SUBTALAR JOINT RECONSTRUCTION

The single axis subtalar joint is a hinge joining the talus and calcaneus that allows adaptation of the foot on uneven ground. This joint modifies the forces of ambulation imposed on the rest of the skeleton and influences the performance of the more distal foot articulations as well. When the structure and function of this joint are altered by trauma, instability, arthritis, infection, or tarsal coalition, subtalar reconstruction, usually in the form of arthrodesis, may prove to be a very successful procedure in treating the patient's resultant disability.

The subtalar joint is, in this author's opinion, a very under appreciated joint. Even though it is estimated that up to 3 percent of the general population may have an asymptomatic talocalcaneal coalition present from a very young age and function very well, patients with a stiffened subtalar joint secondary to post-traumatic subtalar osteoarthrosis have very poor biomechanical function.

Many patients presenting with "ankle" pain or who have pain from an ankle sprain that "just won't go away", may actually have subtalar pathology as an etiology for their discomfort. It is the astute orthopaedic surgeon who can recognize and successfully treat this pathology. Subtalar arthrodesis performed for the appropriate indications has proven to be one of this author's most gratifying, time-tested procedures in alleviating pain and improving function in patients so affected. Therefore, it is prudent that we understand the anatomic and functional aspects of the subtalar joint.

The subtalar joint consists of three separate facets for articulation between the talus and calcaneus (Figure 1). A large uni-planar posterior facet is the most readily identified. The middle and anterior facets cradle the talar head. The direction of the subtalar axis is posterior, inferior, and lateral. Individual variations are numerous. In people with pes planus the axis of the subtalar joint is more horizontal than in those with more normal feet. A patient with flat feet often will have excessive wear on the medial border of his foot and shoe due to the greater supinating and pronating affect of the leg on the foot with this more horizontal subtalar joint. On average, Manter has shown that the mean axis of motion of the subtalar joint is about 42 degrees with a range of 29 to 47 degrees inclination in the sagittal plane relative to the horizontal line and 16 degrees with a range from 8 to 24 degrees of medial deviation in the transverse plane relative to the long axis of the foot along the second ray.

Functioning as a mitered hinge between the talus and calcaneus, the subtalar joint is, therefore, aligned at about 45 degrees to the horizontal and allows translation of transverse rotation occurring in the tibia into the foot. With subtalar arthrodesis, these rotational and other forces are transferred to adjacent nonfused joints in the foot and the ankle.

Many authors have attempted to measure the residual motion in the foot and ankle after selective arthrodesis in the foot. Wilson has described the presence of tarsal hypermobility
after subtalar fusion. On the other hand, Mann and Baumgardner reported a 50 percent loss of forefoot abduction and adduction after an isolated subtalar arthrodesis.

This author has fairly frequently encountered patients after successful subtalar arthrodesis that will have a transient synovitis of the ankle during the first two to three months after cessation of postoperative casting. These patients are counseled preoperatively and postoperatively regarding the mechanics of their hindfoot and ankle and how these mechanics are affected by subtalar fusion. Most patients seem to understand that the ankle is also a hinge and that, having the subtalar joint fused; rapid walking with long strides on uneven surfaces may cause the ankle to sustain forces out of its usual plane of motion. The patients are told that the ankle normally functions as a hinge, and when they are so active on an uneven surface, they are asking it to function more as a universal joint. This excessive out-of-plane stress applied to the ankle is the etiology of temporary ankle synovitis after subtalar arthrodesis.

Another clinical correlation that is pertinent here is the congenitally stiffened subtalar joint that occurs with clubfoot and certain forms of arthrogryposis. These patients often by adolescence have developed a "ball and socket" type of ankle, because of the stresses transferred to the developing joint above the stiffened talocalcaneal articulation.

Most authors proposing isolated arthrodesis of the subtalar joint as a therapeutic measure have concluded that, while degenerative radiographic changes can be appreciated at the ankle, talonavicular, and calcaneocuboid joints after isolated subtalar fusion, in most cases these radiographic changes of arthrosis do not correlate with clinical symptoms. Most of these patients are indeed asymptomatic at these often radiographically-abnormal joints on either side of the subtalar arthrodesis site.

**SUBTALAR ARTHRODESIS**

**INDICATIONS:**
By far the most commonly employed method of reconstructing the subtalar joint is by arthrodesis. This is considered by most authors a salvage technique. That is, one which is used to alleviate pain and correct deformity, but which is not necessarily reversible. This salvage technique involves sacrificing some of the preoperative "normal" joint structure, function, and motion in an attempt to eliminate pain.

A successful subtalar arthrodesis, however, in the clinically appropriate position of 3 to 5 degrees of hindfoot valgus, can greatly improve the function of the patient with preoperative subtalar arthritis and/or deformity. Most of these patients, who have undergone such a successful arthrodesis, when interviewed postoperatively, would gladly trade motion for stiffness in order to achieve pain relief. Many of my postoperative patients have remarked that their subtalar joint was so stiff preoperatively anyway, that they don't miss the painful small arc of preoperative motion that they traded for the pain free, surgically ankylosed joint they have obtained postoperatively.

