Comparison of Neurovascular Structures at Risk During Ankle Arthroscopy

A Cadaveric Study

Ramez Sakkab, DPM*
Varsha Ivanova, DPM†
Monica Jung, DPM, MS†
Kristina Corley, DPM†
Jae Yoon Kim, DPM†
Gautam Sowda, BS†
Kevin Miller, DPM‡

Background: Arthroscopy has become increasingly common for diagnosis and treatment of ankle joint pathology. The four most common portals used for ankle arthroscopy are the anteromedial, anterolateral, posteromedial, and posterolateral. Anatomy of neurovascular structures along the ankle can significantly vary.

Methods: The distance of neurovascular structures was compared with anatomical landmarks of ankle arthroscopic portals to verify safe zones for scope insertion. Twenty-six fresh frozen cadavers were used, with dissection of standard anatomical landmarks and neurovascular structures. Portals were made and verified with a 2.7-mm arthroscope.

Results: Significant differences were found in mean distances between anatomical landmarks except for the peroneus tertius tendon to the intermediate dorsal cutaneous nerve ($P = .181$; all others, $P < .0001$). In quantifying a scope space, the anteromedial and anterolateral portals had the largest margin of error at 0.82 cm and 1.04 cm, respectively. The saphenous nerve and vein were an average of 1.39 cm and 1.23 cm, respectively, from the anteromedial portal. The peroneus tertius tendon was an average of 0.23 cm from the intermediate dorsal cutaneous nerve. The tibialis anterior tendon was an average of 1.10 cm lateral to the medial gutter; the peroneus tertius tendon, 1.31 cm medial to the lateral gutter; and the Achilles tendon, 0.94 and 0.73 cm from the medial and lateral gutters, respectively.

Conclusions: Among common ankle arthroscopic approaches, the anterolateral portal features the highest anatomic variability. These data support the standard protocol of beginning with the anteromedial portal to facilitate visualization of lateral-sided anatomy before anterolateral portal placement. (J Am Podiatr Med Assoc 114(2), 2024; doi:10.7547/21-220)

Arthroscopy has become increasingly common for diagnosis and treatment of ankle joint pathology.[1-3] The four most common portals used for ankle arthroscopy are the anteromedial, anterolateral, posteromedial, and posterolateral. All of these portals run close to neurovascular structures (NVSs), making NVSs susceptible to injury during arthroscope insertion.[3,4] A recent meta-analysis found overall complications using anterior or posterior portals to be 3.4% to 9%,[5] with the most common being nerve-related injury. The foot and ankle specialist should be familiar with all relevant structures circumferentially across the ankle joint, as well as their relative distance to one another, allowing for greater reproducibility when placing portals for ankle arthroscopy.

Previous studies have evaluated the distance from portal entry to NVSs but did not specify the amount of distance available between landmarks for portal entry. And to our knowledge, previous reports have not noted the proximity of the ankle

*Phoenix Foot and Ankle Institute, Scottsdale, AZ.
†California School of Podiatric Medicine at Samuel Merritt University, Oakland, CA.
‡NorthBay Healthcare, Fairfield, CA.
Corresponding author: Ramez Sakkab, DPM, Phoenix Foot and Ankle Institute, 7301 E 2nd St, Ste 206, Scottsdale, AZ 85251. (E-mail: rasakkab@gmail.com)

gutters. The purpose of this study was to compare the distances of NVSs from the four ankle arthroscopic portal landmarks to verify safe zones for scope insertion.

Materials and Methods

Twenty-six fresh frozen cadaveric lower extremities transected at the mid-tibia were used for dissection of four arthroscopic ankle portals. Institutional review board approval was waived given the use of cadaveric specimens. Portal placement was performed with the ankle in 20° plantarflexion and without distraction in all of the specimens. Two researchers (R.S., V.I.) were in charge of foot and ankle position. The foot and ankle were fixed to a vice. Meticulous dissections were performed at each portal site to expose NVSs while not disturbing them from their original anatomical locations. The anteromedial portal was created first, medial to the tibialis anterior tendon into the medial gutter. The anterolateral portal was then created lateral to the peroneus tertius tendon into the lateral gutter. The posteromedial portal was created medial to the Achilles tendon and the posterolateral portal was created lateral to the Achilles tendon into the medial and lateral gutters, respectively. All of the portals were created with placement off the malleoli with a technique described by Stetson and Ferkel.[6] The distances from each anatomical landmark to the NVSs at the level of the ankle joint were measured and recorded. Furthermore, an ankle scope (2.7 mm) was later placed to ensure proper portal size and precision. All of the dissections were performed by the same two researchers, and all of the measurements were completed and reviewed by two other researchers (K.C., M.J.) to maintain blinding and consistency.

