Assessment of degenerative changes in disc endplates using DCEMRI and T1ρ

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Target Audience: This presentation is intended for clinicians and researchers who study intervertebral disc degeneration.

Introduction: One of the sequelae of Intervertebral disc (IVD) degeneration is accompanying degenerative changes in adjacent subchondral bone of the vertebral bodies. These changes are classified into three categories by Modic *et al*[1]: Type I changes indicate fissuring of disc endplates and vascularized fibrous tissues; Type II changes suggest endplate disruptions and proliferation of yellow fatty marrow; and Type III indicate bone sclerosis. Although a direct correlation between Modic Changes (MC) and pain was not established to date, some believe that the inflammatory mechanisms associated with those changes play a role in pain generation. Currently, MC is diagnosed based on appearance of high or low intensity regions in T_1 and T_2 weighted (T_1W, T_2W) MRI. However, more objective quantitative imaging methods could provide earlier and more accurate assessment of MC. Dynamic contrast enhanced MRI (DCEMRI) is a method to study blood perfusion in extra-cellular extra-vascular space (EES). We hypothesized that it could be highly sensitive to Type I MC, especially in early stages. Complementary information about the inflammatory phase could be obtained by T1ρ, which is shown to change in other tissues with inflammation[2,3]. In this study, spatial characteristics of DCE-MRI and T1ρ changes in degenerating endplates were investigated.

Methods: This study was approved by the IRB and written consents were obtained from 31 participants (Age: Med.=36, [Min-Max]=[20-57]y; 11 females; 23 asymptomatic controls, 8 patients with low back pain associated with degenerative disc disease).

Images were acquired using a GE 3T MRI system with CTL-spine coil. DCEMRI was acquired using dual-echo FSPGR (16-sagittal slices with 3mm thickness, FOV=31cm, acquisition matrix=310×300, T_R=4.0ms, TE_1=1.1ms, TE_2=2.2ms, flip-angle=12°, 23 frames with 28s frame rate). The contrast (Gd-DTPA 0.1 mmol/kg) was administered manually as a bolus via an antecubital vein at the end of the 2nd dynamic frame. 3D MAPSS pulse sequence[4] with four spin-lock times (TSL)=[0, 20, 40, 60]ms, spin-lock amplitude=400Hz, and T_R=6.5ms, T_E=1.6ms were used for T1ρ. Pixel-by-pixel T1ρ values were calculated based on mono-exponential fitting: $S(TSL)=S_0 \cdot \exp(-TSL/T1\rho)$. T_2W, T_1W images were also acquired and reviewed by two radiologists to assess MCs and disc degeneration. For analysis, an operator manually drew regions of interest (ROI) for endplates and adjacent subchondral bones. Using these ROIs, planes parallel to the cranial and caudal faces of each lumbar IVD were determined and DCEMRI intensity projections onto those planes were calculated for each endplate and subchondral bone. A representative image slice with ROIs and projection planes (magenta dotted line) are shown in Fig. 1. Similarly, T1ρ values were projected onto the same planes.

Results: In three control subjects, the radiologists reported two Type I MC (1.7% of controls' IVDs) and two (1.7%) Type II MC. In four patients, three Type I MC (12.5% of patients' IVDs) and one (2.5%) Type II MC were reported. Fig. 2 illustrates images from two subjects with Type I MC. T_1W, T_2W images and peak contrast enhancement and T1ρ values projected onto endplates and adjacent subchondral bones are shown. Red areas in DCEMRI projection images show regions with high contrast agent uptake. Note that intensity projection images are in oblique-axial orientation. The color scale in T1ρ projection images is in milliseconds, as shown in the color bar.

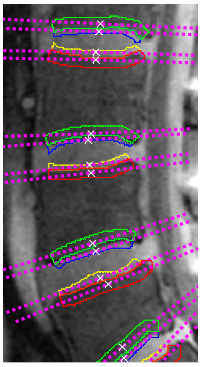

Fig.1. ROIs and IP's projection angles.

Discussion and Conclusion: The results indicate that the subchondral bone regions with degenerative changes show much higher contrast agent uptake compared to normal subchondral bone regions. We also observed that the enhancement was more prominent in Type I MC compared to Type II. This is probably due to increased vascularization and EES (due to edema) in Type I MC, which leads to increased accumulation of contrast agent. Increased T1ρ can be clearly seen in the degenerating subchondral bone, although its spatial extent is usually larger than DCEMRI. This might indicate that the inflammation could be more widespread than the vascularization. These preliminary results show that DCEMRI and T1ρ images might be valuable tools to detect MC earlier with better accuracy. These imaging techniques could also help distinguish different phases of degenerative endplate changes with better specificity.

Acknowledgement: This study is supported by AOSpine SRN and Advancing a Healthier Wisconsin research grants.

References: **1.** Modic MT, et at. *Radiology* 1988;166:193-9. **2.** Zhao F, et al. *Eur. Radiol.* 2012;22:1709-16. **3.** Virta A, et al. *Mag. Res. Img.* 1998;4:385-91. **4.** Li X, et al. *MRM* 2008;59:298-307.

Subj. 208 – Type I MC at Sup.EP of L3/L4 Disc

Subj. 243 – Type I MC at Inf.EP of L5/S1 Disc

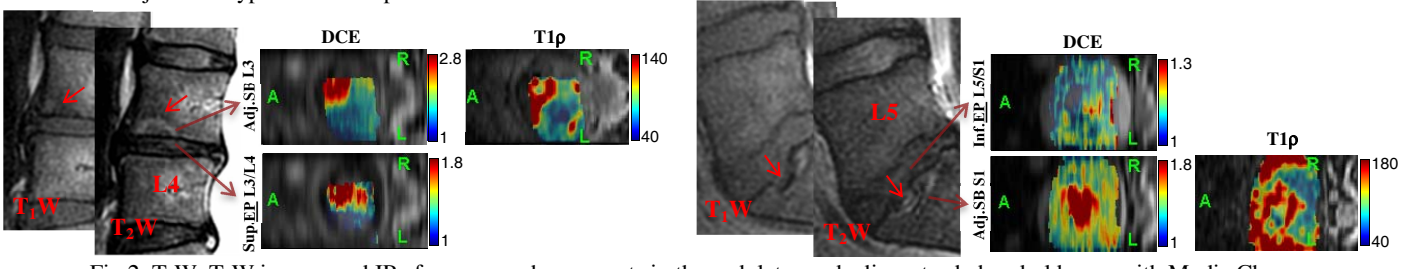

Fig.2. T_1W, T_2W images and IP of average enhancements in the endplates and adjacent subchondral bones with Modic Changes.