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Posterior Ankle Structure Injury During Total Ankle Replacement

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A R T I C L E I N F O

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A B S T R A C T

Total ankle replacement studies have focused on reporting complications that are directly observed clinically or radiographically, including wound problems, technical errors, implant loosening, subsidence, infection, bone fractures, and heterotopic ossification. However, patients can still experience unresolved pain even when these problems have been ruled out. We initiated a study to more clearly define the relative risk of injury to the anatomic structures in the posterior ankle during total ankle replacement using a third-generation implant system. Ten fresh-frozen adult cadaveric below-the-knee specimens were positioned in the intraoperative positioning frame of an approved total ankle replacement system and adjusted to achieve proper foot alignment using fluoroscopic imaging. The relationship between the tibial cutting guide pins and the posterior neurovascular and tendon structures was measured using digital calipers. High rates of posterior structural injury were found. Nearly all proximal–medial pins encountered a posteromedial neurovascular structure, most commonly the tibial nerve. The distal–medial pins mainly encountered posteromedial tendinous structures, in particular, the flexor digitorum longus tendon. The proximal lateral pins were highly likely to encounter the Achilles tendon and the sural nerve. Our results support our hypothesis that the tibial neurovascular structures are at the greatest risk when preparing for and completing the bony resection, particularly with the medial and proximal cuts. Posterior ankle soft tissue structure injuries can occur during implantation but currently with unknown frequency and undetermined significance. Further study of posterior structural injuries could result in a more informed approach to post-total ankle replacement complications and management.

The total ankle replacement (TAR) published studies have focused on reporting the complications that can be directly observed clinically or radiographically and often require surgical remedies. These include wound problems, technical errors, implant loosening, subsidence, infection, bone fractures, and heterotopic ossification (1–8). However, a patient can still experience unresolved pain after TAR even when these problems have been ruled out. In a systematic review of the third-generation TAR outcomes data, Gougoulias et al (9) reported that the incidence of residual hindfoot pain ranged from 23% to 60% at the medium-term follow-up point. This raises the question of alternative pain generators.

One possible explanation is iatrogenic soft tissue injury in the posterior ankle. Neurologic, vascular, and tendon injuries are inherent risks of any form of total joint arthroplasty. However, in the published TAR data, they have been infrequently reported. Recent reports in upper extremity studies have indicated that nerve injury is underrecognized in the postoperative period after shoulder surgery (10–12). This could also be the case with ankle joint replacement.

The possibilities include that these injuries rarely occur, occur with subclinical or indirect effects, or are not being observed and recorded. Given the number of posteriorly directed steps involved in most TAR systems, the close proximity of neurovascular and tendinous structures to the posterior ankle joint, individual anatomic variability, and the increasing number of TAR procedures performed annually, we have come to suspect that underrecognition and thus underreporting might be possible.

In response to the paucity of scientific data on this topic, we initiated a study to more clearly define the relative risk of injury to the anatomic structures in the posterior ankle during TAR using a third-generation implant system. It was assumed that even with newer instrumentation, including captured cutting guides, and that even in experienced surgeons' hands, the inherently narrow safety margins in the posterior ankle would be most relevant at the time of preparing

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Conflict of Interest: Christopher Hyer and Gregory Berlet are consultants for Wright Medical Technology.

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for and completing bony resection. We hypothesized that the posteromedial structures, in particular, the neurovascular structures, would be at the greatest risk.

Materials and Methods

The present study was conducted entirely in a clinical skills and anatomy laboratory and was exempt from institutional review board approval. Ten fresh-frozen adult cadaveric below-the-knee specimens were selected on the basis of the absence of deformity or outward signs of previous trauma or surgery. It was unknown whether any of the donors had had foot or ankle complaints.

Each specimen was positioned in the intraoperative positioning frame of a Food and Drug Administration–approved total ankle replacement system (INBONE® II; Wright Medical Technology, Memphis, TN) and adjusted to achieve proper foot alignment using fluoroscopic imaging. An anatomically sized coupled resection cut guide was used on each specimen and localized to achieve sufficient, but the minimum necessary, bone resection (Fig. 1). All steps were performed according to the manufacturer's recommendations and specifications by surgeons with substantial experience with the INBONE® II system (Wright Medical Technology).

