for K/L 3, and 38 (3.2%) for K/L 4. MME was observed in 1,188 among 1,191 subjects (99.7%, average 4.3 ± 2.0 mm), while the medial tibial osteophyte was also observed in 1190 among 1,191 subjects (99.9%, average 4.1 ± 1.9 mm). MME was associated with cartilage lesions score ($r = 0.409$, $p < 0.01$), subarticular bone attrition ($r = 0.352$, $p < 0.01$), subarticular cysts ($r = 0.285$, $p < 0.01$), marginal osteophyte score ($r = 0.631$, $p < 0.01$), meniscus lesions score ($r = 0.317$, $p < 0.01$), medial tibial osteophyte width ($r = 0.923$, $p < 0.01$). Interclass correlation coefficient (ICC) was 0.95 (95%CI: 0.954-0.963) between MME and the medial tibial osteophyte width. In multiple regression analysis demonstrated that the factor which was most associated with MME was medial tibial osteophyte width ($\beta = 0.867$, $p < 0.01$, adjusted age, sex and BMI).
Conclusions: MME was strongly associated with the medial tibial osteophyte width.

423
COMPARISON OF RADIOGRAPHY, 3T AND 7T MAGNETIC RESONANCE IMAGING FOR ANALYSIS OF DISTAL RADIUS TRABECULAR BONE IN PATIENTS WITH ESTABLISHED OR SUSPECTED WRIST OSTEOARTHRITIS USING FRACTAL SIGNATURE ANALYSIS

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Purpose: The fractal dimension (FD) or signature of cancellous bone takes into account its composite nature, which is determined principally by trabecular number, spacing, and cross-connectivity. In the knee, fractal signature analysis (FSA) has been reported to predict structural outcomes such as radiographic osteoarthritis (OA) progression and total joint replacement. In patients with rheumatoid arthritis, lower FSA scores along the vertical trabeculae of the distal radius were reported to correlate with bone loss in those with increasing radiographic severity. While FSA has the potential to be applied to a larger clinical population as a prognostic tool, its applicability in a routine clinical environment needs to be further explored. For instance, data on FSA of the wrist in OA or pre-OA remains sparse, particularly using magnetic resonance imaging (MRI). High resolution MRI of the wrist is often applied to determine degree and location of structural damage helping in treatment decisions for further management (conservative versus surgical). The potential of MRI-depicted trabecular bone texture as a predictive instrument of treatment outcomes is much less understood. Given its high tissue contrast and superior spatial resolution, 7T ultra-high field MRI may play a role in assessing trabecular bone in this context. However, to date, the comparability of 7T extracted bone structure parameters with more standard measures such as 3T MRI or radiography has not been established. The aim of this study is to compare FSA parameters extracted by different imaging modalities, including radiography, 3T and 7T magnetic resonance (MR) imaging.
Methods: 25 patients with chronic wrist pain (no history of trauma within the last 6 months) referred for outpatient consultation at a tertiary referral center for hand surgery with suspected or confirmed osteoarthritis and/or ligament instability were included (mean age 39.2 ± 15.9, 44 % female). All patients had both a 3T and 7T MRI examination of the wrist, and 23 patients had radiographs. Examinations were performed on clinical 3T (Siemens Magnetom Vida,Erlangen, Germany) and 7T Systems (Siemens Magnetom Terra, Erlangen, Germany). Both MR examinations included coronal T1 spoiled 3D GRE, Volumetric Interpolated Breath-hold Examination (VIBE), and T1 TSE images. 7T examinations included 2 different coronal T1 TSE sequences with variable TE and TR: T1 TSE fast (slice thickness: 2mm, TE: 8.9, TR: 874 ms) and T1 TSE High Res (slice thickness 2mm, TE: 13, TR: 1200 ms). T1 VIBE images were not available in 9 participants for the 3T examinations, and in 1 participant for the 7T examination. 7T T1 TSE fast images were not available in 5 participants. For each imaging modality, regions of interest (ROIs) were created in the distal radius, on a single slice based on 2 manually placed landmarks (Figure 1). FD was calculated for horizontal and vertical structures. We compared those parameters for all available modalities using linear regression and Pearson's correlation coefficient (r) as a measure of correlation.
Results: The Pearson's r coefficients for vertical and horizontal dimensions are presented in Table 1. The Pearson's r were variable across comparisons. We found the highest correlation for vertical FSA dimensions between 7T T1-TSE fast and 7T T1 TSE high res MR images (Pearson's r of 0.63), and the highest correlation for horizontal FSA dimensions between radiography and 7T T1 3D vibe MR images (Pearson's r of 0.56). Overall comparisons for vertical FSA dimensions between 7T T1 VIBE and other modalities were consistently low. Radiography was found to correlate best with 7T T1 VIBE along the horizontal direction (0.56) and with 7T T1 TSE High Res along the vertical direction (0.42).
Conclusions: FSA measures obtained from MRI (3T and 7T) appear to be highly dependent on sequence used and thus, not easily comparable between MRI systems and applied sequences. We found moderate to high correlations for some comparisons. Overall, however, interpretability of structural bone parameters based on the different methodologies is challenging and needs further standardization. However, the small number of participants, and the variable number of participants for the different comparisons are limitations of this study. Future work with more highly powered studies and additional study of the ROI placement are needed to shed more light on this subject.

