Correlation between Subcutaneous Knee Fat Thickness and Chondromalacia Patellae on Magnetic Resonance Imaging of the Knee

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Key words

Chondromalacia patellae, patella, knee pain, osteoarthritis, MRI, obesity, fat thickness

Abstract

Purpose – Chondromalacia patellae is a common cause of anterior knee pain in young patients and can be detected non-invasively with MRI. The purpose of our study was to evaluate the correlation between subcutaneous fat thickness around the knee joint on axial MR images as a surrogate marker of obesity with the presence or absence of chondromalacia patellae.

Methods – A retrospective review of knee MRIs in 170 patients who satisfied the inclusion criteria was conducted. Imaging was performed over a 12-month period on a 1.5T MRI system with a dedicated extremity coil. Two radiologists experienced in musculoskeletal imaging assessed each examination in consensus for the presence or absence of chondromalacia patellae and graded positive studies from 0 (absent) to 3 (full cartilage thickness defect). Measurement of subcutaneous knee fat thickness was obtained on the medial aspect of the knee.

Results – MR findings of chondromalacia patellae were present in 33 patients (19.4%) of which there were eleven grade 1 lesions (33.3%), nine grade 2 lesions (27.3%) and thirteen grade 3 lesions (39.4%). The mean subcutaneous knee fat thickness was significantly higher in the chondromalacia patellae group for all grades as compared to the normal group ($p<0.001$) and there was a significant correlation between subcutaneous knee fat thickness and grades of chondromalacia patellae ($R=0.48$, 95% CI 0.38-0.68, $p<0.001$). Female patients had thicker subcutaneous knee fat and more severe grades of chondromalacia patellae.

Conclusion – Subcutaneous knee fat thickness as a surrogate marker of obesity was positively associated with the presence and severity of chondromalacia patellae on MRI.

Introduction

Chondromalacia patellae is a condition that affects the articular cartilage of the patella. It encompasses a spectrum of clinical severity, ranging from mild fissuring of the articular cartilage to complete cartilage loss and erosion of the underlying subchondral bone. Patients with chondromalacia patellae, particularly adolescents and young adults, may present clinically with anterior knee pain.[1-3] Mechanisms contributing to the development of chondromalacia patellae include knee trauma, structural abnormalities of the knee leading to increased mechanical stress on the articular cartilage and vascular insufficiency within the subchondral bone.[4] Arthroscopy is the gold standard for diagnosing chondromalacia patellae but this remains highly invasive and surgical treatment of chondromalacia patellae is only indicated in a small minority (5-10%) of patients.[3, 5] MR imaging has emerged as a reliable and accurate investigative modality for patients with anterior knee pain and suspected chondromalacia patellae due to its non-invasive nature, multiplanar imaging capabilities and refinements in sequences allowing detailed soft tissue and cartilage imaging.[1-3, 6, 7] To our knowledge, the association between obesity and chondromalacia patellae has not been well

established. In this study, we sought to evaluate the correlation between subcutaneous fat thickness around the knee joint on axial MR images as a surrogate marker of obesity with the presence or absence of chondromalacia patellae.

Materials and Methods

Two-hundred patients underwent an MRI examination of the knee over a one-year period from September 2010 to 2011 in our institution. Patients were eligible for inclusion if their age was between 5-65 years at the time of imaging and MRI images were available for review. Exclusion criteria included patients over 65 years of age, acute knee trauma and recent knee surgery. Of this, a total of 170 patients met the study criteria and were included in this retrospective study. Imaging was performed on a Siemens Magnetom Symphony 1.5T MR system (Siemens AG, Erlangen, Germany) using a CP extremity coil. Standard T1 and short TI inversion-recovery (STIR) sagittal and coronal sequences as well as three-dimensional (3D) axial T2 fast imaging with steady-state free precession (FISP) and sagittal double-echo steady state (DESS) sequences were obtained.

