Knee Surg Sports Traumatol Arthrosc (2016) 24:2119–2123
DOI 10.1007/s00167-014-3475-6

ANKLE

Safety of posterior ankle arthroscopy portals in different ankle positions: a cadaveric study

Halil İbrahim Balcı · Gökhan Polat · Göksel Dikmen · Atacan Atalar · Mehmet Kapıcıoğlu · Mehmet Aşık

Received: 20 June 2014 / Accepted: 4 December 2014 / Published online: 13 December 2014

Abstract

Purpose To investigate anatomic relation of standard and coaxial ankle arthroscopy portals with neurovascular structures during different degrees of ankle motion.

Methods Twenty posterior ankles of ten fresh cadavers were assessed. Posteromedial, posterolateral and coaxial (transmalleolar) portals were created using 4-mm Steinmann pins in accordance with the defined technique in neutral position. The ankles were then dissected, and the distance from the portals to the peroneal tendons, short saphenous vein and sural nerve was measured laterally and that from the tibial nerve, flexor hallucis longus tendon and posterior tibial artery was measured medially. Changes in the distance between these structures were noted in neutral positions, 15° of dorsiflexion and 30° plantar flexion.

Results In the neutral position, the mean distance of the conventional posterolateral portal to the sural nerve was 6 mm (SD 2.9, range 2.7–14.5). The mean distance of the posterolateral coaxial portal to the peroneal tendon was 1.6 mm (SD 0.55, range 1.1–2.9). The mean distance of the posteromedial portal to the FHL was 2.11 mm (SD 1.1, range 0–4.7). The mean distance of the posteromedial coaxial portal to the posterior tibial artery was 6 mm (SD 1.4, range 3.9–9.5). Although not statistically significant, the distance between the portal and neurovascular structures increased in dorsiflexion for the portals placed posteriorly to the neurovascular structures and increased in plantar flexion for the portals placed anterior to the neurovascular structures.

Conclusions In comparison with the portals made in the neutral position, the distance between neurovascular structures and portals changes with portal placement in plantar flexion and dorsiflexion. In clinical practice, therefore, it might be safer to place the posteromedial–posterolateral portals in dorsiflexion and posterolateral–posteromedial coaxial portals in plantar flexion. The tibial nerve is closer to the posteromedial coaxial in dorsiflexion and could be in danger if making this portal with the foot in this position.

Keywords Posterior ankle arthroscopy · Cadaveric study · Safety of portals · Portal complications

H. İ. Balcı · G. Polat (✉) · A. Atalar · M. Aşık
Department of Orthopaedics and Traumatology, Istanbul Medical Faculty, Istanbul University, Millet Caddesi Çapa, Fatih, 34690 Istanbul, Turkey
e-mail: gokhanpolat7@gmail.com

G. Dikmen
Department of Orthopedics and Traumatology, Acıbadem Maslak Hospital, 34398 Istanbul, Turkey

M. Kapıcıoğlu
Department of Orthopaedics and Traumatology, Mardin Kızıltepe State Hospital, Mardin, Turkey

Introduction

Posterior ankle arthroscopy is being used increasingly in the treatment of intra- and extra-articular pathologies [15]. The safety of portals is still debated due to the close relationship with neurovascular structures [22]. Recent studies show that posterior ankle arthroscopic portals are more prone to complications than other ankle arthroscopic portals, and the proximity of the neurovascular structures should be evaluated further [3, 6, 18, 25]. Authors have generally discouraged the use of the posteromedial portal due to the proximity and thus high risk of injury to the tibial and the medial calcaneal nerve [8–10, 16, 17, 24].

