

ANKLE SPRAIN: DIAGNOSIS AND THERAPY STARTS WITH KNOWLEDGE OF ANATOMY

– Written by Pau Golanó, Spain and Jordi Vega, Switzerland

A thorough knowledge of anatomy is imperative for adequate assessment of joint injury. It is particularly important in the ankle joint where sprains are one of the most prevalent injuries of the musculoskeletal system.

Worldwide, approximately one ankle sprain occurs per 10,000 people each day. Nearly half of all ankle sprains are sport-related (occurring during athletic activity). When considering individual sports, basketball is most commonly associated with ankle sprain. Football and running are also among the most common athletic activities which cause an ankle sprain¹. Despite the frequency of ankle

sprain, the injury is often erroneously considered to be inconsequential². As a result of the insignificance assigned to ankle sprain, about 55% of individuals who sprain their ankle do not seek treatment from a healthcare professional. The treatment of inversion ankle injuries is provided by emergency and primary healthcare physicians, athletic trainers, physiotherapists, sports physicians and orthopaedic and trauma surgeons.

Residual symptoms after ankle sprains are reported in 30 to 40% of patients, eventually resulting in chronic pain, muscular weakness and recurrent giving way (instability)³. Ankle sprain can result

in considerable time lost to injury and long-term disability. When ankle sprain occurs in professional athletes the consequence is days lost in training and matches missed due to injury as well as the cost of the rehabilitation.

The vast majority of the ankle sprains involve the lateral collateral ligaments (LCL) and are also referred to as inversion sprain (supination and adduction of the plantarflexed foot) (Figure 1). The LCL consists of the anterior talofibular ligament (ATFL), the calcaneofibular ligament (CFL) and the posterior talofibular ligament (PTFL). The ATFL is the weakest of the three ligaments and is involved in practically

all inversion sprains. Rupture of ATFL is followed by damage to the CFL and finally to the PTFL, when mechanism of injury continues around the lateral aspect of the ankle. However combined ruptures of the ATFL and CFL occur in 20% of cases and the PTFL is usually not injured, unless a true dislocation of the ankle joint occurs. Isolated rupture of the CFL remains very rare⁴.

Some authors estimate that only 5% of all the injuries of lateral ankle ligaments involve the medial collateral ligament (MCL) which is also referred to as the deltoid ligament of the ankle. The incidence of injury may be greater than once assumed. With more sophisticated imaging technologies and ankle arthroscopy, deltoid injuries are being identified more frequently either in isolation or in association with more complicated injury mechanisms. The mechanism of injury to this ligamentous complex is controversial. The primary mechanism of acute MCL injury is eversion or external rotation of the ankle.

Injury of the syndesmosis may be underdiagnosed. The reported incidence of syndesmosis injuries in low impact sports is approximately 5% of ankle injuries. In collision sports such as American football, ice hockey and skiing, incidence appears to be higher. Syndesmosis disruption occurs as the result of relative external rotation and/or (hyper) dorsiflexion of the talus in the mortise, usually in association with axial loading and is commonly combined with a fibular fracture.

Accurate diagnosis is important because both management and prognosis may differ substantially from that of the more common alternative diagnosis of a lateral ankle ligament sprain.

The term 'sprain' includes diverse morphologic conditions with diversity of pathologic conditions. These range from overstretching of the ligament to complete rupture with instability of the joint. Severity of the LCL injuries are graded from I to III, based on the increasing ligamentous damage and morbidity.

- **Grade I sprain:** mild stretching (some ligament fibres torn) of the ATFL with no laxity on examination.



Figure 1: Ankle inversion sprain mechanism (supination and adduction of the plantarflexed foot). The anterior talofibular ligament is the weakest of the three ligaments, and is involved in practically all inversion sprains.

- **Grade II sprain:** moderate injury, frequently with a complete tear of the ATFL and additional partial tear of the CFL. Abnormal laxity may be mild or may not be present.
- **Grade III injury:** complete disruption of both the ATFL and CFL, with a possible capsular tear. Moderate to severe laxity is usually present³.

It is important to clarify the terms ankle ligament laxity, lateral ankle instability and chronic ankle instability, which are often used interchangeably.

- **Laxity** is a physical sign objectively detected on examination.
- **Lateral ankle instability** is the presence of an unstable ankle due to lateral ligamentous injury. The patient may describe this as the ankle giving way.
- **Chronic ankle instability** refers to repetitive episodes of instability resulting in recurrent ankle sprains⁵. Poor anatomical knowledge might lead to an inaccurate examination of the foot

and ankle, incorrect diagnosis or even inadequate treatment⁶. This can lead to an increase in malpractice lawsuits due to anatomic examination shortcomings⁷.

The anterior talofibular ligament is involved in practically all inversion sprains. It is the weakest of the three components of the lateral collateral ligament complex.

