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### Subtalar joint kinematics and arthroscopy: insight in the subtalar joint range of motion and aspects of subtalar joint arthroscopy

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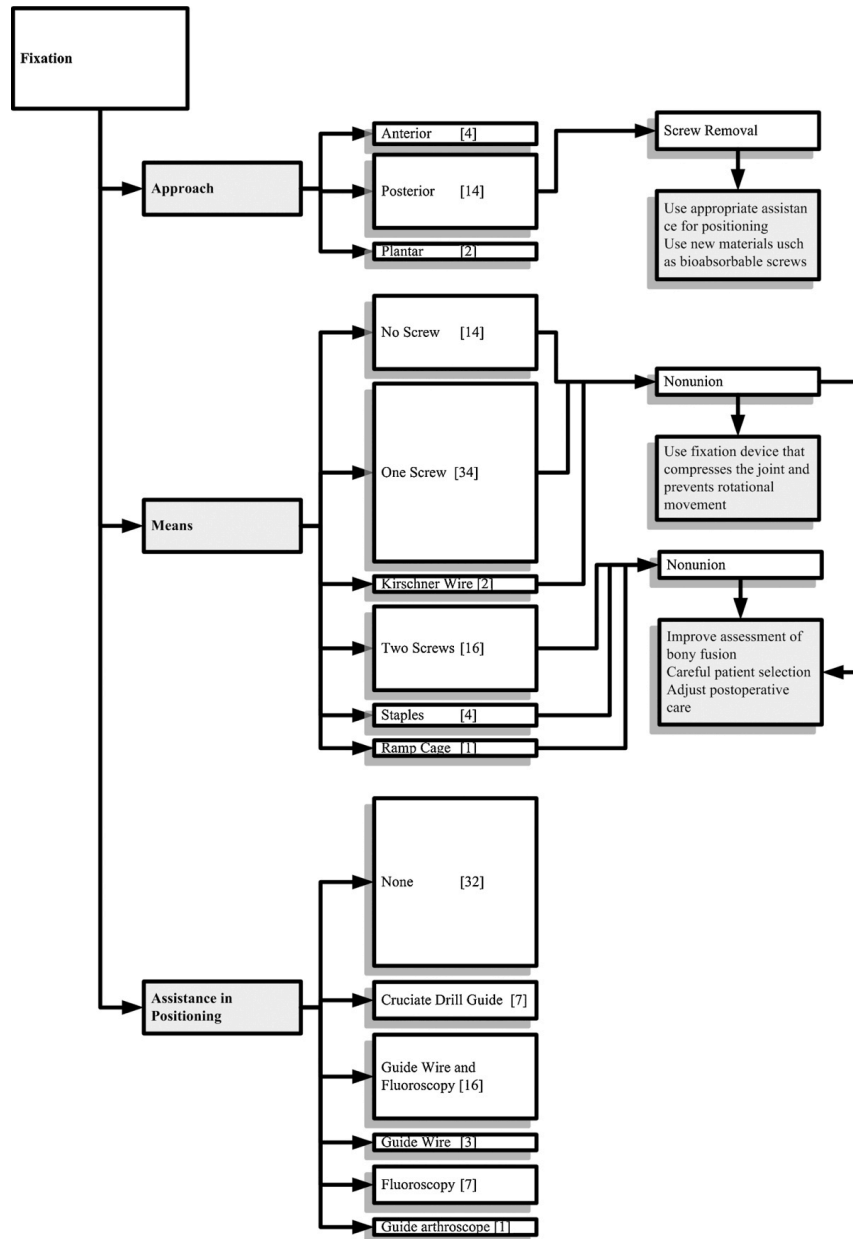
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**Figure 7** Fixation: options, pitfalls and possible solutions. The numbers between square brackets indicate the number of papers describing this approach explicitly.

## Arthroscopy of the posterior subtalar joint

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**ABSTRACT**

The subtalar joint is a functionally important joint of the lower extremity. Due to the complex anatomy of the subtalar joint, radiographic and arthroscopic evaluation of the subtalar joint can be difficult. The development of small diameter arthroscopes with excellent optical capacity along with the precise techniques has allowed subtalar joint arthroscopy to expand. An overview of the indications, contraindications and different approaches for subtalar joint arthroscopy is provided. Furthermore, the literature on arthroscopic treatment and results of sinus tarsi syndrome, os trigonum syndrome and subtalar joint arthrodesis is presented.

**INTRODUCTION**

The subtalar joint is a complex and functionally important joint of the lower extremity that plays a major role in the movement of inversion and eversion of the foot.<sup>1,2</sup> The complex anatomy of the subtalar joint makes arthroscopic and radiographic evaluation difficult. The development of arthroscopes with small diameters and excellent optical capacity along with precise techniques has allowed arthroscopy of the subtalar joint to expand. Anatomic portals and arthroscopic anatomy of the posterior subtalar joint in cadaveric specimens were first described by Parisien and Vangness in 1985.<sup>3</sup> One year later, Parisien published the first clinical report on subtalar arthroscopy, which evaluated three cases with good results.<sup>4</sup> Since then, a number of reports on posterior subtalar arthroscopy and its clinical applications have become available. Lateral and posterior anatomic approaches have been used for performing posterior subtalar joint arthroscopy. Arthroscopic subtalar management has been credited with clear advantages for the patient, including faster postoperative recovery period, decreased postoperative pain, and fewer complications.<sup>5</sup> Although posterior subtalar arthroscopy is still met with some skepticism, the technique has slowly evolved as an alternative to open subtalar surgery.

