Proximity of the Lateral Calcaneal Artery With a Modified Extensile Lateral Approach Compared to Standard Extensile Approach

John Y. Kwon, MD1, Tyler Gonzalez, MD, MBA2, Matthew D. Riedel, MD2, Ara Nazarian, DrSc1, and Mohammad Ghorbanhoseini, MD1

Abstract

Background: The extensile lateral approach (EL) has been associated with increased wound complications such as apical necrosis which may be due partially from violation of the lateral calcaneal artery (LCA). Traditionally, the vertical limb has been placed half-way between the fibula and Achilles tendon, which may be suboptimal given the proximity to the LCA. We hypothesized that placing the vertical limb further posterior (ie, modified EL [MEL]) would increase the distance from the LCA. The purposes of this study were to quantify the location of the LCA in relation to the vertical limb of the traditional EL approach and to determine if utilizing the MEL approach endangered the LCA to a lesser extent.

Methods: 20 cadavers were used. For the EL approach, the fibula and Achilles tendon were palpated and a line parallel to the plantar foot was drawn between the two. A vertical line (VL), representing the vertical limb of the approach, was drawn at the midway point as a perpendicular extending proximally from the junction of the glabrous/non-glabrous skin (JGNG). For the MEL approach, the anterior border of the Achilles tendon was palpated and a similar vertical line (MVL) was drawn 0.75 cm anterior. Dissection was performed and if the LCA was identified crossing the line VL/MVL, the distance from the JGNG was documented.

Results: For the EL approach, the LCA was identified in 17/20 (85%) cadavers at an average distance of 5.0 cm (range 3-7 cm, SD = 1.3 cm) from JGNG. For the MEL approach, the LCA was identified in 4/20 (20%) cadavers at an average distance of 5.9 cm (range 3-6.5 cm, SD = 1.7 cm) from the JGNG (P < .001).

Conclusions: The LCA was encountered 4 times more often during the EL approach as compared to the MEL approach.

Clinical Relevance: A modification of the EL approach may decrease iatrogenic injury to the LCA and may decrease wound complications.

Keywords: lateral calcaneal artery, extensile lateral approach, modified extensile lateral approach, calcaneus fracture, operative technique, wound complications

Introduction

The extensile lateral approach (EL) is a commonly utilized operative approach for the operative treatment of calcaneal fractures. Although affording excellent exposure and facilitating fracture reduction and fixation, wound complication rates have been reported to be as high as 30%.1,15 While multifactorial in nature, operative technique may play a role in these complications.16,17,21 Traditional teaching has suggested that the vertical limb be placed midway between the posterior border of the fibula and the anterior border of the Achilles tendon.3,9,10,18 Furthermore, the vertical limb has been described as extending proximally 2 to 3 finger-breadths above the tip of the fibula or 6 to 7 cm proximal to the junction of the glabrous and nonglabrous skin (JGNG).10 Although this may facilitate fracture exposure, Borrelli and others have identified that such incisions may endanger the lateral calcaneal artery (LCA), the main artery supplying the lateral hindfoot angiosome.3 In addition, although many factors influence wound healing and the development of apical necrosis, increased wound complication rates using...
the EL approach may be partially due to a commonly accepted yet suboptimal incision placement. Borelli et al described distances from specific anatomic landmarks to localize the LCA and its anastomosis with the lateral malleolar and lateral tarsal arteries; nevertheless, these are difficult to implement in the operating room.

A modification to the traditional EL approach (modified EL [or MEL]), as previously described by Seligson and Gould, may make this operative approach safer without compromising exposure. Before the popularization of the extensile lateral approach, Seligson and Gould described in 1984 an approach in which the vertical limb of the incision was placed just anterior to the Achilles tendon with the horizontal limb then curved along the glabrous/non-glabrous junction of the foot to the base of the fifth metatarsal.14 There were few reports in the literature regarding any clinical outcomes utilizing this approach, and Seligson and Gould did not examine the proximity of their proposed incision to the lateral hindfoot vasculature. Furthermore, the original description in 1984 predated most vascular studies that subsequently characterized the blood supply to the lateral hindfoot. Although many surgeons have adopted a more posterior incision placement, there is little literature supporting its efficacy or increased safety.

