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Radiographic monitoring of the distal insertion of the calcaneofibular ligament in anatomical reconstructions of ankle instabilities: A preliminary cadaveric study

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ABSTRACT

Background: The purpose of the study therefore was to determine radiographic landmarks that support the identification of the insertion site of the distal calcaneofibular ligament (CFL) in anatomic ankle ligament reconstructions.
Methods: In 10 lower limb cadaver specimens the midpoint of the distal CFL insertion was dissected and marked with a nail inserted orthogonally. On a standardized lateral radiograph in neutral ankle position a horizontal tangent was aligned to the deepest visible concavity of the tarsal sinus and one vertical tangent to the farthest posterior convexity of the talus. Additionally, a line was drawn from the radiographically marked distal CFL to the fibular insertion of the CFL to determine the CFL–fibular angle.
Results: In relation to the radiographic tangents intersection the mean deviation of the depicted CFL nails was 2.2 mm [SD ±1.1 mm] leading to an angular, circular to slightly oval 6 mm insertion. The scatter-plot of the marked positions convened along a line from the supposed fibular CFL insertion to the intersection in all cases. The mean CFL–fibular angle was 131.7° [SD ±3.16°].
Conclusions: Determining a virtual intersection between a horizontal tangent aligned to the deepest visible concavity of the tarsal sinus and one vertical tangent aligned to the farthest posterior convexity of the talus on a standardized lateral radiograph in neutral ankle position supports an anatomic insertion of the distal calcaneofibular ligament most probably.

1. Introduction

Inversion injuries of the ankle affecting the lateral ligament complex are one of the most common injuries in sports as well as in everyday life [1].

Therefore, scientific research on the diagnosis and treatment of ankle sprains is of great interest and it is widely accepted that non-surgical conservative functional treatment is the favoured treatment strategy in case of injury [2]. Nonetheless, functional impairment, pain or even chronic ankle instability is frequent long-term consequences following inversion injuries in 20–40% of patients [3–5]. If recommended initial non-operative treatment of chronic instability fails and if appropriate ligamentous laxity is detected, surgical stabilization of the ankle may be required to regain stability and joint function by mechanical means [5].

Numerous operation techniques for surgical repair have been described, which basically differ depending on the soft tissue prerequisites [5]: anatomical direct repair with endogenous ligament tissue if adequate tissue is present [6–8], non-anatomic tenodeses reconstruction [9,10] and anatomic reconstruction using different types of various tendon graft [1,3,11–16]. The primary goal of all surgical procedures is to restore mechanical stability without altering physiological hindfoot kinematics [17]. However, anatomy, especially of the distal calcaneofibular ligament, varies from tunnel placements in popular elder recommended procedures [9,6] as well as newer graft reconstruction procedures [12–16]. In reference to this, it is well known that non-anatomic reconstruction procedures may result in inversion restriction [9,17–20], of which even small limitations may influence a normal gait cycle on uneven terrain or may restrict a certain clientele, e.g. athletes [18]. In contrast, anatomical reconstructions seem capable of

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replicating ankle isometry [1,17,21], which has led to a clear recommendation in favour of anatomical reconstruction procedures [11,21], especially if tenodeses or graft augmentations are performed.

However, insertion site and subsequent graft positioning has been described to depend on the presence of indigenous ligament tissue [1], bony landmarks, the surgeons experience or an approximated evaluation upon angles and distances [3,18,22]. Nevertheless, many physicians cannot rely on precise anatomic points for CFL attachment when reconstructing the ligament [18].

Whereas the fibular insertion of the anterior tibiofibular ligament (ATFL) and the calcaneofibular ligament (CFL) has clear identifiable landmarks (osteocartilaginous junction of the fibula, fibular tip), the original site for the distal CFL is vague and may intraoperatively not always be easily identifiable [18]. This is particularly because the peroneal tendon sheaths cover almost the entire ligament and its distal insertion (Fig. 1) [22]. Hence, postoperative controls often reveal a variety of suboptimal tunnel placements, partially severely misplaced.

Therefore the aim of the present study was to determine radiographic landmarks that support the identification of the anatomical insertion site of the CFL in reconstruction procedures. The hypothesized radiographic algorithm could serve as an intraoperative guideline for correct guide wire placement.

2. Materials and methods

Ten lower limb cadaver specimens, harvested 12 cm above the knee joint, were used from eight female and 2 male donors (Ø age: 81 years). The specimens were stored at −20 °C and thawed at room temperature for 12 h before testing. Specimens were then dissected, removing the subfibular fat and excising the peroneal retinaculum. The anterolateral ankle ligaments (ATFL, CFL) were then dissected with a main focus on accurate exposure of the distal insertion of the CFL.

The centre of the osteoligamentous junction of the distal calcaneofibular ligament insertion was then identified and exhibited. Subsequently the centre was marked with a nail inserted orthogonally (nail length 2 cm, Ø nailpoint: 1 mm, Ø nailhead: 3 mm) into the calcaneus (Fig. 2). A standardized lateral radiograph using an image intensifier (GE OEC Fluorostar 7900, GE Healthcare Systems, Buckinghamshire, Great Britain) was taken of each ankle in neutral position (0° dorsiflexion, 10–15° internal rotation). Corresponding to radiographic guidelines [23], special attention was given to achieve a right angle between the lower leg and the foot sole. Furthermore it was paid attention to achieve an accurate coplanar exposure of the distal tibial and talar joint surfaces, as well as to project the medial and lateral malleolus upon each other. Beyond radiographic guidelines, we positioned the fibula not only in the mid or dorsal third of the tibia [23] but exactly upon the mid third of the tibia.