In this author's practice, the most common indication for subtalar arthrodesis is arthritis, usually of a post-traumatic etiology (Figure 2). These patients complain of daily pain in the hindfoot, usually associated with swelling. These patients have more difficulty walking on uneven surfaces than they do on level ground due to loss of the normally accommodating subtalar motion. These patients will frequently "turn over" their ankle, even when walking on a small
stone or pebble in their path. Only occasionally will they complain of locking. This symptom of locking is rare with subtalar arthritis and is usually more commonly attributed to ankle arthritis or loose bodies.

Patients with significant post-traumatic osteoarthrosis of the subtalar joint will often have start-up pain upon arising from the seated position. A similar, related symptom is that of morning stiffness. These patients' symptoms may improve with a diagnostic - and sometimes therapeutic - Xylocaine or bupivacaine injection or with a trial of immobilization in a walking cast. For patients who receive such initial relief from these nonoperative measures, a trial of semi-rigid orthotics or a UCBL type of orthosis may occasionally obviate the need for surgery. Often these patients will improve in a high-top shoe or lace-up type of ankle and hindfoot brace.

As reported by Myerson and Quill, in a series of 43 calcaneus fractures sustained in 42 patients undergoing late operative treatment for the sequelae of calcaneus fracture, very good improvement in function was obtained after subtalar arthrodesis in the appropriately indicated patients. An in situ subtalar arthrodesis was performed in 15 of these patients with post-traumatic osteoarthrosis limited to the subtalar joint after calcaneus fracture. The group of patients undergoing subtalar joint reconstruction by means of an in situ subtalar arthrodesis achieved an average improvement between the preoperative and postoperative foot rating scores of 54 percent. Thirteen of these fifteen patients returned to work in the same job they had held before sustaining their calcaneus fracture. One of the patients remained unemployed after subtalar reconstruction, and another remained in a sedentary occupation and did not return to full activities. These latter two patients ironically had excellent improvement between their preoperative and postoperative foot rating scores (from 5 to 87 and from 67 to 84 respectively).

Figure 3 demonstrates a patient with post-traumatic osteoarthrosis limited to the subtalar joint after calcaneus fracture that underwent successful reconstruction by means of an in situ subtalar arthrodesis with bone graft and internal fixation.

Patients with primary osteoarthrosis will do just as well, if not better after subtalar arthrodesis than those with post-traumatic (secondary) osteoarthrosis of the subtalar joint. The former group of patients will usually have fewer soft tissue problems than the patients with post-traumatic osteoarthrosis. Wound problems, scar formation, significant preoperative deformity, and edema are also more common in the posttraumatic group of patients. Figure 4 (Vincent Peglino?) illustrates a 62-year-old gentleman with primary osteoarthrosis of subtalar joint who underwent a successful subtalar reconstruction by means of arthrodesis using bone graft and internal fixation.

Patients with inflammatory arthritis due to, for example, rheumatoid disease, will only occasionally present with joint destruction limited to the subtalar articulation alone. Usually cartilage loss, joint space narrowing, and synovial hyperplasia in these patients with inflammatory arthritis are severe enough on presentation to warrant not only subtalar arthrodesis, but rather, triple arthrodesis because of extensive hindfoot and transverse tarsal joint involvement.

Indications for an "in situ" subtalar arthrodesis include primary and secondary (post-traumatic)
osteoarthrosis, as well as inflammatory arthritis due to rheumatoid or seronegative arthritic disease, crystalline disease such as gout or pseudogout, infection, or even the sequelae of primary synovial disorders such as pigmented villonodular synovitis and hemophilic arthropathy. Other indications for an in situ subtal arthrodesis would include neuropathic or neuromuscular joint abnormalities as are seen in diabetes mellitus, Charcot-Marie-Tooth disease, cerebral palsy, or after cerebral vascular accident. Occasionally avascular necrosis of the talus without collapse and without significant bone loss will present an indication for in situ subtal arthrodesis with bone grafting. If these patients do have significant talar bone loss or collapse with diminished hindfoot and heel height, then the surgeon will have to consider bone block distraction arthrodesis by the technique described later in this chapter.

Occasionally patients with congenital or dysplastic deformities due to talipes equinovarus, severe pes planus, or tarsal coalition not amenable to bar resection will be candidates for subtal arthrodesis in an in situ position (Figure 5). Occasionally a patient with posterior tibial tendon insufficiency or rupture will be a candidate for subtal arthrodesis. I have on occasion encountered a patient with a failed subtal arthroereisis and foreign body synovitis with joint destruction who will be a candidate for subtal arthrodesis.

An in situ subtal arthrodesis after trauma is performed when the calcaneus fracture patient has subsequent subtal osteoarthrosis, but the height of the heel is more normal, and there is normal tibiotalar alignment. An ostectomy of the lateral aspect of the calcaneus can be performed when peroneal tendinitis is accompanied by impingement. Tendinitis is diagnosed if the patient's pain is concentrated along the course of the peroneal tendons and if it becomes worse with passive dorsiflexion and resistance to eversion of the hindfoot.

