

Original Article

Ankle fusion percutaneous home run screw fixation: Technical aspects and soft tissue structures at risk

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ABSTRACT

Introduction: The objective of this cadaveric study was to identify the number of attempts necessary for a perfect positioning of the ankle fusion home run screw and the neurovascular and tendinous structures at risk.**Methods:** Eleven cadaveric limbs were used. Guidewires were percutaneously placed into the distal posterolateral aspect of the leg, under fluoroscopic guidance, with the ankle held in neutral position. Malpositioned guidewires were not removed and served as guidance for the following wires. The number of guidewires needed to achieve an acceptable positioning of the implant was noted. Neurovascular and tendinous injuries were assessed, and the shortest distance between the closest guidewire and the soft tissue structures was measured using a precision digital caliper.**Results:** Mean number of guidewires needed to achieve acceptable positioning of the implant was 2.34 (SD 0.81, range 2–4). The mean distances between the closest guide pin and the soft tissue structures of interest were: Achilles tendon 5.35 mm (SD 2.74 mm); peroneal tendons 9.65 mm (SD 5.19 mm); posteromedial neurovascular bundle 12.78 mm (SD 7.14 mm). The sural bundle was in contact with the guide pin in 5/11 specimens (45.5%) and impaled in 3/11 specimens (27.3%). The average distance from the sural nerve bundle was 3.58 mm (SD 2.16 mm).**Conclusions:** The placement of percutaneous ankle fusion home run screws is technically demanding requiring multiple attempts for acceptable placement. Important tendinous and neurovascular structures are in close proximity to the guidewires. The sural bundle was either injured or in direct contact with the guide wire in approximately 73% of the cases. When using a home run screw, a mini-open approach is recommended.**Level of evidence:** Level V, cadaveric study.

1. Introduction

Various studies have compared arthroplasty to arthrodesis and despite the increasing role of total ankle arthroplasty in the setting of ankle arthritis, there are some patients where ankle arthrodesis remains the preferred method of treatment [1,2]. An ankle arthrodesis can be performed either open or arthroscopically [3,4]. When an arthroscopic approach is used, the fusion is typically fixed with a percutaneously placed, cross screw construct [3,4].

With regards to the surgical technique, once the joint has been prepared, percutaneous screws are usually placed across the joint with various screw constructs described. Most commonly, the ankle fusion is

fixed with 2–3 cannulated screws and described constructs include parallel transmedial malleolar screws, parallel translateral malleolar screws or crossed screws [2]. Various studies have shown that 3 screw constructs are superior to those with only 2 screws [2,5,6]. Specifically, placement of the so-called percutaneous “homerun screw” from the posterolateral tibial metaphysis centrally into the talar neck has been previously described as a commonly used technique, more frequently in the US and Latin America, both to augment an open arthrodesis or as one of the three screws utilized in an arthroscopic ankle fusion construct [7–10]. As the patient is in a supine position for the arthrodesis procedure, often an ipsilateral bump under the buttock must be added or the table must be tilted to accommodate a more lateral position of

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the patient for ease of insertion.

Complications related to the placement of percutaneous ankle fusion screws can occur and often include iatrogenic injury of surrounding soft tissue structures. Injury to neurovascular structures, especially the sural nerve, have been reported in other posterior ankle procedures, at a rate reported ranging from 0–18% [11]. A study by Donley et al. similarly found that rates of injury to the sural nerve is seen related to the placement of guidewires as well as K-wires for temporary fixation in various settings such as calcaneal fractures, peroneal tendon work and placement of percutaneous fifth metatarsal screws [12]. Keeling and Schon performed a cadaveric study assessing the anatomy of the sural nerve as it relates to percutaneous screw placement in ankle fusion. In this study, the authors confirmed that the sural nerve courses close to the lateral border of the Achilles and is at risk with placement of percutaneous screws during ankle fusion as was previously described by Aktan Ikiz et al. [13,14]. In their study, after placement of a guidewire through a small incision, they dissected the surrounding area and reported no instances of direct nerve injury. The authors noted that the average distance from this guidewire was 0.9 ± 0.12 mm from the sural nerve and the average distance from the tibial nerve was 6.5 ± 0.17 mm [14]. They did not place the guidewire in a truly percutaneous fashion nor did they specify the number of attempts made to achieve an acceptable pin positioning.

