Intra- and inter-scanner variability of knee cartilage T2 in human knees at 3.0T: a multivendor comparision study

S. Balamoody[1], C. E. Hutchinson[1], J. C. Waterton[1,2], T. G. Williams[1], M. Bowes[3], and R. Hodgson[4]

[1]ISBE, University of Manchester, Manchester, United Kingdom, [2]AstraZeneca, Alderly Edge, Cheshire, United Kingdom, [3]Imorphics, Manchester, United Kingdom, [4]MARIARC, University of Liverpool, Liverpool, United Kingdom

Introduction: MR imaging can provide biomarkers of cartilage quality in Osteoarthritis (OA). Previous studies have shown that hyaline cartilage transverse relaxation time T2 is sensitive to changes in cartilage hydration and collagen fibril microstructure. The National Institute of Health Osteoarthritis Initiative (NIH OAI) is 5-year study (N= 4796) investigating imaging biomarkers of OA; T2 is the only MRI marker of cartilage quality being studied. The NIH OAI study is conducted on 4 Siemens 3.0T scanners. The ability to conduct multicentre and multivendor trials would have the potential for reducing study time and cost by facilitating patient recruitment and throughput. Philips Medical Systems and GE Healthcare also manufacture 3.0T scanners. The study aim is to determine whether cartilage T2 values are comparable between the different vendors at 3.0T.

Method: *Data Acquisition:* 12 subjects (9 male, 3 female) with symptoms of knee OA had their most symptomatic knee scanned on each of 3 vendors' 3.0T scanners. Mean age was 49.3±10 years (range 32-59y); mean BMI 28.3 ±6.2 kg/m^2 (22.1-44.2Kg/m^2); subjects had one or more risk factors for OA. The three systems used are located in the UK: Manchester (Philips), York (GE), Liverpool (Siemens). The OAI study protocol was used for the Siemens platform. With collaboration from Philips and GE, OAI-equivalent protocols were optimised for the respective platforms. The T2 map sequence used was a multi-slice multi-echo (MSME) sequence (7 echoes for Siemens and Philips, 8 echoes for GE) – sequence parameters as in [1]. Subjects were non-weight-bearing for 30 minutes prior to each scan. The RF knee coils used were transmit-receive (GE), receive-only (Siemens) and 8-channel phased-array (Philips). Test-retest reproducibility data were obtained using 5 subjects on the Philips scanner only (one subject's patella values were excluded due to image artefact). A phantom with 12 test tubes of different T2 values was also scanned at the three sites (previously presented [1]).
Image Analysis- Manual cartilage segmentation of the first TE images from the MSME sequence was performed by a single observer blind to subject identity using proprietary software (Endpoint, Imorphics Ltd. Manchester, UK). To avoid partial volume effects, only voxels wholly contained within the segmentation were included in the analysis. Transverse relaxation rate (R2) values were obtained by plotting the log of the signal values to the corresponding TE values with a mono-exponential linear least squares fit, neglecting Rician noise bias. Statistical calculations were performed using R2 values and inverted to obtain T2 values for presentation.
Statistical analysis- Variability was assessed using the root-mean-squared Coefficient of Variation (RMS COV) and bias assessed by Bland-Altman Analysis and 2-sided paired t-tests.

Results:

Region	Scanner pair	R2 RMS COV	T2 Mean Difference (ms)	T2 SD (ms)	95% CI (ms) lower bound	95% CI (ms) upper bound	Paired t-test p-value
Femur	S vs P	5.5%	-2.8	2.6	-7.9	2.3	0.003
	S vs. G	16.0%	-10.0	2.4	-14.6	-5.3	0.000
	P vs. G	12.2%	-7.1	2.7	-12.4	-1.9	0.000
Medial Tibia	S vs P	4.2%	-1.2	2.3	-5.7	3.3	0.095*
	S vs. G	11.5%	5.4	2.7	0.2	10.7	0.000
	P vs. G	13.4%	6.6	2.8	1.1	12.2	0.000
Lateral Tibia	S vs P	8.6%	2.8	4.3	-5.6	11.2	0.045
	S vs. G	12.6%	5.9	3.2	-0.4	12.2	0.000
	P vs. G	17.5%	8.7	3.4	2.0	15.3	0.000
Patella	S vs P	4.8%	-0.8	3.0	-6.7	5.0	0.355*
	S vs. G	18.1%	-8.7	5.3	-19.0	1.6	0.000
	P vs. G	16.1%	-7.8	4.0	-15.7	0.0	0.000

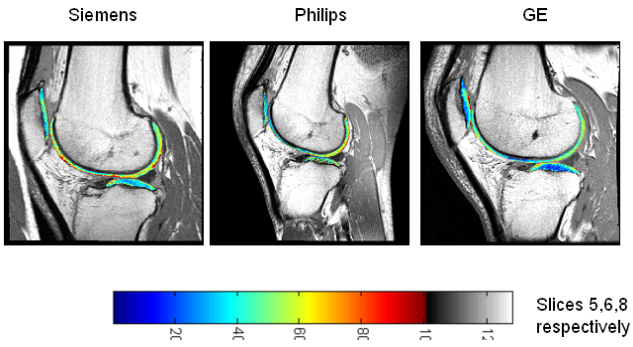

Figure 1: (above) Example of cartilage T2 map overlayed on 1st TE of MSME sequence. Slice taken from same volunteer in similar slice location on all three scanners.
Table 1: (left) Scanner pair comparisons. R2 RMS COVs and mean difference with 95% upper and lower confidence limits obtained by Bland-Altman analysis. P=Philips, S=Siemens, G=GE.

Phantom data showed Philips data overestimated T2 while GE data was accurate. In knees, Philips intra-scanner R2 RMS COVs were <3% (intra-session) and 3.2-6.3% (inter-session) for all regions. Inter-scanner knee R2 RMS COVs for Philips vs. Siemens were similar to the Philips intra-scanner inter-session values. GE knee T2 values were systematically lower compared to the other scanners.

Discussion: This is the first study to investigate differences in cartilage T2 mapping between scanners of different vendors at 3.0T. In vivo cartilage T2 analysis poses many challenges which limit accuracy and reproducibility of measurements, e.g. stimulated echoes, magnetisation transfer, partial volume. Inter-scanner precision errors can be comparable to intra-scanner precision, however, significant inter-scanner differences can also exist. Moreover, in this study the knee T2 differences were not predicted from the phantom data. Such differences should be investigated prior to undertaking a multivendor T2 study.

Acknowlegments: C. Bos (Philips Medical Systems), S. Dezonie (GE Healthcare), G. Green (YNIC, York). L. Gregory (TIU, Manchester), and AstraZeneca (Cheshire) for financial support, Imorphics (Manchester) for image analysis.
References: 1. Balamoody S., Hutchinson C.E., Waterton J.C. et al, "Intra- and inter-scanner variability of T2 mapping at 3.0T: a multivendor study", ISMRM British Chapter, 2007.