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REVIEW ARTICLE

Dynamic ultrasound of peroneal tendon instability

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ABSTRACT

Ankle snapping may be caused by peroneal tendon instability. Anterior instability occurs after traumatic superior peroneal retinaculum injury, whereas peroneal tendon intrasheath subluxation is atraumatic. Whereas subluxation is mainly dynamic, ultrasound allows for the diagnosis and classification of peroneal instability because it allows for real-time exploration. The purpose of this review is to describe the anatomic and physiologic bases for peroneal instability and to heighten the role of dynamic ultrasound in the diagnosis of snapping.

INTRODUCTION

Peroneus brevis (PB) and peroneus longus (PL) muscles are active stabilizers of the ankle joint. Peroneal tendon disorders mainly include tenosynovitis, tendinopathy, tear and instability.¹ Although peroneal tendon instability was first described in ballet dancers in 1803 by Monteggia, it also occurs in athletes who ski and those who play football, rugby and basketball.^{2,3} Peroneal tendon instability symptoms are aspecific and consist of pain, retromalleolar tenderness and snapping, which can be detected by an audible pop, usually due to a jerking movement of the tendons.^{4,5}

To our knowledge, no recent or precise statistical data exist about peroneal tendon instability. Nevertheless, according to Neuerstatter et al, it seems to be a very common condition in asymptomatic subjects,⁶ in which two very distinct patterns can be encountered: traumatic anterior instability secondary to superior peroneal retinaculum (SPR) injury or atraumatic intrasheath subluxation due to muscular hypotonia and anatomic variants.¹ According to Butler et al, traumatic instability is an uncommon occurrence that happens only after 0.3–0.5% of ankle injuries, whereas non-traumatic instability was described in 20% of the general population.⁷ CT and MRI may be strictly normal or they may diagnose direct and indirect signs of instability, such as permanent anterior peroneal tendons dislocation, which is either associated with aspecific signs of tendinopathy or not. Unfortunately, peroneal instability is mainly a transient phenomenon, which could explain numerous false-negative static imaging results.^{4,8–10} Dynamic ultrasound (dUS) seems to be the modality of choice, as it allows real-time

exploration to assess abnormal motions of peroneal tendons, subluxation and dislocation.^{1,5,11} Furthermore, it is a low-cost, widely spread and radiation-free technique that can be used in patients with metallic hardware.¹² Indeed, recent literature has emphasized the precise and specific role of dUS in the diagnosis of peroneal instability and in distinguishing between these two injury patterns. In 2013, Lee et al described the common causes of peroneal tendon disorders including instability patterns, but without precise correlation to anatomic variants and physiological and clinical features.^{1,4,11,13} Then, the distinction between the two different injury patterns may be challenging, since the border between physiologic and pathologic features is often unclear.¹¹ More recently, in 2015, Taljanovic et al¹ described all these lesions and predisposing factors, such as a shallow retromalleolar groove, peroneus quartus muscle, low-lying PB muscle belly, absent retinaculum and ligamentous hyperlaxity. Nevertheless, in our opinion, focusing on the technique of dUS and its findings is necessary in order to understand and diagnose transient subluxation, something that MRI cannot depict alone.

The aim of this review was to review the anatomic and physiologic bases for peroneal instability, heighten the role of dUS and, above all, to clarify physiological and pathological snapping.

ANATOMY

The PB muscle emerges from the distal two-thirds of the lateral aspect of the fibula, the interosseous aponeurosis, and inserts onto the basis of the fifth metatarsal bone. The

Figure 1. An asymptomatic 24-year-old male. Ultrasound image (a) short axis at the level of the retromalleolar fibular groove and schematic drawing (b) showing slightly concave retromalleolar groove (white arrows), superior peroneal retinaculum (arrowheads), fibrocartilage ridge (star), distal muscular fibres of the peroneus brevis (PBm), peroneus brevis tendon (PBt) and peroneus longus tendon (PLt). LM, lateral malleolus; M, malleolus.

PL arises from the lateral tibial plateau, the head, and the proximal two-thirds of the lateral aspect of the fibula and the interosseous aponeurosis, and inserts onto the proximal aspect of the first metacarpal bone.¹¹ The muscles become progressively tendinous 4 cm before the fibular distal tip, and the PB tendon descends anteromedially to the PL tendon.

