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European Journal of Radiology 54 (2005) 189–198

EJR
EUROPEAN JOURNAL OF RADIOLOGY

www.elsevier.com/locate/ejrad

Imaging the post-operative meniscus

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Received 20 January 2005; received in revised form 24 January 2005; accepted 28 January 2005

Abstract

Considerable developments have occurred in meniscal surgery, and consequently in the imaging of post-operative menisci, over the last 15 years. A drive to preserve meniscal physiologic function for as long as possible, in order to delay osteoarthrosis, has resulted in limited partial meniscectomies, meniscal repairs and meniscal transplants. Each of these techniques affects the imaging appearance of the meniscus, reducing the accuracy of conventional MRI in predicting recurrent tears. The specificity of conventional MRI can be improved by employing at least two T2-weighted sequences, but this still leaves a shortfall in sensitivity. In an attempt to increase the diagnostic accuracy of cross-sectional imaging, MR arthrography (MRA) and CT arthrography (CTA), have been applied to the post-operative meniscus. Sensitivities and specificities for these two techniques approach 90% in predicting recurrent meniscal tears. In the setting of clinical symptoms and gross meniscal deficiency, meniscal allografts are being transplanted with increasing frequency. In these transplants meniscal degeneration, fragmentation and separation are common findings, but the role of imaging in the management of these patients has not yet been well defined. This review explores the imaging techniques available for the evaluation of the post-operative meniscus, their strengths and weaknesses, and the reasons that they may find a place in a rational strategy for imaging of the symptomatic post-operative knee.

Keywords: MRI; CT; Knee; Meniscus; Surgery

1. Introduction

The radiologist, who is presented with a patient who has undergone meniscal surgery, faces a number of challenges. The evolution of surgical technique has led to developments in meniscal preservation, repair and replacement. At the same time, advances in radiological hardware have provided a variety of new techniques for assessment of the meniscus. While surgeons continue to assess the efficacy of their latest operative techniques, radiologists strive to validate their imaging techniques in this small, but complex, anatomical area. For decades, conventional fluoroscopic arthrography was the radiological technique for investigating meniscal disease [1,2], but this has now been replaced by MRI [3–6]. Conventional arthrography has the merit of allowing dynamic examination of the knee. Stressed valgus and varus manipulation can help to displace the apposed edges of a tear which may not be apparent with MRI [7]. Interpreting conventional arthrographic images requires considerable skill because real-time fluoroscopy is needed to interpret the three-dimensional anatomy, which is projected onto a two-dimensional radiograph. This skill has now, largely, been lost as MRI provides a relatively quick, non-invasive method of obtaining cross-sectional information, the analysis of which is not dependent on a single operator. But MRI alone can have significant limitations in the evaluation of the post-operative meniscus. MR arthrography (MRA) and CT arthrography (CTA) have been developed in an attempt to address these limitations.

This review concentrates on MRI, MRA and CTA of the knee in patients with previous meniscal surgery. The details and optimization of each of these techniques are described. Three categories of meniscal surgery, resection, repair and replacement, are considered in turn. In each case, the question

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doi:10.1016/j.ejrad.2005.01.024

of what the surgeon needs to know, and what the limitations to those answers are, is discussed.

2. Surgery

Over the years, the surgical management of meniscal disease has progressed from open complete excision of the meniscus to arthroscopic partial resection and, more recently, techniques to repair and replace the meniscus. Open total meniscectomy was, for decades, the standard surgical treatment for all degenerative and traumatic meniscal disease warranting intervention [8]. The role played by the menisci in spreading the transmission of forces from the femoral condyle to the tibial plateau during weight-bearing became clearly understood nearly 30 years ago [9]. Without the dissipation of forces through the deforming hoop of fibrocartilage, which is the meniscus, osteoarthrosis rapidly ensues because the area of contact between the femoral condyle and tibial plateau is significantly reduced [10–12].