A subtalar distraction bone block arthrodesis is performed when the patient has subtalar osteoarthrosis associated with pain in the anterior aspect of the ankle, and loss of the height of the heel of more than 8 millimeters compared with that of the opposite foot (as demonstrated on a standing lateral radiograph). Anterior tibiotalar impingement is best demonstrated by a talar declination angle of 20 degrees or less on a standing lateral radiograph of the patient's foot. This angle is formed by the longitudinal axis of the talus and the plane of support on a lateral radiograph made with the patient weight bearing, and is a measure of the horizontal attitude assumed by the talus. See Figure 6.

Authors Preferred Technique for In Situ Subtal Arthrodesis

The patient is brought to the operating room, where general or spinal anesthetic is administered. Local anesthesia is usually insufficient for this procedure. The patient is positioned supine on the operating room table with a well-padded bump under the ipsilateral buttock in order to slightly internally rotate the involved extremity. This affords good access to the hindfoot from its lateral as well as the medial side. A thigh tourniquet is used for intraoperative hemostasis (Figure 7).

Our patient is positioned supine on the operating room table with the operated foot within four inches of the end of the table to allow for percutaneous insertion of a calcaneotalar guide pin and screw if necessary. The preferred fixation technique, as the reader will see later, is from dorsal to plantar, but this option is not always available, and, therefore, it is important to have
the patient positioned appropriately and close to the end of the table before the procedure begins.

The involved extremity is prepped and draped in the usual sterile, free fashion after noting the anatomic bony, tendinous, and nervous landmarks. Landmarks for the lateral incision include the anterior process of the os calcis, the fibula, and the peroneal tendon. In some very thin patients with passive inversion of the foot, one can see the dorsolateral cuticular branch of the superficial peroneal nerve subcutaneously. Structures at risk include the peroneus tertius, the lateral common toe extensors, the dorsolateral cuticular branch of the superficial peroneal nerve, the peroneal tendons and sural nerve (Figure 8).

A radiolucent operating room table is not necessary for this procedure unless the surgeon is employing intraoperative C-arm fluoroscopy to complete the operation. I have found it easier to reduce the arthrodesis site and provisionally fix it with a threaded guide wire from a cannulated screw set. Then I will obtain intraoperative plain films, the cassettes for which are quite readily positioned under and along side the foot and heel. In this manner intraoperative C-arm fluoroscopy is not necessary.

I prefer a lateral, sinus tarsi approach to the hindfoot through a skin incision paralleling Langer's skin lines. One short transverse skin incision is all that is required here (Figure 8). Alternatively, a longitudinally oriented incision over the sinus tarsi can be made. I have found that the risks of injuring tissues through the lateral transverse incision paralleling the skin lines is minimal and leaves a much more manageable scar than one that is longitudinal. Access is not quite as good through the longitudinal incision, and the advantage of placing it parallel to the neurovascular structures is outweighed by the benefits that the transverse approach allows.

Instrumentation commonly employed for subtalar arthrodesis includes sharp beveled chisels, curettes and rongeurs. A cannulated screw system is not absolutely necessary, but is of great advantage in this procedure. I like to have a set of orthopaedic staples available for supplemental fixation in the case of osteopenic bone or failed screws. I will often have a small fragment screw set available, but much more commonly I use 6.5 millimeter or 7.0 millimeter cannulated screws for fixation.

The incision is made and carried down just through the dermis with sharp dissection. The incision usually extends from the lateral border of the common toe extensors and peroneus tertius tendon dorsally and anteriorly all the way to the peroneal tendons plantarward and laterally. In cases of severe preoperative deformity, it is often necessary to open the sheath of the peroneal tendons for retraction. The sural nerve is then retracted posteriorly with the peroneal tendons. Often I will open just the lateral portion of the long toe extensor tendon sheath. This affords excellent medial exposure because these tendons can be retracted all the way to the medial side of the head and neck of the talus (Figure 9).

I then raise a distally based flap of the short toe extensor muscles. I try to leave a proximal cuff of the ankle capsule and extensor retinaculum and fascia to which I repair this flap at the end of the case. The contents of the sinus tarsi are excised, and the appropriate retractors are placed (Figure 10).
Thus, we expose the posterior facet of the subtalar joint. Employing a lamina spreader at some point during the dissection is of great help in exposing this area. We can see and protect all the way over to the flexor hallucis longus tendon posteriorly and the posterior tibial tendon medially if enough distraction is applied across the joint. A chisel, curette and rongeur are used to excise the remaining articular surfaces of all facets on both sides of the subtalar joint. Small, thin wafers of articular cartilage and subchondral bone are taken on each side. Alternatively, large angled wedges of bone and cartilage can be taken to correct preoperative deformity (Figure 11).

I position the lamina spreader anteriorly while working on the posterior facet of the subtalar joint. I position the lamina spreader in the posterior facet once I have completed that dissection and want to turn attention to the middle and anterior facets.

One should also remove with a sharp curette the talocalcaneal interosseous ligament and other soft tissue structures between the posterior and middle facet. The cortical and cancellous bone here between the articular surfaces can often be removed with this curette, leaving healthy bleeding cancellous bone for apposition across the arthrodesis site. One must be careful not to damage the lateral side of the talonavicular joint through this approach if one's intention is only to fuse the subtalar joint, leaving the transverse tarsal joints unscathed.