The purposes of this study were to quantify the location of the LCA in relation to the vertical limb of the traditional EL approach in order to provide surgeons a reliable calculation at which they may encounter this structure and to determine if using the MEL approach endangered the LCA to a lesser extent.

Materials and Methods

Twenty fresh-frozen transtibial cadaver specimens were used for this study. For the EL approach, the posterior border of the fibula, 2 cm proximal to the distal tip, as well as the anterior border of the Achilles tendon were palpated. A line parallel to the plantar foot was drawn between these 2 points. This line was measured and a vertical line (VL), representing the vertical limb of the traditional EL approach, was drawn at the midway point as a perpendicular extending proximally from the JGNG for a distance of 7 cm.

For the MEL approach, the anterior border of the Achilles tendon was palpated and a similar vertical line (MVL) was drawn 0.75 cm anterior to the Achilles border. This was extended 7.0 cm proximal from the JGNG. If the LCA was identified crossing line VL or MVL, the distance from JGNG was documented (Figure 1). The average distance between the vertical limbs of the EL approach and the MEL approach was 1 cm (range 0.5-1.5 cm, SD = 0.3 cm).

All dissections were performed by 2 staff orthopaedic surgeons well versed in the treatment of calcaneus fractures. The skin incision was made in standard fashion using a 15-blade. Blunt dissection was then performed from superficial to deep in-line with the skin incision in a fashion similar to operative dissection during the treatment of calcaneus fractures. Dissection through subcutaneous tissues adjacent (anterior or posterior) to the skin incision was not performed. If the LCA was identified crossing the dissection in line with the skin incision, the distance from JGNG was measured using a caliper. The LCA was not disturbed from its native position and sutures were placed to reapproximate the skin incision prior to performance of the other approach. The size of the feet were measured as the longest distance from the heel to the distal most phalanx.

Results

For the EL approach, the LCA was identified in 17/20 (85%) cadavers at an average distance from the JGNG of 5.0 cm (range 3.7-7 cm, SD = 1.3 cm) (Figures 2 and 3). For the MEL approach, the LCA was identified in 4/20 (20%) cadavers at an average distance from the JGNG of 5.9 cm range 3.6-5 cm, SD = 1.7 cm) (P < .001) (Figure 4). There was a weak correlation between foot size and the distance from point JGNG at which the LCA was encountered (Pearson correlation, r = 0.15). The average distance between the vertical limbs of the EL approach and MEL
approach was 1 cm (range 0.5-1.5 cm, SD = 0.3 cm) (Table 1). The sural nerve was identified in 13 of 20 cadavers (65%) using the EL approach at an average distance of 5.4 cm (range 3.9-7 cm, SD = 1.2 cm) from the JGNG and 5/20 times (25%) utilizing the MEL approach at an average distance of 6.1 cm (range 3-7 cm, SD = 0.6 cm) from the JGNG.

**Discussion**

Calcaneus fractures account for 1% to 2% of all lower extremity trauma, and indications for operative treatment continue to be refined. Common issues associated with nonoperative treatment of calcaneus fractures include varus malalignment, subtalar arthrosis, anterior ankle impingement, shoe wear problems, and peroneal tendinopathy/impingement. To avoid these potential complications, many advocate for the operative treatment of displaced intra-articular calcaneus fractures.

The most commonly used operative approach for calcaneus fractures is the extensile lateral approach. Although attributed to several surgeons, the EL approach was popularized by Zwipp and Bernishke. It has been commonly described as an L-shaped incision with the vertical limb placed midway between the posterior border of the fibula and the anterior border of the Achilles tendon extending to 2 to 3 fingerbreadths above the tip of the fibula. The horizontal portion of the incision starts at the intersection of the vertical limb and junction of the glabrous and nonglabrous skin of the heel. Historically, several other laterally based incisions have been used for the treatment of calcaneus fractures. In 1948, Palmer et al described the use of a 6-cm curvilinear incision placed below the fibula to access the posterior facet for the operative treatment of 23 cases utilizing iliac crest bone grafting without internal fixation. While reporting improved outcomes relative to conservative treatment, there was no mention of wound complications. Multiple other incisions have been described for the treatment of calcaneus fractures including the medial approach, combined medial and lateral approaches, limited lateral approach, modified Kocher approach, modified Gallie approach, Smile incision, as well as the Ollier approach. Increasingly, the sinus tarsi approach, centered from the distal aspect of the fibula and directed toward the fourth metatarsal base, has been used for the treatment of intra-articular calcaneus fractures. Although the ST approach may be more amenable for Sanders type IIA and IIB fractures, recent literature has demonstrated comparable radiographic and functional outcomes but significantly
lower wound complications when compared with patients treated with the EL approach.\textsuperscript{12,16,21}

