# QUANTITATIVE UTE MRI OF HUMAN TEMPOROMANDIBULAR DISC: RELATION TO BIOMECHANICAL PROPERTY

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**INTRODUCTION:** Proper biomechanical function of the discs of the temporomandibular joint (TMJ) is needed for normal jaw movement. Biomechanical weakening of the disc may be involved in disorders of the TMJ, leading to wear and perforation at advanced stages. Current MR diagnoses[1,2] focus on morphologic evaluation but not quantitative tissue parameters, which may be sensitive to biomechanical changes. Additionally, TMJ tissues generally have inherently short T2 values; their quantitative evaluation benefits from ultrashort time-to-echo (UTE) techniques.[3,4] Indentation testing,[5] applied to TMJ tissues,[6] allows for local biomechanical characterization due to small tip size. The objective of this study was to determine the relationship between indentation stiffness and quantitative MR properties (conventional and UTE) of human TMJ discs.

**METHODS:** ***Samples.*** Five mm thick TMJ slices (n=22; **Fig.1A**) were sectioned from 5 frozen cadaveric skulls (true sagittal plane relative to the TMJ) (78±12.3 yrs, mean±SD; 2F/3M) with a band saw (Exact, Apparatebau, Germany). ***MR Imaging.*** Apparatus. GE 3T Signa HDx MR scanner with modified T/R switch with a 3" surface coil. Conventional MRI. Spin echo (**SE**) **T2** mapping sequence was performed: FOV=8 cm, slice=2 mm, matrix=320x256, TR=2000 ms, TE=10~70 ms, FA=90°, BW=±42 kHz. UTE MRI. 2D projection-reconstruction sequences[4] were used. For all sequences, FOV=8 cm, slice=2 mm, readout=512, projections=355 to 511, FA=50-60°, BW=±50 kHz, NEX=2. For **UTE T2*** quantification, TR=300 ms, TE=12 µs to 20 ms (5 TEs) were used. For **UTE T1rho** quantification,[4] TR= 500 ms, $TSL_{prep}$=0.02 to 14 ms (4 TSLs) and fat-suppression was used. ***Indentation Testing.*** Bony parts of sample slices were secured on a solid platform with clamps. TMJ discs were compressed with a 0.8 mm diameter plane-ended cylinder indenter, to a depth of 100 µm while load was measured. Indentation was performed at multiple sites 0.5 mm apart (**Fig.1A**), and stiffness, load divided by compression depth, was determined for 600+ sites. ***Image Analysis***. Circular regions of interest (**Fig.1B**), size of the indenter, were selected using semi-automated Matlab routine to ensure correct spacing. Signal intensity were averaged and fit to appropriate mono-exponential functions to determine SE T2, UTE T2* and UTE T1rho properties. The image analysis was repeated 3 times to ensure consistent ROI selection. ***Statistics.*** Regional variation of indentation stiffness (**Fig.1C**) was assessed using repeated measures ANOVA (α=0.05). Linear regression and Pearson correlation between MR and indentation properties were assessed.

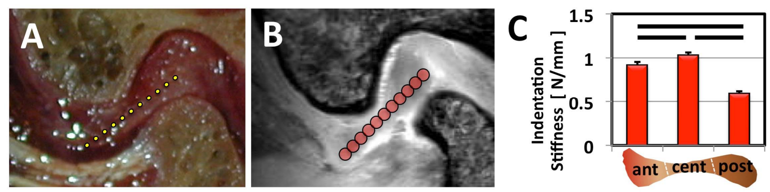


**Fig.1:** (**A**) Sample slice and indentation sites (dots). (**B**) UTE T1rho image and ROI. (**C**) Regional variations in indentation stiffness.

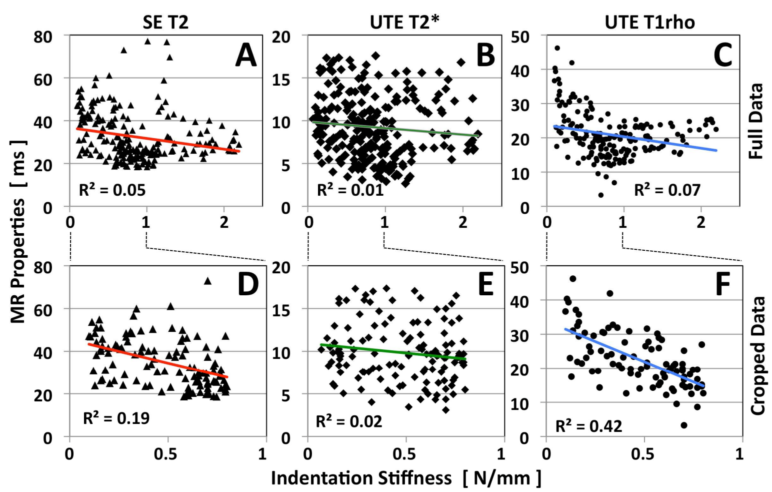


**Fig.2:** Correlation between MR properties and indentation stiffness for (**A,D**) SE T2, (**B,E**) UTE T2* and (**C,F**) UTE T1rho sequences.

**RESULTS:** Indentation stiffness (**Fig.1C**) was the lowest (softest) in the posterior region of the disc (p<0.001). MR properties initially did not correlate strongly with indentation stiffness (**Fig.2ABC**). However, an inverse relation was observed for the data in the lower range of indentation stiffness (~<0.8 N/mm). Data was cropped and re-analyzed. Significant trends (each $p<10^{-4}$) of decreasing MR property with increasing indentation stiffness was found for SE T2 (**Fig.1D**) and UTE T1rho (**Fig.1F**); strength correlation was stronger for UTE T1rho ($R^2$=0.42) than SE T2 ($R^2$=0.19).

**DISCUSSION**: These results suggest sensitivity of UTE T1rho measurement to biomechanical properties of TMJ disc. The lack of correlation for the upper range (~>0.8 N/mm) indentation stiffness may be due to artifact of indentation in the narrow central regions of the disc which exhibited significantly higher stiffness compared to other regions (**Fig.1C**); in this region, disc is adjacent to much stiffer condylar or temporal bone and the apparent stiffness of the disc may have been exaggerated.[7] In contrast, wider anterior and posterior regions of the disc are less likely to be affected by this problem. In addition, the lack of correlation involving UTE T2* may be due to susceptibility arising from longer TEs. Use of UTE T1rho measurement may be useful for longitudinal assessment of TMJ disc degeneration involving biomechanical changes, before severe structural deterioration occurs.

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**REFERENCES**: [1]Chirani+ *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; [2]Vilanova+ *Semin Ultrasound CT MR* 2007; [3]Gatehouse+ *Clin Radiol* 2003; [4]Du+ *Magn Reson Med* 2010; [5]Bae+ *Arthritis Rheum* 2003; [6]Tanaka+ *J Dent Res* 2006; [7]Bae+ *J Biomech* 2006