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ORIGINAL PAPER

Sonographic visibility of the main posterior ankle ligaments and para-ligamentous structures in 15 healthy subjects

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Abstract

The present article describes the ultrasound (US) appearance of ligaments and paraligamentous structures which are not included in standard US imaging of the ankle: the posterior inferior tibiofibular ligament (PITFL), the transverse tibiofibular ligament (TTFL), the posterior talofibular ligament (PTFL), the posterior intermalleolar ligament (PIL), the synovial recess (SR) of the posterior joint and the os trigonum (OT). Two skilled operators examined 15 ankles in 15 healthy volunteers. Correlation between thickness of the main ligaments and body mass index (BMI) was also analyzed. Compound and tissue harmonic imaging (THI) were carried out using 12-, 6–15- and 9-MHz linear probes. Exploration of the posterior ankle ligament complex is accurately described including correct ankle position, echogenicity, shape, direction and thickness. Both operators identified and measured the main ligaments (PITFL, TTFL and PTFL) in all volunteers (Intraclass Correlation Coefficient ranged from 0.8 to 1); both operators also detected SR and OT in 2/15 ankles and posterior intermalleolar ligament (PIL) in 5/15 ankles. Pearson's test showed a significant correlation (<0.05) between TTFL thickness and BMI. Also, a dynamic study was carried out showing tension of the PTFL during dorsiflexion in 7/15 subjects. Our results highlight the potential role of accurate US imaging in detecting posterior ankle ligament involvement in acute and chronic traumas. To our knowledge, there are no previous articles in the literature dealing with this topic providing an accurate description of the US procedure, and in particular, no study has been carried out to identify OT.

Keywords Ankle ligaments · Musculoskeletal ultrasound · Posterior tibiofibular ligament · Posterior talofibular ligament

Introduction

The posterior talofibular ligament (PTFL) and the posterior syndesmotic ligaments (PSL) are the main ligamentous structures of the posterior ankle compartment. PTFL is the posterior part of the lateral collateral ligament of the ankle joint, the so-called triquetrum complex [1], and till now it has not been adequately studied with US in healthy subjects [2, 3]. US investigation of PTFL is considered very difficult because of its deep location and it has furthermore been neglected also due to its rare involvement in ankle traumas [4, 5]. For the same reasons, also PSL composed of the posterior inferior tibiofibular ligament (PITFL) and the transverse tibiofibular ligament (TTFL) (Fig. 1b, c) is not accurately examined in standard US imaging of the ankle. US imaging is furthermore hindered by the complex anatomy of these structures, and MR imaging is, therefore, currently considered as the method of choice [6].

Lesions of all these ligaments are rare. Most lesions are partial and usually caused by distortion of the ankle and plantar flexion (the same injury mechanism causing damage to the anterior ankle ligaments) [4]. In the present study, we investigated the value and feasibility of US imaging in the identification and characterization of these complex ligament and paraligamentous structures. The aim of this study is to describe the anatomy and US features of the posterior ankle ligaments and paraligamentous structures to demonstrate US examination feasibility, especially in patients with ankle trauma including uncommon injuries.

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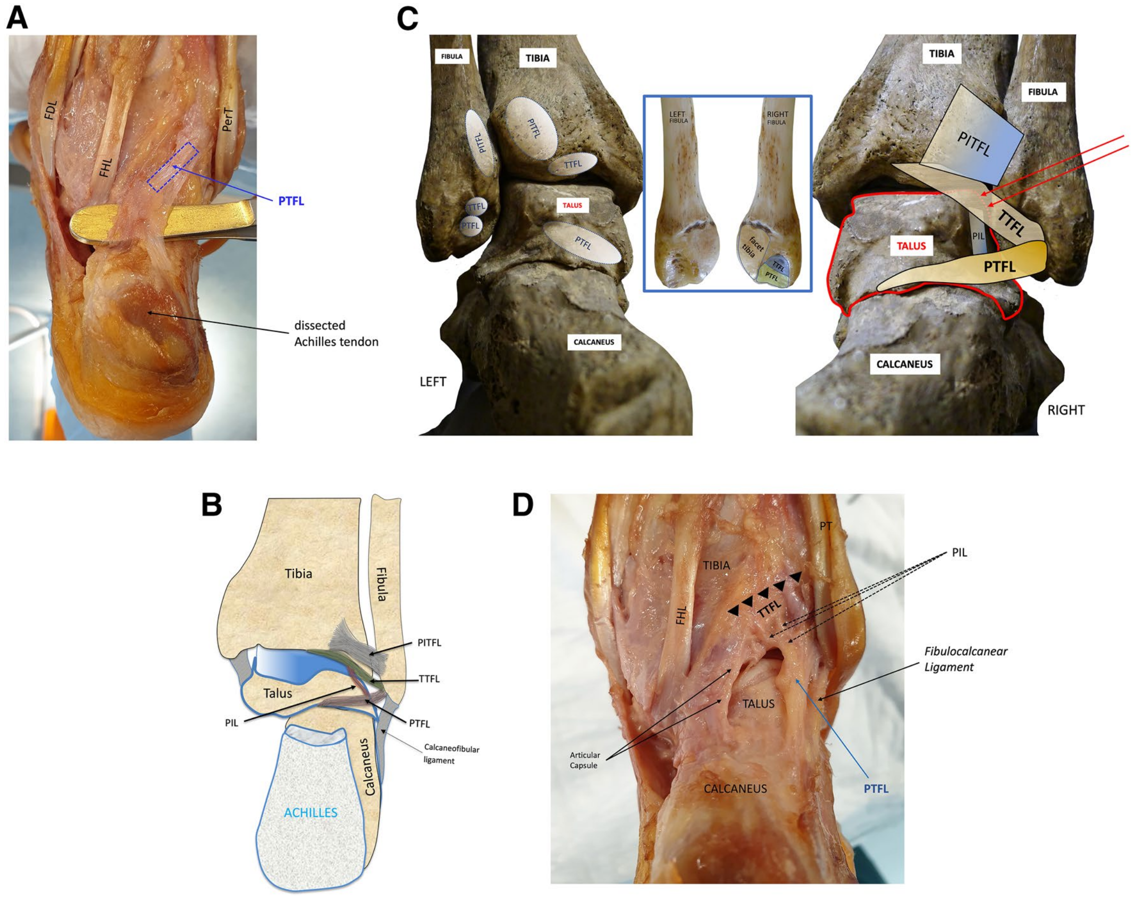