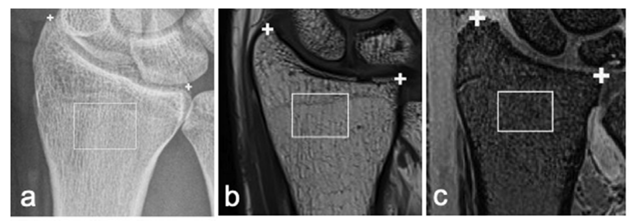

Figure 1: Examples of region of interest (ROI) placement on radiography (a), T1-TSE (b) and T1-VIBE (c) coronal MR images. The ROIs are automatically generated after manual placement of 2 points consisting of the distal radial styloid and the ulnar/distalmost aspect of the radius.

Table 1: Pearson's r values for horizontal (white background cells) and vertical (grey background cells) structures comparing fractal dimensions (FD) between the available radiographic and MR modalities. For each comparison the number of subjects is presented between parentheses.

	Radiography	3T - T1 TSE	7T - T1 TSE – fast	7T – T1 TSE – HighRes	3T – T1 Vibe	7T – T1 Vibe
Radiography		0.21 (23)	0.06 (18)	-0.18 (23)	0.15 (15)	0.56 (22)
3T – T1 TSE	0.33 (23)		0.50 (20)	0.33 (25)	0.53 (16)	0.28 (24)
7T – T1 TSE – fast	0.38 (18)	0.45 (20)		0.34 (20)	0.46 (13)	0.43 (20)
7T – T1 TSE – HighRes	0.42 (23)	0.46 (25)	0.63 (20)		-0.10 (16)	-0.10 (24)
3T – T1 Vibe	-0.26 (15)	-0.18 (16)	0.44 (13)	0.35 (16)		0.20 (16)
7T – T1 Vibe	0.14 (22)	-0.04 (24)	0.18 (20)	0.09 (24)	0.13 (16)	

VIBE: Volumetric Interpolated Breath-hold Examination / Spoiled 3D GRE
T1-TSE fast: slice thickness: 2mm, TE: 8.9, TR: 874 ms
T1 TSE High-Res: slice thickness 2mm, TE: 13, TR: 1200 ms

424
ULTRASOUND-BASED CARTILAGE OUTCOMES DIFFERENTIATE HEALTHY AND MEDIAL FEMORAL CARTILAGE DAMAGE AFTER ANTERIOR CRUCIATE LIGAMENT INJURY: A PRELIMINARY INVESTIGATION

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Purpose: Ultrasound imaging is a clinically feasible tool to assess femoral articular cartilage following acute knee injuries. Previous studies have validated an ultrasound assessment of femoral cartilage thickness. However, traditional ultrasound cartilage thickness assessments rely on a single straight-line distance and do not determine the mean thickness throughout a cartilage region. Further, it is unknown whether ultrasound echo-intensity (i.e., magnitude and variation of the pixel signal intensity) is related to cartilage damage following anterior cruciate ligament injury. Therefore, we aimed to provide preliminary evidence for the construct validity of quantitative ultrasound-based cartilage outcomes versus an established arthroscopic cartilage grading system.
Methods: We recruited individuals between 18 and 35 years of age with a primary unilateral ACL injury at a pre-operative visit with an orthopaedic surgeon. Participants were excluded if they had a history of lower extremity surgery, injured either knee within the last 6 months (other than ACL injury), or previously been diagnosed with any form of arthritis. With the knee in maximal knee flexion, a transverse

