*Research Article*

# Relationship between Full-thickness Articular Cartilage Defect and other MRI Features in Suspected Low Grade Knee Osteoarthritis.

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## Abstract
**Aim:** To evaluate the relationship of knee joint full thickness cartilage loss in suspected low grade osteoarthritis and other morphological joint changes. **Methods:** Lequesne index pain scoring and conventional magnetic resonance imaging MRI study were done for ٣٥ knees suffered from non-traumatic knee pain with preserved joint space between July ٢٠١٢ and December ٢٠١٣, using ١.٥ Tesla closed MRI. Cartilage scoring for full-thickness loss was done using MRI osteoarthritis of the knee score (MOAKS) with assessment of other joint and peri-articular features as a whole organ evaluation. Low grade osteoarthritis was defined as Kellgren Lawrence (KL) radiographic grading scale as grade ٠–٢ with unimpaired joint space. Correlation analysis was done between the cartilage score and other variables. **Results:** There was significant reasonable positive correlation between the Lequesne scoring and full-thickness cartilage loss in patella-femoral (PF) compartment and significant low positive correlation with medial femoro-tibial (MFT) full-thickness cartilage loss. Regarding the full-thickness patello-femoral cartilage loss; there was significant high positive correlation with the bone marrow lesion (BML) and significant reasonable positive correlation with presence of loose bodies. Regarding the full-thickness medial femoro-tibial cartilage loss; there was significant very high positive correlation with presence of loose bodies, and significant high positive correlation with KL score and compartmental osteophyte scoring, and significant reasonable positive correlation with bone marrow lesion, medial extrusion of the medial meniscus, medial meniscal hypertrophy and ganglion cyst. **Conclusion:** In suspected low grade osteoarthritis, presence of loose bodies or bone marrow edema like lesionwarrants thorough evaluation of articular cartilage in PF and MFT compartments for full-thickness cartilage loss.
**Key words:** Magnetic resonance imaging, full-thickness cartilage loss, low grade osteoarthritis.

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## Introduction
Osteoarthritis (OA) is the most common forms of arthritis and can be considered as one of the leading causes of disability in elders. This highly prevalent disease occurs when the dynamic equilibrium between the breakdown and repair of the synovial joint tissues become unbalanced.[١]

When considering synovial joint is an organ; OA represents failure of that organ, and can be initiated by abnormalities arising in any of its constituent tissue. Early investigators tended to regard OA as an isolated disease of articular cartilage, but although cartilage loss is the prominent feature in the disease, OA is not exclusively

a disorder of articular cartilage; the entire synovial joint organ is affected in OA, resulting in structural and functional organ failure. Multiple components of the joint are adversely affected by OA, including the peri-articular bone, synovial joint lining, adjacent supporting connective tissue elements and osteochondral overgrowth (osteophytes).[٢&٣]

The human knee is a complex joint having three compartments: the patella-femoral, and the medial and lateral femoro-tibialjoints. The medial compartment is subjected to more stress than the lateral compartment, which may account, In part, for why OA affects the medial tibiofemoral compartment in men and women, ٧٥٪ of knee OA affects the medial compartment as opposed to ٢٥٪ affecting the lateral compartment.(٤)

Generally, OA begins as fatigue fracture of the collagen meshwork followed by increased hydration of the articular cartel-age. Subsequent molecular changes takes place including fibrillation of the cartilage with weakening of type II collagen network, articular cartilage fissuring in areas of maximum mechanical stress, loss of proteoglycans from the matrix into the synovial fluid, synovial hypertrophy causing joint pain by nerve stimulation, proliferative osteochondral changes at the joint margins and in the femoral notch with formation of marginal and non-marginal osteophytes, increased subchondral plate thickness with development of subchondral bone cysts, loose bodies formation after fragmentation of osteochondral surfaces.(٥&٦)

Because different tissues are involved in OA, MRI has been tailored to include different sequences for whole organ assessment of OA to assess hyaline cartilage, bone marrow, ligaments, menisci, and tendons.(٧)

