Comparison of Neurovascular Structures at Risk with the Lateral Extensile Incision versus the Sinus Tarsi Incision: A Cadaveric Study

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Statement of Purpose

The best surgical incision to visualize, reduce and stably fixate displaced intra-articular calcaneal fractures remains controversial. The lateral extensile approach (LEA) and the sinus tarsi approach (STA) are two currently used incisional approaches with the STA demonstrating a lower wound complication rate. The proximity to the neurovascular structures from the two incisions has not yet been quantified and compared. The purpose of this study is to measure the proximity of the lateral calcaneal artery (LCA) and the sural nerve (SN) to the LEA and STA to quantify the neurovascular complication risk of the two incisional approaches in an attempt to explain the differences in the wound complication rate.

Methodology

Twelve fresh-frozen cadaveric lower extremities were dissected with both the LEA and the STA. Each cadaver served as its own control. The LEA was made first with a vertical limb from the distal fibula to the glabrous skin junction and a horizontal limb from the distal end of the vertical incision to the base of the 5th metatarsal. The STA was then made from the distal tip of the fibula to the 4th metatarsal base. The LCA and SN were carefully dissected and exposed. The distances of both structures were measured from the proximal, apex and distal end of the LEA and from the proximal end of the STA. Care was taken during the dissection not to disturb the original positions of the artery and the nerve.

For each variable, chi-squared analysis was performed to calculate intra-variable p-values, where <0.05 was deemed statistically significant. For comparison between variables, paired t-tests were performed, with a p-value <0.05 being deemed statistically significant. For comparison between 3 or more variables, analysis of variance (ANOVA) was performed. Particularly, ANOVA was utilized for all points of the LEA, and again for the STA compared to the proximal and distal points of LEA. Data analysis and plotting was conducted through SAS University Edition.

Figure 1. Gross location of the lateral extensile and sinus tarsi incisions.

Literature Review

The LEA and STA are two commonly utilized incisions to visualize displaced intra-articular calcaneal fractures.[1] The treatment goals for displaced intra-articular calcaneal fractures are to restore height and width, to correct any varus deformity, and to align articular surfaces.

One major complication of the LEA is wound healing, with non-healing wounds subsequently leading to infection, revisional surgeries, and even amputations.[2-4] Recent clinical studies have shown lower wound complication rates with the STA than with the LEA, wound complication rates range from 5.0-6.1% for the STA compared to 13.3-29% for the LEA.[3,4] Bibbo et al. found that a pre-operative non-Dopplerable signal from the LCA led to non-healing wounds in the apical region and wound dehiscences or sloughs with the LEA.[4] With this information, we hypothesized that the LEA holds a higher risk of iatrogenic injury to the LCA compared to the STA due to its anatomical proximity to the LCA.

Another complication that is frequently reported with displaced intra-articular calcaneal fractures include iatrogenic sural nerve injury. Studies have shown a slightly increased rate of sural neuritis for the LEA (6.6- 7.7%) compared to the STA (0.0-5.0%).[6,7] The sural nerve has been known to be located ~12.76 mm posterior to the lateral malleolus.[5] Our STA was confined anterior to the fibula, whereas the vertical limb of the LEA was placed posterior to the fibula. We hypothesized that the LEA has a higher risk of iatrogenic injury to the sural nerve than the STA due to the rate of sural neuritis and the location of the nerve.

The LEA has been historically used for its visualization with a 61% greater exposure to the lateral calcaneus compared to the STA.[5] Basile et al. found that although the LEA may provide greater exposure, the STA was comparable in quality of reduction, fixation and functional outcomes with shorter operation times.[7] In addition, literature studies have shown a lower wound complication rate and sural nerve injury rate with the STA compared to the LEA.[5-7] The results from our study provides a possible reasoning behind this.

Figure 2. Relationship of the sural nerve to the sinus tarsi approach.

Figure 3. Relationship of the sural nerve and lateral calcaneal artery to the lateral extensile approach.

Results

The lateral calcaneal artery was found 1.61±1.03 cm posterior to the proximal end of the STA, 0.68±0.23 cm anterior to the proximal end of the LEA, and 2.50±0.91 cm anterosuperior to the apex of the LEA. The LCA was found significantly closer to the proximal end of LEA than the proximal end of the STA at a mean difference of 0.94 cm (p=0.01; 95% CI: 0.21 to 1.67). The LCA was found closer to the proximal end of the STA than its distance to the apex of the LEA, but this finding was not significant (p>0.09; 95% CI: -1.4963 to 0.1519).

