Neurovascular Structures at Risk with Ankle Arthroscopic Portals: A Cadaveric Study

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Statement of Purpose

The four most common ankle arthroscopic portals, anteromedial (AM), anterolateral (AL), posteromedial (PM), and posterolateral (PL), run close to neurovascular structures (NVS) which may be susceptible to iatrogenic injury, particularly during scope insertion. Previous studies have evaluated the distance from portal entry to neurovascular structures, but do not specify the distance between anatomical landmarks relevant to portal entry. The purpose of this study is to compare the distance of NVS from the four ankle arthroscopic portals and their landmarks to determine sizes of safe zones for scope insertion.

Methodology

Twenty-six fresh-frozen cadaveric lower extremities were dissected at the four ankle arthroscopic portals. Meticulous dissections were performed at each portal site to expose NVS, while not disturbing them from their original anatomic location. The AM portal was created medial to the tibialis anterior tendon (TAT) into the medial gutter, with the great saphenous vein and nerves dissected for measurement. The AL portal was created lateral to the peroneus tertius tendon (PTT) into the lateral gutter, where the intermediate dorsal cutaneous nerve (IDCN) was localized. The PM portal was created medial to the Achilles tendon (AT), and the PL portal was created lateral to the AT into the medial and lateral gutters, respectively (**Figures 1-3**). The sural nerve was dissected for the AL portal, and the tibial nerve was dissected for the PM portal. The distances from each anatomical landmark to the neurovascular structures at the level of the ankle joint were measured and recorded. A 2.7mm ankle scope was placed to ensure proper portal size. Each extremity served as its own control. Cadaveric limbs with orthopedic implants that impeded our dissections were excluded.

Statistics began with Kruskal-Wallis test to determine parametric and non-parametric data. Descriptive data and comparison of means was conducted with Wilcoxon signed-rank test and ANOVA as appropriate. All statistical analysis was conducted via SPSS 24.0 (IBM, Armonk, NY).

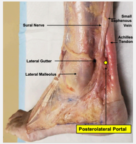

Figure 1. Posterolateral portal dissection located lateral to the AT and medial to sural nerve and small saphenous vein.

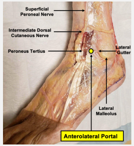

Figure 2. Anterolateral portal located medial to lateral malleolus and lateral to PTT along with IDCN.

Literature Review

Ankle arthroscopy is an important, minimally invasive tool for the diagnosis and treatment of numerous pathologies.[1] In comparison with arthroscopic surgery at other joints, neurovascular complications occur more often with 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 done by Ferkel et al.[3] Similarly, Deng et al. encountered an overall incidence of complications of 7.69%, with injury to the superficial peroneal nerve, or the IDCN, being most prevalent.[4] A meta-analysis of ten cadaveric studies analyzing the NVS and tendinous structures at risk in ankle arthroscopy by Yammine et al. reported a total of 14 nerve injuries; ten of those injuries were to the SPN, with 6 incurred through the AL portal.[5] Recognizing this information, we hypothesized that the AL portal holds the highest risk for iatrogenic injury to the IDCN.

The anatomic variation of the SPN and its branches are established in the literature, and the distance from the SPN to the AL portal is highly varied.[6] Buckingham et al. measured a distance of 0.5 ± 2.5 mm, Schiebling et al. measured a distance of 5.5 ± 3.5 mm, and Woo et al. measured a distance of 1.8 ± 1.25 mm between the AL portal and the SPN in a collective total of 35 cadavers. [6-9] Thus, we hypothesized that the distance from the AL portal to the IDCN would show considerable variation across its anatomic distribution.

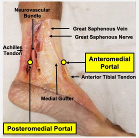

Figure 3. Anteromedial and Posteromedial portals. The AM portal is located medial to TAT and lateral to great saphenous vein and great saphenous nerve. And PM portal is located medial to the AT and lateral to the neurovascular bundle.

Results

Table 1. Measurements between anatomic landmarks to neural structure or ankle joint gutter.

Portal: Landmark to Structure	Mean (range) (cm)	SE (cm)
Anteromedial:		
TAT - medial gutter	1.10 (0.5 - 2.1)	0.492
TAT - saphenous nerve	1.39 (0.5 - 2.1)	0.412
TAT - saphenous vein	1.23 (0.2 - 2.2)	0.539
Anterolateral:		
PTT - lateral gutter	1.31 (0.5 - 2.1)	0.423
PTT - IDCN*	0.23 (-1.2 - +1.8)	0.8137
Posterolateral:		
AT - lateral gutter	0.94 (0.1 - 1.8)	0.431
AT - sural nerve	0.89 (0.1 - 2.2)	0.411
Posteromedial:		
AT - medial gutter	0.73 (0.2 - 1.6)	0.447
AT - tibial nerve	0.90 (0.1 - 1.9)	0.449

**Mean distance not significantly different against all others (p=0.181), SE: Standard error*

Results cont.