WHAT IS THE CURRENT AVAILABLE ANATOMICAL EVIDENCE?

Recent studies showed a lack of anatomical knowledge amongst clinicians⁶. Clinicians are becoming more reliant on potentially unnecessary and expensive imaging investigations, neglecting the basic art of physical examination based on a strong knowledge of human anatomy. This seems to be due to the drastic change in medical education (undergraduate medical curriculum) in which anatomy teaching is less-emphasised. Additionally, with the introduction of minimally invasive and arthroscopic surgery, we have learnt to avoid detailed anatomy considerations.

Compared to other joints, the ligaments of the ankle have not been studied in great detail. Descriptions in the literature often forget the precision of the orientation and attachment points. In our opinion, knowledge of anatomy has to be applied to the different stages of diagnostic and therapeutic approaches. This is particularly important in the physical examination of the patient, the interpretation of the additional imaging studies and during the resulting surgical treatments.

The goal of this manuscript is to give a synthetic anatomical description of the structures involved in ankle sprain that will be useful to the readers. Our

anatomical recommendation will be very useful in several aspects, from the physical examination to its diagnosis and especially for surgical treatment when necessary.

LATERAL COLLATERAL LIGAMENT

Located on the lateral part of the joint, the LCL includes three fascicles or ligaments, entirely independent from one another:

- The anterior talofibular ligament.
- The calcaneofibular ligament.
- Posterior talofibular ligament.

Anterior talofibular ligament

The anterior talofibular ligament (ATFL) plays an important role in limiting anterior

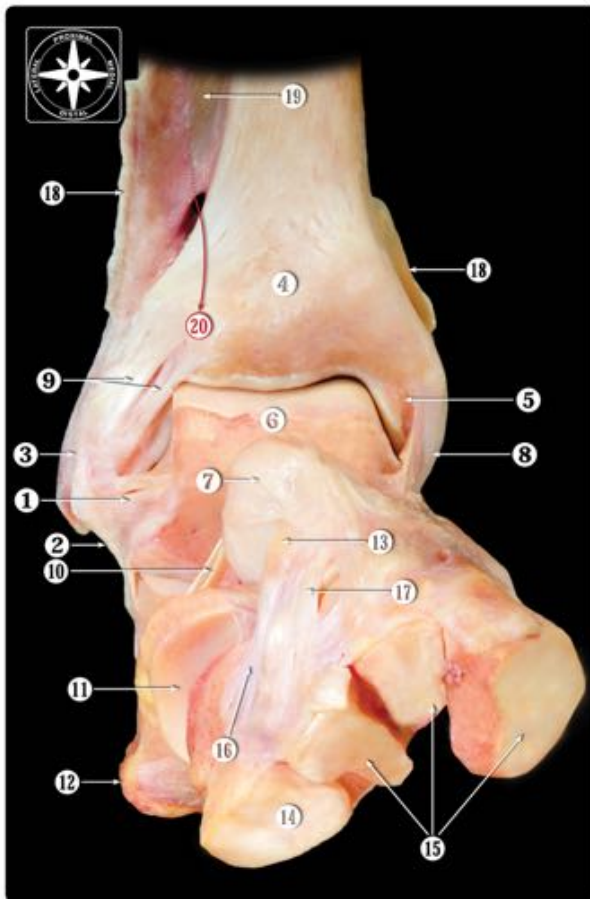


Figure 2: Anterior view of the osteoarticular layer of the foot and ankle joint. The foot was disarticulated at the tarsometatarsal joint. 1=anterior talofibular ligament, 2=calcaneofibular ligament, 3=lateral malleolus, 4=tibia, 5=medial malleolus, 6=body of the talus, 7=head of the talus, 8=medial collateral ligament, 9=anterior tibiofibular ligament (and distal fascicle), 10=cervical ligament, 11=articular surface of the calcaneus for the cuboid bone, 12=lateral process of the calcaneal tuberosity, 13=navicular bone, 14=articular surface of the cuboid for V and IV metatarsal bones, 15=articular surfaces of cuneiforms at the level of the tarsometatarsal joint, 16=dorsal cuboideonavicular ligament, 17=dorsal cuneonavicular ligament, 18=superior extensor retinaculum (cut), 19=interosseous membrane, 20=course of the anterior or perforating peroneal artery.

