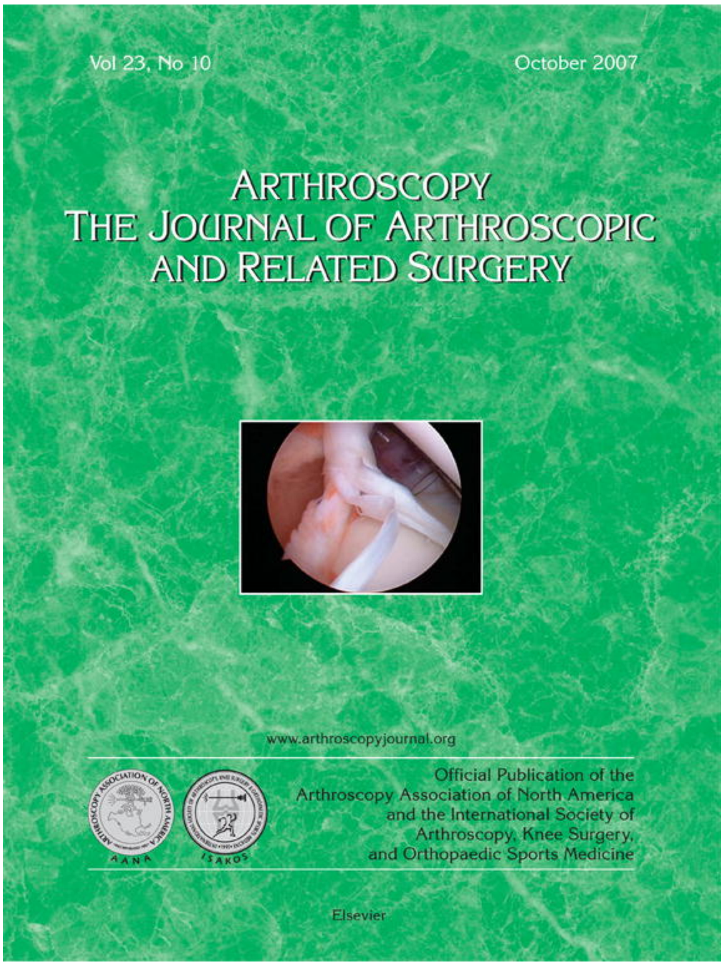
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Modified Posterior Portals for Hindfoot Arthroscopy

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Purpose: The purpose of this study was to determine the course and safe distances achieved with modified coaxial portals for hindfoot arthroscopy and report the clinical results. **Methods:** We used 30 embalmed cadaveric ankle specimens and 10 fresh-frozen ankle specimens for anatomic measurements and trial operations. The posteromedial portal via the posterior tibial tendon sheath was first established. The posterolateral portal was subsequently created immediately behind the posterior border of the lateral malleolus and anterior to the peroneal tendons via an inside-out technique. The coaxial portals were finally established with cannulas left in place. In the clinical series, posterior ankle arthroscopy was performed on 18 ankles in 15 patients. All patients were evaluated for any complications with a mean follow-up of 38 months. **Results:** The posterior tibial nerve, posterior tibial artery, and peroneal artery were located a mean distance of 8.7 mm, 10.1 mm, and 12.9 mm, respectively, from the near edge of the Kirschner wire as a reference to the coaxial portals. The sural nerve and lesser saphenous vein were at greater distances of 27.6 mm and 28.3 mm, respectively. The mean West Point score at the time of the latest follow-up was 91.5 points (range, 76 to 100 points), and there were 9 excellent results, 3 good results, and 1 fair result. No patients showed any complications related to the modified coaxial portals. **Conclusions:** The modified coaxial portals seemed to have large distances to the neurovascular structures in our anatomic study. Clinically, this technique was safe, effective, and reproducible. **Level of Evidence:** Level IV, therapeutic case series. **Key Words:** Ankle joint—Arthroscopy—Tendons—Surgery.

