Anatomic and MRI study of the subtalar ligamentous support


Summary: The diagnosis of subtalar instability remains difficult both clinically and radiographically. The authors present an anatomic and MRI study of the subtalar ligamentous support. The anatomic study has consisted in dissections and sections of cryoconserved hindfeet (15 cases) which precises the organisation of ligamentous bundles in the lateral (sinus tarsi) and central (canalis tarsi) subtalar compartments, mainly represented by the trilayered inferior extensor retinaculum, the cervical talo-calcaneal ligament and the interosseous talo-calcaneal ligament. MRI study (1.5 tesla) of anatomic specimens was performed according to defined types of sections: sagittal, coronal, coronal oblique, axial transverse. The correlations of anatomic and MRI sections allowed a precise interpretation of the subtalar ligamentous support as anatomically described. A complementary clinical MRI study was performed which allowed the validation of "the inversion test": this test optimizes the visualization of the different ligamentous structures. Relative to the difficulties of conventional imaging procedures, MRI appears of clinical relevance in the diagnosis of subtalar instabilities. This technique allows direct visualization of ligaments (or their rupture) and therefore a better evaluation of subtalar involvement in ankle sprain. This paper present a functional concept in MRI articular ligamentous restraints concern.

Étude anatomique et IRM du complexe ligamentaire sous-talien en position statique et en inversion

Résumé: L’instabilité sous-talienne reste de diagnostic difficile tant cliniquement que radiographiquement. Les auteurs présentent une étude anatomique et par IRM du complexe ligamentaire sous-talien. L’étude anatomique, basée sur les dissections et coupes de 15 pieds précise l’organisation des différents faisceaux ligamentaires, répartis dans le compartiment latéral (sinus tarsi) et le compartiment central (canalis tarsi) et représentés par le retinaculum inférieur des extenseurs (formé de trois plans distincts), le ligament cervical talo-calcanéen, le ligament interosseux talo-calcanéen. L’étude IRM (1,5 tesla) a été réalisée selon différents plans de coupe : sagittal, coronal, coronal oblique, transverse. La corrélation des coupes anatomiques et IRM permet de retrouver avec précision les différents faisceaux ligamentaires décrits. Cette étude a été complétée par une étude IRM clinique qui a permis de valider le "test en inversion" qui optimise, pour toutes les coupes, la visualisation des structures ligamentaires. L’IRM apparaît très intéressante dans l’approche des instabilités sous-taliennes en permettant une vision directe des faisceaux ligamentaires (ou leur éventuelle lésion) et plus généralement dans l’approche des instabilités de cheville qui peuvent associer des lésions ligamentaires tibio-tarsiennes et sous-taliennes. Ce travail introduit la notion d’IRM "fonctionnelle" qui semble pouvoir être développée dans le cadre de l’exploration des structures ligamentaires de stabilisation articulaire.

Key words: Subtalar ligamentous support — Subtalar instability — IRM

Soft tissue inversion injuries of the ankle most commonly involve the ligamentous structures of the lateral aspect of the ankle and sinus tarsi. These injuries can result in severe pain and/or instability of the ankle and subtalar joints particularly in athletes. Subtalar instability is now a well recognised clinical entity, the diagnosis of which remains difficult both clinically and radiographically. It is worth reviewing again the anatomy of the subtalar ligaments due to the complexity and variable description in the literature. The aim of this study is to define accurately the normal anatomy of the subtalar ligamentous complex and
correlate anatomical sections with those obtained by magnetic resonance imaging (MRI). This radio-anatomical study includes a functional examination of the articular structures in forced inversion, a particularly important position clinically, in the assessment of subtalar instability.

Material and methods

1. The anatomical study consisted of the dissection of fresh cadaveric hindfeet (10 cases). The dissection was performed plane by plane from superficial to deep using a lateral surgical approach (from the lateral malleolus to the base of the fifth metatarsal). The study essentially concentrated on the fascio-ligamentous structures of the subtalar joint and the identification of the individual components by their attachments and orientation.

