

# An anatomical study about the arthroscopic repair of the lateral ligament of the ankle



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## ABSTRACT

**Background:** The purpose of this anatomical study was to determine the relationship of the structures involved in the arthroscopic repair of the anterior talofibular ligament.

**Methods:** Dissection of fifteen lower leg cadaveric specimens was made and distances in the anterior direction from the reference-point at the lateral malleolus origin of the anterior talofibular ligament were measured, to the talar insertion of the ligament, to the superficial peroneal nerve at 60° and 90° in relation to the lateral malleolus axis in the sagittal plane, and to the inferior extensor retinaculum.

**Results:** The mean ± SD distance to superficial peroneal nerve from the reference-point was 25 ± 6 (range 17–35) mm at 60°, and 32 ± 9 (range 24–48) mm at 90° in relation to the lateral malleolus axis. The mean ± SD distance to the inferior extensor retinaculum was 20 ± 5 (range 14–29) mm. The mean ± SD length of the anterior talofibular ligament was 21 ± 4 (range 13–29) mm.

**Conclusions:** The superficial peroneal nerve demonstrated the greatest variance in its anatomy. An accessory incision to include the inferior extensor retinaculum in the repair should not surpass the 22 mm distance from the lateral malleolus in the anterior direction, due to the risk of damaging the nerve.

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## 1. Introduction

Ankle sprains are one of the most common sports related injury. Around 80% of the sprains are related to the anterior talofibular ligament (ATFL), while the remaining 20% affect both the ATFL and calcaneofibular ligament (CFL). Rarely, the posterior talofibular ligament is involved [1].

Most ankle sprains recover fully with non-operative treatment but 20–30% develop chronic ankle instability [2]. Mechanical instability is due to the laxity caused by ligaments tears and poor healing, whereas functional instability is due to proprioceptive and muscular deficits after ankle sprain. Nevertheless they often occur as a combination [3].

The classic Broström procedure is a repair of the lateral ligaments including the ATFL and the CFL, frequently associated with a proximal advancement of the inferior extensor retinaculum (IER), the Gould modification. This remains the first-line procedure

for patients with chronic lateral ankle ligament laxity requiring surgical treatment.

The long-term results of the non-anatomic reconstructions of the lateral ankle ligaments revealed an increased incidence of degenerative changes in the hind foot, and its use have decayed in favor of other procedures [2].

Anatomic reconstruction with tendon graft or transfer procedures require precise placement and tensioning of the graft. Failure to achieve this may alter the biomechanics of the joints resulting in joint loading alterations. Generally these types of procedures have been reserved for patients who have failed a prior Broström-Gould repair or patients who may stress their ankle to a greater degree than normal (high body mass index, heavy labor occupation, sports requirements, or congenital ligament laxity) [2].

Studies have reported a high incidence of intra-articular pathology associated with chronic ankle instability and some recommend an ankle arthroscopy simultaneously when a surgical repair is chosen [4–6].

Moreover, several arthroscopically assisted or minimally invasive surgery procedures to achieve lateral ankle stabilization have been described in the orthopedic literature in recent years.

The first arthroscopic repair technique was reported in 1987, and consisted in the use of staples as a fixation method [7]. In

Abbreviations: ATFL, anterior talofibular ligament; CFL, calcaneofibular ligament; IER, inferior extensor retinaculum; SD, standard deviation.

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another technique described a bone tunnel was used but without a clinical analysis [8].

The majority of the minimally invasive procedures performed nowadays require a suture anchor fixation. In general, they have in common the exposure of the anatomic origin of the lateral ligaments on the distal fibula followed by placement of one or more suture anchors into the fibula. They differ in the passage of the sutures through the ATFL, CFL, and retinaculum to affect a repair/augmentation procedure. Although there has been an increasing number of techniques described, only eleven papers with clinical results have been published in English literature [9–19], presented in Table 1.

These studies appear to show good results with short-term follow-up, in spite of having a high rate of complications in some series, ranging from 0 to 36%. Iatrogenic damage to the superficial peroneal nerve (SPN) is frequently reported.

The techniques used standard anterolateral and anteromedial portals for the anterior ankle arthroscopy and placement of the anchors. Most authors also described an accessory incision ranging 10–20 mm anterior to the tip of the lateral malleolus to pass the sutures through the ATFL and the IER.

