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Pictorial Essay

Spring Ligament of the Ankle: Normal MR Anatomy

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The plantar calcaneonavicular or spring ligament is visualized inconsistently and incompletely on routine MR images of the foot. This ligament is a vital stabilizer of the longitudinal arch of the foot, providing support for the head of the talus, which rests on the ligament's central portion. Laxity or rupture of the spring ligament permits plantar flexion of the talus. This motion results in valgus alignment of the calcaneus and a flat-foot deformity (pes planovalgus). Laxity or rupture of the spring ligament can develop in cases of chronic dysfunction of the posterior tibial tendon [1]. In rupture of the posterior tibial tendon, surgical management may include plication of the spring ligament in addition to repair or reconstruction of the tendon to stabilize the medial column of the foot [2]. Thus, the status of the spring ligament can be a significant consideration in preoperative planning. This pictorial essay illustrates the normal MR anatomy of the spring ligament, the planes of imaging required for optimal depiction of the ligament, and the neighboring structures with which the ligament can be confused.

Normal Anatomy

The spring ligament is a thick triangular sheet that arises from the undersurface of the sustentaculum tali and attaches to the inferior and medial surfaces of the navicular bone (Figs. 1 and 2A). The spring ligament fills the bony gap between the anterior part of the calcaneus and the navicular bone. Medially, the spring ligament is supported by the anterior fibers of the superficial deltoid ligament (tibiospring fibers) with which it blends (Fig. 1). The posterior tibial tendon runs superficial to the tibiospring fibers (Fig. 2A). The plantar expansion of the posterior tibial tendon provides

some support to the inferior aspects of the spring ligament. Laterally, the spring ligament is contiguous with the medial band of the bifurcate ligament, occasionally separated from it by a layer of fat (Fig. 2B). The bifurcate ligament is a Y-shaped ligament joining the medial superior aspect of the anterior calcaneus to the neighboring aspects of the navicu-

Fig. 1.—Fresh cadaveric dissection, medial exposure. Flexor retinaculum of foot has been resected (straight solid arrows), and posterior tibial (open arrow) and flexor digitorum longus (curved arrow) tendons have been reflected anteriorly. Flexor hallucis longus tendon (FH) has been retracted. Tibiospring portion of deltoid ligament (arrowheads) has been incised. Spring ligament (asterisk) spans sustentaculum tali (ST) and navicular bone (N). TA = anterior tibial tendon.

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Fig. 2.—Three-dimensional surface renderings of hindfoot (reconstructed from T1-weighted MR images).

A, Medial view of hindfoot shows medial aspect of spring ligament (red) spanning sustentaculum tali (ST) and navicular bone (N). Posterior tibial tendon (green) is seen superficial to spring ligament.

B, View from below shows plantar aspects of spring ligament (red) and adjacent bifurcate ligament (green).

lar bone and the cuboid bone. Avulsion injuries of the bifurcate ligament can result in a familiar and characteristic fracture of the superior aspect of the anterior process of the calcaneus. Plantar to the bifurcate ligament is the calcaneocuboid (short plantar) ligament.

The complex orientation of the spring ligament precludes its complete depiction in a single imaging plane. From an imaging perspective, the spring ligament can be conceptualized as consisting of two parts: a medial, vertical portion (continuous with the deltoid ligament) and a plantar, horizontal portion (contiguous with the bifurcate ligament and short plantar ligament).

MR Anatomy

MR imaging was performed with a 1.5-T unit with a 17-cm transmit-receive extremity coil or with single or dual (Helmholtz configuration) 3-in. (7.6-cm) surface coils placed over the sides of the hindfoot. Spin-echo T1-weighted images were acquired with a 3-mm section thickness.

The spring ligament is depicted inconsistently on routine MR images of the foot [3]. Axial images at the level of the talonavicular articulation show the medial aspect of the spring ligament (Fig. 3) deep to the posterior tibial tendon and continuous with the tibiospring portion of the deltoid ligament. The medial portion of the spring ligament can be difficult to distinguish from the posterior tibial tendon at their conjoined insertion along the navicular bone. Axial or oblique axial images of the plantar aspect of the spring ligament are limited by volume averaging, usually depicting only portions of this aspect of the ligament (Figs. 4A and 4B). Axial imaging in mild plantar flexion (25–35°) of the ankle is slightly more effective in this regard (Fig. 4C).

True sagittal images through the hindfoot will better show the full span of the plantar aspect of the spring ligament [4] (Fig. 5A). Mild plantar flexion also assists visualization of the spring ligament in this plane. Laterally, the bifurcate ligament should not be mistaken for a portion of the spring ligament (Fig. 5B).