Four 2.4-mm Steinmann pins were placed in the 4 holes of the resection guide and were designated by position: proximal medial, distal medial, proximal lateral, and distal lateral (Fig. 2). Each pin was purposefully driven through the back of the ankle and soft tissues. The specimen was then removed from the positioning frame and flipped to the prone position. The posterior skin was reflected medially and laterally, and meticulous soft tissue dissection was performed to assess the relationships of the pins to the tibial nerve, posterior tibial artery and vein, the tibialis posterior, flexor digitorum longus, and flexor hallucis longus tendons, sural nerve, Achilles tendon, and peroneal tendons.

Our primary endpoint was direct contact between a given pin and a neurovascular or tendinous structure. Our secondary endpoint was the distance to the nearest named structure from any pin not making direct contact. Because the cutting guide constrains bone-cutting instruments to straight-line paths between the pins, the structures at risk from these instruments were inferred from the relationships of pins and named structures.

Results

The results are summarized in the Table. In general, high rates of posterior structure injury were found, including injury to >1 structure per pin in some specimens. Nearly all proximal–medial pins encountered a posteromedial neurovascular structure, most commonly the tibial nerve (Fig. 3). Distal medial pins mainly encountered posteromedial tendinous structures, in particular, the flexor digitorum longus tendon (Fig. 3). The proximal lateral pins were highly likely to encounter the Achilles tendon and the sural nerve (Fig. 4). The apparent exception was the distal lateral pin, which injured the sural nerve in 1 specimen but only passed within 3.4 ± 3.2 mm of the sural nerve in the other specimens. The peroneal tendons were consistently within the retrofibular groove and therefore were considered remote from the path of the instruments.

Fig. 1. Anteroposterior view of the ankle with the captured cut guide in position.

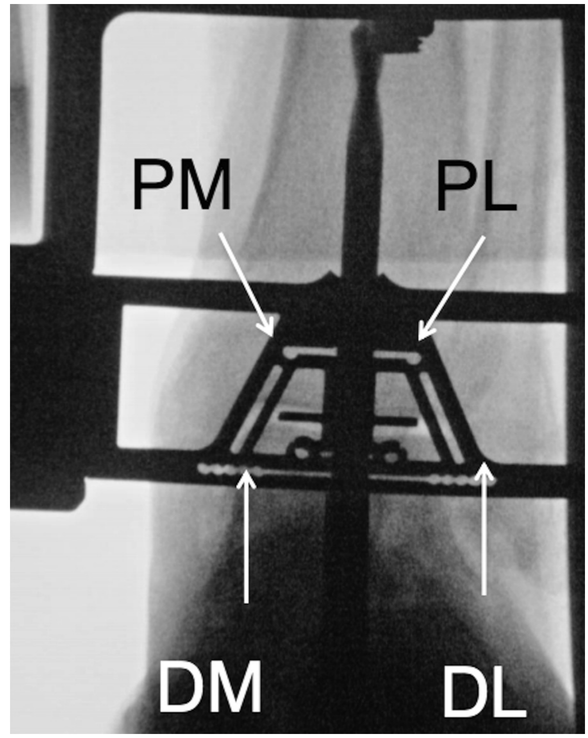

Fig. 2. Pin locations in the cut guide. DL, distal lateral; DM, distal medial; PL, proximal lateral; PM, proximal medial.

Discussion

Based on the primary outcome measure of direct contact between the pins and structures, our results support our hypothesis that the tibial neurovascular structures are at the greatest risk when preparing for and completing the bony resection, particularly with the medial and proximal cuts. Furthermore, these data indicate that if a pin or cutting tool has been errantly placed too deeply, it can reasonably be assumed that ≥1 structure was contacted.

For the present study, we intentionally drove the pins further posteriorly than would be intended in a living operation. This was done to make potential injuries evident. Our findings have affirmed the importance of meticulous surgical technique when performing TAR. Although modern systems are highly instrumented, this does not ensure protection from inadvertent injury to nearby soft tissue structures. In particular, in the proximal margins of the tibial resection, the safety tolerances are very narrow. In addition, normal anatomic variances can narrow this tolerance further.

Table
Frequency of posterior ankle structure injury by pin location

Variable	Neurovascular Structure (%)			Tendon (%)			
	TN	TA/TV	SN	FHL	FDL	TP	AT
PM	60	30	—	10	30	—	10
DM	—	20	—	—	60	20	—
PL	—	—	60	—	—	—	90
DL	—	—	10	—	—	—	—

Abbreviations: AT, Achilles tendon; DL, distal–lateral; DM, distal–medial; FDL, flexor digitorum longus; FHL, flexor hallucis longus; PL, proximal–lateral; PM, proximal–medial; SN, sural nerve; TA/TV, tibial artery/tibial vein; TN, tibial nerve; TP, tibialis posterior.