## Materials and methods

This analytic observational study was conducted in the MRI unit, department of Diagnostic Radiology, Faculty of Medicine, Ain Shams University, during the period from July ٢٠١٢ to December ٢٠١٣, after being approved by the Medical Ethics Committee. Thirty four patients who had unimpaired joint space on AP knee radiograph (low KL class ٠-٢) and suffered from non-traumatic knee pain were referred to the MRI unit for MRI examination were recruited in the study; the total number of studied knees is thirty five knees. Thorough counseling and a written informed consent was obtained from each patient prior to participating in the study. The inclusion criteria were: knee pain and adult age group ≥ ١٦ year. The exclusion criteria were: recent knee trauma, known rheumatoid arthritis or crystal arthropathy, suspected malignant marrow infiltration, suspected osteomyelitis, suspected reflex sympathetic dystrophy of the knee.

All recruited patients were submitted to

١- Analysis of the knee pain using the index of severity for osteoarthritis of the knee created by Lequesne MG et al.,(٨&٩)

٢- MRI study of the knee by***Achieva ١.٥ tesla Philips closed MR scanner***using knee surface coil, then semi-quantitative whole joint assessment was done using MRI osteoarthritis knee score (MOAKS).

The sections for Lequesne indexscore are:

**a) <u>Pain or discomfort:</u>**

- Pain or discomfort during nocturnal bed-rest (scored as ٠= none, ١= only on movement or in certain positions & ٢= without movement).
- Duration of morning stiffness or pain after getting up (scored as ٠= if it was one minute or less, ١ = > ١ and < ١٥ minutes & ٢ = ≥ ١٥ minutes).
- Remaining standing for ٣٠ minutes increases pain (scored as ٠= no, ١= yes).
- Pain on walking (scored as ٠= none, ١= only after walking some distance & ٢= after initial ambulation and increasingly with continued ambulation)
- Pain or discomfort after getting up from sitting without use of arms (scored as ٠= no & ١= yes)

**b) <u>Maximum distance walked:</u>**

- Maximum distance walked (scored as ٠= unlimited, ١= > ١ kilometer but limited, ٢= about ١ kilometer {about ١٥ minutes}, ٣= about ٥٠٠-٩٠٠ meters {about ٨-١٥ minutes}, ٤=[from ٣٠٠-٥٠٠ meters, ٥ from ١٠٠-٣٠٠ meters & ٦ = < ١٠٠ meters).
- Walking aids required (scored as ٠= none, ١= walking stick or crutch & ٢= ٢ walking sticks or crutches)

**c) <u>Activity of daily living:</u>**

- Able to climb up a standard flight of stairs (scored as ٠= easily, ٠.٥= with mild difficulty ١= with moderate difficulty, ١.٥= with marked difficulty & ٢= impossible).
- Able to climb down a standard flight of stairs (scored as ٠= easily, ٠.٥= with mild difficulty ١= with moderate difficulty, ١.٥= with marked difficulty & ٢= impossible).
- Able to squat or bend at the knee (scored as ٠= easily, ٠.٥= with mild difficulty ١= with moderate difficulty, ١.٥= with marked difficulty & ٢ = impossible).
- Able to walk on uneven ground (scored as ٠= easily, ٠.٥= with mild difficulty ١= with moderate difficulty, ١.٥= with marked difficulty & ٢= impossible).

**Index score of severity and handicap:**

٠= none, ١-٤= mild, ٥-٧= moderate, ٨-١٠= severe, ١١-١٣= very severe, > ١٤= extremely severe.

