Effect of Registration on Fractional Anisotropy Values

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Introduction: Group analysis is commonly used for objectively investigating the effect of disease, treatment efficacy, identification of biomarkers etc. Group analysis generally requires registering individual images to a template or atlas. While group analysis is commonly performed in humans, it is much less common in rodents which are used in preclinical studies. Image registration generally involves some type of interpolation. In humans interpolation has relatively small effect because of the large anatomical structures. However, many of the anatomical structures in rodents are relatively small compared to the applied spatial resolution and image registration could introduce significant partial volume averaging that could affect the MRI-derived quantitative measures such as fractional anisotropy (FA). Specifically, in this study we investigated the influence of different types of registration on the FA values of splenium (scc) and genu (gcc) in adult Sprague Dawley rats.

Material and Methods: MRI studies were performed on a Bruker 7T MRI scanner on five male Sprague Dawley rats. The animals were anesthetized with Isoflurane (2%) and fixed in an animal bed. Vital signs were constantly monitored (breathing frequency, rectal temperature, pulse rate, blood oxygen levels). A surface and volume coil was used in cross coil mode to acquire diffusion weighted images with a four shot EPI Spin Echo protocol (128 by 128 matrix, spatial resolution 0.27 by 0.27 by 1.0 mm) with 42 directions in icosahedral bipolar orientation (b value 800 mm^2/s) for the recording of diffusion weighted data (1). The diffusion weighted images were preprocessed as described elsewhere (2). We used AIR (3), FSL (4), ANTS (5), and DTI-TK (6) for registering individual brain volumes to an in house created digital atlas based on diffusion weighted images. The FA values were calculated with DtiStudio and analyzed with ImageJ's ROI Manager. The FA values in the registered images were calculated by identifying the structures on the Paxon and Watson atlas. The FA values in individual animals were measured by manually placing the ROIs.

Results: As seen in Figure 1 registration resulted in a significant reduction (2-way ANOVA, $p<0.05$, Bonferroni posttest) in the FA compared with the unregistered data. This reduction appears to be independent of the registration technique. The maximal reduction, by 40%, was observed after the registration.

Discussion: Our results demonstrate that registration significantly reduces the FA values, independent of the registration techniques. Even tensor based registration (DTI-TK) did not improve the results. We suggest that the interpolation used in the registration methods results in significant partial volume averaging with the neighboring gray matter structures, resulting in reduced FA value. The registration on the FA values may be reduced by acquiring DTI data at very high resolution. However, this may not always be possible in in vivo. Our results suggest that caution should be exercised in interpreting the group analysis results of FA in rodents.

References: 1. Bockhorst et al, J Neurosci Res. 86, 1520 (2008); 2. Bockhorst et al, Proc Intl Soc Magn Reson Med 2583 (2009); 3. Woods et al, J Comput Assist Tomogr 22, 139 (1998); 4. Smith et al, Neuroimage 23 Suppl 1, S208 (2004); 5. Avants et al, Neuroimage 54, 2033 (2011); 6. Zhang et al. Medical Image Analysis 14 (2010).

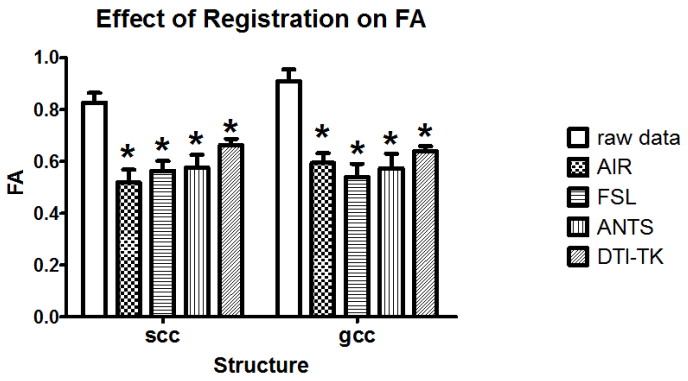

Figure 1: Effect of various registration algorithms on the FA values in genu and splenium of the rat's corpus callosum. (2-way ANOVA, $p<0.05$, Bonferroni posttest)