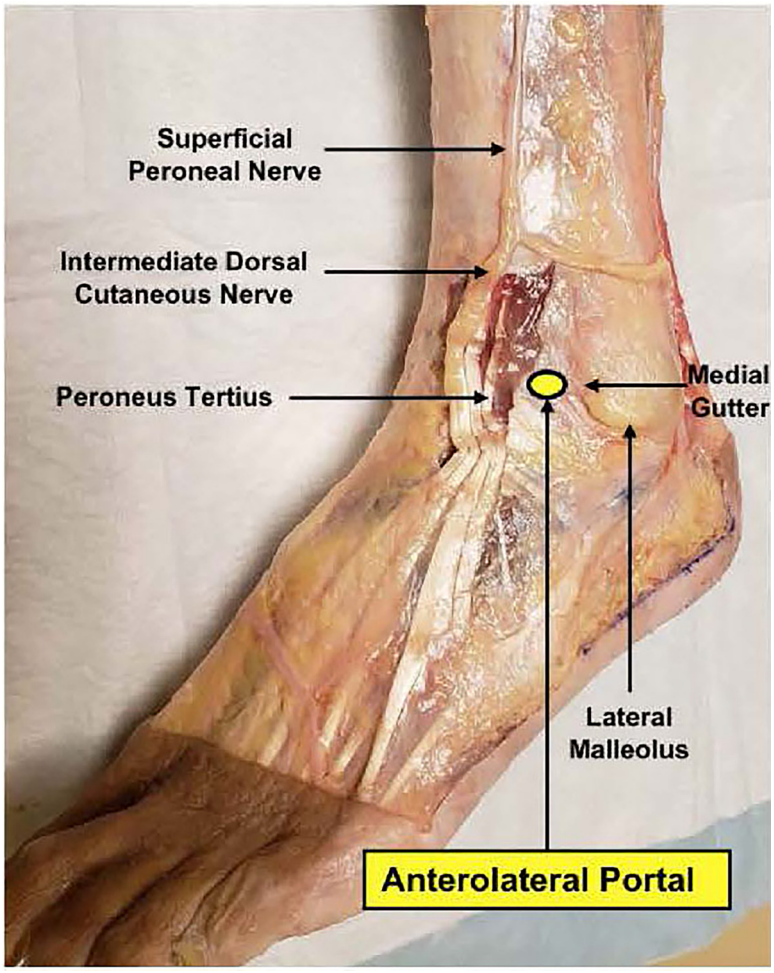


Figure 1. Anterolateral portal located medial to the lateral malleolus and lateral to the peroneus tertius tendon along with the intermediate dorsal cutaneous nerve.

