Initial T_1 Measurements of the Human Achilles Tendon Using UTE Imaging at 3 T

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INTRODUCTION:

The Achilles tendon is commonly involved in mechanical tendonopathies and spondyloarthritis. The short T_2 of the normal tendon makes early changes difficult to assess with conventional MR sequences. Ultrashort echo time imaging (UTE) [1] allows the tendon to be directly visualised with high intensity allowing quantification, such as T_1 relaxometry. T_1 measurements may be useful for assessing Achilles disease directly or for other techniques such as pharmacokinetic modelling of contrast enhancement. The aim of this work was to determine whether a saturation recovery (SR) UTE longitudinal recovery (T_1) measurement was feasible in the human Achilles tendon where the SR-UTE sequence was initially corroborated in phantoms with an assumed 'gold standard' inversion recovery (IR) spin echo (SE) sequence.

METHOD

Phantom Calibration: 4 phantom tubes with various measured T_1 values from a Eurospin QA phantom were scanned using a Siemens 3 T Verio system, 4 cm loop coil and single slice SR-UTE sequence. Parameters were: TR = 2.2 s + SR delay; TE = 0.07 ms; in-plane matrix = 128 x 128; voxel size = 0.8 x 0.8 mm and slice thickness = 3 mm. 7 SR delay times of 100, 200, 400, 600, 800, 1000 and 1200 ms were acquired. The SE-IR sequence used parameters: TR = 4 s; TE = 9.6 ms; in plane matrix = 128 x 128; voxel size = 0.8 x 0.8 mm slice thickness = 3 mm and IR-delays of 50, 100, 200, 400, 600, 800, 1000 and 1200ms. Data from the UTE sequence using no SR delay pulse and SE sequence using no IR pulse were acquired to provide S_0 for T_1 fitting.

In vivo: 6 healthy asymptomatic subjects (4 male; 2 female; age 38 ± 7 [mean ± stdev]) were scanned using a Siemens 3 T Verio system and 4 cm loop receive coil. The Achilles tendon was scanned parallel to the main magnetic field, B_0 using a single slice SR-UTE sequence as for phantom calibration with 4 SR delay times of 100, 400, 800 and 1200 ms and no SR delay. The total acquisition time was 1 hour.

Measurement and Fitting of T_1: ROI (shown in figure 1) were drawn within the Achilles tendon (N = 6) and fat anterior to Achilles Tendon (N = 4) in the SR-UTE images with all data fitted for T_1 using a two parameter fit for T_{SR} and F to $S(T_{SR}) = S_0(1-(1-F)*\exp(-T_{SR}/T_1))$.

RESULTS:

The phantom calibration T_1 measurement results showed good comparison between the 'gold standard' IR-SE and SR-UTE sequence with 6.1 ± 4.9 % difference (mean ± stdev) and no significant difference observed with Students paired T-test.

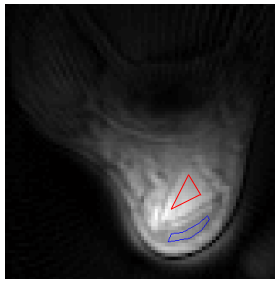

Figure 1. SR-UTE image (SR delay = 800 ms). Blue ROI = Achilles tendon; red ROI = fat

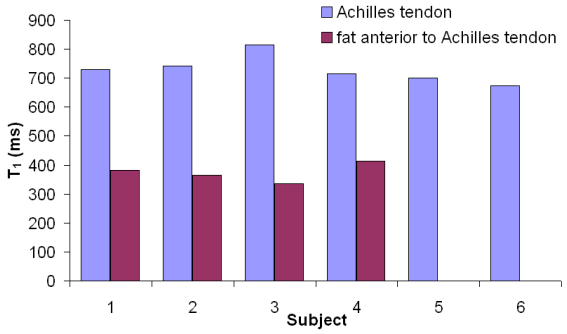

Figure 2. T_1 measurements for Achilles tendon and fat.

The T_1 measurements for all subjects are shown in figure 2, with the mean for Achilles tendon and fat anterior to Achilles tendon being 729 ± 48 ms and 374 ± 33 ms respectively. Saturation was found to be imperfect with F = 0.12 ± 0.05 (mean ± stdev) for the Achilles tendon and 0.18 ± 0.13 (mean ± stdev) for fat anterior to the Achilles tendon.

DISCUSSION AND CONCLUSION: T_1 measurements of fat are comparable to those previously reported [2]. T_1 measurements of the Achilles tendon have previously been reported in cadaveric specimens at 3 T [3, 4] and in-vivo at 1.5 T [5] using a UTE sequence. This study differs in that the T_1 values of the Achilles tendon presented here are in-vivo and the values measured here are somewhat higher than those reported ex-vivo at 3 T (631ms and 598 ms respectively) [3, 4]. This could be due to differences between cadaveric and in-vivo tissues (such as level of hydration, temperature, or whether the tendon is under load) or imperfect RF saturation; other factors could be regional differences in T_1 (it has also been shown that T_2 differs depending on location [6]) or differences in the subject population. T_1 measurements are feasible and may be useful for quantifying Achilles tendonopathy as well as for other techniques such as quantitative contrast enhancement

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