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Review

Magnetic resonance imaging of Hoffa's fat pad and relevance for osteoarthritis research: a narrative review

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SUMMARY

Objective: To give an illustrative overview of Hoffa's fat pad pathology with a radiologic emphasis on the anatomy, on technical considerations, and on imaging differential diagnoses in the context of osteoarthritis (OA) imaging research.

Design: A PubMed database search including only English literature and covering a 20 year period was performed. The search was based on but no limited to the query terms “Hoffa”, “Hoffa's fat pad” or “infrapatellar fat pad (IPFP)” in combination with “synovitis”, “OA”, and “magnetic resonance imaging (MRI)”. The literature search yielded 289 publications that were screened for relevance; additional references were included when these were considered of importance.

Results: Several anatomic variants and pathologic conditions may be encountered when assessing Hoffa's fat pad including tumors and tumor-like lesions such as osteochondroma, tenosynovial giant cell tumor (TGCT) (and pigmented nodular synovitis) and arthrofibrosis, traumatic changes including contusions and anatomic variants such as recesses. The latter may be accountable for differences in cross-sectional area or volume changes over time. Signal changes are commonly used in OA research as surrogate markers for synovitis but are non-specific findings.

Conclusions: Quantitative approaches to evaluate 3D parameters of Hoffa's fat pad are increasingly applied and their role in regard to structural progression and clinical manifestations of disease needs to be further elucidated. In applying such approaches, knowledge of the detailed anatomy and potential pitfalls that may be a result of anatomical variants, inflammatory disease manifestations and additional diverse pathologies encountered seems to be paramount.

Introduction

Hoffa's fat pad, also known as the infrapatellar fat pad (IPFP), which are terms that will be used synonymously in this review article, is an intracapsular extra-synovial structure in the anterior knee joint. Structurally it is composed of adipose tissue similar to subcutaneous fat[1]. It is thought to improve the distribution of the lubricant effect of intra-articular joint fluid by increasing the synovial surface[2], and to reduce the impact of loading by absorbing forces generated in the knee joint[3]. Its preservation even under extreme starvation conditions – where subcutaneous fat is eliminated – suggests a central role in knee joint homeostasis[4]. Hoffa's fat pad has long been seen as a bystander in knee osteoarthritis (OA) with only marginal metabolic relevance. However, Hoffa's fat pad is a major source of cytokines such as interleukin (IL)-6, tumor necrosis factor (TNF)-α and adipokines such as leptin and the recent

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recognition of the potential importance of these factors in joint metabolism has lead to increased appreciation for the clinical significance of the fat pad. Further, the correlation of the quantity of leptin and other adipokines produced with the quantity of fat mass has provided a rationale for measuring fat pad size[1,4,5]. Synovial inflammation seems to be present in a majority of persons with knee OA at least some time during the course of the disease and Hoffa's fat pad appears to play a central role in the mediation of joint inflammation[6,7].

Magnetic resonance imaging (MRI) has become a recognized tool in OA research including assessment of inflammatory disease manifestations, which is commonly performed on either non-enhanced MRI using surrogate signal changes in Hoffa's fat pad or on contrast-enhanced scans by direct assessment of the synovium[8–14]. Other MRI applications are also being increasingly applied in the field of OA research such as dynamic contrast enhanced (DCE) MRI, which allows the evaluation of inflammatory synovial activity by assessing the degree of perfusion of the synovial tissue[12]. MR-detected synovitis has been found in all stages of disease including early ones[15,16]. It also has been associated with pain, severity of disease[17] and shown to be predictive of structural changes[18,19]. Although CE-MRI is the current standard for assessment of synovitis in rheumatoid arthritis, synovitis in large epidemiological OA studies has usually been assessed on non-CE-MRI. In a pathologic study by Fernandez-Madrid and coworkers[20], hypointense signal alterations in Hoffa's fat pad seen on non-CE sagittal T1-weighted spin-echo images correlated with mild chronic synovitis. This work led to the assumption that synovitis might be assessed on non-CE-MRI, and hyperintense signal changes seen in Hoffa's fat pad on fat suppressed (FS) proton density (PD)- or T2-weighted spin-echo-type sequences were suggested as a surrogate marker for whole knee synovitis[21,22]. In addition to synovial assessment of Hoffa's fat pad, most recently the volume of the IPFP has become a subject of interest. Beneficial associations have been reported between IFPP maximal area and radiographic OA, structural changes and pain[23], and a protective effect of the IPFP in regard to structural progression, as assessed by tibial cartilage volume change, was evidenced in older women[3]. As the IPFP may have protective role through shock absorption potentially resection of the IPFP may need to be more carefully discussed in a clinical setting[23]. Whether IPFP quantification offers promise in the clinical assessment of a patient with knee OA remains to be shown; presently these measurements are performed in a research context only. Despite the increasing interest in Hoffa's fat pad within the field of knee OA research, the diversity of normal anatomic variants and the wide spectrum of pathologic findings commonly encountered in routine clinical practice need to be considered when evaluating this important joint structure and making it a focus of research interest.