Fig. 1 **a** A Cadaveric specimen with dissected Achilles tendon showing PTFL. FHL: flexor hallucis longus tendon; FDL: flexor digitorum longus tendon. **b** Schematic drawing illustrating the posterior talofibular ligament (PTFL) and other main ligamentous structures (PITFL, TTFL, PIL) of the posterior compartment of the ankle. The Achilles tendon is dissected. **c** Schematic drawing of a skeleton foot illustrating the ligament insertions onto the left ankle; the right ankle shows the anatomical spatial arrangement of the posterior ligament complex. Double red arrows indicate the close anatomical relationship between the talus (trochlea) and TTFL: the lateral part of TTFL is almost in contact with the pronounced and sharp lateral margin of the talus. The central box (blue frame) shows the medial surface of the lower extremity of two fibulae with TTFL (light blue) and PTFL (light green) insertion onto the little inferior fibular depression. **d** Cadaveric specimen (ankle in external rotation) with dissected Achilles tendon showing the posterior ligament complex with PIL, TTFL, PTFL. *FHL* flexor hallucis longus tendon, *PT* peroneal tendons

Materials and methods

Normal anatomy

PTFL is the most distal of the main ligamentous structures of the posterior ankle compartment (Fig. 1a–c). It is a strong and thick ligament and it is defined as an intracapsular but extrasynovial structure [7]. It is considered as a capsular thickening like that of the calcaneofibular ligament and anterior talofibular ligament [8]. The posterior bundle of the lateral collateral ligament, i.e., the third bundle of the triquetrum [1], is the most robust of the three and it imprints the astragalus bone where it inserts (Fig. 2) [9]. PTFL lies approximately 1.5–3 cm under the skin, below the peroneal tendons. It originates from the lateral malleolus and is positioned in a little depression behind the articular surface of the bone (Fig. 1c) running horizontally or slightly obliquely downwards, towards the medial side of the talus. The ligament ends on the posterior surface of the talus next to the anatomical groove (trochlea) that provides passage to the flexor hallucis longus tendon. The ligament may include the os trigonum (OT), an inconstant ossicle present in 7–13% of adults, described for the first time by Rosenmuller in 1804 [10, 11]. The posterior surface of the talus is not wide due to the trochlear inclination and it looks more like a margin than a surface. The medial portion is formed by the groove for the flexor hallucis longus tendon. The lateral lip of this bone channel is more accentuated and protruding than the medial one (Fig. 3a) and visualization is important to identify the deep posterior ligamentous complex. Sometimes, the lateral lip

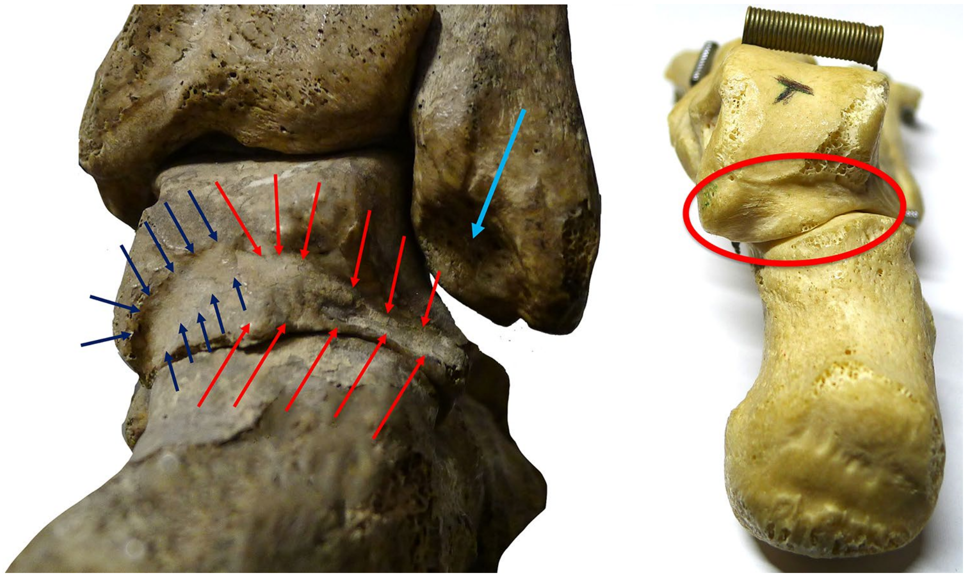

Fig. 2 Skeleton foot (rear view) showing the bone imprint on the talo produced by PTFL: red arrows on the left and red oval on the right. Blue arrows on the left show the FHL groove. Light blue arrow shows the bone depression where TTFL–PTFL are inserted

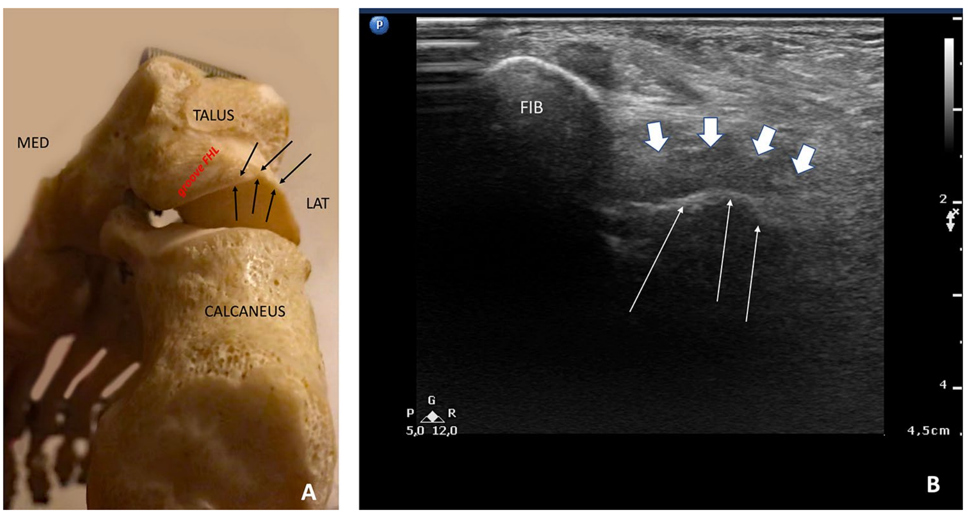

Fig. 3 **a** Rear view of a skeleton foot showing the lateral lip (part of the posterior margin of the talus) of the bone channel in which the FHL tendon is running. This anatomic portion of the talus is more accentuated and protruding (black arrows) than the medial lip, thus a good anatomical landmark for PTFL insertion. **b** US transverse section of the back of the ankle providing a long axis view of PTFL (white arrow heads) using a 12-MHz probe set at 10-MHz frequency. The thin white arrows show the anatomical bone landmark (the protruding posterior margin of the talus). *Fib* fibula

