

# Accuracy of Computed Tomography (CT) Imaging in Detecting Thyroid Cartilage Invasion in Laryngeal Squamous Cell Carcinoma

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## Background

Laryngeal cancer is a common malignancy of the head and neck, with the majority of cases being squamous cell carcinomas (SCC). Given that the elderly population represents the fastest growing subpopulation in North America and Europe, the proportion of patients with advanced laryngeal cancer will continue to rise<sup>1</sup>. This further increases the relevance of research into a cancer that has the highest global incidence at the ages of 65-69 and greatest prevalence at around 60-80 years of age<sup>2</sup>.

The staging of laryngeal cancer through computed tomography (CT) imaging is essential for ultimate management, where cancers that invade the outer cortex of the thyroid cartilage are staged as T4 and are generally treated with total laryngectomy, whereas T3 staged cancers are increasingly managed with the organ preserving approaches of chemotherapy and radiation (CRT)<sup>3,4</sup>. Given that underestimating thyroid cartilage invasion results in the potential for the cancer to go undertreated, which could increase the risk of recurrence<sup>5</sup>, and that overestimating results in overtreatment with laryngectomy, the accurate staging and diagnosis of laryngeal SCC is imperative.

## Purpose

**To assess the accuracy of CT imaging in detecting thyroid cartilage invasion compared with post-operative pathology amongst a cohort of patients who received total laryngectomy for advanced laryngeal SCC.**

## Methods

### Study Design and Patient Selection:

Retrospective review of 143 patient electronic medical records of those who had preoperative CT for suspected laryngeal masses at London Health Sciences Centre (LHSC) from January 2009 through December 2019.

### Inclusion Criteria:

- Laryngeal/hypopharyngeal SCC on histopathology
- Cases post-2009
- Laryngectomy as primary treatment
- No prior head and neck surgery/radiation

### Exclusion Criteria:

- Surgery >40 days after CT scan (n=39)
- Incomplete patient records (n=2)
- No mention of thyroid cartilage invasion on pathology report (n=2)

**CT Imaging Acquisition:** Images were preoperatively acquired using the Canon Genesis 320 slice scanners and the Canon Aquilion Prime 80 slice scanner, both at 0.5mm resolution. Before 2018, General Electric 64 and 16 slice scanners at 0.625 mm resolution were used.

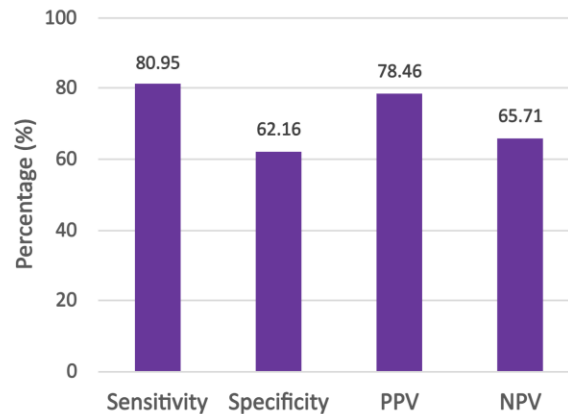
**Histopathological Evaluation:** All pathology reports were reviewed for mention of thyroid cartilage invasion and the reported staging. Thyroid cartilage invasion was marked as either invasion present or no invasion present.

**Statistical Analysis:** Positive predictive value (PPV), negative predictive value (NPV), specificity and sensitivity of CT in detecting thyroid cartilage invasion compared to pathological post-operative specimen evaluation was calculated.

## Results

**Table 1.** Patient and tumor characteristics.

|                                    |                | N=100 (%)  |
|------------------------------------|----------------|------------|
| Age at diagnosis, range (mean)     |                | 48-91 (66) |
| Sex, N(%)                          | Male           | 80 (80)    |
|                                    | Female         | 20 (20)    |
| Primary Site, N(%)                 | Supraglottic   | 44 (44)    |
|                                    | Glottic        | 31 (31)    |
|                                    | Subglottic     | 4 (4)      |
|                                    | Hypopharyngeal | 21 (21)    |
| Days from CT scan to OR, mean (SD) |                | 21 (9)     |



**Figure 1.**

Clinicopathological correlation of CT to post-operative pathology in detecting thyroid cartilage invasion; PPV, positive predictive value; NPV, negative predictive value

## Discussion

The results of this paper demonstrates that CT, as compared to the gold standard of post-operative pathology review, is sensitive (80.9%) in detecting thyroid cartilage invasion, however it is less specific (62.2%). The PPV and NPV of CT was 78.5% and 65.7%, respectively. Therefore, CT appears to be more effective in correctly detecting thyroid cartilage invasion but less effective in determining the absence of thyroid cartilage invasion.