It is recognized that in the hands of most surgeons, obtaining optimal positioning of a percutaneous guidewire for placement of ankle fusion screws, especially the “homerun screw”, is technically demanding and not always achieved on the first attempt. It was therefore hypothesized that although the final guidewire placed in this setting may not directly contact a nerve, in most cases, more than one attempt at guidewire placement is made and each pass represents its own risk to the surrounding neurovascular structures. The current study aimed to determine how many attempts are required to achieve an acceptable position of a percutaneous guidewire for placement of a cannulated ankle fusion “homerun screw” and further, to determine the incidence of neurovascular and neighboring soft tissue injury around the ankle joint when all guidewire placement attempts are considered as this is the most clinically relevant measure of risk in this setting.

2. Methods

For this study, eleven fresh frozen below knee cadaveric limbs were used. Given the cadaveric nature of the study, the ankle joints were not prepared for fusion. All guidewire placement and dissection were performed by a single fellowship trained foot and ankle surgeon with 16 years of clinical experience, and more than 250 ankle fusion procedures performed independently. Guidewires (3.2 mm) from the Stryker (Selzach, Switzerland) 7.0-mm headless cannulated set were percutaneously placed into the distal posterolateral aspect of the leg (Fig. 1). Under fluoroscopic guidance, with the ankle held in neutral position, the 3.2 mm guidewire was placed into the posterolateral tibial metaphysis and into the talar neck distally. Malpositioned guidewires were not removed but rather served as a guide for revising the position of the subsequent guidewires until acceptable position was obtained. No additional passes of the malpositioned wires were attempted as this would introduce additional risk to surrounding structures that would not be apparent on our dissection. For that reason, each attempt at wire passage was performed with a new wire. No redirecting of the initial attempt was performed to ensure risk to surrounding structures was minimized and each wire passed could be analyzed upon our dissection as it remained in its initial position. The number of guidewires needed to achieve an acceptable positioning of the final pin and subsequent implant was noted. Acceptable positioning of the guidewire was assessed using lateral and anteroposterior fluoroscopic views of the foot and the ankle, and defined as the wire positioned in the distal metaphysis of the distal tibia and passing through the middle third of the talar neck.

Once final guidewire placement was obtained, dissection from the posterolateral skin of the ankle to the posterior aspect of the distal tibia and talus was then performed. Local tendinous and neurovascular structures were each individually assessed for any injury. Measurements of the shortest distance between the closest guide pin and all local soft tissue structures were performed using a precision digital caliper. The term “direct contact” is used when a guidewire was found to be in contact with a structure of interest but there was no macroscopic injury seen. The term “impaled” indicates that the guidewire passed through the structure of interest. For the purposes of this study, screws were not placed over the guidewires.

Simple descriptive statistics were performed to describe the number of guidewire attempts required for optimal placement and the distance from each guidewire to each structure of interest. This included mean values, standard deviation (SD) and 95% confidence intervals (95% CI). In addition, the rate of injury to each structure under consideration was determined.

3. Results

The mean number of guidewires needed to achieve an acceptable positioning was 2.36 (SD 0.81, range 2–4). The relationship between all attempted guidewires and the soft tissue structures at risk are outlined in Table 1. The mean distances between the closest guide pin and the soft tissue structures of interest were: Achilles tendon 5.35 mm (SD 2.74 mm); peroneal tendons 9.65 mm (SD 5.19 mm); posteromedial neurovascular bundle 12.78 mm (SD 7.14 mm). The sural bundle was in contact with the guide pin in 5/11 specimens (45.5%) and impaled in 3/11 specimens (27.3%) (Fig. 2). In the remaining 3 specimens, the average distance from the sural nerve bundle was 3.58 mm (SD 2.16 mm).