presents a more protruding profile due to fusion of OT and the rest of the talus [12]. PTFL is inserted onto this lateral lip and for this reason, it is a good landmark of this first deep ligament.

Posterior syndesmotic ligaments lies proximally to PTFL and it is composed of PITFL and TTFL (Fig. 1b, c). PITFL is the most proximal, superficial and thin ligament of this complex. TTFL, also called the transverse ligament by Quain and Morris [13], is the most distal, deepest, thickest and strongest ligament of the complex. It may have a tibial slip (Fig. 1b, c), i.e., the posterior intermalleolar ligament (PIL), which originates from PTFL and blends with TTFL [14, 15]. This tibial slip is inconstant with varying size and shape (Fig. 1d) [16] and it may cause synovial impingement [17]. The complex of the tibiofibular syndesmosis is actually a joint composed of various ligaments situated anteriorly and posteriorly at the distal part of the tibia and fibula [15]: the anterior inferior tibiofibular ligament and Bassett's Ligament (if any) in the anterior portion of the ankle which are easily assessed using US [9, 18], and PITFL with TTFL (and above these, the interosseous ligament) in the posterior part of the ankle, which are more difficult to assess using US. TTFL is situated closely to PTFL and it is distinctly thicker than PITFL. TTFL is inserted deeply at the posterior and medial surface of the lateral malleolus, immediately behind and below the articular facet for the tibia and talus. At this point, there is an oval depression, situated vertically, and in the most declining portion, PTFL is inserted (Fig. 1c); while TTFL insertion is just above [19]. From this fibular insertion, TTFL runs obliquely and medially until the posterior tibial margin. This direction forms an angle ranging from 20° to 40° with respect to PTFL. It should be kept in mind that the lateral part of TTFL is in contact with the pronounced and sharp lateral margin of the talus (Figs. 1c, 4a). From this position, it runs horizontally and then downwards, bordering the posterior margin of the tibia where it inserts [13]. The lateral insertion of PTFL and TTFL onto the inferior extremity of the fibula, behind and below the articular facet for the tibia and talus, is generally poorly visualized on US, although in some cases it may be visible during dorsiflexion.

Patients and methods and US scanning technique

Posterior talofibular ligament and PSL were studied in 15 healthy volunteers. One foot in each subject was randomly chosen with no preference for right and left. No volunteer presented a history of recent or past ankle trauma. All US examinations were carried out by two experienced operators using Philips HD 15 and a multifrequency linear transducer (12 MHz) or GE EQ9 and a matrix linear probe (6–15 MHz) or a 9-MHz linear multifrequency probe. All