Arthroscopy of the ankle posterior compartment remains a technically demanding procedure because of the proximity of the posterior neurovascular structures and potential high risks of injury.[1] Access to the posterior compartment through the anterior portals via a distraction technique has been reported in the literature[2] but has not been widely accepted because of the technical complexity and potential risks to the articular cartilage. Conventional posterior portals have also been well described.[1] In addition to safety reasons, technical difficulties have been reported in addressing posteromedial lesions and in performing posterior ankle synovectomy.[3] Van Dijk et al.[4-6] have reported on a 2-portal endoscopic approach to the hindfoot. Although this procedure was considered to be simple, the main shortcoming was the requirement to remove the posterior capsule even if it was healthy. Acevedo et al.[3] developed coaxial portals for posterior ankle arthroscopy in 2000 (Fig 1). A posterolateral portal was first established immediately posterior to the peroneal tendon. While the obturator remained within the posterior ankle capsule, an inside-out technique was used to establish the posteromedial portal directly behind the medial malleolus adjacent to the posterior tibial tendon. The coaxial line connecting the 2 posterior portals coursed parallel to the axis of the posterior ankle compartment (Fig 1). The authors considered the coaxial portals as with higher safety and better

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The authors report no conflict of interest.

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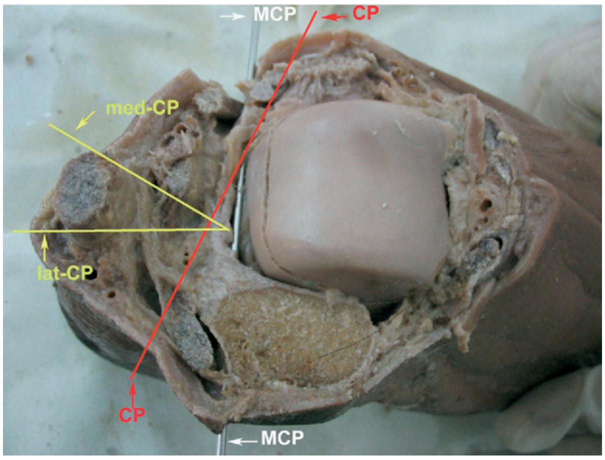

FIGURE 1. The 3 posterior ankle portals. The medial and lateral conventional portals (med-CP and lat-CP) pass adjacent to the Achilles tendon, the coaxial portals (CP) run laterally from behind the peroneal tendons directing anteriorly and medially to the posterior aspect of the medial malleolus, and the modified coaxial portals (MCP), which are marked by the Kirschner wire as a reference, run medially via the posterior tibial tendon sheath directing laterally to the posterior aspect of the lateral malleolus anterior to the peroneal tendons.

visualization of the posterior compartment when compared with the conventional posterior portals. We started to use the coaxial portals in 2001 and were encouraged by our early results, but we found that the posteromedial portal was not always established with success (especially in obese patients). Under the circumstances of unsatisfactory joint distension and posterolateral portal malplacement, it was even more difficult to follow the coaxial line to establish the posteromedial portal, and extreme caution was required not to place the obturator too anteriorly, which could injure the articular surface, or too posteriorly, which could damage the neurovascular bundle. Therefore the coaxial portals were modified by moving the coaxial line from a location posterior to the peroneal tendons to a location anterior to them (Fig 1). In addition, it was recommended that the posteromedial portal be established first.

Our hypothesis was that our modification would result in a simplified procedure with more consistency and reproducibility and, more importantly, would decrease the possibility of iatrogenic injuries. The purpose of this study was to determine the course and safe distances from neurovascular structures achieved with these modified coaxial posterior portals and to report both the results and complications of 15 consecutive patients starting in 2001.

METHODS

Anatomic Study

Thirty embalmed cadaveric ankle specimens were used for the anatomic portion of this study. The posteromedial portal was initially established, and a 2-mm Kirschner wire was inserted and proved to be in the posterior compartment. The Kirschner wire was then pushed laterally, aiming at the posterior border of the lateral malleolus by palpation, and finally emerged behind the lateral malleolus. With the Kirschner wire in place, the specimens were then sectioned in an axial plane just parallel to the Kirschner wire (Fig 1). A micrometer was used to measure the perpendicular distances from the edge of the Kirschner wire to the closest border of each structure to an accuracy of 0.1 mm. Measurements were made by 2 of the authors to assess and limit interobserver error. For each distance, the measurement was repeated 6 times, and 3 readings were obtained for each author.

