# Turbo-FLASH Imaging of swallowing function at 3T

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**Introduction**: The ability to image the swallowing process with MR imaging would be of clinical significance in patients with dysphagia, at aspiration risk, or undergoing surgical procedures for upper aerodigestive tract pathology; it would provide a means to assess deglutition without ionizing radiation, with the additional capabilities of direct visualization of regional anatomy and multiplanar imaging. MRI of the swallowing process remains a challenge given the rapidity of the swallowing process (1-2 s long), and the presence of the large air column of the aerodigestive tract. Unlike cardiac imaging, substantial variation is seen amongst repeated swallows. Prior efforts at MR imaging of swallowing have made use of SSFSE (1,2), true-FISP (3), and turbo-FLASH imaging (4,5). In previous comparative work between EPI, FLASH, and turbo-FLASH imaging (6), turbo-FLASH imaging was determined as having the optimal degree of spatial to temporal resolution. Given improvements in SNR provided by higher-field imaging, our goal was to determine the utility of a turbo-FLASH dynamic imaging on a 3 Tesla magnet to evaluate the swallowing process.

**Methods:** MR imaging was performed on 3.0T Trio magnet (Siemens Medical Systems, Erlangen, Germany) with a 4-channel multichannel head coil, and a dual-channel neck coil. Turbo-FLASH sequence parameters were as follows: TR/TE 120/1.2 ms, slice thickness 10 mm, matrix 80 x 192, FOV 217 x 260 mm, parallel acceleration factor 2 (GRAPPA). Thirty sequential images were acquired in 3.6 seconds. Four healthy volunteers underwent MR imaging in accordance with IRB protocol. Imaging was performed in the midsagittal plane, as well as in the axial plane at the level of the oropharynx. Positive oral contrast in the form of a sports protein drink (Nutrament, Mead Johnson and Company) was delivered via a suspended IV bag and roller clamp tubing to allow for patient control of bolus delivery while in the magnet.

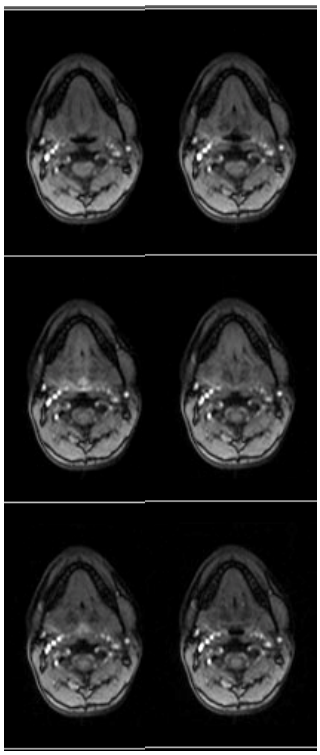

Figure 1. Selected images (every other image) from axial sequence

**Results:** Image contrast and spatial resolution are maintained in this sequence with a temporal resolution approaching that of conventional videofluoroscopy (110 versus 33 msec). We found that continued increases in the parallel acceleration factor to three introduced unacceptable image noise. Axial imaging (Figure 1) consistently demonstrated early depression of the tongue base, passage of contrast into the oropharynx, followed by apposition of the tonsillar pillars mediated by pharyngeal constrictors. This was followed immediately by posterior movement of the tongue base to result in complete closure of the airway, with bolus. On sagittal imaging (Figure 2), the aerodigestive tract from the oral cavity to the cervical esophagus is well-delineated. Tongue motion, velopharygeal closure, hyoid and laryngeal elevation and movement of the epiglottis were well-depicted. Figure 3 shows the temporal evolution of the swallowing process, as measured at the tongue base.

**Conclusion:** Turbo-FLASH 3T imaging of swallowing may by useful in the evaluation of swallowing. In particular, the axial dynamic representation of deglutition provides imaging of this process not currently afforded by any alternate imaging modality. Combining parallel imaging with high field MRI may enable us to provide a superior alternative to videofluoroscopy.

**References:** 1. Isogai S, et al. Proc ISMRM 2000; 8:1120. 2. Hartl DM, et al. Dysphagia 2003; 18L 255-262. 3. Barhausen J, et al. Eur Rad, 2002; 12:129-133. 4. Kitano H, et al. Dysphagia 2002; 17:187-191. 5. Sato Y, et al. Br J Rad 1995; 814: 1099-1102. 6. Anagnostara A, et al. JMRI 2001; 14: 194-199.

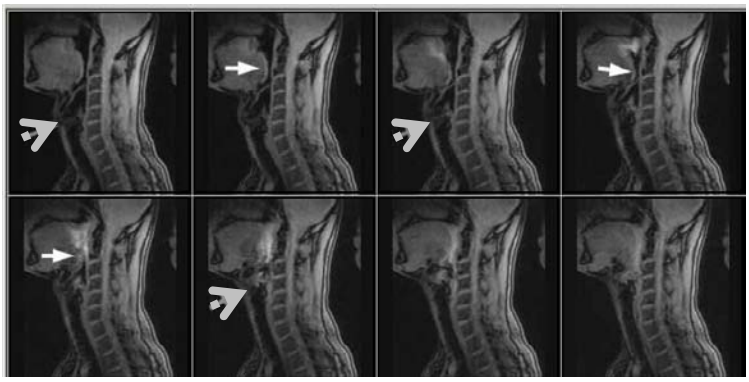

Figure 2. Consecutive images from sagittal axial sequence demonstrates passage of the postitive oral contrast agent through the upper aerodigestive tract. In particular the motion of the tongue base (white filled arrow) and laryngeal elevation (gray empty arrow) are well depicted.

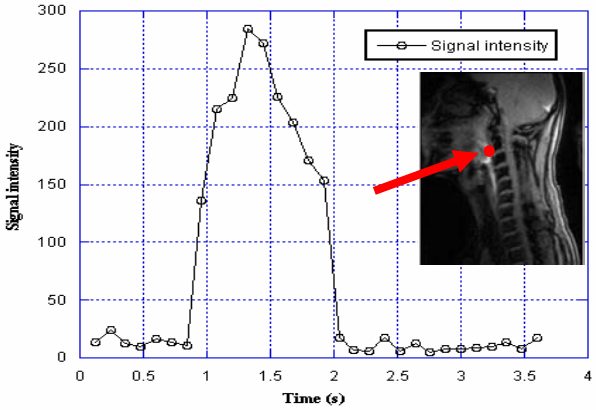


Figure 3. Temporal evolution of the swallowing process, as measured at the oropharyngeal airway (red-circle in inset).