

The relationship between limited MRI section analyses and volumetric assessment of synovitis in knee osteoarthritis

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MRI; Synovitis; Osteoarthritis; Knee; Quantitative; Volume

AIM: To assess whether simple, limited section analysis can replace detailed volumetric assessment of synovitis in patients with osteoarthritis (OA) of the knee using contrast-enhanced magnetic resonance imaging (MRI).

MATERIALS AND METHODS: Thirty-five patients with clinical and radiographic OA of the knee were assessed for synovitis using gadolinium-enhanced MRI. The volume of enhancing synovium was quantitatively assessed in four anatomical sites (the medial and lateral parapatellar recesses, the intercondylar notch and the suprapatellar pouch) by summing the volumes of synovitis in consecutive sections. Four different combinations of section analysis were evaluated for their ability to predict total synovial volume.

RESULTS: A total of 114 intra-articular sites were assessed. Simple linear regression demonstrated that the best predictor of total synovial volume was the analysis containing the inferior, mid and superior sections of each of the intra-articular sites, which predicted between 40-80% ($r^2=0.396$, $p<0.001$ for notch; $r^2=0.818$, $p<0.001$ for medial parapatellar recess) of the total volume assessment.

CONCLUSIONS: The results suggest that a three-section analysis on axial post-gadolinium sequences provides a simple surrogate measure of synovial volume in OA knees.

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Introduction

Osteoarthritis (OA) refers to a heterogeneous group of disorders that is strongly associated with ageing; the pathological process involves all the joint components.^{1,2} Synovitis is commonly present in OA, and its importance in processes such as chondrolysis is well recognized.³ Although there are many studies of the synovium in rheumatoid arthritis (RA), there are fewer studies evaluating

the synovitis of OA using magnetic resonance imaging (MRI).⁴⁻¹⁰ A recent MRI study on a large cohort of patients with OA of the knee has found an association between the degree of synovial thickening with the severity of knee pain.⁴

Quantification of synovitis may be achieved using estimations of volume¹¹ by manual outlining of enhancement in post-gadolinium diethylenetriamine penta-acetic acid (Gd-DTPA) images¹² or by using semi-automated methods.^{7,8,13} Østergaard et al.¹⁴ have previously demonstrated that a quantitative synovitis volume obtained from axial T1-weighted post-Gd-DTPA fat-suppressed (FS) images correlated well with the volume of synovitis in a single sagittal section in RA knees.¹⁴

If the synovium is important as a pain-related

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“target” for OA therapies,⁴ and if synovitis is to be examined as a predictor of joint structural deterioration, simple and reliable methods for assessing the synovium are important. As quantitative measurements of synovial volume are complex and time-consuming, the aim of this study was to evaluate a range of synovial section analysis methods for the OA knee requiring only basic imaging software and compare the results with a more detailed, MRI assessment. Four anatomical sites were investigated: the medial and lateral parapatellar recesses, the intercondylar notch and the suprapatellar pouch.

Materials and methods

Thirty-five patients with clinical and radiographic (Kellgren Lawrence Grade 2 or above) OA of the knee were assessed for synovitis using gadolinium (Gd-DTPA)-enhanced MRI using a dedicated protocol of sequences. All patients fulfilled the American College of Rheumatology criteria (clinical and radiographic criteria).¹⁵ The study protocol was approved by the local ethical review committee and all patients gave informed written consent to their participation in the study. Patients were selected if they had pain, but were not selected on the basis of clinical suspicion of synovitis. Exclusion criteria included the presence of another inflammatory arthritis (e.g. gout), intra-articular corticosteroid injection within the previous 3 months or arthroscopy within the previous 6 months.

MRI methodology

MRI of the knee was performed using a 1.5 T Gyroscan ACS-NT whole-body machine (Philips Medical Systems, Best, the Netherlands). A Philips quadrature receiver knee coil was used and patients were placed in the supine position for imaging. Quantitative assessment of synovitis volume was performed using axial T1-weighted post-Gd-DTPA

fast suppressed (FS) images, repetition time (TR) 650 ms, echo time (TE) 15 ms, section thickness/section gap 3 mm/0.3 mm, field of view (FOV) 160, RFOV 80%, matrix size 256×256 and number of signal averages (NSA) 2; Gd-DTPA was administered by injection at 0.2 ml (0.1 mmol)/kg body weight as a 14 s bolus. Post-Gd-DTPA sequences began at 4.5 min post-injection.

Image analysis

Four anatomical sites per knee were evaluated: the medial and lateral parapatellar recesses, suprapatellar pouch and intercondylar notch. Axial T1-weighted post-Gd-DTPA FS images were chosen in preference to other planes as they allowed the assessment of the four anatomical sites on one set of images. These images were processed using a commercially available image analysis software package, Analyse (Analyze-Direct, Lenexa, KS, USA). This software allowed the generation of regions of interest (ROIs) that delineated the enhancing synovium in the four anatomical sites in consecutive sections by manual outlining. The number of enhancing pixels within the ROI was calculated in each section and converted to an area measurement. The volume of synovitis in each anatomical site was calculated using the following formula:

$$\text{Vol}_{\text{synvol}} = \sum (\text{Ar}_{\text{synvol}} \times \text{ST})$$

where ST represents the sum of the section thickness and the section gap and $\text{Ar}_{\text{synvol}}$ represents the area of the ROI in each section.¹⁶ A single observer performed all the detailed volume analyses 6 months before section analyses were performed in a blinded fashion.

The intercondylar notch on the axial sequence was defined as the space lying between the femoral condyles and limited by a line tangential to the posterior surface of the condyles (Fig. 1(a)). Synovitis in the medial and lateral parapatellar

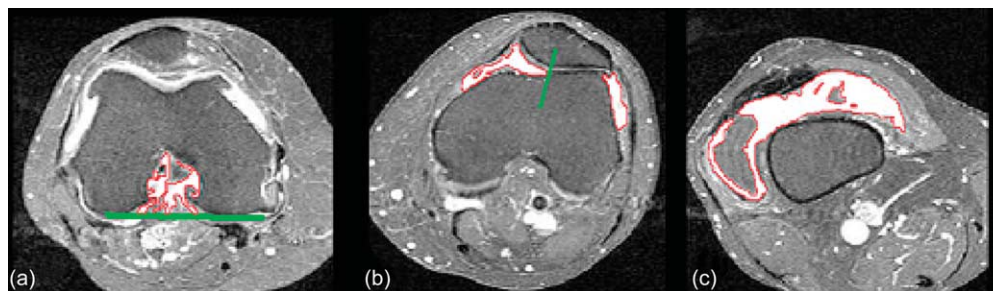


Figure 1 T1-weighted post-Gd-DTPA FS axial image with ROI (a) intercondylar notch, (b) medial and lateral parapatellar recess, and (c) suprapatellar pouch indicated.

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