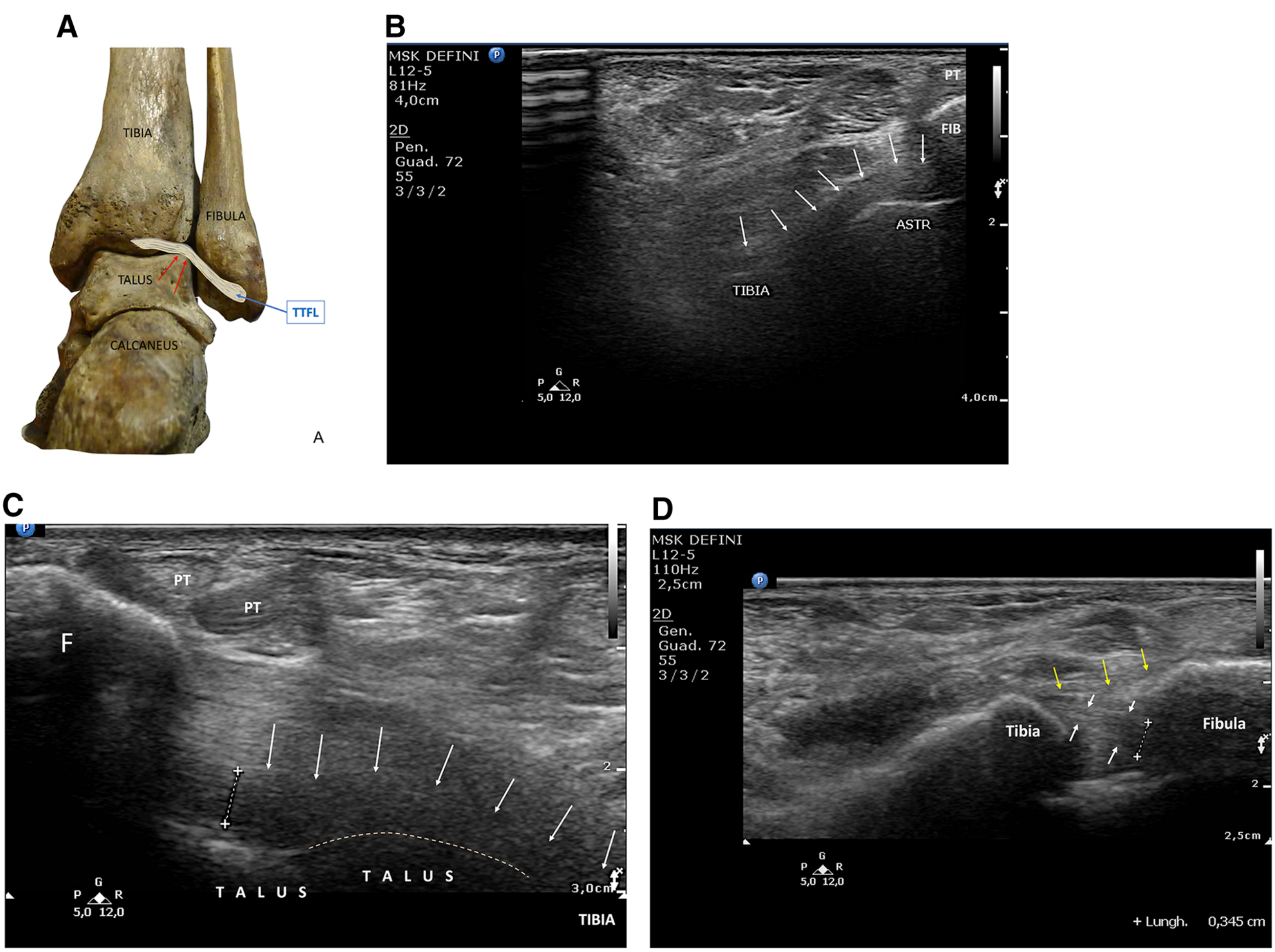

Fig. 4 **a** Schematic drawing of a skeleton foot illustrating TTFL and the close anatomical relationship with the trochlea. The lateral part of TTFL is curved and is in contact with the pronounced lateral margin of the talus (double red arrows). **b** US transverse section of the back of the ankle using a 12 MHz probe set at 5–7.5-MHz frequency. The long axis of TTFL (white arrows) presents an extended and curved shape in contact with the pronounced lateral margin of the talus (ASTR) before its insertion onto the tibia. Fib: fibula; ASTR: talus, PT: peroneal tendons. **c** US transverse section of the back of the ankle using a 12-MHz probe set at 10-MHz frequency. The long axis of TTFL between the calipers: this arched ligament (white arrows) runs along the lateral margin of the talus before insertion onto the tibia. F: fibula; PT: peroneal tendons. **d** US transverse section of the back of the ankle using a 12-MHz probe set at 10-MHz frequency. The proximal portion of TTFL looks like a short ligament originating from the fibular profile inserting onto the tibia: in this portion of the ankle the two bones are very close. Above TTFL, the distal part of PITFL (yellow arrows) is evident

subjects were studied using compounding (resolution mode) and tissue harmonic imaging (THI) [20, 21]. Each examination included the following ligaments and paraligamentous structures from proximal to distal ankle: (1) PITFL; (2) TTFL; (3) PIL; (4) PTFL; (5) synovial recess (SR) if distended; (6) possible presence of os trigonum (OT). All subjects were studied in supine position with the ankle in neutral position (the foot forms an angle of 90° respect to the major axis of the leg) or in prone position with the foot coming out from the bed and in the same neutral position. Probe frequency had to be reduced to 10–7.5 MHz if the ligament was deeper than 1.5–2 cm; in alternative, in case of suboptimal visualization, a probe with a lower frequency (9 MHz linear) was chosen by both operators. The focal zone was carefully selected (focal zone position should cover the anatomic structure to be investigated). For the assessment of PITFL, which is the most superficial of the three ligaments, the probe must initially be positioned on a transverse plane in the upper part of the ankle, lateral to the Achilles tendon. Then, the probe is turned slightly upwards about 30°–40° from the external malleolus towards the tibia keeping as anatomical landmarks the bone profiles of both tibia and fibula (Fig. 5a, b). Once the long axis of PITFL has been identified, it is not difficult to find the underlying TTFL by moving the probe slightly downwards, while maintaining the same inclination. The long axis of TTFL is located in a deep plane, 1.5–2.5 cm from the skin like PTFL, which is situated immediately below. TTFL is easily detected due to its thickness (thicker than PTFL); it is in contact with the lateral margin of the talus, bordering the posterior deep margin of the tibia where it inserts (Fig. 4a–c). The closeness of the ligament to the lateral edge of the talus does not mean that it is inserted onto this bone and it should therefore not be confused with PTFL. To identify the long axis of the PTFL ligament lying just below TTFL, the probe has to be placed horizontally and posteriorly or slightly obliquely downwards, starting from