The EL approach has been associated with a high wound complication rate.\textsuperscript{1,4,11} Abidi et al demonstrated a 32% wound complication rate in a series of 64 calcaneus fractures treated operatively.\textsuperscript{1} Folk et al reported on 190 calcaneus fractures treated with the EL approach and demonstrated a 25% wound complication rate, with 83% of these requiring operative intervention.\textsuperscript{11} In order to limit wound complications and apical necrosis, both the vascular anatomy of the lateral hindfoot as well as alternative operative approaches have continued to be investigated. Because high rates of wound complications may be secondary to disruption of the vascular supply to the lateral skin flap, many have sought to better define the vascular anatomy of the lateral heel. Andermahr et al utilized 10 cadavers to assess the intraosseous and extraseoseous arterial circulation of the adult calcaneus. They identified the LCA to be the major artery supplying the malleolar plexus, lateral calcaneus, and the lateral heel soft tissues. Based on the anatomic location of the LCA, the authors concluded that the lateral blood supply is inevitably interrupted when a traditional lateral approach to the calcaneus is used and may lead to soft tissue complications and bone infarction because the LCA provides 45% of the intraosseous blood supply to the calcaneus.\textsuperscript{2}

Borrelli et al used a similar protocol to identify the vascular supply to the lateral foot soft tissue flap. They also demonstrated that the main vascular supply to the lateral hindfoot was via the LCA, which is at risk through the extensile lateral approach.\textsuperscript{5} Bibbo et al assessed the patency of the LCA preoperatively using a Doppler prior to ORIF of intra-articular calcaneus fractures, emphasizing the importance of this artery. The authors examined 90 calcaneus fractures, 85 of which had positive preoperative Doppler signal along the course of the LCA. All patients underwent ORIF via an EL approach, with wound complications occurring in 6/90 calcaneus fractures. All 5 patients who had no preoperative Doppler signal had wound complications.\textsuperscript{4} Elsaidy et al examined cadavers to assess anatomic landmarks to help surgeons avoid the LCA. They used a standard EL approach with the vertical limb placed midway between the Achilles and posterior border of the fibula as classically described. The authors described a triangular danger zone with the 3 vertices centered at the tip of the lateral malleolus, the point at which the LCA pierces the deep fascia (range 3–4.5 cm) and the point at which the LCA crosses a horizontal line between the lateral malleolus and the insertion point of the Achilles tendon. This triangle is roughly in the area of the

<table>
<thead>
<tr>
<th>Specimen</th>
<th>EL Approach</th>
<th>MEL Approach</th>
<th>Foot Size</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>LCA (cm)</td>
<td>Sural Nerve (cm)</td>
<td>LCA (cm)</td>
</tr>
<tr>
<td>1</td>
<td>4.8</td>
<td>4.4</td>
<td>−</td>
</tr>
<tr>
<td>2</td>
<td>4</td>
<td>4.4</td>
<td>−</td>
</tr>
<tr>
<td>3</td>
<td>3.9</td>
<td>3.9</td>
<td>5.4</td>
</tr>
<tr>
<td>4</td>
<td>3</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>5</td>
<td>7</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>6</td>
<td>3.5</td>
<td>7</td>
<td>6.5</td>
</tr>
<tr>
<td>7</td>
<td>6</td>
<td>7</td>
<td>−</td>
</tr>
<tr>
<td>8</td>
<td>5</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>9</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>10</td>
<td>7</td>
<td>6.5</td>
<td>−</td>
</tr>
<tr>
<td>11</td>
<td>6</td>
<td>5.5</td>
<td>−</td>
</tr>
<tr>
<td>12</td>
<td>4.75</td>
<td>4.5</td>
<td>−</td>
</tr>
<tr>
<td>13</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>14</td>
<td>6.5</td>
<td>4.5</td>
<td>−</td>
</tr>
<tr>
<td>15</td>
<td>−</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>16</td>
<td>3.75</td>
<td>5.5</td>
<td>3</td>
</tr>
<tr>
<td>17</td>
<td>6</td>
<td>7</td>
<td>−</td>
</tr>
<tr>
<td>18</td>
<td>4</td>
<td>5</td>
<td>6.5</td>
</tr>
<tr>
<td>19</td>
<td>4</td>
<td>−</td>
<td>−</td>
</tr>
<tr>
<td>20</td>
<td>5.3</td>
<td>−</td>
<td>−</td>
</tr>
</tbody>
</table>