suprapatellar ultrasound assessment was used to image the femoral cartilage in the individual's injured knee within a week before their scheduled ACL reconstruction. Three images were recorded and a single reader manually segmented the total femoral cartilage cross-sectional area of each image. A custom program automatically separated the cartilage segmentation into standardized medial and lateral femoral condyle regions (Figure). This program calculated the following cartilage outcomes in each region and averaged over the three images: 1) mean cartilage thickness (calculated by dividing the cartilage cross-sectional area by the cartilage length; $ICC_{2,k}$ =0.99), 2) echo-intensity mean (average grey-scale pixel value ranging from 0 - 255; $ICC_{2,k}$ =0.99), and 3) echo-intensity standard deviation (variation of the pixel intensity within the region; $ICC_{2,k}$ =0.94 - 0.97). An experienced orthopaedic surgeon with a sub-specialty in sports medicine prospectively graded the medial and femoral condyle using the Outerbridge grading system at the time of ACL reconstruction. We created a dichotomous cartilage damage variable based on the Outerbridge score: 1) normal cartilage: Outerbridge = 0; 2) cartilage damage: Outerbridge $\geq$1 (i.e., Outerbridge 1 = cartilage softening and swelling). We performed independent samples t-tests to compare the mean cartilage thickness, echo-intensity mean, and echo-intensity standard deviation between individuals with and without evidence of arthroscopic cartilage damage. Effect sizes with 95% confidence intervals were also used to identify the magnitude of difference between the groups.

Results: The twenty-five participants were primarily female (n=16), with an average height of 174 ± 10 cm, an average mass of 76.5 ± 15.3 kg, 24 ± 5 years old, and an average time of 49 ± 51 days since ACL injury. The average maximal knee flexion angle was 127 ± 12 degrees. In the medial femoral condyle, echo-intensity mean and standard deviation are greater in individuals with normal cartilage compared to those with cartilage damage (Table). In the lateral femoral condyle, there are no differences between cartilage ultrasound outcomes between individuals with and without arthroscopic cartilage damage.

Conclusions: Prior to ACL reconstruction, an ultrasound assessment detects hypo-intense and less heterogeneous medial femoral cartilage in individuals with arthroscopically identified medial femoral cartilage damage. Future studies are needed to confirm that cartilage echo-intensity mean and standard deviation is an accurate measure of cartilage damage related to a magnetic resonance based measure of cartilage composition.

Figure. Standardized Femoral Cartilage Segmentation. We used a custom program to take an overall cartilage manual segmentation (A), and use a standardized method to automatically separate the cartilage (B). This abstract focused on cartilage in the medial and lateral regions. The custom program calculated the mean cartilage thickness by dividing the regional cartilage cross-sectional area (B) by the regional cartilage length (C).

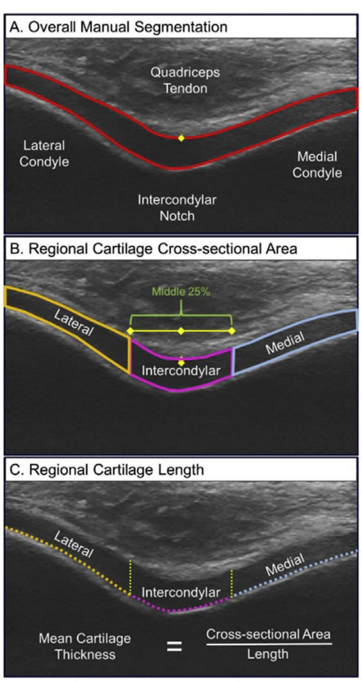

Table. Comparison of Femoral Cartilage Ultrasound Outcomes between individuals with and without Arthroscopic Cartilage Damage. SD = standard deviation. 95% CI = 95% confidence intervals.

