Utilizing Magnetic Resonance Imaging to Assess Medial Neurovascular Structures at Risk with Ankle Syndesmotic Fixation

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STATEMENT OF PURPOSE

The posterior tibial neurovascular (NV) structures are relatively safe in ankle syndesmotic fixation while the greater saphenous vein and saphenous nerve are more at risk due to anatomic location at the medial tibia. Syndesmotic fixation inserted from the lateral side is intended to be placed deep to the fascia and periosteum on the medial tibia, however, drill bits, long screws, and endobuttons can easily penetrate to cause injury to the saphenous NV structures. Clamp placement and needle passers can also injure the medial NV structures and cause chronic nerve pain (Figure 1).

This study is intended to quantify the location of the saphenous NV structures in relation to standard syndesmotic fixation placement guidelines at the 2 cm and 3.5 cm levels proximal to the ankle joint.

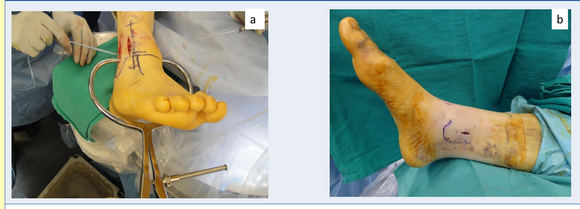
LITERATURE REVIEW

Literature regarding the saphenous NV injury in ankle fractures is limited. Kaiser et al evaluated the relative location of the saphenous NV structures as they traversed from proximal posterior to distal anterior. Using a grid system, NV structures were deemed at risk with qaudracortical screw fixation (1). Pirrozzi et al found that 11/20 or 55% of sutures buttons were inserted with some entrapment of the medial NV structures. Pirrozzi et al also found that the average distance of the button to the saphenous NV structures was 4.9 mm (2). Lehtonen et al also evaluated 10 cadaveric specimens with suture button placement and the relative risk to the saphenous NV structures. They evaluated suture buttons placed at 1, 2, and 3 cm above the tibial plafond and found the average distance to be 7.1±5.6, 6.5±4.6, and 6.1±4.2 mm respectively (3). Reb et al also looked at 10 cadaveric specimens at the same respective levels 1, 2, and 3 cm and found that 11/30 interval measurements had direct impingement on the greater saphenous vein (4).

METHODOLOGY & PROCEDURE

Retrospective review was done on 40 MRI studies in patients without history of ankle or syndesmotic injury. Axial MRI images were analyzed at 2.0 and 3.5 mm proximal to the tibial plafond to digitally measure the location of the saphenous NV structures in relation to the nearest tibial cortex and distance anterior or posterior to the tibiofibular bisection (figure 2). The respective levels were measured and the bisection of the tibia and fibula was made (figures 3, 4). The relative distance was measured from the bisection to the saphenous NV structures (figure 5). Also noted was the relative location of the saphenous NV structures anterior or posterior to the bisection (figure 6). Lastly the saphenous NV structures were measured from the nearest tibial cortex (figure 7).

Figure 1. Injury to the saphenous NV structures can occur during clamp reduction, drilling, or hardware placement

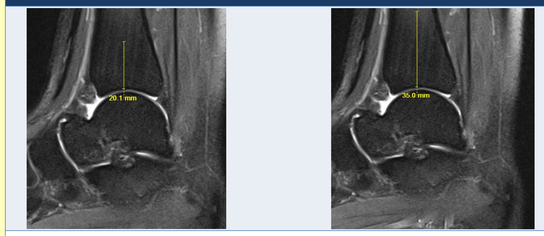


Clamp placement and passage of needle for endobutton fixation (a), can cause saphenous NV injury. Lack of medial incision or ability to palpate the saphanous NV structures due to swelling adds risk.

Figure 2. Measurement technique based on MRI in uninjured ankles

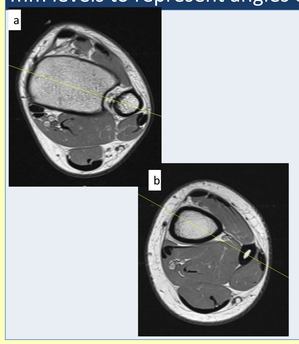
- The sagittal image is used to identify the 2.0 cm and 3.5 cm levels proximal to the tibiotalar joint (Figure 3)
- A line was made bisecting the tibia and fibula on the axial image at each respective level (2.0 cm and 3.5 cm) to represent the angle of syndesmotic fixation (Figure 4)
- The distance from the bisection to the saphenous NV structures was calculated (Figure 5, 6)
- The distance from saphenous NV structures to the nearest tibial cortex was also measured at both levels (Figure 7)

Figure 3. Measuring the distance from the tibiotalar joint



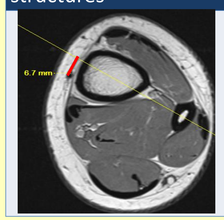
Sagittal images were used to measure 2.0 cm and 3.5 cm proximal to the tibiotalar joint which represents the typical levels of syndesmotic fixation.

