MRI OF THE ACHILLES TENDON ENTHESIS WITH ULTRASHORT TE (UTE) PULSE SEQUENCES: CT, RADIOGRAPHIC AND ANATOMIC CORRELATION

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Introduction: To date, the contribution from magnetic resonance (MR) imaging to the study of the normal Achilles tendon enthesis has been limited. The principal tissues found at the insertion site, including the fibrous connective tissue of the Achilles tendon itself, uncalcified and calcified fibrocartilage, periosteum and cortical bone all have short T2s and characteristically display little or no signal with conventional pulse sequences. As a result it is difficult or impossible to separately identify specific tissues at the enthesis.

By using ultrashort echo time (UTE) pulse sequences with TEs 20-50 times shorter than those of conventional pulse sequences, signal can be detected from tissues with short T2s (1, 2) and, in a preliminary study, it was suggested that the tissues of the Achilles tendon enthesis could be identified, although no correlative anatomic studies were performed (3). In this study we have used UTE sequences to image the Achilles tendon enthesis in cadavers and correlated the appearances with computed tomography, soft tissue radiography, anatomic and histologic studies.

Methods: Six cadaver specimens were examined with MR including conventional and ultrashort TE (UTE) imaging (2) and Computed Tomography (CT). The specimens were sectioned at 3 mm intervals corresponding to the MR and CT examinations and were examined with Faxitron soft tissue imaging. The sectioned specimens were photographed and selected tissue samples were prepared for histological examination.

Results: There was a close correspondence in each case between the specimens and the MR appearances (Fig 1). In the transverse plane higher signal as well as absence of the typical fascicular pattern was observed in sesamoid fibrocartilage. These appearances were obvious with UTE appearances and either not apparent, or only evident to a much smaller extent with conventional T1 weighted MR sequences.

No evidence of calcification was observed with CT or Faxitron imaging in areas of higher signal of the six specimens. Histology confirmed that the observed high signal was in areas of enthesial, periosteal or sesamoid fibrocartilage.

Discussion: The fibrocartilage at the enthesis within the tendon and the periosteum can be demonstrated. This was usually because of its higher signal intensity on UTE and sequences. The sequences show different extent of sesamoid fibrocartilage probably reflecting the different sensitivities of the two sequences to T1 and T2 differences. These differences are consistent with fibrocartilage having a shorter T1 and T2 than dense fibrous connective tissue.

In addition, in the transverse plane it was possible to demonstrate absence of the fascicular pattern of the tendon with an amorphous ground glass appearance in sesamoid fibrocartilage. This is likely to be a result of the basket-weave pattern of the fibers within sesamoid fibrocartilage. The fascicular pattern was apparent in all three planes but best recognized in a plane transverse to the fascicles. This reduced partial volume effects and produced contrast in a way that has been described for nerve fascicles (4).

The three distinct fibrocartilages of the Achilles enthesis described in this study were comparable in structure and position to those seen in previous studies of humans (5) and the rat (6). Their presence probably reflects the special mechanical environment at the distal part of the tendon with distinctive histopathological features present both at the enthesis and in the bursal wall.

The enthesial fibrocartilage creates a gradual change in mechanical properties near its interface with bone, and its prominence may related to the constant tension in the Achilles tendon during standing and to the mobility of the ankle joint. (7)

3D data suggest that there is a close correspondence between both the position and the size of the sesamoid and periosteal fibrocartilage (8) probably because of their functional interdependence. The superior tuberosity of the calcaneus (on which the periosteal fibrocartilage is located) acts as a pulley for the distal part of the Achilles tendon. A corresponding area of the tendon must thus be structurally modified to withstand the compression on the tendon that comes from its contact with that pulley, hence the sesamoid fibrocartilage.

This study provides histologic confirmation for the use of UTE imaging to demonstrate the anatomic features of entheses and may allow new insights into the biomechanical and pathological features of this region.

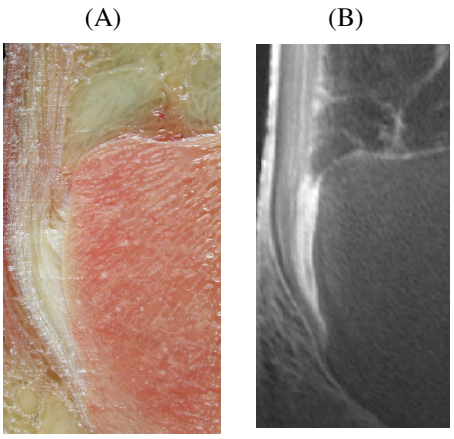

Figure 1 Gross specimen anatomy (A) and UTE (B) images. The region of high signal intensity on the UTE image corresponds closely to the lighter area (sesamoid fibrocartilage) on the corresponding specimen (A).

References

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