Topographical Variation of T2 Relaxation Time in Adult Knee Cartilage at 1.5T

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INTRODUCTION

The topographical variation in T2 relaxation time of normal articular cartilage in different knee segments *in vivo* has not been reported before. T2 has previously been related to the integrity [1] and arrangement [2] of the collagen network, collagen [3] and water content [4], as well as to mechanical properties of cartilage [5]. The biochemical and biomechanical properties of articular cartilage varies in different location of the knee joint [6], thus it is essential to explore the range of normal variation of cartilage MRI parameters, such as T2 relaxation time.

MATERIALS AND METHODS

Ten males and ten females (age 21-27 years, mean 22.5) were enrolled to the study and informed consent was obtained. One asymptomatic knee per subject was imaged at 1.5T (GE Signa TwinSpeed 1.5 T, GE Healthcare, Milwaukee, WI) using a transmit/receive knee coil. Both axial and sagittal multi-slice multi-echo spin echo measurements with an improved slice profile (TR/TE=1000/10-80ms, ETL=8, FOV=140x105mm, 256×192 matrix, 3mm slice thickness) were performed to determine the T2 relaxation time. A workstation (Advantage Windows 4.0, GE Healthcare, Milwaukee, WI) with GE Functool software was used to calculate T2 relaxation maps.

Central sagittal slices of the medial and lateral tibiofemoral joint as well as medial and lateral patellar facets (sagittal) and superior and inferior halves (axial) of patellae were chosen for T2 analysis. The cartilage surfaces were divided into 24 segments for ROI analysis, and each segment was divided into deep and superficial zones of approximately equal thickness. The nomenclature as proposed by Eckstein et al. (2006) was used after modifications [7] (Fig. 1).

Statistical analysis of T2 values was performed with SPSS software. The Mann-Whitney test was used to test the differences between genders and the Wilcoxon test for the other analyses. Additionally, the Friedman post hoc test was used for comparing different segments within a condyle. A p-value of less than 0.05 was considered as an indication of statistical significance.

RESULTS

T2 values were measured from altogether 466 segments. In four subjects part of the anterior segments could not be analysed because of a wrap-around artefact in the sagittal images. The T2 values for different sites are presented in Figure 2. In all segments the T2 values were statistically significantly higher in the superficial zone. There were no difference between T2 values of males and females.

In both the superficial and deep zones, the lateral condyle had statistically significantly higher T2 values in acLF and pcLF segments as compared to acMF and pcMF segments. In the tibial condyles, cMT had significantly higher values as compared to cLT. When the segments within a condyle were compared, the deep and superficial zones separately, significant differences were observed between different sites of the medial femoral condyle (superficial zone: acMF-pcMF and acMF-apMF; deep zone: acMF-apMF, acMF-ppMF and pcMF–apMF; segments mentioned first had lower values). Correspondingly, differences were observed also in the lateral femoral condyle (superficial zone: acLF-alTrF, plTrF-pcLF, acLF-pcLF, acLF-apLF and ppLF-pcLF; deep zone: ppLF-alTrF). In the tibial condyle, a significant difference was found between deep zones of aLT and cLT, the anterior segment having a higher value.

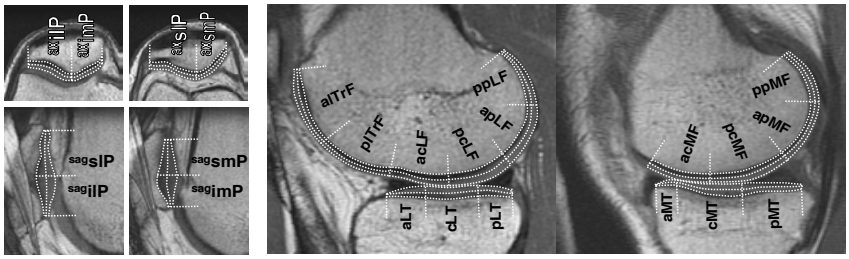

Fig. 1: The division and nomenclature of the cartilage segments. Additional prefixes added to the proposed nomenclature [7] are "a" for anterior, "c" for central, "p" for posterior, "s" for superior, "i" for inferior, "ax" for axial imaging plane and "sag" for sagittal imaging plane.

For patellae, the values of the lateral and the medial as well as the superior and the inferior segments were compared. There was a statistically significant difference between the superior and inferior segment of the medial facet in both deep and superficial zones in both imaging planes, the superior segment having higher values. There was no such difference in the lateral facet or between the medial and lateral facets.

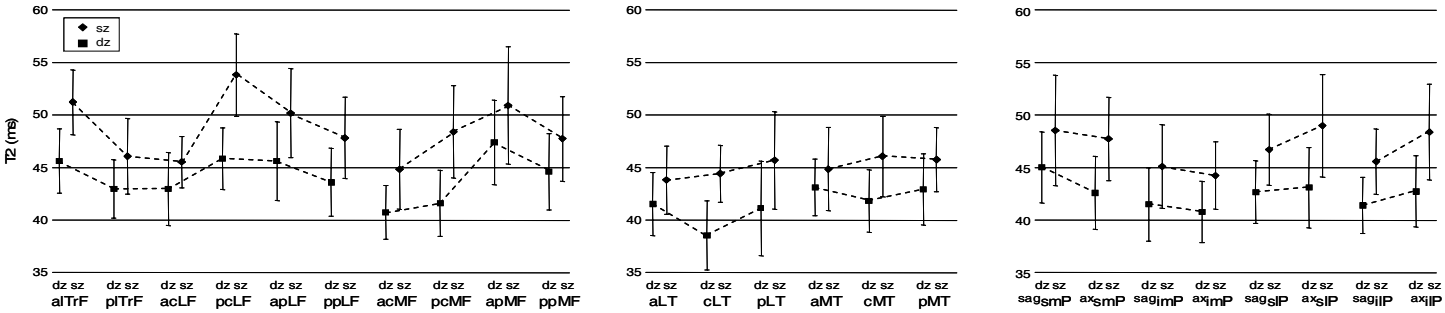

Fig. 2: The T2 values (mean±SD) of the segments analyzed in deep (dz) and superficial zones (sz). The nomenclature is presented in Fig. 1. N=20 except in alTrF, ^{sag}smP and ^{sag}imP (n=18), and ^{sag}slP and ^{sag}ilP (n=16).

DISCUSSION

In this study, the depth-wise and topographical variation of cartilage T2 *in vivo* was assessed. T2 values were significantly higher in the superficial zone as compared to the deep tissue at all locations (10% and 4ms difference on average). This is consistent with previous findings on depth-wise variation of T2 [8]. Significant variation in T2 at different topographical locations was observed, which is consistent with previous findings on the variation in biochemical and biomechanical properties of articular cartilage in different cartilage segments of the knee [6]. The topographical variation shows a trend toward higher T2 values at the load bearing area of the femoral condyles for both deep and superficial zones. This finding can only partly be explained by the magic angle effect, and is likely also related to the different macromolecular composition and structure at different sites.

The considerable depth-wise and topographical variation observed in cartilage T2 at different joint surfaces indicates the need for a comprehensive assessment of different joint locations and cartilage depths for a reliable assessment of T2 of articular cartilage. In a full-thickness or full-joint ROI measurement any anticipated T2 changes may be masked by the normal variation of T2 and thus their use is not recommendable.

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