**INDICATIONS AND CONTRAINDICATIONS**

Subtalar arthroscopy may be applied as a diagnostic and therapeutic instrument. The diagnostic indications for subtalar arthroscopy include persistent pain, swelling, stiffness, locking, or catching of the subtalar area resistant to all conservative treatment.<sup>5,6</sup> In addition, subtalar joint arthroscopy can be used for visual assessment of the subtalar articular surfaces when persistent pain is present after a chronic ankle sprain or a fracture of the os calcis.<sup>7</sup> Therapeutic indications for subtalar joint arthroscopy include debridement of chondromalacia, subtalar impingement lesions, excision of osteophytes, lysis of adhesions with post-traumatic arthrofibrosis, synovectomy, and the removal of loose bodies. Other therapeutic indications are instability, debridement and drilling of osteochondritis dissecans, retrograde drilling of cystic lesions, removal of a symptomatic os trigonum, and calcaneal fracture assessment and reduction.<sup>8,9</sup> Arthroscopic arthrodesis of the subtalar joint was introduced in 1994.<sup>10</sup>

Absolute contraindications to subtalar arthroscopy include localized infection leading to a potential septic joint and advanced degenerative joint disease, particularly with deformity. Relative contraindications include severe edema, poor skin quality, and poor vascular status.

## EQUIPMENT AND SETUP

Two different anatomic approaches are used for arthroscopy of the posterior subtalar joint. The arthroscope generally used for lateral subtalar joint arthroscopy is a 2.7-mm 30° short arthroscope (Box 1). Others prefer to use the 10° or 25° arthroscope of the same diameter for subtalar arthroscopy.<sup>8</sup> In addition, a 70° arthroscope can be helpful to look around corners and to facilitate instrumentation. In subtalar joints that are too tight to allow a 2.7-mm arthroscope, a 1.9-mm 30° arthroscope is advised. A small joint shaver set with a 2.0- and 2.9-mm shaver blade and small abradar is also needed. For a two-portal posterior approach to the posterior subtalar joint, the instrumentation used is essentially the same as for knee joint arthroscopy (Box 2). With this technique, the subtalar joint capsule and the adjacent fatty tissue are partially resected. A sufficiently large working space adjacent to the joint is created, making it possible to use a 4.0-mm 30° arthroscope. The arthroscope is placed at the joint level and looks inside the joint without entering the joint space. The maximum size of the intra-articular instruments depends on the available joint space.

### Box 1.

#### Equipment for subtalar joint arthroscopy

1.9-mm, 2.7-mm 30° and 70° video arthroscopes, cannulae  
 2.0-mm, 2.9-mm full-radius blades, whisksers, and burrs  
 18-gauge spinal needle  
 K-wires  
 Drill  
 Ring curettes, pituitary  
 Small joint probes and graspers  
 Normal saline and gravity system  
 Noninvasive distractor

Distraction of the subtalar joint can be accomplished with noninvasive and invasive methods. The type of distraction chosen depends on the tightness of the joint and the location of disease. Noninvasive distraction during arthroscopy can be done manually by an assistant or by a noninvasive distraction strap around the hindfoot.<sup>11</sup> In most cases, joint distraction is obtained using normal saline and a gravity system. Regarding invasive joint distraction, using talocalcaneal distraction with pins inserted from laterally is a better choice than tibio-calcaneal

distraction, especially with a tight posterior subtalar joint.<sup>12</sup> The disadvantage of using an invasive distractor is the potential damage to soft tissues (ie, the lateral calcaneal branch of the sural nerve) and ligamentous structures, the risk of fracturing the talar neck or body, and infection.

### Box 2.

#### Equipment for subtalar joint arthroscopy using the two-portal approach

4.0-mm 30° video arthroscope, cannulae  
 4.5-mm, 5.5-mm full-radius blades, whisksers, and burrs  
 21-gauge needle  
 K-wires  
 Drill  
 Ring curettes, pituitary  
 Small joint probes and graspers  
 Normal saline and gravity system  
 Noninvasive distractor

## SUBTALAR JOINT ANATOMY

The subtalar joint can be divided, for arthroscopic purposes, into anterior (talocalcaneonavicular) and posterior (talocalcaneal) articulations (Fig. 1).<sup>13-15</sup> The anterior and posterior articulations are separated by the tarsal canal; the lateral opening of this canal is called the sinus tarsi (a soft area approximately 2 cm anterior to the tip of the lateral malleolus). Within the tarsal canal, the medial root of the inferior extensor retinaculum, the cervical and talocalcaneal interosseous ligaments, fatty tissue, and blood vessels are found. The lateral ligamentous support of the subtalar joint consists of superficial, intermediate, and deep layers (Fig. 1).<sup>6-16</sup> The superficial layer comprises the lateral talocalcaneal ligament, the posterior talocalcaneal ligament, the medial talocalcaneal ligament, the lateral root of the inferior extensor retinaculum, and the calcaneofibular ligament. The intermediate layer is formed by the intermediate root of the inferior extensor retinaculum and the cervical ligament. The deep layer comprises the medial root of the inferior extensor retinaculum and the interosseous ligament. The talocalcaneonavicular, or anterior subtalar joint, is composed of the talus, the posterior surface of the tarsal navicular, the anterior surface of the calcaneus, and the plantar calcaneonavicular, or spring ligament. The posterior talocalcaneal, or posterior

subtalar joint, is a synovium-lined articulation formed by the posterior convex calcaneal facet of the talus and the posterior concave talar facet of the calcaneus. The joint capsule is reinforced laterally by the lateral talocalcaneal ligament and the calcaneofibular ligament. This joint also has a posterior capsular pouch with small lateral, medial, and anterior recesses. Arthroscopic visualization of the subtalar joint is limited to its posterior facet. The anterior portion of the subtalar joint is generally thought to be inaccessible to arthroscopic examination because of the thick ligaments that fill the sinus tarsi.

