# High-Resolution Imaging of the Laryngeal Cartilages: Volunteer and Cancer Patient Studies

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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 [1]. Laryngeal cartilage invasion is considered by most clinicians to be a contraindication to primary radiation therapy, since it implies a greater likelihood of radiation treatment failure. However, it can be difficult to assess cartilage invasion by current imaging modalities (CT and conventional MRI), unless the invasion is extensive. In this work, we demonstrate the benefits of high-resolution MR to image the laryngeal cartilages.



Figure 1: Neuro-vascular array (a) and dedicated 3-channel array (b).

**Methods:** Our dedicated 3-channel array [2] is shaped on a half-cylinder that fits most neck geometries (Fig. 1b). Each element is a square coil of side 5 cm, with optimal sensitivity 2 cm below the skin surface, which is the mean maximal depth of thyroid cartilage in the healthy adult [3]. We improved the array in two ways. First, to ensure preamplifier decoupling, a $\pi$ network was tuned for each channel at the junction with the scanner [4]. Second, we implemented an intensity correction method to compensate for the coil sensitivity profile that makes subcutaneous fat undesirably bright. The method fits a low-order polynomial to the image [5]. Polynomial coefficients are computed by solving a complex optimization problem using cvx [6]. To demonstrate the performance of our array, we compared it with an 8-channel neuro-vascular array (MRI Devices®) (Fig. 1a) and imaged the thyroid cartilage of volunteers and patients using a GE 1.5 T scanner and a T1-weighted Fast Spin Echo sequence with the following parameters: TR/TE = 450-550/12-13 ms, bandwidth = ±16 kHz, echo train length = 3, matrix size = 256x224.



Figure 2: Conventional (a,d) and high-resolution uncorrected (b,e) and corrected (c,f) axial images of a healthy volunteer. Two slices are shown. Intensity correction compensates for the sensitivity profile of the coil. Resolution is respectively $0.9{\times}0.9{\times}5$ $mm^3$ and $0.4{\times}0.4{\times}1$ $mm^3$. Non-ossified thyroid (Th) and cricoid (Cr) cartilages, barely distinguishable from muscle in (a,c), are nicely delineated in (b,c,e,f).

**Results and Discussion:** Figure 2 shows the coil comparison on a healthy male volunteer. The FOV was 20/10 cm and the slice thickness 5/1 mm for the conventional/high-resolution scans. Note that the voxel volume was divided by a factor of 20 between the two scans. In this 24-year-old subject, the cartilages are mainly non-ossified and present a contrast very similar to muscle, which makes them difficult to distinguish in conventional images. High-resolution imaging reveals the perichondrium as a dark line delineating the cartilages. The intensity correction is effective and robust.

Figure 3 presents the clinical CT and MR images of a male patient with a T3 carcinoma of the right hemilarynx. In this 55-year-old subject, cartilage is mainly ossified. In the CT images, the right thyroid and cricoid cartilages are sclerotic, and the right arytenoid cartilage is eroded. In the axial T1-weighted images, the right thyroid and cricoid cartilages are mildly hypointense, and this was interpreted as likely reactive change rather than tumor infiltration. Radiation therapy was administered. Figure 4 shows the coil comparison on this patient, post-treatment. We performed the high-resolution scan 45 days after the clinically indicated conventional scan. The FOV was 20/10 cm and the slice thickness 5/2 mm for the conventional/high-resolution scans. The laryngeal mass resolved and the thyroid and cricoid cartilage signal normalized**.** Despite motion artifacts—always more pronounced post-treatment and visible in both scans—the improvement in resolution is striking. In the high-resolution images, the cartilages are well delineated and, as a sidenote, the radiation effects on skin become visible.



Figure 3: Pre-treatment CT (a,b) and conventional (c,d) MR images. The tumor is denoted by T. Sclerosis of the right thyroid and cricoid cartilages is noticeable (arrows). The right arytenoid cartilage is eroded (circles).

**Conclusion:** We have shown that the resolution of laryngeal MR images of cancer patients can be dramatically improved by the use of a dedicated array. We believe that such an increase in resolution will be beneficial to assess subtle cartilage invasion and to distinguish true invasion from reactive signal changes.

**References:**
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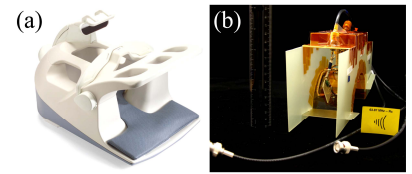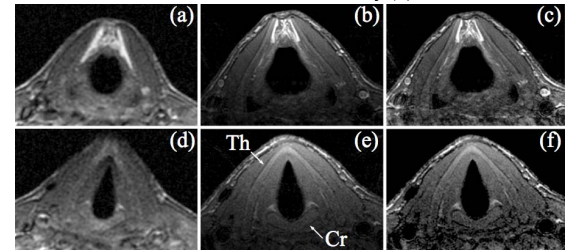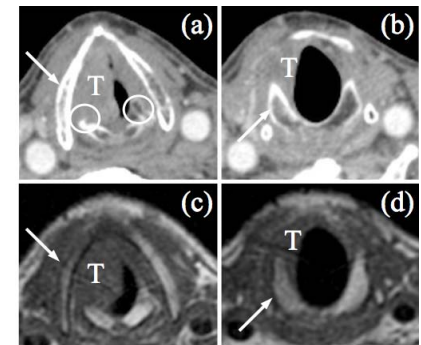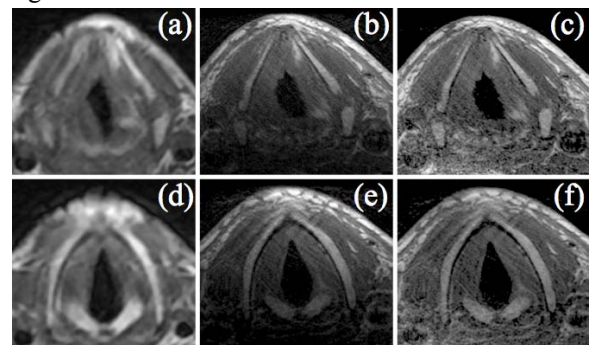[5] Styner, IEEE-TMI, 19:153-165, 2000
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Figure 4: Post-treatment conventional (a,d) and high-resolution uncorrected (b,e) and corrected (c,f) MR images. Resolution is respectively $0.9{\times}0.9{\times}5$ $mm^3$ and $0.4{\times}0.4{\times}2$ $mm^3$. The signal intensity in thyroid and cricoid cartilages is normal. The right arytenoid cartilage was eroded by the tumor and is absent.