Ten fresh-frozen below-knee specimens were used for a trial of the operation. The posteromedial and posterolateral portals were successfully established in all specimens. Arthroscopic synovectomy was performed in 5 specimens. After these procedures were completed, the ankle capsule was opened parallel to the joint line. The integrity of each structure surrounding the posterior compartment was observed and recorded.

Clinical Series

From 2001 to 2004, posterior ankle arthroscopy was performed on 18 ankles in 15 patients. Their ages ranged from 21 to 66 years (mean, 42.3 years) at the time of arthroscopy. Indications for arthroscopy were loose bodies in 3 patients, recalcitrant synovitis in 4, continued pain after extensive conservative treatment in 4, and prolonged osteoarthritis or traumatic arthritis in 4.

Arthroscopic findings, surgical intervention, and postoperative rehabilitation were documented. The patients were evaluated at 6 months, 1 year, and 2 years postoperatively and at the latest follow-up. All were examined directly by 1 author (J.G.) and were evaluated by means of the West Point ankle scoring system,[7] in which 90 to 100 points indicates an excellent result, 80 to 89 points indicates a good result, 70 to 79 points indicates a fair result, and less than 70 points indicates a poor result.

Surgical Technique

The patient is placed in the supine position with a thigh tourniquet applied at 350 mm Hg of pressure. Preoperative antibiotics were not prescribed. No traction was used in any case. Anterior compartment arthroscopy is performed through standard anteromedial and anterolateral portals. The posteromedial portal is then established by an incision measuring approximately 1 cm located about 8 mm proximal to the tip of the medial malleolus and immediately adjacent to the posterior border of the medial malleolus. The sheath of the posterior tibial tendon is opened, and the posterior tibial tendon is retracted posteriorly. At the bottom of the sheath lies the posterior capsule, which appears as a soft spot. This soft spot is always penetrated and spread with a mosquito clamp with ease, followed by a 4.5-mm cannula and blunt obturator. Intracapsular placement is subsequently ascertained by observation of fluid return as well as brief insertion of the 4-mm 30° arthroscope. Routine inspection of the posterior compartment is finished, and the posterior edge of the lateral malleolus is well identified arthroscopically (Fig 2A). An extra-long blunt-tipped obturator or Wissinger rod is then inserted through the cannula and directed toward the posterior edge of the lateral malleolus. The rod is used to palpate the posterior edge of the lateral malleolus and penetrate the capsule immediately behind the posterior border of the lateral malleolus and anterior to the peroneal tendons by palpation on the skin surface. After tenting of the skin on the lateral ankle, the skin over the rod is incised and a 4.5-mm cannula is passed in a retrograde manner over the obturator or Wissinger rod and into the posterior compartment. The coaxial portals are finally established with cannulas left in place (Fig 2B). The inflow occurs through the arthroscopic sheath, and the outflow is intermittently achieved through suction in the shaver. The arthroscope and shaver may then be exchanged accordingly.

Initially, we used a 2.7-mm 30° arthroscope and associated instruments with consideration of an iatrogenic injury because of the narrow space between the