At the level of the retromalleolar groove, both tendons share a common synovial sheath and are stabilized by the SPR (Figure 1). The SPR originates from the periosteum of the posterolateral surface of the fibula, passes over the tendons and attaches in the aponeurosis of the Achilles tendon.⁴ At the fibular insertion of the SPR, a small triangular fibrocartilage ridge is often present and allows the concavity of the groove to increase.^{14,15}

Distally to the tip of the fibula, tendons lie on the calcaneofibular ligament and are stabilized by the inferior peroneal retinaculum.¹¹ They share a common sheath before dividing above the peroneal tubercle and passing through their own sheaths. The PB tendon is anterior to the tubercle and to the PL, respectively, whereas the PL is located between the tubercle and the retrotrochlear eminence¹⁵ (Figure 2). At the level of the cuboid bone, the PB remains superficial and lateral, whereas the PL courses medially towards the plantar arch. The peroneal tendons are innervated by the superficial peroneal nerve,¹¹ while the peroneal muscles produce

plantar flexion, pronation and eversion of the foot and ankle and act as dynamic stabilizers of the ankle.⁴

Numerous anatomic variants can be observed and may be involved in peroneal injuries. The retromalleolar groove, for example, may have different shapes; an MRI study reported that the groove was concave in 28% of patients, flattened in 43% of patients, convex in 18% of patients and irregular in 11% of patients.¹⁴ SPR may be absent or have various insertion types, such as conjoined insertion onto the aponeurosis of the calcaneal tendon and the lateral calcaneus or isolated attachment to the calcaneal tendon.¹⁵ The location of the musculotendinous junction of the PB is also highly variable and may represent a cause of snapping if low lying.¹⁴ Peroneus quartus is an accessory muscle that usually emerges from the PB muscle and inserts onto the retrotrochlear eminence of the calcaneus.¹⁵ The peroneal tubercle and retrotrochlear eminence represent two bony osseous prominences that may be a cause of impingement when hypertrophic.¹⁴ In 20% of the population, a small sesamoid called os peroneum may be present within the PL tendon at the level of the cuboid tunnel.¹⁶

INSTABILITY PATTERNS

Two distinct patterns may be reported according to the integrity of the SPR and the type of tendinous displacement.

Figure 2. Normal anatomy of the peroneal tendons at the level of the calcaneus. Schematic drawing (a), ultrasound image (b) short axis and surgical view using tendinoscopy (c). Peroneal tendons share a common sheath before coursing with their own sheath at the level of the peroneal tubercle (Tu). Peroneus brevis (PB) is anterior to peroneal tubercle whereas peroneus longus (PL) courses within a trochlea (Tr) anterior to the retrotrochlear eminence (E).

Figure 3. Oden classification. Grade I: superior peroneal retinaculum (SPR) is stripped from the malleolus. Grade II: fibrous ridge is detached from the SPR. Grade III: bony avulsion is associated with SPR injury. Grade IV: posterior SPR complete tear. PB, peroneus brevis; PL, peroneus longus.

ANTERIOR INSTABILITY

The most common type is pre-fibular instability, which consists of an abnormal anterior displacement of the tendon over the fibula. It is most often dynamic rather than static and always occurs after ankle traumas causing SPR injury. The Oden classification describes the different types of SPR injuries^{17,18} (Figure 3):

- Type 1: pouch at the fibular insertion site
- Type 2: tear at the fibular insertion site
- Type 3: bony avulsion at the fibular insertion site
- Type 4: posterior tear.

Types 1 and 3 occur most frequently (Figure 4). Tendinous instability may affect the tendon integrity and may lead to tenosynovitis with either a partial or complete tear.¹⁸ The main symptoms are lateral pain and a snapping sensation, and an abnormal displacement of a cord-like structure over the distal fibula may be encountered at clinical examination.

INTRASHEATH INSTABILITY

Another entity consists of retromalleolar subluxation when snapping occurs in the retromalleolar groove and consists of subluxation of the tendons on each other without SPR disruption or evidence of previous trauma. Clinical symptoms include a popping or snapping feeling and lateral ankle pain. Peroneal muscle contraction may also cause an audible click without any clinical evidence of tendinous displacement over the lateral malleolus. Two subtypes can be distinguished: Type A if tendons are normal and Type B if the PB has an associated longitudinal split.¹⁹

Retromalleolar instability seems to be associated with a normal SPR and anatomic variants such as a dysplastic retromalleolar groove, although this pattern remains debated in the literature.^{19,20} According to Thomas et al, low-lying PB muscle belly and peroneus quartus represent the most common causes of retromalleolar instability. Surgical treatment consists of the resection of muscle fibres

Figure 4. A 32-year-old male with Grade 1 superior peroneal retinaculum (SPR) tear. Ultrasound image (a) short axis at the level of the retromalleolar fibular groove and schematic drawing (b) showing SPR (arrows) which is stripped (double headed arrows) from the lateral malleolus. Note the intact fibrocartilaginous ridge (star). LM, lateral malleolus; PB, peroneus brevis; PL, peroneus longus.

