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

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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] reduces transport of gas and solutes into the disc, and this may result in disc degeneration. Conversely, endplate health may be crucial for the success of biological disc treatment. While conventional MRI sequences (e.g., fast spin echo[2]) have been effective at evaluating disc degeneration, CEP and regions near it have not been evaluated directly, as the MR appearance is that of signal void due to their short T2s and T2*s (~<1 ms). Ultrashort time-to-echo (UTE) techniques use TEs of ~μs and capture signal from the regions near CEP.[3] The objective of this study was to evaluate fresh cadaveric lumbar spine using UTE and fast spin echo T2-weighted sequences, in order to describe normal and abnormal patterns of UTE signal near the CEP, and to determine if UTE signal patterns are associated with disc degeneration.

METHODS: ***Samples.*** Lumbar spines (n=29) from cadavers (59±10.1 yrs, mean±SD; 9 female) were obtained from tissue bank within ~2 days of death. ***MR Imaging.*** Apparatus. GE 3T Signa Twinspeed MR scanner with modified T/R switch with a 6" birdcage coil. UTE. 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. 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. ***Evaluation.*** UTE Appearance of Endplate. 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. Levels with subchondral irregularities (e.g., fracture[5]) were excluded, since evaluation of UTE signal became confounded with undulating signals from multiple tissue types. Disc Grading. T2-weighted fast spin-echo images were used to classify discs into 5 grades of degeneration (grade 1=normal) based on structure, morphology, and signal intensity.[2] ***Statistics.*** To determine the effect of level (L1 inferior to L5 superior) on endplate UTE pattern, Friedman's test with posthoc comparison (Bonferroni-adjusted α=0.05) was used. The same test was used to determine the effect of level (L1/2 to L4/5) on disc grade. To determine an association of UTE pattern with grade of the adjacent disc, a contingency table and chi-square test (α=0.05) was used.

RESULTS: In UTE MR images of lumbar spines, a characteristic, well-defined linear high-intensity signal (**Fig.1AC**) was found at nearly all endplate regions. Areas of focal abnormal signal pattern (**Fig.1C**) were found in 36 of 168 endplate levels. The level of endplate did not affect ($p=0.3$) frequency of abnormal UTE signal (**Fig.2**). In contrast, disc degeneration was significantly affected by disc level ($p<0.05$), where L3/4 had significantly lower grades than L4/5 ($p<0.05$). Finally, a significant ($p<0.001$) association was found between high disc grade and increased frequency of abnormal UTE pattern (**Fig.3**).

DISCUSSION: These results suggest that, in UTE MR images of human lumbar spine, the linear high-intensity signal at or near CEP is found normally in regions near the CEP, and alterations in the regions may manifest as abnormal patterns. The association between disc degeneration and UTE abnormality, but the lack of level-effect on UTE pattern, suggests a non-biomechanical basis such as the hindrance of transport. In contrast, level-dependence of disc degeneration suggests a biomechanical basis such as variations in inter-segmental stability.[6] Both mechanisms may affect disc degeneration. It remains to be established which tissue structure gives rise to the normal UTE pattern; in the knee, calcified and deep layer uncalcified cartilage were found to be sources of UTE signal.[7] With additional work, direct assessment of endplate region using UTE MRI may become a useful clinical tool for early detection of disc diseases.

ACKNOWLEDGMENTS: NIH, General Electric.

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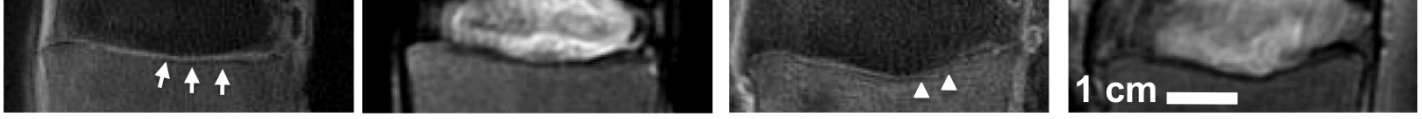

Fig.1: (**A**) Normal UTE signal near the endplate, characterized by high-intensity lines (arrows). (**C**) Abnormal UTE signal including focal loss and irregularity (triangles). (**B,D**) Corresponding T2-weighted spin-echo images exhibit signal voids near the endplates.

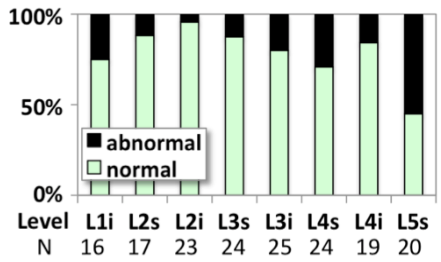

Fig.2: Frequency of normal and abnormal UTE signal patterns at each level.

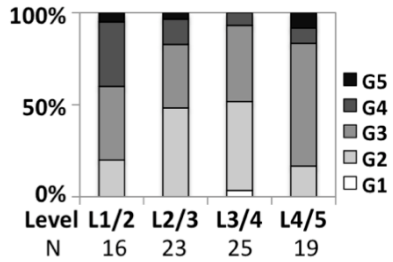

Fig.3: Frequency of different disc grades (1 to 5) at each level.

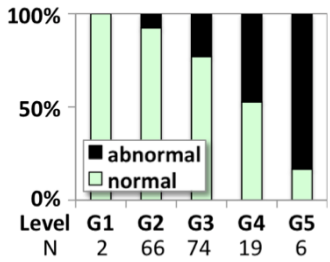

Fig.4: Frequency of UTE patterns for for different disc grades (1 to 5).