Research Article

Correlation between Focal Nodular Low Signal Changes in Hoffa’s Fat Pad Adjacent to Anterior Femoral Cartilage and Focal Cartilage Defect Underlying This Region and Its Possible Implication

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Purpose. This study investigates the association between focal nodular mass with low signal in Hoffa’s fat pad adjacent to anterior femoral cartilage of the knee (FNMHF) and focal cartilage abnormality in this region. Method. The magnetic resonance fast imaging employing steady-state acquisition sequence (MRFIESTA) sagittal and axial images of the Bl and Cl region (described later) of 148 patients were independently evaluated by two reviewers and categorized into four categories: normal, FNMHF with underlying focal cartilage abnormality, FNMHF with normal cartilage, and cartilage abnormality with no FNMHF. Results. There was a significant association (p = 0.00) between FNMHF and immediate adjacent focal cartilage abnormality with high interobserver agreement. The absence of focal nodular lesions next to the anterior femoral cartilage has a very high negative predictive value for chondral injury (97.8%). Synovial biopsy of focal nodular lesion done during arthroscopy revealed some fibrocollagenous tissue and no inflammatory cells. Conclusion. We postulate that the FNMHF adjacent to the cartilage defects is a form of normal healing response. One patient with FHMHF and underlying cartilage abnormality was rescanned six months later. In this patient, the FNMHF disappeared and normal cartilage was observed in the adjacent region which may support this theory.

1. Introduction

Chondral and osteochondral injuries of the knee are common. This has been documented in magnetic resonance imaging (MRI) studies [1], in studies of asymptomatic athletes [2], and in patients undergoing knee arthroscopy [3, 4]. These injuries are often seen in young and active individuals, and unfortunately, the joint cartilage has limited capacity for repair. Many peer review articles have demonstrated comparable diagnostic accuracy of MRI to conventional arthroscopy in detecting chondral abnormalities in the knee [5, 6]. Although the presence of concomitant medial meniscus tear and anterior crucial ligament injury on MRI may alert the radiologist to search for possible chondral abnormalities, these do not localize them [7]. There are also articles that have demonstrated the role of synovium in tissue repair [8–10]. To this end, we proposed that the presence of focal nodular mass with low signal in Hoffa’s fat pad adjacent to anterior femoral cartilage of the knee (FNMHF) is strongly associated with underlying cartilage abnormalities as a form of normal healing response. If this is substantiated in our study, this would no doubt help physicians to predict cartilage damage and discourage surgeons from shaving off any reactive synovial changes adjacent to the anterior femoral condyle during arthroscopy which may contribute to the healing process. Furthermore, the absence of FNMHF on
MRI would indicate a low likelihood of an acute chondral injury.

2. Material and Methods

This is a prospective study to investigate if there is a relationship between FNMFH and cartilage defects underlying this region. Approval was obtained from the Medical Ethics Committee at the University Malaya Medical Centre in 2013.

2.1. Inclusion and Exclusion Criteria. Patients between the ages of 15 to 50 years who underwent MRI of the knee between May 2012 and June 2014 at the University Malaya Medical Centre were included in this study. Patients with a history of recent trauma, surgery, or joint prosthesis; recent arthroscopy less than 6 months prior to MRI; intra-articular or systemic corticosteroid use less than 3 months before MRI; septic arthritis; medial plicae; inflammatory arthritis; and more than 3 mm generalized synovitis in the superior patellar recess of the knee suggesting presence of generalized synovitis were excluded from this study.

2.2. Patient Preparation. A patient was not required to fast unless sedation was required. Patients were told to remove all metallic and electronic objects before entering the scan room.

2.3. MRI Study Protocol/Sequences. Scans were performed on clinical 3.0T Sigma® Hex MR Systems (GE Healthcare, Milwaukee, Wisconsin, USA). A routine MR knee protocol that included sagittal 3D fast imaging employing steady-state acquisition (FIESTA) (TE/TR 3.0/6.455 ms) sagittal proton density weighted (PDW) (TE/TR) and axial 3D FIESTA (TE/TR 3.008/6.427 ms) images was used. Section thickness was 2.0 mm, intersection gap was 1.0 mm, field of view was 18 × 18 cm, and the matrix was 384 × 256 pixels.

2.4. Data Collection and Storage. MRI images were transferred to General Electric workstations for reporting, processing, measurements, and analysis. The images were stored on the picture archiving and communicating archiving system.

Two independent reviewers looked specifically for FNMFH on FIESTA images that is adherent to the anterocentral (B1) and anteromedial (C1) regions of the medial femoral condyle (MFC) and lateral femoral condyle (LFC) (Figures 1–3). The articular cartilage of the outer third regions of the MFC and LFC (A) have cartilage in all sections (Figure 2). The articular cartilage of the inner third regions of the MFC and LFC (C) is incomplete posteriorly (Figure 3). The correlation of the above mapping system to the known ICRS system of arthroscopic mapping was taught to the surgeon (Figure 4) [11].