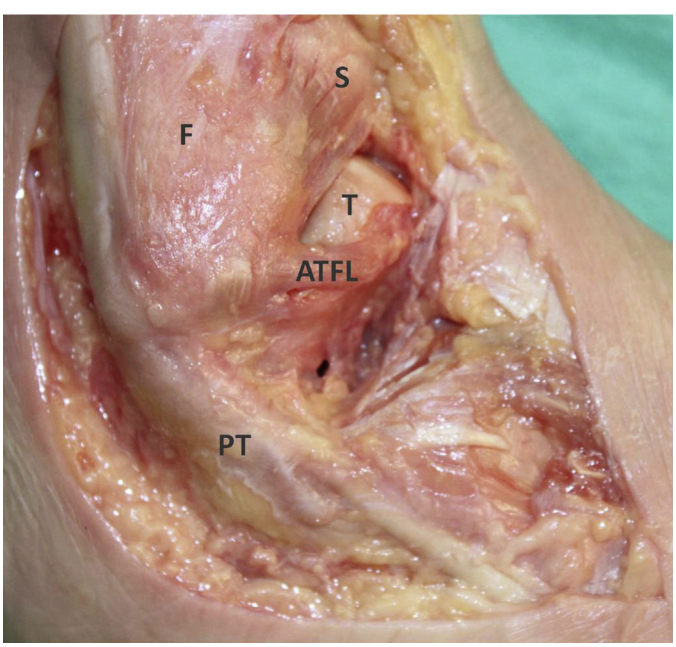

Fig. 1. Dissected specimen, right side, lateral view lateral (F: fibula, S: syndesmosis, T: talus, AFTL: anterior talofibular ligament, PT: peroneal tendons).

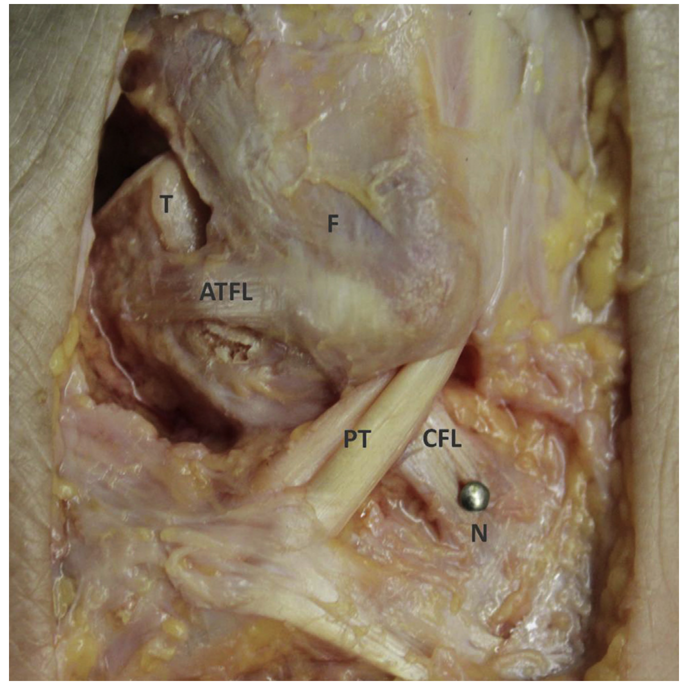

Fig. 2. Dissected specimen with marked distal CFL, left side, lateral view (N: mark-nail, F: fibula, T: talus, AFTL: anterior talofibular ligament, CFL: calcaneofibular ligament, PT: peroneal tendons).

In congruence to preliminary anatomical considerations in all radiographs one horizontal line was digitally aligned to deepest visible concavity of the tarsal sinus and one vertical line to the farthest posterior convexity of the talus, irrespective of the shape of the posterior talar process (Fig. 3).

Additionally, we drew a line from the radiographically marked distal CFL to the fibular insertion of the CFL, centred 8 mm from the distal fibular tip [3,18]. Corresponding to Burks and Morgan [18], we determined the angle between the posterior cortex of the fibula and the line between the marked distal CFL insertion and the fibular CFL insertion (CFL–fibular angle, Fig. 4).

The study was approved by the Institutional Review Board.

3. Results

After dissection, all ten harvested specimens showed normal, uninjured ankle ligament anatomy, especially of the CFL, and could thus be used for the study. All radiographs were taken in the same manner.

Drawing a vertical tangent line from the posterior convexity of the talus and a perpendicular tangent line from the deepest visible concavity of the tarsal sinus, a 6 mm diameter zone around the intersection most frequently depicted the distally marked CFL insertion (Fig. 3). Mean deviation of all depicted nails around the crossing tangents was 2.2 mm [SD ±1.1 mm], all single values are shown in Table 1. Eight of ten nails where depicted within a circular 6-mm diameter zone (radius 3 mm) around the intersection of the