Neurovascular Structures At Risk with a Modified Posteromedial Incision for Posterior Pilon Variant Fractures: A Cadaveric Study

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Statement of Purpose

Posterior malleolar fractures with articular impaction and posteromedial extension through the medial malleolus are termed posterior pilon variant fractures. Despite the lack of consensus regarding the optimal surgical approach for this fracture pattern, a posterolateral incision is commonly implemented for posterior malleolar fractures. However, with posteromedial involvement, a modified posteromedial incision provides direct visualization of both the posteromedial and posterolateral fragments. The purpose of this study is to examine the proximity of neurovascular structures to the modified posteromedial incision for posterior pilon variant fractures.

Methodology

Ten fresh-frozen cadaver lower extremities (between ages 51-94 years old; 7 right-sided and 3 left-sided; 5 male and 5 female) were dissected to examine the neurovascular structures at risk with a modified posteromedial incision. A 12-centimeter (cm) incision was made 1-cm medial to the proximal insertion of the Achilles tendon on the calcaneus (Figure 1). The sural nerve was identified and explored along its course from midline to its distal lateral position along the Achilles tendon (Figure 2). The tibial nerve and posterior tibial artery and vein were visualized immediately deep to the incision (Figure 3). A horizontal measurement was recorded for the distance of the sural nerve from the proximal aspect of the incision. Next, a vertical measurement was recorded for the depth of the neurovascular bundle at the midway point of the incision.

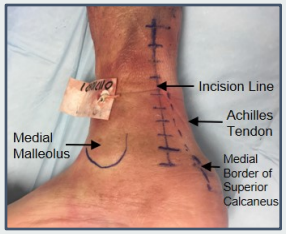

Figure 1. Modified posteromedial incision.

Literature Review

In 2000, Sigvard Hansen termed posterior pilon as a variant of posterior malleolar fractures; this was later modified by Weber, who further described this fracture pattern as an extension into the posterior colliculus, creating posteromedial and posterolateral fragments (1). A posterolateral incision is the most commonly employed surgical approach; however, damage to the sural nerve is a grave concern (1-3). Jowett et al. performed a cadaveric study in 12 legs to determine the proximity of the sural nerve and lesser saphenous vein to the posterolateral incision (3). The authors reported that in ten of 12 legs, these structures crossed over the incision at a mean distance of 56.7 mm and 61.0 mm, respectively. In four out of 12 legs, the sural nerve ran closely and parallel to the incision throughout its entire length. The exact location of where the sural nerve crosses the incision varies and the authors were unable to calculate an average measurement for this determinant. Due to the variability and risk of sural nerve injury, Jowett et al. suggest utilizing a different approach to access posterior pilon fractures.

Limitations of the posterolateral approach not only include potential iatrogenic injury to the sural nerve but also to the perforating peroneal artery (4). Furthermore, visualization and fixation of the posteromedial fragment may be hard to access due to either strong attachments from the deltoid ligament or soft tissue entrapment. To limit these potential complications, Assal et al. developed the modified posteromedial approach in 6 patients with pilon variant fractures (5). This approach provides direct visualization of the posterior tibial metaphysis and malleoli to allow for robust fixation of these structures. Wang et al. modified this approach with a transverse incision parallel to the talar neck and a vertical incision medial to the Achilles tendon (1). The incision curves above the three main branches of the posterior tibial artery using a full thickness fasciocutaneous flap to protect these structures. The authors concluded that this approach also results in adequate visualization, direct reduction, and stable fixation; all of the fractures healed at an average of 13.1 weeks without malalignment or articular step off.

In 2017, Assal et al. investigated three common approaches in 12 cadaveric legs for posterior malleolar fractures: posteromedial, posterolateral, and modified posteromedial (6). The posteromedial approach allowed direct visualization of the medial two-thirds of the posterior malleolus, but did not provide exposure of the lateral one-third. In contrast, the posterolateral approach was regarded as a safer alternative as the neurovascular bundle is protected by flexor hallucis longus (FHL); however, the Achilles and FHL created a barrier to the medial plafond. Assal et al. concluded that the modified posteromedial approach is superior to the posterolateral and posteromedial approaches not only for its direct exposure of the distal posterior malleolus, syndesmosis and fibula but also because it created the least amount of traction on the neurovascular bundle when using a strain gauge.

