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Quantification of Posterior Ankle Exposure Through an Achilles Tendon-Splitting Versus Posterolateral Approach

Jeanne C. Patzkowski, MD[1]; Kevin L. Kirk, DO[1]; Justin D. Orr, MD[2]; Brian R. Waterman, MD[2]; Jess M. Kirby, MD[3]; Joseph R. Hsu, MD[1]
Fort Sam Houston, TX; El Paso, TX; Cornelius, NC

ABSTRACT

Background: **The optimal surgical exposure to the posterior ankle for trauma and reconstruction is a source of debate. We hypothesized that the Achilles tendon-splitting approach would provide greater exposure to the posterior ankle than the posterolateral approach.** ***Methods:*** **Forty surgical approaches were performed from twenty fresh-frozen cadavers. Achilles tendon-splitting and posterolateral approaches were performed using a randomized crossover design for surgical sequence. Six landmarks (medial malleolus, ankle joint, subtalar joint, incisura fibularis, lateral malleolus and medial gutter) were identified by direct visualization or palpation. A calibrated digital photograph was taken and Image J (http://rsb.info.nih.gov/ij/) was used to calculate the surface area of the distal tibia and talus exposed in neutral and dorsiflexion.** ***Results:*** **Using a posterolateral approach, the average distal tibia exposed was 11.3cm^2 in neutral and 10.2 cm^2 in dorsiflexion. The average talus exposed was 2.0 cm^2 in neutral and 2.4 cm^2 in dorsiflexion. Using an Achilles tendon-splitting approach, the average exposed distal tibia was 33% more (15.0 cm^2) in neutral and 43% more (14.6 cm^2) in dorsiflexion. The average talus exposed was 47% more (3.0 cm^2) in neutral and 76% more (4.2 cm^2) in dorsiflexion. All increases in exposure were statistically significant. The medial malleolus was visualized in 19 tendon-splitting and six posterolateral approaches. The medial gutter was visualized in 20 tendon-splitting and 13 posterolateral approaches. These differences were statistically significant. All other landmarks could be visualized through both approaches.** ***Conclusion:*** **The Achilles tendon-splitting approach provided significantly greater exposure of the posterior distal tibia and talus compared to the posterolateral approach.** ***Clinical relevance:*** **Prospective studies will help determine if the tendon-splitting approach is a safe and clinically useful approach for surgeries in which direct access to the entire posterior ankle and subtalar joint are required.**

Key Words: Posterolateral Ankle Approach; Achilles Tendon-Splitting Approach; Tibia Nonunion; Tibia Malunion; Posterior Tibia; Posterior Malleolus; Posterior Talus

INTRODUCTION

The ideal surgical approach to the posterior ankle and hindfoot is a source of debate.[1,2,4,6,8–10,15–17] The posterolateral (PL) approach is commonly used and provides ample access to the posterior ankle, subtalar joint, and fibula. Limitations of the approach include wound healing complications, risk of damage to the peroneal artery, sural nerve, and inadequate exposure of medial-sided structures.[2,4,8,9,17]

A direct posterior Achilles tendon-splitting (TS) approach has been described.[2,8,10] Advantages of the TS approach include excellent visualization of all posterior ankle and hindfoot structures, the ability to release posterior, medial and lateral capsules while maintaining blood supply to the sinus tarsi, and respect for the peroneal and posterior tibial angiosomes of the distal posterior leg.[2,3,8,10,21] Concerns regarding the use of this approach include long and short-term integrity of the Achilles tendon, painful or cosmetically unacceptable scarring, and wound healing complications.[2]

The purpose of this study was to quantify the amount of surgical exposure of the posterior distal tibia and talus afforded by use of the PL and TS approaches. We hypothesized that the TS approach would provide greater exposure to

[1]San Antonio Military Medical Center, Fort Sam Houston, TX.
[2]William Beaumont Army Medical Center, El Paso, TX.
[3]United States Army Trauma Training Center, Cornelius, NC.

