Effects of Gd bolus on DTI measurements in Skeletal Muscle

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Purpose/Introduction: Diffusion tensor imaging (DTI) is now a commonly used MR procedure. However, it is done either before or after Gd contrast enhanced scans without sound knowledge of the agent's effect on DTI measurements. We propose to investigate whether the presence of a standard clinical dose of Gd-DTPA-BMA affects the outcome of DTI measurements. Human calf skeletal muscle was chosen to allow simple comparisons between tissues with differing vascular density (gastrocnemius vs. soleus muscles).

Methods: In a study approved by our research ethics board, normal healthy volunteers (N=3 male, mean age = 30.5 ± 3.7yrs) were examined using a twin speed 3.0 T Excite MR system (General Electric Medical Systems, Milwaukee, WI). Volunteers were free of vasomodulating medications and substances for 12 hours prior to scanning. The right calf was immobilized in a standard transmit-receive extremity coil. Prior to diffusion scans a SPGE single slice structural scan was acquired for ROI analysis. Diffusion scans were completed before and after a bolus (0.2 mmol/kg Gd-DTPA-BMA, Omniscan, GE Healthcare, Milwaukee, WI) injection. Diffusion images were acquired using a cardiac gated twice-refocused SE (EPI) sequence [1] with 6 b-values with increasing gradient strengths ranging from 104 to 305 s/mm^2 in six non-collinear diffusion directions. (δ=21ms, Δ=27.4ms, TE=76.5ms, TR = 6000ms, 12 mm thick, 20cm FOV, 64x64 matrix). For both the soleus and gastrocnemius, eigenvalues, fractional anisotropy (FA), and trace values (at each b-value) were calculated using in-house developed MatLab programs (The MathWorks Inc., Natick, MA).

Results and Discussion: Both soleus and gastrocnemius muscle showed differing diffusion characteristics, as expected. For both muscles, at all b-values examined, ADC was reduced following contrast administration (**Fig. 1**). This difference appeared more pronounced at lower b-values, possibly the result of 'pseudo-diffusion' [2], or IVIM. Lower b-values probe the blood pool which would contain the bulk of the contrast agent. However, even at higher b-values the calculated ADC's were significantly reduced (paired t-tests: for all b-values gastrocnemius ranges from P<0.003 to P<0.03, soleus from P<0.01 to P<0.03). The magnitude of reduction in ADC is greatest for soleus, likely explained by it's greater vascular density [3]. Changes in FA and the trace of the tensor were significantly different following contrast injection, in both muscles and across all b-values. In addition, greater variability in these parameters was observed for lower b-values, likely the result of blood-pool derived pseudo-diffusion (i.e. perfusion effects) [2]. The percent change in gastocnemius derived eigenvalues, between pre and post contrast, were inconsistent across b-values (**Fig. 2**). Conversely the soleus muscle showed a consistent depression of λ_1, λ_2, and λ_3 following Gd administration.

	% FA Change		% ΔTr	
b-value	**G**	**S**	**G**	**S**
104	-39.0±1.8	-51.4±29.1	23.8 ±2.7	34.3 ±9.3
125	-27.8±16.0	-43.7±22.4	29.9±13.3	36.9 ±1.4
184	-59.5±8.0	-43.6±1.2	14.3±5.3	26.5 ±7.5
230	-43.9±3.2	-42.5±1.2	19.1±1.2	26.3 ±9.6
287	-39.0±3.8	-32.2±1.0	18.4±5.7	24.7 ±5.5
305	-35.7±2.4	-33.7±3.8	19.3 ±4.0	24.7 ±6.7

Table 1: Percent difference (pre vs,. post Gd contrast injection) in FA and DTI trace for gastrocnemius (**G**) and soleus (**S**) muscles.

Conclusions: As differences in all DTI calculated parameters were measured it is suggested diffusion tensor images are acquired prior to any Gadolinium based contrast enhancement scans. Differences in lower b-value acquired DTI are more pronounced post-Gd, likely due to the pseudo-perfusion effect that these scans are sensitive to.

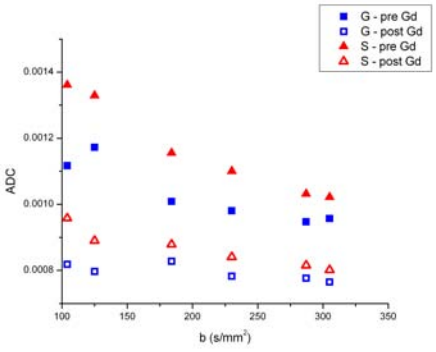

Fig. 1. Pre and post Gd ADC values for soleus and gastrocnemius muscles over a range of b-values.

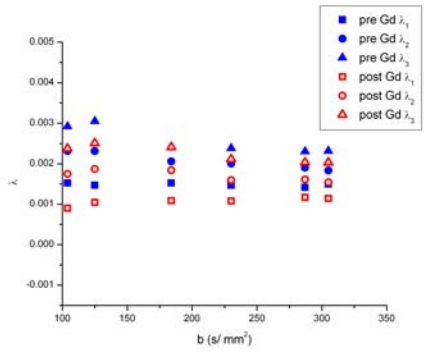

Fig. 2. Pre (blue) vs. post (red) Gd contrast injection DTI eigenvalues for gastrocnemius muscle.

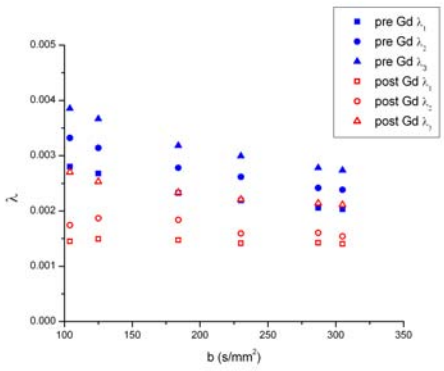

Fig 3. Pre (blue) vs. post (red) Gd contrast injection DTI eigenvalues for soleus muscle.

References: **[1]** Reese *et al.* (2003) *MRM*. 49:177; **[2]** Le Bihan, D *et al.* (1991). *MRM*. 19:221; **[3]** English *et al.* (1991) *MRM* 21:264.