Surg Radiol Anat (1994) 16 : 87-91

Surgical and Radiologic Anatomy
Journal of Clinical Anatomy

Ultrasono-anatomy of the ankle ligaments

JL Brasseur[1], A Luzzati[2], JY Lazennec[2, 3], H Guérin-Surville[2, 3], B Roger[1] and P Grenier[1]

[1] Service de Radiologie Centrale, [2] Service d'Orthopédie, Hôpital de la Pitié-Salpêtrière, 47, boulevard de l'Hôpital, F-75013 Paris, France
[3] Laboratoire d'Anatomie, Faculté de Médecine Pitié-Salpêtrière, 105, boulevard de l'Hôpital, F-75634 Paris Cedex 13, France

Summary. The ligaments of the ankle are superficial and easily accessible at ultrasonography. Suprisingly, the reliability of this technique has never been proven. With this goal in mind, ten ankles were subjected to a ultrasono-anatomic comparison. The five principle ligamentous fascicles (three on the lateral side and two on the medial side) measured at ultrasonography and the values verified after dissection. This study shows that the ligaments of the ankle are analyzed with ultrasonography and that the measures done are valid and have a precision of 2 mm for the anterior fascicle and the lateral fascicle of the lateral ligamentous plane Due to its simplicity and its low price, ultrasonography appears to be an important method in evaluating the ligaments and the degree of seriousness of ankle sprains.

Correspondence to : JL Brasseur

Echo-anatomie des ligaments de la cheville

Résumé. Les ligaments de la cheville sont superficiels et aisément accessibles à l'échographie. Par contre, la fiabilité de cette technique pour l'étude de ces ligaments n'a, à notre connaissance, jamais été validée. Dans ce but, dix chevilles firent l'objet d'une corrélation écho-anatomique. Les cinq faisceaux ligamentaires principaux (trois sur le versant latéral et deux sur le versant médial) ont mesurés à l'échographie et les valeurs été vérifiées après dissection. Cette étude montre que les ligaments de la cheville peuvent être analysés en échographie et que les mesures effectuées sont valables et d'une précision de l'ordre de 2 mm pour le faisceau antérieur et le faisceau moyen du plan ligamentaire latéral. L'échographie paraît donc, par sa simplicité et son faible prix, constituer en élément important du bilan ligamentaire et de la gravité des entorses de la cheville.

Key words: Ultrasonography — Ankle — Ligaments

Traumatic lesions of the ankle ligaments are frequent, but this pathology does not benefit from the contribution of ultrasonography and few studies have appeared in the literature [2, 3, 4, 7]. Numerous other imaging methods supply a direct image (computered tomography [5], MRI [6, 8, 9]) or an indirect image (forced movement, arthrography, tenograpy), but a precise evaluation of the ligamentous state of the ankle remains difficult and is, in fact, rarely done, especially in emergency cases. To determine the number of the ligaments affected and the extent of the lesions (especially, presence or not of a complete ruptu-re) seems to be, nevertheless, an attractive goal. The significance of ultrasonography in the evaluation of the traumatic ligamentous lesions seems to be twofold: accessible technique and little constraining in