With this lateral approach to the subtalar arthrodesis site, one must avoid the tendency to remove too much bone from the lateral side of the hindfoot relative to the medial. While hindfoot valgus is preferred to any varus malunion that may occur, it is easy with this approach to avoid removing enough bone and diseased articular cartilage medially. If not enough medial bone is removed, then a significant valgus malunion can result, leading to worsened hindfoot mechanics due to subfibular impingement and abnormal shoe wear. The lamina spreader is of great benefit in exposing the medial side of the subtalar arthrodesis site.

The next step is to obtain and place either autogenous or allograft bone. Alternatively, there are other commercially available sources of bone void fillers and substitutes. In otherwise healthy patients without contraindications, the author prefers an autogenous bone graft. This can be harvested from the ipsilateral proximal or distal tibia or from between the two tables of the ilium on the same side.

Bone grafting is indicated in cases of bony deficiency, to increase the rate of fusion, and to increase the surface area available for arthrodesis. Bone grafting is also indicated in cases of salvage arthrodesis, revision arthrodesis, and for structural support of the reconstructed hindfoot. The graft is used in a “moldable” type of technique to fill in these areas of deficient bone and optimize fusion rates. I would estimate that I use bone graft material in greater than 95 percent of the subtalar arthrodeses I perform.

The appropriate position of arthrodesis for the subtalar joint is approximately 3 to 5 degrees of valgus. There is some room for error beyond this range of position, but varus positioning should be avoided.

Attention is then turned to fixation once the bone graft is placed. As mentioned above, there are at least two alternatives for screw fixation at the subtalar arthrodesis site using the in situ
technique. A percutaneous inferior to superior calcaneotalar fixation technique can be achieved with cannulated screws (Figure 12). In this case, the entry point of the threaded guide wire from the cannulated screw set is on the heel posterior to its weight bearing subcalcaneal surface. The direction of the guide wire is both perpendicular to the posterior facet and centered in the talus in the parasagittal plane.

Alternatively, dorsal to plantar fixation can be done. I find this is easiest using this transverse lateral incision paralleling Langer's skin lines over the sinus tarsi. Using a metatarsal retractor, placed at the level of the talar neck and bringing the dorsal neurovascular structures out of harm's way, a guide wire can be placed through the extra-articular shoulder of the talus just distal to the ankle in a dorsal to plantar direction. This then crosses the arthrodesis site and bone graft into the posterior tuberosity of the os calcis (Figure 3).

After placing the pins, one can obtain an intraoperative radiograph of the foot in the lateral position. An AP of the ankle is usually sufficient for judging the pin's position in the parasagittal plane, although an axial view (which is a little harder to obtain intraoperatively) can be obtained. I have found that with experience and using a dorsal to plantar fixation technique I can palpate the posterior inferior aspect of the os calcis to make sure that my guide wire is completely intraosseous without obtaining an x-ray at this step. I, therefore, cut down on intraoperative time and x-ray exposure by obtaining only one set of films after the screw is placed over the wire. It is probably safest, however, to obtain two sets of films, one after placement of the wire and one after placement of the screw. Alternatively, this technique can be performed with continuous C-arm fluoroscopic control.

The screw head is countersunk and the measurement of length obtained. In cases of young, hard or post-traumatic or sclerotic bone, tapping is indicated. I then place the screw with my gloved finger over the arthrodesis site through the lateral wound. Once the screw head impacts the cortical surface of the talus, interfragmentary purchase and compression can be appreciated.

After obtaining the appropriate x-rays, which will demonstrate satisfactory position, alignment, and fixation, the guide wire can be removed and tourniquet deflated (Figure 3).

Meticulous closure is done after deflating the tourniquet and insuring hemostasis. Usually the great amount of bleeding cancellous bony surfaces afforded by this procedure, as well as the bone grafting, will necessitate placement of a closed suction drainage tube. Our dressing is a bulky compressive type dressing that does not include any circumferential plaster. Either a straight posterior plaster splint with the ankle at neutral to 5 degrees of dorsiflexion is applied, or U-shaped coaptation splints are used. The patient is admitted postoperatively for one or two nights. He is seen at the office two weeks after surgery, when the initial operative dressing and skin sutures or staples are removed. At this point the patient is placed in a nonweight bearing short leg cast. He returns to the office four weeks after that cast is placed for the application of a short leg walking cast. On average, solid union is obtained at 10 to 12 weeks, when casting may be discontinued.

Alternatively, at the 6 week postoperative mark, a compliant, trustworthy patient can be managed in a removable fracture orthosis. Most patients will remark at the first postoperative visit that preoperative discomfort is gone if satisfactory fixation has been achieved at surgery.
In reviewing our series of subtalar arthrodesis for all indications, union rates are well over 98 percent with the in situ technique. Hardware removal rate is less than 1 patient in every 20. Since switching from a calcaneotalar to a dorsal to plantar screw fixation technique, employing appropriate countersinking measures, I have not had an indication to remove any screws placed for subtalar arthrodesis.