The anterior talofibular ligament is closely related to the ankle joint capsule and is typically composed of one, two or three separate bands. It originates at the anterior margin of the lateral

malleolus, and its center is on average 10 mm proximal to the tip of the fibula as measured along the axis of the fibula, with an overall width of 6–10 mm. Runs in an anteromedial direction into its insertion on the talar body immediately anterior to the joint surface, being virtually horizontal to the ankle in the neutral position [20]. The fibular obscure tubercle was described previously as a tubercle anterior to the apex of the fibula, and its utility as a landmark is not clear [21]. The inferior extensor retinaculum is a thickened portion of the sural fascia, with a X or Y shape. An attachment of the IER to the fibular periosteum can function in a role similar to that of the calcaneofibular ligament (CFL) in stabilizing the subtalar joint, although this theory has been questioned [22].

Proper anatomic knowledge is important for a correct surgical treatment. There are several studies already published that make a description of the branch variation of the superficial peroneal nerve or its relation to the anterior ankle arthroscopic portals [23,24].

Nonetheless we believe that a more directed study for the repair of the ATFL through mini-invasive procedures can be useful, than just for the anterior arthroscopy of the ankle in general. Additionally, more accurate information is obtained from the calculation of the distances to an palpable and identifiable landmark.

**Table 1**  
Studies of anterior talofibular ligament arthroscopic repair with suture anchors.

Study (year)	No. of ankles	Mean age in years (range)	Mean follow-up in months (range)	AOFAS score <sup>a</sup>		Complications (no. of ankles)
				Pre-op	Post-op	
Corte-Real and Moreira [9]	28	33 (15–54)	28 (6–48)	NA	85 (65–100)	Delayed wound healing (3) Superficial peroneal nerve numbness (3 [1 persistent]) Additional acute ankle sprain (2) Deep venous thrombosis (1) Total 32% (9)
Nery et al. [10]	38	29 (15–53)	118 (72–168)	NA	90 (44–100)	No complications (2 ankles with low AOFAS score <sup>a</sup> , 44 and 47).
Kim et al. [11]	28	39 (22–55)	16 (13–25)	61 ± 16	92 ± 6	Portal-site irritation (4) Superficial infection (1) Prominent asymptomatic suture knots (3) Additional acute ankle sprain (2) Total 36% (10)
Vega et al. [12]	16	29 (17–46)	29 (17–46)	67 (59–77)	97 (95–100)	Delayed wound healing (1) Superficial infection (1) Total 13% (2)
Cottom and Rigby [13]	40	46 (15–83)	12 (6–21)	41 (23–64)	95 (84–100)	Deep venous thrombosis (1) Neuritis of intermediate dorsal cutaneous nerve (1) Distal fibular fracture (1) Total 8% (3)
Labib and Slone [14]	14	NA	3 (2–14)	NA	93 (80–100)	No complications
Acevedo and Mangone [15]	73	35	28	NA	NA	Recurrent instability (1) Persistent pain (3) Neuritis (5) Total 12% (9)
Matsui et al. [16]	19	28	12	NA	NA	Numbness of the superficial peroneal nerve (2) Total 11% (2)
Yoo and Yang [17]	63	NA	6	67 ± 15	97 ± 5	Inversion deficit of 10° (3) Neuritis of the intermediate dorsal cutaneous nerve (2) Total 8% (5)
Yeo et al. [18]	(W/internal brace) 22 25	35	12	66 ± 22 68 ± 2	98 ± 17 90 ± 2	Inversion deficit of 10° (2) Total 9% (2) Superficial peroneal nerve injuries (2) Sural nerve injury (1) knot pain (2) Total 20% (5)
Cottom et al. [19]	45	45 (16–75)	14 (12–20)	49 ± 3	95 ± 4	Superficial infection (3) Total 7% (3)

<sup>a</sup> American Orthopedic Foot and Ankle Society score.

With this in mind, the purpose of this anatomical study was to determine the relationship of relevant structures in the lateral region of the ankle to the origin of the ATFL in the lateral malleolus. In particular the distances to the SPN and the IER, therefore providing a better approach to minimally invasive procedures to ATFL repair.

## 2. Materials and methods

Fifteen lower legs amputated from below the knee were obtained from fresh frozen cadavers of white origin (eight right and seven left). The age and conditions of the specimens were not known. After screening, no deformities, pre-existing scars and other pathologies that could alter the anatomy were found.

All the cadaveric studies were performed at University of Barcelona in Catalonia, Spain, with all specimens being obtained from the body donation program of this University.

