Knee pain and inflammation in the infrapatellar fat pad estimated by conventional and dynamic contrast-enhanced magnetic resonance imaging in obese patients with osteoarthritis: a cross-sectional study

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Acknowledgements:

• Oak foundation for donating the 3T Siemens Verio scanner

• Board of directors BBH and Frh Hospitals for supporting the

• Olga Kubassova and her team at Image analysis, Ltd London for support using the software Dynamika®

Disclosures:

• Mikael Boesen and Rasmus Bouert has acted as Independent non-paid clinical advisors for Dynamika on the clinical advisory board of Image Analysis Ltd, London.
Background:

In the knee, the intraarticular, extra synovial fat pad of Hoffa (infrapatellar fat pad (IPFP)) seems to play a crucial, but not fully understood, role in Knee Osteoarthritis (KOA)

Ioan-Facsinay and Kloppenburg Arthritis Research & Therapy 2013, 15:225
http://arthritis-research.com/content/15/6/225

REVIEW

An emerging player in knee osteoarthritis: the infrapatellar fat pad

Andreea Ioan-Facsinay* and Margreet Kloppenburg
Synovitis / inflammation in KOA
Contrast enhanced(CE)-MRI vs. non-CE MRI

Peripatellar synovitis: comparison between non-contrast-enhanced and contrast-enhanced MRI and association with pain. The MOST study

M.D. Crema †∥*, D.T. Felson §, F.W. Roemer †∥∥, J. Niu §, M.D. Marra †, Y. Zhang §, J.A. Lynch ¶, G.Y. El-Khoury #, C.E. Lewis ††, A. Guermazi †

In summary, we confirmed that signal changes in HFP detected on non-CE MRI are a sensitive but non-specific surrogate for the assessment of peripatellar synovitis. Our data suggests that CE MRI identifies associations of peripatellar synovitis with pain better than non-CE MRI. Assessment of synovitis should ideally be performed on CE MRI when possible.

Imaging of Synovitis in Osteoarthritis: Current Status and Outlook

Daichi Hayashi, MBBS,* Frank W. Roemer, MD,**†
Avinash Katur, MBBS, DNB,* David T. Felson, MD, MPH,*
Scoung-Oh Yang, MD,* Faris Alomran, MD,§ and Ali Guermazi, MD*

Conclusions: Synovitis is increasingly recognized as an important feature of the pathophysiology of OA, although there is conflicting evidence with respect to its association with disease severity and clinical parameters. Contrast-enhanced MRI and ultrasound are the most important methods for assessing synovitis associated with OA.

Assessment of synovitis with contrast-enhanced MRI using a whole-joint semiquantitative scoring system in people with, or at high risk of, knee osteoarthritis: the MOST study

Ali Guermazi, Frank W Roemer, Daichi Hayashi, Michel D Crema, Jingbo Niu, Yuqing Zhang, Monica D Marra, Avinash Katur, John A Lynch, George Y El-Khoury, Kristin Baker, Laura B Hughes, Michael C Nevitt, David T Felson

Conclusions: A comprehensive semiquantitative scoring system for the assessment of whole-knee synovitis is proposed. It is reliable and identifies knees with pain, and thus is a potentially powerful tool for synovitis assessment in epidemiological OA studies.
Synovitis:

Non-Contrast Enhanced (CE) MRI vs. CE-MRI

Proton weighted fat sat  T1 weighted fat sat + Gadolinium
Dynamic contrast enhanced (DCE)-MRI in inflammatory arthritis

DCE-MRI voxel by voxel model-based time intensity analysis
DCE-MRI model-based time intensity curve analysis – Dynamika® in KOA
Purpose:

To investigate the association between knee pain and signs of inflammation in the infrapatellar fat pad (IPFP) in obese patients with knee osteoarthritis (KOA) using both conventional CE-MRI and DCE-MRI derived from a 3T MRI scanner.

Methods:

95 KOA patients all participants in a weightloss trial "Carot light" (ClinicalTrials.gov identifier: NCT00938808) were included in the analysis.
MRI Protocol

MRI of the target knee was performed (image time 30-40 minutes)
- 3T Siemens Verio® system.
- Supine position using a dedicated 16-channel send/receive knee coil.