## PORTAL PLACEMENT AND SAFETY

### Lateral approach

Access to the posterior subtalar joint can be achieved through a lateral approach and a posterior approach. Three portals are recommended for visualization and instrumentation of the subtalar joint using the lateral approach. The anatomic landmarks for lateral portal placement include the lateral malleolus, the sinus tarsi, and the Achilles tendon. The lateral malleolus is routinely palpable. The sinus tarsi is also usually palpable, although it can be filled with large amounts of adipose tissue.<sup>6</sup> Inversion and eversion of the foot may be helpful in palpating the sinus tarsi. The anterolateral portal is established approximately 1 cm distal to the fibular tip and 2 cm anterior to it (Fig. 2). Anatomic structures at risk with placement of the anterolateral portal include the dorsal intermediate cutaneous branch of the superficial peroneal nerve, the dorsal lateral cutaneous branch of the sural nerve, the peroneus tertius tendon, and a small branch of the lesser saphenous vein. The dorsal intermediate cutaneous branch of the superficial peroneal nerve is located an average of 17 mm anterior to the portal. The dorsolateral cutaneous branch of the sural nerve is located an average of 8 mm inferior to the portal.<sup>17</sup> The middle portal is described as being about 1 cm anterior to the tip of the fibula, directly over the sinus tarsi (Fig. 2). The middle portal places no structures at risk during the course of its placement. The posterolateral portal is approximately 0.5 cm proximal to or at the fibular tip and just lateral to the Achilles tendon (Fig. 2). Anatomic structures at risk with placement of the posterolateral portal for subtalar arthroscopy are the sural nerve, the small saphenous vein, and the peroneal tendons. In a study on portal safety, the posterior portal was located 4 mm posterior to the sural nerve in most cases.<sup>17</sup> Literature has also described accessory portals for posterior subtalar arthroscopy.<sup>6,18</sup> The accessory anterolateral and posterolateral portals are used as needed for viewing and instrumentation. The accessory anterolateral portal is usually slightly anterior and superior to the anterolateral portal. The

accessory posterolateral portal is made behind the peroneal tendons, lateral to the posterolateral portal.

### Posterior approach

Posterior subtalar arthroscopy can be performed using a posterolateral and posteromedial portal.<sup>19</sup> This two-portal endoscopic approach to the hindfoot with the patient in the prone position has been credited to offer better access to the medial and anterolateral aspects of the posterior subtalar joint.<sup>12,20</sup> The medial aspect of the posterior subtalar joint is tighter than on the lateral side, possibly increasing the risk of iatrogenic cartilage damage and necessitating the use of an invasive distractor.<sup>18</sup> The tibial nerve, the posterior tibial artery, and the medial calcaneal nerve can be at risk when the posteromedial portal is used.<sup>6,21</sup> Investigators studied the relative safety of the posterior portals for hindfoot endoscopy in anatomic specimens (Table 1).<sup>12,21-23</sup> Mekhail and colleagues measured an average distance between the point of entry of the posteromedial arthroscope and the posterior tibial neurovascular bundle of 1.0 cm (the closest distance was 8 mm).<sup>12</sup> Sitler and colleagues evaluated the safety of posterior ankle arthroscopy with the use of posterior portals with the limb in the prone position in 13 cadaveric specimens.<sup>22</sup> The average distance between the posteromedial cannula and the tibial nerve was 6.4 mm (range, 0–16.2 mm). In addition, the distance between the posterior tibial artery and the cannula averaged 9.6 mm (range, 2.4–20.1 mm) and the average distance between the cannula and the medial calcaneal nerve was 17.1 mm (range, 19–31 mm). The height of the posteromedial portal in relation to the tip of the lateral malleolus is an important determinant regarding the proximity of the relevant anatomic structures to the edge of the cannula. It is unfortunate that not all investigators specified this measure. Other factors that could explain the variety in outcome are the use of joint distraction and the size of the arthroscope. Compared with the conventional posterolateral portal, the posteromedial portal in hindfoot endoscopy is relatively safe and reproducible and can be used for the treatment of intra- and extra-articular hindfoot pathology. The main difference between the two techniques is that the 2.7-mm lateral approach for posterior subtalar arthroscopy is a true arthroscopy technique in which the arthroscope and the instruments are placed within the joint, whereas the two-portal posterior technique (using a posterolateral and posteromedial portal) starts as an extra-articular approach. With the two-portal posterior technique, a working space is first created adjacent to the posterior subtalar joint by removing the fatty tissue overlying the joint capsule and the posterior part of the ankle joint. The joint capsule is then partially removed to

be able to inspect the joint from outside-in, with the arthroscope positioned at the edge of the joint without entering the joint space. As mentioned earlier, the maximum size of the intra-articular instruments depends on the available joint space.

### SURGICAL TECHNIQUE

Subtalar joint arthroscopy is performed with the patient under general or regional anesthesia. A tourniquet is applied to the proximal thigh and is inflated only when required for visualization. Using the lateral approach, the patient is placed in the lateral decubitus position with the operative extremity draped free. Padding is placed between the lower extremities and under the contralateral extremity to protect the peroneal nerve. The contralateral extremity is bent to 90° at the knee. The best portal combination for access to the posterior joint includes placement of the arthroscope through the anterior portal and the instrumentation through the posterior portal. This portal combination allows direct visualization and access of practically the entire surface of the posterior facet, the posterior aspect of the ligaments, the lateral capsule and its small recess, the os trigonum, and the posterior pouch of the posterior joint with its synovial lining. Instrumentation through the anterior portal provides access to the lateral aspect of the posterior facet. The medial, anterior, and posterior aspects cannot be reached well through the anterior portal. In addition, significant risk of iatrogenic damage to underlying subchondral bone exists. Access to the anterior and lateral portions of the posterior facet and structures located in the extra-articular sinus tarsi can also be obtained by placing the arthroscope through the anterior portal and instrumentation through the middle portal. In addition, excellent visualization of the medial and posterior aspects of the posterior facet is possible, even though they cannot be reached by instrumentation through the middle portal. This portal combination is recommended for visualization and instrumentation of the sinus tarsi and anterior aspects of the posterior subtalar joint.