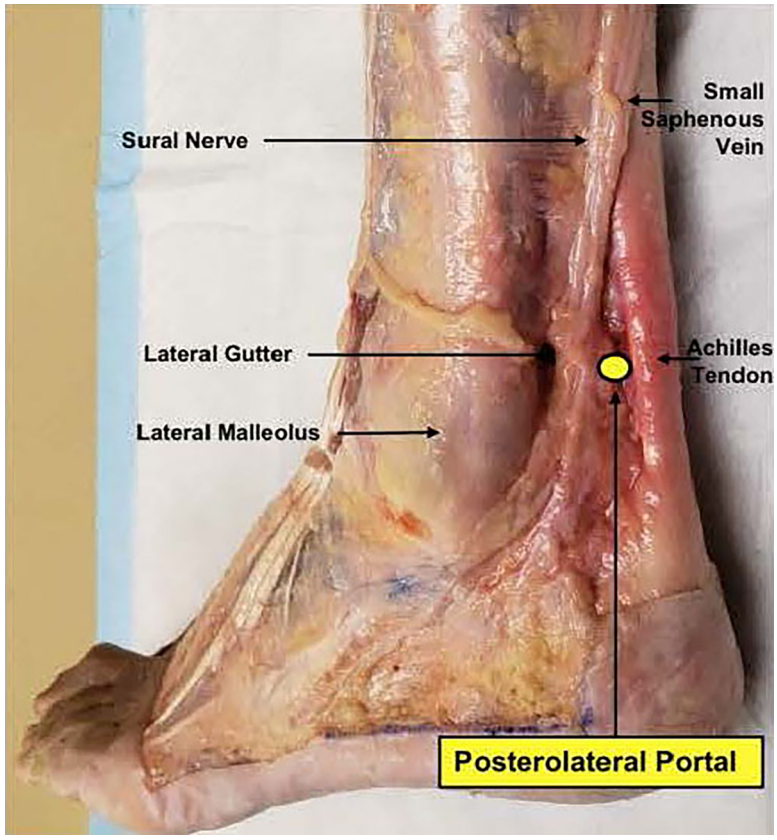


Figure 2. Posterolateral portal dissection located lateral to the Achilles tendon and medial to the sural nerve and small saphenous vein.

Statistics began with the Kruskal-Wallis test to determine parametric and nonparametric data. Descriptive data and comparison of means were conducted with the Wilcoxon signed-rank test and analysis of variance as appropriate. All of the statistical analysis was conducted via SPSS for Windows, Version 24.0 (IBM Corp, Armonk, New York).

Results

All of the locations demonstrated high variability in juxtaposition to NVSs (Figs. 1-3). The greatest inconsistency was noted between the peroneus tertius tendon (anterolateral portal) and the intermediate dorsal cutaneous nerve (IDCN) (mean ± SD, 22.9 ± 81.4 mm medial; range, 30.0 mm). The scattered distribution of the anatomy surrounding the anterolateral portal is visualized in Figure 4. Of note, only the distribution of the tibialis anterior tendon to the saphenous nerve was normally distributed per Kolmogorov-Smirnov testing. However, the differences in variance between landmarks to NVSs or gutters were not significant ($P = .88$).

A one-sample analysis of variance test demonstrated significant differences in the comparison of mean distances between anatomical landmarks, except for the peroneus tertius tendon to the IDCN ($P = .181$; all others, $P < .0001$) (Table 1). Although the range for the IDCN to the peroneus tertius tendon was 3.0 cm, no other grouping had a range greater than 2.1 cm.

To our knowledge, previous studies have not quantified the distance between landmarks and the wall of the malleoli. In the present study, the intervals between anatomical landmarks and the ankle gutter were measured. The tibialis anterior tendon was 1.10 cm lateral to the medial gutter, the peroneus tertius tendon was 1.31 cm medial to the lateral gutter, and the Achilles tendon was 0.94 cm and 0.73 cm from the medial and lateral gutters, respectively. Subtracting these lengths by the scope diameter (4.0 mm or 2.7 mm), a resultant scope space (SS) was quantified. The anteromedial and anterolateral portals had the largest SSs for a 2.7-mm scope at 0.82 cm and 1.04 cm, respectively. However, because the mean SS between the peroneus tertius tendon to the IDCN was not significant,

