ULTRASHORT TIME-TO-ECHO MRI OF HUMAN INTERVERTEBRAL DISC ENDPLATE: ASSOCIATION WITH ENDPLATE CALCIFICATION

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INTRODUCTION: The cartilaginous endplate (CEP), which is situated between the avascular disc proper and the bony vertebral body, plays an important role in homeostasis of the disc. For example, endplate calcification[1] of this region reduces transport of gas and solutes into the disc, and this may result in disc degeneration. Conventional MRI sequences (e.g., fast spin echo[2]) have not been effective at evaluating the CEP, as the MR appearance is that of signal void due to its short T2 and T2* (~<1 ms). Ultrashort time-to-echo (UTE) techniques use TEs of ~μs and capture normal signal from the regions near the CEP as a bright line.[3] A minority of samples exhibit focal loss or irregularity of this signal, suggesting the presence of abnormal changes. It would be useful to determine if an abnormal UTE signal near the CEP is associated with endplate calcification, as dense calcification of CEP may diminish a normal UTE signal. The objective of this study was to evaluate fresh cadaveric lumbar spine tissue using UTE MRI to identify regions of abnormality, and then assess those regions using micro CT to determine calcification in the region near the CEP.

METHODS: ***Samples.*** Lumbar spines (n=2) from cadavers (57 and 75 yrs, male) were obtained from a tissue bank within ~2 days of death. ***MR Imaging.*** A GE 3T Signa Twinspeed MR scanner with a modified T/R switch with a 6" birdcage coil was used. UTE Sequence. A 2D projection-reconstruction sequence[4] was used: sagittal plane, FOV=16 cm, TR=300 ms, TE=0.01 and 10 ms, readout=512, projections=511, slice=3 mm, FA=45°, BW=±62 kHz, NEX=2, no fat-suppression. A second echo image was subtracted from the first echo image. Conventional Sequence. A fast spin-echo T2-weighted sequence was performed with same parameters as the above except: TR=2000 ms, TE~70 ms, matrix=512×512, FA=90°, BW=±31 kHz. ***UTE MR Evaluation.*** The presence of well-defined, linear high-intensity signal (**Fig.1A**) was classified as a normal pattern. When focal loss or irregularity of the signal occurred (**Fig.1B**), it was classified as an abnormal pattern. ***μCT.*** Sites exhibiting normal (n=5) and abnormal (n=4) UTE signal were selected and 5 mm diameter cores were harvested, to include portions of the CEP and vertebral body. Cores were imaged with a Shimadzu SMX-160CTS scanner with the following parameters: 100 kV, 100μA, 1200 views, FOV=6.6 mm, isotropic 13 μm voxels. ***μCT Evaluation.*** A semi-quantitative method[5] was used to grade the appearance of the endplate surface (the interface between bony and cartilaginous endplate) based on roughness (0=smooth, 3=roughest) and the presence of calcium deposits (0=none, 3=severe, with numerous large deposits). ***Statistics.*** To determine the effect of UTE appearance on endplate calcification grades, the Mann-Whitney rank-sum test was used (α=0.05).

RESULTS: In UTE MR images, a characteristic, well-defined linear high-intensity signal (**Fig.1A**) was found at nearly all endplate regions. Areas of focal abnormal signal pattern (**Fig.1B**), found in both spines, were not detectable with conventional T2-weighted images (**Fig.1D**). Cores with normal UTE appearance generally had a smooth surface without calcium deposition (**Fig.1E, Table 1**). In contrast, cores with abnormal UTE appearance tended to have a more roughened surface (p=0.06), along with significantly more (p<0.05) calcium deposits (**Fig.1F, Table 1**) than UTE-normal samples.

DISCUSSION: This preliminary study suggests that there is an association between UTE appearance of the region near the CEP and calcification in the region. While the mechanism of diminished UTE signal (leading to abnormal appearance) remains to be established, calcification of existing tissue (including the CEP) into a material with very low mobile proton density (and thus reduced signal) is a distinct possibility. Hindered transport through a calcified CEP may lead to disc degeneration and render biologic treatment options[6] ineffective. Currently, *in vivo* evaluation of transport across the disc endplate requires intravenous injection of contrast agent and serial imaging.[7] UTE MRI provides an alternative and direct means for evaluation of the CEP and the regions around it, and potentially, their transport function.

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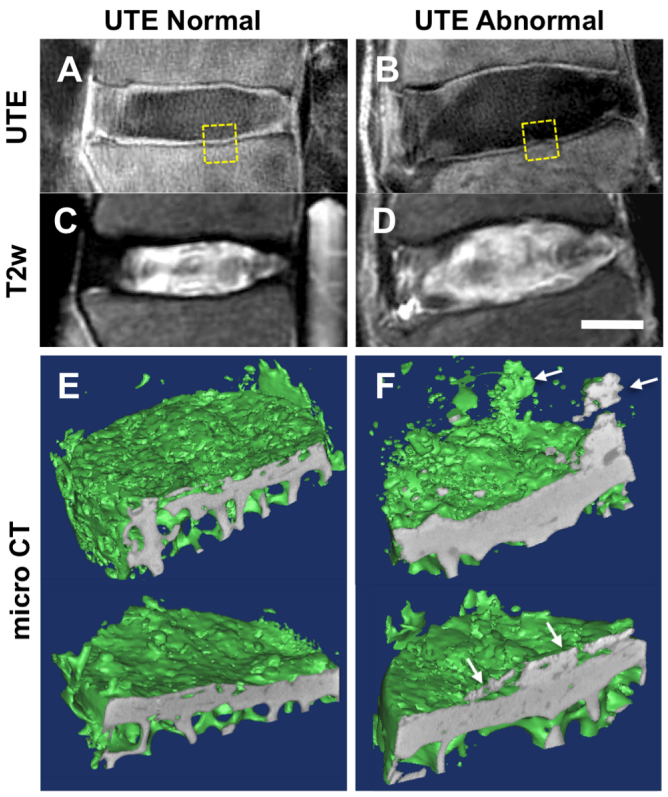

Fig.1: (**A,B**) UTE MRI, (**C,D**) spin-echo T2-weighted MRI, and (**E,F**) μCT 3D reconstruction, shown with vertical cross-section. Sample with (**A,C,E**) normal or (**B,D,F**) abnormal UTE appearance of the endplate region. Dotted boxes (A,B) are locations of μCT samples. Arrows (**E,F**) indicate calcium deposits.

UTE appearance	roughness	calcium deposit
normal	1	0
normal	0	0
normal	1	0
normal	0	0
normal	1	0
abnormal	3	3
abnormal	2	2
abnormal	1	0
abnormal	1	1

Table 1: Semi-quantitative (0=normal, 1=mild, 2=moderate, 3=severe) grading of endplate surface roughness and calcium deposition of UTE normal and abnormal samples.