MRI of the Pulleys of the Digital and Palmar Flexor Tendons Using Short and Ultrashort Echo Time Pulse Sequences

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Introduction

The pulleys of the flexor tendons of the fingers and thumb have an essential role in maintaining the mechanical integrity of the hand. Disruption of the system is seen in a variety of disease and following injury particularly to rock climbers (1). The anatomy of the system is well known and has been described in detail (2,3). The fingers have five annular pulleys and 3-4 cruciate pulleys while the thumb has 2-3 annular pulleys and a single oblique pulley. The palmar aponeurosis also functions as a pulley. MRI and Ultrasound are the imaging techniques of choice but in the most detailed anatomic studies of cadavers performed to date conventional MRI was only able to show two of the five annular pulleys (4). Two other annular pulleys could only be seen after injection of a gadolinium solution into the tendon sheath. The cruciate pulleys of the fingers and the oblique pulley of the thumb and the palmar aponeurosis were not studied (4). The principal tissues of interest (pulleys, tendons, volar plate, periosteum, cortical bone and dermis) all have short T2s and appear as low or zero signal structures using conventional imaging sequences. This makes it difficult to differentiate these structures or see internal detail within them. By using short and ultrashort TE sequences it is possible to detect signal from each of the tissues of interest and develop contrast between and within them. The pulleys contain three layers including a central layer of highly ordered collagen (5) which displays a marked magic angle effect. This can be helpful in identifying structure within the tissue. In this study four fingers and a thumb from a single cadaver hand were studied in order to demonstrate the anatomy of the pulleys of digital and palmar flexor tendons.

Methods and Materials

After initial freezing and thawing, the thumb and fingers of a 77 year old male cadaver were studied with flexor tendons parallel and perpendicular to B_0 as well as angles with components of the cruciate and oblique pulleys at 0^o and at the magic angle. A clinical GE 3T MR system was used with planar surface, solenoidal and birdcage coils. Imaging sequences were all 3D isotopic. They included spoiled gradient echo 2-4 cm FOV, 320x320 to 484x484 matrix, 0.1-0.2 mm slice thickness and TE 1-3 ms, TR 47-100 ms and ultrashort TE (UTE) 320x320, to 448x448 matrix, 3-5 cm FOV, TE 55-550 μs. Image acquisition times varied between 12 and 72 minutes. Fat saturation was used in each case.

Results

Pulleys were demonstrated with high relative signal in each case (Figs. 1,3,4). A marked low signal magic angle effect was seen in the central regions of the annular pulleys (Fig. 2) and over the length of cruciate pulleys and the oblique pulley of the thumb. Continuity was seen between A1 A3 A5 pulleys and the volar plates as well as between the A2 and A4 pulleys and the periosteum. The inner and outer layers of the annular pulleys were relatively high signal with the central signal dependent on its fiber orientation to B_0. Palmar pulleys showed the three layer structure. The volar plate also showed fibrous structures in three layers. Fibrous structures were seen in the dermis and hypodermis and these displayed magic angle effects.

Discussion

From a technical level, high signal was demonstrated in the pulleys, tendons, volar plate, periosteum and skin. Marked magic angle effects were seen centrally within pulleys, tendons, the volar plate and the stratum papillae and the stratum reticulare of the skin. The A1 A3 A5 pulleys, as well as the cruciate pulleys and the oblique pulley of the thumb were demonstrated anatomically for the first time. Layered structure was also seen in the volar plates for the first time. Short and ultrashort TE sequences provide access to levels of detail in the digital flexor tendon and palmar aponeurosis pulleys which have not been possible previously with conventional pulse sequences.

References

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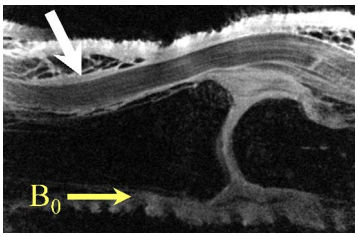

Fig. 1. Sagittal UTE image of finger showing high signal in the A2 pulley (arrow).

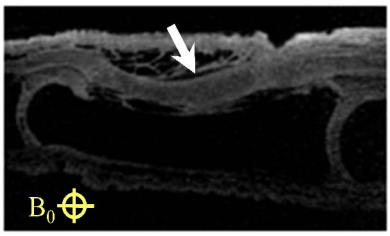

Fig. 2. Sagittal UTE image of finger showing low signal in the A2 pulley (arrow).

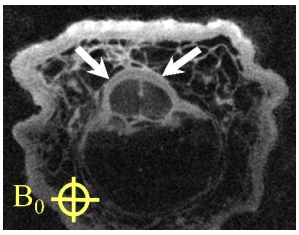

Fig. 3. Axial UTE image of finger showing high signal in the A2 pulley (arrows).

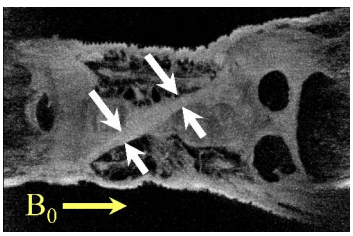

Fig. 4. Coronal UTE image of thumb showing high signal in the oblique pulley (arrows).