Figure 5. A 28-year-old female with dynamic subluxation of the peroneal tendons. Axial ultrasound images and schematic drawing in neutral position (a, b) and dorsiflexion (c, d) showing dynamic peroneus longus (PL) tendon subluxation (dotted curved white arrow) over the lateral malleolus. Superior peroneal retinaculum (white arrows) is stripped from the lateral malleolus (LM). PB, peroneus brevis.

without any deepening of the groove and provides excellent results without any recurrence.²¹

ROLE OF DYNAMIC ULTRASOUND

Ultrasound is able to differentiate tendinous instability from other peroneal disorders such as tenosynovitis, tendinopathy and tears.

Subluxation is mainly dynamic, and static imaging provides false-negative results if performed without dynamic assessment. Ultrasound is the only tool available in the daily routine to provide dynamic examination and to diagnose dynamic subluxation. In addition, ultrasound is a widely available technique that may also depict signs of tenosynovitis or tendinopathy. Even though most patients are treated conservatively, surgical treatment may be used to treat elite athletes.^{18–24} Then, it is important to ensure an adequate diagnosis to reduce avoidable costs, as well as the time it takes to return to previous activities.

ULTRASOUND TECHNIQUE AND NORMAL APPEARANCE

Ultrasound is the most accurate technique for diagnosing peroneal instability because it allows confirmation of snapping

and analysis of aetiologies. Nevertheless, ankle examination with ultrasound must be standardized. First, it is mandatory to assess ligament integrity in order to know if tendinous disorders are either isolated or associated with tibiotalar instability following ankle sprains.^{1,13} Tendinous assessment is performed in axial planes using high-frequency superficial probes. The use of small probes with a large amount of gel may improve the quality of examination. A longitudinal study aims at measuring the height of an interstitial tear if present but is not useful to diagnose snapping; axial images are the most useful for the diagnosis of snapping. The recording of dynamic video and retrospective analysis may help radiologists to ensure the diagnosis and to spread imaging data to the clinician.⁵

Instability must be sought at the level of the retromalleolar groove; the PB is anterior and medial to the PL and has variable muscle belly and myotendinous junction sites. A hyperechoic triangular fibrocartilage is often seen at the SPR fibular insertion site and aims at increasing the concavity of the groove. At the inframalleolar level, both tendons must be assessed separately using slight craniocaudal probe motions, as anisotropy artefacts are constant and tendons have different

Figure 6. A 34-year-old female with dynamic subluxation of the peroneal tendons and associated peroneus brevis (PB) tear. Axial dynamic ultrasound in neutral position (a) and dorsiflexion (b) showing subluxation of the peroneus longus (PL) through a longitudinal split tear of the PB and stripping of the superior peroneal retinaculum (white arrows).

Figure 7. Schematic drawing of different types of peroneal tendon intrasheath subluxation. (a) Normal position. (b) Type A: peroneus brevis (PB) and peroneus longus (PL) have reversed their location and the PL comes to lie deep to the PB. (c) Type B: subluxation of the PL through a longitudinal split tear of the PB.

courses.¹³ Superior and inferior retinacula appear as thin hyperechoic fibrillar structures.

Instability must be depicted dynamically because it is most often transient and snapping occurs at different levels of motion. A patient lying on the examination table in a prone position allows muscular relaxation and may increase ultrasound accuracy. The tendinous aspect is variable according to the degree of dorsal flexion and eversion. In forced dorsiflexion, the PB tendon gets thinner and moves medially and anteriorly to the PL, whereas the SPR becomes convex. It is important to know that intrasheath subluxation may occur in normal subjects. In the study of Neustadter,⁶ it is reported that such subluxation is observed in 4 out of 20 asymptomatic volunteers.

ULTRASOUND PATHOLOGIC FINDINGS

Two types of peroneal instability may be described:

In case of anterior instability, the PB or most commonly PL moves anteriorly over the lateral malleolus partially (subluxation) or completely (dislocation) (Figure 5). Sometimes, when the PB has a longitudinal split, the PL passes through the two bundles of the torn PB and only the anterior bundle of the PB dislocates (Figure 6). At chronic stages, when the PB is completely torn, PL dislocation or luxation may also occur.