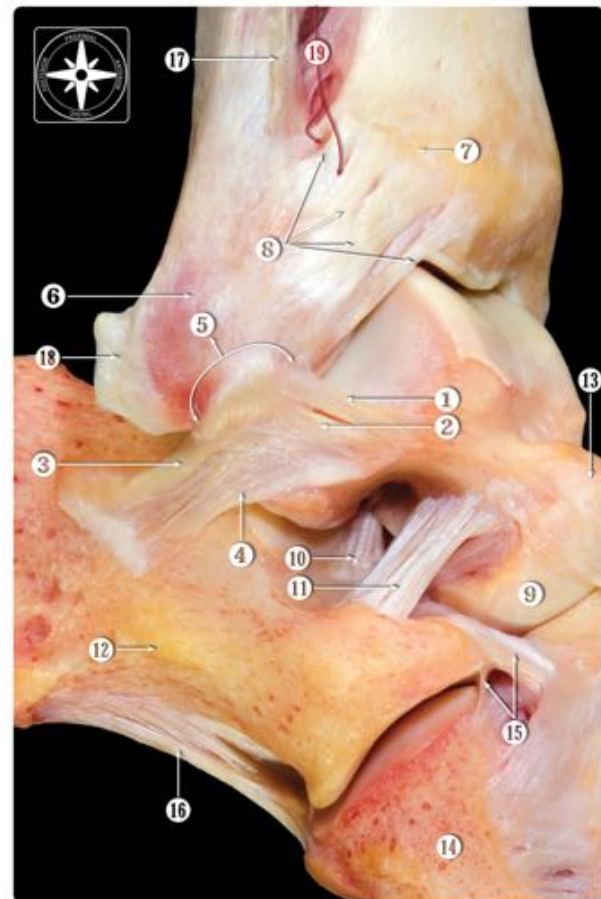
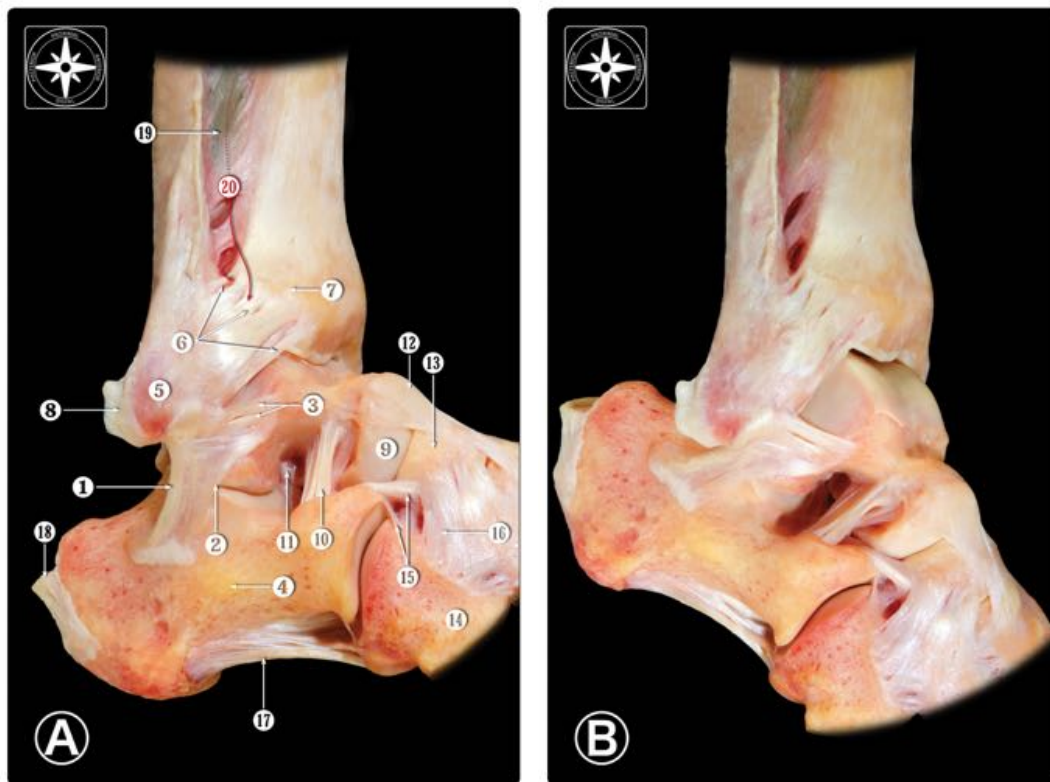


Figure 3: Lateral view of the osteoarticular dissection showing the fibular insertions of the lateral collateral ligaments. 1=anterior talofibular ligament (superior band), 2=anterior talofibular ligament (inferior band), 3=calcaneofibular ligament, 4=lateral talocalcaneal ligament, 5=common fibular origin of the anterior talofibular and calcaneofibular ligaments, 6=lateral malleolus, 7=anterior tubercle of the tibia, 8=anterior tibiofibular ligament (and distal fascicle), 9=head of the talus, 10=interosseous talocalcaneal ligament, 11=cervical ligament, 12=peroneal tubercle, 13=dorsal talonavicular ligament, 14=cuboid bone, 15=bifurcate ligament, 16=long plantar ligament, 17=superior extensor retinaculum (cut), 18=superior peroneal retinaculum (cut), 19=course of the anterior or perforating peroneal artery.

