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 T_1, T_2 or T_2^* 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 T_2 maps and reflecting the IVDs' mechanics.

Methods

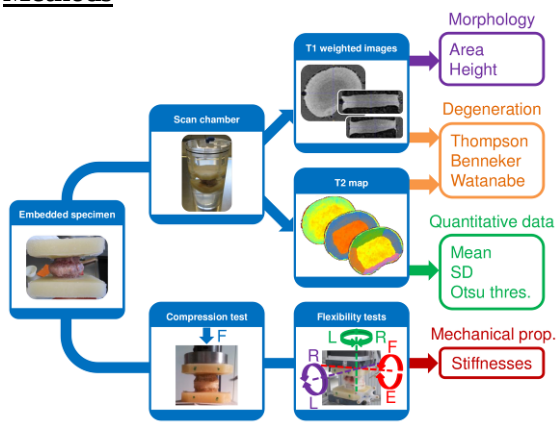

Figure1: Overview of the study

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. T_1 and T_2 weighted anatomical images in axial, sagittal and coronal planes as well as axial T_2 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 (T_{OTSU}) 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. T_2 mean is related to water content, SD and T_{OTSU} 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: R^2=0.84, Th/Wa: R^2=0.8), with compression and torsion stiffnesses. T_{OTSU}^{IVD} and T_{OTSU}^{Post} correlated significantly with Thompson (R^2=0.32 and R^2=0.4) and all but compressive stiffnesses. T_{OTSU}^{AF} correlated with Thompson as well (R^2=0.46) and with all quasi-static stiffnesses. NP measures, age, height, area and stiffnesses showed no correlation.

R^2	Stiffness				
	Comp.	**Tors.**	**Bend.**	**Flex.**	**Ext.**
Thompson	**0.57**	**0.38**	0.23	0.09	0.11
T_{OTSU}^{IVD}	0.23	**0.47**	**0.55**	**0.3**	**0.56**
T_{OTSU}^{AF}	**0.31**	**0.65**	**0.54**	**0.31**	**0.38**
T_{OTSU}^{Post}	0.2	**0.55**	**0.60**	**0.61**	**0.56**

Table1: Correlations with stiffness

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.

T_{OTSU} is clearly a better candidate than T_2 mean and SD for objective degeneration assessment.

References

Gédet et al, J Biomech, 40:1881-1885, 2007.

Watanabe et al, Am. J. Roentg, 189:936-942, 2007.