In case of intrasheath subluxation, there is an intertendinous intrasheath switch at the level of the retromalleolar groove. The PB rotates and takes the place of the PL and inversely, usually in forced eversion (Figure 7).

In a previous study, Neustadter et al⁶ compared ultrasound findings in patients who had surgery for peroneal instability. 10 out of 12 patients had prior SPR trauma, whereas 2 out of 12 patients had normal SPR and retromalleolar switch. The positive-predictive value of ultrasound was 100%. In the Thomas study, all cases of retromalleolar instability were confirmed by ultrasound.²¹ Nevertheless, it is important to keep in mind that a normal examination does not rule out the diagnosis of instability.⁴ The latter is usually sought in eversion and dorsiflexion manoeuvres. The distinction between physiological and pathological subluxation may be difficult to achieve and contralateral assessment is required to distinguish those entities.²⁵ Besides the diagnosis of instability, it is fundamental to acknowledge the tendon's integrity. Peroneal tendons may be normal at early stages but may show signs of tenosynovitis, tendinosis or tear when chronic. Tendinous

damages usually occur initially to the PB tendon as a longitudinal split and will later involve the PL tendon when the PB is torn.¹³

In addition to providing a positive diagnosis, ultrasound helps in defining the precise aetiology for the symptoms. SPR injuries occur after ankle sprains and may consist of distension or partial or complete tear with hyperaemia in colour Doppler imaging. The most common aspect is a stripped retinacular pocket at the lateral side of the malleolus, similar to a Bankart lesion of the shoulder, and represents Type 1 according to the Oden classification. Type 3 consists in bony avulsion of the lateral malleolus.

Anatomic variants such as a low-lying myotendinous junction of the PB or a dysplastic retromalleolar groove are normal findings at surgery, but not in ultrasound. With MRI, the retromalleolar groove can be assessed 1 cm below the tip of the fibula, but its different shapes have not been described with ultrasound yet.¹⁴ A low-lying musculotendinous junction of the PB is difficult to assess because its position varies a lot according to the degree of ankle dorsiflexion.¹⁴ In a control group, Saupe et al used MRI to define a low-lying musculotendinous junction as a position 15 mm distally from the tip of the fibula.¹⁴ Even if it seems difficult to apply this measurement with ultrasound, the

Figure 8. A 32-year-old soccer player with intrasheath subluxation. Endoscopic view of distal muscle fibres (arrows) of the peroneus brevis (PB) before resection. PL, peroneus longus.

Figure 9. A 22-year-old-male with intrasheath subluxation. Axial dynamic ultrasound in neutral position (a) and dorsiflexion (b) showing anterior motion (arrows) of the peroneus brevis (PB) at the level of its myotendinous junction in eversion at the undersurface of the peroneus longus (PL) tendon. PBm, peroneus brevis muscle belly.

presence of muscle fibres at the inframalleolar region over the calcaneofibular ligament in neutral position must alert the radiologist to the potential presence of a low-lying musculotendinous junction (Figure 8).

Peroneus quartus may be observed while using ultrasound, but its role in the onset of peroneal instability is also discussed. Its course is mainly out of the sheath and may rarely be responsible for retromalleolar swelling rather than instability.²⁶ The onset of clinical symptoms seems to depend on the muscle belly size. It can be challenging to differentiate low-lying muscle belly from peroneus quartus. The latter is posteromedial to the PB, is separated from the PB muscle by a fat plane and usually has a thin tendon.⁹ Sometimes, a partial snapping occurs between the hypertrophic muscle belly of the PB and the PL tendon (Figure 9). Such partial snapping may explain false-negative results with ultrasound because they are often difficult to assess.

In case of normal ultrasound findings, CT or MRI may provide information, but are not currently used in daily routine to diagnose snapping.^{4,27} As the tendons are often in

a normal position at rest, static images are unable to diagnose transient instability.

TREATMENT

Most patients are treated conservatively with rest, physiotherapy and footwear changes.

Nevertheless, surgical treatment may be used to treat elite athletes and in case of failure of medical treatment. Surgical procedures using novel techniques of tendoscopy allow for the reduction of scar formations, adhesions or sural nerve entrapments.²⁴ Surgery consists of an SPR plasty, although the deepening of the groove is actually debated.^{18–23}

CONCLUSION

In summary, ultrasound is the most accurate tool for diagnosing peroneal subluxation because it is more dynamic rather than static. It is important to remember that two injury patterns are to be differentiated according to the location of tendinous subluxation and the integrity of the SPR. Tenosynovitis and tendinopathy as well as anatomic variants may also be described by ultrasound.

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