Until Van Dijk et al., the safety, efficacy and anatomic relationships associated with the placement of posterior

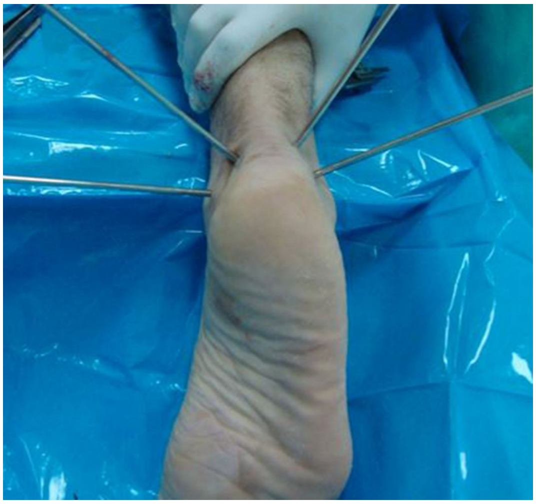

Fig. 1 Posterior ankle arthroscopy portals simulated by four 4-mm Steinmann pins of pre-dissection view of cadaver number 3

portals have been investigated in only a few anatomic studies [10, 17, 24].

Van Dijk et al. [23] described posterior ankle arthroscopy using a portal proximal to the tip of the fibula at the level of the ankle joint in the medial and lateral sides of the Achilles tendon. Lijoi et al. [15] demonstrated that the distance between the neurovascular structures and standard posterior portals increases in the distal part of the ankle joint. In particular, portals located 1 cm proximal to the tip of the fibula are safer than portals 2 cm proximal to the tip of the fibula [15, 21] (Fig. 1).

Acevedo et al. [1] suggested the use of coaxial portals, also known as transmalleolar portals, in posterior ankle arthroscopy, especially for difficult cases such as synovitis and haemophilic arthropathy. Posterolateral coaxial portals are opened in the posterior of the peroneal tendons, while posteromedial portals are opened from the inside out between the posterior tibial tendon and the medial malleolus. Coaxial portals, unlike those described by Van Dijk et al. [23], are located on the anterior side of the neurovascular structures, not on the posterior.

Previous studies have indirectly used MRI to measure the relationships between conventional portals and neurovascular structures. The use of a neutral ankle position and the lowering of the level of the portal towards the tip of the fibula were suggested for the safety of the neurovascular structures [21]. However, we performed a cadaveric study with different ankle motions to determine the safest ankle position for portal placement in clinical practice with a direct measurement of distances between the portals and anatomic structures, which has not been studied before.

The aim of this study was to determine the changes in distances between neurovascular structures and portals related to the ankle position with the cadaver in a prone position.

Materials and methods

Twenty ankles of ten fresh human cadavers (six male, four female) were included in this study. The ethical committee of İstanbul Medical Faculty and Institute of Forensic Medicine approved the study. Selection criteria included the lack of trauma, previous injuries and surgeries to the ankle area, and a duration of <36 h between death and examination. The mean age of samples was 22.3 years (range 18–55).

Cadavers were placed in the prone position with the ankle positioned off the side of the table to allow for full ankle motion and to mimic the real posterior ankle arthroscopy setting. After the sterile draping was applied and the portal and the Achilles tendon were drawn, the joint was

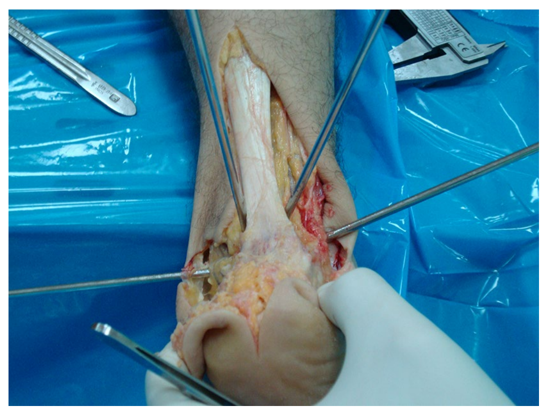

Fig. 2 Dissection of the Achilles tendon with longitudinal and transverse incisions (cadaver no. 3)