2.1. Limited meniscal resection

The overriding principle guiding the extent of a partial meniscectomy is the preservation of as much stable meniscus as possible while excising unstable tissue. It has been shown that the most important anatomical component of the meniscus to preserve is the outer third. It is the circumferential collagenous connective tissue fibres at the periphery of the meniscus that maintain the vast majority of "hoop stresses" during mechanical loading, and it is these stresses that dissipate the transmitted loads across the tibial plateau [13]. The outer third of the meniscus can often maintain much of the shock-absorbing function of the intact meniscus [14]. During meniscectomy, some stable normal meniscus is also often removed if after resection of the unstable fragment, the morphology of the remaining meniscus predisposes to focally high stresses that may lead to a recurrent tear. In other words, the final shape of the residual meniscus must approximate, as close as is possible, to the original semi-lunar shape of the meniscus [15]. In practice, this means that all types of meniscal tears (radial, horizontal, bucket handle and vertical) are treated by one of two types of resection: either a circumferential or segmental meniscectomy (Figs. 1 and 2). A circumferential resection maintains the "hoop-stress" function of the outer third of the meniscus. In contrast, a segmental resection results in the loss of this important biomechanical property of the mensicus.

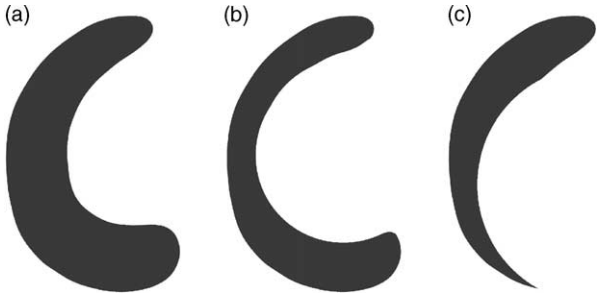

Fig. 1. Diagrammatic representation of the medial meniscus (a) illustrating the two types of partial meniscectomy: (b) circumferential—where the posterior horn and anchor, and therefore the meniscal "hoop" has been preserved; and (c) segmental—where the posterior attachment has been resected and the load transmitting function has been sacrificed.

Menisci with stable horizontal tears can continue to dissipate loading forces through the knee despite the structural damage [16]. For this reason, a more conservative approach is often employed in the management of pure horizontal cleavage meniscal tears. Unlike other forms of unstable meniscal tears, horizontal tears do not have to be completely excised. Following careful arthroscopic probing of the superior and inferior portions of the meniscus (the laminae), only those parts that are found to be unstable will be resected. Therefore, a horizontal cleft, which extends to the articular surface, may remain in the stable residual meniscus following the operation [15] (Fig. 3).

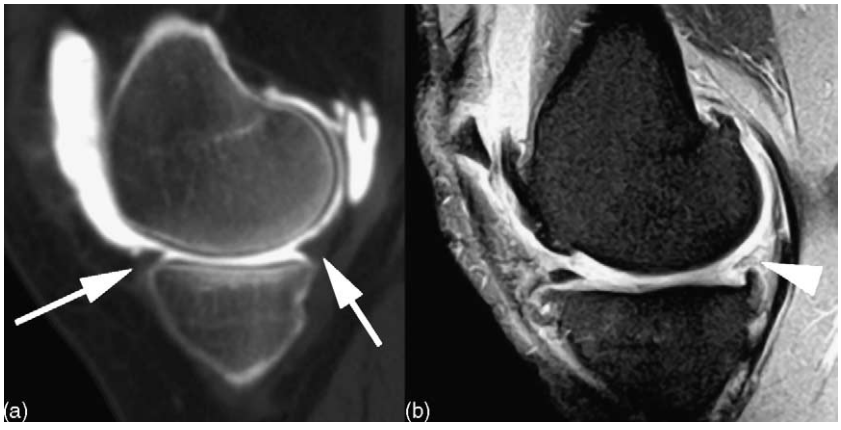

Fig. 2. (a) Sagittal image from a CTA following a circumferential partial meniscectomy. Both anterior and posterior horns (arrows) are reduced in size but the outer third of the meniscus has been preserved throughout. (b) Sagittal fat-saturated proton density demonstrates an absent posterior horn (arrowhead) of the medial meniscus following a segmental resection. Subsequent osteoarthrosis is indicated by large marginal osteophytes.