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Reactive synovitis of the knee joint: MR imaging appearance with arthroscopic correlation

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Abstract *Objective.* To evaluate the use of routine MR imaging sequences in detecting and characterizing secondary reactive synovitis of the knee joint using arthroscopy as the standard of reference.
Design and patients. Fifty consecutive patients with a history of knee pain who were referred for MR imaging and subsequently underwent arthroscopy of the knee comprised the study group. MR images were evaluated for the presence and appearance of synovitis reflected in synovial thickening and irregularity. Synovial thickening was graded on MR imaging as follows: 0=normal, 1=thin line of increased signal intensity, 2=increased signal intensity with frond-like or hair-like projections and a granular appearance of joint fluid. Standard knee imaging protocols were used.
Results. The sensitivity, specificity, and accuracy of MR imaging in detecting synovitis compared with arthroscopy were 88%, 97%, and 95%, respectively. Grade 1 synovitis was best seen on proton-density-weighted images, demonstrating increased signal intensity of the synovium against the relatively low signal intensity of the joint fluid. Grade 2 synovitis was best seen on proton-density images and T2-weighted spin echo and fast spin echo images with fat saturation, demonstrating a granular and linear hair-like appearance of joint fluid. Axial and sagittal imaging planes were most helpful in the diagnosis of synovitis.
Conclusion. Routine MR pulse sequences are useful in identifying the presence and extent of synovial abnormalities. The detection of different stages of synovial pathology should become an important part of the evaluation of the post-traumatic patient as treatment may be altered as a result.

Keywords MR imaging · Knee joint · Synovitis · Trauma · Arthroscopy

Introduction

Synovium is a thin membrane that lines a joint and functions as a filtering system while producing synovial fluid [1]. The synovial membrane may be affected in primary pathologic processes such as septic arthritis, pigmented villonodular synovitis or synovial osteochondromatosis, or it may be involved in systemic processes such as inflammatory arthritis or hemophilia [1, 2, 3, 4]. Synovitis may also be a monoarticular reactive process secondary to intra-articular abnormalities or trauma (secondary reactive synovitis). Significant morbidity is often associated with pathologic processes affecting the synovial membrane and common manifestations include pain and limited range of motion, which may result in restricted overall body activity [5, 6, 7]. The presence of reactive synovitis may indicate a more advanced state of articular inflammation secondary to internal derangement or after trauma.

Post-traumatic synovitis is often associated with conditions such as acute rupture of the anterior cruciate ligament, patellar dislocation, meniscal tear, or osseous contusion. These injuries may result in inflammation, localized synovitis, and subsequent fibrosis [8, 9]. The detection and quantification of synovitis may become an important part of the evaluation of the knee joint allowing a rough assessment of the severity of the process affecting the joint. Also arthroscopic debridement has been shown to be helpful in patients with severe post-traumatic synovitis who do not respond to conservative therapy [8, 9].

MR imaging studies with T1- and T2-weighted spin echo, and proton-density-weighted sequences are usually performed as a noninvasive procedure for patients suffering from knee pain. Although MR imaging, especially contrast-enhanced images, has been shown to be useful in the assessment of primary synovial and systemic abnormalities, there is no consensus on the optimal MR methods for imaging secondary reactive synovitis [7, 10, 11, 12, 13, 14]. The purpose of our study was to evaluate the use of routine MR imaging sequences in the detection and grading of reactive synovitis of the knee joint. We prospectively examined 50 consecutive patients with knee pain who subsequently underwent arthroscopy and compared the MR imaging results with arthroscopy as the standard of reference.

Subjects and methods

During a 3-month period we prospectively studied 50 consecutive patients (23 women, 27 men; 18–74 years old, mean 42 years) with a history of knee pain who were referred for MR imaging of the knee and subsequently underwent arthroscopy. Forty-six patients had a history of knee trauma. None of the patients had a history of rheumatoid or septic arthritis or hemophilia. Twenty-three patients underwent MR imaging within 3 months after the onset of knee pain. Twenty patients presented with knee pain for 3–6 months and seven patients had had knee pain for 6–12 months. MR imaging was performed with a 1.5-T magnet (Signa; General Electric Medical Systems, Milwaukee, Wis.) with a commercially available transmit-receive extremity coil. We used a routine MR knee protocol that included coronal T1-weighted spin echo (TR/TE 600/12 ms) images, sagittal proton-density-weighted (TR/TE 2000/17 ms) images, sagittal T2-weighted spin echo (TR/TE 2000/80 ms) images, coronal T2-weighted fast spin echo (TR/TE 3000/38 ms) images, and axial T2-weighted fast spin echo (TR/TE 3200/54 ms) images, with an echo-train length of eight, and with frequency-selective fat presaturation. Section thickness was 4 mm, intersection gap was 1 mm, field of view was 14 cm, and the matrix was 256×192 pixels. Two acquisitions were used for T1-weighted spin echo and T2-weighted fast spin echo sequences, and one acquisition for T2-weighted spin echo sequences.