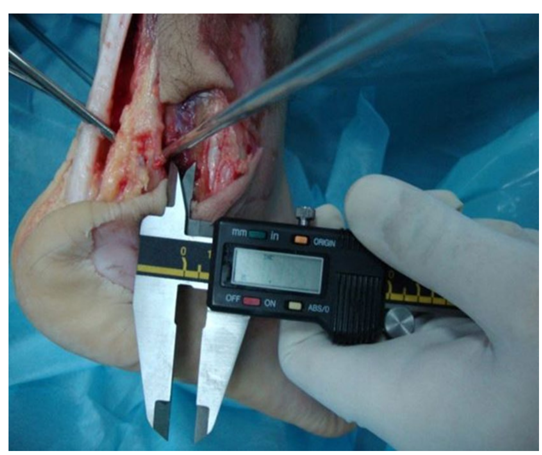

Fig. 3 Dissection measurement of anatomic structures at neutral position using a caliper (cadaver no. 5)

entered from the posterolateral portal in a neutral position using a number 18 spinal needle and injected with 20 ml of saline solution to dilate and achieve working space in the posterior ankle. Following the skin incision, posterolateral portals were constructed using four 4-mm Steinmann pins. Steinmann pins were tapped through the soft tissue for portal placement. In the neutral position, the posteromedial portal and posterolateral portal were opened according to the Van Dijk et al. technique.

The posterolateral coaxial portal was opened 1 cm proximal to the lateral malleolus on the posterior aspect of the peroneal tendons. Although in the original technique [1] the posteromedial coaxial portal is opened from the inside out, we opened from the outside in and retracted the posterior tibial tendon posteriorly. The location of the four Steinmann pins was determined, and dissection was performed using a longitudinal incision on the Achilles tendon and extended on both the medial and lateral sides (Figs. 2, 3). Achillotomy was performed due to the onset of rigour mortis. Measurements were repeated by the same person using a caliper with a sensitivity set to 1/10 of a millimetre in three different ankle joint positions measured with goniometer, including 15° of dorsiflexion, neutral and 30° of plantar flexion (Fig. 4). The distance between the Steinmann pins and the peroneal tendons, sural nerve and vena saphena parva (VSP) on the lateral side and the flexor hallucis longus (FHL), posterior tibial artery, posterior tibial tendon and the tibial nerve on the medial side was documented. Variations in anatomic structures were also noted. Institutional review board (IRB) approval was received from The Institution of Forensic Medicine and the İstanbul University of Medicine ethics committee.

Statistical analysis

Our sample size was composed of 20 ankles of ten fresh cadavers that were examined in the institution of forensic medicine. Statistical analysis was performed using SPSS 16.0 (SPSS Inc., Chicago, IL, USA) software. One-way ANOVA was used to determine statistical significance. p values of <0.05 were considered significant.

Results

At the neutral position, the mean distance of the posterolateral portal to the sural nerve was 6 mm (SD 2.9, range 2.7–14.5) and that from the posterolateral coaxial portal to the sural nerve was 6.2 mm (SD 2.6, range 1–9.8). The mean distance of the posteromedial portal to the FHL was 2.1 mm (SD 1.1, range 0–4.7), to the tibial nerve, 6 mm (SD 1.7, range 1–8.62) and to the posterior tibial artery, 9.5 mm (SD 3.0, range 5.2–13.7). The mean distance of the posteromedial coaxial portal to the posterior tibial artery was 6 mm (SD 1.4, range 3.9–9.5), and the distance to the FHL tendon was 3 mm (SD 1, range 2.1–4.3).

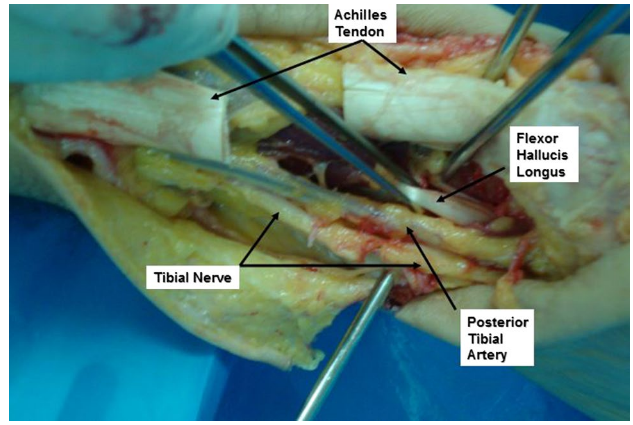

Fig. 4 Tibial nerve anterior to the posterior tibial artery (cadaver no. 3)

During ankle dorsiflexion, the distance between the anatomic structures and the posterior portal increased, but the distance between the posterior coaxial portal and the anatomic structures decreased. During ankle plantar flexion, the distance between the anatomic structures and the standard portal decreased, and the distance between the coaxial portal and the anatomic structures increased. However, none of these changes were statistically significant (p = n.s.).

