The Posteromedial Neurovascular Bundle of the Ankle: An Anatomic Study Using Plastinated Cross Sections

Mircea-Constantin Sora, M.D., Ph.D., Radu Jilavu, Cand.med., Alexander Grübl, M.D., Birgit Genser-Strobl, M.D., Dimitre Staykov, M.D., and Andreea Seicean, Cand.med.

Purpose: The aim of this study was to evaluate the topography of the posteromedial neurovascular bundle of the ankle. The anatomic relation of the posteromedial neurovascular bundle at different levels of the ankle was studied as an aid in planning minimally invasive surgery. A thorough knowledge of the local anatomy is a prerequisite before attempting release of the tibial nerve or when using the posteromedial portal for ankle arthroscopy. **Methods:** A slice anatomy study was performed on 12 intact right male cadaveric lower limbs. The distal third of each limb was cut and the foot positioned in the neutral position. The measurements were performed at the level of the tibiotalar joint, at the tip of the medial malleolus, and at the sustentaculum tali. **Results:** The tibial nerve is predicted to be 11.8 $\pm$ 2.4 mm and the posterior tibial artery 16.7 $\pm$ 3.8 mm anterior from the calcaneal tendon at the level of the tibiotalar joint. At the tip of the malleolus medialis, the tibial nerve is 14.3 $\pm$ 2.5 mm and the posterior tibial artery 22.1 $\pm$ 4.1 mm anterior to the Achilles tendon. The medial plantar nerve is situated at the sustentaculum tali level 8.4 $\pm$ 3.4 mm and the lateral plantar nerve 16.1 $\pm$ 3.1 mm posterior to the sustentaculum. **Conclusions:** On the basis of our anatomic data, a posteromedial portal made at the level of the tip of the medial malleolus seems to be safe, effective, and reproducible. Therefore a portal at this level would be advantageous for an endoscopic tarsal tunnel release or when using the posteromedial portal for ankle arthroscopy. Anatomic characteristics should be kept in mind when ankle surgery is performed, thereby reducing the risk of injury to the medial neurovascular bundle and offering easy access inside the posterior compartment of the ankle. **Clinical Relevance:** This cadaveric study suggests that, by placing the posteromedial ankle portal at the tip of the medial malleolus, the risk of neurovascular injuries could be reduced. **Key Words:** Posteromedial portal—Ankle—Plastination—Tibial nerve—Posterior tibial artery—Ankle anatomy.

The clinical use of ankle arthroscopy for diagnosis and treatment of foot and ankle disorders has increased over the last few decades. Proper portal placement is critical to performing good diagnostic and therapeutic arthroscopy. When the portals are positioned improperly, visualization can be impaired, making diagnosis and treatment more difficult. Of all of the ankle portals, the posteromedial portal has recognized risks because of the proximity of the posterior neurovascular structures and has generally not been recommended. The posteromedial portal passes between the Achilles tendon and the posterior tibial neurovascular bundle. The tibial nerve is the larger branch of the sciatic nerve. From its origin, it descends distally along the posterior aspect of the leg, in front of the posterior tibial vessels. After reaching the medial malleolus, the neurovascular bundle lies superfi-

From the Plastination Laboratory, Center for Anatomy and Cell Biology (M.-C.S., J.R., B.G.-S.), and Department of Orthopedics (A.G.), Medical University of Vienna, Vienna, Austria; Neurology Department, University of Erlangen-Nürnberg (D.S.), Erlangen, Germany; and Case Western Reserve University School of Medicine (A.S.), Cleveland, Ohio, U.S.A.