The grade of cartilage abnormality was assessed using the Modified Outerbridge Classification [12]. There are five grades of cartilage abnormalities. Grade 0 refers to normal cartilage; grade 1 is abnormal intrachondral signal (signal increase in T2 weighted images) but normal chondral surface cartilage; grade 2 is loss of less than 50% of cartilage but without exposure of subchondral bone defect; grade 3 is loss of more than 50% of cartilage thickness but without exposure of subchondral bone; grade 4 is complete loss of cartilage with subchondral bone exposure. Cartilage abnormality had to be present in at least two consecutive slices under the FNMFH. The cartilage was considered to be normal if the band of intermediate signal intensity had a uniform thickness. Each patient’s registration number, sex, and age are recorded. The age and sex of patients are used to find the prevalence of cartilage abnormalities among patients of different ages.
and sexes. The MRIs were then independently reviewed by 2 reviewers and categorized into the 5 above-mentioned categories.

We followed up patients with the FNMFH adjacent to the B1 and C1 on MRI to find out those who went on to arthroscopy. For three of the study patients who went for arthroscopy we asked the orthopaedic surgeon who is involved in this study to take images of the chondral defects and biopsy of FNMFH was taken. The synovial biopsy samples were examined using the haematoxylin and eosin staining protocol.

2.5. Statistical Analysis. Data obtained were keyed into a Microsoft Excel spreadsheet (Redmond, WA). Statistical analysis was done using the SPSS (IBM, USA) version 20.0. Mann-Whitney U test was used to look for differences in ages between groups with versus without FNMFH and also between groups with versus without cartilage abnormality. Chi-square test was used to test the null hypothesis that there is a significant association between FNMFH and cartilage abnormality. p values of less than 0.05 were taken to be statistically significant. The sensitivity, specificity, accuracy, and 95% confidence intervals were calculated. Kappa statistics were used to test interrater agreement for the presence of synovitis and cartilage abnormality.

3. Results

One hundred and forty-eight subjects (149 knees, 596 (149 B1 MFC, 149 C1 MFC, 149 B1 LFC, and 149 C1 LFC) subregions) were included. The mean age of subjects was 30 years (range 13–50 years, ±8.90). Of the 148 subjects, 32.8% were women (n = 49). There was a significant association found between FNMFH and cartilage abnormality (p < 0.01). Considering all four compartments together, there were no significant differences between the groups with versus without FNMFH found for age (p = 0.56). There were also no significant differences between the groups with versus without cartilage abnormality found for age (p = 0.25).

The prevalence of cartilage abnormality in our study population was 32.0% (n = 47). The presence of FNMFH can predict the presence of a cartilage abnormality in the adjacent femoral condyle with a sensitivity of 78.4% and specificity of 97.8%. Good interrater agreement was achieved for the presence of FNMFH and cartilage abnormality (κ = 0.97 for both). The positive and negative predictive values obtained were 70.7% and 98.5%, respectively.

Arthroscopy in this patient revealed focal nodular reactive changes adjacent to the focal cartilage defect in the absence of generalized synovitis (Figure 5). The synovial biopsy samples which were useful to the pathologist revealed fibrocollagenous and fatty tissue with no inflammatory cells (Figure 6).

4. Discussion

Normal synovium is the most vascular portion of the diarthrodial joint and is the first mediator of a disease process. Conditions that cause irritation of the intraarticular structures will cause an inflammatory response within the synovium [13].

Our study is novel as we are trying to demonstrate the protective effects of the normal synovial membrane on the articular cartilage of the knee on MRI. Most studies so far have investigated the role of synovitis in the progression of
of synovial thickening had also vanished (Figure 7(b)). This showed that chondral injury had healed and the focal area

of systemic corticosteroids treatment and the follow-up MRI

LFC (Figure 7(a)). He did not receive any intra-articular or
d a grade 2 cartilage injury to the C1 region of the lateral

cruciate ligament, and medial collateral ligament injuries as

previous sports injury. He sustained lateral meniscus, anterior

scan. The subject was a 29-year-old male with a history of

the subjects had a follow-up MRI 2 years after the initial

is one of the limitations of our study. However, one of

finding as it may imply the provision of healing fibrocollagen

vessels with no inflammation seen and this is an important

revealed fibrocollagenous and fatty tissue containing blood

pattern tends to be normal [18]. Biopsy of the FNMHF

[17] and Kurosaka et al. [18]. The villi were not significantly

to heal the underlying cartilage defect.

Our arthroscopic finding agrees with that of Ayral et al.

[17] and Kurosaka et al. [18]. The villi were not significantly
different from those of normal synovium, retaining their

slender, thin, and membranous appearance. The vascular

pattern tends to be normal [18]. Biopsy of the FNMHF

revealed fibrocollagenous and fatty tissue containing blood

vessels with no inflammation seen and this is an important

finding as it may imply the provision of healing fibrocollagen
to heal the underlying cartilage defect.