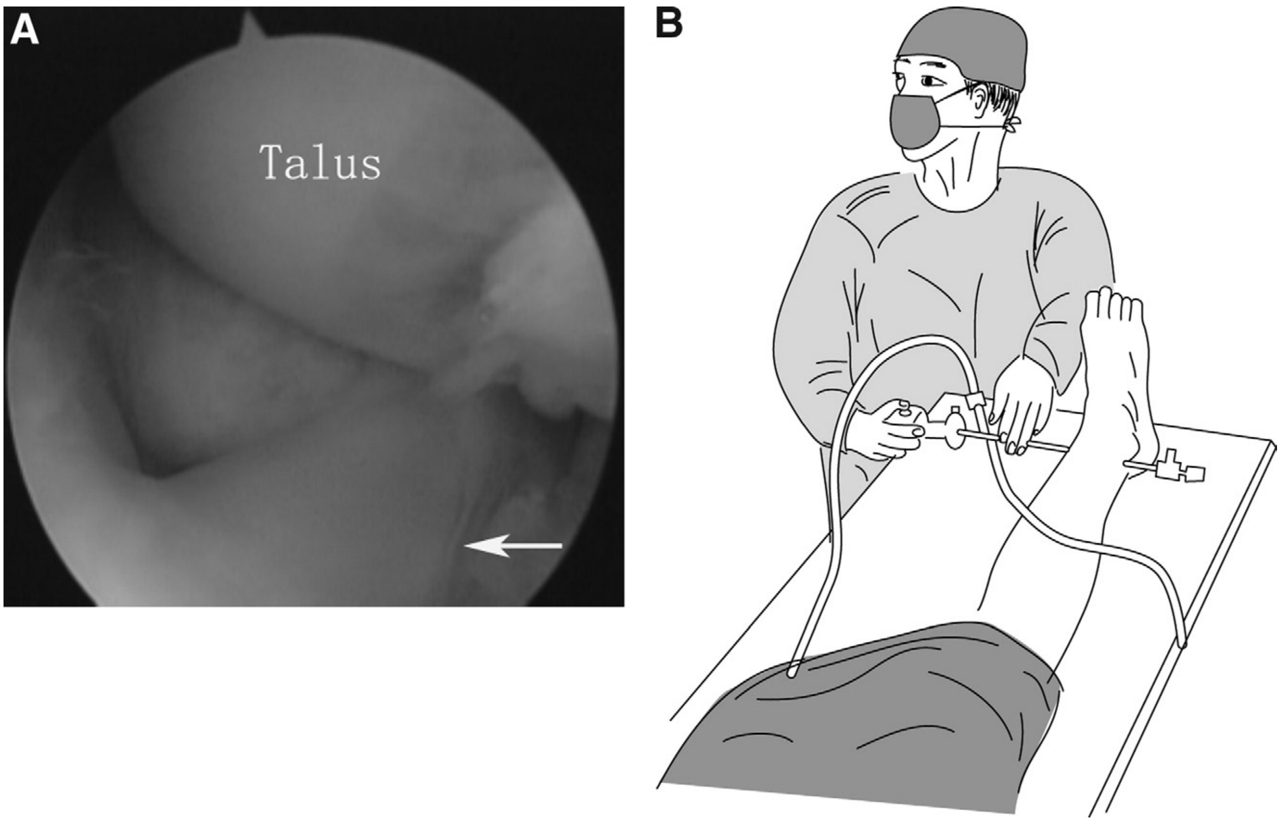

FIGURE 2. (A) The posterior edge of the lateral malleolus (arrow) is well identified arthroscopically. It should be noted that all arthroscopic views were of a right ankle oriented in the supine position with the patient's head toward the left. (B) Creation of modified coaxial portals, outside view.

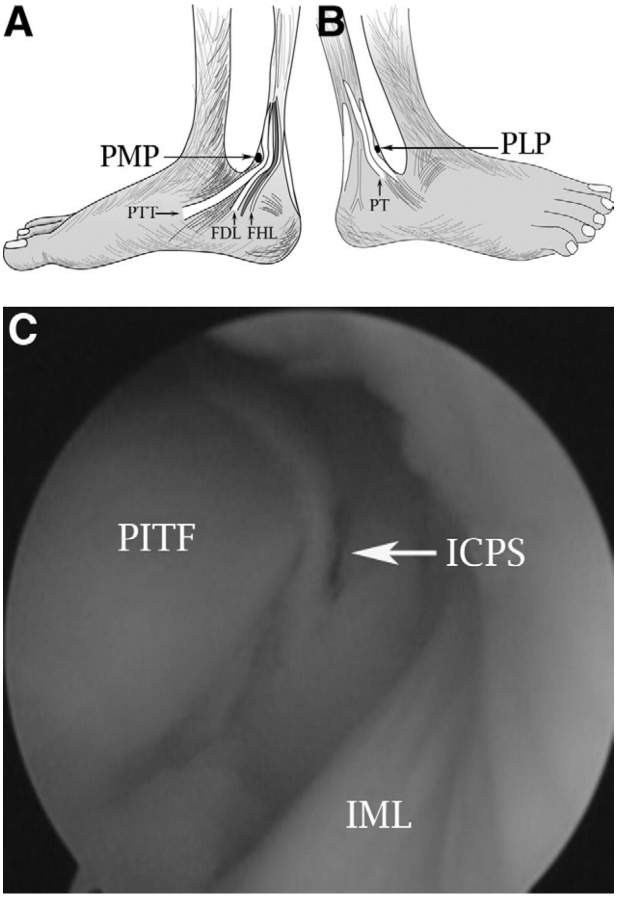

FIGURE 3. (A) Placement of posteromedial portal (PMP), outside view. (PTT, posterior tibial tendon; FDL, flexor digitorum longus tendon; FHL, flexor hallucis longus tendon.) (B) Exit point of posterolateral portal (PLP), outside view. (PT, peroneal tendons.) (C) The interior capsular penetration site (ICPS) was usually located between the PITF and IML.

