Comparison of the accuracy between manual and computerized anatomical delineation techniques in ex-vivo diffusion tensor imaging of the mouse brain.

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Introduction: Standard morphometric quantification of white matter (WM) integrity in brain, using ex-vivo diffusion tensor imaging (DTI), employs manual delineation of anatomical landmarks [1], which is both time consuming and subjective. In this study we evaluated a semi-automated technique to substantially shorten segmentation times and tested its accuracy against two independent raters as a reference standard. Corpus callosum (CC), internal capsule (IC), hippocampus (HP), and fimbria (FI) were studied.

Data acquisition: Eight wild type C57B6J mice (5 month old males), were fixed by delivering 4% formaldehyde PBS solution using a servo-controlled peristaltic pump to maintain normal perfusion pressure. The skull-attached specimens were immersed in a 2mM Gd-DTPA PBS solution for at least 8 days. Consequently, imaging was performed on a 9.4T Bruker magnet using an RF transmit and receive quadrature coil (I.D. 2.5cm) at room temperature (22±2°C). A DTI-SE sequence was implemented using the following parameters: b=0 s/mm^2, b=3000 s/mm^2 along 12 directions [2], TR=300ms, TE=30ms, and 350x100x100 interpolated to 370x200x200 yielding a reconstructed image resolution of 65x65x65µm.

Image processing: DTI indices were calculated by TrackVis using a standard mono-exponential diffusion model [3]. In the manual delineation technique, the two raters manually delineated RGB color encoded FA maps using Allen's brain reference atlas in the native space. In the computerized technique, the same raters manually delineated a group averaged FA template constructed by DTI-TK software [4], and these masks were inverse warped onto the native space as shown in Figure. 1. Structural volumes and FA were analyzed and performance of the methods were quantified by % difference=$2|V1-V2|/(V1+V2)*100\%$. We evaluated % difference between manual delineations performed by rater1vs rater2 (method 1), manual vs computerized delineation performed by rater 1(method 2), and manual vs computerized delineation performed by rater 2 (method 3).

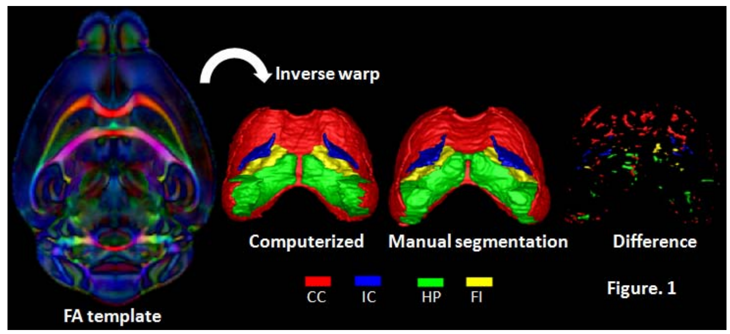


Figure. 1

Results: Discrepancies between rater1vs rater2 (method 1) yielded a 4~32% difference in volume estimates and a 1~7% difference in derived FAs. Discrepancies between manual and computerized delineation performed by the rater1 (method 2) yielded a 3~21% and 1~7% difference in volumes and FAs, respectively. Discrepancies between manual and computerized delineation performed by the rater2 (method 3) yielded a 4~31% difference in volumes and a 1~4% in FAs. Figure.2 summarizes the % difference for each structure of each method. Spatial mismatch between the methods consistently appeared near the anatomical boundaries and Dice metric (reflective of spatial overlaps) yielded 77% (CC), 75% (FI), 65%(IC), and 91%(HP), irrespective of the methods.

Figure. 2A

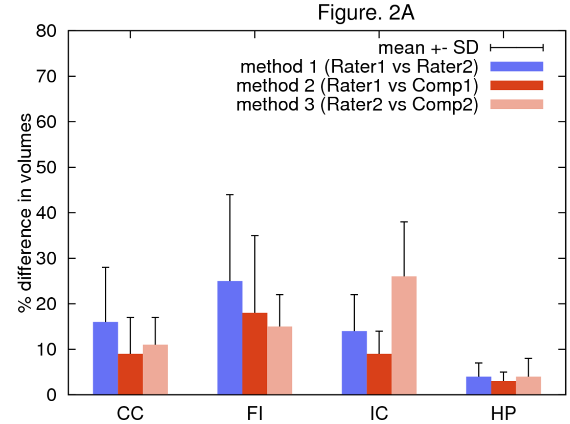
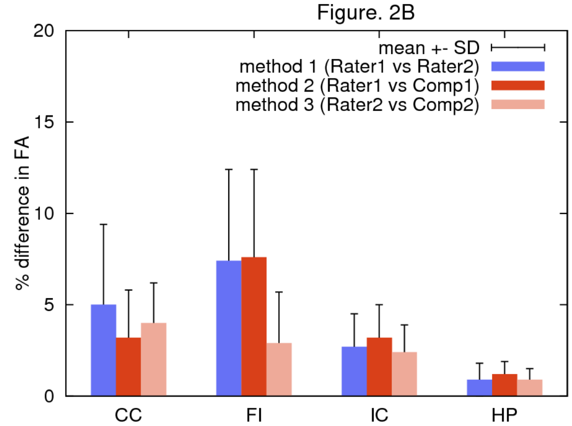


Figure. 2B



Conclusion: In this study, we evaluated a semi-automated computerized method that requires only one delineation in a dedicated template, thereby eliminating the need for delineating each scan separately. An issue associated with computer registration algorithms has been the imperfect registration yielding inconsistent results when compared to manual delineation techniques. However manual delineation techniques are known to be subjective [5]. Therefore we compared the discrepancies caused by subjective bias between raters (manual delineation) and inaccuracies caused by the registration technique (computerized). The computerized technique performed comparable or just below the reliability of the two raters, and we conclude that the computerized method is a time efficient way to analyze both morphometry and FAs in DTI maps.

References: [1] Chuang et al. NeuroImage (2011) [2] Papadakis et al. JMagnReson (1999) [3] Basser et al. Biophysical Journal (1994) [4] Zhang et al. IEEE TransactMedImaging (2007) [5] Bomekamp et al. NeuroImage (2007)