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ISOTROPIC MR IMAGING OF CARTILAGE AND FIBROCARTILAGE FOR OSTEOARTHRITISG. Gold¹, W. Chen², H. Yu², A. Shimakawa², A. Brau², P. Beatty², B. Hargreaves¹¹Stanford Univ., Stanford, CA; ²GE Hlth. Care, Menlo Park, CA

Purpose: Changes in both articular and fibrocartilage tissues may be important in the pathogenesis of osteoarthritis. Myxoid degeneration of the meniscus, for example, presents with increased T2* relaxation times on MR images. Three-dimensional Iterative Decomposition of water and fat with Echo Asymmetry and Least squares estimation (IDEAL) with gradient echo (GRE) with R2* maps (3D T2* IDEAL-GRE) produces fat, water, combined, and R2* relaxation rate maps. We tested the ability of 3D T2* IDEAL-GRE with isotropic resolution to evaluate both cartilage and fibrocartilage in the knee at 3.0T. This method may be useful in longitudinal measures of articular cartilage morphology, as well as characterization of fibrocartilage relaxation times.

Methods: Ten knees of five healthy volunteers (age 24-46) were imaged using a GE Signa HDx 3.0T MRI and an 8-channel knee coil. An investigational version of 3D T2* IDEAL-GRE was done with an echo train length of 3 and a total of 6 echoes of 1.6, 3, 4.5, 5.9, 7.3, and 8.8 ms interleaved in two TRs. Repetition time was of 29 ms, bandwidth of ± 111 kHz, 35-degree flip angle, acceleration factor of 2.6, and 9:23 scan time. Sagittal images with an isotropic resolution of 0.7 mm were acquired with a 256x256 matrix, 17 cm FOV, 140 sections. Signal-to-noise ratio (SNR) was calculated in the water images by dividing the signal by the noise on an identical second acquisition with the radiofrequency pulses turned off. SNR was measured in the posterior horn of the medial meniscus, patella tendon, medial femoral cartilage, and joint fluid. R2* values (1/T2*) were measured from the estimated locations of the red and white zones of the posterior horns of the medial and lateral menisci, as well as the proximal patella tendon 2 cm from its origin. Five volunteers were also imaged with a ultra-short echo time (TE=100 microseconds) sequence using a cones trajectory. R2* maps from that sequence were compared with the Cartesian (TE = 2 ms) acquisition.

Results: Fibrocartilage SNR in the white zone of the posterior horn of the medial meniscus was 36 ± 12 and the patella tendon was 24 ± 7.2 . Cartilage and fluid SNR were 48 ± 11 and 82 ± 18 respectively. R2* values in the white zone of the medial meniscus were significantly lower than in the white zone of the lateral meniscus ($p < 0.001$). Isotropic 3D T2* IDEAL-GRE produced water, fat, combined, and R2* map images. The isotropic resolution allowed for high-quality reformats to highlight fibrocartilage tissues. Higher SNR was seen in the fibrocartilage tissues with the ultrashort echo time sequence, as well as increased signal from cortical bone.

Conclusions: 3D T2* IDEAL-GRE imaging provides isotropic resolution, cartilage morphology, and the ability to evaluate short T2*

structures with R2* maps. 3D isotropic imaging of the knee can be performed at 3.0T with assessment of both cartilage morphology and fibrocartilage relaxation times with a single sequence. The Cartesian acquisition provides sufficient SNR for measurement of T2* values in the menisci and ligaments, while the ultrashort echo time sequence allows evaluation of the cortical bone. These methods may be useful for following multiple joint tissues in longitudinal studies of osteoarthritis.