lateral malleolus and the peroneal tendons, as well as the low volume of the posterior ankle compartment. However, with experience accumulation, we found that a 4-mm 30° arthroscope could also be used satisfactorily with free movement in the posterior compartment and less possibility of damaging the neurovascular structures. Therefore we now routinely use the 4-mm 30° arthroscope, and the 2.7-mm 30° arthroscope is reserved for difficult cases such as a stiff ankle.

RESULTS

Portal Placement

The skin landmark for the posteromedial portal was, on average, 8 mm (range, 5 to 12 mm) above the tip of the medial malleolus, which was equivalent to 2 mm (range, 0 to 3 mm) below the posterior joint line (Fig 3A). The skin landmark for the posterolateral portal was, on average, 14 mm (range, 9 to 24 mm) above the tip of the lateral malleolus, which was equivalent to 2 mm (range, 0 to 4 mm) above the posterior joint line (Fig 3B). The interior capsular penetration site for the posterolateral portal was usually located between the posteroinferior tibiofibular ligament (PITF) and the posterior intermalleolar ligament (IML) (Fig 3C).

Anatomic Study

The modified coaxial portals were successfully created in both embalmed and fresh-frozen specimens. In 3 of 30 embalmed specimens, we found mild contusion to the peroneal tendons, whereas there was no incidence of injury to the peroneal tendons in the fresh-frozen specimens.

The modified coaxial portals provided large distances to the structures surrounding the posterior compartment as a result of the posterior capsule separating the arthroscope and instruments from any neurovascular structures (Fig 1). The distances between the structures and the near edge of the Kirschner wire are summarized in Table 1. Because no significant interobserver difference was identified, the mean of 6 readings for each distance measurement was taken as the final result.

The structures that could be seen included the posterolateral gutter (Fig 4A), the posteromedial gutter (Fig 4B), one half to two thirds of the posterior talar dome surface, the tibial plafond, and the posterior capsule. The dynamic relation between the ankle mortise and the talus could also be examined while the ankle was undergoing passive dorsiflexion and plantar flexion. The PITF and IML were well identified arthroscopically with a gap between them. With plantar

TABLE 1. *Proximity of Posterior Ankle Structures*

Structure	Mean ± SD (mm)	Range (mm)
Flexor digitorum longus	4.2 ± 1.9	1.1-10.0
Posterior tibial nerve	8.7 ± 2.6	3.0-18.0
Posterior tibial artery/vein	10.1 ± 3.5	4.5-20.1
Flexor hallucis longus	5.3 ± 2.2	3.9-13.2
Peroneal artery/vein	12.9 ± 4.1	7.0-25.1
Peroneal tendons	1.9 ± 0.9	0.0-5.0
Lesser saphenous vein	28.3 ± 5.2	20.5-38.4
Sural nerve	27.6 ± 5.0	18.4-33.5

NOTE. Thirty specimens were studied.