The MR images were evaluated prospectively at the time of the patient's initial presentation by two musculoskeletal radiologists. The MR images were assessed for pathologic conditions such as meniscal tears, chondral lesions, ligamentous abnormalities, and for the presence and appearance of synovial proliferation.

On MR imaging the suprapatellar, infrapatellar, and intercondylar joint regions, and the posterior joint margin, were independently evaluated for synovial thickening and irregularity on all sequences and imaging planes. Synovial thickening was graded on MR imaging on a 3-point scale: grade 0=normal; grade 1=thin line of increased signal intensity; grade 2=increased signal intensity with frond-like or hair-like projections from the synovium and a granular appearance of the joint fluid.

All patients in this study underwent conventional knee arthroscopy within 3 weeks after the initial MR examination. Arthroscopy was performed by two orthopedic surgeons who had the MR imaging report available at the time of surgery. On arthroscopy the suprapatellar, infrapatellar, intercondylar, and posterior joint regions were thoroughly inspected by the surgeon and the presence and location of synovitis was noted.

At arthroscopy synovial abnormalities were described as minimal, mild, moderate, or severe. Minimal and mild changes consisted of elongated synovial villi appearing as long, transparent, finger-like projections with a central red injected vessel. Moderate and severe changes were described when thick fibrous bands, which occur when fibrin exudate from hypertrophied synovitis aggregates to form masses, were seen.

We considered minimal and mild changes on arthroscopy as grade 1 and moderate and severe changes as grade 2. After arthroscopy the MR images were compared with the arthroscopic reports with the orthopedic surgeon, to identify the exact location of the synovial lesion on MR imaging and arthroscopy. The arthroscopic results were used as the standard of reference to determine sensitivity, specificity, and accuracy for the detection of synovitis on MR imaging.

Results

On MR imaging the normal synovial membrane was not visible as a discrete anatomic structure on any of the sequences performed at our image resolution. Synovial thickening due to synovitis was of high signal intensity on proton-density-weighted images (Figs. 1A, 2A) and of intermediate signal intensity on T1-weighted images. On T2-weighted spin echo and fast spin echo images with fat saturation an arthrographic effect was demonstrated when the synovial thickening was of intermediate or low signal intensity, outlined by hyperintense joint fluid (Fig. 3A). We used coronal T1-weighted sequences as part of our standard knee protocol that were helpful only in the detection of extensive synovitis. Joint effusions were a common finding in our patients with synovial abnormalities (n=38) and were easily detected with MR imaging. These fluid collections typically demonstrated low signal intensity on proton-density-weighted images and were of hyperintense signal intensity on T2-weighted images. Synovial proliferation demonstrated variable morphologic features, ranging from thickened and smooth to irregular modularity on MR imaging.

Synovial abnormalities were best seen on sagittal and axial imaging planes. Grade 1 synovitis was best seen on proton-density-weighted images, which demonstrated a thin line of increased signal intensity of the synovium (Fig. 1). Grade 2 synovitis was best seen on proton-density-weighted images and T2-weighted spin echo and fast spin echo images with fat saturation, which demonstrated a granular and linear hairy appearance of joint

