PICTORIAL REVIEW

MRI of peroneal tendinopathies resulting from trauma or overuse

R SCHUBERT, MD

Radiologie am Europa-Center, Berlin, Germany

ABSTRACT. In spite of highly efficient diagnostic modalities at our disposal, pathological conditions of the peroneal tendons still tend to be underdiagnosed as a cause of lateral ankle pain. The purpose of this review is to summarise and illustrate common and less common MRI findings in repetitive or single mechanical lesions of the peroneal region as well as predisposing anatomical variants.

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Peroneal tendon (PT) pathology is not uncommon, but is infrequently reported in the literature. It is the main differential diagnosis of lateral ankle pain, next to capsular and ligamentous injuries. Given that normal tendons hardly ever get torn as a result of a single trauma, anatomical predisposition plays an important role in the pathogenesis of degenerative tendinosis and subsequent partial or complete tears of the PT. Rather infrequent causes for primary tenosynovitis are inflammatory conditions of the tendon sheath, *e.g.* rheumatic or infectious diseases [1]. Ruptured tendons typically exhibit pre-existing degenerative changes on biopsy studies [2]. In spite of some limitations, MRI is the current method of choice for imaging tendons and fibrocartilage. The MRI appearance of different types and grades of tendon injuries has been exhaustively described [3]. T_2 weighted images perpendicular to the tendon course are particularly appropriate for visualising tendinosis and partial or complete tendon rupture, as well as inflammatory changes of the tendon sheath (tenosynovitis). We used T_2^* gradient echo (GRE) sequences as well as T_2 fast spin echo (FSE) sequences; the higher sensitivity of the former allowed for detection of degenerative or traumatic lesions of fibrocartilage [4] and crystal or haemosiderin deposits in the tendon sheaths. However, when looking for tendinosis, the magic angle effect (MAE) must be considered as a source of bright signal in healthy tendons. With short echo time sequences, a signal increase in the absence of morphological change is a normal physical phenomenon in tendons oriented at approximately 55° to the main magnetic field (Figure 1). Because PTs change direction along their course, the MAE cannot be avoided completely by positioning the foot [5]. The change in

Figure 1 T_1 spin echo (SE) sagittal image of the lateral ankle. Bright signal of both the peroneus brevis tendon and the peroneus longus tendon below the lateral malleolus owing to the magic angle effect in a T_1 SE sequence. The foot is positioned at approximately 10° plantar flexion with the patient supine in a closed MR scanner with cephalocaudal main field direction.

Address correspondence to: Dr Roberto Schubert, Radiologie am Europa-Center, MVZ für bildgebende Diagnostik und Nuklearmedizin, Nürnberger Straße 67, Schöneberg, 10787 Berlin, Germany. E-mail: dr.schubert@mvz-radiologie.de

direction of PTs also necessitates T_2 weighted imaging in at least two planes to obtain perpendicular sections of the entire tendon from the myotendinous junction down to the insertion. The scanning protocol used here included T_2^* weighted axial GRE images through the ankle and hindfoot and coronal T_2 FSE images from the metatarsal bases to the Kager triangle, thus sectioning the PTs perpendicular in their supra- and inframalleolar course. Additional longitudinal fat-suppressed images are recommended to assess the extent of the disease and detect intrasheath fluid collections [3]. This article illustrates the normal MRI anatomy of the fibular and plantar PT compartments, the significance of anatomical variants and typical injuries or overuse syndromes along the tendon course.

Normal anatomy

The peroneus brevis (PB) muscle originates medial to the peroneus longus (PL) muscle, from the lateral surface of the fibula and the intermuscular septa in the distal two-thirds of the lower leg. The PL muscle arises from the proximal fibula, the lateral tibial condyle and the adjacent intermuscular septae and fasciae [1]. At the level of the ankle, both tendons share a common synovial sheath that is held in place by a fibro-osseous tunnel. This tunnel is bordered anteriorly by a sulcus in the dorsal fibula, called the retromalleolar groove (RMG), and posterolaterally by a fibrous band, the superior peroneal retinaculum (SPR). The SPR originates from the lateral margin of the distal fibula and the RMG and inserts most typically onto the aponeurosis of the Achilles tendon or the lateral calcaneus (Figure 2). The

Figure 2 T_2^* gradient echo axial image of the ankle. The superior peroneal retinaculum (arrowheads) can be identified as a thin hypointense band on transverse sections through the lateral malleolus.