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Corresponding Author:
Jeanne C. Patzkowksi, MD
Orthopaedic Surgery Resident
San Antonio Military Medical Center
3851 Roger Brooke Drive
Fort Sam Houston, TX 78234
E-mail: Jeanne.patzkowski@us.army.mil

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the posterior distal tibia and talus and would improve visualization of medial sided osseous structures when compared to the PL approach.

MATERIALS AND METHODS

Institutional Review Board approval was obtained prior to initiation of this study.

Twenty paired, direct donor, fresh-frozen cadaveric specimens were obtained and 40 surgical approaches were performed utilizing a cross-over randomization design for surgical sequence. Matched limbs were separated and the left limbs were randomized to either the PL or TS approach. The approach was marked with a permanent marker on the postero-superior aspect of the leg outside of the proposed surgical field. The opposite approach was assigned to the matched right-sided limb and marked in the same fashion. There were no surgical incisions, signs of previous soft tissue trauma or severe peripheral vascular disease visualized on any of the limbs from the level of the knee to the foot.

Two fellowship-trained foot and ankle surgeons (K.L.K., J.D.O.) performed the surgical approach marked on each limb in the same fashion. The PL approach was performed with the limb in the lateral decubitus position. A 10-cm incision centered between the posterior aspect of the fibula and the lateral border of the Achilles tendon was made starting at the distal tip of the fibula and extending cephalad (Figure 1). The sural nerve was identified, peroneal tendons retracted laterally, and the flexor hallucis longus tendon (FHL) retracted medially. The soft tissue was cleared from the visualized tibia and talus (Figure 2). An osteotomy of the tibia or fibula was not performed.

The TS approach was performed with the limb in the prone position. A 10-cm incision centered directly over the Achilles tendon was made starting at the level of the distal tip of the fibula and extending cephalad (Figure 3). A longitudinal incision was made through the Achilles tendon in line with the incision and full thickness flaps were created including skin, subcutaneous tissue, paratenon and tendon (Figure 4). The FHL was retracted medially. Soft tissue was cleared from the visualized tibia and talus (Figure 5). An osteotomy of the tibia or fibula was not performed.

Following completion of the surgical exposure, retractor location was standardized with one each at the distal tip of the fibula, distal tip of the medial malleolus, and on the medial and lateral aspects of the tibial diaphysis at the superior extent of the surgical incision. The length of the incision was measured again prior to retractor placement to ensure there had been no inadvertent extension of the length of the incision during the surgical exposure. Retractors were placed and held by the same investigator for each specimen during data collection, and only one finger applied to each retractor.

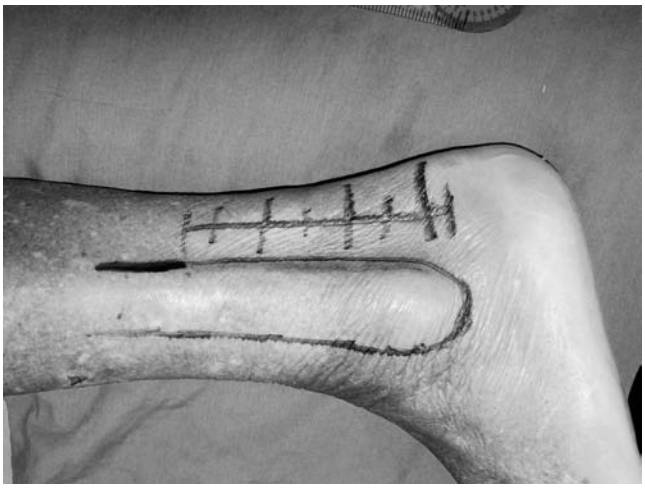

Fig. 1: Surgical incision for posterolateral approach.

Fig. 2: Surgical exposure using posterolateral approach.

Fig. 3: Surgical incision for tendon-splitting approach.

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There was no quantification of the force of retraction. Digital photographs were taken of the dissected limbs with a 1.5-cm metric ruler placed flush against the posterior aspect of the distal tibia in the field of the photograph. For both approaches, photographs of the exposure were taken prone, first in neutral ankle dorsiflexion followed by maximum dorsiflexion. All photographs were taken by the same investigator (J.C.P.).