The specimens were laid on their medial surface, maintaining the ankle in neutral position. An exposure of the lateral structures of the ankle was made, with a careful dissection of the cutaneous and subcutaneous fat tissue. The superficial peroneal nerve and IER were identified and avoided. Then a window was created in the sural fascia, posterior to the IER, to allow visualization of the ATFL and CFL (Figs. 1 and 2).

The number of ATFL bands (single, double or triple) was noted. As described in previous studies, we considered a band as a collection of fascicles separated by a interval that would allow the passage of vascular branches [20,25].

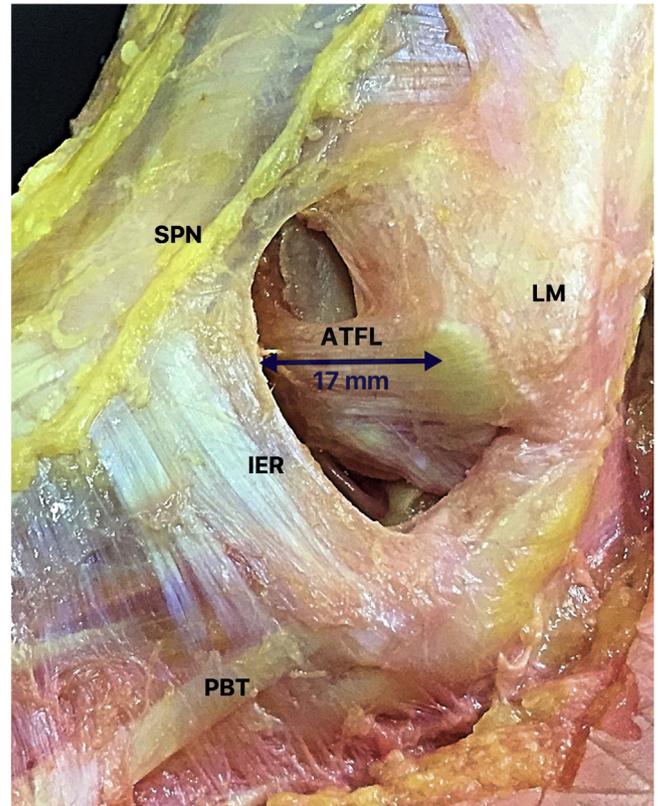
The measurements were made with the reference-point at the peroneal origin of the ATFL, in the middle of its width (10 mm from the tip of the lateral malleolus), or the center of the most superior bundle when the ATFL had multiple bundles.

The following distances were measured:

- The distance from the ATFL origin center to the superficial peroneal nerve was measured at 60° and at 90° in relation to the



**Fig. 1.** Lateral view of the the position of a left ankle in neutral, with a superficial dissection of the lateral structures. ATFL – anterior talofibular ligament; SPN – superficial peroneal nerve; IER – inferior extensor retinaculum; LM – lateral malleolus.



**Fig. 2.** Lateral view of a left ankle, with a superficial dissection of the lateral structures. ATFL – anterior talofibular ligament; SPN – superficial peroneal nerve; IER – inferior extensor retinaculum; LM – lateral malleolus; PBT – peroneus brevis tendon. The arrow shows the distance from the ATFL origin center to the IER.

axis of the lateral malleolus in the sagittal plane. The 60° angle was chosen to measure the distance in a direction adjacent to the anterolateral portal. The measurement in the 90° angle was in the direction of the accessory incision, anterior to the lateral malleolus, made to pass the sutures in the arthroscopic repair techniques.

- The distance from the ATFL origin center to the IER at 90° in relation to the axis of the lateral malleolus in the sagittal plane.
- The length of the ATFL from its lateral malleolus origin center at the talar insertion center was measured.

