

# Magnetic Resonance Findings and Serum Creatine Kinase Measurements in Acute Human Skeletal Muscle Injury

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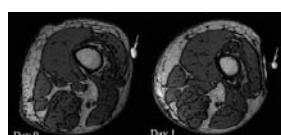
**Introduction:** Measurement of blood serum creatine kinase (CK) is a widely used biochemical test to grade/stage musculoskeletal pathology. This test suffers from lack of anatomical specificity and a brief diagnostic window as the CK level returns to normal well before healing is complete. Magnetic resonance imaging (MRI), in particular, diffusion tensor magnetic resonance imaging (DT-MRI) has been successfully used to detect changes in pathological muscle tissue due to injury [1,2,3]. The eigenvalues and eigenvectors of the diffusion tensor provide information about local tissue anisotropy. In addition, tissue fractional anisotropy (FA) and apparent diffusion coefficient (ADC) may be calculated, which provide reliable estimation of altered cellular geometry [4]. In this study, we applied DT-MRI to temporally characterize structural changes associated with acute skeletal muscle injury. Muscle biopsy was utilized as the experimental model since it allows for localization of injury and control for time. Correlation of DT-MRI with serum CK was performed.

**Subjects and Methods:** In a study approved by our local research ethics board, patients recruited in our outpatient clinic (n=7) were imaged using a 3.0T shortbore scanner and standard quadrature knee coil (GE Healthcare, Milwaukee, WI). DT-MRI was performed using a spin echo EPI pulse sequence with 25 motion probing directions,  $b=200$  s/cm<sup>2</sup>, TE=61.7 ms, TR=6 sec, FOV=20 cm, NEX=12. The matrix size was 64x64, 3mm slice thickness. The resultant SNR using these parameters was approximately 40 across subjects. Water diffusion was characterized by the FA and the ADC. Calculation of eigenvalues ( $\lambda_1, \lambda_2, \lambda_3$ ), FA and ADC were performed using in-house programs developed using MatLab (The Mathworks, Natick VA). In addition to DT-MRI, high-resolution T1-weighted images (SPGR, 256x256, 20 cm FOV, 1 mm slice thickness) were acquired. Scans were performed immediately before and after biopsy, and on days 2, 6, 8, 15, 24 and 31 post-biopsy. Blood serum was collected at each scanning session for subsequent CK assessment. One representative case of DT-MRI and serum CK is presented. This patient has myopathy and was medically treated.

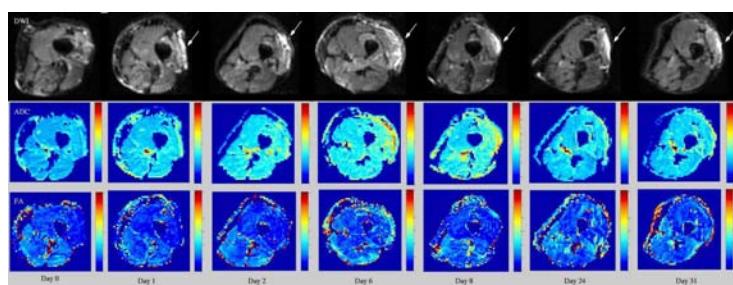
**Results and Discussions:** T1-weighted images (Fig.1) did not show any biopsy-associated abnormalities. However, DT-MRI (Fig.2) demonstrates the extent of the lesion due to biopsy (high intensity areas on DWI images). In addition, DT-MRI clearly indicates substantial muscle tissue abnormalities lasting as long as 31 days post-biopsy, which correlates with the results by Shellock et al. [5] and by Fleckenstein et al. [6] based on T1 (STIR) and T2-weighted MR images. In addition, ADC maps demonstrate the biopsy lesion and extent of extra-lesion involvement (e.g. edema) much clearer than FA maps (Fig.2). Conversely to our DT-MRI results, serum CK had returned to normal before day 31 (Table 1) and clinically the patient was asymptomatic by day 8.

**Conclusions:** Our results indicate that DT-MRI is very sensitive to muscle tissue alteration in the post-injury period. In addition, DT-MRI shows muscle tissue abnormalities persisting as long as 31 days post-biopsy while the standard clinical biochemistry method, using serum CK, had returned to normal by this time. Therefore, not only does CK lack specificity for skeletal muscle damage, it also does not accurately reflect temporal dynamics associated with skeletal muscle damage and repair.

**References:** [1] W.A. Murphy et al. [2] A.A. DeSmet. *Skeletal Radiol.* 22:479,1993. [3] N.J. Olsen et al. *Cur.Rheumatol.Rep.* 7:106,2005. [4] P. Basser, D.K. Jones. *NMR Biomed.* 15,456,2002. [5] F.G. Shellock et al. *Radiology* 179:659,1991. [6] J.L. Fleckenstein et al. *Musculoskeletal Radiol.* 172:793,1989.



**Fig.1.** Axial T1-weighted images of human thigh muscles obtained before and immediately after biopsy. The arrows point to fiducial marker over biopsy site.



**Fig.2.** Axial images of human thigh muscles obtained before and immediately after biopsy, and days 2, 6, 8, 24, 31 post-biopsy. Top row: DWI images; middle row: ADC maps; bottom row: FA maps. The arrows (high intensity on DWI images) indicate site of biopsy.

data	serum CK concentration in blood
Day 0 (pre-biopsy)	1030
Day 1 (immediately after biopsy)	1110
Day 8 (post- biopsy)	882
Day 31 (post-biopsy)	134

**Table 1.** Serum CK concentration in blood for one of the patients (representative case).