In the posterolateral portal, changes in distances during plantar flexion and dorsiflexion for the sural nerve were 0.6 and 0.7 mm for the VSP and 1.1 mm for the peroneal tendon. In the posteromedial portal, these changes for the FHL were 0.5 and 0.7 mm for the tibial nerve and 0.7 mm for the posterior tibial artery. In the posteromedial coaxial portal, changes in distances during plantar flexion and dorsiflexion for the posterior tibial artery were 0.8 and 0.9 mm for the tibial nerve and 0.8 mm for the FHL. In the posterolateral coaxial portal, changes during plantar flexion and dorsiflexion for the sural nerve were 1.0 mm, for the VSP, 0.9 mm and for the peroneal tendon, 0.5 mm. Changes in distance between the tibial nerve and the posteromedial coaxial portal during dorsiflexion and plantar flexion were significant ($p = 0.03$). Although not statistically significant, the distance between the posterior ankle arthroscopy portals and the anatomic structures was greater than in the posterior coaxial portals (p = n.s.).

We observed two important anatomic variations (Fig. 5) n cadaver number 3, and the tibial nerve was anterior to the posterior tibial artery. On cadaver number 7, the sural nerve was anterolateral to the VSP, and there was no evidence of decussation between the sural nerve and the VSP at the musculocutaneous junction level of the Achilles tendon.

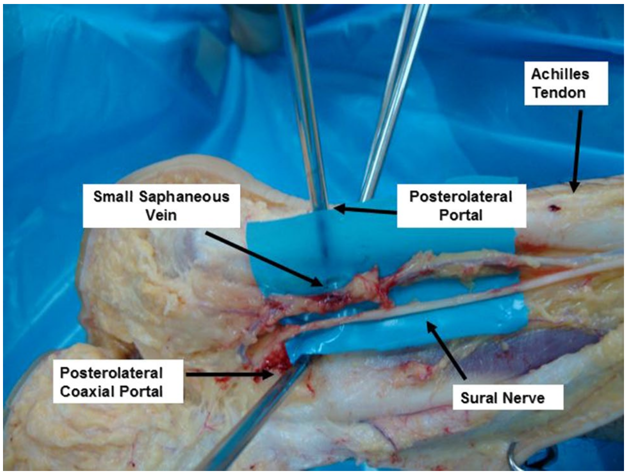

Fig. 5 Sural nerve placed anteriorly according to short saphenous vein (cadaver no. 7)

Discussion

We evaluated the safety of posterior ankle portals in different ankle motions in this study. The most important finding of this study was the recommendation of the ankle dorsiflexion for the conventional posterolateral–posteromedial portals and plantar flexion for the posteromedial–posterolateral coaxial portals.

Complication rates of 0.7–17 % in posterior ankle arthroscopy have been reported in many studies. Neurovascular injuries account for half of all complications [2, 4, 5, 11–14, 16, 18]. Ferkel et al. published a complication rate of 9.8 % in their study of 518 patients [19]. The rate of complications can be minimized through knowledge of the relationships between portals and anatomic structures.

Because of problems in visualization and safety, many different portals have been described for both the medial and lateral sides. These portals can be divided into two groups according to anterior or posterior placement of the neurovascular structures. In our study, we chose posterior standard portals [23] placed on the posterior as well as posterior coaxial portals [1] placed anterior to the neurovascular structures in both the medial and lateral parts of the ankle. During sagittal motion of the ankle, dorsiflexion of the ankle joint brings the neurovascular structures anteriorly, and plantar flexion brings them posteriorly. However, the portals also move on the sagittal, coronal and axial planes.

