Ultrashort TE (UTE) imaging of the Extensor Tendon Functional Entheses of the Finger

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Background

Entheses are regions where tendons, ligaments or joint capsules are connected to bone. They are transition zones between flexible and rigid tissues and stress concentrates at the junction between these two types of tissue as a result of their widely different mechanical properties. The structure of entheses can be understood in terms of the need to disperse this stress, and this need can be related to the gross anatomy, histology and biochemistry of the tissues of entheses including the presence of calcified and uncalcified fibrocartilage in the junctional region. Conventional clinical magnetic resonance (MR) imaging has not been helpful in demonstrating the key tissues present in normal entheses. All these tissues have short transverse relaxation times (T2s), and show little or no signal with typical clinical pulse sequences which have echo times (TEs) of about 8-20 msec or longer. As a result the component tissues of entheses have not previously been identifiable with imaging. Ultrashort TE (UTE) pulse sequences with TEs 100-1000 times shorter than those routinely available on clinical MR systems can detect signal from the different tissues of entheses before this has decayed to very low levels and so allow the different tissues to be demonstrated with great clarity. A critical concept is that of a functional enthesis where there is no direct attachment of tendons or ligaments to bone, but tendons or ligaments are subject to compression or shear forces and undergo adaptations similar to these seen in classical entheses. This is may be seen with wrap-around tendons, but there has been considerable interest in this concept with the extensor tendons of the fingers which are subject to compression when the proximal and distal interphageal joints are flexed. Detailed high resolution studies of the fingers have been performed with purpose designed coils but it has not been possible to demonstrate the expected structure changes with imaging although histological studies have shown evidence of presence of fibrocartilage (1-4).

Materials and methods

The basic 2D UTE pulse sequence used in this study consisted of a "half pulse" excitation in the form of half of a sinc rf pulse applied with a slice selection gradient. These are both rapidly terminated, and followed as soon as T/R switching allows, by radial k-space sampling beginning on the ramp and continuing on the plateau of the gradient. The pattern was repeated with the polarity of the gradient reversed and the two sets of complex data were added to give a slice selected radial line of k-space from the center out. The 2D UTE sequence has been applied to six cadaver specimens and four normal volunteers. Typical UTE imaging parameters included: FOV = 10 to 12 cm, 2 to 2.5 mm thick slice, readout = 512 (actual sampling points = 284), BW = ±62.5 kHz, TR = 300 to 500 ms, TE = 8 μs, 511 projections, axial and/or sagittal imaging plane.

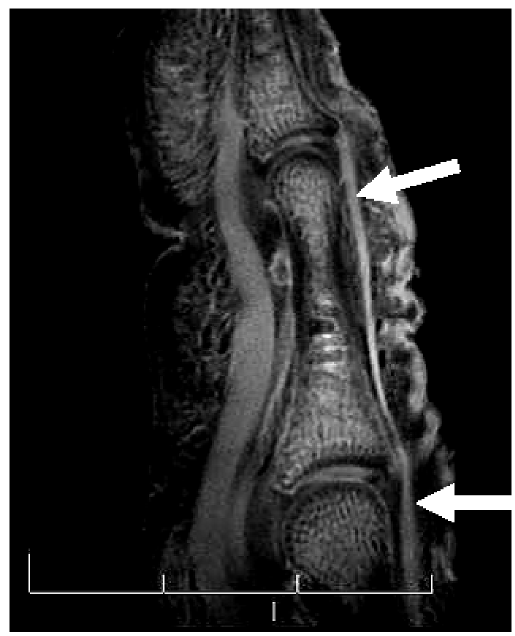

Fig 1 *Dual echo subtracted sagittal UTE imaging of a finger obtained at 3T using a dedicated finger coil. The extensor tendon has a high signal except where it is adjacent to the DIP and PIP where it is mid grey(arrows). On the subtracted image the mid grey appearance corresponds to a longer T2 and is consistent with the presence of fibrocartilage in the functional entheses related to the joints.*

Results and Discussion

Results using UTE imaging and subtraction (Figure 1) showed lower signal regions in the extensor tendons in areas corresponding to the PIP and DIP articulations. The features are consistent with an increase in T2 in fibrocartilage leading to a reduction in signal on the subtraction images. The extend of the low signal region corresponds closely with the region of the tendon which is subject to compression.

This is the first imaging demonstration of the functional entheses in the extensor tendons of the figures. It is of interest from a functional point of view in understanding the adaptation of tissue to mechanical stress. It may also be important in understanding the pattern of disease in psoriatic arthropathy which specifically targets entheses. It is also of the interested from a technical point of view in showing the new options that are now available with UTE imaging.

References

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