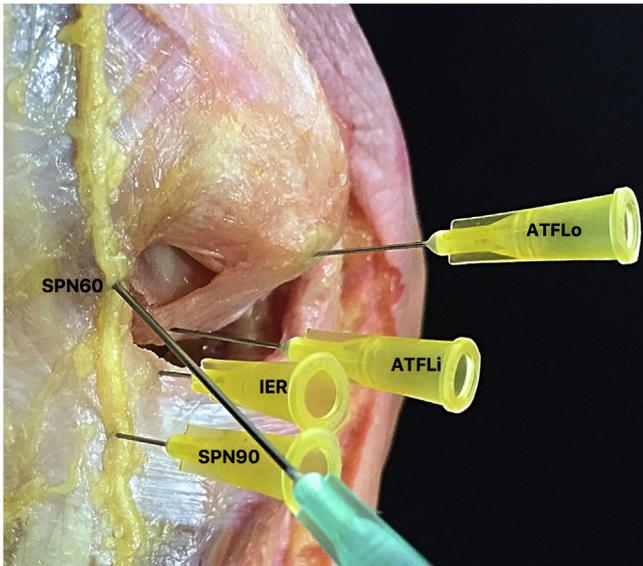
The points of measurement were marked with a needle and a ruler was used (Figs. 3 and 4). The dissections and measurements were accomplished by two independent researchers (Authors 1 and 2).

## 3. Results

The superficial peroneal nerve demonstrated the greatest variance in its anatomy, as the position of its course was very variable, especial at 90° in relation to the axis of the lateral malleolus. The mean  $\pm$  SD distance from the ATFL origin center was of  $25 \pm 6$  (range 17–35) mm at 60°, and  $32 \pm 9$  (range 24–48) mm at 90° (Table 2).

The distance from the ATFL origin center to the IER was less variable than the SPN at 90° in relation to the axis of the lateral malleolus, with a mean  $\pm$  SD of  $20 \pm 5$  (range 14–29) mm.

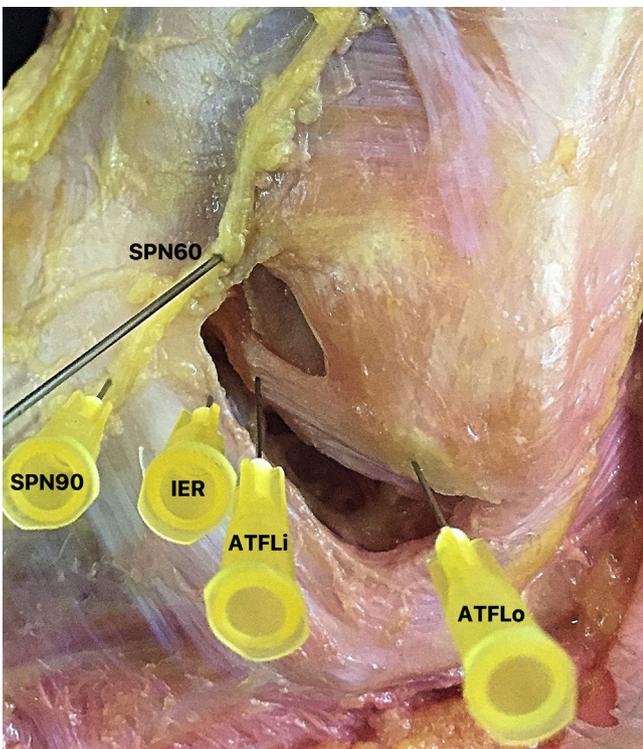
In relation to the morphology of the ATFL, nine of the fifteen (60%) specimens had single-band pattern, and six (40%) specimens had double-band pattern. There were no triple-band pattern specimens (Figs. 5 and 6). We noted that the intersection of the



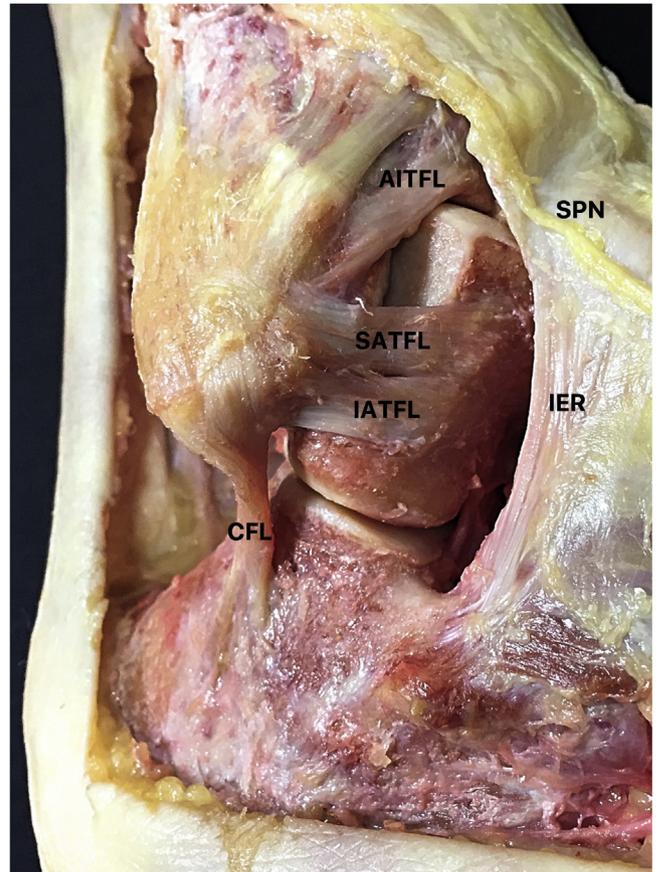
**Fig. 3.** Proximal view of a left ankle, with the placement of the needles to perform the measurements. ATFLo – anterior talofibular ligament origin; ATFLi – anterior talofibular ligament insertion; IER – inferior extensor retinaculum; SPN90 – superficial peroneal nerve at 90°; SPN60 – superficial peroneal nerve at 60°.