The following MRI protocol was used:
- Coronal T1-weighted (T1w) turbo spin echo (TSE)
- Coronal and Sagittal short tau inversion recovery (STIR);
- Sagittal 3D 0.6mm isotropic proton density weighted (PDw) FS TSE SPACE,
- Sagittal GRE 3D T1w 0.5mm volumetric interpolated breath hold examination (VIBE)

Simultaneously with the intravenous injection of 0.1 ml/kg body weight Gadolinium contrast (Prohance®, Bracco Diagnostics Inc., Italy) using a power injector (2 ml/s):

Axial DCE-MRI GRE T1w VIBE sequence
- 18, 5 mm slices every 9 s, with 30 repetitions
- TE 1.86, TR 5.51 FA 15 degrees, FOV 160x160, matrix resolution 192 x 138
- Covering the supra-patellar recess to the insertion of the patella tendon on the tibia.

Following this the static T1w sequences were repeated and used for MOAKS Hoffa synovitis scoring.
Material and Methods:

• **KOOS** (knee injury and osteoarthritis score) is self-reported outcomes on pain, symptoms and quality of life.

• **Hoffa synovitis** assessed according to the definitions in the MRI osteoarthritis knee score (**MOAKS**) for Hoffa synovitis using the 3D T1w CE-MRI.

• **DCE-MRI**
DCE-MRI Analysis

Investigators blinded to the clinical data and the KOOS answers analysed the MR images.

- **DCE-MRI images were analysed using Dynamika®:**
  - **Motion correction** to reduce the enhancement artefacts due to movement
  - **Region of interest (ROI)** around the IPFP in all the axial DCE-MRI images from the tip of the patella pole to the insertion of the patella tendon on tibia and summed into a **volume ROI (VOI)**.
  - The most proximal slice chosen for IPFP-scoring corresponded to the slice in which the patella was still visible.

- **Voxel-by-voxel time intensity curve analysis and** Gadolinium (GD), ME, IRE map were computed in the VOI
  - Perfusion variables used for further analyses:
    - \( \Sigma \text{IRE} \times (\text{N-plateau}+\text{N-washout}) \) ("Inflammation"),
    - \( \Sigma \text{ME} \times (\text{N-plateau}+\text{N-washout}) \),
    - N-plateau+N-washout (number of enhancing voxels)
    - Inflammation/volume of the IPFP within the drawn VOI
Hoffa’s fat pad examples of a region of ROI