Figure 4: Lateral view of the osteoarticular dissection showing the patterns of calcaneofibular ligament strain during the dorsiflexion (A) and plantarflexion (B). 1=calcaneofibular ligament, 2=lateral talocalcaneal ligament, 3=anterior talofibular ligament (superior and inferior bands), 4=peroneal tubercle, 5=lateral malleolus, 6=anterior tibiofibular ligament (and distal fascicle), 7=anterior tubercle of the tibia, 8=superior peroneal retinaculum (cut), 9=head of the talus, 10=cervical ligament, 11=interosseous talocalcaneal ligament, 12=dorsal talonavicular ligament, 13=navicular bone, 14=cuboid bone, 15=bifurcate ligament, 16=dorsal cuboideonavicular ligament, 17=long plantar ligament, 18=calcaneal or Achilles tendon (cut), 19=interosseous membrane, 20=course of the anterior or perforating peroneal artery.



displacement of the talus and plantarflexion of the ankle and is the most frequently injured ligament of the ankle. (Figure 2).

This flat, quadrilateral ligament is in close contact with the capsule. Typically, the ATFL is composed of two bands (Figure 3). Both bands are separated by vascular branches from the perforating peroneal artery and its anastomosis with the lateral malleolar artery⁸. Its close relationship with the branches of the perforating peroneal artery contributes to explaining the presence of localised swelling, echymosis and haemorrhage after an ankle sprain.

In the literature, numerous anatomic descriptions have been given, varying from a single to up to three bands. However, the overall width of the ligament does not appear to vary greatly in relation to the number of bands present, suggesting that the variations observed do not modify the ligament's function. The ligament is approximately 6 to 10 mm in width, 15 to 20 mm in length and 2 mm in thickness⁹.

The ATFL originates at the anterior margin of the lateral malleolus. The centre of this fibular insertion is an average 10 mm proximal to the tip of the fibula as measured along the axis of the fibula. At this level, it is important to recall that the fibular origin (inferior band) shares the fibular of the CFL

origin as recently demonstrated¹⁰. This is a crucial anatomical detail in an anatomical reconstruction (Figure 3).

From its fibular origin, the ATFL runs anteromedially to the insertion at the talus body immediately anterior to their lateral articular surface. When the foot is in the anatomical position, the ATFL runs approximately horizontal. When the foot is plantarflexed, the ligament is nearly parallel to the long axis of the leg. In this position the ligament comes under strain and is vulnerable to injury, particularly when the foot is inverted. However, we must remember that the bands of this ATFL have a different behaviour during the ankle movements. In plantarflexion, the inferior band of the ligament remains relaxed while the superior band becomes tight. In dorsiflexion, the superior band remains relaxed and the inferior band becomes tight⁸. Since the superior band of the ATFL probably restricts inversion in plantarflexion, it may be the most important of the two bundles¹⁰. Understanding these mechanisms of injury is an important point in the patient medical history.

Calcaneofibular ligament

Little attention has been given to this ligament compared with the other

ligaments of the LCL. The calcaneofibular ligament (CFL) is the only ligament of the LCL bridging both the talocrural joint and subtalar joint. This ligament is superficially crossed by the peroneal tendons and only about 1 cm of the ligament is uncovered.

The CFL is a thick, cordlike or fan-shaped ligament that originates at the anterior border of the lateral malleolus, right below the origin of the inferior band of the ATFL, to which it is joined. It is important to note that the origin of this ligament does not reach the tip of the malleolus, remaining free from ligamentous insertions. From its fibular origin, in the neutral ankle position, the ligament courses backwards, downwards and medially. It inserts on a small tubercle in the posterior region of the lateral calcaneus, posterior and superior to the peroneal tubercle (almost 3 cm)¹⁰, which could be used as an osseous landmark during ligament reconstruction (Figure 4a).

The CFL becomes horizontal during extension (plantarflexion) and vertical in flexion (dorsiflexion), remaining tight throughout its entire range of motion (Figures 4a and 4b). A valgus or varus talar position considerably changes the angle formed by the ligament and the longitudinal axis of the fibula. The ligament is relaxed/un-stretched in the valgus position and

tense in the varus position which explains the potential for injury even without dorsiflexion/plantarflexion movement in the ankle⁸.

Posterior talofibular ligament

The posterior talofibular ligament (PTFL) is a strong, thick, fascicled and trapezoidal ligament in an intracapsular and extrasynovial location found in an almost horizontal plane. It originates on the medial surface of the lateral malleolus in the malleolar fossa and courses towards the lateral aspect of the talus, inserting in the posteroinferior border of the talar lateral malleolar surface and the lateral talar tubercle, trigonal process or os trigonum if present (Figure 5).