**Table (١)**: Shows different sequence parameters used for knee MRI examination:

| Sequence / Parameter | T١ TSE Sag | PD SPAIR sag | ٣D WATSc sag | ٣D WATSf sag | mFFEcor | PD SPAIR cor | T٢ TSE Tra | T٢ SPAIR Tra |
|---|---|---|---|---|---|---|---|---|
| Scan time [m:s] | ٣:١٥ | ٢:٥٣ | ٣:٣٨ | ٣:٢٧ | ٢:٥٨ | ٢:٥٣ | ١:١١ | ٣:٠١ |
| Sthickness [mm] | ٤ | ٤ | ------- | ------- | ٤.٥٥ | ٤.٥٥ | ٣.٧ | ٣ |
| Matrix [MxP] | ٢٠٨x١٣٠ | ٢٠٨x١٣٠ | ٢٦٠x٢٦١ | ٢٤٨x٢٤٧ | ٢٥٦x٢٥٦ | ٢٦٤x٢٠٠ | ٢٦٠x٢٠٨ | ٢٤٨x١٩٨ |
| Bandwidth [Hz] | ١٩٥.٥ | ٤٢٠.٩ | ٢١٦.٧ | ٢١٦.٨ | ١٩٧.٣ | ٤٤٨.٣ | ١٢٥.٧ | ٢٤٤.٤ |
| TR [ms] | ٥٠٠ | ٢١١٧ | ٢٤ | ٢٥ | ٨٥٦ | ٢١١١ | ٤١٨٦ | ٤٩١٠ |
| TE [ms] | ١٨ | ٣٠ | ٧.٨ | ٧.٨ | ٩.٢/٩.٣ | ٣٠ | ١٠٠ | ٦٠ |
| FOV [mm] | ١٨٠ | ١٨٠ | ١٨٠ | ١٨٠ | ١٨٠ | ١٨٠ | ١٨٠ | ١٨٠ |
| Water suppression | no | no | no | no | no | no | no | no |
| Fat suppression | no | SPAIR | ProSet | ProSet | no | SPAIR | no | SPAIR |

The joint features which were assessed according to MOAKS included; articular cartilage, BMLs/cysts, osteophytes, Hoffa's synovitis and synovitis-effusion, menisci, ligaments/tendon and peri-articular features.

The study utilized cartilage score for the depth of cartilage damage in fourteen articular sub-regions regardless of cartilage loss morphology using PD SPAIR, ٣D WATSc and multiple fast field echoe (mFFE) sequences for cartilage evaluation. Each articular cartilage region was graded for percentage of loss in this subregionthat is full-thickness loss: grade ٠: none, ١: <١٠٪ of region of cartilage surface area, ٢: ١٠-٧٥٪ of region of cartilage surface area and ٣: > ٧٥٪ of region of cartilage surface area.

For BML scoring, the study generated a single grade for size inclusive of all BMLs, either cystic or non-cystic, into one score in regard to the total volume of the sub-region; grade ٠= none, grade ١ <٣٣٪, grade ٢= ٣٣-٦٦٪ and grade ٣ >٦٦٪. If BML extended to adjacent subregion, it was scored in both, but if it extended to the marrow signal on an osteophyte, it was not scored within the osteophyte.

The study scored the osteophytes for their protuberance size and how far they extend from the joint, rather than their total volume, the largest osteophyte was scored

within a given location, ١٢ specific locations were assessed for osteophyte scoring: medial trochlea (axial/sagittal plane), lateral trochlea (axial/sagittal plane),

central medial femoral condyle (coronal plane), central lateral femoral condyle (coronal plane), central medial tibia (coronal plane), central lateral tibia (coronal plane), posterior peripheral and posterior central margins of medial femoral condyle (axial/sagittal plane), posterior peripheral and posterior central margins of lateral femoral condyle (axial/sagittal plane), medial margin of the patella (axial plane), lateral margin of the patella (axial plane), superior margin of the patella (axial plane) and inferior margin of the patella (axial plane). For posterior medial and posterior lateral femoral condyles, the larger osteophyte for either peripheral or central location was scored. Osteophyte grading was: Grade ٠= none; Grade ١= small; Grade ٢= medium; Grade ٣= large.

Synovitis induced Hoffa's fat pad signal changes, were assessed for presence of diffuse hyperintense signal on T٢/PD-fat suppressed sequences within the fat pad. Hoffa-synovitis score was performed on sagittal images: ٠= normal; ١= mild, ٢= moderate, ٣= severe. Effusion-synovitis was scored on axial T٢/PD-fat suppressed sequences for presence of fluid equivalent signal within the joint cavity excluding any paraarticular cysts or ganglia, it was graded regarding its size and associated capsular distension: Grade ٠: physiologic amount, Grade ١: small fluid in retro-patellar space, Grade ٢: medium size with minimal convexity in supra-patellar bursa, Grade ٣: large amount distending the joint capsule.