Inter- and Intraclass coefficient (ICC):
DCE-MRI VOIs: 0.86-0.99
MOAKS Hoffa synovitis: 0.58 (single reader only intra-ICC)
<table>
<thead>
<tr>
<th></th>
<th>Inflammation</th>
<th>(\Sigma ME \times (N\text{-plateau} + N\text{-washout}))</th>
<th>N-plateau+N-washout</th>
<th>Inflammation/volume</th>
<th>Volume of the IPFP (ml)</th>
<th>MOAKS Hoffa-synovitis (0-3)</th>
<th>KL score (0-4)*</th>
<th>CRP (mg/l)*</th>
<th>Fat mass (%)</th>
<th>KOOS Pain</th>
<th>KOOS Symptoms</th>
<th>KOOS ADL</th>
<th>KOOS QOL</th>
<th>KOOS Sport/Rec</th>
<th>Sex (Female=1, Male=0)</th>
<th>Age (years)</th>
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<td>Inflammation</td>
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<td>(\Sigma ME \times (N\text{-plateau} + N\text{-washout}))</td>
<td>0.93 (&lt;0.0001)</td>
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<td>N-plateau+N-washout</td>
<td>0.87 (&lt;0.0001)</td>
<td>0.98 (&lt;0.0001)</td>
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<td>Inflammation/volume</td>
<td>0.97 (&lt;0.0001)</td>
<td>0.89 (&lt;0.0001)</td>
<td>0.82 (&lt;0.0001)</td>
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<td>Volume of the IPFP (ml)</td>
<td>0.62 (&lt;0.0001)</td>
<td>0.65 (&lt;0.0001)</td>
<td>0.67 (&lt;0.0001)</td>
<td>0.44 (&lt;0.0001)</td>
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<tr>
<td>MOAKS Hoffa-synovitis (0-3)</td>
<td>0.62 (&lt;0.0001)</td>
<td>0.63 (&lt;0.0001)</td>
<td>0.57 (&lt;0.0001)</td>
<td>0.61 (&lt;0.0001)</td>
<td>0.35 (0.0005)</td>
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<td>KL score (0-4)*</td>
<td>0.50 (&lt;0.0001)</td>
<td>0.55 (&lt;0.0001)</td>
<td>0.55 (&lt;0.0001)</td>
<td>0.43 (&lt;0.0001)</td>
<td>0.51 (&lt;0.0001)</td>
<td>0.30 (0.0034)</td>
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<td>CRP (mg/l)*</td>
<td>0.19 (0.07)</td>
<td>0.13 (0.23)</td>
<td>0.15 (0.16)</td>
<td>0.17 (0.098)</td>
<td>0.13 (0.21)</td>
<td>-0.043 (0.68)</td>
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<td>Fat mass (%)</td>
<td>-0.0013 (0.99)</td>
<td>-0.11 (0.28)</td>
<td>-0.18 (0.087)</td>
<td>0.077 (0.46)</td>
<td>-0.32 (0.002)</td>
<td>-0.021 (0.84)</td>
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<td>KOOS Pain</td>
<td>-0.42 (&lt;0.0001)</td>
<td>0.43 (&lt;0.0001)</td>
<td>-0.43 (&lt;0.0001)</td>
<td>-0.37 (0.0002)</td>
<td>-0.39 (0.0001)</td>
<td>-0.21 (0.046)</td>
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<td>KOOS Symptoms</td>
<td>-0.51 (&lt;0.0001)</td>
<td>0.47 (&lt;0.0001)</td>
<td>-0.46 (&lt;0.0001)</td>
<td>-0.49 (&lt;0.0001)</td>
<td>-0.36 (0.0004)</td>
<td>-0.24 (0.021)</td>
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<td>KOOS ADL</td>
<td>-0.33 (0.001)</td>
<td>-0.31 (0.003)</td>
<td>-0.30 (0.003)</td>
<td>-0.28 (0.006)</td>
<td>-0.33 (0.001)</td>
<td>-0.12 (0.25)</td>
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<td>KOOS QOL</td>
<td>-0.43 (&lt;0.0001)</td>
<td>0.42 (&lt;0.0001)</td>
<td>-0.41 (&lt;0.0001)</td>
<td>-0.40 (&lt;0.0001)</td>
<td>-0.36 (0.0003)</td>
<td>-0.19 (0.066)</td>
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<tr>
<td>KOOS Sport/Rec</td>
<td>-0.36 (0.0004)</td>
<td>-0.36 (0.0004)</td>
<td>-0.36 (0.0004)</td>
<td>-0.33 (0.001)</td>
<td>-0.28 (0.006)</td>
<td>-0.12 (0.24)</td>
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<td>Sex (Female=1, Male=0)</td>
<td>-0.17 (0.10)</td>
<td>-0.25 (0.015)</td>
<td>-0.29 (0.005)</td>
<td>-0.037 (0.72)</td>
<td>-0.51 (&lt;0.0001)</td>
<td>-0.038 (0.72)</td>
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<td>Age (years)</td>
<td>0.065 (0.53)</td>
<td>0.060 (0.57)</td>
<td>0.018 (0.86)</td>
<td>0.086 (0.41)</td>
<td>-0.030 (0.78)</td>
<td>0.018 (0.86)</td>
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Data are from 95 subjects unless specified. Correlation coefficients (Spearman’s rho) are shown as the first value and the p-values are shown as the second value. Bold associations (p < 0.05) are indicated by bold. *Data from 94 subjects. Abbreviations: KOOS, Knee injury and Osteoarthritis Outcome Score (washout); ME, Maximal enhancement; Inflammation/volume, \(\Sigma IRE \times (N\text{-plateau} + N\text{-washout})\) divided by the volume of the infrapatellar Osteoarthritis Knee Score; KL, Kellgren-Lawrence; CRP, C-reactive protein; ADL, Function in daily living; QOL, Knee related Quality of life.
Primary Outcome Measures (Spearman’s rank correlation):

- KOOS pain and the perfusion variable, “Inflammation” (r=-0.42, p<0.0001)
- KOOS pain and MOAKS Hoffa-synovitis assessed on CE-MRI (r=-0.21, p<0.046)

Conclusion:

- MOAKS Hoffa-synovitis assessed on CE-MRI and especially the perfusion variables from DCE-MRI reflecting inflammation in the IPFP, were related to pain and clinical symptoms in obese patients with KOA.
- DCE-MRI analysed with a dedicated software and a voxel by voxel time intensity curve method is a promising, and reproducible method to study the impact of inflammation in KOA.
Thank you....😊