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Review

Medial meniscal extrusion: Detection, evaluation and clinical implications

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ABSTRACT

The menisci play an important role in knee kinematics. Their unique anatomy allows them to channel forces generated during knee movements through the larger tibio-femoral condylar surfaces while simultaneously resisting deleterious hoop stresses. Although physiologic meniscal extrusion occurs with every knee joint movement, pathologic meniscal extrusion subjects the knee to persistent and excessive load transmission. This renders the knee structures susceptible to injury or exacerbates worsening of existing knee joint internal derangement. Detection and quantification of meniscus extrusion is important given its association with underlying pathological processes and internal derangements such as cartilage loss, osteoarthritis and meniscal tears. The medial and lateral menisci vary in size, attachments and load transmission, and the medial meniscus is more susceptible to injury. In this article, the authors illustrate the role of meniscus kinematics, and the identification and quantification of medial meniscal extrusion. Multimodality imaging appearances and implications of presence of medial meniscal extrusion in different knee joint pathologies are discussed with review of the relevant literature.

1. Introduction

The medial and lateral menisci are asymmetric, incomplete fibrocartilaginous discs located on the tibial plateaus. Their superior surface is concave and the inferior surface is flat; hence they stabilize the bony knee joint by converting the tibial articular surface into a shallow socket. In addition, the menisci serve as shock absorbers, reduce friction, distribute load and enhance congruity at the knee joint [1]. The medial and lateral menisci differ in their size, shape, attachments and load transmission [2]. The menisci have three segments – anterior horn, posterior horn and body. They are thicker peripherally and thinner centrally. The outer 10–15% of the meniscus has some vascular supply; however, the inner meniscus fibers are relatively devoid of vascularity, rendering tears in the avascular zone less likely to heal [3]. The meniscal attachments only allow a limited range of mobility to the menisci during knee loading [Fig. 1]. It is especially noted with the medial meniscus, where the firmer and greater degree of capsular attachment of the medial meniscus renders it less mobile, and consequently more prone to injury. Meniscal injuries as well as degeneration can result in meniscus extrusion. Degeneration refers to disintegration of collagen fibers within the meniscus due to repetitive use. An extruded meniscus is not only indicative of a meniscal tear, but it could be a manifestation of association with other pathologies in the knee such as cartilage loss, ligament injuries or simply, osteoarthritis. In this article, the authors elucidate meniscal anatomy, kinematics, and quantification of medial meniscal extrusion, and explore the complex role of medial meniscal extrusion (MME) in various knee joint pathologies with review of the relevant literature. The goal of this article is to highlight the importance of MME as a marker of deranged knee function.

2. Meniscus kinematics

During knee joint movement, tensile, compressive and shear forces are generated, some of which are converted to hoop stresses [4]. The menisci resist the hoop stresses and assist in weight bearing by redistributing this load over a larger surface area of the tibio-femoral condyles [1]. Normal menisci are gel-like structures and with the applied load, they flatten while distributing the stresses and physiologically extrude to a certain degree (up to 3 mm), in different directions to counteract the forces [5]. Meniscus pathology impairs efficient load distribution and the above stated flexibility. With meniscal injury or

Abbreviations: 3D, 3-dimensional; ACL, anterior cruciate ligament; BMI, body mass index; CI, confidence interval; DESS, double echo steady state; JSW, joint space width; JSN, joint space narrowing; MMPRT, medial meniscus posterior root tear; MAT, meniscus allograft transplantation; MME, medial meniscus extrusion; MM, medial meniscus; MRI, magnetic resonance imaging; MR, magnetic resonance; OA, osteoarthritis; SSFP, steady state free precession

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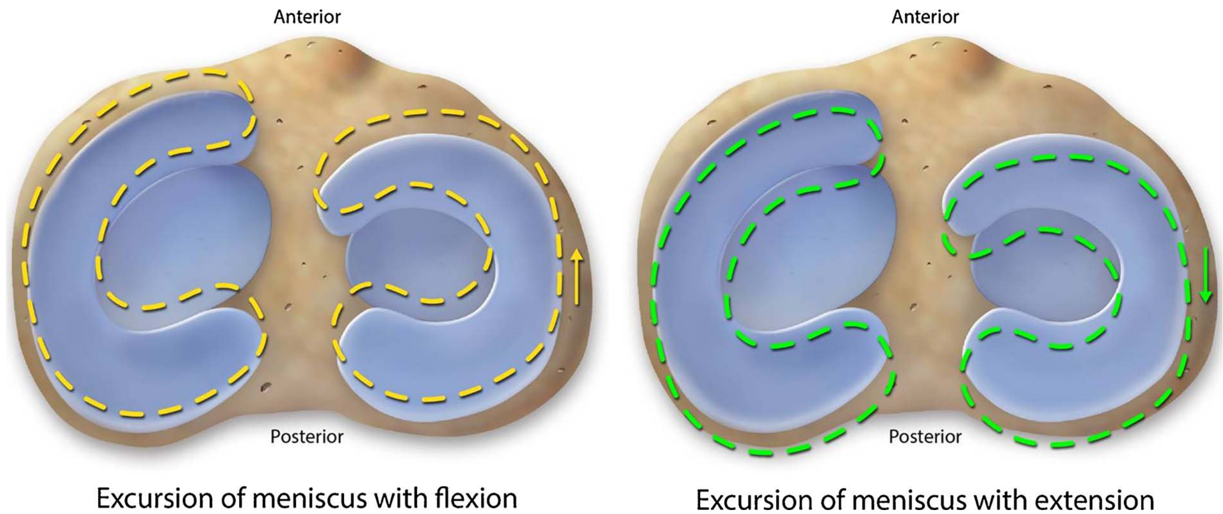