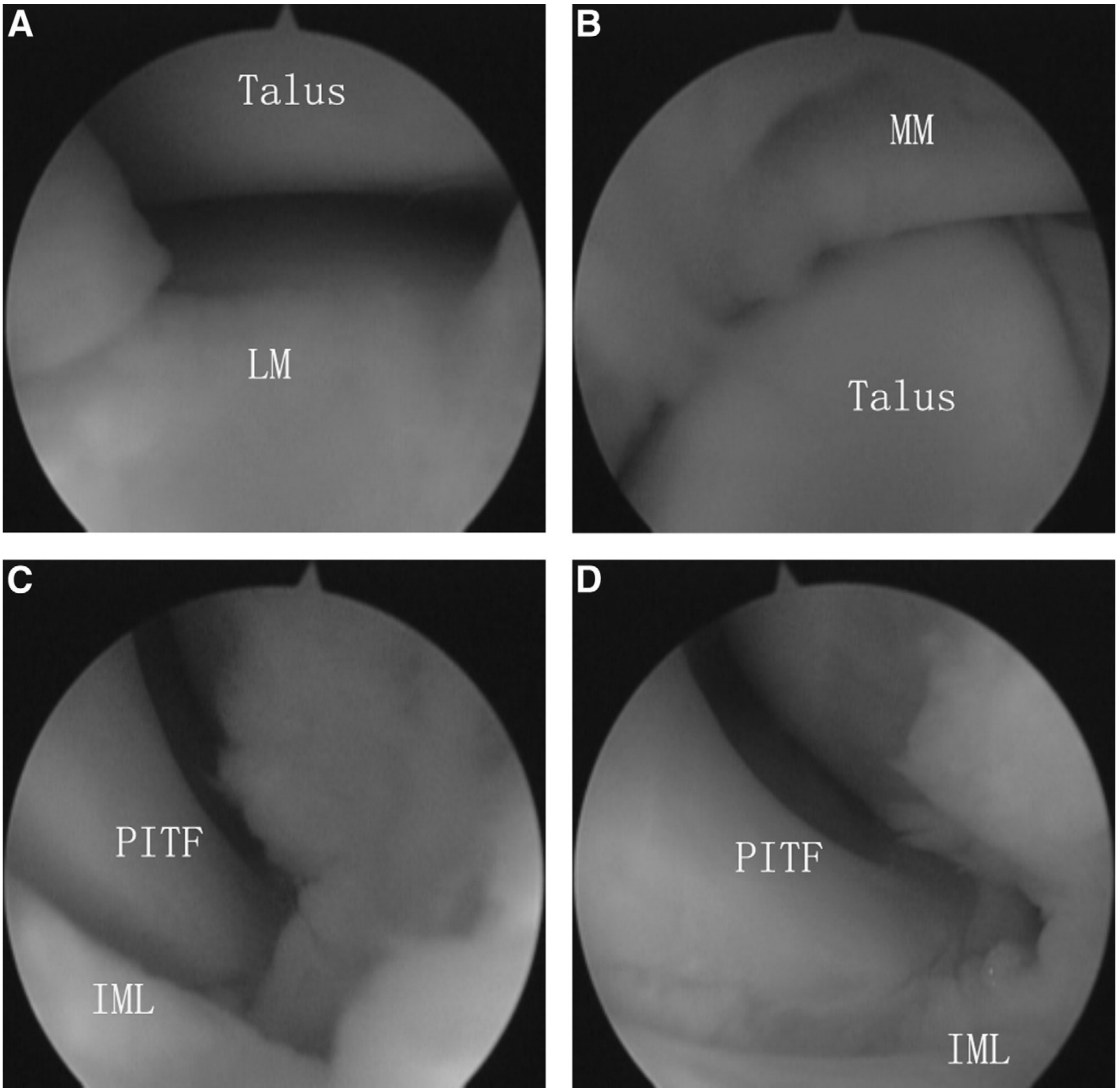

FIGURE 4. The posterior ankle structures that could be seen. (A) Posterolateral gutter. (LM, lateral malleolus.) (B) Posteromedial gutter. (MM, medial malleolus.) (C) The gap between the PITF and IML was reduced with ankle plantar flexion, and the IML became relaxed and blended with the PITF. (D) The gap was restored with ankle dorsiflexion, and the IML became taut and well separated from the PITF.

flexion, the gap was reduced, and the IML relaxed and blended with the PITF (Fig 4C). With dorsiflexion, the IML became taut and well separated from the PITF (Fig 4D).

Clinical Series

In the patient group the surgical time ranged from 45 to 70 minutes, with a mean of 51 minutes. The time needed to establish the coaxial portals in the initial 7 cases was, on average, 7 minutes (range, 4 to 10 minutes), whereas the time for the following cases was, on average, 5 minutes (range, 3 to 7 minutes).

