Dynamic imaging of muscles during speech using interleaved spiral FLASH

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Introduction: The ability to dynamically image the velar (soft palate) region in humans is crucial for a complete understanding of the anatomy and function of the region and for evaluating treatment options and follow-ups for velar inadequacy, a major problem in individuals born with the birth defect of cleft palate. Dynamic MR imaging has been previously applied to study temporomandibular joint **[1]**, the pharynx in sleep apnea **[2]**, tongue deformation during swallowing **[3]**, tongue deformation during speech **[4]**, and imaging of the vocal tract during speech **[5]**. In **[6]**, a dynamic study of the levator veli palatini (LVP) muscle was performed during speech. This muscle raises and lowers the soft palate and, therefore, is one of the most important muscles involved in normal speech production. In **[6]**, information about the muscle's angle of origin and length were examined in relation to speech samples. However, sustained speech samples were required to overcome imaging speed limitations of approximately 1 image per second. In this study, we will use an interleaved spiral acquisition to rapidly image the LVP muscle.

Methods: We use an 8-shot spiral acquisition on a Siemens 3T Allegra head-only MR scanner using the transmit/receive head coil, similar to the method used in **[5]**. The spiral is designed using **[7]** and utilizes a 30 mT/m gradient amplitude, 400 mT/m/ms slew rate, 24 cm field of view, TE/TR/flip angle of 1.8 ms/ 20 ms/ 20° and a matrix size of 128 x 128. The acquisition time per image was 160 ms, giving 6.25 frames per second (fps). A sliding window reconstruction was performed to increase the effective frame rate to 25 fps. A Cartesian FLASH sequence was also acquired for comparison with matrix size of 128x96 (partial Fourier of 3/4) with a TE/TR of 0.97 ms/ 2ms for a frame rate of 6.8 fps. A volunteer was scanned in accordance with the local institutional review board. The subject's voice was recorded using a microphone from Resonance Technologies (Northridge, CA) with active gradient noise cancellation. With accurate localization of the imaging plane, the LVP muscle can remain in-plane during its entire motion, facilitating single slice fast imaging.

Results: Interleaved spiral FLASH and Cartesian FLASH sequences were compared and image quality was very similar between the two acquisitions, indicating that susceptibility artifacts were relatively minor. The quality of the subject's voice recording was also analyzed and qualitatively compared, with the spiral FLASH sequence allowing for better discernment of the subject's voice. We will perform spectrogram analysis to quantify these differences. **Figure 1** shows the imaging slice used to image the LVP muscle. **Figure 2** shows a T2 map of the slice, depicting the LVP muscle. **Figure 3** shows a frame from the spiral FLASH acquisition. **Figure 4** shows a Cartesian FLASH for reference.

Conclusion: Due to the reduced gradient switching from the spiral acquisition, the scanner noise provided qualitatively less masking of the subject's voice when using the spiral acquisition over the Cartesian FLASH. The spiral FLASH sequence provided comparable image quality, showing only minor susceptibility effects.

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