Risks relating to posterior 2-portal arthroscopic subtalar arthrodesis and articular surfaces abrasion quality achievable with these approaches: A cadaver study

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Summary

Introduction: Many techniques for arthroscopic subtalar arthrodesis have been described since 1985. The procedure can be challenging because posterior and anterior portals are used conjoinedly with distraction. A posterior 2-portal approach was described in 2000.

Hypothesis: The goal of this study was to evaluate the quality of the freshening that can be achieved in the posterior subtalar joint using this approach. Does a posterior 2-portal approach allow for a complete freshening of the posterior subtalar joint?

Material and methods: Freshening was performed through an arthroscopic posterior 2-portal approach on 10 cadavers. The quality of bone freshening and proximity of the neurovascular structures to the posterior portals were subsequently evaluated by dissection.

Results: There was one partial laceration of the sural nerve. The posteromedial portal was 6.8 mm (95\% CI: 4.4 to 9.2) away from the posterior tibial vascular pedicle. The entire talar and calcaneal articular surfaces of the posterior subtalar joint were freshened. In eight of 10 cases (95\% CI: 48 to 95\%), the posteromedial process of the talus prevented contact between fragments.

Discussion: This study showed that the entire posterior subtalar joint can be freshened through an arthroscopic posterior 2-portal approach with little morbidity.

Level of evidence: Level IV.
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Introduction

A fusion rate of 84 to 100% has been reported when an open procedure is used for subtalar joint fusion [1,2], however the complication rate can reach 48% [1]. The use of arthroscopy has reduced hospitalization time, complications and nonunion rate [3–9], however the first techniques used were quite difficult to perform [3]. More recently, a posterior 2-portal approach was proposed for this procedure [10]. However the quality of the fusion must not be compromised by choosing to perform this simplified procedure with fewer portals. This led us to perform a cadaver study to evaluate iatrogenic risks and the quality of subchondral freshening. We wanted to be sure that this technically more simple procedure maintains the low surgical morbidity and optimal bone freshening that is required for successful joint fusion.

Material and methods

This study was performed on the two ankles from five cadavers (3 women, 2 men), thus 10 procedures. None of the ankles had any scars. The procedure was performed according to the technique described by Van Dijk et al. [10] by two surgeons who were not familiar with this technique.

The subject was placed prone with the foot hanging freely, so that the ankle and hindfoot could be manipulated. The arthroscope portal was placed lateral to the Achilles tendon, 0.5 cm above the lateral malleolus. A 4 mm trocar was aimed towards the first web and advanced until it contacted bone. The trocar was moved from proximal to distal in the sagittal plane to locate the posterior talar process. Once the arthroscope portal was in place, the posteromedial portal was set up in contact with the Achilles tendon but perpendicular to the first portal so as to not injure the posterior tibial vascular pedicle. A 3.5 or 4 mm shaver was used to create a workspace. The workspace was defined medially by the flexor hallucis longus tendon, as this protects the posterior tibial vascular pedicle. The subtalar joint was then progressively visualized under the posterior talar process. A notch was sometimes made in this process to allow good visualization of the posterior subtalar joint, but the process was not resected.

Joint freshening was performed with a curette and 0.5 mm wide bone scissors. This posterior to anterior freshening allowed the arthroscope and instruments to move into the subtalar space. Freshening was performed until the two surgeons observed through the arthroscope that the subchondral bone was completely and evenly exposed up to the talocalcaneal interosseous ligament in front. The portals were then reversed to verify and finish the freshening.

In the second step, a layer-by-layer dissection of each specimen was conducted to evaluate the spatial relationship and neurovascular injuries induced by each of the two portals. The foot was kept at a right angle and a trocar placed in each scope and instrument portal during the dissection for reference. The shortest distance between the outside edge of the trocar and the epineurium was measured. The posterior subtalar joint was then disarticulated using a posterior approach to evaluate the quality of the freshening on the calcaneal and talar surfaces of the joint. An anterior hinge maintained the relationship between the bones and allowed any areas that were not sufficiently freshened to be located. A photograph was taken of each articular surface, in the same plane as the freshened surface. This digital image was used to calculate the ratio of freshened to non-freshened surface, after these areas were delimiting using imaging software (Image J, Sun Microsystems, Inc. 901 San Antonio Road, Palo Alto, California 94303). Based on the data in these specimens, we established confidence intervals for the general population.

Results

One partial laceration of the sural nerve was observed, which represents 10% of the cases (Fig. 1). Because of the small number of cases, the 95% confidence interval resulted in a range of 0.01% to 42% for the risk of sural nerve injury, which is not statistically sound.

The average distance between the posteromedial portal and the posterior tibial neurovascular bundle was 6.8 mm (95% CI: 4.4 to 9.2). The closest structure was the posterior tibial nerve. There were no injuries to the flexor hallucis longus tendon (Fig. 2).