2. Correlation of the anatomical and MRI sections

Several planes of section were defined for the visualisation of all the ligamentous structures, namely the sagittal, coronal, coronal oblique (35° oblique to the canalis tarsi) and axial planes. Radioclinical correlation was established from a series of sections performed on 5 cryopreserved feet in different planes (2 coronal, 1 coronal oblique, 1 sagittal and 1 axial).

MRI study: The MRI studies were performed on a 1.5 T Philips Gyroscan ACS II high field system using a phased array quadrature extremity coil. The imaging protocol was a gradient echo sequence with the following parameters: T1 weighted volumetric acquisition in the sagittal plane, TE = 9 ms, TR = 34 ms, flip angle = 45°, 256 x 256 matrix, slice thickness of 1 mm, 2 excitations, field of view = 160 mm, with coronal and axial reconstructions, total acquisition time 18 min 34 sec.

Anatomical sections: Sections were obtained at 1-cm intervals using a band-saw. The specimens were immobilised with the ankle in the neutral position prior to freezing in order to give reproducible sections.

Method for comparison: The multiplicity of the MRI sections allowed sufficient choice for accurate correlation with the anatomical sections which for technical reasons were lower in number due to the thickness being at least 1 cm (an average of 10 sections in the sagittal and coronal planes and 5 sections in the axial plane). The choice of sections was essentially based on a comparison of the bony structures. The correlation of the sections by the radiologists and anatomists was initially undertaken independently followed by a consensus opinion.

3. MRI control group

Having established the reliability of the imaging protocol, the study was completed by scanning the feet of five normal volunteers with no symptoms of subtalar joint pathology. The same imaging protocol was used both with the foot in the neutral position as well as in forced inversion. This inversion test was easy to perform by the application of a self-retaining band to hold the foot in the required position, the aim of which was to apply stress to the subtalar ligaments.

Results

Anatomical study

The dissection progressively demonstrates the following structures (Figs. 1, 2, 3, 4, 5):
- a superficial lateral compartment consisting of the ligaments of the sinus tarsi with the inferior extensor retinaculum and the cervical ligament.
- a deep central compartment which essentially is made up of the ligaments of the canalis tarsi with the interosseous talocalcaneal ligament and the deep band of the inferior extensor retinaculum.
- The inferior extensor retinaculum (IER) is seen as a condensation of the fascia of the lower leg. It was named the “ligament frondiforme” by French anatomists but British texts refer to it as the “ligamentum fundiforme”. Three distinct layers of the IER can be identified:
  * the superficial layer inserts onto the lateral border of the anterosuperior tubercle of the calcaneus and extends laterally to reinforce the sheath of the peroneal tendons. Removal of this fascia reveals:
    * the intermediate layer which forms the true pulley for the reflection of the extensor digitorum longus and peroneus tertius tendons. It continues deep to these tendons and the superficial layer to insert onto the lateral aspect of the anterior process of the calcaneus and would appear at this level to represent a thickening of the superficial layer.
    * the deep layer is, in fact, an element of the central compartment. It penetrates the canalis tarsi and blends with the fibers of the interosseous talocalcaneal ligament. It becomes a true sling at the level of the neck of the talus to which it is attached.

- The cervical ligament (also called the anterolateral talocalcaneal or the anterior talocalcaneal ligament) is the strongest element connecting the talus and calcaneus. Its origin is sometimes (4 cases) delineated by a clearly defined bony eminence located at the antero-inferior position of the head of the talus (the tuberculum cervicis). At its origin it is situated between the insertion of the lateral calcaneonavicular ligament anteriorly and the anterior talofibular ligament posteriorly. The cervical ligament inserts into the dorsal surface of the anterior calcaneal tubercle, its fibers interspersing with those of the intermediate layer of the IER. The long axis of the ligament is orientated at an angle of 45-50° to that of the calcaneus in the sagittal plane. Usually it appears as a single fasciculus (8 cases), more rarely as a multifasciculated structure (2 cases).

- Further posteriorly in the lateral compartment, the lateral talocalcaneal ligament can be identified. It takes its origin from the lateral process of the talus and inserts into the calcaneus beneath the posterior talocalcaneal (subtalar) articular surface. This very short ligament parallels the calcaneofibular ligament and can be described as an accessory bundle of this ligament but from which it could be clearly differentiated on our dissections.