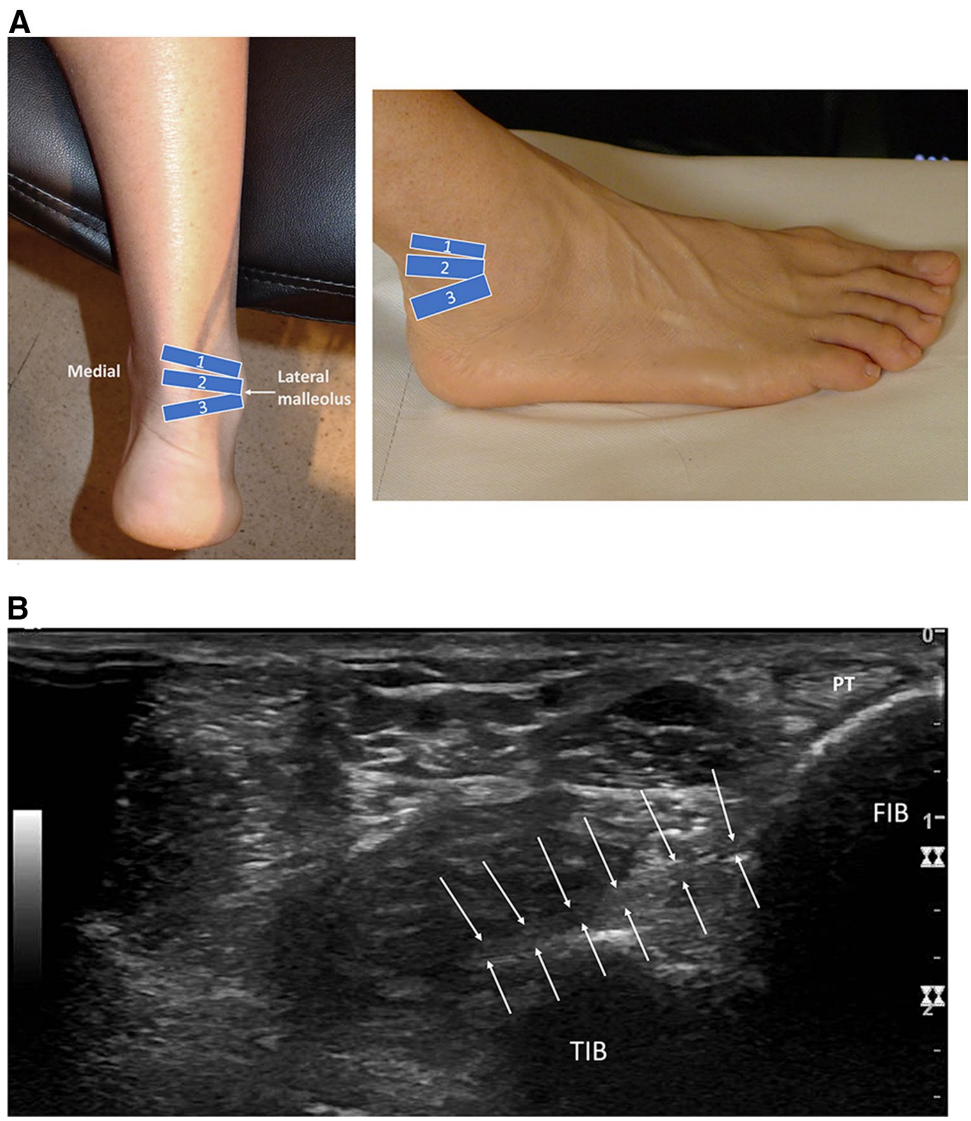

Fig. 5 **a** Probe position for the study of the main posterior ligaments: (1) superior transverse/slightly oblique section of the ankle for long axis view of PITFL; (2) middle transverse section of the ankle for long axis view of TTFL; inferior transverse/slightly oblique section of the ankle for long axis view of PTFL. The probe is positioned lateral to the Achilles tendon, pivoting on the malleolus for the three positions. **b** US transverse section of the back of the ankle: PITFL long axis 6–15 MHz (white arrows). US image using a 15-MHz frequency probe with activated THI and compound imaging. This thin ligament is superficially positioned and is easily studied using a high frequency probe. *PT* peroneal tendons, *FIB* fibula, *TIB* tibia

the posterior portion of the lateral malleolus (Fig. 5a). Also PTFL is lies in a deep position.

As mentioned above, PTFL insertion onto the lateral lip of the talus channel was considered the anatomical US landmark for the flexor hallucis longus tendon, where the tendon inserts, more accentuated and protruding than the medial lip [12] (Fig. 3). PTLF presents a typical elongated triangular shape. When scanning this ligament, it is important to keep in mind that unlike the calcaneofibular ligament, the peroneal tendons are not contiguous with PTLF (the distance between PTLF and the peroneal tendons is at least 1–1.5 cm). However, in some anatomical variants [22], the calcaneofibular ligament can be positioned posteriorly (Fig. 6) and may be confused with PTFL, but in that case it always maintains a close contact with the peroneal tendons and for this anatomical reason it may be easily distinguishable from PTFL. PIL, also called ‘tibial slip’, was investigated in sagittal or oblique/sagittal scanning once PTFL and TTFL were identified by connecting the transverse sections of these two ligaments.

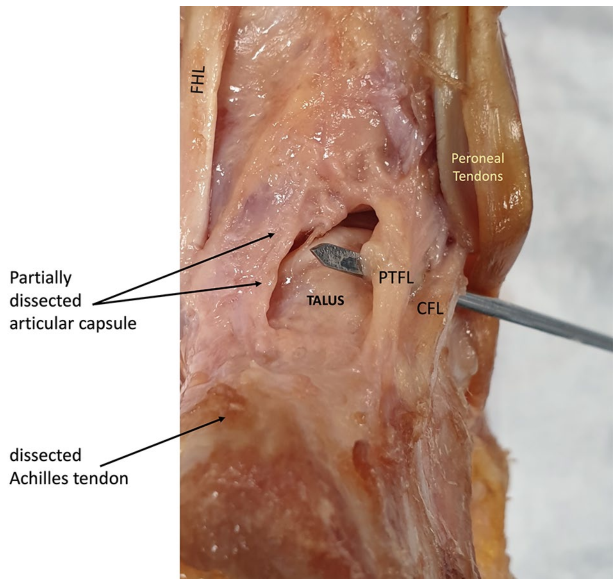

Fig. 6 Cadaveric specimen with dissected Achilles tendon showing the posterior ligament complex with PTFL and close to it, with the same spatial orientation, an ‘atypical’ calcaneofibular ligament (CFL). In some anatomical variations like this, CFL can be in a posterior position. *FHL* flexor hallucis longus

Furthermore, the possibility was investigated that PTFL included OT, an inconstant ossicle encountered in a small percentage of adults. Some PTFL fibers can be inserted onto OT [23] mimicking ligament calcification (Fig. 7).

Finally, once the anatomical structures were correctly identified, the subject was requested to perform dorsal flexion of the foot to permit a dynamic study of the tension of the two lower ligaments (TTPL and PTFL) and to identify a possible SR lying below PTFL. SR may be considered as a part of the posterior recess of the ankle joint (Fig. 11).

Every ligament was evaluated in terms of echostructure, form, and orientation with respect to the scanning plane. Maximum thickness of all ligaments was measured; PTFL and TTFL usually close to the fibular insertion, and PITFL at the middle of the ligament. Mean and standard deviation of ligament thickness were calculated.

Finally, body mass index (BMI) was registered for each subject to detect a possible correlation between the thickness of the three main ligaments (PITFL, TTFL, PTFL) and BMI. PIL was excluded from this calculation due to the great anatomic variability and inconstant visualization.

