HUMAN INTERVERTEBRAL DISC STIFFNESS CORRELATES BETTER WITH THE OTSU THRESHOLD OF ITS AXIAL T2 MAP THAN WITH CLINICAL CLASSIFICATIONS

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Introduction
Degenerative intervertebral disc (IVD) disease represents a major health issue in quality of life and both direct/indirect health care costs. A degeneration assessment using clinical qualitative MRI (magnetic resonance imaging) or T1, T2 or T2* quantitative MRI is possible. However, existing methods are unspecific and depend on operator’s experience and latest grading systems are too complicated for clinical use. Moreover, low-back pain is related to abnormal intervertebral motions thus, this work aims to define an objective criterion for degeneration, based on axial T2 maps and reflecting the IVDs’ mechanics.

Methods
14 spinal units were extracted from 6 human lumbar spines (63-89 y). Posterior elements and all soft tissues but IVDs were removed. Free endplates of the surrounding vertebrae were embedded in PMMA. T1 and T2 weighted anatomical images in axial, sagittal and coronal planes as well as axial T2 mapping of the samples were produced using a 3T TRIO System (Siemens) as in [Watanabe, 2007]. The specimens’ degeneration was evaluated with 3 grading systems (Thompson, Benneker, Watanabe). Mean, standard deviation (SD) and Otsu threshold (TOTSU) were computed for each map in IVD, nucleus (NP), annulus (AF) and anterior, posterior, left and right regions of the AF. Otsu is a histogram-based segmentation method to compute automatically the optimal threshold that maximizes the separability of two classes of values. T2 mean is related to water content, SD and TOTSU to its homogeneity usually assessed subjectively by the clinicians. Quasi-static axial compression, torsion, lateral bending, flexion and extension tests were performed on each IVD via Spine tester device [Gédet, 2007] and stiffnesses were computed from the load-deflection curves.

Results
The grading systems correlated significantly with each other (Th/Be: R²=0.84, Th/Wa: R²=0.8), with compression and torsion stiffnesses. TOTSUIVD and TOTSUPost correlated significantly with Thompson (R²=0.32 and R²=0.4) and all but compressive stiffnesses. TOTSUAFCorrelated with Thompson as well (R²=0.46) and with all quasi-static stiffnesses. NP measures, age, height, area and stiffnesses showed no correlation.

Discussion
The classifications and stiffnesses correlates if the whole IVD is involved in the loading (compression, torsion). Our results suggest that the AF dominates the quasi-static mechanical behaviour of the IVD, especially its posterior part in flexibility tests. TOTSU is clearly a better candidate than T2 mean and SD for objective degeneration assessment.

References