DTI and Fiber Tracking Determined Muscle Abnormalities in an Undiagnosed Myopathic Patient

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Introduction: Numerous diseases of the musculoskeletal system have been successfully examined and evaluated with MRI techniques (1). There are, however, patients with severe muscle pain and fatigue, who cannot be diagnosed within the diagnostic clinical categories. In this investigation, an undiagnosed patient with severe weakness and discomfort was examined with conventional MRI and did not reveal any muscle abnormalities. However, the more advanced techniques of diffusion weighted imaging (DWI) (2) and diffusion tensor imaging (DTI) (3) showed a decreased number of muscle fiber tracks and structural dislocations in the fiber architecture. These findings are discussed in relation to muscle function and life style modifications.

Subjects and Methods: A myopathic undiagnosed male patient was compared with two age- and gender-matched controls. The 39 years old patient had experienced a transient hearing loss, which was treated with corticosteroids as it was thought to be of autoimmune origin. He then developed neurological symptoms such as numbness in his legs, twitching, and weakness, but these symptoms were not supported by neurological examinations. Subsequently, he presented with transient elevation of CPK and musculoskeletal complaints, but again these complaints were not confirmed by the rheumatologist's exam. His health assessment questionnaire (HAQ) scored on a 0 to 10 cm scale showed pain, gastrointestinal (GI) trouble, fatigue, and weakness at levels of 7.2, 5.0, 8.6, and 2.2 cm. The values were out of the range of the two controls.

Thigh muscles of the patient and controls were imaged using a 1.5T Philips MR scanner with a knee coil for signal reception and body coil for excitation. The imaging sequences and parameters were: dual-echo T1-weighted (TR/TE= 500/20,80 ms) and T2-weighted (TR/TE= 2000/20,80 ms) spin-echo images (4 slices, slice thickness = 10 mm, FOV = 200 × 200 mm^2, matrix size = 256 × 256, number of signal averages (NSA) = 1); STIR images (TR/TE = 2000/53 ms, IR delay = 153 ms); DT images (TR/TE = 6000/69 ms, slice-thickness = 5 mm, b value = 600 $s{\cdot}mm^{-2}$, single-shot spin-echo EPI readout, NSA = 12, FOV same as above, matrix size = 112 × 112). T1 and T2 values were calculated based on T1- and T2-weighted images with varied TR or TE values. DTI data analyses and fiber tracking were performed with Philips Pride software, with FA threshold = 0.15 and direction threshold = 108°.

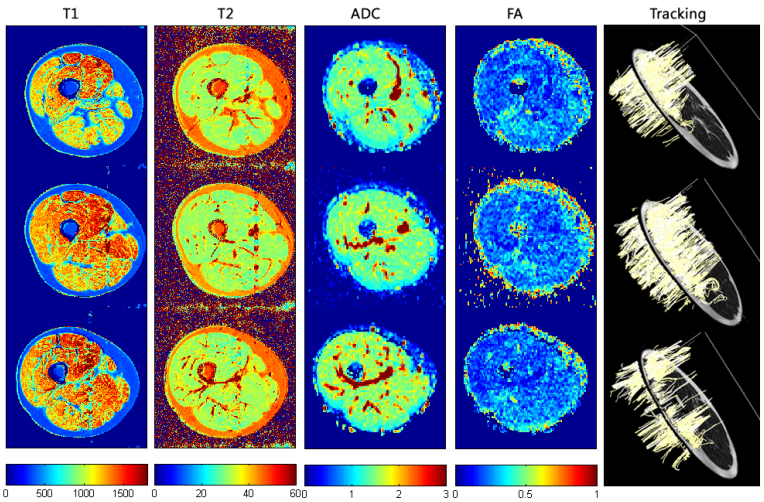

Figure 1. Parameter maps of thigh muscles and VL fiber tracks for the controls (top two rows) and the patient (bottom row).

Results and discussion: Visual analyses of the T1-, T2-weighted and STIR images did not reveal any inflammation or fat infiltration in the muscles of these subjects. Calculated T1 and T2 parameter maps did not show abnormalities in the patient, as shown in Figure 1. In addition, ADC and FA parameter maps were used to evaluate the muscles, and no significant abnormalities were observed as well. Comparisons of T1, T2, ADC, and FA values of vastus lateralis (VL), vastus intermedius (VI), and rectus femoris (RF) muscles are plotted in Figure 2. No significant differences were observed in T1 and T2 values. However, ADC values of VL, VI, and RF muscles of the patient were found to be slightly higher than those of the controls; while FA of VL and RF muscles were slightly lower. This may indicate that DTI parameters are more sensitive to muscle abnormalities than T1 and T2 values. DTI fiber tracking was found to be the most sensitive approach. One example of fiber tracking in VL muscles is shown in Figure 1 (right column). The fiber track densities of the patient are significantly lower than those of the controls. For the patient, the fiber track densities of VL, VI and RF muscles are 33%, 32%, and 72% of the average of those muscles of the controls. The fiber tracks of muscles of the patient are not as aligned or as orderly as control fiber tracks (Figure 1). These data indicate that DT fiber tracking is a powerful method to identify muscle abnormalities in patients with a questionable diagnosis.

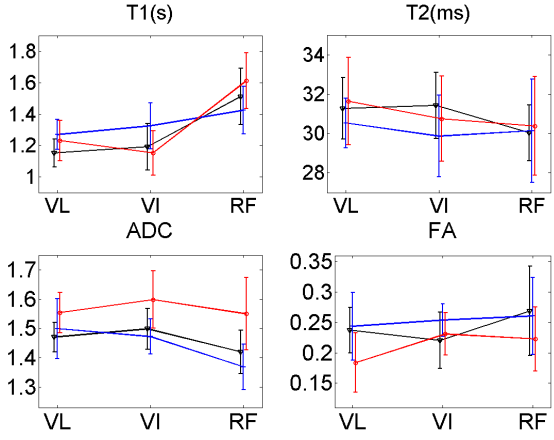

Figure 2. Comparison of T1, T2, ADC, and FA values of VL, VI, and RF muscles of controls (black and blue) and patient (red).

Conclusion: The decreases in the patient fiber track density and distortion in the fiber track architecture could account for weakness, fatigue, and modifications in an active life style. These observations of MRI abnormalities may modify the physicians' evaluations of patient's disabilities and the designs for rehabilitation procedures for restoring normal activity.

References: (1) Fleckenstein JL, et al., Springer-Verlag, NY, 1996. [2] Qi J, et al., JMRI 2008(27):212. [3] Park JH, et al., Arthritis & Rheumatism, 2009(60, Suppl 10):1179.

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