The anterior portal is first identified with an 18-gauge spinal needle, and the joint is inflated with a 20-mL syringe. The needle is removed and a small skin incision made. The subcutaneous tissue is gently spread using a straight mosquito clamp. Using the same path, an interchangeable cannula with a semiblunt trocar is placed, followed by a 2.7-mm 30° oblique arthroscope. The middle portal is now placed under direct visualization using an 18-gauge spinal needle and outside-in technique. When visualized, the needle is removed and replaced with an interchangeable cannula. The posterior portal can be placed at this time using the same outside-in technique. It is easy to become disoriented while arthroscoping the posterior

subtalar joint. The arthroscope may be placed inadvertently in the ankle joint or may penetrate the capsule of the ankle and enter the lateral ankle gutter. For this reason, fluoroscopic confirmation of the position of the arthroscope can be useful.<sup>24</sup>

The technique of the two-portal endoscopic approach to the hindfoot using the posterolateral and posteromedial portals adjacent to the Achilles tendon should be performed as described here (Fig. 3). The posterolateral portal is made at the level or slightly above the tip of the lateral malleolus, just lateral to the Achilles tendon. After making a vertical stab incision, the subcutaneous layer is gently split by a mosquito clamp. The mosquito clamp is directed anteriorly, pointing in the direction of the interdigital webspace between the first and second toe. When the tip of the clamp touches bone, it is exchanged for a 4.0-mm arthroscope shaft with blunt trocar pointing in the same direction. By palpating the bone in the sagittal plane, the level of the posterior subtalar joint can most often be distinguished by palpating the prominent posterior talar process. The posteromedial portal is made just medial to the Achilles tendon. In the horizontal plane, it is located at the same level as the posterolateral portal. After making the skin incision, a mosquito clamp is introduced and directed toward the arthroscope shaft. When the mosquito clamp touches the shaft of the arthroscope, the shaft is used as a guide to travel anteriorly in the direction of the posterior subtalar joint. All the way, the mosquito clamp must touch the arthroscope shaft until the mosquito clamp touches bone. The blunt trocar is exchanged for a 4.0-mm 30° arthroscope. The direction of view is to the lateral side to prevent damage to the lens system. The arthroscope is pulled slightly backward until the tip of the mosquito clamp comes into view. The clamp is used to spread the extra-articular soft tissue just in front of the tip of the arthroscope. The mosquito clamp can now be exchanged for a 4.5-mm full-radius resector to remove the subtalar joint capsule posterolaterally to visualize the joint (Fig. 3). The next step is to remove the posterior talocalcaneal ligament to visualize the posterior and posteromedial part of the subtalar joint. In most cases, it is not possible to introduce the 4.0-mm arthroscope into the posterior subtalar joint; however, the posterior subtalar joint can be adequately visualized from its margins without entering the joint with the 4.0-mm arthroscope. At this time, intra-articular joint pathology can be treated under direct view looking from outside-in using small-sized instruments. After completing the arthroscopic procedure, the portals are closed with sutures. When there is extravasation of fluid into the subcutaneous tissue, the portals are sometimes left open so that the irrigation solution can escape. A compression dressing is applied from the toes to the midcalf. This dressing is removed the following day; ice is applied, with the leg

elevated for 2 to 3 days. The patient is allowed to ambulate with the use of crutches, and weight bearing is permitted as tolerated. The sutures are removed approximately 1 week after the procedure, and the patient is encouraged to start range of motion exercises of the foot and ankle immediately after surgery. If indicated, the patient is referred to a physical therapist for rehabilitation under supervision. The patient should be able to return to full activities at 6 to 12 weeks postoperatively.

#### **Arthroscopic evaluation of the posterior subtalar joint**

When performing diagnostic subtalar arthroscopy, it is imperative to have a reproducible and systematic method of anatomic review to consistently examine the entire joint. A standard 13-point arthroscopic evaluation of the posterior subtalar joint has been advocated by Ferkel and Williams and Ferkel.<sup>6,25</sup> Diagnostic subtalar arthroscopy examination begins with the arthroscope viewing from the anterolateral portal (Fig. 4). From the anterolateral portal, the interosseous talocalcaneal ligament is readily visualized. Medially, the deep interosseous ligament (evaluation area 1) is observed and, as the arthroscope is slowly withdrawn, the superficial interosseous ligament (evaluation area 2) is seen. From the anterior portal, an assessment of the floor of the sinus tarsi may be made. When the arthroscopic lens is rotated more anteriorly, the anterior process of the calcaneus can be evaluated. As the arthroscopic lens is rotated laterally, the anterior aspect of the posterior talocalcaneal articulation (evaluation area 3) is observed. Next, the anterolateral corner (evaluation area 4) is examined, and reflections of the lateral talocalcaneal ligament (evaluation area 5) and the calcaneofibular ligament (evaluation area 6) are observed. The lateral talocalcaneal ligament is noted anterior to the calcaneofibular ligament. The arthroscopic lens may then be rotated medially, and the central articulation (evaluation area 7) is observed between the talus and the calcaneus. Finally, the posterolateral gutter (evaluation area 8) may be seen from the anterolateral portal. The arthroscope is then switched to the posterolateral portal and the inflow cannula is switched to the anterolateral portal. From this view, the interosseous ligament may be seen anteriorly in the joint (Fig. 4). As the arthroscopic lens is rotated laterally, the lateral talocalcaneal ligament (evaluation area 5) and calcaneofibular ligament (evaluation area 6) reflections may again be observed and their relationship noted. From this posterior view, the central talocalcaneal joint (evaluation area 7) may be examined and the posterolateral gutter (evaluation area 8) carefully assessed for synovitis and loose bodies. The posterolateral recess (evaluation area 9) and the posterior gutter (evaluation area 10) are then carefully evaluated in the normal bare area where the articulation ends and the posterior corner of the talus is

assessed. The posteromedial recess (evaluation area 11) is carefully observed, and the posteromedial corner (evaluation area 12) of the talocalcaneal joint and, finally, the most posterior aspect of the talocalcaneal joint is seen (evaluation area 13). By rotating the arthroscope upward while keeping it in area 13, the os trigonum can be visualized on the talus (if present).