The sural nerve was found 0.43±0.56 cm posterior to the proximal end of the STA. Comparatively, the SN was found 0.59±0.96 cm anterior to the proximal end of the LEA, 3.28±0.48 cm anterosuperior from the apex of the LEA, and 0.48±0.47 cm superior from the distal end of the LEA. The distance was significantly closer at the proximal end of the STA compared to the apex of the LEA with a mean difference of 2.85 cm (p<0.01; 95% CI: 2.51-3.20cm). However, the difference in distance to the SN was found to be insignificant between the proximal incision sites of the LEA and the STA (p=0.42, 95% CI: -0.5941 to 0.2691). Similarly, the distal incision site of the LEA had an insignificant difference in distance to the SN compared to the proximal end of the STA (p=0.92, 95% CI: -0.5194 to 0.4194). The mean distance from incision site between the proximal LEA and STA was within a half standard deviation of one another, at 0.475 and 0.425 cm, respectively. Comparisons of data were completed via paired t tests with a degrees of freedom of 11.

	Proximal STA	Proximal LEA	Apex LEA	Distal LEA
Lateral Calcaneal Artery (cm)	1.61	0.68	2.50	
Sural Nerve (cm)	0.43	0.59	3.28	0.48

Table 1. Mean proximities of neurovascular structures from various points of the incisions.

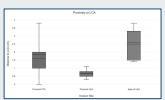

Figure 4. Proximity to lateral calcaneal artery at various points of the incisions.

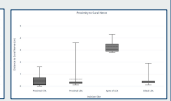

Figure 5. Proximity to sural nerve at various points of the incisions.

Analysis & Discussion

Our study demonstrated that the LCA was significantly closer to the proximal end of the LEA than the proximal end of the STA. This finding suggests that there may be a greater risk for iatrogenic LCA injury with the LEA than with the STA, possibly explaining the higher rate of wound complications with the LEA in the current literature. The distance of the LCA from the apex of the LEA was slightly farther from its distance to the proximal end of the STA, but this finding was not significant. This showed that the increased incidence of skin necrosis and wound complications at the apex of the LEA cannot be explained by the greater perfusion distance from the arterial source.

The SN was encountered frequently at the proximal end of the STA and at the end points of the proximal and distal ends of the LEA during the dissection. Our results showed that the SN runs in close proximity to the ends of both incisions without significant differences in distance. Therefore, higher rate of iatrogenic sural neuritis with the LEA cannot be explained by its proximity to the SN. We infer from the data that the higher rate of iatrogenic sural neuritis with the LEA may be due to encountering the SN at two separate locations.

The limitation of our study is largely inherent to our methods of taking measurements. The skin flap between STA and LEA was not removed and obstructed our visualization of the original positions of the artery and the nerve. In addition, the traumatic nature of displaced intra-articular calcaneal fractures may lead to anatomical variances of or injuries to the LCA and the SN, causing neurovascular risk unrelated to the incisional approach used. In future studies, we suggest dissecting perforating peroneal artery to assess its proximity to the sinus tarsi incision. Our study sets a foundation for future studies to further evaluate and compare the neurovascular risk between the two incisional approaches.

References

1. Meng Q, Wang Q, Wu X, Peng A, Yan J. Clinical application of the sinus tarsi approach in the treatment of intra-articular calcaneal fracture. Medicine (Baltimore). 2018;97(13).
2. Abidi, NA, Dhawan S, Gruen GS, Vogt MT, Conti SF. Wound-Healing Risk Factors After Open Reduction and Internal Fixation of Calcaneal Fractures. Foot Ankle Int. 1998;19(12):856-861.
3. Buckley R, Tough S, McCormack R, et al. Operative compared with nonoperative treatment of displaced intra-articular calcaneal fractures: a prospective, randomized, controlled multicenter trial. J Bone Joint Surg Am. 2002;84-A(10):1733-1744.
4. Bibbo C, Lin SS, Beam HA, Nguyen HMG, Lewis RJ, Kovach SJ. Late Wound Complication Rates for the Lateral Extensile Approach for Calcaneal ORIF When the Lateral Calcaneal Artery Is Patent. Foot Ankle Int. 2014;35(7):652-656.
5. Kline AJ, Anderson RB, Davis WH, Jones CP, Cohen BE. Minimally Invasive Technique Versus an Extensile Lateral Approach for Intra-Articular Calcaneal Fractures. Foot Ankle Int. 2013;34(6):773-780.
6. Yeo J-H, Cho H-J, Lee K-B. Comparison of two surgical approaches for displaced intra-articular calcaneal fractures: sinus tarsi versus extensile lateral approach. BMC Musculoskelet Disord. 2015;16:63.
7. Basile A, Albo F, Via AG. Comparison Between Sinus Tarsi Approach and Extensile Lateral Approach for Treatment of Closed Displaced Intra-Articular Calcaneal Fractures: A Multicenter Prospective Study. The Journal of Foot and Ankle Surgery. 2016;55(3):513-521.
8. Alsten Ibiz ZA, Ugarteri II, Bilgo O. The anatomic features of the sural nerve with an emphasis on its clinical importance. Foot Ankle Int. 2005;26(7):560-567.
9. Bedigrew KM, Blair JA, Possley DR, Kirk KL, Hsu JR. Comparison of Calcaneal Exposure Through the Extensile Lateral and Sinus Tarsi Approaches. Foot & Ankle Specialist. 2016;11(2):142-147.

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