Quantitative Characterization of the Connective Tissues of the Fingers in Cadaveric Specimens: T1 and T2* Measurements Using Ultrashort Echo Time (UTE) MR Imaging in 3T

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INTRODUCTION

In routine clinical MRI, heavily T2-weighted pulse sequences are used to detect the signal from long T2 relaxation components in tissues. However, there are also tissues such as tendons, ligaments, calcified fibrocartilage and cortical bone that have short T2 relaxation times (1). After excitation the MR signal from these tissues decay very rapidly. Little or zero signal is detected with conventional clinical pulse sequences with echo times (TE) several milliseconds (ms) or longer. These short T2 tissues therefore appear dark in all pulse sequences routinely used in clinical MRI. It has not been possible to characterize the tissues by measuring T1 and T2 values. Ultrashort TE (UTE) pulse sequences with TEs 100-1000 times shorter than those routinely used on clinical scanners can detect signals from these short T2 tissues and allow them to be directly imaged and quantified (2). TE is a critical performance indicator in UTE imaging since the shortest detectable T2 is on order of TE (3). Here we present UTE imaging (minimal TE = 8 μs) and quantitative T1 and T2* characterization of the connective tissues of the fingers on a clinical 3T MR scanner.

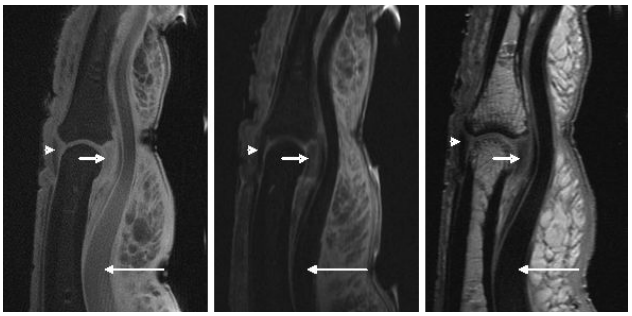

Fig 1 *Sagittal UTE imaging of the finger with fat saturation shows high signal in the volar plate (short arrow), flexor digitorum profundus tendon (long arrow), and dorsal extensor tendon (arrow head) compared to PD-weighted FS FSE imaging (middle) and T1-weighted FSE imaging (right).*

MATERIALS AND METHODS

Six fresh frozen hand specimens were harvested from five nonembalmed cadavers for this study. 3 inch surface coil was used. The MR protocol included sagittal and coronal PD-weighted fat suppressed (FS) FSE. Sagittal and coronal dual echo UTE pulse sequence was used with and without fat suppression. TR/TE = 450/0.008-7 ms, slice thickness = 2 mm, field of view (FOV) = 8 cm, readout = 512, 511 half projections. For T1 measurement a UTE saturation recovery technique was used where a short duration hard (232 μs) or Gaussian pulse (500 μs) was employed to saturate all the magnetization followed by UTE acquisition at a series of saturation recovery times (TSR) ranging from 10 ms to 2500 ms, slice thickness = 2 mm, FOV = 8 cm, readout = 512, 511 half projections. For T2* measurement UTE acquisition with variable TE delays ranging from 100 μs to 20 ms were applied. Other parameters included: TR = 300 ms, slice thickness = 2mm, FOV = 8 cm, readout = 512, 511 half projections, with FS. The MR images were evaluated to identify and interrogate normal areas of the following tissues: central slip extensor tendon, flexor digitorum profundus and superficialis tendons, PIP volar plate, MCP main collateral ligaments, interosseous muscles and ligaments, and MCP calcified and deep layer cartilage. Regions of interest (ROIs) were placed at the central portion of the all anatomic structures for quantitative analysis.

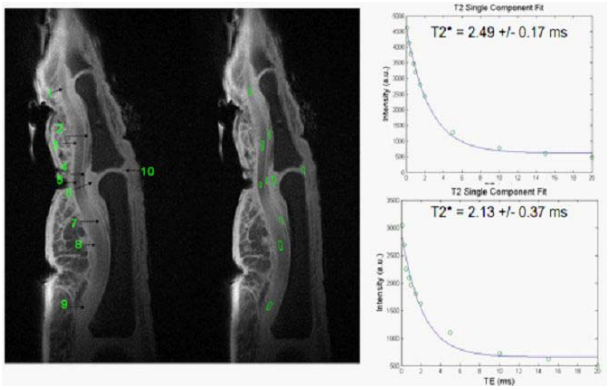

Fig 2 *T2* estimation of the short T2 tissues in finger using variable TE UTE acquisition with fat saturation (left) and selected single component exponential signal decay fitting curves for the flexor digitorum profundus tendon (#1) and flexor digitorum superficialis tendon (#4).*

RESULTS AND DISCUSSION

The UTE MR imaging technique, as compared to standard commercially available MR sequences, provides significantly increased signal in the short T2 tissues of the finger as demonstrated in Fig. 1. The UTE TSR and T2* measurement techniques allow reproduceable quantitative evaluation of the short T2 tissues of the finger (Figures 2 and 3) Table 1 summarizes the T2* and T1 measurements for the connective tissues of the finger from six cadaveric specimen samples.

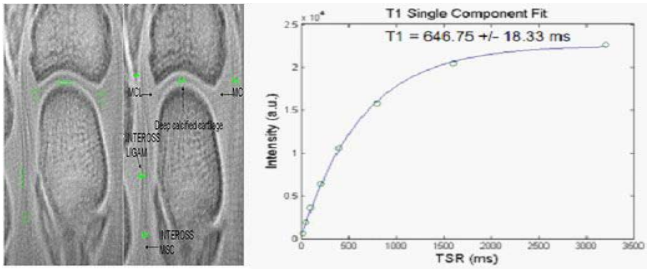

Fig 3 *T1 estimation of the main collateral ligament (#2) using saturation recovery UTE acquisition technique applied in the coronal plane.*

CONCLUSIONS

UTE sequences provide high signal imaging of the short T2 tissues. T1 and T2* measurements can be performed to evaluate the short T2 tissues in the finger using a clinical scanner.

Tissues	Flexor digitorum profundus tendon	Flexor digitorum superficialis tendon	Dorsal extensor tendon	Volar plate	Main Collateral Ligament	Deep Layer of Cartilage
T2* (ms)	2.49 +/- 0.17	2.13 +/- 0.37	3.24 +/- 0.95	6.61 +/- 1.71	5.30 +/- 0.25	4.21 +/- 1.61
T1 (ms)	490.04 +/- 17.69	523.57 +/- 19.82	562.96 +/- 16.85	474.73 +/- 5.91	646.75 +/- 18.33	635.88 +/- 11.03

REFERENCES

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