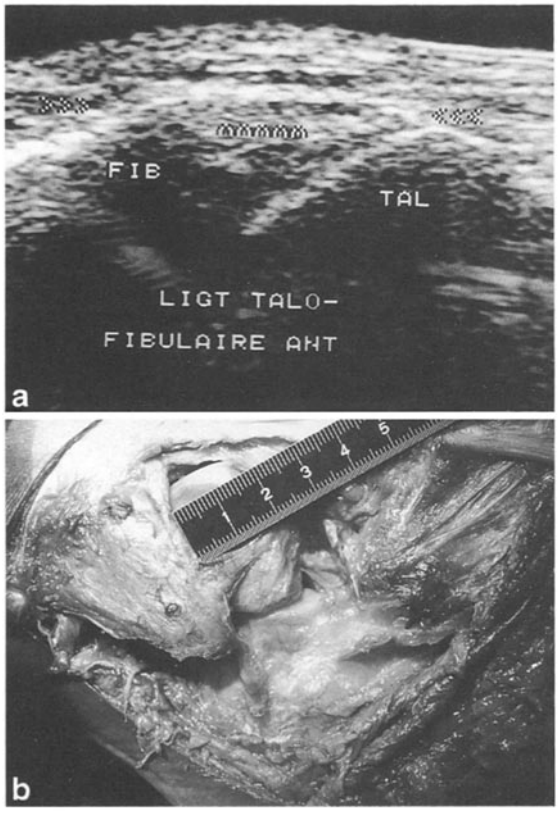


Fig. 1a, b
Anterior talofibular ligament

Ligament talo-fibulaire antérieur

emergency and better analysis of lesions at the chronic stage. Surgical comparison being rare, an anatomic comparison is necessary, so as to verify if the elements seen with ultrasonography correspond to the different anatomic structures.

Material and methods

Anatomic basis

The fasicules of the lateral ligamentous plane diverge from the lateral malleolus, flattening the latter against the talus. The lateral malleolus of the talus is sometimes flat, other times concave, and even presenting two true facets.

Among these three diverging ligaments, only the lateral ligament is calcaneofibular and also participates in the coaptation of the sub-talar joint. This ligament is difficult to define. Reinforcements of variable topography are described concerning it [10]. Most of the time, its surgical analysis needs an opening of the sheath of the muscle fibers, so as to be certain that it is not torn.

The deltoid ligament is divided into superficial and deep layers. The deep layer is composed of two fascicles, anterior and posterior. The anterior fascicle starts at the anterior border of the medial malleolus and disappears at the medial part of the talus. The posterior fascicle, which is in a very oblique posterior position, runs from the inferior side of the medial malleolus to the posterior side of the talus. The anterior fascicle is tenuous and sometimes even discontinuous. However, the short, thick, and solid posterior fascicle is often compared to the posterior talofibular ligament of the lateral collateral ligament. It is because of this fascicle that the medial malleolus fractures in sprains or in fractures due to twisting. This very resistant fascicle is sometimes called the "posterior tibio-talar ligament".

The association of the posterior tibio-talar and posterior talofibular ligaments coming from each malleolus and attached to the posterior side of the talus represent the posterior fibrous plane of reinforcement of the talo-crural joint, interrupted by the groove of the tendon of the flexor hallucis longus.

Sonographic study

All of the examinations were done by the same operator using a probe of 7.5 MHz (high resolution) with the interposition of a pocket of water allowing a better approach of the superficial structures.

Ten anatomic specimens were thus studied with ultrasonography and the length of different ligamentous fascicles was measured between their zones of insertion. The anterior tibio-talar part of the medial ligament was not looked for because of its inconsistency and its extremely spindly appearance. Also, the reinforcement of the calcaneofibular ligament [10] was not studied. The study thus concerns three ligaments and two medial planes [1, 5].

