

## High resolution MRI and CT investigation of laryngeal soft tissues and skeletal structures

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### Introduction

Visualization of the laryngeal cartilages and soft tissues using magnetic resonance imaging (MRI) and computer tomography (CT) is very difficult due to very small structures, differential ossification of the cartilages, and the respiratory and swallowing movements of the larynx during the tomography [1-4]. Therefore, the functional biomechanics of the laryngeal cartilages is controversially described [1,2]. With modern tomography technologies and post-process imaging software, the visualization of small details of the laryngeal anatomy is possible. The aim of the study was to visualize and compare the laryngeal skeletal structures and soft tissues in detail by MRI and CT.

### Materials and Methods

The study included 20 sequential fresh human cadaveric larynges (10m, 10f, mean age 66years [39-87]) which were fixed in a special mounting appliance (see Fig. 1a). The study was divided into two data acquisition steps: First, MRI data acquisition was performed on a clinical 3T scanner (Tim Trio, Siemens<sup>®</sup>) using a wrist coil (see Fig. 1b) and a 2D Turbo Spin Echo sequence (60 transversal slices, 256x256 matrix, slice thickness 0.9mm, pixel size 0.234mm x 0.234mm, TR 645ms, TE 12ms, FA 130°) (see Fig. 2a). Second, CT scans were acquired using a Volume-CT (Toshiba<sup>®</sup>, Aquilion ONE, 120kV tube voltage, 1s rotation time, 120mm range, 1mm slice thickness, Axial Reconstruction) (see Fig. 2b). Acquired DICOM-data was post-processed off-line using the software Mimics<sup>®</sup> (Materialize<sup>®</sup>) (see Fig. 3).

### Results

In all 20 human cadaveric larynges, the laryngeal cartilages could be visualized clearly using MRI and CT. The male thyroïdal cartilages were more ossified than the female thyroïd. Investigating MRI data shows that the corticallis and the marrow space of the thyroid and cricoid, the laryngeal muscles and soft tissues could be well visualized, especially the perichondrium (1) of the cartilages and the ligament of the vocal fold (2). The contrast between non-ossified cartilages and laryngeal muscles is low, while the contrast between the ossified parts of the cartilages and soft tissues was high (see Fig. 2a). On the other hand, examining CT data points out that the ossified corticales of the thyroid and cricoid and the marrow space was well visualized. The arytenoid cartilages were visible due to the high contrast to the soft tissue. The soft tissues, especially the laryngeal muscles, could not be discriminated with the CT. The contrast between non ossified cartilages and soft tissue was low (see Fig. 2b). The segmentation of ossified cartilages was performed automatically in MRI and data. Soft tissues were automatically segmented in MRI data, while in CT data, segmentation between laryngeal muscles, mucosa and fat was not possible. Non-ossified cartilages had to be segmented manually in MRI and CT data. The segmentation results were visualized in 3D (see Fig. 3).

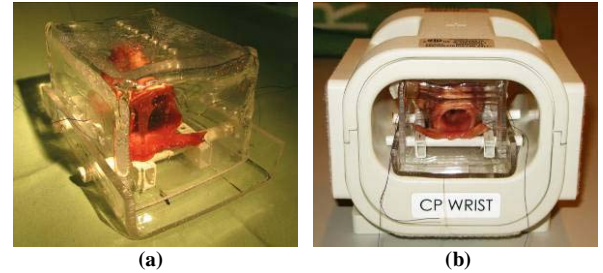
### Discussion

The assessment of the thyroid and cricoid is dependent of the ossification. The ossification of the hyaline cartilages increases with advanced age. Male larynges ossify more than female larynges. The thyroid and cricoid ossifies in most instances, while the arytenoid cartilages do not ossify routinely [4-6]. With the used T1-weighted MRI sequence, one can discriminate between soft tissues and non-ossified cartilage very well. Especially the laryngeal muscles were visible. Therefore, the MRT seems to be superior for visualizing laryngeal muscles and soft tissues (see Fig. 2a). Using CT, the differentiation between soft tissue and cartilage was possible. The arytenoid cartilages are well visible, also in cases, when the cartilages are not strongly ossified. Therefore, the CT seems to be superior to visualize the small cartilage structures due to a higher contrast to the soft tissues (see Fig. 2b).

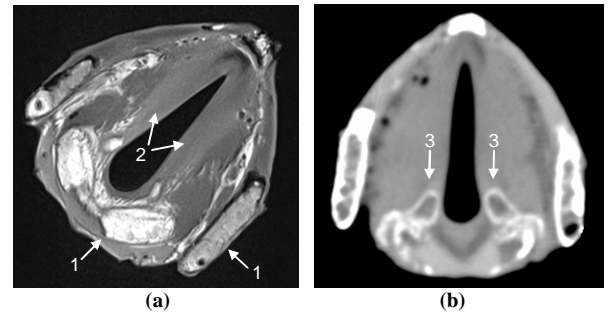
### References

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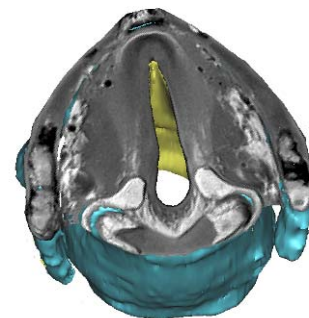
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**Fig. 1:** (a) Mounting appliance for the larynx fixation including a fresh human cadaveric larynx. (b) Wrist coil containing the mounting appliance.



**Fig. 2:** (a) MRI-Scan along the vocal folds, visualization of the perichondrium (1) and the ligament of the vocal folds (2). (b) CT-Scan along the vocal folds: Inhomogeneous Ossification of the thyroid and cricoid, visualization of the corticallis of the arytenoid cartilages (3).



**Fig. 3:** Superior view on the laryngeal cartilages (blue) and soft tissues (yellow) of the segmented MRI data. Cut on the level of the vocal folds.