Images were reviewed in consensus by two radiologists experienced in musculoskeletal imaging with more than 5 years experience. Subcutaneous fat thickness measurements and assessment for chondromalacia patellae were performed separately. Subcutaneous knee fat was measured on axial T2 3D FISP sequences (TR 17.0 ms, TE 9.5 ms, matrix 256 x 180, slice thickness 1.5 mm) at the level of maximal patellar cartilage thickness on the medial aspect of the knee joint (Figure 1). Measurement points were taken between the medial knee skin surface and posterior aspect of the medial femoral condyle corresponding to the level of maximum patellar cartilage thickness. All measurements were performed on a Syngo Studio Advanced V36A PACS workstation (Siemens AG, Erlangen, Germany). Each MR study was

evaluated for the presence or absence of chondromalacia patellae including compartmental involvement, patellar subluxation, joint effusion and patellofemoral degenerative changes. Studies positive for chondromalacia patellae were subsequently graded 1-3 according to the modified Noyes classification (Table 1).[7, 8]

Statistical analyses were performed using SPSS 16.0 (SPSS Inc, Chicago IL, USA). Data are expressed as mean $\pm$ SD where appropriate and one-way ANOVA was used to compare subcutaneous knee fat thickness and the presence and grade of chondromalacia patellae. Post-hoc ANOVA analysis with Scheffe multiple comparisons was then performed to assess the mean difference in subcutaneous knee fat thickness between grades of chondromalacia patellae compared to normal knees without chondromalacia patellae. Chi-square tests were subsequently used to compare gender differences in the group with chondromalacia patellae. Linear regression was used to analyse the correlation between subcutaneous knee fat thickness and chondromalacia patellae by way of the Pearson correlation coefficient. A p-value of < 0.05 was taken to be statistically significant.

Results

One-hundred and seventy patients (111 male, 59 female) were included in the study with a mean age of 33.1 years (range 9-62). MR findings of chondromalacia patellae were present in 33 patients (16 male, 17 female; 19.4%) and absent in the remaining 137 patients (90.6%). The mean age of patients with chondromalacia patellae was 44.3 years (range 22-62) in males and 47.1 years (range 18-62) in females ($p=0.476$).

In the group with chondromalacia patella, there were 11 grade 1 lesions (33.3%, Figure 2A), nine grade 2 lesions (27.3%) and 13 grade 3 lesions (39.4%, Figure 2B and C). The majority of chondromalacia patellae involved the lateral patellar facet (23 patients, 69.7%) followed by the medial patellar facet (8 patients, 24.2%) and a small minority involved both medial and lateral aspects of the patellar cartilage (2 patients, 6.1%). The mean subcutaneous knee fat thickness was significantly higher in the chondromalacia patellae group for all grades as compared to the normal group ($p<0.001$). Normal knees had a mean subcutaneous fat thickness of 1.88 ± 0.87 cm versus 3.13 ± 0.61 cm in grade 1, 2.69 ± 0.67 cm in grade 2 and 3.43 ± 1.05 cm in grade 3 chondromalacia patellae knees (Figure 3). Post-hoc analysis of mean differences in subcutaneous fat thickness between different grades of chondromalacia patellae compared to normal knees showed significant differences between normal knees (grade 0) and grade 1 and 3 chondromalacia patellae ($p<0.001$) but not grade 2 chondromalacia patellae ($p=0.06$). There was a significant and strong correlation between subcutaneous knee fat thickness and grades of chondromalacia patellae (Pearson's correlation coefficient, $R=0.48$, 95% CI 0.38-0.68, $p<0.001$).

Despite being present proportionally in both genders, there was a trend towards more severe grades of chondromalacia patellae in females as compared to males ($p=0.140$, Figure 4). This

corresponded to a thicker mean subcutaneous knee fat thickness in females when compared to males in both normal subjects and subjects with chondromalacia patellae (Figure 5). When analysed separately by gender, the presence and severity of chondromalacia patellae also corresponded significantly to a greater mean subcutaneous knee fat thickness in both male ($p<0.001$) and female patients ($p=0.002$).

Discussion

Anterior knee pain originating from the patellofemoral compartment is a very common clinical symptom in young individuals.[9] Chondromalacia patellae is a well recognised cause of anterior knee pain and can be investigated by non-invasive techniques such as MR imaging of the knee joint or less frequently, by arthroscopic evaluation.[1-3, 6] Indeed, MR imaging has been shown to be superior to clinical symptoms and physical examination in diagnosing chondromalacia patellae.[3] The spectrum of pathological change that occurs in the articular cartilage can range from mild cartilage softening, oedema and fissuring but progression will ultimately result in full thickness cartilage loss and the development of osteoarthritis. This condition is important to recognise as chondromalacia patellae may be much more common than initially thought. In our unselected population of young patients (mean age 33.1 years) undergoing MR imaging of the knee, chondromalacia patellae was seen in 19.4% of studies, of which 39.4% were in the most severe category with involvement of subchondral bone. This figure may be even higher in selected cohorts presenting with anterior knee pain.[3]