Abbreviations: EL, extensile lateral; LCA, lateral calcaneal artery; MEL, modified extensile lateral.
classically described vertical limb of the EL approach, once again demonstrating that the LCA is in danger when this approach is used. In conclusion, they recommended placing the incision posteriorly to avoid the LCA although they did not quantify this distance.8

Despite several studies clearly describing the anatomic positioning of the LCA and risk of iatrogenic injury using the EL approach, a more posterior incision has not been uniformly adopted. This is likely due to the lack of previous cadaveric or clinical studies demonstrating its increased safety. Although many surgeons have anecdotally reported decreased wound complications after adopting a more posteriorly placed incision (including the senior author), there is little formal evidence in the literature to directly support its use. Furthermore, despite the publication of the work by Borelli et al in 1999, various texts, book chapters, studies, and other medical sources published after this date continue to perpetuate suboptimal incision placement despite the evidence. For example, the latest edition of a popular foot and ankle text indicates that the vertical limb of the extensile approach should be placed “halfway between the anterior border of the Achilles tendon and the posterior border of the fibula.”19 Orthobullets.com, one of the most widely used online resources for orthopedic surgeons and residents, states a similar incision placement.24 Even the Arbeitsgemeinschaft für Osteosynthesefragen (AO) Foundation, the premier founding organization dedicated to the treatment of musculoskeletal trauma, currently describes the extended lateral approach as follows: “the posterior arm of the incision is placed midway between the fibula and Achilles tendon.”

The results of our current study demonstrate that the LCA is commonly encountered when using the traditional EL approach. Furthermore, the current investigation demonstrates that by moving the incision of the vertical limb posteriorly to a location 0.75 cm anterior to the Achilles tendon (on average 1 cm posterior to the traditional incision) as previously recommended by Seligson and Gould, the risk of encountering the LCA decreased more than 4-fold. Therefore, using the MEL approach greatly reduced the risk of iatrogenic injury to the LCA, which may decrease wound complications without altering operative exposure. If surgeons continue to prefer traditional incision placement, the results of our study offer a better understanding of where one may encounter the LCA using the JGNG as a simple operative landmark, which may reduce the risk of iatrogenic injury. We did find a weak correlation between foot size and the distance from point JGNG at which the LCA was encountered. Therefore, the surgeon should be aware of foot size in their operative patients and how this might influence the location of the LCA when using either approach.

Although not the goal of the study, we did examine the relationship of the sural nerve to the EL and MEL approaches. In addition, although not having any known influence on wound healing, iatrogenic injury of the nerve and neuroma formation can cause additional morbidity in the form of numbness, paresthesias, or dysesthesias. The sural nerve was identified more than twice as often using the EL approach compared with the MEL approach. To our knowledge, no previous study has been performed comparing sural nerve injury using a standard extensile approach compared with a more posterior incision.

Weaknesses of the current investigation include the fact that this was a cadaveric study to demonstrate the anatomic relationship between the LCA and incision placement without supportive clinical data. Although it can be inferred that the increased likelihood of encountering the LCA using the EL approach may result in increased risk of iatrogenic injury despite excellent operative technique, corroborative clinical studies are needed to truly determine if a modified approach is safer and results in decreased wound complications.

Conclusions

The LCA was encountered 20% of the time using the MEL approach compared with 85% with the EL approach. A modification of the extensile lateral approach, as previously described by Seligson and Gould, may decrease iatrogenic injury to the LCA, which may result in decreased wound complications.

Author Note

Research performed at BIDMC, Harvard Medical School, Boston, MA.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References