4. Discussion

Ankle arthrodesis continues play an important role in the treatment of ankle arthritis. The majority of studies have reported that a three-screw construct including a “homerun screw” as previously described are optimal in this setting [7–10]. This biomechanically important and technically challenging augmenting screw is placed from the posterolateral tibial metaphysis proximally into the center of the talar neck distally. The percutaneous nature of its insertion represents a risk to local soft tissue structures. As mentioned, a previous similar study by Keeling and Schon assessed the risk of neurovascular injury with pin placement through a small incision after blunt dissection and although in close proximity, they did not report any direct injury to the local neurovascular structures in their series of 5 specimens [14]. Their study however, did not use a true percutaneous insertion of the guidewire nor did it mention specifically to how many attempts were performed until the optimal and therefore final guidewire placement was achieved. The present study found that each specimen required an average of 2.36 ± 0.81 attempts (range 2–4) to obtain optimal guidewire placement. Each of these percutaneous guidewires were left in situ to allow assessment of the level of risk to surrounding structures when all attempts are included. Each of these wires brings with it its own inherent risk to the surrounding structures which cannot be overlooked.

When all attempts at percutaneous guidewire placement were considered, the risk to local soft tissues, most notably the sural nerve was far greater than previous described in the literature. No direct contact with the Achilles tendon, peroneal tendons or posteromedial neurovascular structures were observed despite these structures being in close proximity (a mean distance of 5.35 mm, 9.65 mm and 12.8 mm respectively). The sural nerve was either injured or in direct contact with the guide wire in the majority (73%) of cases, contrary to the only other previous cadaveric study where no sural nerve contact was noted. In the cases where the sural nerve was not directly contacted or impaled, it was an average of only 3.6 mm from the closest guidewire. It is

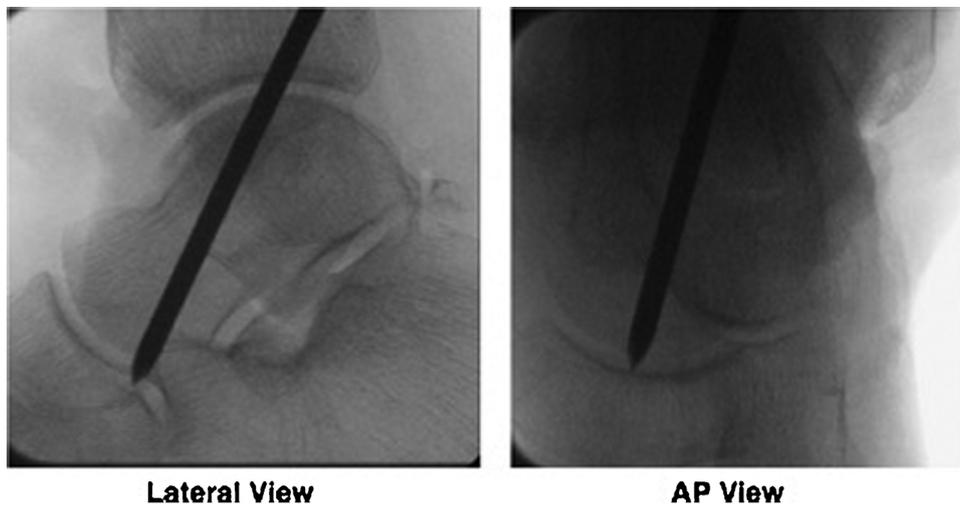


Fig. 1. Fluoroscopic and clinical images of a guidewire for the “homerun screw”. This AP and Lateral view demonstrate a 3.2 mm guidewire placed percutaneously under fluoroscopic guidance on AP and lateral view in optimal position.

important to note that these distances relate to the 3.2 mm guidewire only. When the drill and finally the 7.0 mm screw are placed over this guidewire, the distance from the surrounding soft tissues at risk becomes 1.9 mm less in every direction. This illustrates even greater risk to surrounding structures when the entire procedure is performed.

