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RAPID 3D-T_1 MAPPING OF CARTILAGE WITH PARALLEL IMAGING AT 3.0T

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Purpose: The objective of this work was to rapidly acquire T_1-weighted images using a three-dimensional fast low angle shot (3D FLASH) sequence in combination with generalized auto-calibrating partially parallel acquisitions (GRAPPA) and variable-flip-angle (VFA) method at 3.0T.

Methods: 3D T_1 maps of model systems (Gd and agarose phantoms), bovine cartilage, and human subjects were constructed on a 3.0T clinical whole body MR scanner (Magnetom Tim Trio, Siemens Medical Solutions, Erlangen, Germany) employing a phased-array (PA) knee coil (18 cm diameter, 8-channel transmit/receive). The T_1 values of model systems measured using the 2D inversion-recovery fast-spin-echo (IR-FSE) sequence were considered as reference method to validate the rapid 3D method for comparison. Then the rapid 3D-T_1 mapping method was applied to 3 healthy (n=3 males, mean age =26 years) and 2 clinically diagnosed OA subjects (1 male, 1 female, mean age 50 years). Global and regional T_1 of patellar, femoral and tibial cartilage were analyzed and compared with that of conventional reference method (without parallel imaging). Total scan time to acquire a whole knee joint (FOV=13cm, NEX=2, slices=112; TR/TE=15ms/6.5ms) with 0.7mm^3 isotropic resolution was ~5 minutes with parallel imaging (acceleration factor 2). The reproducibility of the rapid 3D-T_1 maps was quantified using coefficient of variation (CV) and a non-parametric rank test (Wilcoxon signed rank test) to determine whether there were any statistically significant differences between median T_1 with different acquisition schemes.

Results: 3D-T_1 maps of the phantom were constructed using PA-coil with iPAT1, iPAT2, iPAT3, and iPAT4. CV of the median T_1 of the phantom across different acquisition methods was 6.22%. The standard deviation of the median T_1 of femoral, tibial, patellar cartilages, and the average across different acquisition schemes was observed to be between 14.65-45.58ms, 42.84-72.73ms, 85.64-108.73ms, and 38.54-70.04ms respectively across the subjects. RMS-CV of median T_1 of femoral, tibial, patellar cartilages, and the average among the subjects was between 7.51-9.85, 7.25-9.90, 8.20-11.09, and 7.61-8.50 respectively. The differences between the median T_1 acquired with different methods were statistically insignificant for all the analyzed cartilages (P 0.34). However, there is a statistically significant difference with contrast agent injection (P<0.05). In current study, rapid 3D-T_1 mapping with VFA and parallel imaging with different acceleration factors (AFs 1, 2, 3, and 4) seems to have no obvious influence on the T_1 mapping (before and after contrast agent administration).

Conclusions: The preliminary results demonstrate that the rapid 3D-T_1 mapping obtained using VFA with parallel imaging are highly reproducible in an agarose phantom and in human knee joint *in vivo*. It is possible to quantify 3D-T_1 mapping of whole knee joint (with 0.7mm^3 isotropic resolution) under ~5 minutes with excellent *in vivo* reproducibility at 3.0T.

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REPRODUCIBILITY AND LONGITUDINAL CHANGE IN THE ANATOMIC-AXIS ANGLE IN KNEE RADIOGRAPHS: IMPLICATIONS FOR RELATING PROGRESSIVE MALALIGNMENT TO JOINT SPACE NARROWING IN KNEE OSTEOARTHRITIS

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Purpose: Varus-valgus malalignment of the lower extremity, for which the gold-standard metric is the mechanical-axis angle measured in a long-limb radiograph, is a potent risk factor for progression of knee osteoarthritis (OA). Recent evidence suggests that the anatomic-axis angle (AAA), measured in a knee radiograph, is a valid baseline indicator of the risk of progression of OA posed by malalignment. However, the lack of information on the reproducibility of AAA in repeat examinations has precluded our ability to distinguish longitudinal change in the AAA, which may reflect structural progression of knee OA, from measurement error. Accordingly, we conducted a pilot study to examine the reproducibility of AAA in repeat examinations and the association between changes in AAA and joint space narrowing (JSN) in patients with knee OA.

Methods: Subjects were 35 adults [64% female, 90% white, 51% with BMI >30] with Kellgren and Lawrence (K&L) grade 2-3 OA in one or both knees (70 total knees, 47 with K&L grade 2-3 OA). Each subject underwent x-ray examination of both knees according to standardized positioning procedures for the fluoroscopically assisted semiflexed AP (SF-AP) view [1] and the non-fluoroscopic PA metatarsophalangeal (MTP) view [2]. The MTP exam was repeated within 1 hr. Follow-up exams by both protocols occurred 14 months later. Minimum medial tibiofemoral joint space width was measured manually with a screw-adjustable calipers and graduated magnification loupe. AAA was measured medially by goniometer, as described by Kraus et al [3].

Results: In only 3 of 70 knees did the AAA in the repeat baseline MTP views differ by more than 1° [intraclass correlation (ICC) = 0.982]. Furthermore, AAA in the MTP view was highly reproducible over the 14-mo follow-up interval (ICC = 0.921), However, among the 47 K&L grade 2-3 knees, 14-mo change in JSW in MTP radiographs was unrelated to the change in AAA over the same interval (see table).

| | 14-mo Change in minimum medial JSW, mm | | | | | |
| | MTP Radiographs | | | SF-AP Radiographs | | |
Change in AAA	Knees	Mean	SD	Knees	Mean	SD
≥2° valgus	8	+0.18	0.98	8	+0.28	0.33
1° valgus	8	+0.25	0.73	7	-0.13	0.30
0°	15	-0.01	0.68	16	-0.21	0.58
1° varus	9	+0.28	0.41	14	-0.11	0.39
≥2°	7	0.00	0.42	2	n/a	

AAA measurements in concurrent SF-AP and MTP radiographs were only moderately correlated (r = 0.552). In addition, the ICC for angle measurements in serial SF-AP views (0.597) suggests that AAA is more variable over time in this view than in the MTP radiograph. However, as shown in the table, K&L grade 2-3 OA knees in which the AAA became more valgus (≥2°) in the serial SF-AP views (N=8) exhibited an *increase* in mean JSW, compared to an overall loss of JSW in SF-AP views of all other OA knees (P<0.05).

Conclusions: Values for AAAs measured in radiographs obtained by different protocols for standardizing the position of the knee are not interchangeable. The MTP protocol, for which positioning standards emphasize knee flexion and rotation, yields a highly reproducible measurement of AAA. However, the utility of this marker of malalignment for explaining OA progression may