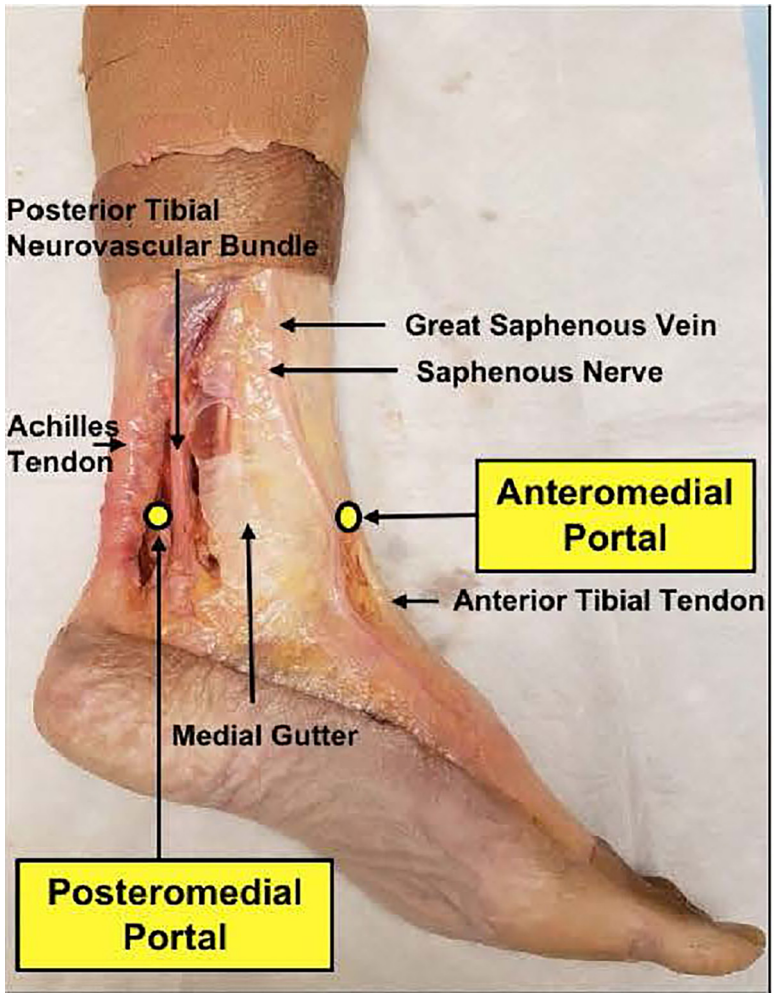


Figure 3. Anteromedial and posteromedial portals. The anteromedial portal is located medial to the tibialis anterior tendon and lateral to the great saphenous vein and the saphenous nerve. The posteromedial portal is located medial to the Achilles tendon and lateral to the neurovascular bundle.

the anteromedial portal had the longest SS of statistical significance ($P < .0001$). As such, this portal site may have the greatest amount of available space, and thus the most room for error.

The saphenous and sural nerves were nearly equidistant from the Achilles tendon, at 0.896 cm medially and 0.8923 cm laterally, respectively. In addition, both posterior portals localized a smaller SS than their anterior counterparts, at 0.67 cm and 0.46 cm of SS for the posteromedial and posterolateral portals, respectively.

Discussion

Ankle arthroscopy is an important, minimally invasive tool for the diagnosis and treatment of various pathologies.[1,3,4] Compared with arthroscopic surgery of other larger joints, neurovascular complications occur more often in ankle arthroscopy, emphasizing the importance of determining anatomical safe zones in relation to the four portals.[2]

The most common complication of ankle arthroscopy is neurologic injury, accounting for up to half of the 9% complication rate in a study by Ferkel et al.[3] Similarly, Deng et al[4] encountered overall complications at a rate of 7.69%, with injury to the superficial peroneal nerve (SPN) being the most prevalent.[4] A meta-analysis of ten cadaveric studies analyzing the neurovascular and tendinous structures at risk in ankle arthroscopy by Yammine and Assi reported a total of 14 nerve injuries; ten of those injuries were to the SPN, with six of the injuries incurred through the anterolateral portal.[7] Given this information, we hypothesized that the anterolateral portal holds the highest risk for iatrogenic injury to the IDCN.

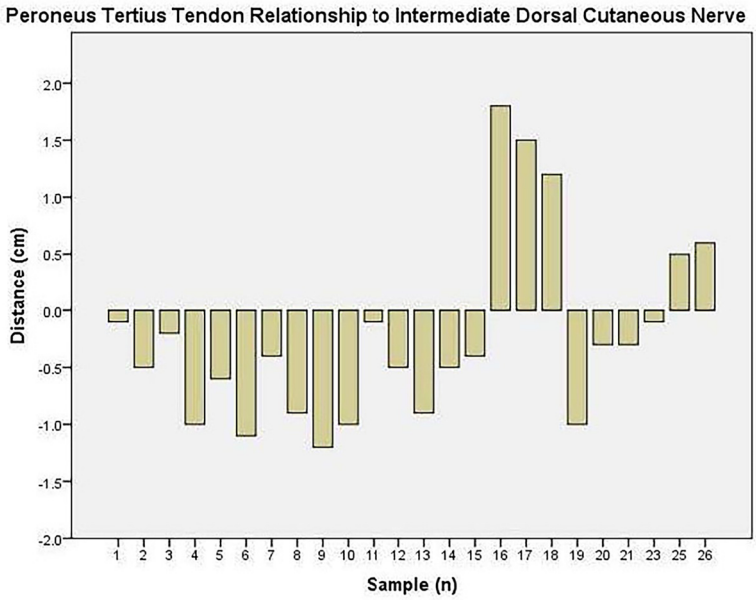


Figure 4. Histogram illustrating the high variability of the intermediate dorsal cutaneous nerve in relation to the peroneus tertius tendon near the anterolateral portal. Positive values represent lateral distribution; negative values, medial distribution.