ATFL and CFL was near the fibular obscure tubercle, but with some variation on its direction, and apparently more associated to the ATFL origin. Furthermore, we found in four cases (27%) an expansion of ligament tissue between the ATFL and CFL (Fig. 8).

The measurement of the ATFL from its lateral malleolus origin center at the talar insertion center was the more consistent, with a mean ± SD length of 21 ± 4 (range 13–29) mm.



**Fig. 4.** Lateral view of a left ankle, with the placement of the needles to perform the measurements. ATFLo – anterior talofibular ligament origin; ATFLi – anterior talofibular ligament insertion; IER – inferior extensor retinaculum; SPN90 – superficial peroneal nerve at 90°; SPN60 – superficial peroneal nerve at 60°.



**Fig. 5.** Anterolateral view of an extensive dissection of the lateral ligaments in a right ankle. SATFL – superior band of the anterior talofibular ligament; IATFL – inferior band of the anterior talofibular ligament; CFL – calcaneofibular ligament; AITFL – antero-inferior tibiofibular ligament; SPN – superficial peroneal nerve; IER – inferior extensor retinaculum.

**4. Discussion**

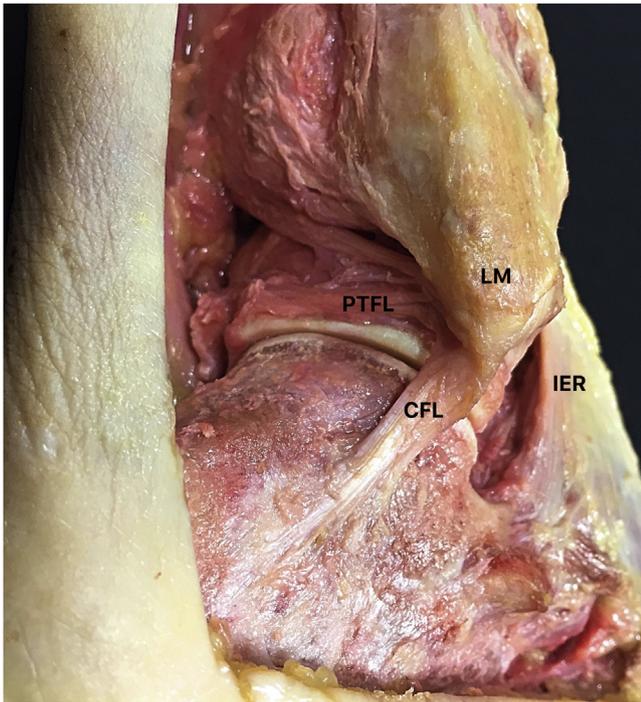
The lesion of the superficial peroneal nerve is an important cause for complications in arthroscopic ATFL repair. At 60° in relation to the axis of the lateral malleolus, in a location near the anterolateral portal, the mean distance from the ATFL origin center

