Application of Small Surface Coil for Cancer Detection in Laryngeal Cartilage

J. C. DiCarlo[1], G. E. Gold[2], E. J. Damrose[3], D. G. Nishimura[1]

[1]Electrical Engineering, Stanford University, Stanford, CA, United States, [2]Radiology, Stanford University, Stanford, CA, United States, [3]Otolaryngology, Stanford University, Stanford, CA, United States

Introduction

Laryngeal cancer afflicts 13,000 people per year. Most patients undergo intensive radiation and chemotherapy to preserve the larynx, but those patients who fail therapy usually require total laryngectomy, with devastating effects on the patient's quality of life. Detection of early cartilage invasion is critical in determining the optimum treatment modality for these patients [1]. Cartilage invasion leads to the failure of radiation and chemotherapy to control invasive disease. Early detection of cartilage invasion could allow patients to undergo partial laryngectomy, allowing preservation of the majority of the vocal apparatus while still eradicating disease. High resolution imaging of the cartilage may increase our ability to detect subtle cartilage invasion. MR imaging of supraglottic lesions using an anterior neck surface coil has demonstrated tumor-induced cartilage signal changes [2]. Improved resolution in this region can be obtained using smaller surface coils. The reduction of inductive noise volume with decreasing coil size leads to SNR increases of a factor of $d^{(-5/2)}$, where d is the coil diameter [3]. Small surface coils have previously shown to produce high-resolution images of the skin and triangular fibrocartilage complex [4-6]. We demonstrate the use of small surface coils for higher-resolution imaging of the thyroid cartilage.

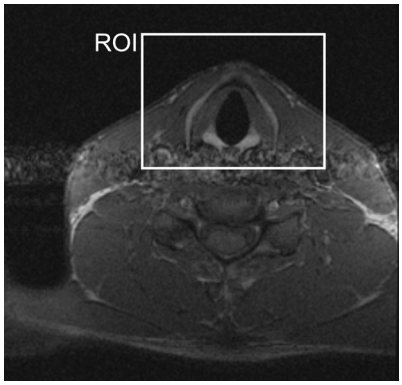

Figure 1. Thyroid cartilage in a normal volunteer. Axial 16-cm FOV image acquired with the anterior neck coil. The 3x2-cm ROI is shown.

Methods

Normal volunteers were scanned using a GE Excite 1.5 T MR scanner equipped with 40 mT/m amplitude and 150 T/m/s slew rate gradients. Images were acquired using the GE anterior neck coil and a 38 mm-diameter Doty surface coil, with a home-built match cable for Q-spoiling during transmission. T_1-weighted spin-echo sequences with TR of 800 ms and minimum full TE of 14/17 ms for the neck/small coil scans were used [2]. The sequence used with the anterior neck coil had FOV=16 cm, 4-mm slice thickness, and 625 µm in-plane resolution, resulting in a scan time of 3:25. For the scans with the 38-mm coil, a higher-resolution sequence was used to give 208 µm in-plane resolution with 2-mm slice thickness, at a FOV of 8 cm for a scan time of 5:07. Frequency encoding was performed in the A/P direction to minimize aliasing artifact in the region of interest (ROI) from neck vasculature. SNR was measured at two locations: the most anterior portion of the cartilage (closest to the 38-mm surface coil) and in a portion more posterior (furthest from the 38-mm surface coil.) Finally, the estimated SNR of the neck coil at the resolution achieved by the 38-mm coil was calculated by scaling the measured SNR by the factor by which voxel size decreased and the square root of the factors by which readout time and number of phase encodes increased, giving a measure of the SNR gain factor of the 38-mm coil.

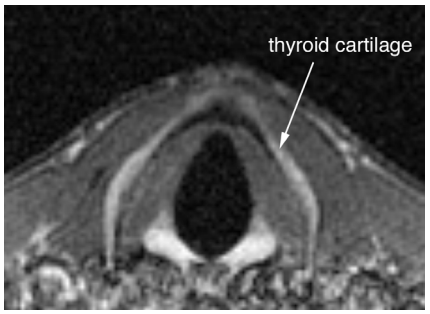

Figure 2. Above acquired T_1-weighted image in normal volunteer (using the anterior neck coil) zoomed to ROI. Image resolution is 625 µm in-plane, with 4-mm slice thickness.

Results

Figure 1 shows the full 16-cm image acquired using the neck coil, along with the region of interest (ROI) including the thyroid cartilage. Figure 2 shows the zoomed region of interest from Figure 1. Figure 3 shows the 3x2 cm ROI from the 8-cm image acquired using the 38-mm coil. There is a small signal drop from RF eddy currents due to the proximity of the brass screw of the tuning variable-capacitor to the slice chosen. Despite the artifact, boundaries on both sides of the thyroid cartilage are well visualized. Table 1 gives measured SNR values in the 2 regions of cartilage chosen, along with the estimated equivalent SNR of the neck coil at the higher-resolution scan.

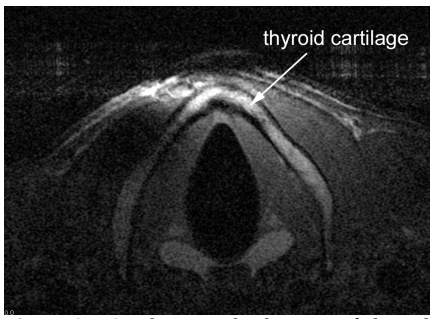

Figure 3. Axial T_1-weighted image of thyroid cartilage in same normal volunteer, using 3.8-cm surface coil. Image resolution is 208 µm in-plane, with 2-mm slice thickness.

Conclusion

A 38-mm surface coil increases SNR by a factor of 9-20, depending on the portion of cartilage considered. This increase in SNR allows high-resolution imaging of thyroid cartilage with excellent delineation of the cartilage boundary. By potentially improving earlier detection of cartilage invasion, this technique could radically alter treatment recommendations for laryngeal cancer patients. Patients with early cartilage invasion would undergo partial laryngectomy rather than radiation and chemotherapy, affording early eradication of invasive disease and allowing patients to avoid the devastating sequelae of total laryngectomy.

References

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Table 1. Measured SNR in the thyroid cartilage.

Coil/Scan	Voxel size	Measured at most posterior location	Measured in most anterior region
Anterior neck coil (low-resolution scan)	0.625 x 0.625 x 4 mm	15	10
38 mm surface coil (high-resolution scan)	0.208 x 0.208 x 2 mm	11	17
Neck coil SNR at higher resolution (predicted from scaled acquired low-resolution scan SNR)	0.208 x 0.208 x 2 mm	1.2	0.81
Predicted SNR gain factor in going from anterior neck coil to 38-mm coil after adjusting for voxel size, scan time	-	**9**	**20**