The plantar portion of the spring ligament (Fig. 6A) has an oblique course, crossing anteromedially from calcaneus to

Fig. 3.—Axial MR images of medial portion of spring ligament.

A, At level of superior aspect of talonavicular articulation, slender tibiospring portion of deltoid ligament (curved arrows) is seen deep to posterior tibial tendon (straight arrows). Note deep fibers (tibiotalar fibers) of deltoid ligament (arrowhead).

B, Axial image through more inferior aspect of talonavicular articulation shows medial aspect of spring ligament (curved arrows). This portion of ligament can be difficult to distinguish from posterior tibial tendon close to their insertion on navicular bone (straight arrows).

Fig. 4.—Axial MR images of plantar portion of spring ligament.

A and B, Commonly, only partial visualization of plantar portion of spring ligament (*arrowheads*) is achieved on individual axial images. Volume averaging can limit assessment of overall integrity of ligament. Note adjacent fibers of short plantar ligament (**B**, *arrows*) lateral to spring ligament.

C, Plantar fibers of spring ligament (*arrows*) occasionally can be imaged successfully on axial images acquired with foot in mild plantar flexion.

Fig. 5.—Sagittal MR images through hind-foot.

A, Usually, plantar portion of spring ligament (*white arrows*) is well seen on only one or two consecutive 3-mm sagittal images (1.5-mm gap). Note partial visualization of short plantar ligament (*black arrows*). T = talus, C = calcaneus, N = navicular bone.

B, More laterally, bifurcate ligament is seen spanning anterosuperior part of calcaneus and navicular bone (*arrows*). *Arrowheads* = interosseous talocalcaneal ligament, N = navicular bone, C = calcaneus.

navicular bone, 40–55° to the longitudinal axis of the calcaneus. Hence, the best plane for imaging the plantar portion of the ligament is an oblique sagittal plane (Fig. 6B). The appropriate degree of obliquity can also be approximated by externally rotating the foot 45°. These oblique sagittal images should be obtained with the ankle in neutral position or minimally dorsiflexed. In contrast, true sagittal images through the hindfoot show the spring ligament to best advantage when the ankle is in plantar flexion (Fig. 5A).

Finally, the transitional part of the spring ligament, the junction of the medial and plantar portions, can be seen to

best advantage on an oblique axial image at 35–45° from the true axial plane (Fig. 7). The medial plantar transition area of the spring ligament is the thickest part of the ligament.

Conclusions

The spring or calcaneonavicular ligament is a vital stabilizer of the longitudinal arch of the foot. Despite its considerable size and caliber, the spring ligament is not readily imaged on MR studies because of its complex, multidimensional orientation. The plantar and medial aspects of the lig-

Fig. 6.—Oblique sagittal MR images of plantar portion of spring ligament.

A, Axial scout image shows appropriate oblique sagittal imaging plane (*black line*), 40–55° from longitudinal axis of calcaneus. *Curved arrow* = spring ligament, *straight solid arrow* = posterior tibial tendon, *arrowhead* = flexor digitorum longus tendon, *open arrow* = flexor hallucis longus tendon.

B, Oblique sagittal image shows plantar aspect of spring ligament to advantage (*straight solid arrows*). Also noted is intersection of flexor digitorum longus and flexor hallucis longus tendons (“knot of Henry,” *open arrow*) and plantar expansion of posterior tibial tendon (*curved arrow*). These images should be obtained with ankle in neutral position or minimal dorsiflexion.

Fig. 7.—Oblique axial MR images of medial plantar transition area of spring ligament.

A, Coronal scout view of hindfoot shows oblique axial plane (*black line*) chosen to best depict medial plantar transition area of ligament. *T* = talus, *solid arrows* = spring ligament, *open arrow* = posterior tibial tendon, *arrowhead* = plantar expansion of posterior tibial tendon.

B, Thickest portion of spring ligament, between plantar and medial portions (*arrows*), is well seen, distinct from adjacent posterior tibial tendon (*arrowhead*). *T* = talus, *ST* = sustentaculum tali.

ament cannot both be imaged to advantage in a single imaging plane. The plantar aspect of the ligament is best depicted on oblique sagittal images obtained approximately 45° to the long axis of the calcaneus, with the ankle in neutral position or minimally dorsiflexed. The medial portion of the ligament is more easily imaged, being well depicted on axial and oblique axial images through the talonavicular articulation. The spring ligament should not be confused with adjacent and related structures such as the expansion of the posterior tibial tendon, the tibiospring portion of the deltoid ligament, the short plantar ligament, or the bifurcate ligament.

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