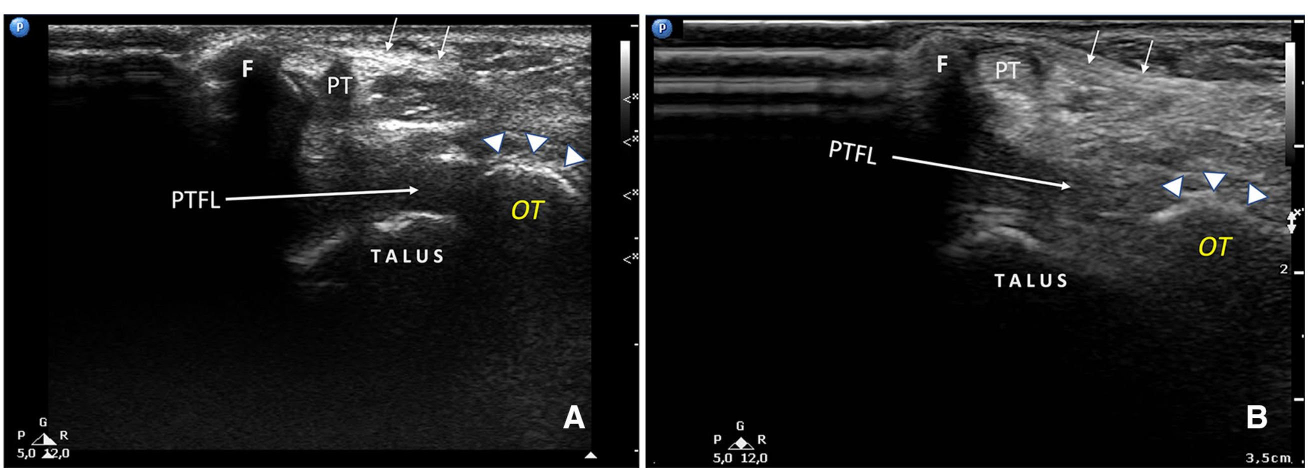

Fig. 7 US transverse section of the back of the ankle using a 12-MHz probe set at 10-MHz frequency: long axis of PTFL. At the distal part of this ligament, there seems to be a calcification; however, it is not a calcification but an ossicle: the os trigonum (OT). Small arrows: superior peroneal retinaculum; *PT* peroneal tendons, *OT* os trigonum, *F* lateral malleolus

Statistical analysis

Shapiro–Wilk test was carried out to verify the normality of the distributions. Pearson's test and linear regression were performed to study the relationship between variables.

As regards the inter-rater reliability, the intraclass correlation coefficient (ICC) was calculated to measure the level of agreement between the two operators. In accordance with the guidelines, an ICC range 0.8–1 indicated an excellent agreement.

The level of significance was set at 0.05. Statistical software R 3.5.0 was used to conduct the analysis.

Results

A total of 15 feet were examined: 8 left and 7 right feet. The healthy volunteers counted 8 women and 7 men. Mean age was 34.1 ± 12.2, range 18–59; mean body mass index (BMI) was 22.4 ± 3.1, range 16.6–27.2. Both operators detected PITFL in all subjects using a 12-MHz or 15-MHz probe. Following the outline of the tibia and fibula on a transverse section in the superior portion of the ankle, PITFL was identified angled slightly obliquely upwards from the fibula to the tibia. It appeared superficial, flat and hyperechoic presenting a mean thickness of 1.2 mm ± 0.2 (range 1.0–1.6 mm) (Table 1). Proceeding with the same probe orientation (see attached animation movie) slightly below this superficial structure, both operators identified TTFL in all subjects by changing the US probe frequency to 10–7.5 MHz adjusting the focus and gains accordingly. TTFL appeared as a deep thick cord-like ligament showing a slightly semi-arch course (Fig. 4c) running towards the deep planes. It was continually hypoechoic due to anisotropy and presented a mean thickness of 4.1 mm ± 0.4 (range 3.3–4.9 mm). When TTFL lays deeper than 2–2.5 cm (in 9/15 subjects), it was better visualized using a 9 MHz linear probe. Anyway in all 15 subjects TTFL did not lie deeper than 3 cm. Continuing distally but orienting the probe on a transverse plane or slightly downwards from the fibula to the talus (see attached movie), PTFL was detected by both operators in all subjects. It presented a typical hypoechoic triangular shape caused by anisotropy and an appearance similar to the profile of a toucan (Fig. 8a) with the fibula profile looking like the head and the beak representing the ligament. PTFL was hypoechoic like TTFL due to anisotropy; it presented a mean thickness of 3.3 mm ± 0.2. In only one subject, a rather thick ligament of 3.7 mm was observed, range 2.9–3.7 mm. Furthermore, in one subject, two deep ligaments in the same transverse section were detected (Fig. 8b): TTFL with oblique orientation

Table 1 Thickness, standard deviation and range of thickness of the four ligaments

	Thickness	SD	Range (mm)
PITFL	1,2 mm	0,2	1.0–1.6
TTFL	4,1 mm	0,4	3.3–4.9
PTFL	3,3 mm	0,2	2.9–3.7
PIL	1,6 mm	0,1	1.2–1.9

PITFL posterior inferior tibio fibular ligament, *TTFL* Transverse tibiofibular ligament, *PTFL* posterior talo fibular ligament, *PIL* posterior intermalleolar ligament