Various other studies have considered the risk to the sural nerve in percutaneous procedures such as arthroscopic ankle fusion, percutaneous Achilles repair, and arthroscopic triple fusions [15–17]. In these cadaveric studies, the sural nerve was indeed found to have a highly variable course along the posterolateral aspect of the hindfoot and a subsequent high level of risk for direct injury. A previous anatomic assessment of 30 cadaveric specimens performed by Aktan Ikiz et al. described the sural nerve typically coursing just lateral to the Achilles tendon at a level 7 cm above the distal most aspect of the fibula [13]. It is important to note however that this study and the work done by Lawrence et al found that in upwards of 21% of cases, the sural nerve in fact contacted the distal fibula rather than coursing typically 14 mm infero-posterior to it, illustrating the variability seen in different patients that needs to be considered [18].

Unlike the findings of Keeling and Schon which demonstrated no contact with the sural nerve, an unacceptably high rate of injury to the sural nerve was found in the present study. This highlights the need to perform an incision followed by blunt dissection prior to placement of any guidewire in this region as suggested by Keeling and Schon [14]. The caveat to this is that preliminary attempts at guidewire placement cannot be overlooked. Our findings support the recommendations by Keeling and Schon to optimize fluoroscopic guidance prior to any guidewire placement by placing the wire extra-corporeally over the skin, confirming its placement using fluoroscopy and marking the entry point on the skin accordingly.

Often in practice, after various attempts are made and the acceptable placement is subsequently obtained, an incision is then made over this final wire prior to drill or screw placement is completed. This

approach does not protect structures from the preceding guidewire placement. The necessity of various attempts to obtain acceptable placement was specifically shown in our study and when this factor was considered specifically, the rate of injury to the sural nerve was found to be higher than reported elsewhere in the literature. The clinical implications of this finding cannot be directly elucidated due to the cadaveric nature of this study. It is anticipated however, that in those cases where the nerve was impaled, and quite possibly in all 8 patients where the sural nerve was either injured or in direct contact with the guide wire, patients would be symptomatic. It is also anticipated that in a real clinical setting, the number of attempts to insert adequately positioned guidewires would be higher, considering the challenges regarding positioning of the patient and fluoroscopic imaging.

This study is limited due primarily to its cadaveric nature. The specimens utilized did not have any level of deformity or bony architecture changes related to underlying arthritis and in addition, the joints were not prepared for fusion. It is possible that the risk to surrounding soft tissues could differ in a clinical setting when these factors are present. As the “homerun screw” is often used in addition to other cross screws and/or a plate, it should also be considered that the lack of additional fixation in this study could pose a limitation as additional hardware may affect the exact placement of the homerun screw guidewire.

The cadaveric nature of this study also limits the clinical reproducibility of the procedure itself. As mentioned previously, the patient is often supine or in a semi lateral position to allow ease of screw insertion. The use of a below knee cadaver does not have the challenges of clinical positioning as it is far easier to position the cadaveric foot in a position most suitable to the surgeon, without the limitations of the rest of the limb. Although a larger sample of cadaveric specimens assessing this question then previously available in the literature was presented, the still relatively small number of specimens in the present study affects the ability to fully represent anatomic variability of the sural nerve

Table 1

Summary of relationship between guidewires and structures at risk in 11 specimens. Although most structures at risk were not contacted by the guidewires, the sural nerve was either injured or in direct contact with the guide wire in 73% of cases.

