Diffusion-Weighted Imaging (DWI) for Evaluation of Muscle Diseases: Dermatomyositis and Polymyositis

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Synopsis
Diffusion-weighted imaging (DWI) shows potential for evaluation of inflammatory myopathies, such as dermatomyositis (DM) and polymyositis (PM). Regions of inflammation in muscles of DM patients showed anisotropy and elevated apparent diffusion constants (ADC), which were partially normalized following immunosuppressive therapy. With the PM patients, regions of extensive fat replacement showed ADC values lower than that of normal muscle and anisotropy in the z direction, indicating residual structural morphology. DWI provides useful information for characterization of myopathies and evaluation of therapy.

Introduction
Dermatomyositis is an inflammatory myopathy characterized by a typical rash, weakness, muscle inflammation, vasculitis and elevated serum CPK. Polymyositis also presents with weakness, fatigue, and inflammation in the early stages, but with time progressive fat infiltration can completely replace essential muscle groups. T1- and T2-weighted images, as well as STIR images, have been used for quantitative evaluation of inflammatory myopathies (1,2). The present report describes DWI studies which provide additional information that may relate to the pathogenesis of muscle disease.

Methods
Imaging of the thigh muscles of 14 myositis patients and 5 normal controls was performed using a 1.5 T Signa LX clinical scanner and an extremity coil. Axial T1- and T2-weighted images were acquired for calculation of T1 and T2 relaxation times, and STIR images were quantified with signal intensities. DW images were obtained using a DW-EPI pulse sequence with acquisition parameters: TR/TE 6300/112 ms, FOV 26, 128 X128 matrix, slice thickness 10 mm with 10 mm spacing, and 22 diffusion gradients (b values) ranging from 0 to 1000 s/mm² (3,4). Images were acquired in x, y, z, and combined directions independently. Signal intensities were plotted as S/So versus b values and fitted with a biexponential equation for determination of ADC short (intracellular) and ADC long (extracellular). Selected patients demonstrate the clinical potential of DWI.

Results
Dermatomyositis: A 43-year old woman presented with typical rash, severe weakness, and CPK levels of 1495 IU. Inflammation in the vastus muscles was observed on T2-weighted images (Fig. 1A) and verified by elevated T1 and T2 values. The biceps femoris was essentially unaffected. DWI data for the vastus lateralis showed a 20% increase in the ADC short value (Table 1) and elevated ADC long for the capillary bed. After four months of therapy, the patient showed significant clinical improvement, and MRI analyses demonstrated reduced inflammation. ADC values were also improved, but not completely normalized.

Polymyositis: In the early stages of PM (acute), muscles with inflammation had ADC values similar to DM muscles (Table 1). For another patient, a 74-year old male with chronic PM, MRI showed total fat replacement and atrophy of the vastus muscles but sparing of the biceps femoris and semimembranosus (Fig. 1B). Fat within the vastus muscle region had T1 and T2 values identical to those of superficial fat. ADC short was lower than normal muscle values and showed anisotropy in the y direction.

Discussion
ADC values provide unique information regarding molecular motion which may relate to the delivery of metabolites and oxygen to muscles. In DM muscles with inflammation, elevated ADC short reflects the increased fluid observed on T2-weighted and STIR images. When inflammation is partially resolved by therapy, ADC values decrease accordingly. Elevated ADC long values may result from vasculitis which hinders transport across the endothelium. With chronic PM, low ADC short values and anisotropy suggest that fat replacement occurs within the fascial structure of muscles. By contrast, superficial fat shows random motion. Slow, progressive fat infiltration can restrict delivery of metabolites and thereby contribute to muscle atrophy.

References

Table 1: ADC short and ADC long for vastus lateralis (VL) and biceps femoris (BF) muscles in control and patients

<table>
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<tr>
<th>Subjects</th>
<th>VL ADCs (×10⁻⁹ m²/s)</th>
<th>BF ADCs (×10⁻⁹ m²/s)</th>
<th>VL ADCl (×10⁻⁹ m²/s)</th>
<th>BF ADCl (×10⁻⁹ m²/s)</th>
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<td>Control</td>
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<td>23.3</td>
<td>11.4</td>
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<tr>
<td>DM (2nd Visit)</td>
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<td>22.3</td>
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<tr>
<td>PM (acute)</td>
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<td>22.5</td>
<td>6.4*</td>
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<td>PM (chronic)</td>
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<td>8.6</td>
<td>11.6*</td>
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* values for semimembranosus (SM)

Fig. 1: T2-weighted images of thigh muscles for DM patient with inflammation (A) and PM patient with fat replacement and atrophy (B)