romash MM. Reconstructive osteotomy of the calcaneus with subtalar arthrodesis for malunited calcaneal fractures. *Clin Orthop* 1993;290:157-60.
8. Lindsay WRN, Dewar FP. Fractures of the os calcis. *Am J Surgery*;95:556-76.
9. Carr JV, Hansen ST, Benirschke SK. Subtalar distraction bone clock fusion for late complications of os calcis fractures. *Foot Ankle* 1988;9:81-6.
10. Myerson M, Quill GE. Late complications after os calcis fractures. *Clin Orthop* 1963;30:111-5.
11. Amendola A, Lammen S. Subtalar arthrodesis using an interpositional iliac crest bone graft after calcaneal fracture. *Foot Ankle Int* 1996; 11:608-14.
12. Bednarz P, Beals T, et al. Subtalar distraction bone block fusion: An assessment of outcome. *Foot Ankle Int* 1997;18:785-91.
13. Flemister Jr AS, Infante AF, Sanders RW, et al. Subtalar arthrodesis for complications of intra-articular calcaneal fractures. *Foot Ankle Int* 1999;20:18-24.
14. Therman H. Huffner T. Schraft E. Long term results of subtalar fusions after operative versus nonoperative treatment of os calcis fractures. *Foot Ankle Int* 1999;20:408-16.
15. Fellman J, Zollinger H. Surgical fusion of the subtalar joint – changing concepts in changing times. *Orthop Ihrf* Grenzgeb;1996; 134:341-45.
16. Burton D, Olney C, Bradford W, Horton GA Late results of subtalar distraction fusion. *Foot Ankle Int* 1996;19:197-202.
17. Easley ME, Tmka JH, Schon LC, Myerson MS. Isolated subtalar arthrodesis. *J Bone Joint Surg Am* 2000;82:613-24.