SPR may include a small, fibrocartilaginous ridge at the fibular insertion, thus deepening the RMG. The calcaneofibular ligament acts as an additional stabiliser on the medial side of the tunnel [6]. In the fibular groove, the PB tendon (PBT) is typically situated adjacent to the bone, anteromedially to the PL tendon (PLT). Its profile on transverse sections is flat or mildly crescentic, whereas the PLT shows rounded contours [1]. The inferior peroneal retinaculum is a less important stabiliser of the PT distal to the fibular tip. It originates from the posterior lateral rim of the sinus tarsi in continuation with the inferior extensor retinaculum and inserts into the retrotrochlear eminence of the calcaneus [6]. At the hindfoot, the PLT normally undercrosses the PBT and runs plantar and deep (medial) to it (Figure 3). The PBT inserts into the lateral base of the fifth metatarsal. The PLT is inflected medially to the plantar region at the cuboid notch and inserts into the plantar surfaces of the first metatarsal base and the medial cuneiform bone (Figure 4).

Anatomical variants

Malleolar

In most individuals, the fibular RMG has a concave or flat border with a smooth surface [7]. A convex or irregular RMG may predispose to lateral dislocation and attrition damage to the PTs [1]. These variants are present in up to one-third of healthy subjects (Figure 5) [7].

Extension of PB muscle tissue below the level of the RMG (Figure 6) has been associated with PBT tears, probably due to crowding and increased pressure under the SPR. The average distance of the distal muscle end from the fibular tip in patients with PBT tears is significantly lower than in control groups without tears [8]. Foot position in the coil must be considered when assessing the distal extension of the peroneal muscles.

Peroneus quartus (PQ) is a generic term for a group of accessory muscles which arise from the distal fibula and run medial and posterior to the PBT and PLT within the peroneal compartment (Figure 7). They have their own tendons, distinct from the PBT and PLT, and show variable insertions, mostly into the retrotrochlear eminence of the calcaneus. The reported prevalence, based on cadaveric dissections, varies from 12% to 22%. The presence of a PQ muscle is usually asymptomatic. However, it can occasionally cause crowding under the SPR, predisposing to PBT pathology [1, 3, 9].

Inframalleolar

The peroneal tubercle (Figure 8) is a bony protuberance of the lateral calcaneus that is present in approximately half of the general population [1, 7]. It separates the PBT from the PLT. 90% of peroneal tubercles in normal volunteers were sized as ≤ 4.6 mm in one study [7]. Enlargement of ≥ 5 mm may irritate the PLT and lead to tendinosis and attrition ruptures [10].

The os peroneum (OP) is a sesamoid bone of variable shape and size in the PLT. It is normally located near the

Figure 3 Consecutive coronal T_2 weighted fast spin echo sections showing the course of the peroneus brevis tendon (short arrows) and the peroneus longus tendon (long arrows) from the fibular tip to their respective insertions.

lateral calcaneocuboid joint, proximal to the plantar inflexion of the PLT (Figure 9). Its prevalence on radiographs has been reported variably up to 30% [11]. The OP has occasionally been associated with acute traumatic or chronic attrition injuries of the PLT, especially in a cavovarus foot [12]. However, the mere presence of an OP does not predispose to degenerative tendon disease [11].

Pathological conditions

Tendinopathies

Imaging features

MRI is the most reliable non-invasive test to determine the extent of degenerative and inflammatory changes in tendon tissues and differentiate them from partial or subtotal ruptures. The MRI appearances of different types and grades of tendon injuries have been

elaborately described elsewhere [3]. An overview is given in Figure 10.