A group of fibres originate at the upper edge of the ligament near its origin and courses in an upward, medial direction until the insertion site, called the posterior

intermalleolar ligament by Paturet in 1951⁸. The posterior intermalleolar ligament has been the subject of recent studies because of its involvement in posterior soft tissue impingement syndrome of the ankle. Plantarflexion makes it relaxed and it becomes susceptible to being trapped between the tibia and the talus, leading to impingement, especially when there are predisposing factors such as trigonal process (Stieda process) and os trigonum or a prominent dorsal process of the calcaneus.

Hyperdorsiflexion trauma of the ankle tenses the ligament and can be assumed to produce either injury or rupture of this ligament or osteochondral avulsion⁸.

MEDIAL COLLATERAL LIGAMENT

The medial collateral ligament (MCL) is a strong, broad ligament with a multifascicular appearance that fans out from the medial malleolus towards the navicular, talus and calcaneus (Figure 6a). Because of its various contiguous and

MEDIAL COLLATERAL LIGAMENT

SUPERFICIAL LAYER	<i>Tibiospring ligament (major component)</i>
	<i>Tibionavicular ligament (major component)</i>
	<i>Superficial tibiotalar ligament (additional band)</i>
	<i>Tibiocalcaneal ligament (additional band)</i>
DEEP LAYER	<i>Deep posterior tibiotalar ligament (major component)</i>
	<i>Anterior deep tibiotalar ligament (additional band)</i>

Table 1: Bands or components of each layer of the MCL.

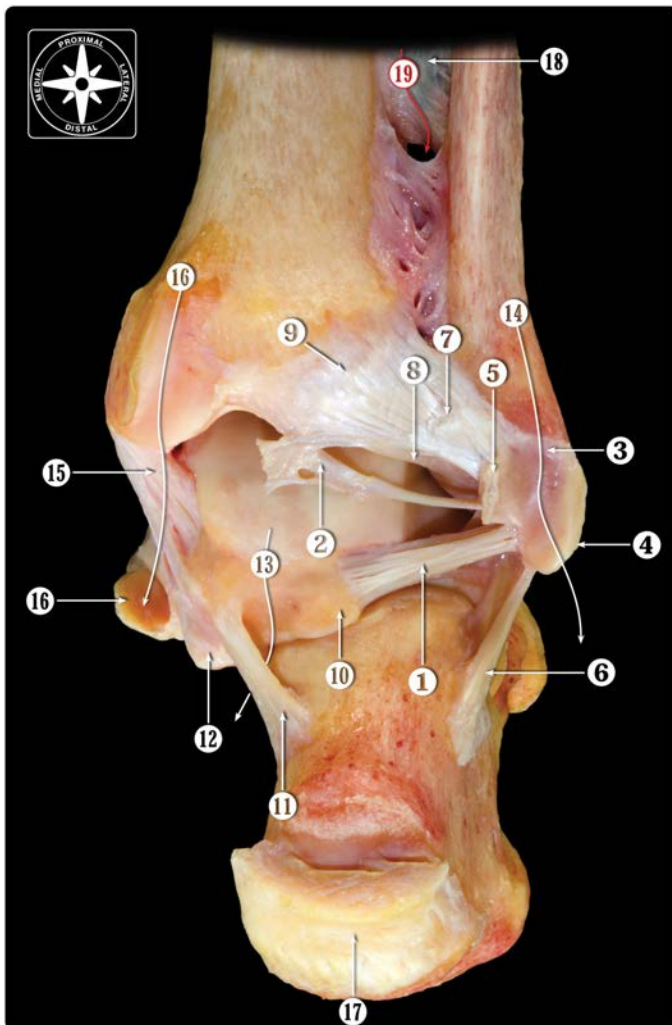


Figure 5: Posterior view of the anatomical dissection of ankle joint ligaments. 1=posterior talofibular ligament, 2=posterior intermalleolar ligament (cut), 3=lateral malleolus, 4=superior peroneal retinaculum (cut) - fibrocartilaginous rim, 5=fibular origin of the fibulotalocalcaneal ligament (cut), 6=calcaneofibular ligament, 7=superficial component of the posterior tibiofibular ligament, 8=deep component of the posterior tibiofibular ligament or transverse ligament, 9=posterior tubercle of the tibia, 10=lateral talar tubercle, 11=flexor hallucis tendon retinaculum, 12=medial talar tubercle, 13=flexor hallucis tendon course, 14=peroneus longus and brevis tendons course, 15=medial collateral ligament, 16=tibialis posterior tendon course (cut), 17=calcaneal or Achilles tendon (cut), 18=interosseous membrane, 19=course of the anterior or perforating peroneal artery.

poorly defined fascicles or components, the anatomic descriptions show several interpretations with artificial division being common. However, most people agree that it is composed of two layers, superficial and deep, separated by a fat pad and each is formed of multiple components. The most commonly accepted description of the MCL is the one originally proposed by Milner and Soames¹¹. Six bands or components have been described for the MCL: three of them are always present (the tibiospring ligament, tibionavicular ligament and deep posterior tibiotalar ligament), whereas the presence of the other three may vary

(superficial posterior tibiotalar ligament, tibiocalcaneal ligament and deep anterior tibiotalar ligament) (Table 1).