The meniscus extrusion was scored; the medial meniscus was scored for medial and anterior extrusion relative to tibial margin excluding any osteophytes, the scoring was performed where extrusion is maximum. The lateral meniscus was also scored for anterior and lateral extrusion excluding any osteophytes. Grading for extrusion: Grade ٠: <٢ mm; Grade ١:٢-٢.٩ mm, Grade ٢:٣-٤.٩ mm; Grade ٣: >٥ mm.

The meniscal morphologic changes in both medial and lateral menisci were scored at the anterior, body and posterior horn as presence or absence (Y/N) of signal not extending through meniscal surface, vertical tear (includes radial and longitudinal tears) that extend to both the femoral and tibial surfaces as high signal on at least two slices, horizontal and radial tearextending from the periphery of the meniscus to either a femoral or tibial surface on at least two slices, complex tear that extends to both the tibial and femoral surfaces and ≥ ٣ points on those surfaces, root tear (posterior horn), partial or complete maceration manifested with loss of morphological substance, meniscal cyst and meniscal hypertrophy.

The definite complete tear of the anterior cruciate and posterior cruciate ligaments was recorded as either present or absent. The patellar tendon score: ٠: no signal abnormality, ١: signal abnormality present.

The study scored the presence or absence of the following peri-articular abnormality:pes anserine bursitis, ilio-tibial band ITB signals, popliteal cyst, infra-patellar bursal fluid signal, pre-patellar bursal fluid signal, ganglion cyst and loose bodies.

Results of pain score and MRI scoring system were recorded means ± SD or numbers and percent [N (%)] Correlation analysis between MOAKS joint features with each other and with Lequesne pain index score was done, r value >٠.٢ <٠.٤ was considered low correlation, r= >٠.٤ <٠.٦ was considered reasonable correlation, r= >٠.٦ <٠.٨ was considered high correlation, r= >٠.٨ was considered very high correlation. P value <٠.٠٥ was considered significant.

## Results

The mean age of the patients was ٣٨.٢±١٢.٧ y ranged from ١٦-٦٤y, of those ١٩ males of total ١٩ examined knees and ١٥ females of total ١٦ examined knees. The Lequesne score was ranged from ١.٥-٨ with mean of ٤.٢±١.٥.

The full thickness cartilage defect in PF compartment was present in ٨ (٢٢٪)cases,

all of them has grade ١, whereas full thickness cartilage defect in MFT compartment was present in ٨ (٨.٥٪) cases, one has grade II defect and the others have grade ١ defect, in LFT compartment there was ١ (٢.٨٪) case has grade I cartilage defect.
Correlation statistics were done between full-thickness cartilage loss, Lequesne score and other scored joint features (table ٢-٤)

**Table (٢)**: Shows correlation between PF full-thickness cartilage score and Lequesne index pain score and other relevant joint features.

| | Joint feature | N = ٣٥ | |
|---|---|---|---|
| | | r | p |
| PF full thicknesscartilage score | L score | ٠.٥٤ | <٠.٠٠١ |
| | BML in PF | ٠.٦٣ | <٠.٠٠١ |
| | Osteophytes in PF | ٠.١٤ | ٠.٢ |
| | Loose bodies | ٠.٤٥ | <٠.٠٥ |

As shown in table ٢, there was high positive correlation between full thickness PF cartilage defect and bone marrow lesions, and reasonable positive correlation between PF full thickness cartilage defect and Lequesne index scoring and loose bodies.