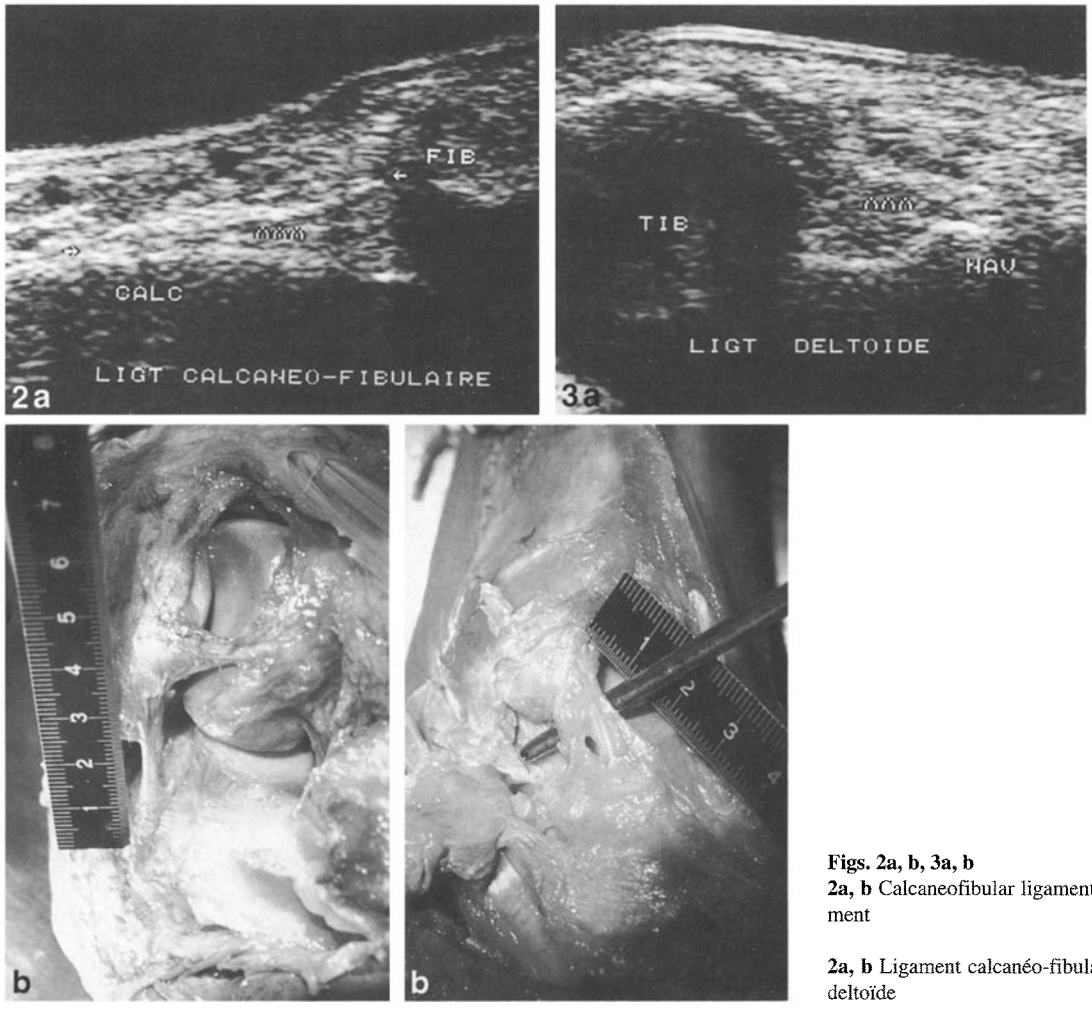
In order to facilitate the study, the ligamentous fascicles are put under slight tension in this varus position for the lateral plane and in the valgus position for the medial plane.

Anatomic study

The ten ankles were examined a half day following the ultrasonographic examination. The insertions of the ligamentous fascicles were defined so that they could be measured precisely.

The dissections were performed with an embalmed cadaver using a separate lateral and medial approach.

The evaluation of the calcaneofi-



Figs. 2a, b, 3a, b
2a, b Calcaneofibular ligament. **3a, b** Deltoid ligament

2a, b Ligament calcanéo-fibulaire. **3a, b** Ligament deltoïde

bular ligament required an opening of the sheath of the fibular muscles and an anterior dislocation of the two tendons.

The exploration of the posterior tibio-talar part of the medial ligament required forward displacement of the posterior tibial neurovascular mass with the tendons of the posterior tibial m., flexor hallucis longus and flexor digitorum longus. The deltoid ligament is dissected to the talonavicular joint.

The anterior tibio-talar part was neglected in dissections, because it is too tenuous and variable.

Lastly, the sonographic and anatomic findings were compared.

Results

Ultrasonographic appearance

At ultrasonography, all the ligaments present as a fine well-defined hyperultrasonogenic band, which is distinct from the neighboring structures. These structures appear relatively hypeultrasonogenic, because of a more significant fluid component.

