Ultrashort TE (UTE) imaging of the temporomandibular joint (TMJ) at 3T

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Background

The temporomandibular joint (TMJ) is an articulation of anatomic and biomechanical complexity. It is affected by a variety of osseous and soft tissue conditions that alter structure and compromise function (1). TMJ pain and dysfunction are important clinical problems. While diagnostic capabilities have progressed remarkably due to advances in MR imaging (2-5), significant challenges remain. The fibrocartilaginous nature of TMJ tissues comprised largely of short T2 components, make their MR imaging evaluation technically difficult. Ultrashort echo time (UTE) pulse sequences allow signal from short T2 tissue components to be detected and provides quantitative assessment of predominantly short T2 tissue components in the clinical setting for the first time (6, 7). Here we report the application of UTE sequences to imaging and quantification of TMJ of cadaver samples and volunteers on a clinical 3T scanner.

Materials and methods

Two dimensional UTE sequences are performed by using a half excitation radiofrequency pulse with radial mapping of k-space from the center followed by another half excitation and repeated radial mapping with the polarity of the slice selection gradient reversed. The data from the two half excitations are added to produce a single radial line of k-space. This process is typically repeated through 360° in 512 steps. A fast transmit/receive switch was installed on our 3T scanner, allowing a TE of 8 μs to be used. In addition to 2D UTE imaging, 2D and 3D gradient echo and fast spin echo sequences were employed to image the TMJ for comparison. T2* was measured using UTE acquisition with a series of TE delays, ranging from 0.1 ms to 25 ms. T1 was measured using UTE saturation recovery approach, where a short duration saturation pulse was used to saturate all magnetization from both short and long T2 tissues, followed by UTE acquisition at a series saturation recovery time (TSR) to detect the recovery of longitudinal magnetization. Exponential fitting of the signal decay and recovery was performed to calculate T2* and T1, respectively. Typical UTE imaging parameters included: FOV = 10 cm, 2 mm thick slice, readout = 512, BW = ±62.5 kHz, TR = 500 ms, TE = 8 μs, 511 projections. Two cadaver samples and five volunteers were included in this study.

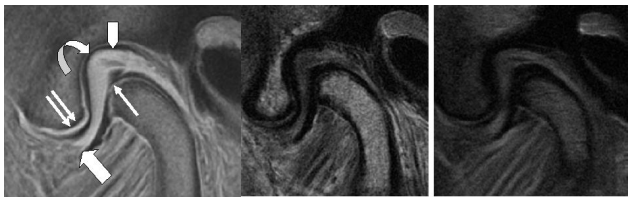

Fig 1 Fat-suppressed UTE sagittal imaging of cadaveric TMJ shows excellent delineation of the disc (thick and curved arrow) and condylar fibrocartilage (thin arrow). Corresponding fast spin echo T1- (middle) and PD-weighted (right) images provide poor structural delineation.

Results and Discussion

Figure 1 shows UTE imaging and proton-density weighted fast spin echo imaging of the TMJ of a cadaver. UTE provides excellent details of the disc as well as the condylar fibrocartilage, which is only vaguely depicted by PD-FSE sequence. T1 and T2* measurements of the disk and fibrocartilage are shown in Figure 2 and 3, respectively. The TMJ disc has a T2* of 6.97 ms and T1 of 658 ms at 3T, while the condylar fibrocartilage has a shorter T2* of 3.21 ms and T1 of 927 ms at 3T. The shorter T2* and longer T1 makes the fibrocartilage more challenging to image and quantify with conventional pulse sequences.

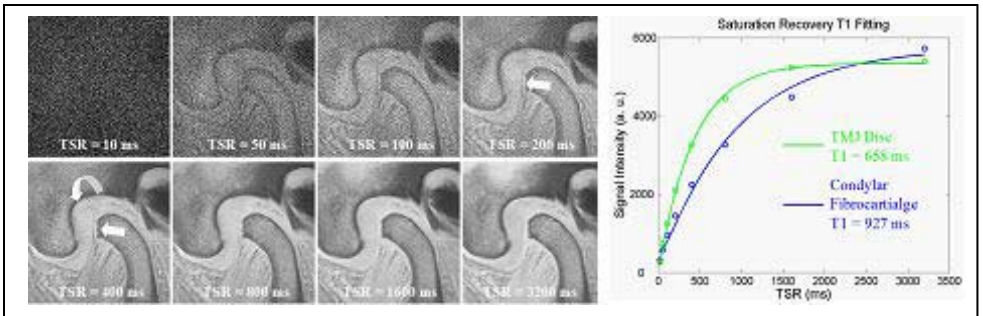

Fig 2 Selected saturation recovery UTE images are shown in the left four columns. T1 fitting for the TMJ disc (curved arrow) and condylar fibrocartilage (arrow) is shown in the right figure. The fitted T1 values are 658 ms for the disc and 927 for the condylar fibrocartilage.

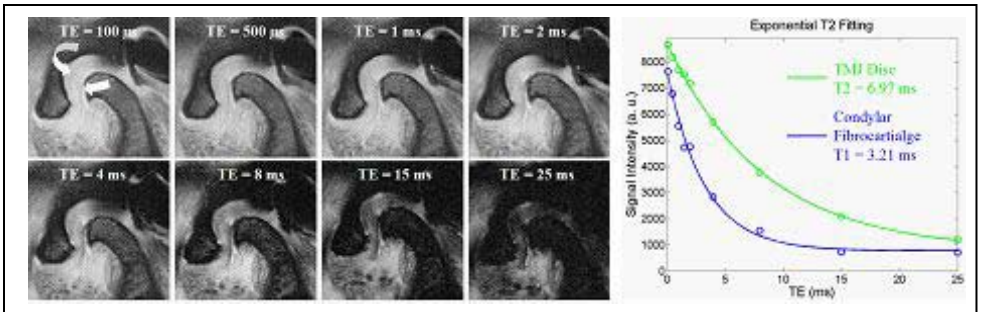

Fig 3 UTE images at a series of TEs and T2 fitting for the TMJ disc (curved arrow) and condylar fibrocartilage (arrow). The fitted T2 values are 6.97 ms for the disc and 3.21 for the condylar fibrocartilage.

Conclusion

TMJ disc and condylar fibrocartilage can be imaged and quantified with 2D UTE sequences with high spatial resolution and high contrast. This could have important diagnostic implications for the detection of early structural breakdown as well as offering a non-invasive means of assessing response to therapy.

References

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