In patients undergoing subtalar arthrodesis for flatfoot deformity or significant post-traumatic deformity of long-standing duration associated with some degree of talipes equinus, I will always at least consider performing at the same anesthetic as the subtalar reconstruction, a percutaneous tendo-Achilles lengthening to improve ankle mechanics postoperatively.

In the series of late complications of fractures of the calcaneus reported by Myerson and Quill, the most successful results were obtained in patients who had had a subtalar arthrodesis. With regard to the calcaneus fracture indication for subtalar arthrodesis, Reich noted "arthrodesis in the old cases gives a uniformly excellent result and materially shortens the period of disability". This author too has found that the best results in the late treatment of calcaneus fractures can be obtained in patients who had had a subtalar arthrodesis with either an in situ or posterior bone block distraction method.

Carr, et al described a bone block arthrodesis technique commonly employed by this author. They modified a procedure that had been described initially by Gallie in 1943. In the series reported by Myerson and Quill 12 of the 14 patients who had undergone bone block distraction type of subtalar arthrodesis after calcaneus fracture had a good result. Two of the poor outcomes in that series resulted from varus malunion of the arthrodesis site, which was later corrected satisfactorily with a closing wedge valgus osteotomy of the calcaneus. With the patient in the lateral decubitus position at surgery, correct alignment of the arthrodesis site can be difficult to judge. Just the same, in patients who have a loss of heel height, the posterior distraction bone block arthrodesis technique is preferable to an in situ subtalar arthrodesis because it restores the length of the gastrocnemius-soleus complex and the normal talocalcaneal and tibiotalar relationships. This technique also facilitates decompression of the peroneal tendons through the same incision.

**INDICATIONS FOR BONE BLOCK DISTRACTION SUBTALAR ARTHRODESIS**

The indications for this technique of fusing the subtalar joint are the same as those given above for "in situ" subtalar arthrodesis. Additionally, patients are candidates for the distraction technique if they have greatly diminished heel height. It would seem that talocalcaneal height, as measured on a standing lateral radiograph of the foot, which is shortened more than 8 millimeters compared to a similar radiograph of the uninvolved contralateral side, is most critical. These patients also may be considered for the bone block distraction technique if they have concomitant calcaneofibular abutment or peroneal tendon impingement. Manoli and co-authors presented at the 20th (I will have to check this) annual meeting of the American Orthopaedic Foot and Ankle Society in San Francisco in 1997 results of a large series of patients undergoing bone block distraction arthrodesis of the subtalar joint in whom the distraction alone was used to decompress the peroneal tendons and calcaneofibular recess. These authors felt that distraction alone could afford such improvement in the mechanics of
the hindfoot that lateral wall ostectomy in order to decompress the subfibular recess was not always necessary.

Dramatic improvement between preoperative and postoperative foot pain and function scores were noted by Myerson and Quill in patients undergoing bone block distraction subtalar arthrodesis after calcaneus fracture in which the preoperative deformity was remarkable. For fourteen such patients undergoing this distraction arthrodesis technique, there was an average improvement between preoperative and postoperative foot scores of 91 percent. Patients undergoing subtalar reconstruction by means of this distraction arthrodesis technique practically doubled their preoperative foot scores after the procedure. This percentage improvement is even more remarkable than that obtained in the group of 15 patients undergoing an in situ subtalar arthrodesis in that series no doubt because patients undergoing the more technically demanding distraction technique had more significant preoperative pain and deformity. In this very telling series of 14 patients undergoing bone block distraction subtalar arthrodesis, only 2 patients remained unemployed after salvage surgery.

**TECHNIQUE FOR SUBTALAR DISTRACTION BONE BLOCK ARTHRODESIS**

The patient undergoing subtalar bone block distraction arthrodesis is most commonly positioned in the lateral decubitus position with the affected side up. This procedure requires general or spinal anesthesia and a thigh tourniquet for hemostatic control. Care is taken to pad all bony prominences, and an axillary role is used in the down axilla. Usually the patient is securely fastened to the table using a bean bag and chest braces. The ipsilateral iliac crest is prepped, as is the involved lower extremity from the knee distally, and the latter is draped free in a sterile fashion (Figure 14).

After elevating and exsanguinating the limb by gravity, the tourniquet is inflated and the procedure done.

The technique of subtalar bone block distraction arthrodesis involves a straight lateral, longitudinally oriented incision. This incision is much easier to close than is a transverse or curvilinear incision once the hindfoot is distracted into the appropriate length. It is also much easier with this longitudinally oriented incision to avoid neurovascular and tendinous structures which may be prominent in this area of the lateral hindfoot and which may be tethered by any preexisting scar or soft tissue loss. The sural nerve is identified and protected. In cases of revision surgery with painful, sometimes iatrogenic sural neuromas, the nerve may need to be sacrificed at a normal more proximal level, transposing the stump of the more normal nerve into the belly of the peroneus brevis muscle. Usually the peroneal tendons are reflected anteriorly within their sheath out of harm’s way. In this fashion a very thick soft tissue lap is raised and can be retracted anteriorly and superiorly. Care is taken not to undermine either the anterior or posterior soft tissues. Usually no subcutaneous dissection between the dermis and Achilles tendon is either indicated or recommended (Figure 15).