#### **RESULTS**

Posterior subtalar arthroscopy has been shown to be beneficial over the past several years. Williams and Ferkel collected information on 50 patients who had hindfoot pain who underwent simultaneous ankle and subtalar arthroscopy.<sup>25</sup> Twenty-nine patients had subtalar pathology consisting of degenerative joint disease, subtalar dysfunction, chondromalacia, symptomatic os trigonum, arthrofibrosis, loose bodies, or osteochondritis of the talus that was treated arthroscopically. The anterolateral and posterolateral portals were used to visualize the posterior subtalar joint; distraction (invasive and noninvasive) was used in all cases. At an average follow-up of 32 months, these investigators reported good to excellent results in 86% of the patients. Overall, less favorable results were noted with associated ankle pathology, degenerative joint disease, age, and activity level of the patient. No operative complications were reported. Goldberger and Conti retrospectively reviewed 12 patients who underwent subtalar arthroscopy for symptomatic subtalar pathology with nonspecific radiographic findings.<sup>26</sup> The preoperative diagnoses were subtalar chondrosis in 9 patients and subtalar synovitis in 3 patients. The anterolateral and posterolateral portals were used to visualize the posterior subtalar joint. A femoral distractor was applied in patients when visualization was difficult. The follow-up averaged 17.5 months. The average preoperative American Orthopaedic Foot and Ankle Society (AOFAS) Hindfoot Score was 66 (range, 54–79); the average postoperative score was 71 (range, 51–85). In the 7 patients who improved after subtalar arthroscopy, the average improvement was 10 points on the AOFAS Hindfoot Score. Four patients' symptoms progressively worsened after surgery; all 4 were diagnosed as having grade 4 chondromalacia of the subtalar joint at the time of arthroscopy. Three of these patients progressed to subtalar arthrodesis at an average of 18 months following the arthroscopy. It is of interest that all patients stated that they would have the surgery again. In addition, 2 patients were very satisfied with the surgery, 6 patients were satisfied, and 4 patients were satisfied with reservations; none were dissatisfied. No operative complications occurred in this series. The investigators concluded that subtalar arthroscopy is the most accurate method of diagnosing subtalar articular cartilage damage but has limited therapeutic benefit in the

treatment of early degenerative joint disease. The preoperative imaging studies tended to be less accurate predictors of subtalar cartilage damage than arthroscopy.

### **Sinus tarsi syndrome**

Sinus tarsi syndrome was first described by O'Connor in 1958.<sup>27</sup> It has historically been defined as persistent pain in the tarsal sinus secondary to trauma (80% of the cases reported).<sup>28</sup> There are no specific objective findings in this condition. The exact etiology is not clearly defined, but scarring and degenerative changes to the soft-tissue structure of the sinus tarsi are thought to be the most common cause of pain in this region.<sup>6</sup> Walking on uneven terrain can result in pain and a feeling of instability. Clinical examination reveals pain on the lateral aspect of the hindfoot aggravated by firm pressure over the lateral opening of the sinus tarsi. Relief of symptoms with injection of local anesthetic directly into the sinus tarsi confirms the diagnosis. Surgical removal of the contents of the lateral half of the sinus tarsi improves or eradicates symptoms in roughly 90% of cases.<sup>29</sup> Kashuk and colleagues stated that the application of arthroscopic techniques for decompression of the sinus tarsi has proved useful, is technically easy, and allows for a rapid recovery.<sup>18</sup> Oloff and colleagues presented 29 patients who underwent subtalar joint arthroscopy for sinus tarsi syndrome by way of an anterolateral approach.<sup>28</sup> Subtalar joint synovectomy was the most common procedure performed; 12 patients had additional procedures. The mean postoperative AOFAS Hindfoot score was 85 (range, 59–100) and there were no complications. All 29 patients stated they were better after surgery and would undergo the procedure again without reservation. Earlier results and those of Oloff and colleagues suggest that arthroscopic synovectomy alone is associated with symptom resolution in patients who have sinus tarsi syndrome as opposed to the open methods that involve the removal of the entire lateral contents of the sinus tarsi.<sup>28</sup> According to Frey and colleagues, sinus tarsi syndrome is an inaccurate term that should be replaced with a specific diagnosis because it can include many other pathologies such as interosseous ligament tears, arthrofibrosis, synovitis, arthrofibrosis, and joint degeneration.<sup>30</sup>

### **Os trigonum syndrome**

The os trigonum is an unfused accessory bone found in close association with the posterolateral tubercle of the talus.<sup>31</sup> Impingement of the os trigonum, or os trigonum syndrome, is a common condition in ballet dancers and athletes and initiated by repetitive trauma. Symptomatology is caused by extreme plantar flexion, whereby the os trigonum is

compressed between the posterior border of the tibia and the superior surface of the calcaneus. Clinically, pain can be elicited on palpation at the level of the posterior ankle joint and deep to the peroneal tendons. After failing appropriate nonoperative treatment, surgical excision of the bony impediment is recommended. Marumoto and Ferkel performed a series of these arthroscopic procedures and reported favorable results in 11 patients after a mean follow-up period of 35 months.<sup>32</sup> Ferkel also reported successful use of the arthroscope in the management of symptomatic os trigonum.<sup>6</sup>

### **Arthroscopic subtalar arthrodesis**

Arthroscopic subtalar arthrodesis was intended to yield less morbidity, preserve the blood supply, and preserve proprioception and neurosensory input.<sup>33</sup> The decision to proceed with this surgical technique grew out of the success with arthroscopic ankle arthrodesis. The main indications for arthroscopic subtalar arthrodesis include persistent and intractable subtalar pain secondary to degenerative osteoarthritis, rheumatoid arthritis, and post-traumatic arthritis.<sup>11,34-36</sup> Other indications include neuropathic conditions, gross instability, paralytic conditions secondary to poliomyelitis, and posterior tibial tendon rupture.<sup>37</sup> Factors that play a role in determining when arthroscopic subtalar arthrodesis is appropriate include the severity of the deformity and the amount of bone loss.<sup>11</sup> As with open subtalar arthrodesis, patients must have failed conservative treatment to qualify for arthroscopic subtalar fusion. The contraindications to this specific procedure are previously failed subtalar fusions, gross malalignment requiring correction, and significant bone loss.<sup>37</sup>