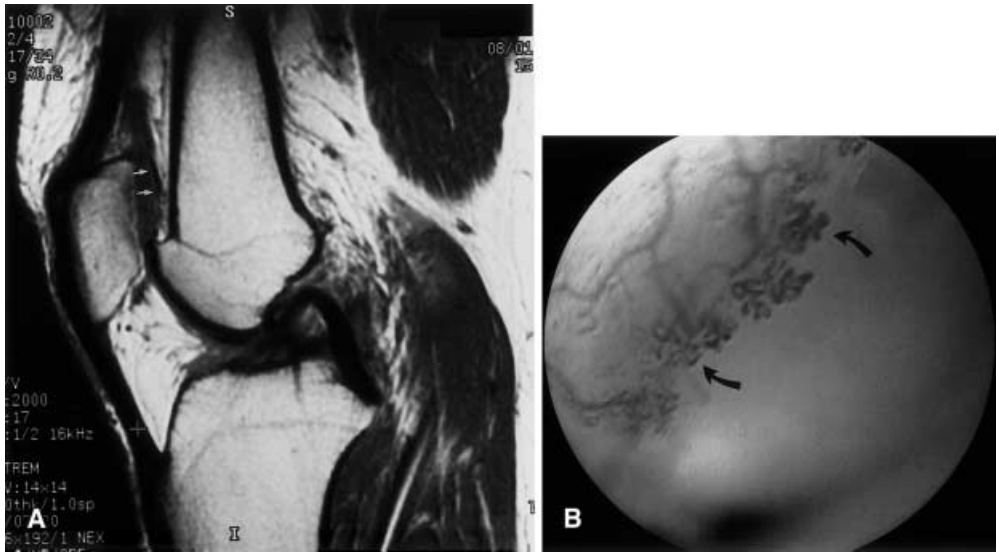

Fig. 1A, B A 30-year-old man with post-traumatic knee pain. **A** Sagittal proton-density-weighted image (TR/TE 2000/17 ms) shows a thin line of increased signal intensity in the suprapatellar pouch (*arrows*), consistent with a grade 1 lesion. **B** Arthroscopic photograph of the same patient demonstrates mild synovitis in the suprapatellar joint region (*arrows*), consistent with a grade 1 lesion

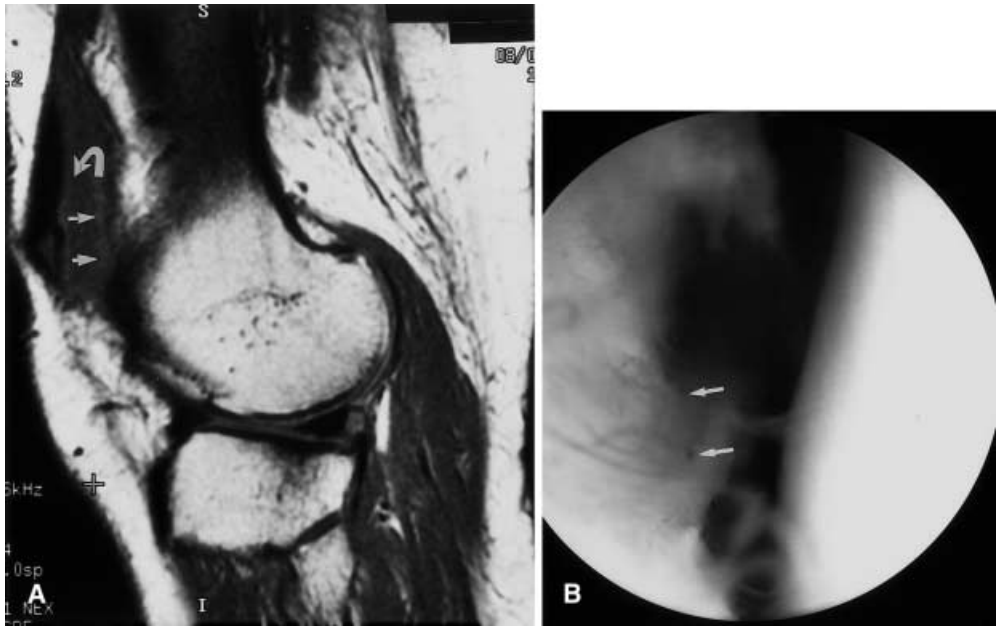

Fig. 2A, B A 45-year-old man with a medial and lateral meniscal tear. **A** Sagittal proton-density-weighted image (TR/TE 2000/17 ms) shows a thick line of increased signal intensity within the suprapatellar pouch (*straight arrows*), indicating a grade 2 lesion. Note the decreased signal intensity of the joint effusion (*curved arrow*). **B** Arthroscopic photograph of the same patient reveals abundant synovitis in the suprapatellar pouch (*arrows*), consistent with a grade 2 lesion.

fluid, secondary to synovial proliferation in the traumatic effusion (Figs. 2, 3). Coronal T1-weighted sequences were only helpful in the diagnosis of prominent synovial proliferation.