Anatomic structure	Mean distance (mm)	SD (mm)	Min distance (mm)	Max distance (mm)	95% CI	In contact n (%)	Transected n (%)
Achilles tendon	5.35	2.74	2.75	13.55	4.39, 9.42	0	0
Peroneal tendons	9.65	5.19	4.03	16.15	6.97, 12.33	0	0
Medial NV bundle ^a	12.78	7.14	6.2	20.56	11.20, 17.33	0	0
Sural nerve	3.58	2.16	1.61	5.90	-0.32, 2.28	5 (45.5%)	3 (27.3%)

^a NV = neurovascular, SD = standard deviation.

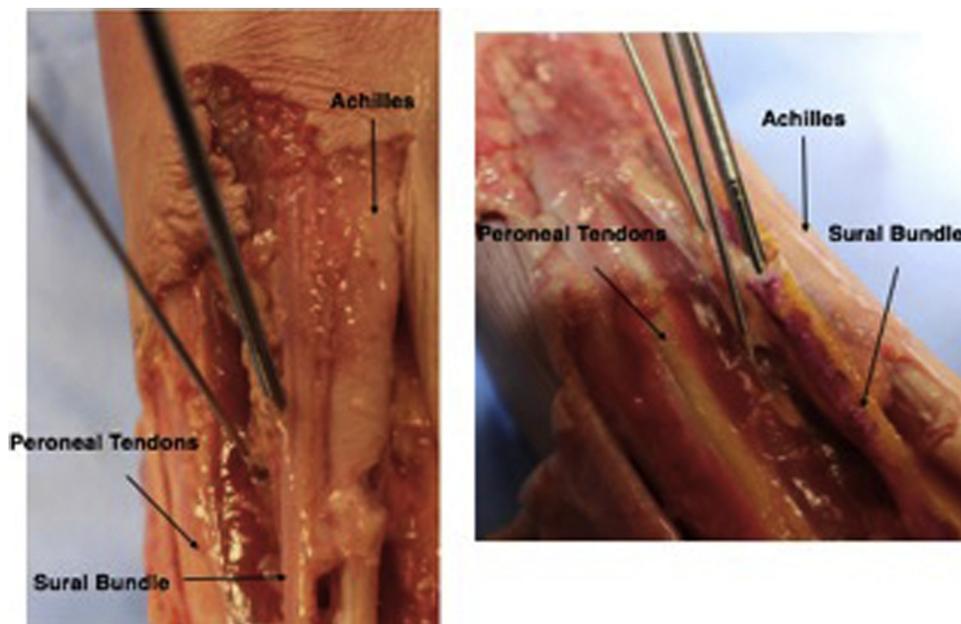


Fig. 2. Example of two specimen dissections following percutaneous placement of three guidewires. The specimen on the left required two guidewire attempts to achieve acceptable position. The second wire impaled the sural nerve. In the specimen on the right, three attempts were required, with one of the wires impaling the sural bundle.

fully within the sample.

In conclusion, the placement of a percutaneous ankle fusion home run screw often requires multiple attempts at guidewire placement. Our cadaveric study showed that important tendinous and neurovascular structures are in close proximity with the guidewire and that the sural bundle is either injured or in direct contact with the guide wire in approximately 73% of the cases. For surgeons that use the home run screw as part of their ankle fusion fixation technique, we would recommend a preliminary incision determined with fluoroscopic guidance, followed by blunt dissection should be considered prior to placement of any potential guidewires. This is preferred over performing an incision after a percutaneously placed final guidewire to be used for cannulated instrumentation or screw placement. It is recommended that all attempted guidewires are left in situ to aid in positioning of subsequent wires to both optimize attempts and reduce risks to surrounding structures. That said, all guidewire attempts, as well as the subsequent screw placement pose a risk to important soft tissue structures in this region so it is prudent to recognize this risk, plan accordingly and perform an incision prior to any guidewire attempt.

Conflict of interest

The authors for this report certify that they have no relevant affiliations or connections to any organization with any financial interest or non-financial interest in the content of this report. Further, the authors report no other conflicts of interest as it relates to this report.

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