Peroneus brevis tendon

The spectrum of PBT injuries ranges from tendinosis (Figure 11) to complete tendon ruptures (Figure 12). Tears of the PBT rarely present as isolated findings [13]. They are often associated with one or more anatomical variants at the malleolar level (Figure 13) [13, 14]. Tendinopathies or tears of the PBT are found in young athletes as well as in elderly people. They are thought to be induced by repetitive stress and friction against the bone in the RMG. This would explain why the adjacent PBT is more often involved in this region than the more posteriorly located PLT. In up to one-third of PBT tears, however, concomitant lesions of the PLT are present (Figure 13) [1]. This holds particularly true for the peroneal split syndrome, referring to a longitudinal (split) tear of the PBT. If the tear is complete, the PLT moves forward into the gap, thus

Figure 4 Axial section (T_1 fat-saturated post-contrast image) along the oblique course of the peroneus longus tendon (arrow) in the plantar region.

preventing reunion of the PBT slips and eventually gaining contact with the fibular bone (Figures 14 and 15). MRI has been reported as 83% sensitive and 75% specific in the detection of a PBT tear, compared with intraoperative findings [13].

In some patients, the position shift of the PT in the fibro-osseous tunnel under the SPR is only temporary and can be elicited by a forceful eversion–dorsiflexion manoeuvre. This has been visualised pre-operatively by ultrasound and termed intrasheath subluxation of the PT [15].

Peroneus longus tendon

In addition to being involved in the PBT split syndrome, the PLT is also exposed to increased stress over fixed bony pulleys at the cuboid notch, and, if present, the peroneal tubercle. Isolated PLT injuries

Figure 5 Proton density fast spin echo axial image of the lateral ankle. An irregular or convex retromalleolar groove (arrow) is present in about one-third of healthy individuals.

may be degenerative, sports-related or associated with trauma. A cavovarus hindfoot position seems to be a predisposing factor. Foot mechanics may be seriously impaired by PLT ruptures, but asymptomatic cases have also been described. The final diagnosis is commonly delayed. Partial or split tears in the middle portion of the PLT (Figure 16) often occur in the presence of a hypertrophied peroneal tubercle (>5 mm). Complete tears are more frequently found at the fibro-osseous tunnel of the cuboid notch, where the PLT is deflected to the plantar area [16]. Conversely, the cuboid bone may be affected by chronic PLT overuse tendinopathy, leading to bone erosion and oedema (Figure 17) [17].

Tendinosis and attrition ruptures of the distal PLT have been related by some authors to the presence of an OP [18]. Although there is not enough evidence to support this view [11], the OP may show oedematous marrow changes in chronic PL tendinopathies (Figure 18). In the presence of an OP, complete PLT ruptures typically present either as a fracture through the OP with diastasis of the fragments or as a posterior dislocation of the whole OP attached to the proximal tendon stump (Figure 19) [19]. MRI is highly accurate in predicting partial or complete PLT tears, especially when oblique coronal T_2 weighted images of the PLT are obtained [16].

Figure 6 Four axial proton density fast spin echo sections through the lateral ankle. The musculotendinous junction of the peroneus brevis (arrows) reaches far below the retro-malleolar groove.

Figure 7 T_2^* gradient echo axial image of the lateral ankle. The peroneus quartus muscle (arrow) runs through the retromalleolar peroneal compartment posteromedial to the peroneus brevis tendon and the peroneus longus tendon.

Figure 8 Axial T_2^* gradient echo image through the calcaneus (left) and sagittal proton density fast spin echo at the lateral ankle (right) depicting a large peroneal tubercle, which separates the peroneus brevis tendon (short arrow) and the peroneus longus tendon (long arrow) at the inframalleolar hindfoot.

Figure 9 Sagittal T_1 spin echo (right) and coronal T_2 fast spin echo (left) images of an os peroneum adjacent to the calcaneocuboid joint.

	T1	T2
Normal
Peritendinitis, Paratenonitis
Tendinosis (Tendinitis)
Longitudinal split tear
Tenosynovitis
Partial tear
Full thickness tear
Complete tear with gap

Figure 10 Schematic diagram of T_1 and T_2 weighted cross-sectional MRI findings in tendinopathies caused by overuse or trauma. Parallel orientation of the tendons towards the main magnetic field is assumed to exclude the magic angle effect.