Loose bodies were found in 8 ankles in 5 patients and were removed easily. The recalcitrant synovitis was finally diagnosed as rheumatoid arthritis in 2 patients and tuberculosis in 2 patients, and synovec-

TABLE 2. *Preoperative and Postoperative Evaluation Results*

	No. of Patients	Range of Motion (°)	West Point Score (Points)
Preoperative*	15	50.2 ± 6.6	63.1 ± 8.0
Follow-up			
1 yr*	15	56.5 ± 5.2	86.9 ± 5.4
2 yrs*	15	58.1 ± 4.8	88.0 ± 7.6
Latest†	13	59.4 ± 5.9	91.5 ± 8.2

*Eighteen ankles were included.
†Thirteen ankles were included.

tomy was performed. In 4 patients who had continued pain despite extensive conservative treatment preoperatively, arthroscopy yielded the diagnosis of a meniscus-like lesion at the anterolateral gutter in 1, anterior bony impingement in 2, and localized synovitis at the posterolateral gutter in 1. The lesions were resected by a shaver, and the osteophytes were also resected with a small chisel. Radiofrequency chondroplasty associated with arthroscopic debridement was performed in the other 4 patients. Posterior soft-tissue impingement as a result of a frayed PITF or IML was treated with careful debridement in 3 patients.

No patient was lost to follow-up. The range of motion of the ankles and the mean West Point scores of all patients at each evaluation are reported in Table 2. The mean West Point score at the time of the latest follow-up was 91.5 points (range, 76 to 100 points), and there were 9 excellent results, 3 good results, and 1 fair result. Five patients who had been diagnosed as having loose bodies and posterior soft-tissue impingement, loose bodies, early-stage tuberculosis, anterolateral soft-tissue impingement and loose bodies, and localized synovitis at the posterolateral gutter, respectively, had near-normal ankle range of motion before surgery. They reported no change postoperatively. The 10 other patients achieved improvements in hindfoot activity levels.

There were no complications related to the modified coaxial posterior portals. At a mean follow-up of 38 months (range, 24 to 50 months), no patient had any signs or symptoms of nerve dysfunction, tendinopathy, or infection.

DISCUSSION

The principal finding of this study was the establishment of the modified coaxial portals via the posterior tibial tendon sheath for hindfoot arthroscopy. Hindfoot arthroscopy is currently considered a challenging procedure.[1] Two methods have been described in the literature.[1,2] The first was a distraction technique,[2] in which both the arthroscope and instruments were inserted from the anterior portals and then went into the posterior compartment. It was sometimes difficult to access lesions in the posterior compartment through the anterior portals, which was why the second method was developed, with direct establishment of the posterior portals. Conventional posterolateral, posteromedial, and trans–Achilles tendon portals have been described in the literature.[1] The posterolateral portal passes between the Achilles tendon and the sural nerve. The posteromedial portal passes between the Achilles tendon and the posterior tibial neurovascular bundle. The conventional posterior portals approach the posterior compartment at an acute angle to each other. Therefore, if the distention of the ankle capsule is limited, the space available can make posterior compartment arthroscopy difficult. A variety of neurovascular injuries have also been reported.[1]

Van Dijk et al.[4-6] described a 2-portal endoscopic approach to the hindfoot. Posterolateral and posteromedial portals similar to the conventional portals were established for either the arthroscope or shaver. The arthroscope and shaver touched each other extra-articularly at the level of the ankle joint. The fatty tissue overlying the joint capsule as well as the capsule itself must be removed before the posterior compartment is entered. Although this approach has been popularized by many authors,[8-11] it also has the same risks of injuring the neurovascular structures as conventional portals. Clearly, the main disadvantages derive from over-vigorous resection of the posterior capsule, which might lead to potential ankle instability if the PITF or posterior talofibular ligament is inadvertently removed, and postoperative generalized scarring around the posterior compartment, which might restrict ankle dorsiflexion. Furthermore, it is also difficult to access the most posteromedial corner underneath the tibial neurovascular bundle or the most posterolateral corner underneath the peroneal tendons. This approach seems reasonably suitable for posterior extracapsular lesions rather than intra-articular lesions.[12,13]

The posterior coaxial portals were reported by Acevedo et al.[3] in 2000. The arthroscope and instruments approach the posterior compartment at an obtuse angle, which might provide a larger viewing field and facilitate arthroscopic manipulation, especially for addressing the posteromedial lesions adjacent to the neurovascular bundle, when compared with the 2 previously mentioned posterior portals. However, the most difficult area to access when using this technique was the posterolateral recess that was covered by the peroneal tendons.