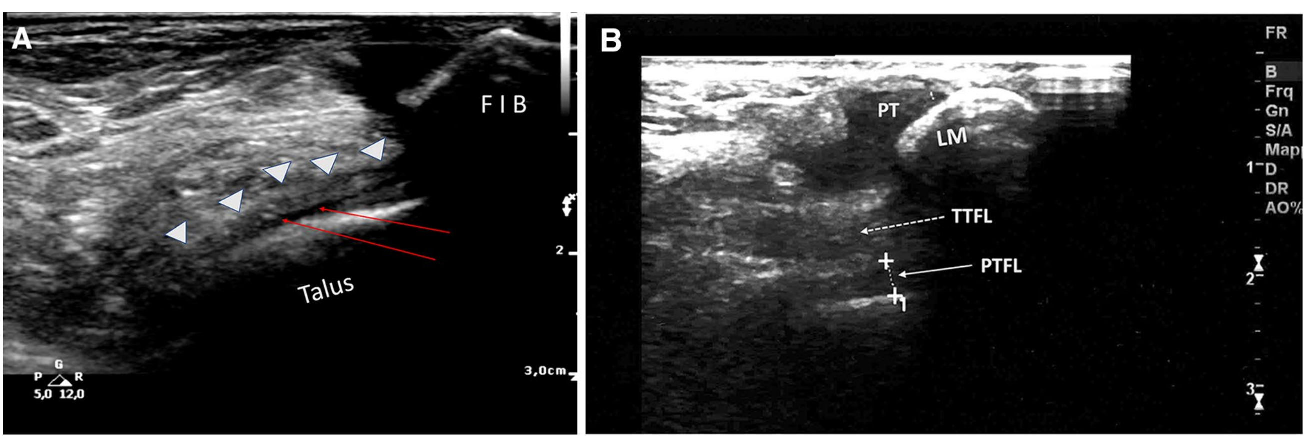

Fig. 8 **a** US transverse section of the back of the ankle providing a long axis view of PTFL (white arrow heads) using a 12-MHz probe set at 12 MHz. In this subject, the ligament is superficially positioned (1.5–2 cm) thus permitting a higher frequency setting. PTFL presents a typical elongated triangular shape with the silhouette of the lateral malleolus (FIB) forming a typical "Toucan's head" shape. In this subject, the two red arrows show a small longitudinal tear of the ligament. FIB: lateral malleolus (fibula). **b** US transverse section of the back of the ankle using a 6–15-MHz probe set at 13 MHz and activated compound imaging. In this subject, two deep ligaments in the same transverse section were detected: long-axis of TTFL with oblique orientation upwards, towards the tibia, and long-axis of PTFL (between the calipers) towards the talo in downward direction. Note the difference in thickness between the two ligaments. *PT* peroneal tendons, *LM* lateral malleolus

upwards towards the tibia, and PTFL towards the talo, running in a downward direction. In only 5/15 subjects (33%), the presence of PIL was clearly demonstrated by both operators on longitudinal or oblique/longitudinal scans (Fig. 9) showing a thin structure (mean 1.6 mm, ±0.1 mm, range 1.2–1.9 mm). On oblique/sagittal scans, PIL appeared as a small thin ligament which connected the transverse section of PTFL and TTFL (Figs. 1b, c, 9). Once the main ligaments of the posterior ankle were correctly identified, all subjects performed dorsiflexion to permit assessment of the tension of these ligaments. In 7/15 (46.6%), tension of PTFL was clearly demonstrated (Fig. 10) by both operators; whereas, no subject showed tension of TTFL. Finally,

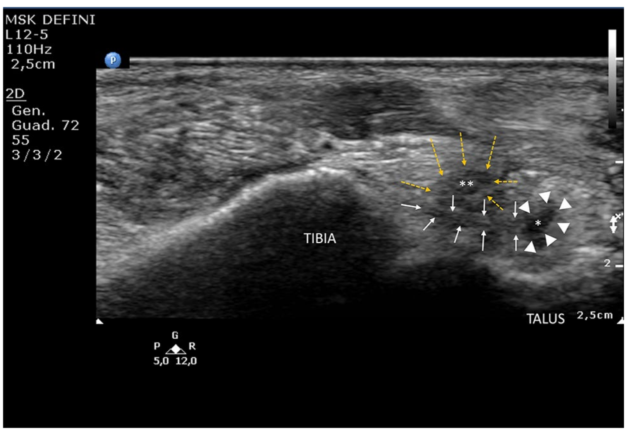

Fig. 9 US sagittal section (lateral to the Achilles tendon) of the back of the ankle using a 12 MHz probe set at 10 MHz frequency showing the long axis of PIL (white arrows) which joins the transverse section of PTFL (white arrow heads, single asterisk) and TTFL (yellow arrows, double asterisk). The anatomical variability of PIL makes it poorly identifiable at US imaging; however, PIL may cause impingement with the posterior synovial joint

using the same maneuver both operators identified slightly enlarged SR in 2/15 (13.3%) just below the lateral insertion of PTFL (Fig. 11b). A small liquid collection was located between the bone surface and the deeper part of PTFL close to the peroneal insertion. Only in one subject, a simultaneous minimal distention of the anterior recess of the articulation occurred. Finally, both operators detected OT in 2/15 subjects (13.3%) (Fig. 7); this finding was confirmed by traditional radiography.

Correlation between TTFL and BMI was positive, moderate/high and statistically significant ($r = 0.61$; p value $= 0.016$). Positive correlation means that one factor increases in direct proportion with the other factor. No correlation was found between BMI, and PITFL/PTFL thickness (PITFL: $r = 0.220$; p value $= 0.43$; PTFL: $r = 0.455$; p value $= 0.088$). The value of the intraclass correlation coefficient (ICC) was calculated to measure the agreement between operators: PTFL: 0.93 (p value < 0.0001); TTFL: 0.99 (p value < 0.0001); PITFL: 0.88 (p value $= 0.0003$); PIL: 0.82 (p value $= 0.008$). These ICC values indicate an excellent level of agreement between the operators, thereby ensuring a good inter-rater reliability.

Conclusions

Posterior talofibular ligament and PSL are the main ligamentous structures of the posterior ankle. The ankle is one of the most common sites of musculoskeletal injury both in athletes and in the general population [4]. In particular, ankle sprains represent almost 85% of the total number of ankle injuries. Sprains can partially or completely disrupt ankle ligaments leading to acute and chronic joint instability as well as pain. At present, PTFL and PSL are not

