High-resolution Larynx Imaging

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Introduction: Laryngeal cancer is the most common non-cutaneous cancer in the head and neck. The initial treatment is typically radiation therapy. If the tumor persists or recurs, then total laryngectomy is often required. Laryngeal cartilage invasion is considered by most clinicians to be a contraindication to primary radiation therapy, since it implies a greater likelihood for radiation treatment failure. Cartilage invasion is, however, difficult to assess by current imaging modalities (CT and conventional MRI). We believe that high-resolution MRI might be highly beneficial for detecting subtle cartilage invasion. Improving on preliminary results [1], we designed a three-element coil array and used two specific pulse sequences to enable 3D coverage of the larynx with high-resolution.

Methods: Coil: Although small circular coils are beneficial for high-resolution imaging [1], their geometry is not well suited for the larynx. To address this issue, we first built a dedicated 2-inch square coil. The coil was shaped on a half-cylinder that fits most neck geometries. A 2-inch square coil has optimal sensitivity for an ROI located 2 cm below the skin surface, which is the mean maximal depth of thyroid cartilage in the healthy adult [2]. We used 12 AWG copper wire to limit the coil resistance, and we mitigated dielectric losses by splitting the coil with two capacitors [3]. A PIN-diode circuit ensures Q-spoiling during transmit. To cover the cartilage region while maintaining high SNR, we then expanded this coil into a three-coil array (Fig. 1). We placed the capacitors in a mid-plane and used balancing. This preserves symmetry so that side-to-side comparisons can be interpreted clinically [4]. The coils were overlapped to inductively decouple the nearest neighbors. We relied on the preamplifiers to decouple the two side coils.

***Fig. 1**: Dedicated 3-element array (before packaging).*

Pulse Sequences: Conventional clinical protocols for larynx imaging use a neurovascular array and T_1- and T_2-weighted 2D Fast Spin Echo (FSE) sequences, some with fat/water separation. FSE is an option for imaging at high-resolution, but we were also interested in alternative sequences that offer contiguous 3D coverage in a clinically feasible scan time. We investigated two 3D pulse sequences:

The 3D Fast Large Angle Spin Echo (FLASE) sequence exploits the steady state attained with relatively short TR (~80 ms) when a large flip angle pulse is used (~140°): a reasonable scan time is then possible [5]. As a spin-echo sequence, it is immune to the off-resonances that are expected at the air/tissue interfaces. With a short TE and a single echo, it avoids the blurring of shorter T_2 species like hyaline cartilage. We acquired navigators in all directions for 3D motion correction [6].

The 3D Concentric Rings trajectory efficiently collects multiple echoes for robust water-fat separation. It offers a 50% reduction in scan time with respect to the corresponding Cartesian sequence [7]. We used a set of 128 uniformly spaced concentric rings to encode kx, ky and slice encoding along kz to achieve 3D spatial coverage. Gradients were designed for the outermost ring, and then scaled down to acquire one ring per TR. The central 64 rings for each kz plane were acquired over 3 revolutions to enable fat/water separation. Separate fat and water images for each slice were calculated using an iterative multi-point Dixon method.

Results and Discussion: We scanned healthy male volunteers using a GE Excite 1.5T whole body scanner (40 mT/m, 150 mT/m/ms). Figures 2 and 3 show sections from FLASE datasets. The cartilage is well delineated. Figure 4 demonstrates fat-water separated images using the Concentric Rings trajectory. Although a primary disadvantage of non-Cartesian trajectories is usually their off-resonance behavior, the Concentric Rings trajectory, with multiple revolutions for fat/water separation, exhibits strong immunity to off-resonance blurring [7]. The Concentric Rings trajectory is currently implemented in a spoiled-GRE sequence but spin-echo and fast spin-echo versions are possible.

Conclusion: With a dedicated three-element array, both the FLASE and the fat/water separated Concentric Rings sequences provide high-resolution, 3D coverage of the laryngeal cartilage in clinically feasible scan times.

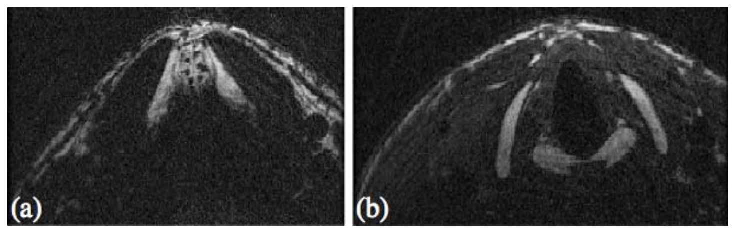

***Fig. 2**: Two sections from the same 3D FLASE scan: (a) Petiole of the epiglottis and (b) Cricothyroid articulation. FOV=8x5x3.2 cm^3, resolution=312µmx391µmx1mm, TR/TE=80/14ms, scan time=5min34s.*

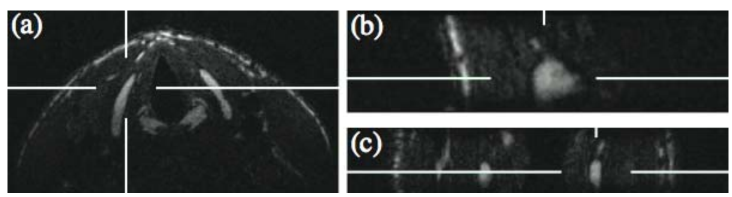

***Fig. 3**: Isotropic 3D FLASE images: (a) Axial, (b) Sagittal, and (c) Coronal sections through the 3D dataset. FOV= 13x6.5x1.6 cm^3, resolution=500$µm^3$, TR/TE=80/14ms, scan time=5min34s.*

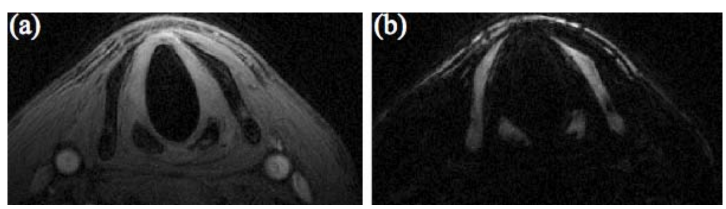

***Fig. 4**: 3D Concentric Rings: (a) Water and (b) Fat images. FOV=10cm^3, resolution=390µmx390µmx2mm, TR/TE=14.6/2.5ms, scan time=1min34s.*

References:

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