Optimizing Diffusion weighted imaging of skeletal muscle.

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Purpose: High SNR and good image quality is very important in DTI studies of skeletal muscle[1]. When optimizing a diffusion-weighted sequence for skeletal muscle many decisions regarding the acquisition have to be made to get the most accurate results regarding fiber tractography and quantitative determination of diffusion parameters. An important step in protocol optimization is to define the number of diffusion gradients and signal averages with respect to the total examination time available. Additionally, one can choose a spin-echo or stimulated echo sequence with unipolar or bipolar diffusion gradients, which have different characteristics regarding SNR, diffusion weighting, T_1 and T_2 decay and sensitivity to eddy currents. The purpose of this educational poster is to define a framework for choosing the most optimal protocol for diffusion-weighted MRI of skeletal muscle.

Outline of Content: Skeletal muscle has a low T_2, thus a short TE is needed to obtain high SNR. There are a number of diffusion weighted sequences available, each with their own strengths and weaknesses.. The following sequences will be discussed: i.e.. spin echo Stesjkal-Tanner sequence[2], Twice refocused spin echo sequence[3], spin echo with one and two bipolar gradients[4], combined spin echo Stesjkal-Tanner and bipolar and stimulated echo Stesjkal-Tanner [5] (see figure 1). Simulations for each method can be used to describe the signal as a function of b-value and SENSE factor at a chosen maximal gradient strength, half Fourier factor and acquisition matrix. This allows for determination of the optimal SENSE factor for each b-value and method (figure 2). Furthermore, the eddy currents with a single exponential decay constant can be characterized (figure 1, green line). Deciding which sequence depends strongly on the application, the available gradient system and the coil setup. Furthermore, the region of interest will determine the acquisition matrix size, the number of slices needed and if the acquisition needs to be done in multiple stacks.

Once the correct sequence and parameters are chosen corresponding to the desired region of interest and research purpose, the next step is to optimize the reminder of the research protocol. Depending on the number of slices and the total measurement time further choices have to be made about how many signal averages and gradient directions can be used and which TR is optimal.

Summary: The wide variety of acquisition protocols described in literature reflect the many choices one can make in DTI of skeletal muscle. There is no general optimized protocol which is suitable for every muscle, measurement setup or application. However this presentation will show how simulation of the available options can reveal their strengths and weaknesses and allow for the best choice in each individual application (see figure 3).

References: [1] B. M. Damon. 2008, MRM; [2] E.O. Stejskal et.al. 1965 J Chem Phys; [3] T.G. Reese et. al. 2003, MRM; [4] U. Gamper et. al. 2007, MRM; [5] G. Steidle et. al. 2006 MRM.

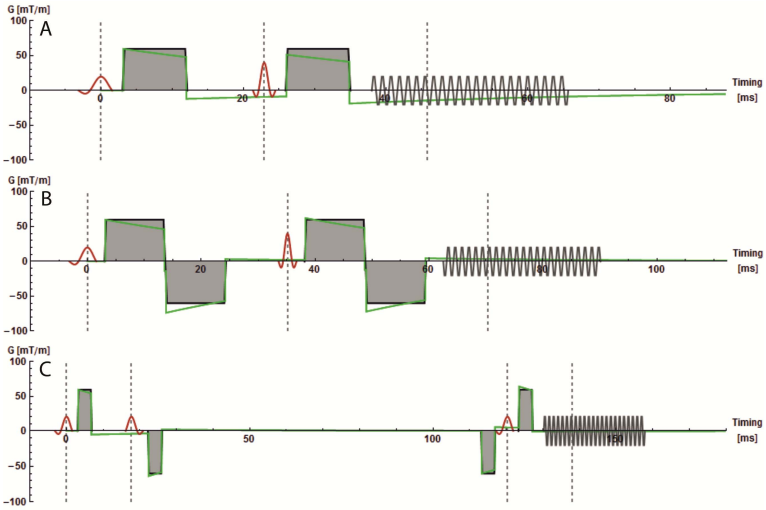

Figure 1: *Three examples of possible diffusion weighted pulse sequence, overlaid in green is the buildup and decay of eddy currents due to the gradient switching. A) Spin echo Stejskal-Tranner. B) Spin echo with two bipolar gradient pairs. C) Stimulated echo Stesjkal-Tanner with eddy current nulling gradients.*

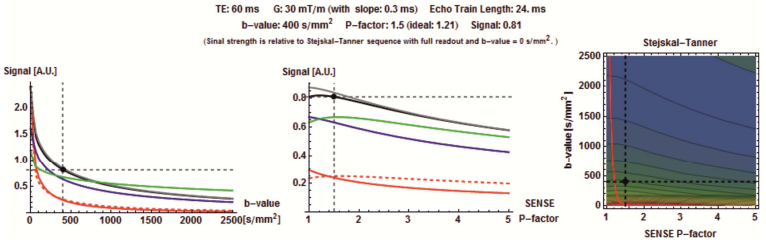

Figure 2: *Comparison of signal for different pulse sequences. A) Signal as function of b-value. B) Signal as function of SENSE factor. C) Optimal SENSE factor at different b-values.*

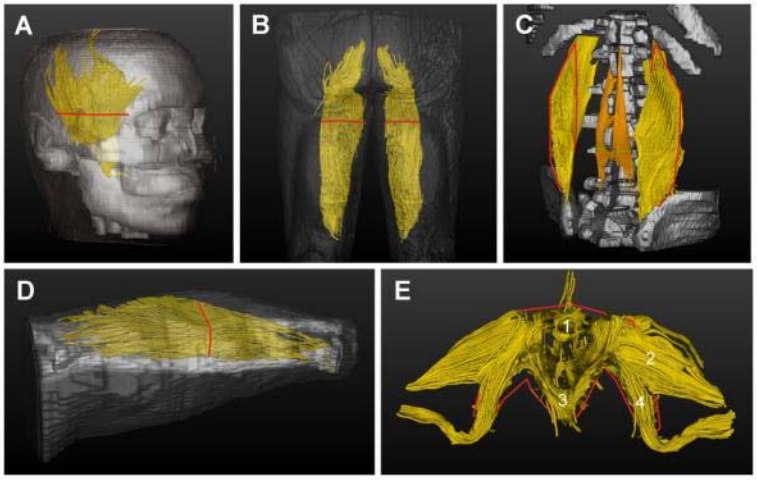

Figure 3: *Aplication of skeletal muscle DTI: A) Masticator muscles. B) Upper legs. C) Lower back. D) Forearm. E) Pelvic Floor.*