In general, the procedure is performed as described here. The anterolateral and posterolateral portals are used in an alternating fashion during the procedure for viewing and for instrumentation. All debridement and decortication is performed posterior to the interosseous ligament. It is not as important to try to fuse the middle facet, although this can be done after resecting the contents of the sinus tarsi. The anterior facet of the subtalar joint is even more difficult to reach and is generally not fused. A primary synovectomy and debridement are necessary for visualization, as with other joints. Debridement and complete removal of the articular surface of the posterior facet of the subtalar joint down to subchondral bone is the next phase of the procedure. After the articular cartilage has been resected, approximately 1 to 2 mm of subchondral bone is removed to expose the highly vascular cancellous bone. Care must be taken not to remove excessive bone, which would lead to poor coaptation of the joint surfaces. After the subchondral plate is removed, small-spot-weld holes measuring approximately 2 mm in depth are created on the surfaces of the calcaneus and talus to create

vascular channels. Careful assessment of the posteromedial corner must be made because residual bone and cartilage can be left there that can interfere with coaptation. The joint is then thoroughly irrigated of bone fragments and debris. In general, no autogenous bone graft or bone substitute is needed for this procedure. A joint defect and the sinus tarsi can be filled with small cancellous bone chips through an arthroscopic portal if desired. The foot is then put in the appropriate positions (about 0°–5° of hindfoot valgus) and the joint is compressed together. The fixation of the fusion is performed with a large cannulated self-drilling and self-tapping 6.5- or 7-mm lag screw. The guide pin is inserted from the dorsal anteromedial talus and angled posterior and inferior to the posterolateral calcaneus. It is important to place the guidewire under fluoroscopy with the ankle in maximum dorsiflexion to avoid any possible screw head impingement on the anterior lip of the tibia. Full weight bearing is allowed as tolerated at any time following surgery. In general, patients can tolerate full weight bearing without crutch support within 7 to 14 days after surgery. Tasto advocated the use of a small lamina spreader through the anterolateral portal during the procedure to improve visualization and facilitate the maneuvering of surgical instruments.<sup>37</sup> This technique has been successfully performed in patients who have primary degenerative joint disease of the subtalar joint without gross deformity or bone loss (Table 2).

#### **Subtalar arthroscopy and treatment of calcaneal fractures**

The development of wound complications is a major concern in the open reduction and internal fixation of displaced intra-articular calcaneal fractures.<sup>38</sup> Percutaneous, arthroscopically assisted screw osteosynthesis was developed to minimize the surgical approach without risking inadequate reduction of the subtalar joint. The method was applied in selected cases of displaced intra-articular calcaneal fractures with one fracture line crossing the posterior calcaneal facet (Sanders type II fractures). Percutaneous leverage is performed with a Schanz screw introduced into the tuberosity fragment under direct arthroscopic and fluoroscopic control. The subtalar joint space is evaluated with respect to intra-articular displacement and position of the fragments by way of the posterolateral portal. When small chips or avulsion fragments are present, they can be removed through a second, anterolateral portal with a small grasper or shaver. After anatomic reduction is achieved, the fragments are fixed with three to six cancellous screws introduced by way of stab incisions. Gavlik and colleagues treated 15 patients with this method and achieved good to excellent results in 10 patients, with a minimum of 1 year of follow-up.<sup>39</sup>

#### **Complications**

The most likely complication to occur is an injury to any of the neurovascular structures in the proximity of the portals being used. Possible complications following subtalar joint arthroscopy include infection, instrument breakage, and damaging the articular cartilage. In addition, the use of invasive and noninvasive distraction devices can lead to various complications.<sup>40</sup> Because of the limited number of reports on posterior subtalar arthroscopy, no detailed information on the incidence of complications associated with this technique is available. In a series of 49 subtalar arthroscopic procedures using the lateral three-portal technique for treating various types of subtalar pathologic conditions, only five minor complications were reported.<sup>30</sup> There were three cases of neuritis involving branches of the superficial peroneal nerve. One patient had sinus tract formation and one had a superficial wound infection. Other studies report no complications with posterior subtalar arthroscopy; Ferkel evaluated 50 patients, with an average follow-up of 32 months (range, 16–51 months) and found no major complications following posterior subtalar arthroscopy. With arthroscopic arthrodesis of the subtalar joint, in two instances hardware problems were encountered requiring removal of the lag screw.<sup>34,37</sup> Jerosch reported algodystrophy in one patient who was treated with arthroscopically assisted subtalar arthrodesis.<sup>41</sup>

#### **SUMMARY**

Diagnostic and therapeutic indications for posterior subtalar arthroscopy have increased. Subtalar arthroscopy can be performed using the lateral or the posterior two-portal technique, depending on the type and location of subtalar pathology. Arthroscopic subtalar surgery is technically difficult and should be performed only by arthroscopists experienced in advanced techniques. Arthroscopy of the subtalar joint and sinus tarsi is a valuable tool in the investigation of hindfoot pathology when conservative treatment fails and subtalar fusion is not indicated. There is a need for prospective clinical studies to provide data on the results and complications of subtalar arthroscopy.

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## TABLES

**Table 1** Posteromedial portal safety for posterior subtalar and hindfoot arthroscopy determined with anatomic dissection studies

Reference	No. of specimens	Achilles tendon	Flexor hallucis longus tendon	Tibial nerve	Posterior tibial artery	Medial calcaneal nerve
Feiwel and Frey, 1993 [21]	18	—	—	7.5 (0–13)	12.6 (3–20)	2.5 (0–6)
Mekhail et al, 1995 [12]	6	—	—	a	a	a
Sitler et al, 2002 [22]	13	0.6 (0–5.5)	2.7 (0–11.2)	6.4 (0–16.2)	9.6 (2.4–20.1)	17.1 (19–31)
Lijoi et al, 2003 [23]	10	—	—	13.3 (11–17)	17.3 (15–21)	14.7 (8–20)

Values are average distances (and range) to relevant anatomic structures measured in millimeters. Abbreviation: —, not measured by authors.

a Tibial neurovascular bundle: 10 mm (at least 8 mm).

