Real-Time MRI of Swallowing in Upright Position

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Introduction: Swallowing disorders are difficult to study because they have multiple etiologies and involve the careful coordination of many different oral structures. These oral structures are not readily visible in their natural state, nor are their mechanics completely understood. Imaging techniques can provide direct evaluation of the oral structures under dynamic conditions but current methods are too invasive (x-rays in the case of videofluoroscopy), do not provide simultaneous imaging of all the structures of interest (ultrasound), do not provide ideal soft tissue contrast (videofluoroscopy) or are not performed in a natural position (conventional MRI).

The SP 0.5 T GE interventional MRI scanner allows a person to be scanned in an upright position (Fig. 1). Swallowing function can then be studied in a natural position [1] using appropriate substances necessary to evaluate the swallow processes (liquids, gels, course food) that also can act as contrast media. We have adapted our real-time system [2] for this particular application.

Methods: We implemented the RTHawk real-time system that provides real-time acquisition and reconstruction and allows for interactive control of the scan plane location and dynamic adjustment of imaging parameters such as FOV and flip angle. Constrained by the gradient hardware of the 0.5T GE SP system (12 mT/m, 16 T/m/s gradient), we designed a slightly undersampled 6 interleave spiral acquisition capable of acquiring 5.5 frames per second with a resolution of 2.6 x 2.6 x 5 mm over a 20 cm FOV. An acquisition time of 16 ms was chosen as a compromise between total speed and off-resonance artifacts. A sliding window reconstruction algorithm was used to reconstruct the data at 33 fps providing a smooth temporal transition between frames. To achieve a better sensitivity of the entire swallowing mechanism from the base of the skull to below the larynx, a receive-only 5" coil encircling the jaw was used, as shown in Fig. 1.

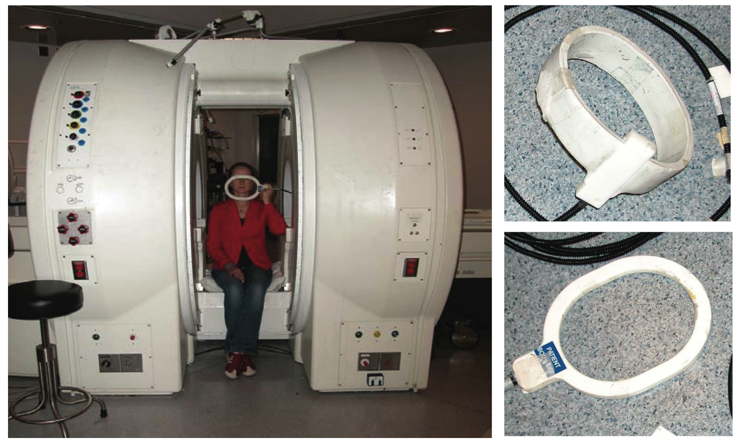

Figure 1: Hardware configuration. The subject sits at the center of the open scanner. An RF surface coil is placed around the neck or encircling the jaw.

Results: To demonstrate the feasibility of the system, three healthy volunteers were studied. The subject was asked to swallow a bright liquid (blueberry juice) while imaging in a midline sagittal plane. Figure 2 shows sample frames from the continuous acquisition where the movements of all of the oral structures involved in the swallowing process can be clearly identified simultaneously. The arrows indicate the location of the juice bolus. It can be clearly observed how the bolus gets transported from the back of to tongue to the esophagus.

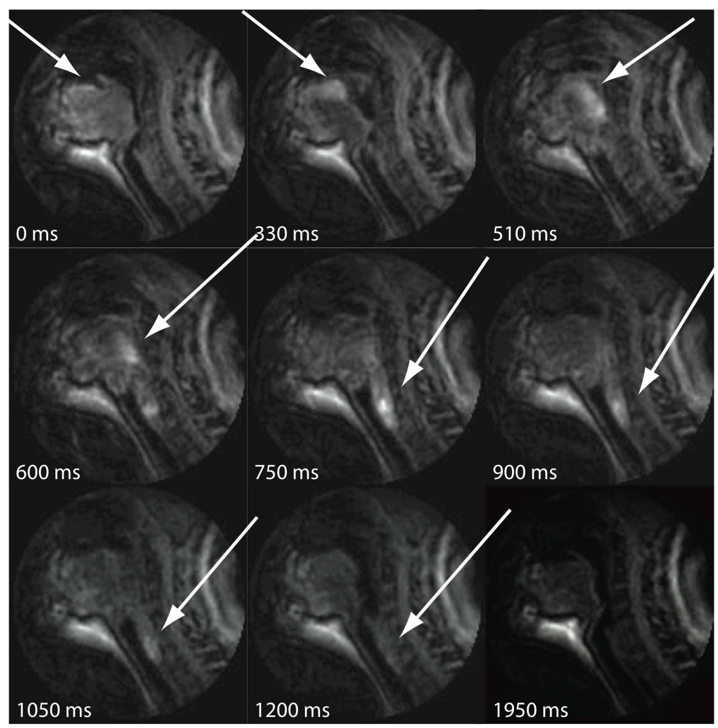

Figure 2: Selection of frames from a swallowing study. The subject swallows a bolus of blueberry juice. The arrows indicate the location of the bolus.

Discussion: The initial studies show promising results as the structures of interest can be clearly visualized. No significant artifacts were observed in the boundaries with the air cavities. The acquisition rate is adequate to identify many of the oral structure movements for swallowing.

References: [1] Honda Y., et al, JMRI 26:172-176, 2007.
[2] Santos JM, et al. 26th IEEE EMBS, 1048, 2004.