Fig. 1. Line diagram showing normal excursion of the meniscus with flexion (a) and extension (b) of the knee.

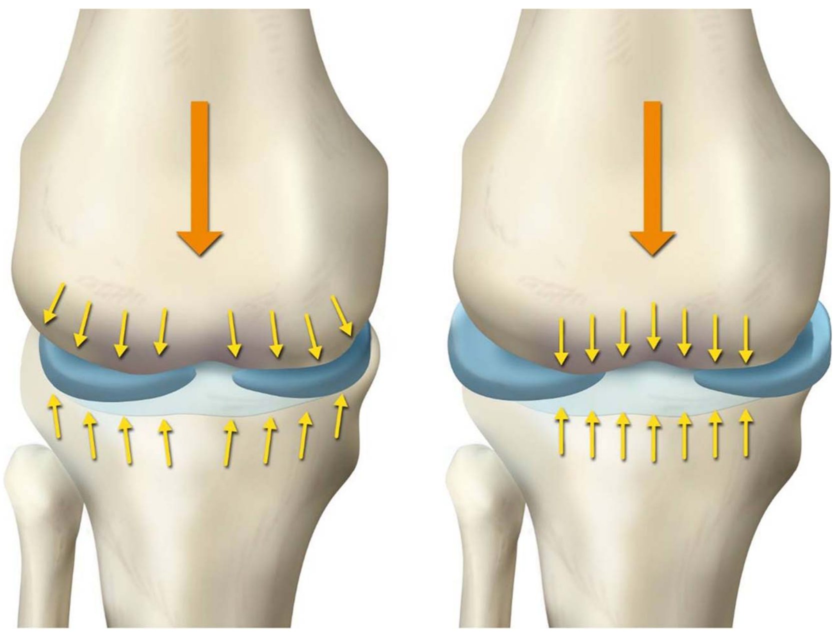

Fig. 2. Line diagram demonstrating distribution of weight at the knee in a normal (a) and extruded (b) meniscus.

degeneration, pathologic meniscus extrusion occurs in varying directions and persists. Thus, the same load now gets transmitted over a smaller articular surface area resulting in accelerated chondral and subchondral degeneration [Fig. 2]. Most commonly meniscus extrusion is seen in the presence of meniscus root degeneration and meniscus root tears, but it also occurs with osteoarthritis, knee malalignment and capsular tears [1,5,6]. Meniscal extrusion may also be related to body habitus. While Crema et al. [6] found no independent association of increased body mass index (BMI) with meniscus extrusion, Ding et al. [7] and Raynauld et al. [8] showed that a higher BMI correlates with more severe meniscus extrusion.

3. Imaging modalities

Imaging modalities used to detect meniscus extrusion include plain radiographs, ultrasound (US), computed tomography (CT) and magnetic resonance Imaging (MRI). Radiographs provide indirect evidence of meniscus extrusion and are useful if they are obtained in a weight bearing position. Thus, one can evaluate the joint space narrowing, presence of buttressing osteophytes and if correctly windowed, meniscus extrusion and/or chondrocalcinosis can be seen [9] [Fig. 3a,b]. US does not involve ionizing radiation and can show the knee joint line and integrity of the body of the meniscus and/or extrusion [10]. US is however not useful for evaluation of the tibiofemoral cartilage or for direct assessment of the anterior and posterior horns or roots of the menisci [Fig. 4]. On CT, menisci are seen as hyperdense structures. Degeneration and/or tears may be surmised in presence of decrease in density and/or altered morphology. Foot plate bony avulsions are much easier to identify at the root ligament attachments. In addition, meniscus extrusion, chondrocalcinosis and large tears can be identified. However, CT is not weight bearing in most instances unless performed as cone beam CT [11]. Dual source spectral CT is being introduced in the musculoskeletal domain for identification of ligament, tendon and bony injuries [12]. This newer version of CT might be useful for meniscal evaluation given the highly organized structure of the meniscus [Fig. 5]. CT-arthrography is an additional technique to visualize the integrity and position of the menisci. Apart from case reports, there is no scientific literature describing the diagnostic performance of above modalities in the detection of meniscus extrusion. MRI is highly sensitive and is currently the reference standard for detection