Most of the MCL is covered by tendons (posterior tibial muscle and flexor digitorum longus) as it extends down the leg to the bony insertions in the foot.

SYNDESMOTIC TIBIOFIBULAR LIGAMENTS

Four ligaments stabilise the ankle mortise by securing the fibula against the tibia within the peroneal incisura of the tibia:

- The anterior tibiofibular ligament.
- The posterior tibiofibular ligament.

- The transverse tibiofibular ligament.
- The interosseous tibiofibular ligament.

The inferior segment of the interosseous membrane also helps stabilising the tibiofibular syndesmosis.

The anterior tibiofibular ligament is the weakest of all the syndesmotoc ligaments. The ligament originates in the anterior tubercle of the tibia. Its fibres extend in a distal and lateral direction to the insertion site in the anterior margin of the lateral malleolus and reach the superior band of the ATFL. On careful inspection, the ligament is obviously divided into several fascicles that give it a multifascicular

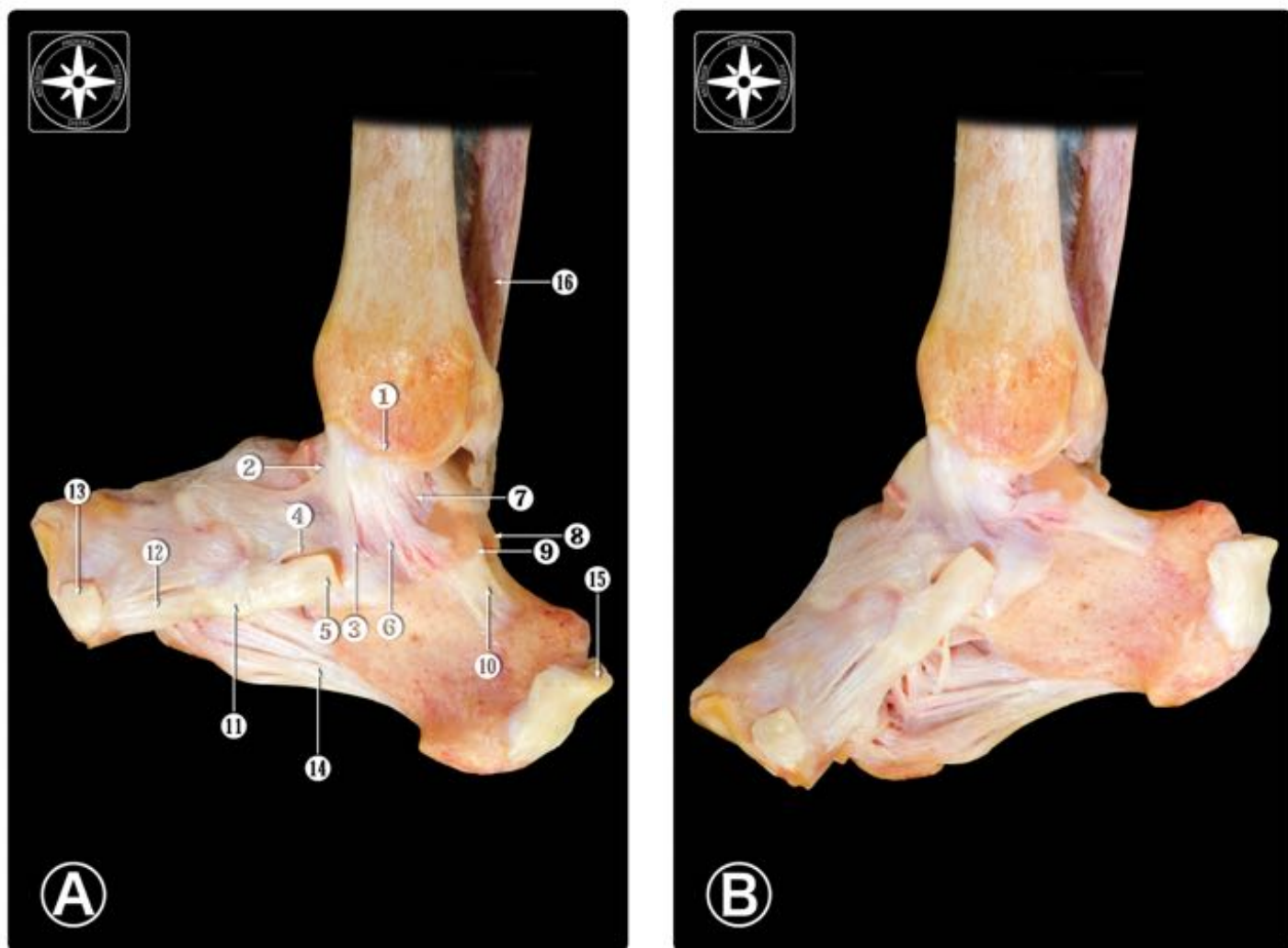


Figure 6: Medial view of the anatomical dissection of the main components of the medial collateral ligament. A) Dorsiflexion. The components located anteriorly to the bimalleolar axis are relaxed. B) Plantarflexion. The components located anteriorly to the bimalleolar axis are tensed. 1=medial malleolus, 2=tibionavicular ligament, 3=tibiospring ligament, 4=spring ligament (superomedial calcaneonavicular ligament), 5=tibialis posterior tendon (cut), 6=tibiocalcaneal ligament, 7=deep posterior tibiotalar ligament, 8=lateral talar tubercle, 9=medial talar tubercle, 10=flexor hallucis longus tendon retinaculum, 11=navicular tuberosity, 12=plantar cuneonavicular ligament, 13=tibialis anterior tendon (cut), 14=long plantar ligament, 15=calcaneal or Achilles tendon (cut), 16=fibula.

morphology. The most distal fascicle appears to be independent from the rest of the ligament. This distal fascicle covers the angle formed by the tibia and fibula and comes into contact with the dorsolateral border of the talus. The knowledge of this configuration is important to understand the anatomic bases for anterolateral soft tissue impingement⁸ (Figures 2, 3 and 4).

PHYSICAL EXAMINATION

Because of pain and inflammation following an acute ankle sprain, it is difficult to determine the ligament involvement during exploration. However, the difficulty with full weight-bearing and the restriction of active range of motion will be helpful to consider the grade of ligamentous injuries. For instance, the inability to toe rise or hop on the injured foot suggest a complete tear of the ATFL. Tenderness and swelling on the medial side are highly indicative of deltoid ligamentous injury, but history taking (or eversion trauma) is essential to differentiate it from post inversion medial