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Magnetic resonance imaging (MRI) of the knee: Identification of difficult-to-diagnose meniscal lesions

F. Lecouvet*, T. Van Haver, S. Acid, V. Perlepe, T. Kirchgesner, B. Vande Berg, P. Triqueneaux, M.-L. Denis, E. Thienpont, J. Malghem

Department of radiology and medical imaging, institut de recherche expérimentale et clinique (IREC), université catholique de Louvain (UCL), cliniques universitaires Saint-Luc, avenue Hippocrate 10/2942, 1200 Brussels, Belgium

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Abstract This article characterizes common meniscal pathologies, reviews magnetic resonance imaging (MRI) diagnostic criteria for meniscal tears, and identifies difficult-to-detect tears and fragments and the best MRI sequences and practices for recognizing these lesions. These difficult-to-diagnose meniscal lesions that radiologists should consider include tears, meniscocapsular separation lesions, and displaced meniscal fragments. Meniscus tears are either vertical, which are generally associated with traumatic injury, horizontal, which are associated with degenerative injury, or combinations of both. MRI has a high sensitivity for tears but not for fragments; MRI performance is also better for medial than lateral meniscal lesions. Fragment detection can be improved by recognizing signs secondary to migration, especially signs of epiphyseal irritation and mechanical impingement. Radial and peripheral tears, as well as those close to the posterior horn insertion, have been traditionally difficult to detect, but improvements in arthroscopic knowledge, identification of common lesion patterns, and selection of the proper MRI sequence and plane for each lesion type mean that, when properly used, MRI is an invaluable tool in detecting all types of meniscal tears.

* Corresponding author.
E-mail address: frederic.lecouvet@uclouvain.be (F. Lecouvet).

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Knee pathology is one of the most common indications for musculoskeletal imaging. In particular, evaluation of meniscal lesions, whether of degenerative or traumatic origin, accounts for a large proportion of the knee examinations performed with magnetic resonance imaging (MRI). Knowledge of meniscal pathology and MRI appearances of degenerative and traumatic meniscal lesions has advanced over the years. Studies on the performance of MRI with surgical correlation have identified the most frequently missed meniscal lesions, so that radiologists and arthroscopists know where actively search for meniscal diseases [1—3]. Discussions among clinicians, surgeons, and arthroscopists have advanced the clinical knowledge of the ''tricky'' lesions that should be known by radiologists. After a brief review of the typical meniscal lesions, this paper describes these ''must know'' lesions.

Characteristics of meniscal pathology

Lesion definitions

Generally speaking, meniscal lesions manifest as:
- tears, which are characterized by abnormal intrameniscal signal that extends to the meniscus surface;
- substance loss, wherein the meniscus loses its normal triangular shape;
- displaced meniscal fragments which may remain attached to the parent meniscus or break free from this meniscus.

MRI has high sensitivity and specificity for diagnosing meniscal tears. However, this diagnostic value is more limited for fragment detection. Hence, meniscal fragments must be actively searched for in the common locations of displacement [4].

Meniscal tear patterns

On MRI, a tear presents as an abnormal intrameniscal signal on T2-weighted or proton density MR images that unambiguously contacts the meniscal surface; that is, the tear is visible on at least 2 consecutive slices or on 2 images acquired in different planes [5,6].

These tears are categorized according to their patterns using the same classifications used by arthroscopic surgeons (Fig. 1) [7]. Vertical tears are oriented perpendicularly to the tibial plateau. Vertical tears may be longitudinal (follow the long axis of the meniscus), radial (perpendicular to the long axis of the meniscus), or oblique/vertical flap (combination of radial and longitudinal also known as ''parrot beak'' tears). Vertical tears, in particular posterior, peripheral, and longitudinal tears, are commonly caused by trauma. Horizontal tears are more typically caused by degeneration and contact with the meniscal articular surface. A pure horizontal tear divides the meniscus in half and runs parallel to the tibial plateau with the tear exiting at the meniscal apex. A true horizontal tear has also been referred to as a horizontal cleavage tear or a ''fish mouth'' tear, given the appearance at arthroscopy. A horizontal flap tear describes horizontally oriented tears that contact either the femoral or tibial articular surface rather than the meniscal apex. Lastly, complex tears show combinations of the patterns described above.

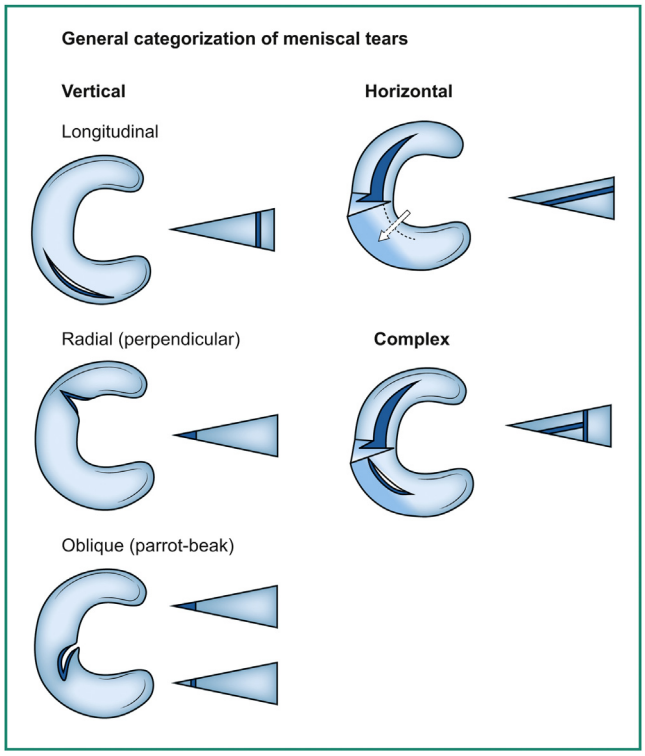

Figure 1. Illustrations of typical meniscal tears according to their orientation. Vertical tears may be longitudinal, radial, and oblique and are most often due to trauma. Horizontal tears are most often due to degeneration. Complex tears combine several orientations.

Loss of substance

A degenerative or traumatic meniscal lesion may result in loss of meniscal tissue. Loss of substance results from migration and may be followed by fragment separation. This loss of substance causes the normal triangular shape of the meniscus to be absent on MRI sections. In extreme cases, loss may be ''total'', being either chronic in the terminal phase of osteoarthritis or following extensive meniscectomy; or acute due to meniscal displacement, for example in intercondylar ''bucket-handle'' tears).

Fragments and displaced flaps

A portion of the meniscus may become displaced. When the meniscal tissue remains attached to the parent meniscus, it is referred to as a displaced flap. Detached meniscal tissue is referred to as a free meniscal fragment. Potential migration sites must be known and systematically checked when knee MRI are interpreted. For instance, the fragment may remain in contact with the parent meniscus, be found in a joint space, or migrate a considerable distance from the parent meniscus. The most common locations for migration are the superior and inferior meniscal recesses and the intercondylar notch (Fig. 2).