Importantly, this study reveals that there is a crucial subset of patients (22%) who underwent laryngectomy with pre-operative clinically staged T4 disease, however post-operatively were found by pathology to not have thyroid cartilage invasion. There was also a clinically significant proportion of patients (34%) who did not have clinically staged T4 disease who underwent laryngectomy anyways and were later found to have thyroid cartilage invasion. Table 2 compares our results to those of similar studies, and across these studies, PPV was comparably low at around 64-78%, however there is wide variability in sensitivity ranging from 46%-100%. This wide range illustrates need for future study to elucidate factors impacting CT identification of thyroid cartilage invasion.

Ossification is noted to increase with age, and non-ossified cartilage has been shown to appear almost indistinguishable from tumours<sup>6</sup>. This may be relevant for the decreased specificity of CT in detecting the absence of thyroid cartilage invasion in our study which has an increased average age compared with prior studies (66). Given the declining 5-year survival rate of laryngeal cancer over the past few decades, improving the staging and treatment decisions for this patient population is crucial.

**Conclusions:** CT is sensitive, however, less specific in detecting thyroid cartilage invasion and there is a clinically important subset of patients who were under- (34%) and over- (22%) staged. Examining thyroid cartilage ossification patterns is a future direction to help elucidate factors that complicate CT identification of thyroid cartilage invasion in laryngeal SCC.

**Table 2.** Comparison of diagnostic accuracy of CT in detecting thyroid cartilage invasion across previous studies.

| Author                    | Mean Age | No. Patients | Imaging Modality | Sensitivity (%) | Specificity (%) | PPV (%) | NPV (%) |
|---------------------------|----------|--------------|------------------|-----------------|-----------------|---------|---------|
| MacNeil et al. (2023)     | 66       | 100          | CT               | 81              | 62              | 78      | 66      |
| Li et al. (2011)          | 57       | 61           | MDCT             | 100             | 97              | 78      | 100     |
| Koopmann et al. (2016)    | 65       | 120          | MDCT             | 46              | 89              | 76      | 69      |
| Pietragalla et al. (2020) | 69       | 40           | CT               | 78              | 87              | 64      | 93      |
| Wojtera et al. (2022)     | 61       | 223          | CT               | 69              | 60              | 66      | 64      |

## References

1. Genden EM, Ferlito A, Rinaldo A, Silver CE, Fagan JJ, Suarez C, et al. Recent changes in the treatment of patients with advanced laryngeal cancer. *Head Neck*. 2008;30:103-110. doi:10.1002/hed.20715
2. Nocini R, Molteni G, Mattiuzzi C, Lippi G. Updates on larynx cancer epidemiology. *Chin J Cancer Res*. 2020;32(1):18-25. doi:10.21147/j.issn.1000-9604.2020.01.03
3. Hermans R. Staging of laryngeal and hypopharyngeal cancer: value of imaging studies. *Eur Radiol*. 2006;16(11):2386-2400. doi:10.1007/s00330-006-0301-7
4. American Society of Clinical Oncology, Pfister DG, Laurie SA, et al. American Society of Clinical Oncology clinical practice guideline for the use of larynx-preservation strategies in the treatment of laryngeal cancer. *J Clin Oncol*. 2006;24(22):3693-3704. doi:10.1200/JCO.2006.07.4559
5. Li B, Bobinski M, Gandour-Edwards R, Farwell DG, Chen AM. Overstaging of cartilage invasion by multidetector CT scan for laryngeal cancer and its potential effect on the use of organ preservation with chemoradiation. *Br J Radiol*. 2011;84(997):64-69. doi:10.1259/bjr/6670901
6. Dadfar N, Seyyedi M, Forghani R, Curtin H. Computed tomography appearance of normal nonossified thyroid cartilage: implication for tumor invasion diagnosis. *J Comput Assist Tomogr*. 2015;39(2):240-243. doi: 10.1097/RCT.0000000000000196