Table 1. Measurements Between Anatomical Landmarks to Neural Structure or Ankle Joint Gutter

Portal: Landmark to Structure	Distance (Mean ± SE [range] [cm])
Anteromedial	
Tibialis anterior tendon to medial gutter	1.10 ± 0.492 (0.5 to 2.1)
Tibialis anterior tendon to saphenous nerve	1.39 ± 0.412 (0.5 to 2.1)
Tibialis anterior tendon to saphenous vein	1.23 ±0.539 (0.2 to 2.2)
Anterolateral	
Peroneus tertius tendon to lateral gutter	1.31 ± 0.423 (0.5 to 2.1)
Peroneus tertius tendon to IDCN[a]	0.23 ± 0.8137 (−1.2 to 1.8)
Posterolateral	
Tibialis anterior tendon to lateral gutter	0.94 ± 0.431 (0.1 to 1.8)
Tibialis anterior tendon to sural nerve	0.89 ± 0.411 (0.1 to 2.2)
Posteromedial	
Achilles tendon to medial gutter	0.73 ± 0.447 (0.2 to 1.6)
Achilles tendon to tibial nerve	0.90 ± 0.449 (0.1 to 1.9)

Abbreviation: IDCN, intermediate dorsal cutaneous nerve.
[a]Mean distance not significantly different against all others ($P = .181$).

The anatomical variation of the SPN and its branches is well-established in the literature,[7,8] and the distance from the SPN to the anterolateral portal is highly varied. Buckingham et al[9] measured a mean ± SD distance of 0.5 ± 2.5 mm, Scheibling et al[10] measured 5.5 ± 3.5 mm, and Woo et al[11] measured 1.8 ± 1.25 mm between the anterolateral portal and the SPN in a collective total of 35 cadavers.[9-12] We hypothesized that the distance from the anterolateral portal to the IDCN would show considerable variation in its anatomical distribution.

The measurements quantified comfortably fall within 1 SD of those published in a meta-analysis of ankle arthroscopy cadaveric studies.[7] Similar to this work, the present results found the IDCN and tendinous structures to be at highest risk for iatrogenic injury. Although the saphenous nerve's relation to the tibialis anterior tendon (mean, 13.9 mm) followed a bimodal distribution. Such consistency may corroborate the standard technique of first creating the anteromedial portal. In contrast, the labile location of the IDCN supports the fact that SPN injury is one of the most frequent complications of ankle surgery.[4,11] Furthermore, the results reinforce the technique of anteromedial portal creation first, followed by better visualization of the lateral anatomy. The IDCNs of five specimens were located lateral to the portal, rather than the archetypal medial distribution. Undoubtedly, these variants contributed significantly to data distribution. And other anatomical variants may have existed. Although ankle position and lack of distraction were consistent, there was potential for error or loss of ankle positioning. Studies have noted that plantarflexion and dorsiflexion impact portal

anatomy.[13] Here, two researchers who confirmed positioning did not watch measurements to ensure sagittal plane placement was not lost. One other nascent concern is falsely identifying a medial dorsal cutaneous nerve or an undivided SPN as the IDCN. However, no variant branches of the perforating peroneal or anterior tibial artery were observed, as have been described elsewhere.[12] Overall, the considerable number of cadaveric specimens (n = 26) contributed to the statistical significance achieved in comparative analysis. This number is greater than that found in two recent reports that contained varied results.[14-16]

The present study had other clear limitations, including but not limited to methodologic criteria, potential errors in consistency of measurements, and modifications to cadaveric limbs. Increased accuracy could have occurred by averaging the measurements of multiple observers. Of note, five of 26 cadaveric limbs (19%) had 2-0 braided polyester suture and bone anchors in the posterosuperior calcaneus. The NVSs of these limbs were evaluated to ensure that they were undisturbed before inclusion. Other limitations are those inherent to investigations pertaining to fresh frozen cadavers, a constrained sample size, and sample heterogeneity.

In conclusion, the present results suggest that landmarks near the anteromedial portal demonstrate the least anatomical variance, whereas those near the anterolateral portal demonstrate the greatest. The four most common portals of ankle arthroscopy have a mean of 7.3 to 13.1 mm of length between the anatomical landmark and the adjacent ankle joint gutter. Foot and ankle surgeons can use the present data when planning portal placement and analyzing the complications thereof.

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