**Table 2**

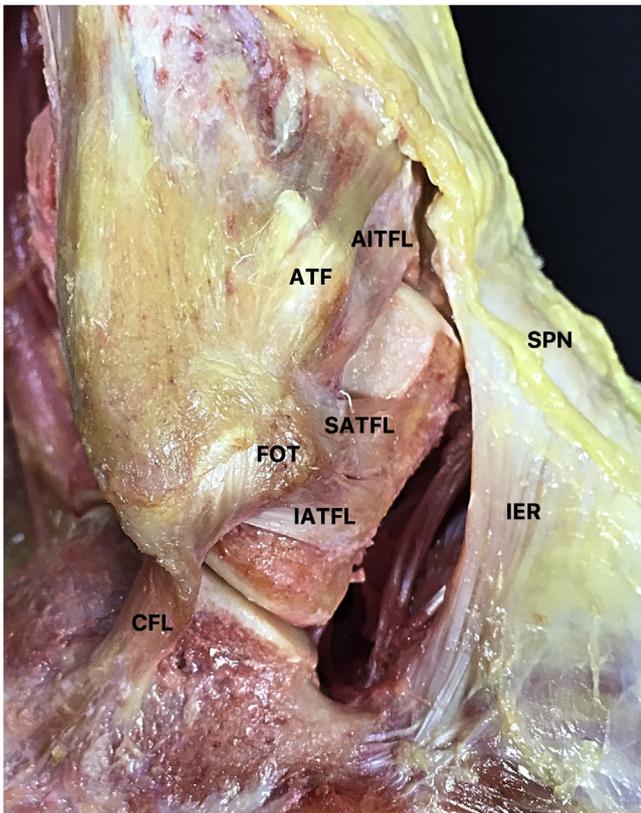
Measurements of the distance from the origin of the anterior talofibular ligament (mm).

Specimen	SPN 60°	SPN 90°	IER	ATFL
1	27	34	15	13
2	31	43	28	19
3	28	48	18	22
4	17	24	20	23
5	22	29	19	23
6	32	43	21	25
7	21	25	20	24
8	20	25	14	19
9	34	46	29	20
10	35	37	23	24
11	25	28	20	29
12	24	26	16	20
13	21	24	14	17
14	22	27	17	18
15	22	26	22	18
Mean ± SD	25 ± 6	32 ± 9	20 ± 5	21 ± 4
Range	17–35	24–48	14–29	13–29

SPN – superficial peroneal nerve. IER – inferior extensor retinaculum. ATFL – anterior talofibular ligament. SD – standard deviation.



**Fig. 6.** Posterolateral view of an extensive dissection of the lateral ligaments in a right ankle. LM – lateral malleolus; CFL – calcaneofibular ligament; PTFL – posterior talofibular ligament; IER – inferior extensor retinaculum.



**Fig. 7.** Lateral view of an extensive dissection of the lateral ligaments in a right ankle. SATFL – superior band of the anterior talofibular ligament; IATFL – inferior band of the anterior talofibular ligament; CFL – calcaneofibular ligament; AITFL – antero-inferior tibiofibular ligament; SPN – superficial peroneal nerve; IER – inferior extensor retinaculum; FOT – fibular obscure tubercle; ATF – anterior tubercle of the fibula.

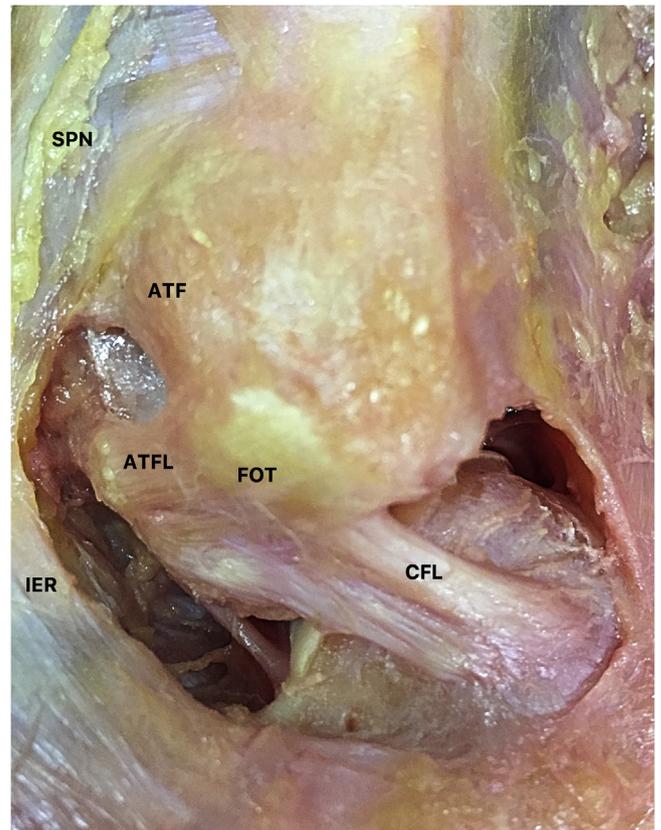
was 25 mm, but there was a wide range of distances from 17 to 35 mm. The nerve lateral excursion should also be taken in account when placing the anterolateral portal [26]. We hypothesize that a more lateral position of the portal, lateral to the SPN, could be advised in order to avoid damage with the placement of the portal or passing of subcutaneous sutures.