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Address correspondence and reprint requests to Mircea-Constantin Sora, M.D., Ph.D., Center for Anatomy and Cell Biology, Medical University of Vienna, Währingerstrasse 13/3, 1090 Vienna, Austria. E-mail: mircea-constantin.sora@meduniwien.ac.at

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cial and is covered only by fascia and skin. In the posteromedial region of the ankle the neurovascular bundle passes through the tarsal tunnel.[1]

The tibial nerve has, on the medial side of the ankle, specific relations with the surrounding structures. Knowledge of the topographic landmarks that border the tarsal tunnel and the posteromedial neurovascular bundle ensures appropriate incision placement for endoscopic as well as open tarsal tunnel release surgery. Various groups have investigated the medial posteromedial neurovascular bundle by anatomic dissection[2,3] and by performing magnetic resonance imaging[4] or ultrasound.[5] Plastination produces transparent body slices with intact structures and transparent connective tissues, without producing any artifacts. This technique is unique because it offers the possibility to produce a series of transparent slices that can be easily processed morphometrically.[6-10]

The purpose of this study is to identify topographic landmarks that can be used consistently to predict the location of the posteromedial neurovascular bundle. The position of the posteromedial neurovascular bundle was investigated without moving any structures by use of the plastination method to find a safe zone to place the posteromedial ankle portal. This study investigates the positions of the tibial nerve and the posterior tibial artery, as well as their relation to each other.

METHODS

Twelve intact right male cadaveric lower limbs were used. The limbs were selected with exclusions for severe tibial artery disease, and none of the cadavers had any indication of ischemic ulceration or gangrene at all. The cadavers' ages ranged between 65 and 84 years, with a mean of 73.6 years. A stainless steel wire, 1 mm thick, was inserted from distal through the calcaneal bone into the tibia to maintain the position of the foot. All specimens were frozen at −80°C and then cut into slices, with a mean thickness of 1.5 ± 0.26 mm, starting 4 cm distal to the tip of the medial malleolus and finishing 1 cm proximal to the tibiotalar joint, obtaining at least 20 slices from each specimen. On each slice, 2 markers were placed, one anterior and the second posterior. Between each section, 0.4 mm was lost because of the thickness of the saw blade.

The original area size of the frozen slices was recorded by scanning their caudal aspect with an Epson GT-10000+ Color Image Scanner (Epson America, Long Beach, CA). Each slice was measured on 4 marked positions to determine the mean thickness: 3 mm from the anterior, posterior, right, and left borders of the slices. The slices were stored at −25°C overnight, then dehydrated in cold (−25°C) acetone series, and degreased with methylene chloride for 1 week. Impregnation was performed at +5°C with E12 epoxy resin (Biodur, Heidelberg, Germany). The slices were cast between 2 sheets of tempered glass with a flexible gasket used as a spacer (2 mm). After bubble removal, the flat chambers were placed horizontally at 15° and left at room temperature for 1 day, after which they were placed in an oven at 45°C for 4 days. Finally, the caudal surfaces of the plastinated slices were scanned into a computer by use of an Epson GT-10000+ Color Image Scanner. In every scan a ruler was used as a calibration marker. By comparing the area data for the fresh and plastinated slices, we could determine the shrinkage rate for each slice, which was considered in calculations. For measurements, we used UTHSCSA ImageTool software for Windows, version 2.0 (University of Texas Health Science Center at San Antonio, San Antonio, TX). Each measurement was done 3 times, and a mean value was calculated. The measurements of the neurovascular structures were taken from the borders of these (Fig 1). Statistical analysis was done with SPSS software for Windows, version 11.0 (SPSS, Chicago, IL). Descriptive statistics were used to calculate the means and SDs.

After plastination, the ankle with the posteromedial neurovascular bundle was reconstructed 3-dimensionally.[11] Although the scanned images could have been used directly for computer modeling, we decided to include an extra step involving manual tracing so that alignment could be more closely controlled. Scanned images of the tissue slices were printed and manually traced. Alignment guides were transferred to each tracing. Each manual tracing was placed on a scanner so that fiducial points aligned with a base alignment tracing attached to the scanning bed. Once scanned, these images (JPEG format) were loaded into WinSURF (version 4.0; SURFdriver Software, Kailua, HI) and traced from the monitor.[12,13] Once all contours were traced, the ankle was reconstructed and visualized. After reconstruction, the measuring tool available in WinSURF was used to record height, width, and depth measurements from the model.

RESULTS

The thin 1.5-mm slices produced were transparent and hard, with good optical qualities. The finished E12 slices provided excellent anatomic detail down to the