

The Role of Diffusion Tensor Imaging in the Characterization of Myopathy Caused by Systemic Sclerosis – Initial Results

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Introduction: Scleroderma is a chronic autoimmune disease characterized by fibrosis, predominantly of the skin and vessels. The diffuse form or systemic sclerosis (SSc) is rapidly progressing and can also affect internal organs, frequently the kidneys, oesophagus, heart and lungs, but also the skeletal muscle. Systematic muscle pathological studies report a high prevalence of skeletal muscle involvement. No definite criteria exist for the diagnosis of scleroderma-associated myopathy. Clinically, the SSc-associated myopathy shares many features with polymyositis or dermatomyositis. Mimura *et al.* (1) reported a higher prevalence of heart involvement in myopathy-associated SSc and presented a higher frequency of pulmonary fibrosis and contractures of the phalanges in this group as compared to that of SSc-patients without myopathy.

Non-invasive procedures such as MR imaging provide data that may be useful not only in the characterization of the disease but also in therapeutic decisions and long-term management of these patients. Short inversion time inversion-recovery (STIR) magnetic resonance (MR) is a well-established method to non-invasively detect and monitor inflammatory myopathies (2-4). Diffusion tensor imaging (DTI) is able to display diffusional anisotropy of tissue. Initially used for neuronal fiber tracking, DTI has been proven to be a powerful non-invasive tool for providing information about tissue characteristics and pathology. DTI-based tissue characterization may reflect the microarchitecture of the muscle (5-6).

Aim of the present study was the characterization of SSc-associated myopathy based on STIR imaging and DTI.

Materials and Methods: Six patients (2 male, 4 female, 48±4yrs) suffering from SSc with myopathy and 3 healthy volunteers (37±8yrs) were examined in a 1.5 T whole-body MRI scanner (Magnetom Avanto, Siemens Healthcare, Erlangen, Germany). All the patients had active disease requiring new or intensified treatment (cyclophosphamide, prednisone). A body transmit/receive body coil was used for all measurements. Coronal STIR images (TR/TE, 4580/87; inversion time, 150 ms) were acquired during a whole-body examination. At affected sites of the body, additional axial STIR images (TR/TE, 4270/103; inversion time, 160 ms, 7 mm slice thickness) and diffusion images were acquired (most often the upper and/or lower leg as well as the trunk). In the present study, patients with affection of the lower leg were chosen. The diffusion tensor was measured in transverse slices through the lower leg. The tibialis anterior muscle (Ta) and the medial head of the gastrocnemius muscle (Gm) were evaluated (see **figure 1**). Maps of the mean diffusivity (ADC, given in $10^{-3}\text{mm}^2/\text{s}$) and the fractional anisotropy (FA) were calculated. Diffusion images were acquired using a diffusion-weighted stimulated echo (STE) EPI sequence with following sequence parameters: TR = 3200 ms; TE = 35 ms; TM = 150 ms; slice thickness 4 mm; 4 averages; receiver bandwidth 2440 Hz/Px. The voxel size was 3 x 3 x 4 mm. The chosen b-values were 0 and 600 s/mm^2 .

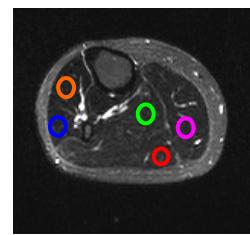


Figure 1: Axial STIR in a healthy volunteer. The analyzed muscles in a counterclockwise direction: tibialis anterior (Ta), peroneus longus (Per), medial head of gastrocnemius (Gm), lateral head of gastrocnemius (Gl), soleus muscle (Sol).

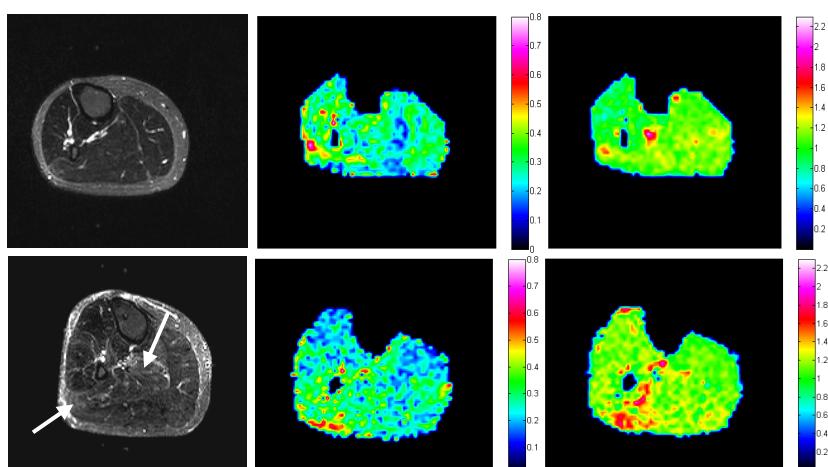


Figure 2: STIR images, FA and ADC maps of one healthy subject (female, 32 yrs, upper row) and one patient (lower row). Note the increased signal intensity especially in the lateral head of the gastrocnemius muscle and the soleus muscle (arrows). Note also the infiltration of dermis and the subcutaneous tissue in the STIR images of the SSc-patient.

	Volunteers		Patients	
	FA	ADC	FA	ADC
Ta	0.22 ± 0.01	1.04 ± 0.01	0.23 ± 0.01	1.18 ± 0.02
Per	0.28 ± 0.01	1.02 ± 0.19	0.29 ± 0.01	1.20 ± 0.17
Gm	0.21 ± 0.02	1.05 ± 0.02	0.22 ± 0.02	1.19 ± 0.04
Gl	0.27 ± 0.21	1.10 ± 0.01	0.27 ± 0.01	1.28 ± 0.04
Sol	0.27 ± 0.01	1.11 ± 0.01	0.26 ± 0.02	1.20 ± 0.03

Results: Two patients showed no affections of the gastrocnemius muscle in the STIR images, one showed no affections in the Ta muscle. FA and ADC values of the affected muscles were assessed. The mean values of the volunteers and the SSc-patients are given in **table 1**. Additionally, visually not involved muscle groups were also determined (data not shown). Two exemplary subjects are presented in **figure 2**. The SSc-patients and the volunteers showed comparable FA values in the affected muscle groups. In contrast, the ADC values in the SSc-patients showed an increase between 8-19%. Interestingly, some muscle groups with invisible changes in STIR imaging showed discrete changes in ADC as could also be seen in the exemplary patient in **figure 2**.

Discussion: In most SSc patients, muscle biopsy detects perimysial fibrosis with or without perimysial inflammatory cells, microangiopathy, and type 2 fiber atrophy, but little if any myofiber destruction (7). This could explain the presented results since fractional anisotropy values were mainly unchanged while the mean diffusivity was increased. This correlates with the theoretical assumption that the diffusion of water increases in the perimysial space leading to an overall increased diffusivity. In conclusion, correlated with STIR imaging, the mean diffusivity of affected muscle groups showed an increase while the fractional anisotropy remained unchanged. This could be explained by the mainly perimysial changes in the musculature while the myofibers remain unchanged. It might be possible that changes in mean diffusivity may be present even before changes in the STIR imaging occur. The investigation of early ADC changes should be the aim of a following prospective study.

References:

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