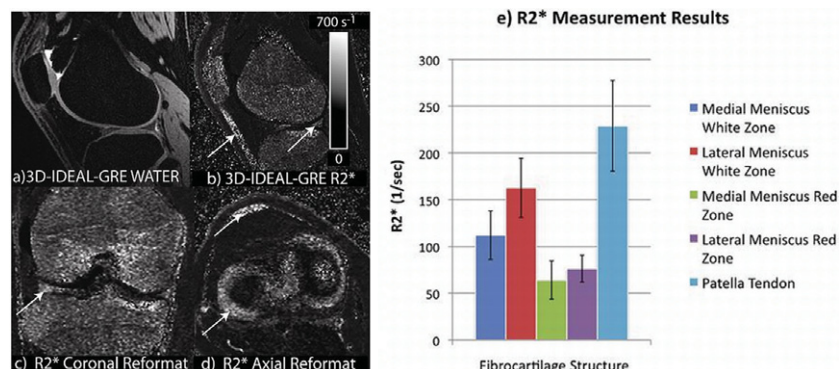
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INTER- AND INTRA-OBSERVER REPRODUCIBILITY OF THE RADIOGRAPHIC KELLGREN-LAWRENCE SCORING SYSTEM IN HAND OSTEOARTHRITIS (HOA)E. Maheu¹, C. Cadet², G. Baron³, F. Berenbaum¹, X. Chevalier⁴, L. Gossec⁵, D. Loeuille⁶, J.-F. Maillefer⁷, B. Mazières⁸, F. Rannou⁹, P. Richette¹⁰, P. Ravaud³¹Rheumatology - St Antoine Hosp., Paris, France;²Rheumatologist, Paris, France; ³Biostatistics Dept - Bichat Hosp., Paris, France; ⁴Rheumatology - Henri Mondor Hosp., Créteil, France; ⁵Rheumatology - Cochin Hosp., Paris, France;⁶Rheumatology - Vandoeuvre Hosp., Nancy, France; ⁷Rheumatology - CHU Dijon, Dijon, France; ⁸Rheumatology - CHU Larey, Toulouse, France; ⁹Rehabilitation Dept - Cochin Hosp., Paris, France; ¹⁰Rheumatology - Lariboisière Hosp., Paris, France

Purpose: Background: Kellgren-Lawrence (KL) radiographic scale is the most widely used tool altogether to define OA, to assess OA severity and to follow-up radiographic progression. Both the exact definition used for grading and the inter- and intra-observer reproducibility have been questioned in knee OA. Although widely used for case-definition, its reliability has never been studied in HOA.

Objectives: To study the cross-sectional inter- and intra observer reproducibility of KL radiographic grading in HOA.

Methods: Radiographs: 20 postero-anterior radiographs of both hands of HOA patients (covering radiographic spectrum of the disease) obtained at random from an ongoing clinical trial. **Reading sessions:** Radiographs were numbered from 1 to 20 at random for each reading session. Only one hand was scored (right or left). Magnification of joint images was allowed and noted, when used. 10 experienced readers (assistant/professors in rheumatology) read twice the 20 X-rays at a minimum interval of 15 days. They were instructed to score the KL method (grades: 0 to 4), using the KL score as detailed by Kallman [1], and their own view of the definition of KL grades. No preliminary training session was organised. During 1st session they also scored joint space narrowing (JSN) and osteophytes (Ost) (0-4). **Joints examined:** distal interphalangeal (DIP), proximal interphalangeal (PIP), metacarpophalangeal (MCP), scapho-trapezial and trapeziometacarpal



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joints (total: 16 joints) were scored. *Statistics:* Intra-class correlation coefficient with 95% confidence interval (CI) for both inter- and intra-observer precision; Bland-Altman graphical method for the intra-observer precision.

Results: Inter-observer reproducibility was moderate (table), but improved at 2nd reading. Intra-observer was good for most readers but highly variable according to the reader (very good for 3 readers, fair for 6 and bad for 1). The less reproducible joints groups were MCPs, then thumb base joints. Surprisingly osteophytes accounted for slightly less weight than JSN (42% vs 58%).

Table 1. Inter- and Intra-observer reproducibility of KL grading in HOA

	ICC	95% CI
Inter-observer reproducibility 1st reading		
Total Ost score (0-64)	0.55	0.36-0.72
Total JSN score (0-64)	0.57	0.38-0.74
Total Kellgren-Lawrence score (0-64)	0.50	0.26-0.69
Inter 2nd reading:		
Total Kellgren-Lawrence score (0-64)	0.60	0.36-0.77
Intra-observer reproducibility		
Reader 1	0.91	0.72-0.96
Reader 2	0.74	0.47-0.89
Reader 3	0.89	0.68-0.96
Reader 4	0.98	0.93-0.99
Reader 5	0.85	0.44-0.96
Reader 6	0.74	0.45-0.90
Reader 7	0.85	0.70-0.93
Reader 8	0.83	0.67-0.92
Reader 9	0.84	0.59-0.95
Reader 10	0.39	0.15-0.64

Conclusions: Whereas intra-observer precision is high for most readers, inter-reproducibility of KL radiological grading in HOA is poor. A KL scoring aid system should be designed in order to improve the inter-reproducibility.

Disclosure of Interest: None to declare

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References

[1] Kallman et al. AR 1989;32:1584-91.