Furthermore, most of the mini-invasive repair techniques describe an accessory incision, anterior to the tip of the lateral malleolus. At 90° in relation to the axis of the lateral malleolus, the mean distance of the SPN from the ATFL origin center was 32 mm. But this distance had the highest standard deviation (9 mm) and a range of 24–48 mm. This variability and the difference of 24 mm in the range creates uncertainty and increases the risk of nerve damage when placing an accessory incision. Probably, a more distal position of this decreases the risk of damage, as the nerve runs further anterior.

In addition, an augmentation of the repair of the ATFL with the IER is frequently made with the passage of one of the sutures subcutaneously in a location anterior to the lateral malleolus.

The average difference between the distance of the SPN and the IER from the ATFL origin at 90° in relation to the axis of the lateral malleolus was 13 mm, and the minimal distance observed was 4 mm. So the incorporation of the IER in the repair without direct visualization can cause lesion to the SPN, either by entrapment or irritation by prominent suture knots.

The IER anatomical variability and its resistance to proximal mobilization toward the ATFL origin as led to the hypothesis that, in most cases, the structure used to reinforce the ATFL repair is not the IER itself, but the sural fascia [27].



**Fig. 8.** Lateral view of an extensive dissection of the lateral ligaments in a left ankle. ATFL – anterior talofibular ligament; CFL – calcaneofibular ligament; SPN – superficial peroneal nerve; IER – inferior extensor retinaculum; FOT – fibular obscure tubercle; ATF – anterior tubercle of the fibula.

In our study the delimitation of the borders of the IER was not clear in some cases, as this structure is a continuous of the sural fascia. Nonetheless it was less variable than the SPN, the mean distance  $\pm$  SD to the ATFL origin center was  $20 \pm 5$  (range 14–29) mm.

Most authors use an accessory incision 10–20 mm anterior to the tip of the lateral malleolus in order to pass a suture through the IER. Between these limits, we agree with the proposition that in some cases the augmentation is made with the sural fascia and not the IER. Moreover, its mobilization to lean it to the malleolus seemed difficult, because it was not a very elastic structure in our observation [27].

Since the superior band of the ATFL probably restricts inversion in plantarflexion, the most common position of the foot at the time of injury, it may be the more important of the bands [28], and that is the reason why we choose to measure this band when there were multiple bands. In our work there was no triple-band ATFL observed, and in fact, it seems a less frequent anatomic variant [20,25]. Nevertheless, in the review of the articles presented in Table 1, the morphology of the ATFL was not a factor taken into consideration when deciding the type of repair [9–19].

The fibular obscure tubercle was recently reported as landmark to assist mini-invasive procedures to treat chronic ankle instability, as it was near the intersection of the ATFL and CFL [29]. In our study the fibular obscure tubercle was present in most of the specimens, but its location was more related to the center of the ATFL origin than the intersection of the ATFL and CFL. Nonetheless this is an observational opinion, as measures were not made (Figs. 7 and 8). In some specimens (four) there was a small expansion of ligament tissue between the ATFL and the CFL, but the inconsistency of this finding makes a theoretical tensioning of the CFL by repair of the ATFL implausible. We found a mean length of 21 mm of the ATFL, similar to other results described in the literature [30].

The extrapolation of the results to living tissue is an inherent limitation of the present cadaver study. Moreover, it does not take into account a possible anatomical distortion in an ankle with chronic instability.

In conclusion, the treatment of chronic ankle instability through minimally invasive techniques, namely with suture anchors, has some risk of complications. Most of these seem to be linked to the close anatomic relations between the structures involved, and the variability of the SPN.

In the techniques where an accessory incision is made to include the IER in the repair, the more anterior the placement, the better the chance to incorporate the IER itself than the sural fascia. But this should not surpass the 22 mm distance from the lateral malleolus due to the risk of damaging the SPN, according to our results.

### Conflict of interest

The authors declare that they have no conflict of interests.

### Authors contribution

All authors were fully involved in the study and preparation of the manuscript. This material has not been and will not be submitted for publication elsewhere.

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