Ultrashort echo time MRI for quantification of tendon disease in spondyloarthritis.

R. J. Hodgson[1], N. Menon[2], A. J. Grainger[2], P. O'Connor[2], D. McGonagle[3], P. Helliwell[3], P. Emery[3], and M. D. Robson[4]
[1]LMBRU, University of Leeds, Leeds, Yorkshire, United Kingdom, [2]Leeds Teaching Hospitals NHS Trust, [3]University of Leeds, [4]University of Oxford

Introduction: The Achilles tendon is commonly involved in spondyloarthritis (SpA). There is increasing interest in quantifying tendon changes to monitor disease progression and response to treatment. While conventional MRI is excellent for demonstrating changes in the surrounding tissues (e.g. retrocalcaneal bursitis, calcaneal oedema), assessment of the tendon itself is limited by its short T2 (~2ms [1]); abnormalities are only seen if the T2 is substantially increased or the tendon is thickened. Recently, short echo time (STE) MRI (TE~2ms) and contrast enhanced ultrashort echo time (UTE) imaging have been shown to be effective at demonstrating tendinopathy [2]. The aim of this work was to quantify signal changes, assess inter-observer variability and compare patients with SpA to healthy volunteers.

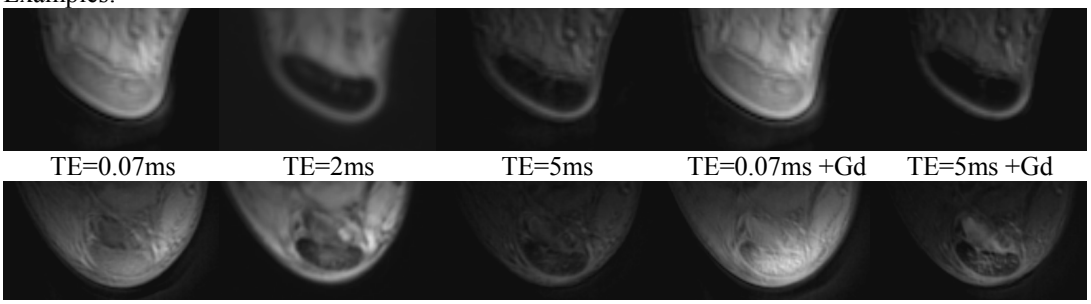
Methods: Achilles tendons of 24 symptomatic patients with SpA and 14 normal volunteers were studied. MRI was performed at 3T using a 4cm receive surface coil. 2D axial UTE images were acquired with nominal TE=0.07 and 5ms from each excitation (TR=100ms, flip-angle=45º) before and after intravenous Gd-DOTA. STE 3D-SPGR images were also acquired (TR=7ms, TE=2ms, flip-angle=15º). The 3D-SPGR images were reconstructed to similar slices to the UTE images. The entire cross-section of the Achilles tendon was outlined 0.5cm above the calcaneus. The signal intensity of the tendon was measured from each sequence. The following ratios were calculated: (i) $RE_{0.1}$: (post-contrast UTE - pre-contrast UTE) / pre-contrast UTE, (ii) RE_5: (post-contrast TE=5ms – pre-contrast TE=5ms) / pre-contrast TE=5ms, (iii) RTE_2: pre-contrast TE=2ms / pre-contrast UTE, (iv) RTE_5: pre-contrast TE=5ms / pre-contrast UTE. The contrast-to-noise ratios for enhancement (post-contrast – pre-contrast / noise) were measured for UTE ($CNR_{0.1}$) and TE=5ms (CNR_5) images. In 10 subjects measurements were made independently by 2 radiologists and the inter-observer intraclass correlation coefficient ($ICC_{3,1}$) and RMS error was calculated. Results from SpA patients and normal volunteers were compared. Correlations between the measurements and clinical parameters were sought. Using the clinical diagnosis of SpA as a gold standard, receiver operator curves were calculated and the area under the ROC curve were calculated.

Results: CNR was higher on UTE than gradient echo (TE=5ms) images (9.3 vs 4.5, $p<0.001$).

	$RE_{0.1}$	RE_5	RTE_2	RTE_5
$ICC_{3,1}$	0.998	0.995	0.995	0.983
RMS error	8%	12%	4%	7%
SpA vs. Control - mean (sd) p-value	0.24 (0.24) vs 0.05 (0.03) **p=0.008**	0.38 (0.43) vs 0.12 (0.23) NS	12.0 (4.8) vs 6.5 (2.2) **p<0.001**	0.25 (0.08) vs 0.19 (0.04) **p=0.007**
Area under ROC (95% CI)	0.76 (0.61-0.91)	0.67 (0.49-0.85)	0.90 (0.79-1)	0.76 (0.61-0.91)

Age was negatively correlated with enhancement (Spearman's rho=0.4, p=0.03). No significant correlations were shown with disease duration or CRP.

Examples:



Conclusions: 4 measurements have been presented, 3 of which require UTE imaging. All showed good inter-observer reproducibility. The 3 UTE techniques were significantly higher in patients with SpA and gave ROC curves which were significantly better than chance for distinguishing SpA patients from normal volunteers. The ratio of tendon signal intensity on a 2ms SPGR image to a UTE image appeared to be the best measurement with good-excellent discrimination of SpA patients and healthy volunteers and has the advantage of not requiring intravenous contrast.
In conclusion, ultrashort echo time measurements based on $T2^*$ and contrast enhancement show promise for quantifying disease in the Achilles tendon in spondyloarthritis.

[1] Filho GH et al. AJR 2009;192:117-122 [2] Hodgson RJ et al. ISMRM 2010