

DEMONSTRATION OF THE COLLAGENOUS COMPONENTS OF PERIPHERAL NERVE WITH SHORT AND ULTRASHORT TE (UTE) PULSE SEQUENCES.

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Introduction

The objective of this study was to apply short and ultrashort (UTE) pulse sequences to demonstrate and distinguish between the collagenous components of the peripheral nerves (**external epineurium, internal epineurium and perineurium**). Assessing the integrity of these structures is critical for grading peripheral nerve injuries (PNI) and determining the need for neurosurgical repair [1]. Conventional MR sequences used for neurography do not provide either the contrast or the resolution necessary to differentiate these connective tissues from the neural tissue within the nerve. Short and ultrashort TE (UTE) pulse sequences, which can detect and highlight short T2 components, were used to demonstrate these tissues at 3T and 11.7T.

Material and Methods:

Samples. Examinations were performed on dissected human tibial and median nerves from donor cadavers. Samples of up to 3 cm of length were prepared and mounted in a plastic tube containing Fomblin™ (Solvay Plastic). **MR Imaging.** A 3T (GE Healthcare, Milwaukee) clinical scanner with a dedicated solenoid coil was used. 2D multi-echo spin echo sequences were used with FOV 20 x 20 x 1.7 mm, TEs of 20-165 ms. 2D/3D UTE and inversion recovery UTE (IR-UTE) sequences were also used with FOV 10-20 x 10-20 x 0.7-1.7 mm, TR 1500 ms, TIs ranging from 180 to 500 ms, TEs from a minimum of 10 μ s to 24 ms. Magnitude and phase images were produced. For the assessment of magic angle effects, the long axis of the sample was oriented from 55° to 90° relative to B₀. 11.7 T (Bruker Biospin, Billerica) 2D spin echo images were also acquired with a spatial resolution of 60 x 60 x 400 μ m, TE 9 ms, TR 5000 ms, fat saturated and number of excitations (NEX) 6.

Results:

UTE subtracted images demonstrated the external and the internal epineurium (Fig. 1-A, B, C). IR-UTE sequences also highlighted the epineurium (Fig 1-D). A TI value of 280 ms nulled the perineurium and neural tissue together with the endoneurium. A TI value of 200 ms nulled the external epineurium. The perineurium was demonstrated at 11.7 T on high resolution images (Fig. 2). 3T IR-UTE sequences with the sample oriented at 90° to B₀, did not demonstrate the perineurium on the later echo image at 11 ms (Fig.3-A), but this was seen at an orientation of 55° (Fig. 3-B). Phase imaging demonstrated contrast between neural and connective tissues at both TE 10 μ s and 11 ms (Fig. 4) at 3T.

Discussion:

Use of Short and UTE pulse sequences allowed identification of, and distinction between the external and the internal epineurium, as well as the perineurium within peripheral nerves. Conventional fat saturated spin echo sequences with a long TE, usually demonstrate the fascicular pattern within nerves, but do not show the epineurium due to its short T1 and short T2, and do not distinguish the perineurium from neural tissue.

The perineurium may contribute significantly to the signal detected with routine sequences, due to its long T2. This may be the result of higher proton density compared to the internal epineurium, which contains loose and compact collagen fibers. Orientation of the sample may change the contribution to signal from the perineurium, due to the magic angle effect. Phase imaging has been already successfully applied to CNS and connective tissues, and these results are promising for its implementation on peripheral nerve for the study of susceptibility. Use of short and UTE sequences provides a more comprehensive view of the signal and contrast characteristics of peripheral nerve than conventional sequences, including specific visualization of the connective tissue components. This may considerably help in assessing the integrity of these structures and the need for surgery in PNI.

References: 1.Sunderland, S. Brain, 1951. 74(4): p. 491-516.

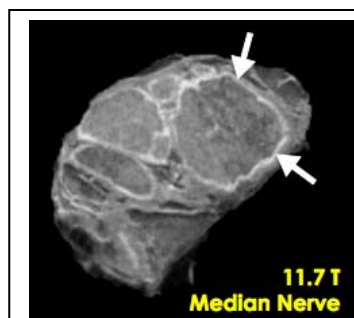
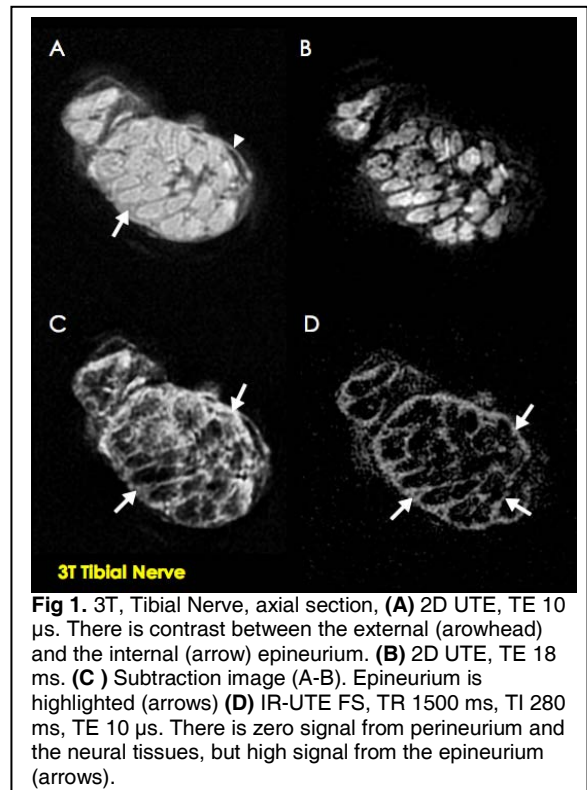


Fig 2. 11.7 T, median nerve, axial, spin echo, TR 5000, TE 9 ms. Perineurium is highlighted (arrows).

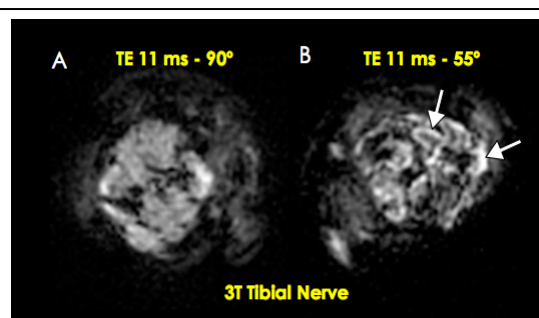


Fig 3. Magic angle effect. 3T, Tibial nerve, axial. IR-UTE with TE 11 ms oriented at 90° (A) and at 55° (B) to B₀. Note the high signal of the perineurium (arrows) with the sample at the magic angle.

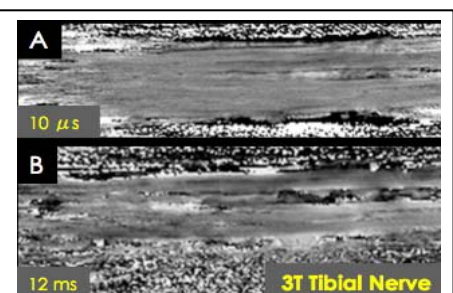


Fig 4. Susceptibility effect. Tibial nerve, sagittal, 3D UTE, TE 10 μ s (A) and 12 ms (B), phase images. There is phase difference between the connective and neural tissues at TE 10 μ s. This is greater at TE 12 ms.