Most of our patients did not have follow-up MRIs which

is one of the limitations of our study. However, one of

the subjects had a follow-up MRI 2 years after the initial

scan. The subject was a 29-year-old male with a history of

previous sports injury. He sustained lateral meniscus, anterior

cruciate ligament, and medial collateral ligament injuries as

well as grade 2 cartilage injury to the C1 region of the lateral

femoral condyle injuries. The initial MRI showed FNMHF

and a grade 2 cartilage abnormality in the C1 region of the

LFC (Figure 7(a)). He did not receive any intra-articular or

systemic corticosteroids treatment and the follow-up MRI

showed that his chondral injury had healed and the focal area

of synovial thickening had also vanished (Figure 7(b)). This

suggests that the FNMHF seen on the first MRI was most

likely normal healing synovial proliferation.

This differs from the synovial thickening found in

osteoarthritic knees. Although the general consensus on

the histological appearance of synovitis in osteoarthritis

and secondary reactive synovial proliferation is that it is

nonspecific with overlapping features, in a study of 9 patients

with mild osteoarthritis, synovial biopsies in all patients

showed mild chronic synovitis. There was modest degree of

papillary hyperplasia of synovial membrane, a mononuclear
cell infiltrate, and proliferation of small blood vessels [19].

Thus, even in the absence of synovial thickening on MRI, our

synovial biopsy proves there is normal synovial proliferation

without evidence of inflammation which may suggest an

ongoing healing process.

We can postulate that the FNMHF behaves in a similar

fashion to the omentum, plugging the leak in the hollow

viscus, mending the chondral injury. This has paramount

importance as arthroscopists have a tendency to scrape off

any excess synovial proliferation, believing it not only has

nothing to do with healing but also contributes to possible

impingement.

The potential for cartilage repair seems to be better in

younger individuals and it has been stated that the ideal

patient for cartilage repair surgery is younger than 45 years

old and has asymptomatic isolated chondral defect with no

evidence of osteoarthritis [20]. All but two of our study

patients fit this profile. One patient had two chondral lesions

and the other was 47 years of age. Therefore, it would be rea-
onable to suggest that should these and other young patients

with small isolated chondral lesions undergo arthroscopy, any

reactive synovitis encountered should not be shaved off as this

may impair the healing process. One further area of study

which may be important is whether patients with FNMHF

with cartilage abnormality may be more likely to benefit

from mesenchymal stem cell or other regenerative injections

into the joint as the stem cells and regenerative agents may

incorporate into the FNMHF and assist the healing process.

5. Limitation

There were several limitations to our study. Initially, we

had 383 patients. However, many subregions were excluded

because they were not assessable, mainly because of motion

artefacts or field inhomogeneity at baseline and/or follow-

up, which did not allow scoring of the features in these

subregions.

We did not take into consideration the duration of any

existing symptoms and the time interval between onset and

MRI examination. Further studies are needed to investigate

the effect of treatment on the evolution of synovial prolifera-
tion and to substantiate the role of synovium in the repairs of

chondral lesion.

Another limitation of our study was the lack of systematic

surgical correlation. Such correlation is ideally obtained

with arthroscopy, in which the articular compartments are

assessed thoroughly. Use of this technique is not universally

accepted, however, and differs greatly among orthopaedic

surgeons [6]. Furthermore, it is not ethically acceptable to

![Figure 6: Histology of synovial biopsy. Section shows fibrocollagenous and fatty tissue containing blood vessels. No inflammation seen.](image-url)
perform an arthroscopy however minuscule the complications are, particularly when imaging findings are normal. Even though we could prove an association between synovitis and cartilage injury of the knee, we cannot be sure of the chronological order of these features. During the course of our study, we looked specifically at the anterior femoral condyle region as this region provided the largest area of synovial covering and any thickening in this region would be easily appreciated.

We excluded the weight bearing subregions such as B2 and C2 regions in the medial and lateral femoral condyles which we noticed also had cartilage abnormalities. One could argue that this may have introduced bias. We did not have histological proof of secondary reactive synovitis in most cases, because either there was no indication for arthroscopy or arthroscopy was declined by the patient. Perhaps if the study was carried out over an extended period of time, these patients could have been followed up to assess the resolution or progression of these cartilage defects on MRI.

6. Conclusion

Our study showed that routine MRI pulse sequences are useful in identifying the presence of FNMFH which may assist to locate cartilage defects in the knee. As we know surgeons today are more aggressive in management of grade 2 to grade 4 cartilage defects so locating these cartilage defects is important. In cases where arthroscopy is performed and FNMFH is noted, it would be advisable that surgeons should probably refrain from shaving off this reactive process which is likely to be a healing process. Further study of FNMFH in relation to its role in assisting injectables such as PRP and mesenchymal stem cells in the healing process by forming natural scaffolding should be conducted in the future.

Competing Interests

The authors declare that they have no competing interests.

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