This narrative review aims to give an illustrative overview to clinicians and also to the interdisciplinary research community with a radiologic emphasis on the anatomy, on technical considerations, imaging pathologies encountered and their differential diagnosis in the context of OA imaging research.

Methods and design

To extract relevant studies, an extensive PubMed database search including only English literature and covering the period from January 1st 1995 to January 1st 2015 was performed. The search was based on but no limited to the query terms “Hoffa”, “Hoffa's fat pad” or “IPFP” in combination with “synovitis”, “OA”, and “MRI”. The literature search yielded 289 publications that were screened for relevance with focus on the interdisciplinary audience of Osteoarthritis Cartilage and clinical application. Included were original research articles and review articles. Excluded were case reports and publications other than in English. Additional references were included when these were considered of importance. The literature was sorted and will be presented according to the topics technical considerations, normal anatomy and abnormal

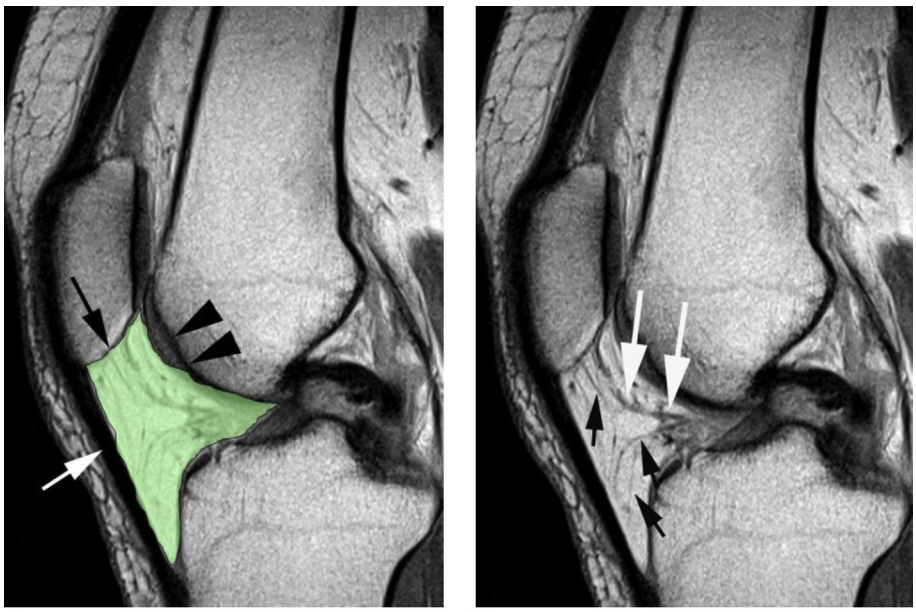

Fig. 1. Anatomy of Hoffa's fat pad. A. Sagittal T1-weighted spin echo MRI. The IPFP is an intracapsular but extra-synovial structure (colored in green-transparent) limited by the patellar tendon anteriorly (white arrow), and the synovial-lined knee joint posteriorly. Superiorly it attaches to the inferior surface of the patella (black arrow), and projects posteriorly to the intercondylar notch via two alar synovial folds, which fuse forming the infrapatellar plica. Supero-posteriorly Hoffa's fat pad neighbors the cartilage of the femoral trochlea (black arrowheads). B. Identical image without overlay shows low signal foci seen within the fat pad that represent infrapatellar plica (white arrows) and vessels (small black arrows).

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