Six anatomic landmarks were analyzed for each limb at the immediate conclusion of each approach to determine if the landmark was visible, palpable with a freer, or neither. These included the posteromedial aspect of the medial malleolus, posterior ankle joint, posterior subtalar joint, incisura fibularis, posterolateral aspect of the lateral malleolus and medial gutter. At the conclusion of data collection (anatomic landmarks and digital photography) the opposite surgical exposure was performed.

Fig. 4: Longitudinal incision in Achilles tendon.

Fig. 5: Surgical exposure using tendon-splitting approach.

The digital photographs were analyzed using a computer software program, ImageJ.[20] ImageJ is a free, publicly available software program from the National Institutes of Health and has been utilized in numerous scientific and orthopaedic publications for data analysis through image capture.[5,7,11,13,18,19,22] This program compares a known distance, the metric ruler in the surgical field, with the number of pixels in the photograph. Once calibrated, the square area of exposed distal tibia and talus was calculated for each photograph.

Statistical analysis was performed utilizing the Wilcoxon test for comparison of square area of the distal tibia and talus for each approach in each position (neutral vs. maximum dorsiflexion), and Fisher's Exact testing for analysis of visualization of anatomic landmarks. The study was powered to detect a difference of 25% square area exposed with beta of 0.8. Significance was set at $p = 0.05$.

RESULTS

Using a TS approach, the average square area exposed of distal tibia and talus in neutral and maximum dorsiflexion was significantly greater than the area exposed using the PL approach (Table 1). There was a 33% increase in the amount of exposed tibia in neutral ($p = 0.022$), a 43% increase in amount of exposed tibia in dorsiflexion ($p = 0.001$), a 47% increase in amount of exposed talus in neutral ($p = 0.048$), and a 76% increase in the amount of exposed talus in dorsiflexion ($p < 0.001$).

There was a statistically significant increase in visual exposure of medial sided structures using the TS approach. The posteromedial aspect of the medial malleolus was visualized in 19 TS and six PL approaches ($p < 0.001$). The medial gutter was visualized in 20 TS and 13 PL approaches ($p = 0.008$). All other anatomic landmarks could be visualized through both approaches. Landmarks that were not visualized were palpable in all cases.

DISCUSSION

Posterior surgical exposures to the ankle and hindfoot have been described for numerous operative indications.[1–4,6,8–10,14–17] These include operative fixation of posterior ankle fracture-dislocations, tibia nonunion and malunion, pilon fractures, ankle and subtalar arthrodesis, Achilles tendon repair or reconstruction, calcaneal osteotomy, and hindfoot deformity correction. Posterior approaches are advantageous in cases of large posterior fracture fragments, or in cases where a direct reduction of the posterior or central articular surface is necessary. They may also be used when

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Table 1: Osseous Exposure Utilizing the Posterolateral and Tendon-Splitting Approaches

	Exposed tibia in neutral (cm^2)	Exposed tibia in dorsiflexion (cm^2)	Exposed talus in neutral (cm^2)	Exposed talus in dorsiflexion (cm^2)
Tendon-Splitting	15.0	14.6	3.0	4.2
Posterolateral	11.3	10.2	2.0	2.4
P value	0.022	0.001	0.048	< 0.001

insufficient or damaged soft tissue is present anteriorly or laterally that would preclude the use of anterior and lateral approaches.[1]

The PL approach is frequently used to address these difficult operative cases. In general, the approach is reported to afford good visualization of the posterior ankle and subtalar joints, and has the advantage of allowing simultaneous fixation of the posterior tibia and fibula with one incision.[4] However, the PL approach affords only limited visualization of posteromedial and/or central fragments, comminution and marginal impaction.[1,6] Haraguchi et al. demonstrated that 20% of posterior malleolus fractures extended into the posteromedial aspect of the tibia or into the medial malleolus.[12] Bois et al. reported on 17 patients treated with a posteromedial approach for ankle fracture dislocations with large posteromedial fragments. Two had been previously treated utilizing only a PL approach, and required revision due to an unrecognized posteromedial fragment.[6] In these cases, several authors have recommended a combination of posteromedial and PL approaches to achieve adequate reduction.[1,6,14,15]