We made some modifications to this technique by drifting the coaxial line anteriorly and establishing the posterolateral portal anterior to the peroneal tendons using the inside-out technique after establishment of the posteromedial portal. Our method coincides with the study of Sim et al.[14] As advocated by us and Sim et al., it is very easy to create the posteromedial portal. Because the sheath underlying the posterior tibial tendon blends so closely with the posterior capsule that it is generally difficult to distinguish between them, it appears very convenient to penetrate the sheath and directly enter the posterior compartment. The peroneal tendons run immediately adjacent to the posterior border of the lateral malleolus and have considerable movement until they enter the shallow groove at the distal posterior part of the lateral malleolus. Therefore it is appropriate to place the posterolateral portal at a proximal position slightly above the posterior ankle joint line because the peroneal tendons will move away from the obturator and thus have minimal risk to be injured when the obturator is pushed laterally and squeezed into the narrow space between the lateral malleolus and the peroneal tendons.

Concerning the narrow space between the lateral malleolus and the peroneal tendons, we initially decided to use the 2.7-mm arthroscope. Therefore the 2-mm Kirschner wire was chosen as a reference of measurement in our anatomic study. Nevertheless, at the later stage of our study, we accidentally found that the 4-mm arthroscope could also be easily passed through the narrow space. The safe distances obtained from the anatomic study might mimic that of the 2.7-mm arthroscope rather than the 4-mm arthroscope in the clinical setting. That was one of the two limitations of our anatomic study. The second limitation is that the safe distances might have been minimized because the ankle capsules were not distended.

Because different experimental methods were applied in the previous studies and ours and all of the anatomic studies were only approximations,[1,3,8,10] it was hard to compare the results from different authors. The anatomic data of Acevedo et al.[3] showed that the coaxial portals were essentially equidistant to the neurovascular structures compared with conventional portals. However, their results seemed to show smaller mean distances between the portals and the neurovascular structures in comparison to ours. The main reason behind this was that our coaxial line was advanced anteriorly.

Given the lack of adequate visualization with the previous approaches for ankle arthroscopy, the normal anatomy of the posterior ligament is still confusing. Our coaxial portals provide better visualization of the posterior compartment, allowing us to thoroughly explore the posterior ligament in either a static or dynamic manner. According to our data, we considered the IML as a constant structure and the PITF and IML as two distinctive structures. The results coincided with the report of Golano et al.[15] from Spain.

In the study of 10 cadaveric ankles by Acevedo et al.,[3] splitting of the posterior tibial tendon was reported in 1 ankle. Mild contusion of the peroneal tendons was found in 3 specimens in our cadaveric study. However, no occurrence of tendinopathy has been seen at a clinical follow-up of more than 3 years. The reason for this may be that the peroneal tendons became more rigid after the processing of formalin and thus had less capacity to stand aside when the obturator came in contact with them.

There was no incidence of penetration or contact of any of the posterior neurovascular structures, either medially or laterally, in either our anatomic or clinical study. No patients showed any signs of neurovascular dysfunction, and there were no cases of infection or bleeding. The clinical results reflected the safety of the modified coaxial portal technique.

As indicated by Acevedo et al.,[3] coaxial portals are preferable to conventional portals for extensive access to the posterior compartment. Compared with the portals advocated by Acevedo et al., our modified portals are much more parallel to the posterior joint line and thus provide more extensive access to the posterior compartment lesions, especially located at the far medial or lateral corner covered by neurovascular bundles and tendons.

Our modification not only retains the advantages of coaxial portals but also simplifies the procedure with a short learning curve.[16] Our inside-out technique to create the posterolateral portal facilitates reproducibility. The Wissinger rod or obturator courses along the axis of the posterior compartment, which reduces straying of the rod or obturator away from behind the lateral malleolus and toward the neurovascular bundle.

CONCLUSIONS

The modified coaxial portals seemed to have large distances to the neurovascular structures surrounding the posterior ankle compartment in our anatomic study, thus yielding greater safety. Clinically, these portals not only facilitate maneuverability and reproducibility but also provide extensive access to the posterior compartment lesions, especially located at the far medial or lateral corner covered by neurovascular bundles and tendons.

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