On arthroscopy 60 synovial lesions were detected in 39 of 50 patients. The suprapatellar joint region was affected in the majority of cases (n=26), followed by the infrapatellar (n=16), the intercondylar (n=11), and posterior (n=7) joint region. On arthroscopy a total of 200 surfaces were graded in 50 patients. Seventy percent of the surfaces were normal (n=140) and 30% (n=60) demonstrated arthroscopic findings of synovitis. Grade 1 synovitis was seen in 35% (n=21) and grade 2 synovitis in 65% (n=39) of the surfaces. On MR imaging 57 lesions were detected in 38 of 50 patients. Using all sequences together and considering only detection of an arthroscopically observed synovial abnormality, seven false negative and four false positive results were found on MR imaging.

The seven lesions that were not detected on MR imaging involved four grade 1 and three grade 2 lesions. Three of the false negative lesions were located in the posterior joint region, two in the intercondylar joint region, one in the infra- and one in the suprapatellar joint region. Three patients with a false negative result on MR imaging demonstrated a meniscal tear with local-

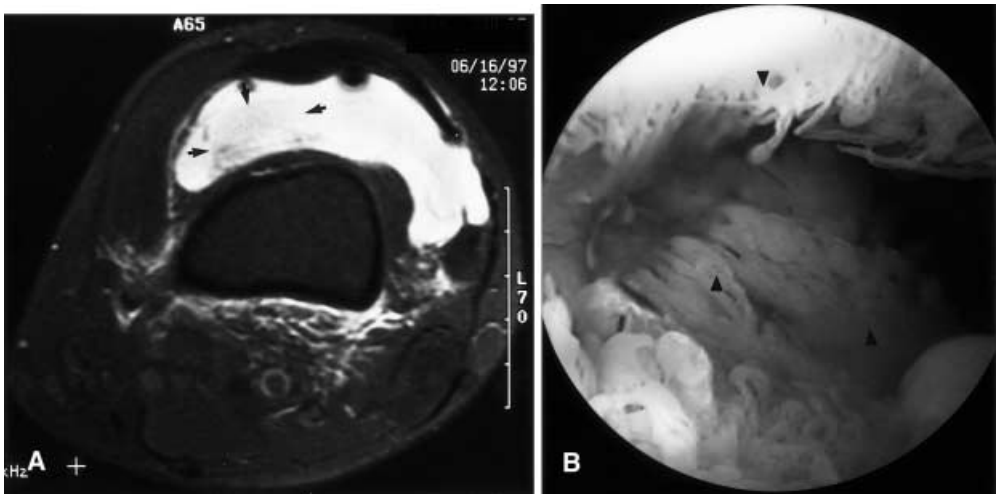

Fig. 3A, B A 23-year-old woman with locked knee secondary to an impinging loose body. **A** Axial T2-weighted fast spin echo image with fat saturation (TR/TE 3200/54 ms) demonstrates frond-like proliferation of the synovium (*arrows*), consistent with a grade 2 lesion. **B** Arthroscopic photograph of the same patient reveals severe synovitis within the suprapatellar pouch (*arrowheads*), consistent with a grade 2 lesion

ized synovitis in the region of the tear. One patient showed patellar tethering with little hypertrophic synovium, and two patients had chondromalacia of the lateral patella with localized synovitis. One patient with false negative MR imaging results showed a tear of the anterior cruciate ligament that was covered by hemorrhagic synovium.

The four lesions that were false positive on MR imaging consisted of two grade 1 lesions and two grade 2 lesions. Two false positive lesions were found in the suprapatellar and two lesions in the intercondylar joint region. On arthroscopy one patient showed an avulsion of the medial retinaculum without signs of synovitis. In two patients a loose body was seen that was mistaken for focal nodular synovitis on MR imaging. One patient with a false positive MR imaging result demonstrated chondromalacia of the patella without signs of synovitis.

Sensitivity of MR imaging in the detection of the presence of synovitis was 88%, specificity was 97%, and accuracy was 95%. The MR imaging grading system correlated in 69% of the cases with the arthroscopy grading.