Cartilage Outcomes	Normal (n=13)	Cartilage Damage (n=12)	t (p-value)	Effect Size (95% CI)
MEDIAL FEMORAL CONDYLE				
Mean Thickness (mm)	1.99 ± 0.34	2.22 ± 0.38	-1.56 (0.132)	-0.62 (-1.42 - 0.18)
Echo-intensity mean (0-255)	78.80 ± 6.87	71.64 ± 4.64	3.02 (0.006)	1.17 (0.32 – 2.02)
Echo-intensity SD (0-255)	10.29 ± 2.09	8.08 ± 0.97	3.35 (0.003)	1.29 (0.43 – 2.16)
LATERAL FEMORAL CONDYLE				
Cartilage Outcomes	Normal (n=12)	Cartilage Damage (n=13)	t (p-value)	Effect Size
Mean Thickness (mm)	1.94 ± 0.31	1.83 ± 0.27	0.95 (0.350)	0.37 (-0.42 - 1.16)
Echo-intensity mean (0-255)	72.85 ± 7.81	76.12 ± 5.11	-1.25 (0.225)	-0.48 (-1.28 – 0.31)
Echo-intensity SD (0-255)	8.48 ± 0.98	8.79 ± 1.43	-0.63 (0.534)	-0.24 (-1.03 – 0.54)

425
LOCATION AND TIMING OF THE FIRST OSTEOPHYTE AFTER ARTHROSCOPIC KNEE SURGERIES

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Purpose: Preventing disease development and/or progression of osteoarthritis of the knee (KOA) has been sought from standpoint of not only social welfare but also social economy. Due to rapid progression of aging society the requirement is growing worldwide. Unfortunately effective method is still open to be explored and researchers are straggling to establish it. One possible first step is to achieve this will be to detect initial change of KOA as early as possible. Imaging biomarkers are thought to be suitable for this purpose due to its property to assess only corresponding joint without being affected by systemic changes. And MRI has been thought to be ideal modality and several imaging technique to detect subtle changes of cartilage have been developed and advocated. But time and cost are big blemish that MRI demands. Alternatively we tried to find possible imaging biomarker that could be detected with x-ray as modality because it will enable mas screening of population. For this purpose in mind we examined MRI data of OAI and found that osteophytes (OPs) formed at several sites in the knee joint worked as possible predictive biomarker for radiographic KOA development. Among them incidence of OP formation at posterior condylar notch of the femur was dominant. Considering the location of the OP we named it as hidden OP on plain x-ray (HOPX) first but later we found it was detectable with tunnel view radiography. In the present paper we investigated the timing of HOPX formation after knee joint surgery (ACL reconstruction or meniscectomy) with tunnel view and compared other OPs detected with anteroposterior (AP), lateral, skyline view retrospectively. The hypothesis of the study is HOPX formation precedes other OPs.

Methods: Included in the study were 1) those who had pre-operative four-directional x-rays of the knee (comprising anteroposterior (AP), lateral, skyline, and tunnel views) were available; 2) those who received arthroscopic meniscectomy due to symptomatic meniscal injuries or arthroscopic ACL reconstruction due to instability of the knee; 3) no OP formation observable on the x-rays at the time of surgery; 4) follow-up x-rays comprising four-directional x-rays available on a regular basis (every 6 months or every year); and 5) availability of more than three-year follow-up x-rays. Two orthopedic surgeons served as examiners and assessed the knees on the 0-3 scale reported by Altman et al. for the existence of OP from x-rays. A score of 1 or more was regarded as positive for OPs. Time and location of first OP emergence were recorded and HOPX and other sites were compared.

Results: Total of 57 knees were identified (29 meniscectomized knees and 28 ACL reconstructed knees). Average of the subjects were 19.2 years old (12.6 y/o for meniscectomized knees and 25.8 y/o for ACL reconstruction). Average follow up period was 4.4 year. The first OP observed at an average of 3.1 year after arthroscopic surgery. Twenty-four knees (24/57: 42%) exhibited OP formation in the observed period. Isolated OP was detected in posterior condylar notch (HOPX) in 18 knees (18/24: 75%) isolated other sites in 3 knees. Concomitant OP formation was observed in 3 knees where HOPX and lateral tibial plateau OP in lateral meniscectomized knees. Thus in 21 knees (21/24: 87.5%) HOPX was the possible first OP in the knee joint.

Conclusions: In this paper, we reported HOPX was the mostly first OP if ever observed at relatively high percentage after knee surgeries. Although in some knees other sites exhibited OP earlier than HOPX, possible usefulness that HOPX had as a predictive biomarker was