The lateral wall is exposed completely, and subperiosteal dissection is done distally so that the lateral wall ostectomy may be completed with a chisel if indicated. One usually has to take a great deal more bone than might have been anticipated preoperatively in order to adequately decompress the calcaneofibular recess (Figure 16).
The retrocalcaneal recess is then débrided with a rongeur, and an attempt should be made to identify the location of the subtalar joint. Osteotomes, chisels and rongeurs are used to prepare the subtalar joint for arthrodesis. Occasionally it is helpful to insert a large bore (18 gauge) needle into the suspect subtalar remnant and localize this appropriately with an intraoperative lateral x-ray of the foot.

A lamina spreader is placed in the wound and used to distract the talocalcaneal joint remnant. The debridement is completed, and often it is necessary to take a lateral x-ray of the foot to determine the height of the bone block to be harvested from the pelvis (Figure 17).

A tricortical iliac bone graft is taken, and an attempt is made to contour this piece of bone to a trapezoidal shape. When this bone is placed in the talocalcaneal arthrodesis site, the trapezoidal shape helps avoid the tendency to distract the joint into varus position. Once a bone graft is inserted, the lamina spreader may be removed.

One must take great care to place the bone graft either centrally or in the medial side of the arthrodesis site so that we can avoid the tendency to tilt the joint into varus. The talocalcaneal arthrodesis site is usually fixed with a fully-threaded 6 millimeter cancellous screw or with a fully threaded 7 millimeter cannulated screw. Having the screws fully threaded helps the surgeon avoid too much interfragmentary compression. Often this and the addition of cancellous bone graft around the tricortical piece of bone graft helps maintain the distracted position between the talus and calcaneus. X-rays are obtained in the operating room (Figure 18).

As an alternative to shaping the bone graft and placing it on the medial side, a medially applied tibiocalcaneal distraction device such as the femoral distractor may be applied before inserting the bone graft.

Figure D demonstrates that the heel height for this gentleman who sustained a calcaneus fracture with significant subsequent subtalar osteoarthrosis was improved with the bone block distraction technique from 60 millimeters preoperatively to 73 millimeters postoperatively.

**OPEN REDUCTION AND PRIMARY SUBTALAR ARTHRODESIS OF CALCANEUS FRACTURES**

Occasionally a patient with a very comminuted, severely displaced joint depression type calcaneus fracture will present a significant therapeutic challenge to the orthopaedic surgeon. These very difficult cases raise some important issues that are the subject of debate in our orthopaedic literature. These injuries can be severely disabling if not treated operatively.

The surgical options are open reduction and either internal fixation or internal fixation coupled with primary subtalar arthrodesis. Both procedures have as a goal the restoration of height and width of the hindfoot. The standard operative approach and fixation techniques are very similar, regardless of whether an arthrodesis is to be performed.

By combining primary subtalar arthrodesis at the time of calcaneal fracture fixation, all of the
pathologic fracture components can be managed simultaneously. This one procedure addresses the changes in heel height, heel width, and abnormal talar declination angle. This one stage procedure also eliminates the risk of post-traumatic osteoarthrosis of the subtalar joint if the primary arthrodesis is successful.

Disadvantages inherent in primary arthrodesis at the time of open reduction and internal fixation of calcaneus fracture include the potential complications of any open procedure (anesthesia risks, infection, and hardware difficulties), as well as the following other potential disadvantages. These procedures are very extensive with a great deal of soft tissue dissection and are technically demanding. This technique does not afford the patient the benefit of rigid, compression type fixation at the arthrodesis site because of the comminution and bone grafting inherent in this injury. Large amounts of avascular bone and hardware are placed in an already compromised swollen foot, which may even be associated with a compartment syndrome. Often pelvic bone grafting, which may be required, can add further morbidity.

On balance, however, in my experience, patients with severely comminuted intra-articular calcaneus fractures would do very poorly without operative management. It is unrealistic to expect that badly comminuted and severely depressed fractures will do well with nonoperative care. It is often felt by this author that the worse the comminution and joint depression, the greater indications for operative intervention. Primary arthrodesis after calcaneus fracture reduction and fixation is indicated when there is disruption of the articular surfaces and marked comminution of the posterior facet. Although subsequent salvage arthrodesis is an acceptable alternative, it is often preferable to perform the arthrodesis primarily if the potential for failure of primary fixation alone is high.

On balance, therefore, it may be preferable to perform primary subtalar arthrodesis incorporating bone graft at the time of open reduction, internal fixation of certain severely comminuted depressed calcaneus fractures.

**TECHNIQUE: OPEN REDUCTION AND PRIMARY SUBTALAR ARTHRODESIS FOR COMMINUTED CALCANEUS FRACTURES**

This author prefers a lateral operative approach. I employ a standard L-shaped lateral incision as I would for open reduction and internal fixation of the vast majority of calcaneus fractures I encounter. Although bone grafting is rarely necessary in acute management of the common calcaneus fracture, in cases where I anticipate the need for primary subtalar arthrodesis, the iliac crest is routinely prepared and draped as well as the distal affected limb.