The association between obesity and chondromalacia patellae has been recognised but poorly established with few studies conducted to date. It has been observed that obesity and increased fat mass were both associated with more cartilage defects in the knee.[10, 11] This

is also seen in the paediatric population where Widhalm and colleagues demonstrated abnormalities in the knee articular cartilage in a population of 20 morbidly obese children and adolescents.[12] Our results support the findings of these studies in demonstrating a strong positive correlation between subcutaneous knee fat thickness, as a surrogate marker of obesity with the presence and severity of chondromalacia patellae on MR imaging. As chondromalacia patellae may be reversible in the early stages, it is important for early changes to be recognised, both on MR and arthroscopic evaluation, particularly in obese patients who may benefit from weight reduction programmes or bariatric intervention.[13]

A number of limitations in this study have to be acknowledged. The retrospective nature of the study did not allow for physical measurements such as body mass index (BMI) to be obtained. However, the use of subcutaneous knee fat thickness as a surrogate marker of obesity, whilst not necessarily an accurate reflection of BMI, did clearly demonstrate a positive correlation to the severity of chondromalacia patellae. Secondly, it was not possible to exclude a type 2 statistical error in the subgroup comparison of mean subcutaneous knee fat thickness between grade 2 chondromalacia patellae with normal knees where statistical significance was just missed. This may be related to the relatively small number of patients in this category. Nevertheless, this study also has a number of strengths as it includes a large, unselected patient population undergoing MR imaging of the knee which is reflective of a typical patient cohort in a general diagnostic imaging department. Our patients were mostly young and are therefore, the most likely group to present clinically with symptoms of chondromalacia patellae. To our knowledge, this is the first study to directly evaluate the correlation between obesity, as reflected by subcutaneous knee fat thickness and chondromalacia patellae.

Conclusion

Chondromalacia patellae is a common condition in young individuals and may present clinically with symptoms of anterior knee pain. The thickness of subcutaneous knee fat as a surrogate marker of obesity was positively associated with the presence and severity of chondromalacia patellae on MR imaging. This study highlights the importance of obesity as a contributor to the development of patellofemoral joint pathology, particularly chondromalacia patellae and the need to identify this on imaging studies of the knee.

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Figure Legends

Figure 1 – Measurement of subcutaneous knee fat thickness on axial T2 3D FISP sequences of the knee joint between the medial knee skin surface and the posterior aspect of the medial femoral condyle, at the level of maximum patellar cartilage thickness.

Figure 2 – Axial T2 3D FISP images demonstrating **A**, focal abnormal signal intensity in the patellar cartilage (black arrow) consistent with Grade 1 chondromalacia patellae, **B**, focal superficial cartilage loss of approximately 50% (white arrowhead) with abnormal signal intensity in the patellar cartilage but preservation of underlying subchondral bone, **C and D**, complete loss of cartilage on the lateral patellar facet with erosion of subchondral bone (white arrows) consistent with Grade 3 chondromalacia patellae. Note the differences in medial subcutaneous knee fat thickness between the three patients, being thicker in Grade 3 chondromalacia patellae.

Figure 3 – Mean subcutaneous knee fat thickness in normal knees and different grades of chondromalacia patellae. Patients with chondromalacia had thicker subcutaneous knee fat layers compared to normal subjects. The mean difference in subcutaneous knee fat thickness was statistically significant (*) between normal knees and grade 1 and 3 chondromalacia patellae ($p < 0.001$) but not for grade 2 chondromalacia patellae ($p = 0.06$).

Figure 4 – Number of patients with different grades of chondromalacia patellae by gender. There was an inverse trend between gender and severity of chondromalacia patellae with higher grades of chondromalacia patellae seen in female patients.

Figure 5 – Mean subcutaneous knee fat thickness in normal knees and different grades of chondromalacia patellae by gender. Male and female patients with chondromalacia had thicker subcutaneous knee fat layers compared to normal subjects ($p<0.001$ and $p=0.002$ respectively).