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GENERATION OF A MUSCLE FIBRE ORIENTATION ATLAS OF THE IN VIVO TONGUE

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Summary: Purpose: While diffusion tensor imaging based brain atlases are common, no attempts have been made to generate tongue atlases. An atlas based on tongue muscle fibre orientation may automate segmentation of tongue muscles in order to predict tongue functionality after surgery. In this work, we aim to generate a tongue atlas, based on in vivo muscle fibre architecture.
Methods: Diffusion-weighted images (DWIs) were acquired of 10 healthy volunteers in a 3T MRI. Two repetitions were made with opposing phase-encoding directions, voxel size of 3mm isotropic, b-value of 700s/mm2 in 64 directions, and scan time of 10 minutes. The acquisition was repeated after repositioning the subject within an hour. DWIs were corrected for Bo-inhomogeneity, eddy current distortion, and rigid motion. Fibre orientation distributions (FODs) were calculated using constrained spherical deconvolution. An initial template atlas was generated by alignment of all 10 FOD volumes on centre of mass. Subsequently, all FOD volumes were registered to the current template using an FOD-based registration. The template was replaced by the average of registered FOD volumes, and afterwards the registration was repeated on the updated template. To assess reproducibility, the processing was repeated using the second acquisitions. Finally, to determine the improvement of FOD-based registration compared to DWI-based registration, a DWI-based template was generated similarly by registering averaged bo-images instead of FODs. Template quality was assessed by calculating similarity on a voxel-level of FODs between ten subjects transformed to the template and the template using the spherical harmonic L2-norm (L2) and angular correlation coefficient (ACC), and paired t-tests (5% significance level). Finally, fibre tractography was calculated from the atlas.
Results: Both repetitions of FOD-based templates display significantly better similarity in both repetitions, compared to the DWI-based template ($P<0.001$). The templates from both repetitions were not significantly different ($P>0.05$). Tractography of the atlas displays several tongue muscles visually in agreement with an anatomical atlas.
Conclusion: For the first time, an atlas based on muscle fibre orientation has been created of the in vivo human tongue. This tongue atlas may facilitate automated segmentation of tongue muscles in subjects to evaluate impaired tongue function after tumour resection.