In a study on cadavers, Sitler et al. [19] measured the distances of the posteromedial and posterolateral portals to the neurovascular structures through MRI and dissection. The examination was performed in the prone position. They demonstrated that these two portals can safely be used if technical rules are obeyed. In addition, a study by Feiwell and Frey [7] confirmed that the prone position suggested by Sitler et al. [19] was a safer method. Lijoi et al. [15] showed that the distance to the neurovascular structures in posteromedial and posterolateral portals increases distally. Portals 1 cm proximal to the tip of the fibula are safer than portals 2 cm proximal to the tip of the fibula.

Acevedo et al. suggested a coaxial portal on the medial and lateral sides, particularly for patients with synovitis. In their clinical practice, the posterior medial coaxial portal was opened via the inside out technique just near the posterior tibial tendon [6]. In our study, the portal was opened just posterior to the medial malleolus while securing the posterior tibial tendon. Although not statistically significant, plantar flexion relaxed not only the tendon but also the neurovascular structures and decreased the risk of injury.

Ürgüden et al. [21] examined the relationship between the neurovascular structures and the posteromedial and posterolateral portals in different ankle positions. They measured twenty ankle joints in six fixed positions with the ankle and hindfoot in the supine position using MRI and concluded that virtual portals close to the tip of the fibula in the neutral position for both portals are safe. They also evaluated the sural nerve approach to the portal line at the position of dorsiflexion varus, dorsiflexion valgus, dorsiflexion neutral and neutral varus. These findings were in contrast to our finding for the same portals. In direct measurement, placement of the patient in the supine position for MRI measurement and the lack of portal simulation in Ürgüden et al.'s study [21] may be the reason for these differences.

Our study had some limitations. First of all, our study allowed both ankle motion and the direct measurement of the distance between portals simulated by Steinmann pins and the neurovascular structures. Although we used fresh cadavers, rigour mortis prevented us from simulating varus and valgus motion, and achillotomy was necessary to provide complete sagittal motion of the ankle joint. Subtalar release could be performed to provide subtalar motion that would change the placement of the Steinmann pins. Other limitations of this study included minimal changes in the positions of Steinmann pins due to their loosening during dissection, the need to perform achillotomy due to onset of rigour mortis and the measurement of distance by the same person due to the changes in distances after the dissection making repeat measurements practically impossible. In addition, the decrease in fluid in dead tissue may affect the distances between anatomic structures and portals in cadavers. However, this study may provide some idea about surgical risks [20]. Another limitation of this anatomic cadaveric study was that the portals were all made in one position, and thus, were unable to definitively determine the effect of portals created in a different position.

Additionally, we might include MRI to examine the position of critical structures prior to an anatomic dissection, as dissection could change the distances measured.

According to the results of our study, we suggest that arthroscopic surgeons should open the conventional posterolateral–posteromedial portals in dorsiflexion and the posteromedial–posterolateral coaxial portals in plantar flexion to avoid to damage to anatomic structures.

Conclusions

In comparison with the portals made in the neutral position, the distance between neurovascular structures and portals changes with portal placement in plantar flexion and dorsiflexion. Therefore, it might be safer to make the posteromedial–posterolateral portals in dorsiflexion and posterolateral–posteromedial coaxial portals in plantar flexion. The tibial nerve is closer to the posteromedial coaxial in dorsiflexion and could be in danger if making this portal with the foot in this position.

Conflict of interest None.