This procedure is not indicated in patients with significant swelling of the foot and ankle, open fracture, infected fracture blisters, and minimal degree of displacement of a two-part fracture as revealed on preoperative C.T. scan. This procedure should not be performed on patients with a dysvascular extremity or the very elderly or the very osteopenic patient. Pneumatic tourniquet control is used at the thigh level.

An anterior flap with a large L-shaped lateral hindfoot incision is elevated in a very thick fashion. The peroneal tendon, sural nerve, skin and subcutaneous are elevated as one, and the calcaneus fracture and subtalar joint remnant identified. The calcaneofibular ligament is identified and transected. Open reduction and internal fixation of the calcaneus fracture is
carried out as best possible in routine fashion, described well elsewhere. Almost always a lateral wall buttress plate is required. The transverse tarsal joints are reduced, and the medial segment of the calcaneus fracture is reduced under the talus.

The articular surface of the inferior aspect of the talus is denuded with fine flexible chisels, and a high-speed dental bur may also be employed. Chisels and bur may also be used to remove any remaining articular cartilage from the posterior facet on the calcaneal side of the subtalar arthrodesis site.

Cancellous bone graft is packed into the cavity anterior and inferior to the subtalar joint. Heel height is restored after calcaneus fracture repair, and a threaded guide wire or two are passed percutaneously from the posterior inferior nonweight bearing surface of the os calcis through the body of the os calcis across the subtalar arthrodesis site into the body and neck of the talus. This author prefers fully-threaded cancellous screws be inserted over the guide wires in cannulated screw fashion to hold the joint reduced. This repair preserves the height of the calcaneus and maintains reduction without severely compressing the compromised talocalcaneal surfaces. It is impossible to achieve interfragmentary compression in such comminuted bones. It is often easier to apply the lateral buttress plate after the cannulated calcaneotalar screws are placed. Alternatively, if reduction of the calcaneus fracture is carried out and fixed before placement of the calcaneotalar screws, the guide wires can usually be passed between the screws that were used for calcaneus fracture fixation.

The wound is closed over closed suction drainage tubes, and the patient placed in a plaster splint with the ankle in slight dorsiflexion. The tourniquet is deflated and hemostasis obtained prior to wound closure. The surgeon must be very careful that no tension has been applied upon the skin edges before skin closure. Intraoperative lateral radiographs confirm reduction at the fracture with fixation and restoration of a more normal hindfoot height and width.

**SUBTALAR RECONSTRUCTION BY METHODS OTHER THAN ARTHRODESIS**

Arthroereisis, the procedure employing interposition of silicone or other material between the talus and calcaneus, usually in the sinus tarsi, to correct hindfoot valgus and pes planus, is not appropriate for discussion in this chapter. This procedure is used to correct valgus of the hindfoot by reducing, but not eliminating motion. The reader is referred to the Current Topic Review article published by Peters and Sammarco in Foot and Ankle in August of 1989.

Perhaps the most commonly encountered subtalar abnormality requiring reconstruction by methods other than arthrodesis is that of talocalcaneal tarsal coalition. In the appropriately selected patient, resection of the talocalcaneal bar (be it bony, cartilaginous or fibrous) and interpositional arthroplasty may restore function and provide pain relief (Figure 5).

Talocalcaneal bar resection and interpositional arthroplasty is indicated classically in the patient less than 18 years of age. More recent experience reported by Ouzounian at the North American Foot and Ankle Association meeting in 1995 and my own clinical experience would indicate that I might consider this procedure in any patient less than about 35 to 40 years old if other prerequisites and indications are met.

These other prerequisites for successful bar resection and interpositional arthroplasty are as
follows. The patient should not have any superimposed arthritis of the hindfoot or transverse tarsal joints. These patients must have normal transverse tarsal joints and preferably a normal ankle as well. A relative indication for talocalcaneal bar resection as opposed to arthrodesis might be the patient who meets all the other prerequisites for this procedure, but does have some arthrosis of the ankle, a mild ball and socket ankle, or minor osteochondrosis dissecans of the ankle. In these cases, resection and preservation of the talocalcaneal joint would be preferred over arthrodesis in order to lessen the potential stress transfers to the abnormal ankle after subtalar arthrodesis.

A patient is a candidate for successful bar resection if the coalition involves less than approximately 25 percent of the width of the talocalcaneal joint as seen on a coronal preoperative C.T. scan of the hindfoot.

Even patients with occasional peroneal spasm due to this tarsal coalition may be considered satisfactory candidates for its resection if they are indeed active and if their symptoms are refractory to conservative care such as the use of semi-rigid orthotics, casting, and use of ankle supports. Also, to be considered a candidate for the bar resection procedure, the patient needs to understand that there is a potential need in the future for arthrodesis of his subtalar joint if this primary arthroplasty should fail. If the patient is willing to accept this risk, then he is a satisfactory candidate for talocalcaneal bar resection and interpositional arthroplasty.

Autogenous materials that are readily available in the operative field to interpose between the talus and calcaneus after bar resection include intrinsic extensor muscle and fascia, fat, periosteum or tendinous structures in descending order of preference.

