Does the scanner make a difference? Interscanner variability of tibial cartilage T2 relaxation time – A comparison of three 1.5T and one 3T scanner of one manufacturer

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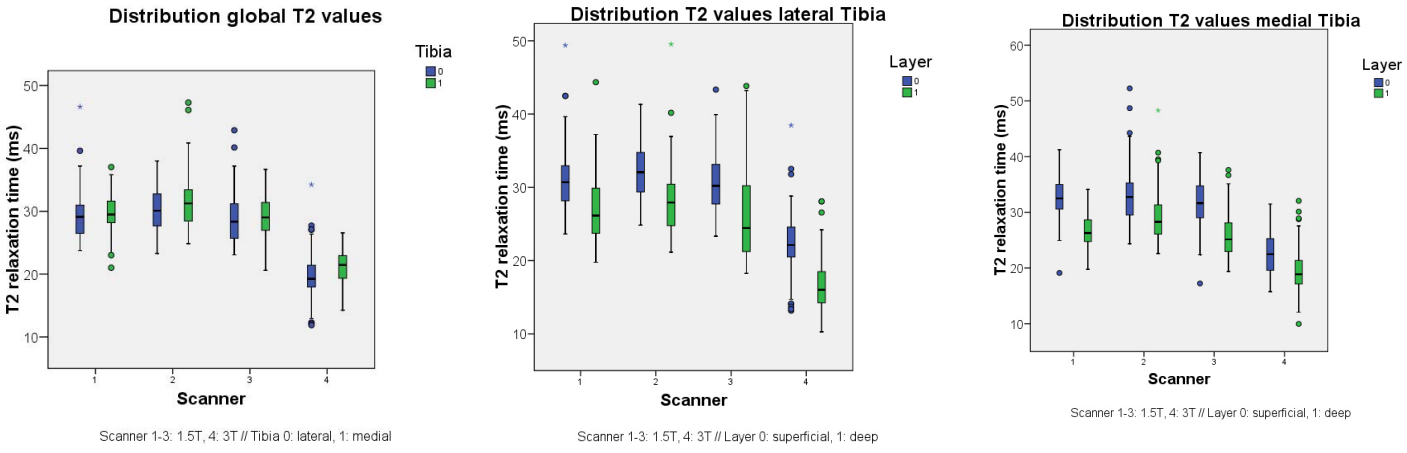
Purpose: T2 relaxation time measurements are increasingly implemented in trials as a quantitative measure for cartilage integrity in cartilage repair and in osteoarthritis (1-3). Currently no data exist in the literature about the variability of T2 measurements between different MRI scanners. However, this may have substantial impact on the sensitivity to change and hence the size of the study population in OA or cartilage repair trials. Therefore the purpose of this study was to evaluate the interscanner variability of T2 in the tibial cartilage between three different 1.5T scanners and a 3T scanner of one manufacturer.

Materials and Methods: The right knees of 12 healthy volunteers were examined in three different 1.5T scanners and a 3T scanner of the same manufacturer consecutively in one session using a coronal T2-w FS multiecho sequence (TR 3000ms/ TE 13.2ms/ 8 echos/ resolution 0.6^2x$3mm^3$). Sequence parameters and gradient strengths were kept identical at 1.5T. TR and TE were adapted at 3T for contrast optimization. Medial and lateral tibial cartilage plates were segmented separately and reconstructed in 3D. A global average T2 value was calculated for the complete cartilage plate (global), and after subdiving the cartilage plate into a superficial and a deep layer, a layer based value was calculated per MR-section (exponential fit). Differences were compared by the Wilcoxon-Test, the variability between 1.5T scanners calculated by the intra- and interindividual standard deviation and the agreement of T2 values was assessed by the interclass correlation coefficient (ICC) (SPSS, $p<0.05$ considered as significant).

Results: Mean global T2 was 28.9-31.4 ms at 1.5T and - as expected - lower values were obtained with 19.7-21.3 ms at 3T (approximately 30% shorter). Mean global differences were 2.2-2.9 ms (1.5T vs 1.5T) and 9.3-10.7 ms (1.5T vs 3T). Layerwise differences were 2.6-5.6 ms (1.5T vs 1.5T) and 6.5-11.5 ms (1.5T vs 3T). The T2 difference between the 1.5T scanners was 28% of the difference between 1.5T and 3T scanners. One 1.5T scanner showed significantly higher T2 for both global and layerwise values. Intraindividual standard deviation for T2 was significant different between the 1.5T scanners (global 2ms (7%), layers 2.7ms (9.4%)), but smaller than the interindividual "biological" variability (similar for both field strength with 2.8-3 ms (8.7-13.6%) global, 3.5-3.7ms (14.5-21.8%) for layers).Global ICC was good (0.67-0.83) between the 1.5T scanners, except for one 1.5T scanner pair with fair results (0.29) for the medial tibia. Layerwise ICC was good to excellent (0.56-0.88) for the superficial layer and moderate to good (0.46-0.8) for the deep layer except for the same 1.5T scanner pair as above with fair results (0.27) for the deep medial tibia.

Conclusion: Significant variability of healthy cartilage T2 within the same individuum can be found when acquiring T2 at different 1.5T scanners from the same manufacturer. A mean T2 variability of 7% for global values and 9.4% for layerwise calculated values have to be expected when comparing datasets from different MR-scanners of one manufacturer. This results in a minimal detectable change ($\sqrt{2}$ x coefficient of variation) of 10% for global and 13% for layer based T2 values. This appears sufficient to differentiate between healthy and diseased cartilage which may differ by 70% to 180% (4-5) from normal values. However, it may well substantially limit our ability to detect more subtle changes to be expected under intervention and in follow-up studies over time. In order to reduce measurement error and increase sensitivity to change, especially in longitudinal and multi-center trials, it is advisable to utilize not only scanners from the same vendor but to chose identical scanner types within the product lines of a vendor.



Graphics: The graphics show the average global (left) and layerwise (middle, right) T2 values for the different 1.5T and the 3T scanner.

Literature:

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