References

1. Acevedo JI, Busch MT, Ganey TM, Hutton WC, Ogden JA (2000) Coaxial portals for posterior ankle arthroscopy: an anatomic study with clinical correlation on 29 patients. Arthroscopy 16:836–842
2. Barber FA, Click J, Britt BT (1990) Complications of ankle arthroscopy. Foot Ankle 10(5):263–266
3. Carmont MR, Stroud R, Bjorndalen H, Crowther J, Ribbans WJ, Griffin D (2012) The safety profile of a retrospective accessory postero-lateral hind foot portal: the risk of sural nerve damage during visualisation of the Achilles tendon insertion. Foot Ankle Surg 18(2):128–131
4. Chen YC (1976) Clinical and cadaver studies on the ankle joint arthroscopy. J Jpn Orthop Assoc 50:631–651
5. Committee on Complications of the Arthroscopy Association of North America (1986) Complications in arthroscopy: the knee and other joints. Committee on Complications of the Arthroscopy Association of North America. Arthroscopy 2(4):253–258
6. Donnenwerth MP, Roukis TS (2013) The incidence of complications after posterior hindfoot endoscopy. Arthroscopy 29(12):2049–2054
7. Feiwell LA, Frey C (1993) Anatomic study of arthroscopic portal sites of the ankle. Foot Ankle 14(3):142–147
8. Ferkel RD (1999) Arthroscopy of the foot and ankle. In: Coughlin MJ, Man RA (eds) Surgery of the foot and ankle, 7th edn. Mosby, St. Louis, pp 1257–1297
9. Ferkel RD, Fasulo GJ (1994) Arthroscopic treatment of ankle injuries. Orthop Clin N Am 25(1):17–32
10. Ferkel RD, Fischer SP (1989) Progress in ankle arthroscopy. Clin Orthop Relat Res 240:210–220
11. Ferkel RD, Heath DD, Guhl JF (1996) Neurological complications of ankle arthroscopy. Arthroscopy 12(2):200–208
12. Ferkel RD, Small HN, Gittins JE (2001) Complications in foot and ankle arthroscopy. Clin Orthop Relat Res 391:89–104
13. Guhl JF (1988) New concepts (distraction) in ankle arthroscopy. Arthroscopy 4(3):160–167
14. Karlsson J (2012) Low risk of complications during ankle arthroscopy. Knee Surg Sports Traumatol Arthrosc 20(8):1419
15. Lijoi F, Lughi M, Baccarani G (2003) Posterior arthroscopic approach to the ankle: an anatomic study. Arthroscopy 19(1):62–67
16. Martin DF, Baker CL, Curl WW, Andrews JR, Robie DB, Haas AF (1989) Operative ankle arthroscopy. Long-term followup. Am J Sports Med 17(1):16–23
17. Parisien JS, Vangsness T, Feldman R (1987) Diagnostic and operative arthroscopy of the ankle. An experimental approach. Clin Orthop Relat Res 224(224):228–236
18. Smyth NA, Zwiers R, Wiegerinck JI, Hannon CP, Murawski CD, van Dijk CN, Kennedy JG (2014) Posterior hindfoot arthroscopy: a review. Am J Sports Med 42(1):225–234
19. Sitler DF, Amendola A, Bailey CS, Thain LMF, Spouge A (2002) Posterior ankle arthroscopy: an anatomic study. J Bone Joint Surg Am 84-A(5):763–769
20. Unlu MC, Kesmezacar H, Akgun I, Ogut T, Uzun I (2006) Anatomic relationship between elbow arthroscopy portals and neurovascular structures in different elbow and forearm positions. J Shoulder Elb Surg 15(4):457–462
21. Ürgüden M, Cevikol C, Dabak TK, Karaali K, Aydin AT, Apaydin A (2009) Effect of joint motion on safety of portals in posterior ankle arthroscopy. Arthroscopy 25(12):1442–1446
22. Wang L, Gui J, Gao F, Yu Z, Jiang Y, Xu Y, Shen H (2007) Modified posterior portals for hindfoot arthroscopy. Arthroscopy 23(10):1116–1123
23. Van Dijk CN, Scholten PE, Krips R (2000) A 2-portal endoscopic approach for diagnosis and treatment of posterior ankle pathology. Arthroscopy 16(8):871–876
24. Voto SJ, Ewing JW, Fleissner PR Jr, Alfonso M, Kufel M (1989) Ankle arthroscopy: neurovascular and arthroscopic anatomy of standard and trans-Achilles tendon portal placement. Arthroscopy 5(1):41–46
25. Zengerink M, van Dijk CN (2012) Complications in ankle arthroscopy. Knee Surg Sports Traumatol Arthrosc 20(8):1420–1431