Sodium, CEST and T2* of Human Achilles tendon in Subjects after Ciprofloxacin Treatment

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Introduction

It has been shown previously that ciprofloxacin treatment may induce Achilles tendon disease manifested by irregular collagen fiber arrangement, hypercellularity, and decreased glycosaminoglycan content, similar to tendon overuse injuries in athletes[1]. Recently, it has been investigated that Achilles tendon biochemistry can be non-invasively visualized by modern MRI approaches, such as sodium imaging[2], or bi-exponential T2* mapping[3,4]. The aim of this study was to investigate whether these new biochemical MRI techniques are sensitive enough to reveal biochemical changes in Achilles tendon in subject undergoing ciprofloxacin treatment.

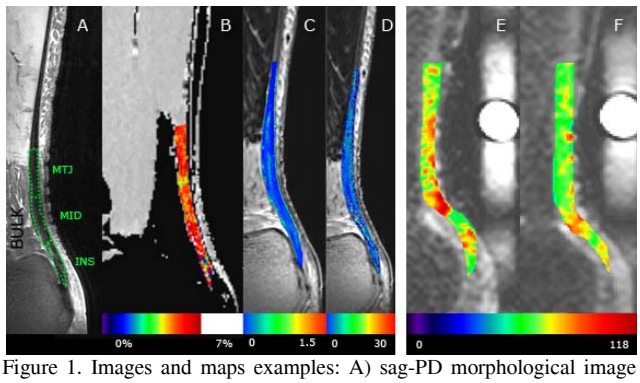

Figure 1. Images and maps examples: A) sag-PD morphological image (INS-insertion, MID-mid portion, MTJ-musculo-tendon junction); B) gagCEST map; C) T_2* short component; D) T_2* long component; E) sodium image with reference sample (**before** ciprofloxacin treatment); F) sodium image with reference sample (**after** ciprofloxacin treatment)

		before/10d	before/5m	10d/5m
BULK	T2*s	0.942	0.188	0.155
	T2*l	0.968	0.816	0.881
	gagCEST	0.054	0.104	0.253
	sodium	**0.036**	0.066	0.704
INS	T2*s	0.433	0.140	0.163
	T2*l	0.488	0.226	0.381
	gagCEST	0.304	0.197	0.088
	sodium	**0.002**	**0.035**	0.763
MID	T2*s	0.584	0.900	0.084
	T2*l	0.679	0.839	0.447
	gagCEST	0.195	0.078	0.052
	sodium	0.168	0.088	0.592
MTJ	T2*s	0.686	0.489	0.121
	T2*l	0.590	0.802	0.675
	gagCEST	0.221	0.072	0.127
	sodium	0.075	0.149	0.899

Table 1. The p-values calculated by using paired t-test. Statistically significant values are typed in bold. Sodium imaging as an only technique was able to distinguish between different time points (before ciprofloxacin treatment and directly after)

Materials and Methods

Seven subjects (14 ankles in total) were included in the study (32±12 years). The local ethics commission approved this study, and all volunteers and patients gave written, informed consent. All subject underwent MR examinations at 7 Tesla (Siemens, Erlangen, Germany) in three time points: 1) before ciprofloxacin treatment; 2) 10 days after; and 3) 5 months after. MRI examinations consisted of four methods: • *sag-PD-TSE* to acquire morphological images for VIMATS scoring [5]; • *sag-vTE-sodium* sequence (matrix 256^2, TA 14:59min, 3 slices, TE 2.45ms, TR 40ms, slice thickness 6mm); • *gagCEST mapping* (3D, TE 3.2ms, TR 7.3ms, TA 9:45min) [6]; and • *T2* mapping* with vTE (10 TEs 1.12 to 26.48 ms, TR 34ms, matrix 608x432, TA 10:57min). Individual parameters were compared between respective time points using a paired t-test in SPSS.

Results

Example images are depicted on the Figure 1. Mean sodium signal[a.u.] was 126±20, 102±15 and 118±26 in three time points; T2*s[ms] was 0.45±0.13, 0.37±0.08 and 0.57±0.39 and CEST values[a.u.] 4.73±0.75, 4.72±0.62 and 4.86±1.12. Normalized sodium signal was able to distinguish between the Achilles tendon before ciprofloxacin treatment and ten days after. Five month after the treatment, there was a significant change, however, observed only in INS area. As for other parameters, neither of them showed ability to distinguish between respective time points (Table 1), although some of them were close to significance level (e.g. CEST).

Discussion

As it was shown previously, sodium MRI could work as a marker for GAG changes in Achilles tendon during pathological processes. This study showed that it may be sensitive enough to visualize macromolecular alterations which are present after ciprofloxacin treatment. Interestingly, gagCEST does not demonstrate this ability, although the p-value for BULK was only slightly above 0.05. T2* reflects mostly the water and collagen interplay, therefore, the results were expected as they are.

Conclusion

Sodium MRI was proven to be a potential marker for Achilles tendinopathy after ciprofloxacin treatment.

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