The direct posterior Achilles TS approach has been reported for use in ankle and subtalar arthrodesis and hindfoot deformity correction. Reported advantages of the approach include excellent visualization of the posterior ankle and subtalar joint, Achilles tendon, medial calcaneus, and improved evaluation of hindfoot deformity and correction.[2,8,10] The incision, centered between the posterior tibial and peroneal angiosomes, respects the vascular supply to the posterior leg. Yepes et al. noted a persistent hypovascular region in the midline directly overlying the Achilles tendon and recommended avoiding direct posterior approaches.[23] After noting the presence of cutaneous perforators but prior to performing both their vascular dissections and angiography, the authors removed the Achilles tendon and paratenon. We find their results difficult to interpret given the findings of Attinger et al. that the rich vascular plexus surrounding the Achilles tendon keeps the skin above the tendon viable.[3] Although several small series have reported low rates of Achilles tendon morbidity following use of the TS approach,[2,8,10] larger, prospective studies are necessary to determine the short and long term risks associated with its use.

A major strength of this study is the large number of exposures performed. All exposures were performed by surgeons facile with both approaches. Additionally, the data set includes not only the square areas of the exposed distal tibia and talus, but also includes anatomic landmarks which may help surgeons determine if the TS approach would be useful during preoperative planning.

We acknowledge several limitations. This is a cadaveric study so we cannot offer any insight into the safety, clinical efficacy or functional outcomes related to the two approaches studied. We utilized a cross-over randomization design for surgical sequence. This allowed us to perform more dissections on fewer cadavers. While there may be concern that the approach performed second will have a larger area exposed due to stretching of the tissue and the previous incision, we noted no significant difference between the data collected in the first and second rounds of dissections. We did not evaluate the posteromedial approach. We chose to compare the TS against the PL approach due to the more frequent use of the PL approach reported in both trauma and foot and ankle literature. However, as a few cases of complex posterior pilon fractures treated with a combination of PL and posteromedial approaches have been described,[1,14,15] this may have made for an interesting comparison in our study. Lastly, a two dimensional digital photograph does not perfectly replicate a three dimensional joint surface. The two dimensional image, however, likely underestimates the amount of articular area exposed. In the operating room, the soft tissue retractors could be placed in any location and moved to afford even more exposure. We intentionally did not allow this movement to avoid inadvertently biasing our results.

This study demonstrated that the surgical exposure of the posterior distal tibia and talus is significantly greater when utilizing an Achilles tendon-splitting approach as compared to a posterolateral approach in both neutral and maximum dorsiflexion. This was evident both in the square area of bony surfaces exposed, and in visualization of medial-sided anatomic landmarks. As expected, the area of exposed talus was further enhanced in both approaches by placing the ankle joint into maximum dorsiflexion. There was no decrease in the ability to visualize the lateral-sided anatomic landmarks when using the TS approach. The centrally located incision of the TS approach allowed access to medial and lateral structures with minimal skin retraction. While the retractors could be adjusted in the operating room using the PL approach, access to the medial ankle and subtalar joints

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may require more aggressive soft tissue retraction. Although our results demonstrated a significant increase in osseous exposure using the TS approach, the approach should not be considered an absolute replacement to the PL, but rather an alternative to consider during preoperative planning. In our experience, utilization of the TS approach is limited by the need for more proximal exposure of the tibia, as this would require splitting the gastrocnemius and soleus musculature. In these situations, the senior authors prefer to utilize the PL approach.

CONCLUSION

The Achilles tendon-splitting approach provides significantly greater exposure of the posterior distal tibia and talus compared to the posterolateral approach, particularly with regard to exposure of far medial sided structures. Prospective studies are needed to determine if the tendon-splitting approach is a safe and clinically useful approach for all surgeries in which direct access to the entire posterior ankle and subtalar joint are required.

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