compression pain. If there is a deltoid ligament injury it is extremely important to rule out a syndesmosis sprain or fracture. The tibiofibular syndesmosis sprains should also be considered in association with ankle sprains. Tenderness and pain on palpation in the anterior aspect of the syndesmosis and interosseous membrane are the most important physical findings. However, 40% of patients having pain on the anterior syndesmosis ligament have no rupture there.



Figure 7: Ottawa foot and ankle rules. X-ray is required only if there is any pain in the areas identified in red colour. A) Lateral view. B) Medial view.

OTTAWA ANKLE RULES

An ankle X-ray is required only if there is any pain in the malleolar zone and any of these findings:

Bone tenderness along the distal 6 cm of the posterior edge of the tibia or tip of medial malleolus

Bone tenderness along the distal 6 cm of the posterior edge of the fibula or tip of the lateral malleolus

An inability to bear weight both immediately and in the emergency department for four steps

OTTAWA FOOT RULES

A foot X-ray is required only if there is any pain in the midfoot zone and any of these findings:

Bone tenderness at the base of the 5th metatarsal bone

Bone tenderness at the navicular bone

An inability to bear weight both immediately and in the emergency department for four steps

Table 2: Ottawa foot and ankle rules.

TOP 10

- 1** *Ankle sprain is one of the most frequent injuries of the musculoskeletal system.*
- 2** *A thorough knowledge of anatomy is imperative for adequate assessment of joint injury.*
- 3** *The most common mechanism of injury in lateral ankle sprains occurs with forced plantarflexion and inversion of the ankle.*
- 4** *The anterior talofibular ligament is the most commonly injured ligament, followed by the calcaneofibular ligament.*
- 5** *The anterior talofibular ligament plays an important role in limiting anterior displacement of the talus and plantarflexion of the ankle.*
- 6** *After an ankle sprain, the lateral collateral ligament rupture should be considered when difficulty with full weight-bearing, restriction of active range of motion, inability to toe rise or hop and tenderness and swelling on the lateral side of the ankle are present.*
- 7** *The incidence of medial collateral ligament or syndesmosis injuries after an ankle sprain is low, but should not be dismissed.*
- 8** *Most patients with acute ankle sprains can be successfully managed with conservative care, such as bracing and physical therapy.*
- 9** *Approximately 15 to 20% remain symptomatic after several months, with most common complaints described as ankle weakness, giving way, pain and occasional stiffness.*
- 10** *When lateral ankle instability is diagnosed, ligamentous reconstruction for recurrent ankle instability should be performed.*