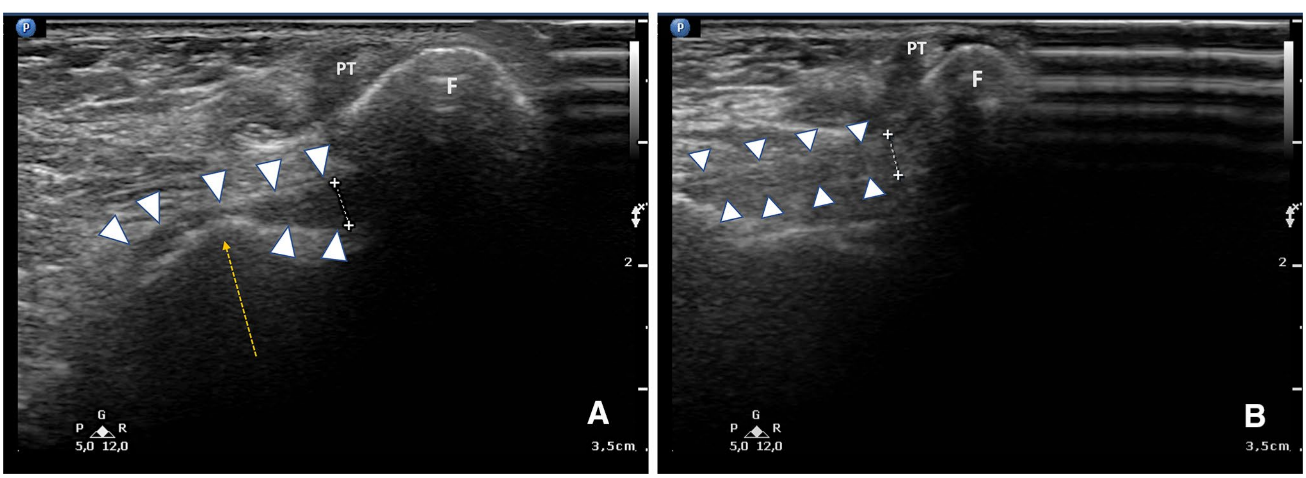

Fig. 10 US transverse section of the back of the ankle using a 12-MHz probe set at 10-MHz frequency: long axis of PTFL (white arrow heads). A: neutral position of the foot; B: dorsiflexion of the foot showing tension and proximal insertion of the ligament. PT: peroneal tendons; F: lateral malleolus. Yellow arrow indicates the anatomical bone landmark (the protruding posterior margin of the talus)

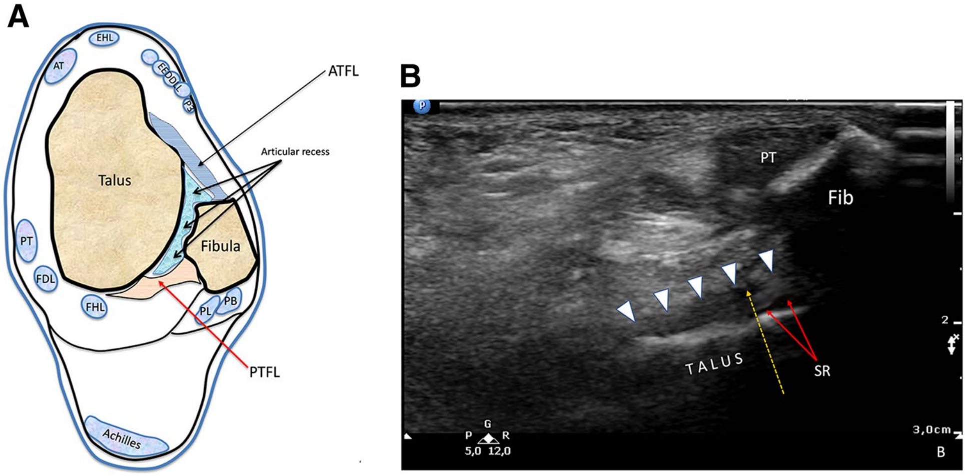

Fig. 11 **a** Schematic drawing illustrating a transverse anatomical section of the ankle at the level of the lateral collateral ligament. The anterior and posterior recess of the ankle joint is shown: the anterior recess just below the anterior talofibular ligament (ATFL) and the posterior recess below the PTFL. **b** US transverse section of the back of the ankle using a 12-MHz probe set at 10-MHz frequency: long axis of PTFL (white arrow heads); the synovial recess (SR) is below the proximal part of PTFL. This subject presents a small discontinuity of the ligament fibers suggesting a small partial tear (yellow arrow)

routinely examined during US imaging of the ankle [2] due to the rare involvement of these ligaments in ankle sprains and to their deep anatomic position. However, the Lauge-Hansen classification [24] of ankle fractures provides excellent information about the traumatic mechanism of ankle sprains and consequently about PTFL and PSL injury rates [25]. The classification clearly highlights the importance of evaluating also this anatomic region to avoid underestimation of ankle injuries. Misdiagnosis of PTFL and PSL injuries can lead to significant consequences on a patient's quality of life [26]. Recent reports in the literature state that US imaging can evidence only part of PSL. Only the superficial components of this complex structure (PITFL) may be effectively visualized during standard US examination [15]. Also US imaging of PTFL is rarely reported in the literature and there are no systematic studies [27, 28]. However, the results of this study demonstrate the great potential of US in the assessment of all structures of the posterior ankle compartment. Both conventional 12-MHz and 9-MHz linear probes can be effectively used depending on the position of the ligament. Using the particular procedures described above, some US features of these ligamentous structures, such as thickness, echogenicity, orientation, anatomical landmarks and anatomic variations may be identified in all subjects. Also a correct foot position during US examination proved to be essential due to the complex spatial orientation of these ligaments. Dynamic studies during foot dorsiflexion were useful not only for revealing the tension of PTFL but also for detecting possible posterior recess distension of the ankle joint appearing as a small anechoic synovial fluid collection just below the peroneal insertion of PTFL.

The anatomical variability of PIL made it poorly visible in our study (33%); however, PIL may cause posterior impingement symptoms [5, 7, 17] and should always be meticulously studied. Finally, US imaging identified the presence of OT within the PTFL structure in 2/15 of the subjects. This detection rate is in accordance with literature [10–12]. To our knowledge, no studies in the literature describe the possibility to identify OT during US examination of the ankle. OT should not be confused with ligament calcification.

The study of these ligaments presents limitations linked to errors which may occur not only in some cases of anatomical variation, but also in very deeply positioned ligaments especially in obese elderly patients and if there are any impediments to the study, such as open wounds or particularly large and fibrotic scars.

As regards biometric data, only ligament thickness was considered because this parameter increases in proportion to the degree of ligament injury [29].We did not evaluate ligament length as TTFL and PTFL present a partially masked insertion onto the bone structures, and due to the particular curvilinear course of TTFL. Finally, correlation between ligament thickness and BMI was positive only in TTFL. The results of our study highlight the potential role of US in detecting the involvement of the posterior ligamentous and paraligamentous structures of the ankle in acute and chronic trauma. To our knowledge, there are no previous reports in the literature on US imaging carried out on these specific structures, and particularly, no study has been carried out to identify the presence of OT.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Human and animal rights All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Informed consent Informed consent was obtained from all individual participants included in the study.

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