In all the specimens, the entire inferior articular surface of the talus and the superior articular surface of the calcaneus was freshened, from the talocalcaneal interosseous ligament of the tarsal sinus in the front to the medial and lateral edges of the cartilage (Figs. 3 and 4) (97.5% CI: 68 to 100%).
Bone contact after freshening was then evaluated. There was contact between the freshened surfaces in two of the 10 cases (Fig. 5). Conversely, in eight of 10 cases (95% CI: 48-95%), a gap still existed. This occurred because a protuberance of the posteromedial tubercle of the talus persisted in front and inside of the flexor hallucis longus tendon groove. This tubercle was not covered with cartilage. It was difficult to visualize intraoperatively because of the presence of the synovial membrane and flexor hallucis longus tendon. This impingement revealed itself after the bones were treated with sodium hydroxide to remove the soft tissues (Figs. 6–8).

**Discussion**

The use of posterior portals for the treatment of injuries to the posterior ankle has progressed slowly, even if it was first described over 20 years ago. In 1985, Parisien and Vangsness proposed that posterior and anterior portals be used together to explore the subtalar joint [11]. They published a cadaver study in 1987 describing in detail the positioning of the anterolateral and anteromedial portals, along with the posterolateral and posteromedial portals to avoid the neurovascular structures [12].

The adoption and use of these portals slowed down when studies describing the risk of the posteromedial portal were published [13,14]. Ferkel et al. [14] advised against use of the posteromedial portal. Feiwell and Frey [13] considered it to be risky because of the proximity of the posterior tibial nerve (7.5 mm). This value is similar to the value of 6.8 mm (95% CI: 4.4–9.2) found in our study. Lijoi et al. [15] measured a distance of 14.7 mm (range 8 to 20). Urgu-
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Figure 7 View of the talus from below, left foot.

Den et al. [16] measured 16.5 ± 5.6 mm and specified that the safest introduction method was to place the portals with the foot in a neutral position, as described by Van Dijk et al. [10]. This distance was measured based on MRI images. The optimal placement of the portals was said to be in contact with the triceps surae muscle, but the diameter of the arthroscope was not taken into account for the measurement. Initial placement of the posterolateral portal and methodical preparation of the work space were important to preventing injuries of the posterior tibial neurovascular structures, as suggested by Acevedo et al. and Sitler et al. [17,18].

Others have described approaches that should be safer for the posterior tibial vascular pedicle: through the Achilles tendon [19], from inside to outside posteromedial, in contact with the medial malleolus [16,17,20]. But these are not completely free of risks. The trans-Achilles tendon approach is not fully endorsed, as some believe it is too traumatic for the tendon [14,21]. A number of factors have led to safer use of the posteromedial portal: an increasing number of indications for arthroscopic evaluation and treatment of hindfoot injuries, precise anatomical description of the region, knowledge that the posterolateral portal should be placed first before the posteromedial portal is placed perpendicular to it and level with the Achilles tendon, and the definition of a safe zone located outside of the flexor hallucis longus tendon.

Figure 8 Left ankle, posteromedial view from the calcaneal tuberosity. Persistence of a posteromedial process which interferes in the contact between freshened subchondral surfaces in the subtalar joint.

The posterolateral portal is a potential source of iatrogenicity as demonstrated by the sural nerve injury. This risk has been highlighted by most of the studies on this subject [22,23], especially the one performed by Abramowitz et al. [22]. Urguden et al. [16] found that the sural nerve was located on average at 11.3 to 13.5 mm from the optimal posterolateral portal position, depending on the position of the foot. They showed that isolated fusion of the posterior part of the subtalar joint was sufficient to ensure ankylosis of all components of this joint [24].

Arthroscopic techniques for posterior subtalar joint fusion were initially developed while avoiding use of the posteromedial portal. Many authors combined anterior and posterior portals [11,25] with scopes of different sizes (2.7 and 3.5 mm) since this joint is difficult to explore, even with use of a distractor [25–27]. Phisitkul et al. [26] evaluated the percent of the subtalar surface that could be visualized when using multiple portals. They were able to visualize 43% ± 13% of the total surface area by using both the posteromedial and posterolateral portals. In a study with 15 cadaver specimens, Frey et al. [25] evaluated the amount of subtalar surface that could be freshened by combining anterolateral and posterolateral portals. They were able to freshen 90% of the articular surface with a 2.7 mm arthroscope without using a distractor. There was no access to medial aspect of the posterior subtalar joint, even when these portals were used in combination. In our study, the entire articular surface of the posterior subtalar joint was freshened with a 4 mm arthroscope and no distraction. However, in cases such as talocalcaneal coalition, access to the posterior subtalar joint could be difficult with a posterior 2-portal approach. Beimers et al. [16] suggest adding a third accessory port in the tarsal sinus to introduce a trocar and provide a degree of distraction.

The potential persistence of a protuberance in the posteromedial tubercle of the talus could interfere with the contact between fragments when compression is applied during fusion or protect against this interfragment contact in the posterior subtalar joint. In fact, if a compression of the posterior subtalar joint seems advantageous to the fusion, there would also be a risk of impingement under the lateral malleolus. This could also result in anterior subtalar joint diastasis and joint incongruency [28,29].

Conclusion

This study confirmed the feasibility of the posterior 2-portal approach, which results in an even freshening of the posterior subtalar articular surface. The cadaver study showed that a posteromedial bony protuberance remained in eight of 10 cases, even though the posterior subtalar articular surfaces had been completely freshened.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.
References