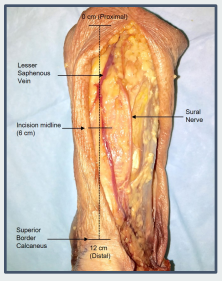

Figure 2. Relationship of sural nerve to modified posteromedial incision.

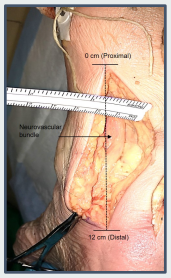

Figure 3. Relationship of neurovascular bundle to modified posteromedial incision.

Results

Subjects	Gender	Age	Laterality	Distance of Sural Nerve (cm)	Depth of NV Bundle (cm)
1	F	66	R	2.3	1.3
2	M	73	R	3	1.8
3	F	79	R	2.2	1.3
4	M	82	L	2.9	0.7
5	M	80	R	2.6	2.9
6	F	94	L	2.8	1.2
7	M	54	R	3.1	1.9
8	F	71	R	2.4	1
9	F	51	R	2.7	1.1
10	M	73	L	2.2	1.8

Table 1. Patient characteristics and data collected.

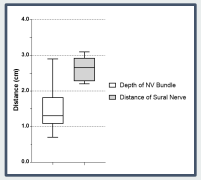

Figure 4. Relationship of modified posteromedial incision to neurovascular (NV) bundle and sural nerve.

The mean and median longitudinal distances from the sural nerve to the most proximal aspect lateral to the incision are 2.62 cm and 2.65 cm, respectively. These values range from 2.2 cm to 3.1 cm. The mean and median vertical distances from the neurovascular bundle to the proximal end of the incision are 1.5 cm and 1.3 cm, respectively. These values range from 0.7 cm to 2.9 cm. The range and average measurements are displayed in Table 1 and Figure 4, respectively.

Analysis & Discussion

Posterior approaches for posterior malleolar fractures have gained popularity compared to indirect reduction through an anterior approach due to ample exposure of the fragments for proper anatomic reduction and fixation. While a posterolateral approach is commonly implemented to gain access to both the fibula and posterior malleolus, this limits the exposure to the medial malleolus in pilon variant fractures. Despite this, a traditional posteromedial incision may not provide enough visualization to the entirety of the lateral tibial plafond, syndesmosis, and fibula. Therefore, Assal et al. developed the modified posteromedial incision to allow for greater exposure of the medial and lateral fragments (5). With incision placement, knowledge of neurovascular structures in the surrounding area is a necessity in pre-operative planning. The measurements obtained in our study, solidify the hypothesis that the modified posteromedial incision not only provides excellent visualization but also is a safe surgical approach for pilon variant fractures.

We found that the average distance of the sural nerve from the proximal aspect of the posteromedial incision was 2.6 cm as it coursed midline over the Achilles tendon. This incision presents as a safer alternative; the posterolateral approach not only limits exposure to the posterior tibial plafond but also poses as a risk to the sural nerve and lesser saphenous vein (3, 6). The mean depth of the neurovascular bundle was 1.5 cm deep to the course of the incision. Despite the bundle being directly deep to the incision, knowledge of its relation will aid in locating the structures easily so that one can place a retractor over the bundle and directly access the posterior tibial plafond.

Proper incision placement depends on the fracture pattern of the posterior malleolus, which is visualized using computed tomography for preoperative planning. Depending on whether the fracture anatomy is an isolated posteromedial or posterolateral fragment, or the more complex pilon variant pattern, incision placement plays a role for direct visualization and exposure. For a pilon variant fracture, the modified posteromedial incision is indicated not only for direct access to vital structures but also to prevent iatrogenic injury to neurovascular structures in the surrounding area.

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