Laterally, the anterior (Fig. 1) and posterior talofibular ligaments have an almost horizontal direction, starting from the last centimeter of the lateral malleolus. The calcaneofibular ligament (Fig. 2) is inferiorly and posteriorly oblique, adhering to the deep plane of the sheath of the fibular muscles.

Medially, the superficial plane (Fig. 3) is arranged in a fan-shaped manner coming from the medial malleolus to be attached to the talus, the calcaneonavicular ligament and the sustentaculum tali.

The thicker posterior tibio-talar ligament is inferiorly and posteriorly oblique.

All the fascicles are located with ultrasonography except the posterior tibio-talar ligament in one of the anatomic preparations. The definition of the fibular and tibial insertion of the posterior fascicles is moreover not possible in certain

Table 1. Measurement of different ligamentous structures
Mesure des différentes structures ligamentaires

Lateral											
Anterior talofibular ligament	Ultrasono	20	20	9	18	15	16	14	19	12	18
	Anat	22	21	10	18	15	16	15	?[b]	13	18
Calcaneofibular ligament	Ultrasono	24	17	17	22	17[a]	20	17	19	18	20
	Anat	24	17	18	23	20[a]	21	17	19	18	18
Posterior talofibular ligament	Ultrasono	10	13	10	13	7[a]	8[a]	11	10	9	7[a]
	Anat	12	14	10	15	12[a]	20[a]	11	11	10	18[a]
Medial											
Deltoid ligament	Ultrasono	17	15	14	14	19	25	18	14	31[a]	21
	Anat	17	17	15	15	20	27	19	16	23[a]	21
Posterior tibio-talar ligament	Ultrasono	12	?[b]	12	12	7	10	7	5	8	10
	Anat	13	12	11	11	8	12	9	7	9	10

[a] These values represent the differences superior to 2 mm between the sonographic measurements and the anatomic verifications
[b]The question marks correspond to measurements, which could not be correctly done

[a] Ces valeurs représentent les différences supérieures à 2 mm entre les mesures échographiques et les vérifications anatomiques
[b] Les points d'interrogation correspondent aux mesures qui n'ont pu être correctement effectuées

Table 2. Lengths (average and extreme) of the ligaments
Longueurs (moyennes et extrêmes) des ligaments

Lateral			
Anterior talofibular ligament	Ultrasono	16 mm	9 - 20 mm
	Anat		
Calcaneofibular ligament	Ultrasono	19 mm	17 - 24 mm
	Anat		
Posterior talofibular ligament	Ultrasono	10 mm	8 - 13 mm
	Anat	13.5 mm	9 - 20 mm
Medial			
Deltoid ligament	Ultrasono	19.5 mm	14 - 31 mm
	Anat		
Posterior tibio-talar ligament	Ultrasono	9.5 mm	5 - 14 mm
	Anat	11 mm	7 - 16 mm

cases, because of their insertion on the deep aspect of the malleolus. The fasbeam of the ultrasound is completely reflected by the osseous structures and cannot reach the insertion of certain ligaments.

Nevertheless, the inferior portion of the superficial plane of medial ligament is sometimes difficult to define, because of its fan-shaped appearance, which leads to the loss of the linear appearance of the structure and then a lack of homogeneity of the ultrasound signal.

Anatomic appearance

Except for the anterior talofibular ligament, which is not defined in a correct way, all the ligaments are found and each insertion is dissected in a satisfactory manner, allowing a precise measurement of the length of the different fascicles.

Measurements

After having eliminated the poorly defined fascicle at ultrasonography (posterior tibio-talar) and the poorly defined ligament at dissection (anterior talofibular), forty-eight measurements are compared.

The difference is less than or equal to, 2 mm in forty-three cases out of forty-eight. This value of 2 mm is chosen in an arbitrary way, because of the possible inaccuracy due to the thickness of the insertion zones.

For three ligaments, ultrasonography underestimates the size of the posterior talofibular ligament in a significant way. In one of the cases, ultrasonography overestimates the measurement of the superficial plane of the deltoid ligament.

