In vivo Comparison of Ultrashort Echo Time (UTE) and Zero Echo Time (ZTE) MRI at 7T

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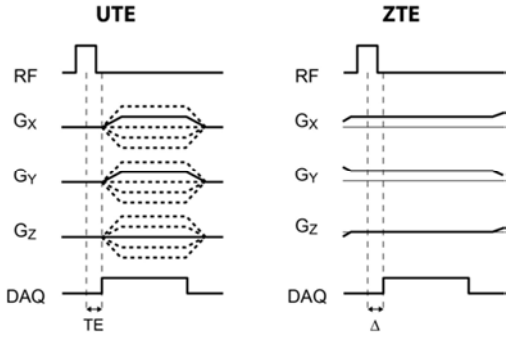
Target audience: Pulse sequence programmers, musculoskeletal and neuro-radiologists

Purpose: Detection of short-T2 (< 1ms) semi-solid tissue components, such as in tendons, calcified cartilage, the meninges, and myelin, is limited with Cartesian MRI acquisitions due minimum TEs. Two promising approaches for imaging these components are ultrashort echo time (UTE) [1] and zero echo time (ZTE) [2,3] pulse sequences. We compared UTE and ZTE acquisitions at 7T with nearly identical scan prescriptions in the brain, ankle, and knee to assess any differences in contrast and artifacts.



Methods: The UTE and ZTE sequences (*at right*) were matched to shared as many sequence parameters as possible including: 3D radial acquisition with isotropic FOV and resolution, 0.56 radial undersampling factor, matched readout durations, matched RF prep pulses, 12 μs 4º hard pulse excitation. The major differences between the sequences were that UTE used gradient ramp sampling and had a TE = 76 μs, while ZTE had a Δ = 22 μs. (With optimizations, TE = 22 μs for UTE is feasible on this system.) All studies were performed in healthy volunteers on a GE MR950 human 7T system with no custom hardware modifications.

Brain studies used: 32-channel receive array, 1.1 mm resolution, adiabatic IR (TI=600ms) with 384 projections per IR pulse, 128 projections per fat sat pulse, 0.77 ms readout duration, 3:45 (UTE) & 4:40 (ZTE) scan times, TR = 2.3ms (UTE) & 1.0 ms (ZTE). Ankle studies used: 32-channel head coil, 0.65 mm resolution, 32 projections per fat sat pulse, 1.3 ms readout duration, 5:15 (UTE) & 4:45 (ZTE) scan times, TR = 2.2ms (UTE) & 2.3ms (ZTE). Knee studies used: 28-channel knee coil, with all other parameters identical to the brain studies.

Results:

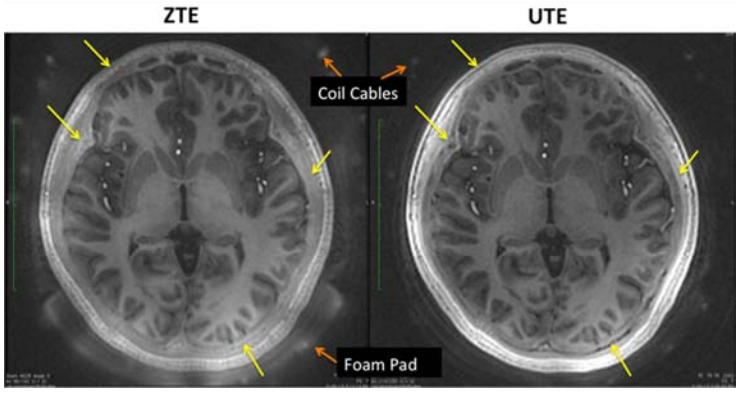


Figure 1: There were no observable signal differences in the cortex between ZTE and UTE. There appears to be more signal from the meninges and skull in ZTE (yellow arrows), likely due to the shorter echo time. ZTE demonstrated slightly larger susceptibility artifacts near the sinuses (not shown).

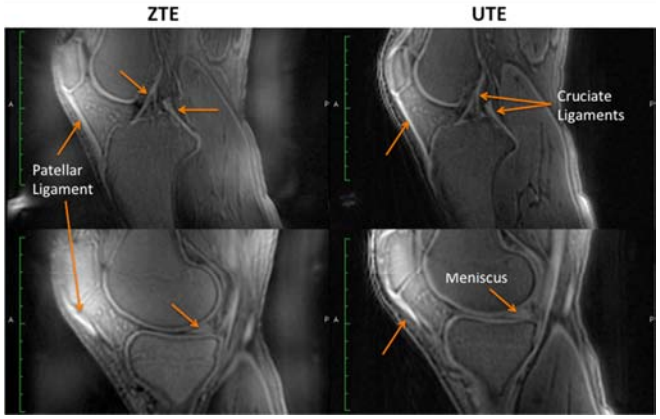


Figure 2: Both ZTE and UTE provided excellent depiction of the tendons in the ankle at high isotropic resolution, including depiction of the fascicular structure in the Achilles tendon. There was a fat suppression failure in both acquisitions.

Discussion & Conclusion: ZTE and UTE MRI demonstrated similar tissue contrast with matched acquisition parameters, with potentially more signal from ultrashort-T2 components in bone with ZTE. They also showed similar off-resonance properties, support for RF preparation pulses and anisotropic FOVs, and were both applied without any hardware modifications to a clinical MRI system. UTE offers advantages of including slab or slice selection to reduce scan times and supports variable TEs. ZTE provides a shorter TE, is less demanding of the gradient hardware and practically insensitive to gradient infidelity, and is relatively quiet due to the slow gradient switching.

References: [1] Bergin et al. *Radiology* 1991;179:777-81. [2] Hafner S. *MRI* 1994;**12**:1047–1051. [3] Madio et al. *MRM* 1995;**34**:525–529. [4] Wu et al. *MRM* 2007;57:554-567.

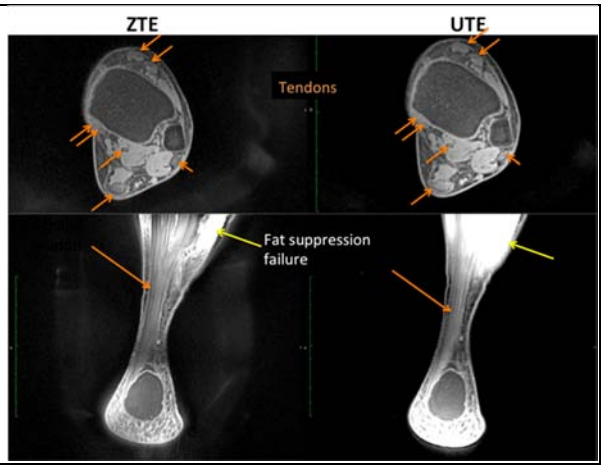


Figure 3: Both ZTE and UTE provided excellent depiction of the ligaments, tendons, meniscus, and cartilage in the knee. Increased ZTE signal was seen from the foam pad and coil components.