Figure 4. Bisection of the tibia and fibula at the 2.0 mm and 3.5 mm levels to represent angles of screw fixation



Yellow line represents the bisection of the tibia and fibula at 2 cm proximal to the tibiotalar joint (a). This was repeated at the 3.5 cm level (b). This line represents the angle of insertion if pins, drills, and screws that have potential to harm the saphenous NV structures. Notice the difference in angles at the respective levels due to variable tibia and fibula anatomy.

Figure 5. Measuring distance from bisection to saphenous NV structures

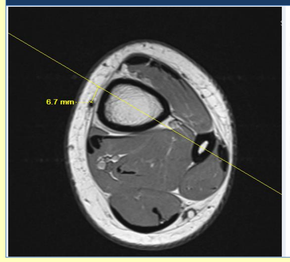


Red line represents distance of saphenous NV structures posterior to the tibiofibular bisection at the 2 cm level which measured 6.7 mm.

Table 1. Patient Characteristics

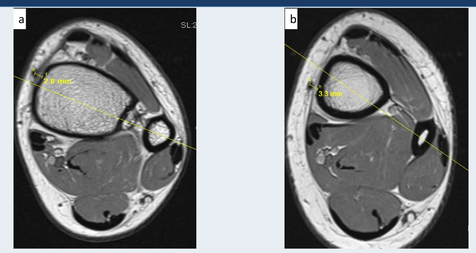
Age (Years)	52.1 ± 15.2	Range 18 – 77
Gender		
Males	14/40	35%
Female	26/40	65%

Figure 6. Locating the relative location anterior or posterior to the tibiofibular bisection



Location of saphenous NV structures were found to be either anterior or posterior depending on level above ankle joint and patient anatomy. The unpredictable location of NV structures adds risk when fixating the syndesmosis.

Figure 7. Measuring distance of saphenous NV structures to the nearest tibial cortex



The distance of saphenous NV structures to the nearest tibial cortex at 2 cm level is shown here measured digitally at 2.8 mm (a) and 3.3 mm at the 3.5 cm level above the ankle joint (b). Drill bits and long screws can easily penetrate this short distance beyond the medial cortex to cause harm.

Figure 8. Injury to the saphenous NV structures can occur during reduction, clamping, drilling, or hardware placement

Common syndesmotic hardware constructs include endobutton (a), syndesmotic screws (b), and ladder (c), each with potential for injury to the saphenous NV structures.

Table 2 . Results

Level Above Ankle Joint	Tib/Fib Bisection to NV Structures	Tibial Cortex to NV Structures
2 cm	3.1mm (0.5-11.2mm)	1.6mm (0.5-5.7mm)
3.5 cm	6.2mm (1.3-12.4mm)	2.7mm (1.3-12.4mm)

RESULTS

40 MIRI studies were evaluated in patients withouth history of anklle injury or syndesmotic injury (table 1).The average distance from the saphenous NV structures to the tibial cortex was 1.6 mm (0.5- 5.7 mm) and 2.7 mm (0.9-6.8 mm) at the 2.0 and 3.5 mm levels respectively. The average distance from the tibial / fibular bisection to the saphenous NV structures was 3.1 mm (0.5 -7.8 mm) and 6.2 mm (1.3-12.4mm) at the 2.0 and 3.5 mm levels respectively (table 2). Of note, the relative NV locations at the 2 cm and 3.5 cm levels were variable with regard to being anterior or posterior to the tibiofibular bisection (table 3).

Table 3. Relative location of saphenous NV structures in comparison to tibiofibular bisection

Level	Posterior	At Bisection	Anterior
2 cm	24/40 (60%)	9/40 (23%)	7/40 (17%)
3.5 cm	38/40 (95%)	1/40 (2.5%)	1/40 (2.5%)

ANALYSIS & DISCUSSION

Insertion of syndesmotic fixation often involves clamping, piercing or penetrating the soft tissue and bone on the medial aspect of the tibia with drills, needles, and fixation devices (figure 8). This is usually done without direct visualization since there is often no medial incision. The results of this study suggest that the saphenous nerve and vein are at risk of injury in syndesmotic fixation. As previously mentioned, Pirozzi et al found entrapment of medial neurovascular structures to be has high as 55% in cadavers undergoing suture button fixation. Pirrozzi also found a similar average of 4.6 mm from NV structures to the suture button. Reb et al found that 36% of their specimens had direct entrapment of the saphenous vein. These NV structures are oftentimes not palpable or visible following ankle trauma and therefore surgeon awareness is the most important factor to minimize injury. Recommendations include pre-tourniquet vein marking, nerve palpation prior to incision or clamp placement, controlled depth drilling when penetrating the medial cortex, attention to screw length, and avoid penetration of the medial endobutton thru the periosteum. Short comings include lack of anatomical dissection in this MRI review or comparison of actual screw placement at the 2.0 or 3.5 cm levels.

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