**Table (٣)**: Shows correlation between MFT full-thickness cartilage score and Lequesne index pain score and other relevant joint features.

| | Joint feature | N = ٣٥ | |
|---|---|---|---|
| | | r | p |
| MFT full thicknesscartilage score | L score | ٠.٣٢ | <٠.٠٥ |
| | BML in MFT | ٠.٤ | <٠.٠٥ |
| | Osteophytes in MFT | ٠.٦٦ | <٠.٠٠١ |
| | Medial extrusion of MM | ٠.٤٢ | <٠.٠٥ |
| | Anterior extrusion of MM | ٠.٢٧ | ٠.٠٥ |
| | Medial meniscal root tear | ٠.١٣ | ٠.٢ |
| | Medial meniscal partial maceration | ٠.١٦ | ٠.١ |
| | Medial meniscal hypertrophy | ٠.٥٦ | <٠.٠٠١ |
| | Loose bodies | ٠.٨ | <٠.٠٠١ |
| | Ganglion cyst | ٠.٤ | <٠.٠٥ |
| | Hoffa synovitis | ٠.١٦ | ٠.١ |
| | Effusion | ٠.٢٩ | <٠.٠٥ |

As shown in table ٣, there was very high positive correlation between full thickness MFT cartilage defect and loose bodies. There was high positive correlation between full thickness MFT cartilage defect and KL score and osteophyte score, whereas there was reasonable positive correlation between MFT full thickness cartilage defect and BML, medial extrusion of medial meniscus and meniscal hypertrophy.

**Table (٤):** Shows correlation between LFT full-thickness cartilage score and Lequesne index pain score and other relevant joint features.

| LFT full thicknesscartilage | Joint feature | N = ٣٥ | |
|---|---|---|---|
| | | r | p |
| | L score | -٠.٢٤ | ٠.٠٨ |
| | BML in LFT | ٠.٢٦ | ٠.٠٦ |
| | Osteophytes in LFT | -٠.٠٩ | ٠.٣ |
| | Lateral meniscal signals | -٠.١٧ | ٠.١ |
| | Lateral meniscal tear | -٠.٠٦ | ٠.٣ |
| | BML at ACL attachment to the bone | -٠.٠٩ | ٠.٣ |
| | Ganglion cyst | -٠.٠٧ | ٠.٣ |
| | Loose bodies | -٠.٠٤ | ٠.٤ |

As shown in table ٤, there was statistically insignificant low positive correlation between full thickness LFT cartilage defect and bone marrow lesion, whereas there was statistically insignificant low negative correlation between full thickness LFT cartilage defect and other relevant compartmental features.

## Discussion

Regarding the knee symptoms in the current study, although the reasonable positive correlation of Lequesne index score and full-thickness articular cartilage defect was found in PF compartment, but, lack of a follow up MRI study that could clarify this relationship, was a limiting factor. Many other joint variables such as effusion, synovitis and meniscal changes could also exert knee symptoms. A longitudinal assessment is recommended to establish such a relationship through assessment of the changes in Lequesne index score and the changes in other joint features.

Regarding the presence of intra-articular loose bodies, there was reasonable correlation and very high correlation with full-thickness articular cartilage defect in PF and MFT respectively, loose body formation is a frequent finding observed in OA and formed by fragmentation of osteochondral surfaces following articular cartilage defect.

Regarding the presence of BML in low grade KL class, the study found positive relationship correlation with full-thickness articular cartilage defect in PF and MFT.Raynauld JP et al., ٢٠٠٨[١٠]studied the correlation between bone lesion changes and cartilage volume loss in knee osteoarthritis and reported correlations between subchondral bone marrow lesion change and cartilage volume loss in the same compartment. On the other hand, Roemer FW et al., ٢٠٠٩ [١١] did not show the same association, and this is likely because they utilized a knee-based approach not a subregional approach that the current study used.

Regarding the meniscal changes in MFT, medial extrusion of the medial meniscus and meniscal hypertrophy were correlated with full thickness cartilage loss. This is can be explained by logic increased risk of cartilage loss for subjects with meniscal extrusion, and this is in concordance with Sharma L et al., ٢٠٠٨[١٢] and Roemer F Wet al., ٢٠٠٩[١١], who studied the knee osteoarthritis and the relationship of meniscal extrusion to subsequent cartilage loss, they confirmed the highly increased risk of cartilage loss for subjects with baseline meniscal damage and extrusion.

Regarding LFT joint features, the paucity of cases {١(٢.٨٪)} that demonstrate full thickness cartilage defect was the major limita-

tion in our study, a larger study is recommended to assess OA changes in LFT compartment.

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