Figure 11 Tendinosis of the peroneus brevis tendon and tenosynovitis of the common peroneal sheath on axial T_2^* (left) and coronal T_2 weighted (right) MR images.

Figure 12 Retromalleolar coronal T_2 fast spin echo (left) and axial T_2^* gradient echo (right) at the ankle. Complete rupture of the peroneus brevis tendon (PBT), with the peroneus longus tendon (PLT) left intact (arrow). The PBT is frayed out and retracted from its normal position, and no healthy tendon slips are visible at the malleolar level. The PLT is slightly thickened, but shows no signal alteration. Both are surrounded by effusion in the common tendon sheath.

Figure 13 Axial proton density fast spin echo (left) and T_2^* gradient echo (right) images of the lateral ankle. Split tear of the peroneus brevis tendon (short arrow) with concomitant tendinosis and intra-sheath dislocation of the peroneus longus tendon (long arrow) in the presence of a convex retromalleolar groove (asterisk) and a peroneus quartus muscle (arrowhead).

Figure 14 Chronic peroneus brevis tendon (PBT) split tear with anterior migration of the peroneus longus tendon (arrow) into the bisected PBT (arrowheads) on axial T_2 fat-saturated MRI (left). Consecutive coronal T_2 images show a “triplicate” appearance of the peroneal tendons (right).

Figure 15 (left to right, top to bottom) Sagittal T_1 spin echo, coronal short tau inversion-recovery and two axial T_2^* gradient echo images. In this case of split peroneus brevis tendon (PBT) tear, the peroneus longus tendon (PLT) has moved through the longitudinal PBT defect and assumed an anterior position adjacent to the fibula. PBT, short arrows; PLT, long arrows.

Figure 16 (left to right) Sagittal T_1 spin echo, axial T_2^* and coronal T_2 images. Longitudinal incomplete tear of the peroneus longus tendon (arrows) in the presence of a large peroneal tubercle.

Figure 17 (top to bottom, left to right) Coronal T_1 short tau inversion-recovery (STIR) and sagittal STIR images. Massive bone oedema of the cuboid around a small indentation contains the normal-appearing peroneus longus tendon (arrows). This may be interpreted as a fatigue fracture.

(a)

(b)

Figure 18 (a) Low signal on T_1 (left) and high signal on T_2 weighted (right) fat-saturated images within and around an os peroneum (OP) (arrows), consistent with bone and soft-tissue oedema. (b) Coronal T_2 fast spin echo images show signal increase of the encircled peroneus longus tendon proximal to the OP, suggestive of tendinosis.

Figure 19 (a) Three sagittal short tau inversion-recovery, two sagittal and one axial T_1 weighted image. Complete rupture of the peroneus longus tendon (PLT) distal to an os peroneum (OP). There is a haematoma in the gap (asterisk), and the OP is dangling from the retracted proximal rupture end (arrows). The distal end of the PLT is also visualised (arrowheads). (b) Coronal T_2 fast spin echo images show discontinuity of the PLT (encircled) on contiguous slices.

Tendon dislocations

PT subluxations or dislocations typically affect both the PLT and the PBT because they share a common sheath which is stabilised within the fibular groove by the SPR. Traumatic injuries to the SPR may cause intermittent or permanent anterior displacement of the tendons out of the RMG and eventually lateral to the fibula (Figure 20) [6]. The dislocation may be permanent or recurrent owing to instability of the PT. Patients

typically give a history of ankle sprain [20]. In non-permanent cases, it is possible to provoke displacement by dorsiflexion–eversion of the foot. MRI can be used to detect ruptures of the SPR or associated split tears of the PBT in subluxations [1, 5].

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Figure 20 Coronal T_2 fast spin echo (left) and axial T_2^* gradient echo (right) images. This patient presented with recurrent dislocation of the peroneal tendons, which could be temporarily repositioned by flexion–inversion of the foot. The superior peroneal retinaculum was discontinuous on transverse MRI sections.

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