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Anatomic Study of the Medial Neurovascular Structures in Relation to Calcaneal Osteotomy

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ABSTRACT

Medial displacement osteotomy of the calcaneous is commonly performed for stage II posterior tibial tendon insufficiency in an effort to improve the valgus deformity of the hindfoot. We performed an anatomic study examining the medial neurovascular anatomy and its relation to the osteotomy in an attempt to determine which structures may be at risk during the procedure.

Calcaneal osteotomies were performed through a lateral approach on 22 fresh-frozen cadaver below-knee specimens. Dissection was then performed medially to identify the Medial Plantar Nerve (MPN), the Lateral Plantar Nerve (LPN), the Posterior Tibial Artery (PTA), and their respective branches. Measurements determined either 1) where the structure crossed the osteotomy or 2) if the structure did not cross, the closest perpendicular distance from the osteotomy and at which point along its length this occurred. Perpendicular distances were recorded in millimeters and position along the osteotomy as a percentage of the total length from the posterosuperior aspect.

An average of four neurovascular structures crossed each osteotomy site (range 2 to 6), most of which were branches of the LPN or the PTA. The MPN did not cross in any of the specimens studied, the LPN crossed in one specimen, and the PTA crossed in two specimens. The MPN distributed no crossing branches. The calcaneal sensory branch of the LPN was identified and crossed in 86% of the cadavers at 19% (+/- 15%) along the osteotomy length. A more distal second branch of the LPN (Baxter's nerve) was identified and crossed in 95% of the specimens at 61% (+/ 20%) along the osteotomy length. A third crossing branch existed in one specimen. Each PTA distributed from zero to three branches which variably crossed the osteotomy at a point from 2% to 100% along its length. The PTA bifurcated in 77% of the specimens at 49% (+/- 9%) along the osteotomy length. A consistent finding in every specimen was the presence of two veins accompanying the PTA with one on either side.

A number of medial neurovascular structures may be at risk when perfoming a calcaneal osteotomy through a lateral approach. A minimum of two structures crossed the osteotomy site at variable positions in this study, although most of these structures represented branches off of the LPN or the PTA, with the LPN and the PTA themselves crossing only infrequently. The authors recommend that the completion of the osteotomy through the medial calcaneal cortex be performed in a carefully controlled manner to reduce the risk of post-operative complications including pain, numbness, and hematoma formation.

Key Words: Calcaneus; Osteotomy; Anatomy; Nerve; Posterior Tibial Tendon

INTRODUCTION

In order to improve patient symptomatology in patients with Stage I posterior tibial tendon insufficiency PTT, Koutsogiannis[3] in 1971 advocated medial displacement calcaneal osteotomy. Subsequently Pomeroy and Manoli,[7] in addition to Myerson,[4,5] presented experience with FDL tendon transfer, lateral column and heel cord lengthening, plus calcaneal osteotomy for a more definitive rebalancing of the mechanical forces in the foot.

While performing calcaneal osteotomies in association with the soft tissue repositionings, it has been the experience of the senior author (SCG) that a few patients have post-operative medial hindfoot pain which radiates distally. This pain correlated with the sensory distribution of Posterior Tibial Nerve terminal branches. Iatrogenic injury

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to these nerve branches while performing the osteotomy was hypothesized to be the cause of the discomfort.

Intuitively, the medial neurovascular structures are at risk during medial displacement osteotomy. However, data regarding the relationship of specific nerves and vessels to the osteotomy site is lacking. The purpose of this study was to define the anatomy of the medial neurovascular structures in relation to the standard osteotomy site.

METHODS

Calcaneal osteotomies were performed on twenty two fresh-frozen cadaver below-knee specimens (12 males, 10 females). Skin incisions were made laterally beginning superior to the calcaneus and posterior to the peroneal tendons. The incision curved gently inferior and distal reaching the plantar edge of the calcaneus. Dissection was taken down to the calcaneus and the osteotomy was initiated with a thin oscillating sawblade in line with the skin incision. Special care was taken to remain within 5 mm posterior to the peroneal tubercle. The goal of the osteotomy was to maintain a 45° angle posterior to the plantar surface of the foot (posterosuperior to anteroinferior), and to achieve a right angle to the lateral border of the calcaneus An osteotome was used to complete the osteotomy along the medial cortex of the calcaneus.