However, all of the measurements are perfectly in agreement at the calcaneofibular ligament (except a difference of 3 mm) and at the anterior talofibular ligament (Table 1).

The values obtained show that the same ligamentous fascicle may have an extremely variable length (for example from 9 to 20 mm at the anterior talofibular ligament), then increasing the statistical value of the comparison.

The average of the measurements obtained is strictly identical between the two methods except at the posterior ligaments, where uitrasonography underestimates them by 3.5 mm on the lateral side and 1.5 on the medial side in relation to the anatomic measurements (Table 2).

Discussion

The ultrasono-anatomic comparison of the ligaments of the ankle is very satisfactory. It is particularly accurate for the anterior talofibular and calcaneofibular ligaments (which are the most important, being the only ones to be usually subject to surgical reconstruction). To our knowledge, this comparison constitutes a new element, since three noticeably different ultrasonographic analyses have been done to this date.

Two studies [3, 7] established a relationship between the size of the ligament in the strained varus position and a post-traumatic lesion, while another [2] indirectly studied the ligamentous lesion with its emphasis put upon the hematoma and the capsular appearance.

Differences appear in certain cases, but they are easily explained. The insertion of certain posterior ligaments on the deep side of the malleolus, able sometimes to interrupt the ultrasound wave, cannot be correctly visualized at ultrasonography. This difficulty, which is variable according to the form of the contour of the malleolus, explains the underestimated measurement of three posterior talofibular ligaments and the difference of the average values for the posterior ligaments. Thus, the measurement of the deltoid ligament is distorted by the inferior arrangement of this ligament (fan-shaped), which can hinder the ultrasonographic study.

Conclusion

The anatomic comparison demonstrates that the ankle ligaments can be studied with ultrasonography in a reliable manner. The measurement of the anterior talofibular ligament and the calcaneofibular ligament is precise and this is confirmed by dissection. In view of this study, ultrasonography constitutes an important element of the precise evaluation of the seriousness of an ankle sprain, because of its simplicity and its low cost.

References

1. Cady J, Kron B (1970) Anatomie du corps humain. Maloine, Paris
2. von Friedrich JM, Heuchemer T, Schumacher KA, Bargon G (1990) Einstaz der Sonographie in der Diagnostik der frischen fibio-talaren Bandläsion. Fortschr Röntgenstr 152 : 173-179
3. Glaser F, Friedl W, Welk E (1989) Die Wertigkeit des Ultraschalls in der Diagnostik von Kapselbandverletzungen des oberen Sprunggelenkes. Unfallchirurg 92 : 540-546
4. Mellerowics H, Stelling E, Kefenbaum A (1990) Diagnostic ultrasound in the athlete's locomotor system. J Sports Med 24 : 31-39
5. Morvan G, Busson J, Wybier M (1991) Tomodensitométrie du pied et de la cheville. Masson, Paris
6. Roger B, Lazennec JY, Laval-Jeantet M (1988) Atlas d'IRM des articulations des membres. Masson, Paris
7. Schricker T, Hien NM, Wirth CJ (1987) Klinische Ergebnisse sonographischer Funktionsuntersuchungen bei Kapselbandläsionen am Knie- und Sprunggelenk. Ultraschall 8 : 27-31
8. Schneck CD, Mesgarzadeh M, Bonakdarpour A, Ross GJ (1992) MR Imaging of the most commonly injured ankle ligaments, part I. Normal anatomy. Radiology 184 : 499-506
9. Schneck CD, Mesgarzadeh M, Bonakdarpour A (1992) MR Imaging of the most commonly injured ankle ligaments, part II. Ligaments injuries. Radiology 184 : 507-512
10. Trouilloud P, Dia A, Grammont P, Gelle MC, Autissier JM (1988) Variations du ligament calcanéo-fibulaire (ligament calcaneofibulaire). Applications à la cinématique de la cheville. Bull Assoc Anat 72 : 31-35

Received May 5, 1993 / Accepted in final form November 26, 1993