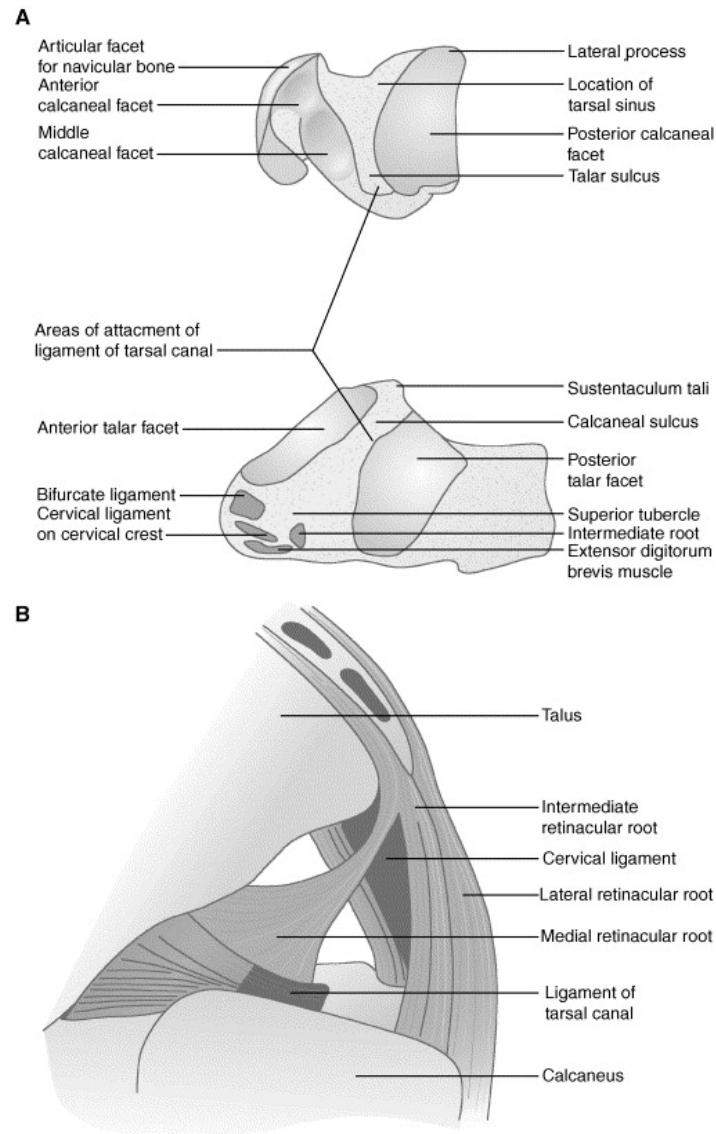
**Table 2** Overview of arthroscopic subtalar arthrodesis

Reference	No. of patients	Main indications	Follow-up	Technique	Results	Time until union	Complications
Jerrosch, 1998 [41]	3	OA	3–5 mo	Supine, cancellous bone autograft	Excellent	3–5 mo	Algodystrophy (1)
Scranton, 1999 [34]	5	OA or PTA	4 had >1 y	Supine, talocalcaneal distraction	Excellent	6 mo	Screw removal (1)
Tasto, 2003 [37]	25	OA (8), PTA (10)	22 mo (6–92)	Lateral, 2-portal	Excellent	8.9 wk (6–16)	Screw removal (1)
Asou et al, 2003 [36]	6	PTA and ankle sprains	10 wk	Lateral, 2 cannulated screws	Excellent	10 wk	None

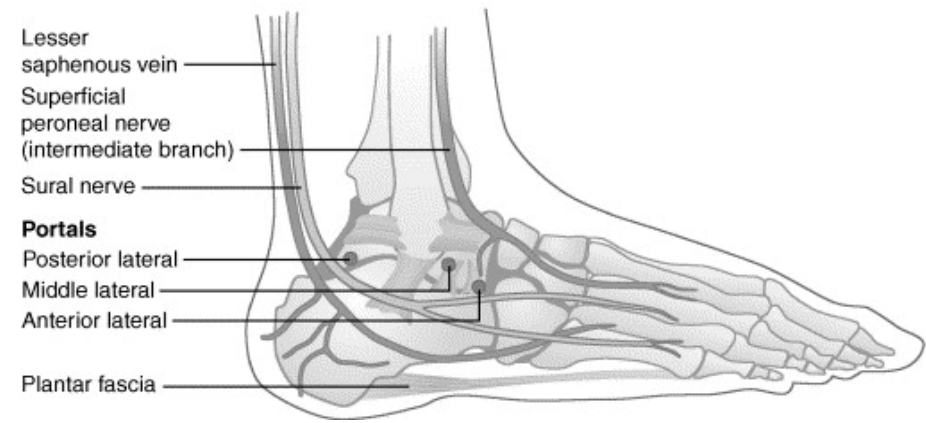
Postoperative regimens were different, possibly having an effect on the outcome. Abbreviations: OA, osteoarthritis; PTA, post-traumatic arthritis.

a Parameters required for a successful arthrodesis were generally defined as evidence of bone consolidation across the subtalar joint, no motion or radiolucency at the screw tract, the clinical absence of pain with weight bearing, and pain-free forced inversion and eversion.