Attention was then turned to the medial side where dissection identified the Medial Plantar Nerve (MPN), Lateral Plantar Nerve (LPN), Posterior Tibial Artery (PTA), and their respective branches (Fig. 1). Initial measurements included the maximal width and length

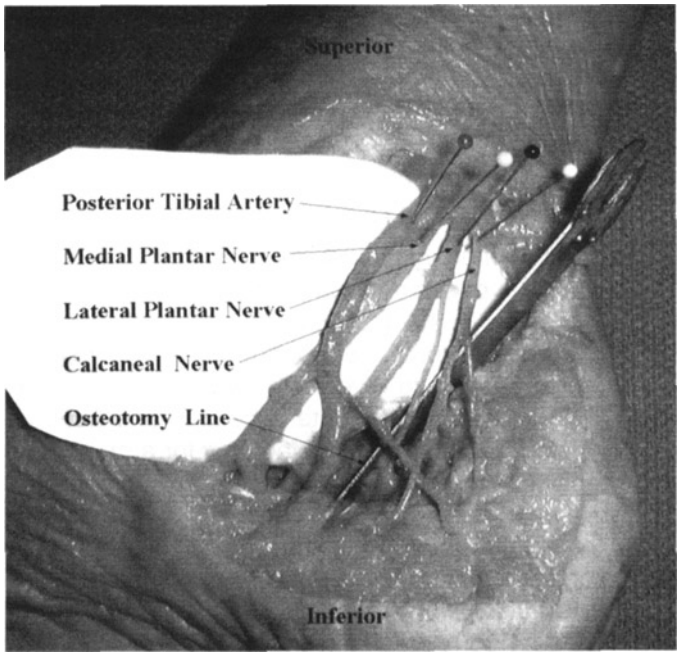

Fig. 1. Medial dissection.

of the calcaneus at the osteotomy site. Once this was recorded, a Kirschner wire was placed through the calcaneus to restore anatomic congruity. The exact angle of the osteotomy with respect to the plantar surface of the foot was then measured with a goniometer.

For the evaluation of the medial neurovascular structures, measurements with dial calipers (Quality Import, South Almonte, CA) determined either:

1) where the structure crossed the osteotomy or;
2) if the structure did not cross, the closest perpendicular distance from the osteotomy and at which point along its length this occurred.

Perpendicular distances were recorded in millimeters and position along the osteotomy as the percentage of total length from the posterosuperior aspect of the cut. (Figs. 2a and 2b). It was elected to use relative percentage of osteotomy length to report the position rather than absolute distance from a specific point, because of the variability in size between calcaneal specimens.

RESULTS

An average of four neurovascular structures crossed each osteotomy site (range = 2 to 6). The MPN did not cross in any of the specimens studied; the LPN in one; and the PTA crossed in two specimens. The average distance of each from the osteotomy and position along the osteotomy length was as follows (with SD in parentheses): MPN = 15.4 mm (+/- 3.3) at 38% (+/- 18%), LPN = 7.4mm (+/- 4.36) at 51% (+/- 25%), PTA = 5.7 mm (+/- 4.71) at 57% (+/- 24%). The MPN distributed no crossing branches. The calcaneal sensory branch of the LPN crossed the osteotomy in 86% of cadavers at an average of 19% (+/- 15%) along the length. In 95% of specimens the LPN distributed a second crossing branch (Baxter's nerve) at an average of 61% (+/- 20%) along the length. A third LPN crossing branch existed in one specimen. Each PTA maintained from zero to three branches which variably crossed the osteotomy at a point between 2% and 100% along the osteotomy length. Consistent findings in every specimen included the PTA being accompanied by a vein on either side. The PTA bifurcated in 77% of specimens at an average of 49% (+/- 9%) along the length of the osteotomy.

The average angle measured for the osteotomy cuts equaled 42° (SD = 6) relative to the plantar aspect of the foot. The length of the osteotomy from posterosuperior to anteroinferior averaged 45 mm (SD = 7) and 26 mm for the width (SD = 4).