Radiographs should be taken according to the Ottawa foot and ankle rules. Initial palpation of certain areas is necessary to exclude fractures associated with ankle sprain. These areas (Table 2, Figures 7a and 7b) included in the Ottawa foot and ankle rules are the commonly used criteria for predicting which patients require X-ray, saving time, money and resources. Following these rules the sensitivity for detecting fractures of the ankle and midfoot associated with ankle sprain is nearly 100%. However the specificity remains relatively low as direct palpation of the bone produces numerous false-positive results because of tenderness of the injured region. For this reason other rules were developed (Bernese ankle rules).

Standard radiographs, if necessary, should include anteroposterior, lateral and mortise views. Foot radiographs are not necessary because the metatarsal bases

are visible in adequately positioned ankle projections. Stress radiography for acute injuries will not change the treatment protocol and is generally not indicated.

Patients without a fracture should then be advised to elevate the leg, apply ice intermittently and limit their walking. A compressive or elastic bandage may be applied. Although Rest, Ice, Compression and Elevation (RICE) therapy is a popular modality in the treatment of acute ankle sprain, insufficient evidence is available. RICE therapy is the treatment of choice for the first 4 to 5 days to reduce pain and swelling. Then protection in an ankle brace is beneficial followed by a period of functional taping and neuromuscular physical therapy which is advised to reduce the risk of recurrent injury.

Successful treatment of grade I, II and III acute lateral ankle ligament injuries can be achieved with individualised aggressive

and non-operative measures in patients with non-sports activity. Acute repair of the lateral ankle ligaments in grade III injuries in professional athletes may give better results.

Based on the current available literature, the level of evidence for delayed physical examination is superior to MRI for accurate diagnosis. A further physical examination 5 to 7 days after sprain can then better diagnose the grade of the ankle sprain. The absence of swelling suggests that there is no ligament rupture, whereas extensive swelling is indicative of ligament injury (based on swelling we can't differentiate between no rupture vs complete rupture, therefore injury instead of rupture should be used). Echymosis can occur 24 to 48 hours after injury. The discoloration is usually along the lateral side and along the heel because of the pooling effect of gravity. Pain on palpation of the ATFL suggests rupture of this ligament. The palpation of the anterior border after ankle sprain is very painful as the ATFL rupture is usually located on the fibular insertion. The CFL, if not injured, can be palpated easily during dorsal flexion of the ankle as a tight cordlike structure originates distally of the lateral malleolus and directed vertically in a distal direction.

The clinical stability tests are better performed in a delayed physical examination. The anterior drawer test is more specific to assess the integrity of the ATFL. Increased anterior translation of the talus with respect to the tibia is a positive sign and indicates a tear of the ATFL, particularly if the translation is significantly different from the opposite side. However, we do not know how much normal physiological translation is, which consequently leads to disagreement. This clinical test by the examiner is subjective and agreement among observers varies. The combination of tenderness at the level of ATFL, lateral haematoma discoloration and a positive anterior-draw test are highly suggestive of ligamentous injury (sensitivity 96%).

Ultrasound and MRI can be useful in diagnosing associated injury, but evidence for its usefulness is lacking compared to delayed physical examination.

If conservative treatment fails and lateral ankle functional instability is established, a



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surgical procedure can be performed. Several operative procedures have been described for the treatment of ankle instability. They have been divided into anatomic repair, non-anatomic reconstruction and anatomic reconstruction. The anatomic repair technique (Broström procedure) is preferred over the reconstruction procedures, being the gold standard technique for lateral ankle instability. However, patients with long-standing instability, poor tissue quality, history of previous repair, generalised ligamentous laxity and cavovarus foot deformity have been reported as having poor results with anatomic repair. Nonanatomic and anatomic reconstructive procedures are options to consider for these patients.

We also recommend reading the article: *Anatomy of the ankle ligaments: a pictorial essay*. *Knee Sports Traumatol Arthrosc* 2010; 18:557-569. You can download it at the following link: <http://link.springer.com/article/10.1007/s00167-010-1100-x> (open access).

All figures were processed using Adobe Photoshop

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Pau Golanó M.D.

Laboratory of Arthroscopic and Surgical Anatomy

Human Anatomy & Embryology Unit

Department of Pathology and Experimental Therapeutics

University of Barcelona

Barcelona, Spain

Department of Orthopaedic Surgery

School of Medicine

University of Pittsburgh

Pittsburgh, USA

Contact: paugolano@gmail.com

Jordi Vega M.D.

Unit of Foot and Ankle Surgery

Etzelclinic, Pfäffikon

Schwyz, Switzerland.

Contact: jordivega@hotmail.com