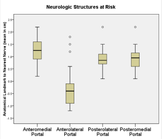

Figure 4. Box plot of arthroscopic ankle portals to pertinent structures.

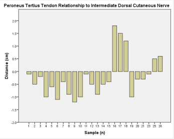

Figure 5. Histogram illustrating variability near the AL portal. Negative and positive values correspond to the nerve medial or lateral to PTT, respectively.

All locations demonstrated high variability in relation to NVS (Figure 4). The greatest inconsistency was noted between the PTT (AL portal) and IDCN (mean 22.9 mm medial, standard deviation of 81.4 mm, range of 30.0 mm). The scattered distribution of the anatomy surrounding the AL portal is visualized in **Figure 5**. Of note, only the distribution of the TAT to the saphenous nerve was normally distributed per Komolgorov-Smirnov testing. However, the differences in variance between landmarks to NVS or gutters was not significant (p=0.88).

One-sample ANOVA testing indicated significant differences in mean distance between anatomic landmarks, with the exception of PTT to the IDCN (p=0.181, all others p<0.001). The values for which are featured in Table 1. While the range for the IDCN to PTT was 3.0 cm, no other grouping had a range greater than 2.1 cm. Moreover, to the authors' knowledge, previous studies have not quantified the distance between landmarks and the ankle joint space. In the present study, the interval between anatomic landmarks and the ankle gutter was measured. The TAT was 1.10 cm lateral from the medial gutter, the PTT was 1.31 cm medial to the lateral gutter, the AT was 0.94 cm and 0.73 cm from the medial and lateral gutter, respectively. Subtracting these lengths by the scope diameter (4.0 or 2.7 mm), a resultant scope space (SS) can be quantified. The AM and AL portals had the largest SS (2.7 mm) at 0.82 and 1.04 cm, respectively. However, as comparisons of mean SS between the peroneus tertius to IDCN was not significant, the medial portal had the longest SS of statistical significance (p<0.001). As such, the AM portal had the greatest room for scope placement.

The saphenous and sural nerves were nearly equidistant from the AT, at 0.896 cm medially and 0.8923 cm laterally, respectively. Additionally, both posterior portals localized a smaller SS than their anterior counterparts. At 0.67 cm and 0.46 cm of SS for the PM and PL portals, respectively.

Analysis & Discussion

The measurements quantified fall within one standard deviation of those published in a meta-analysis of ankle arthroscopy cadaveric studies per Yammine et al.[5] Similar to their work, our results found the IDCN and tendinous structures to be at highest risk of iatrogenic injury. The saphenous nerve's relation to the TAT (mean 13.9 mm) followed a bimodal distribution. Such consistency may corroborate standard technique of first the AM portal. In contrast, the IDCN's labile location supports the notion of SPN injury being one of the most frequent complications of ankle arthroscopy.[4,10] Five specimen's IDCN were located lateral to the portal, rather than the archetypal medial position. These variants significantly altered the mean distance of 2.3 mm observed between the AL portal and IDCN. Potentially, other anatomic variants may have existed, resulting in falsely identifying the medial dorsal cutaneous or an undivided superficial peroneal nerve in lieu of the IDCN. No variant branches of the perforating peroneal or anterior tibial artery were identified, but have been described previously.[11] Overall, the number of cadaveric specimens (n=26), 100% of which had a PTT, contributed to the statistical significance achieved in comparative analysis.

Limitations of the study include but are not limited to: methodologic criteria, potential errors in consistency of measurements, and modifications to cadaveric limbs. Increased accuracy may have been obtained by averaging the measurements of multiple observers. Five of 26 (19%) cadaveric limbs had fiberwire and bone anchors within the posterosuperior calcaneus. Neurovascular structures of these limbs were evaluated to ensure they were undisturbed prior to inclusion. Other limitations are those inherent to investigations pertaining to fresh-frozen cadavers, a constrained sample size, and sample heterogeneity.

In conclusion, our results suggest that landmarks surrounding the AM portal demonstrate the least anatomic variance, and the AL the greatest. The four most common portals of ankle arthroscopy have a mean range of 7.3 mm to 13.1 mm in length between anatomic landmark and adjacent ankle joint gutter. The present data can be utilized by foot and ankle surgeons when planning portal placement and analyzing the complications thereof.

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