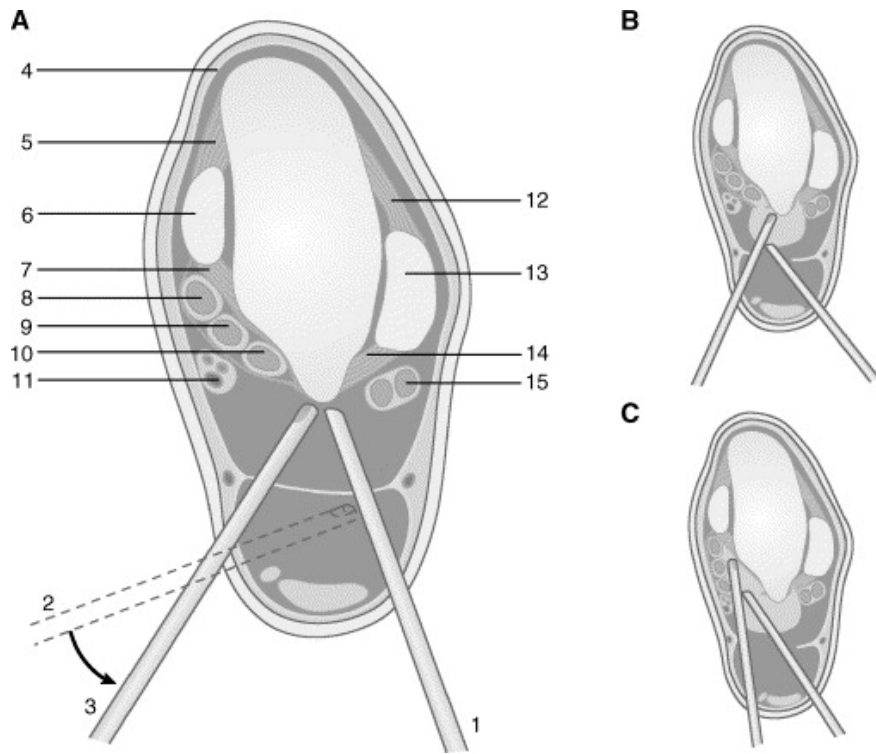
**FIGURES**



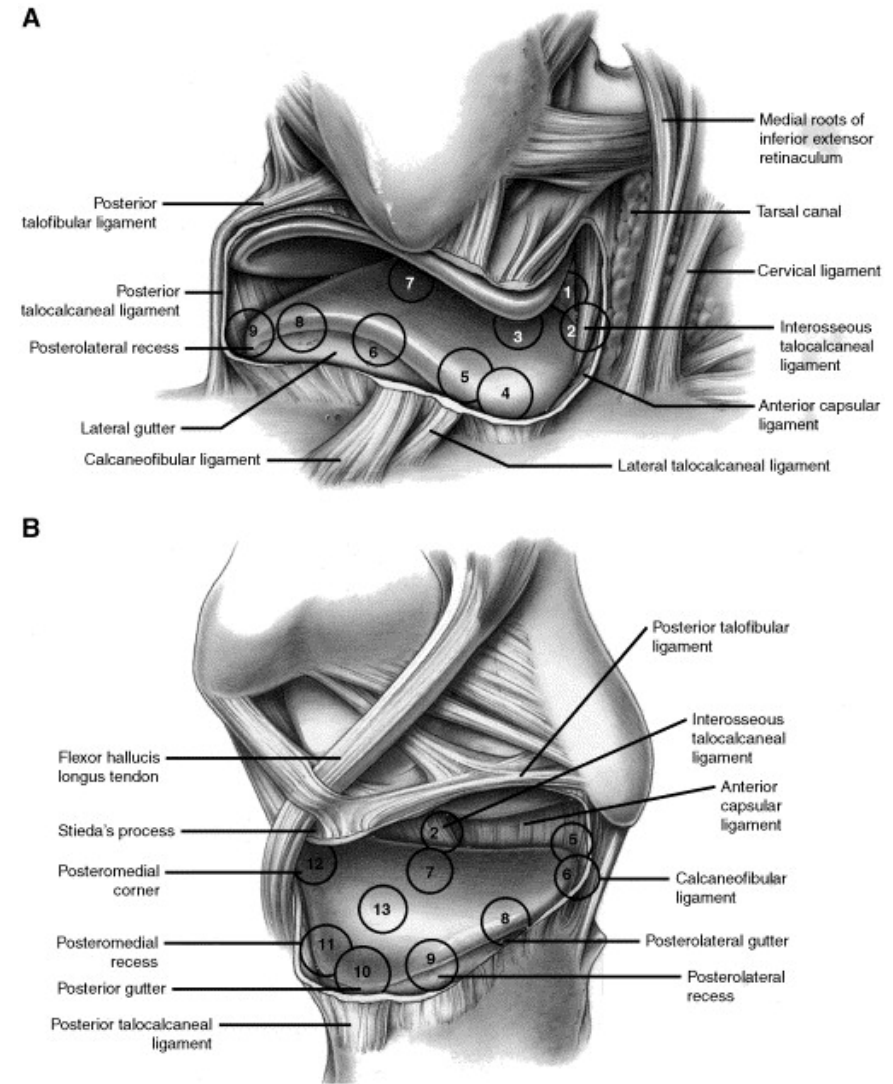
**Figure 1** (A) Anatomy of the subtalar joint. The talus is shown from under its surface and the calcaneus from above (superiorly). (B) Anatomy of the lateral subtalar joint with a view from posterior to anterior.



**Figure 2** Anatomy of the lateral portal sites with the structures at risk.



**Figure 3** (A) Cross-section of the ankle joint at the level of the arthroscope. 1, arthroscope placed through the posterolateral portal, pointing in the direction of the webspace between first and second toe; 2, full-radius resector introduced through the posteromedial portal until it touches the arthroscope shaft; 3, resector glides in an anterior direction until it touches bone; 4, crural fascia; 5, anterior superficial band of the deltoid ligament; 6, medial malleolus; 7, deep portion of the deltoid ligament; 8, posterior tibial tendon; 9, flexor digitorum tendon; 10, flexor hallucis longus tendon; 11, neurovascular bundle; 12, anterior talofibular ligament; 13, fibula; 14, posterior talofibular ligament; 15, peroneal tendons. (B) The arthroscope shaft is pulled backward until the shaver comes into view. The fatty tissue overlying the capsule of the talocrural joint and subtalar joint is removed. The flexor hallucis longus is used as a landmark; it is the medial border of the posterior working area. (C) The shaver and arthroscope are positioned in the area between the tarsal tunnel structures and the ankle joint. A posteromedial capsulectomy can be performed, and calcifications in this area or ossicles located posterior from the medial malleolus can be removed. The instruments can be brought into the posterior part of the ankle joint or subtalar joint when desired.



**Figure 4** (A) The 13-point arthroscopic evaluation of the posterior subtalar joint starts with a 6-point examination, viewed from the anterolateral portal. The posterior subtalar joint is examined starting at the most medial portion of the talocalcaneal joint, progressing laterally and then posteriorly. (B) Seven-point examination, viewed from the posterolateral portal. The posterior examination starts by visualizing along the lateral gutter, going posterolaterally, then posteriorly and medially, and ending centrally. (Adapted from Ferkel RD. Subtalar arthroscopy. Arthroscopic surgery: the foot and ankle. Philadelphia: Lippincott-Raven; 1996. With permission.)