DISCUSSION

Complications reported following calcaneal osteotomies include wound infections,[8] overcorrection,

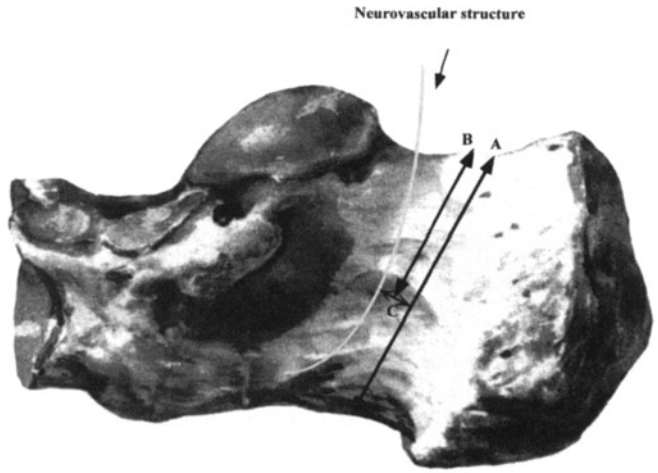

Fig. 2a: Schematic of measurements taken for neurovascular structure that did NOT cross the osteotomy line. View is of medial calcaneus.
A = Osteotomy cut line distance
B = Distance from posterosuperior aspect to point where neurovascular structure comes closest to crossing (expressed as a percentage of total length A)
C = Distance between neurovascular structure and osteotomy line at its closest point (expressed in millimeters)

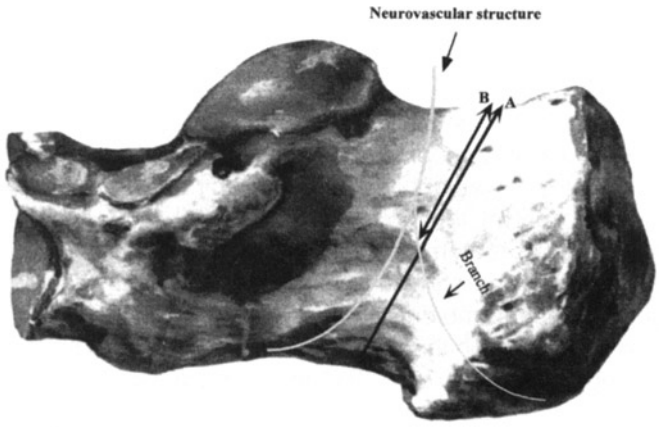

Fig. 2b: Schematic of measurements taken for neurovascular structure that either crosses by itself or has a branch crossing the osteotomy line. View is of medial calcaneus.
A = Osteotomy cut line distance
B = Distance from posterosuperior aspect to point where neurovascular structure crosses (expressed as a percentage of total length A)

undercorrection, loss of correction, joint compression, subtalar joint incongruity, iatrogenic fracture,[1] peroneal tendon abutment,[6] metatarsalgia,[9] hardware related pain,[7] and numbness in the sural nerve distribution of the foot.[7]

The procedure does not involve bone grafting and to date has provided acceptable short term clinical results.[7] As it continues to do so, injury to the medial structures may become a frequently reported complication. No antecedent data exists describing medial neurovascular injuries with this procedure. The senior author (SCG) has observed several cases of post-operative medial hindfoot pain correlating to the terminal branches of the Posterior Tibial Nerve.

When performing a calcaneal osteotomy, the senior author chooses to shift the calcaneus medially approximately 8 mm to 10 mm to gain adequate clinical correction. Based on the average width and shift of the calcaneus medially by 10 mm, a 38% average shift of the calcaneal bone would be achieved.

Numerous neurovascular structures are at risk on the medial side during a lateral approach calcaneal osteotomy. Based on the results of the present study, branches of the PTA and LPN are at particularly high risk. This is why the vast majority of surgeons utilize the lateral approach to the calcaneus. A minimum of two structures crossed the site at variable positions in this study. Most of these structures represented branches off of the LPN and PTA, with the LPN and the PTA themselves crossing only infrequently. Based on these findings, the authors recommend that completion of the osteotomy along the medial calcaneal cortex be performed in a carefully controlled manner to reduce the risk of injury to the medial neurovascular structures and potential post-operative complications including pain, numbness, and hematoma formation.

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