TECHNIQUE FOR TALOCALCANEAL BAR RESECTION AND INTERPOSITIONAL ARTHROPLASTY:

ARTHROPLASTY: In cases of calcaneonavicular bar resection, the author positions the patient supine on the operating room table with a bump under the ipsilateral buttock in order to slightly internally rotate the involved extremity. For these cases, I prefer a sinus tarsi approach interposing fascia and muscle from the short intrinsic toe extensors. Since this is theoretically not a subtalar reconstruction, I will not concern the reader with more of that technique here. Rather we will concentrate on a medial approach for resection of the talocalcaneal medial bar.

The patient is positioned supine on the operating room table with a well-padded bump under the contralateral buttoc in order to slightly externally rotate the involved operative hindfoot. The tourniquet is employed, as is spinal or general anesthesia. This may be supplemented with bupivacaine block of the posterior tibial nerve proximal to the operative field in order to achieve some measure of perioperative analgesia/anesthesia. After standard prep and drape in the usual sterile, free fashion and under pneumatic tourniquet control, the author prefers a longitudinally oriented incision made just inferior to the readily identifiable course of the posterior tibial tendon. In most of these patients the bony prominence of the bar is readily palpated. The posterior tibial tendon can be retracted out of the way, and the neurovascular structures protected. Fascial as well as periosteal flaps may be raised and preserved for later insertional arthroplasty.

Retractors are placed, and the talocalcaneal bar completely exposed. A sharp, beveled bone
chisel or, alternatively, with great caution, a small micro-sagittal saw blade may be used to resect the bar parallel with the medial border of the talocalcaneal cortex. From this point on dissection with a curette and/or rongeur can be used to remove bony prominence and osteocartilaginous bar tissue between the medial aspect of the talus and calcaneus. One must be sure to maintain the greatest portion of sustentaculum tali in order to protect the flexor hallucis longus tendon. The dissection and osteocartilaginous bar removal ceases when the surgeon encounters more normal cartilage at the remaining talocalcaneal articulation.

The joint is irrigated and tourniquet deflated at this point and hemostasis obtained. I always, under direct vision, then manipulate the subtalar joint, ankle and hindfoot to ascertain improvement in motion after bar resection. Interpositional arthroplasty is completed at this point, sewing fascial or peritendinous flaps with absorbable suture material. The skin and dermis are closed, and the patient is placed for no more than 7 to 10 days in a bulky compressive dressing incorporating if the surgeon prefers a plaster splint.

Early range of motion is begun as postoperative pain and wound healing permit. The patient may weight bear to tolerance with crutches, and physical therapy for active and passive range of motion, stretching, exercise and ambulation are begun in the early postoperative period. Early results in the author's personal series would indicate good improvement in motion and function after talocalcaneal bar resection and interpositional arthroplasty.

REFERENCES

LEGENDS FOR FIGURES
Figure 1: Talocalcaneal and subtalar joint anatomy.
P = Posterior facet
M = Middle facet
A = Anterior facet
Figure 2 Preoperative and postoperative lateral foot radiographs of a 36-year-old nurse with subtalar osteoarthrosis who underwent successful subtalar arthrodesis.
Figure 3: Preoperative and postoperative lateral radiographs of a 52-year-old horse breeder with subtalar osteoarthrosis after calcaneus fracture who underwent successful in situ subtalar arthrodesis with autogenous bone graft and cannulated screw fixation.
Figure 4:
Figure 5: C.T. appearance of subtalar joint of a 15-year-old boy who had a prior surgical attempt at resecting a medial talocalcaneal tarsal coalition. This first surgical procedure provided satisfactory pain relief for only 2 years, and this boy and his family are considering the alternative of subtalar arthrodesis for more definitive pain relief.
Figure 6: The talar declination angle is formed by the intersection of perpendicular lines drawn from the axis of the talus and the plane of support; the angle should be approximately 25 degrees.
Figure 7: Intraoperative patient positioning for subtalar arthrodesis.
Figure 8: Anatomic landmarks and proper location of surgical incision.
Figure 9: Surgical exposure for in situ subtalar arthrodesis.
Figure 10: Deep surgical exposure. A distally based flap of extensor digitorum brevis muscle has been reflected, and the contents of the sinus tarsi have been excised. A lamina spreader helps with talocalcaneal distraction and subtalar joint exposure.

Figure 11: Thin wafers of articular cartilage and subchondral bone are removed from each side of the subtalar arthrodesis site.

Figure 12: Percutaneous guide wire and large cannulated screw placement for in situ subtalar arthrodesis employing the calcaneotalar (plantar to dorsal) technique. Cancellous and corticocancellous bone graft has been packed into the subtalar arthrodesis site.

Figure 13: Dorsal to plantar (talocalcaneal) guide wire and cannulated screw placement for in situ subtalar arthrodesis with bone graft. Note the proper entry site for guide wire and screw at the extra-articular "shoulder" of the talus.

Figure 14: Intraoperative patient positioning for bone block distraction subtalar arthrodesis.

Figure 15: Surgical exposure for the distraction subtalar arthrodesis employs a lateral, longitudinally-oriented incision.

Figure 16: Preoperative and postoperative hindfoot C.T. scans indicating the large lateral calcaneal wall ostectomy.

Figure 17: Lateral foot radiograph with lamina spreader in place for talocalcaneal distraction.