The majority of the patients (91%) who underwent MR imaging within 3 months after the onset of knee pain demonstrated MR imaging findings of synovitis. Seventy-five percent of the patients whose symptoms persisted for up to 6 months had signs of synovitis, while 29% of the patients with symptoms for between 6 months and 1 year showed signs of synovitis.

MR imaging was sensitive and specific in detecting synovitis in the suprapatellar and infrapatellar joint region. However, MR imaging showed low sensitivity but high specificity in the evaluation of the posterior joint region (Tables 1, 2).

Four patients (8%) had an isolated synovial abnormality without other knee abnormalities. The remaining patients had meniscal tears (36 patients), abnormalities of the anterior and posterior cruciate ligaments (14 patients), abnormalities of the medial and lateral collateral ligaments (2 patients), and cartilage abnormalities (19 patients) associated with the synovial abnormality.

Table 1 Sensitivity and specificity of MR imaging in the detection of synovitis in the knee joint

	Sensitivity	Specificity
Suprapatellar joint region	96%	87%
Infrapatellar joint region	93%	100%
Intercondylar joint region	81%	94%
Posterior joint margin	57%	100%

Table 2 False positive and false negative results according to the joint region

	False positive results	False negative results
Suprapatellar joint region	2	1
Infrapatellar joint region	0	1
Intercondylar joint region	2	2
Posterior joint margin	0	3

Discussion

Normal synovium, which is usually not visible to the naked eye, is the most vascular portion of the diarthrodial joint and is the first mediator of a disease process. Conditions that irritate the intra- or periarticular structures will often cause a synovial response, most often inflammation [1].

In the typical patient referred for MR imaging in the setting of knee pain, MR imaging is usually performed with emphasis on the evaluation of internal derangement of the knee. There are only a few studies using MR imaging in the evaluation of reactive synovitis [7, 15, 16]. In

acute inflammation (or an acute post-traumatic event), the synovial membrane vasodilates and becomes edematous. In our study this edema of the inflamed synovium was demonstrated as high signal intensity on proton-density-weighted images and higher signal intensity on T2-weighted spin echo images. Foci of synovial proliferation appeared as frond-like densities on proton-density and T2-weighted fast spin echo images with fat saturation. Routine MR pulse sequences were sensitive and specific in identifying these changes.

Several studies have shown that the synovium can be better demonstrated with the administration of gadolinium [14, 17, 18, 19]. However, in the setting of routine knee pain in our study, the additional invasiveness of this procedure did not seem justified as we were attempting to identify synovitis using standard, frequently performed pulse sequences. In cases of trauma to the knee, the injury was often accompanied by significant hemarthrosis – an important association, since the release of iron from ruptured red blood cells stimulates clinically significant synovial changes, i.e., synovitis with pain and swelling.

Most patients with reactive synovitis respond to conservative treatment, such as corticosteroid injections, or physical therapy [8, 9]. Patients with persistent pain who do not respond to conservative treatment may undergo arthroscopic debridement. Several studies have shown that synovectomy decreases the pain and synovitis of the knee, especially after a traumatic injury [8, 9]. Seventy-five percent of our patients who presented with knee pain for up to 6 months and 29% of our patients with persistent knee pain (for between 6 and 12 months) demonstrated signs of synovitis. In 15% of these patients synovitis was the only abnormality found on MR imaging and arthroscopy. Therefore the evaluation of synovial pathology should become an important part of the evaluation of the post-traumatic patient, as patients with persistent knee pain might profit from arthroscopic synovectomy. Also, synovial abnormalities are sometimes the only abnormality found on arthroscopy and can be clinically confused with other types of injuries. In our study 8% of the patients who presented with post-traumatic knee pain had isolated synovitis without other associated abnormalities.

Our study had several limitations. The first is that the orthopedic surgeon had the MR imaging report available at the time of surgery, which was a potential source of bias. Secondly, arthroscopy is an imperfect standard of reference – there are blind spots in the joint that are difficult to assess properly. Another limitation was the lack of measures of inter- and intra observer reproducibility, since the MR images were evaluated by two radiologists in consensus. Another limitation of our study was that there was no direct measurement of the synovium.

In conclusion, MR images of patients with knee pain, especially post traumatic pain, should be carefully evaluated for abnormalities of the synovium. Our study showed that routine MR pulse sequences are useful in identifying the presence and extent of synovial abnormalities and may help the treating physician institute conservative and/or arthroscopic therapy.

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