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ULTRASONOGRAPHY FOR THE INITIAL EVALUATION OF KNEE PAIN TO DIAGNOSE OA

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Purpose: Ultrasound has become a common tool in rheumatology, largely because it is safer, faster, more cost effective and less anxiety-producing than other types of imaging including MRI. While utilized more frequently in the inflammatory arthritides and soft tissue syndromes, many have raised its potential role as a research biomarker and a clinical tool in osteoarthritis (OA). While sonographers are still developing a standardized scoring system, a key component is gray scale imaging to evaluate both osteophytes and wear of the femoral articular cartilage. Our hypothesis is that an initial clinic or bedside ultrasound screen of a patient with knee pain can quickly estimate the presence and degree of knee OA that would otherwise be determined by plain radiography.

Methods: We performed sonography on 29 randomly-selected OA patients (ages 43-79, BMI 22-35) and 4 healthy controls (ages 37-48) from our department's NIH-funded study cohort of knee OA. All of the patients had qualified for study entry with chronic knee pain by ACR criteria and a Kellgren-Lawrence (KL) radiography score of at least 1; the healthy controls' radiographs showed a KL score of zero. The knee ultrasounds were performed within 6 months after the qualifying xray, specifically using gray-

scale imaging to view defects of the femoral articular cartilage (transverse suprapatellar view), as well as osteophytes (longitudinal views at the medial and lateral femoral-tibial joints). We blindly evaluated each patient's images without knowing the name or KL score; the articular cartilage wear was graded from 0 to 4, and the osteophytes were evaluated on the same scale, with an average of these two scores providing an end ultrasound score between 0 and 4. We grouped these ultrasound data and calculated average ultrasound scores for each subcohort of patients by KL grade.

Results: We found a consistently increasing average ultrasound score for each KL-based group. The average ultrasound score for healthy controls with a KL score of zero (n=4) was 0.25 (on a scale of 0 to 4). The group with a KL score of 1 (n=3) averaged an ultrasound score of 1.6. Of the patients with a KL score of 2 (n=12), the average ultrasound score was 2.21. Those with a KL score of 3 (n=11) averaged 2.36, and the group with a KL of 4 (n=2) averaged 3.0. Overall, the correlation coefficient between the KL scores and our ultrasound scores was $R=0.7229$, and $R^2=0.5227$ (Figure 1). We did not find any significant trend of the ultrasound scores in the 28 patients by age or body mass index. Incidentally, we found two patients with extensive synovitis, and two with chondrocalcinosis in the articular cartilage, both of which have been reported in the literature.

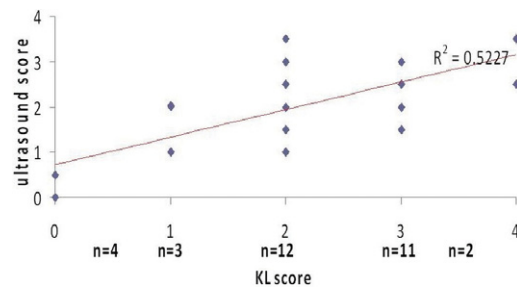


Figure 1. Correlation of KL and Ultrasound Scores (note more than one patients for some data points).

Conclusions: This pilot cohort suggests that ultrasound gray scale scoring of the femoral articular cartilage and femoral-tibial osteophytes provides an accurate estimate of radiographic KL scores. If performed at the clinic or bedside on a patient with knee pain before obtaining xrays, ultrasound could provide physicians with helpful information in diagnosing or excluding OA.

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A COMPARISON OF T2 MAPPING SEQUENCES AT 1.5 TESLA FOR USE IN A CLINICAL TRIAL

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Purpose: The purpose of this study is to compare and assess the different MR imaging sequences available for T2 mapping on a 1.5T magnet for use within a clinical trial.

Methods: A study was carried out using a phantom containing 70 vials with varying concentrations of copper sulfate to provide a wide variety T2 decay times. Eight spin echo sequences were obtained with varying echo times (TR=1500, TE=10, 20, 30, 40, 50, 60, 80, 100ms, FOV=38cm, matrix=256x256, thickness=3.5mm) and the T2 values within each vial was calculated. These values were taken to be the ground truth values. This technique would be impractical in a clinical trial as each series took over six minutes to collect. Due to hardware and software limitations of many imaging systems, it is often impossible to obtain more than four spin echoes in a multi-echo spin-echo sequence. In addition, many hardware and software combinations are not able