Motion Corrected 3D High Resolution Larynx Imaging with a Two-Coil Array

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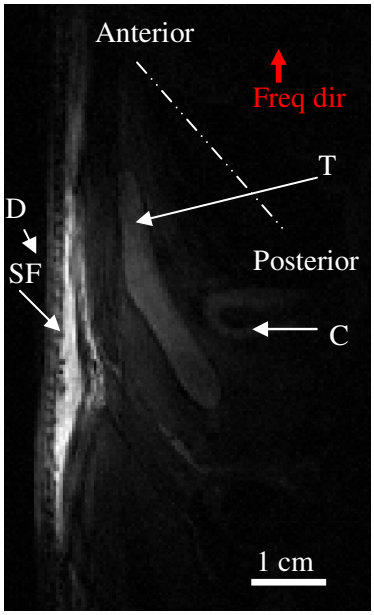
Introduction: Laryngeal cancer is usually treated with radiotherapy and chemotherapy to preserve speech and swallowing abilities. However, if the cartilage has been invaded, this treatment is ineffective and partial or total laryngectomy is required [1]. The latter has a dramatic impact on the quality of life of the patient. If cartilage invasion is detected early, partial laryngectomy, with preservation of speech and swallowing, can be performed in lieu of total laryngectomy. Conventional MRI has been promoted as a way to detect early cartilage invasion [2]. However, we believe that high resolution imaging might be highly beneficial for detecting subtle cartilage invasion. Our early preliminary work showed that a small surface coil provides high SNR in 2D larynx imaging [3]. In this work, we investigate the use of a 3D trajectory to get coverage of the larynx at high resolution in less than 5 minutes with motion correction, and we propose a two-coil array to better fit the larynx geometry.

Methods: Because the cartilage has a short T2, a sequence with a short TE is desirable. The FLASE sequence, which has been investigated for trabecular bone and skin imaging [4], is a Cartesian sequence optimized for short TE imaging, with a minimum-phase excitation pulse and partial encoding in the readout direction. As a spin echo sequence, it is immune to off-resonance. These features make it a good candidate for effective 3D imaging. We acquired navigators in all directions for 3D motion correction. Two one inch diameter receive coils were built and taped to either one or both sides of a cervical collar. We used sum-of-squares to reconstruct the data from the two coils [5]. We scanned healthy male volunteers using a GE Signa 1.5 T whole body scanner with a maximum gradient amplitude of 40 mT/m and a maximum slew rate of 150 mT/m/ms. The following parameters were used: FA 140°, TE 14 ms, TR 80 ms, BW 32 kHz. The respective FOVs were 4*4*1.7 cm^3 for the single coil image, and 8*4*3.4 cm^3 for the two coil array image. For each image, we achieved 310*310*1400 μm^3 resolution in 4 min 12 s. Such a short scan time is critical for clinical feasibility.



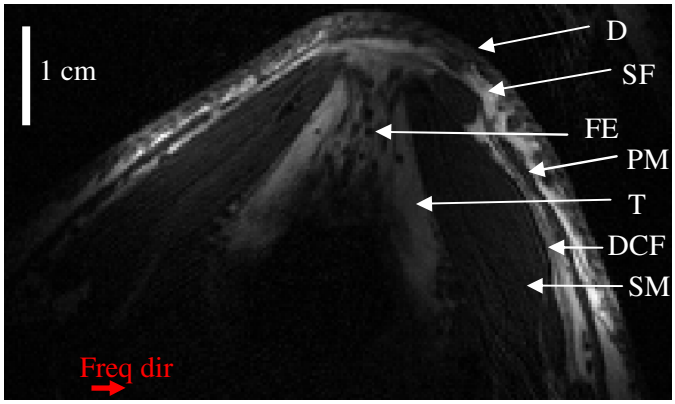


*Figure 1: Left: Cricothyroid articulation imaged with a 1'' diameter surface coil. -- Right: Petiole of the epiglottis imaged with a two 1'' diameter coil array -- For each image, 390*390*1400 μm^3 resolution is achieved in 4 min 12 s. The following structures can be recognized: D: epidermis and dermis, SF: subcutaneous fat, FE: fenestrae of the epiglottis, PM: platysma muscle, E: epiglottic cartilage, DCF: superficial layer of deep cervical fascia, SM: sternohyoid muscle, T: thyroid cartilage, C: cricoid cartilage.*

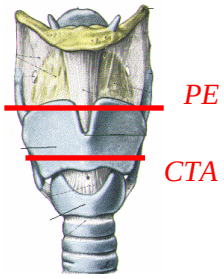


Figure 2: Anatomy of the larynx. PE is the petiole of the epiglottis (right image), CTA is the cricothyroid articulation (left image). [http://www.yorku.ca/]

Results and Discussion: Figure 1 shows axial slices from two different data sets - the location of those slices is depicted in Figure 2. Motion ghostly artifacts have been removed by the motion correction. The left image was taken near the cricothyroid articulation, using one coil. The low signal intensity of the interior of the cricoid cartilage suggests red marrow, as is seen in young adults. The thyroid cartilage is well-seen, with excellent delineation of the cartilage-soft tissue boundary. The right image was taken at the level of the thyroid notch using the two-coil array. The fenestrae of the epiglottis, not typically seen with conventional computed tomography or MRI, are readily visible: high resolution with good SNR has been achieved. However, the images suggest that slightly bigger coils might provide better depth sensitivity. Furthermore, as expected considering the geometry and confirmed by the splitting of the resonances, the coils are coupled. Therefore, further improvement will be obtained by careful decoupling.

Conclusion: We have shown that a two coil array allows high resolution imaging of the laryngeal cartilages. Detailed features are readily visible. The 3D FLASE sequence with motion correction produces images with excellent contrast between cartilage and soft tissue. The images presented here were obtained at levels in the human larynx which are critical boundaries to cancer spread. High resolution MRI, as can be produced with surface coils, may allow for early detection of laryngeal cancer spread and invasion, which in turn will allow for the selection of the most appropriate treatment modality. This technology could have a critical impact in the future treatment of laryngeal cancer, boosting local and regional control rates while affording preservation of speech and swallowing to a greater number of patients with this disease.

References:

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