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Effects of Cervical Hardware on Early Laryngeal Cancer Radiation Outcomes and Functionality

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Abstract

Background: Early-stage (T1/T2) laryngeal cancers are often treated with primary radiation. Studies of other cancers suggest diminished treatment effects and increased side effects with hardware in radiated fields. This study investigates the relationship between cervical hardware and laryngeal cancer radiation outcomes.

Methods: Retrospective chart review of 245 T1/T2 laryngeal cancer patients treated with radiation.

Results: Cervical hardware patients (n = 16) and non-hardware patients (n = 229) had similar demographics. Major complications including osteoradionecrosis (0% vs 2%, p > 0.99) and second primary cancers (13% vs 9%, p=0.64) were comparable. Dysphagia requiring dilation (31% vs 21%, p=0.34) and gastrostomy tube dependence (47% vs 35%, p=0.34) were higher in the hardware group but numbers did not achieve significance.

Conclusions: Demographics and outcomes were similar between groups. While a trend toward worse swallowing function was noted in the hardware group, it did not reach statistical significance, possibly due to small sample size.

INTRODUCTION

Larynx-preserving therapy is a key principle in the treatment of early stage (T1 and T2) laryngeal cancers, given the crucial role of the larynx in speaking, swallowing, and overall patient quality of life. The specific treatment modality chosen depends on patient characteristics, subsite (glottis, supraglottis, subglottis), and degree of tumor involvement [1]. While many T1/T2 cancers are treated with transoral laser microsurgery (TLM) or open partial laryngectomy, approximately 77.6% are treated with primary radiation therapy (RT) [2]. In patients whose comorbidities propose significant risk which outweighs the benefit of surgery, RT alone is considered the standard of treatment for early-stage laryngeal cancers [3,4]. For supraglottic sites, definitive RT has a local control rate of 73-100% for T1 cancers and 60-89% for T2 cancers.[5] Per SEER data from 2004 to 2015, 84.4% of stage I lesions were treated successfully with RT.

Despite the effectiveness of RT and benefits in preserving larynx function, there are several drawbacks to primary RT. Patients may experience complications such as xerostomia, dysphagia, and radiation dermatitis. Some patients may experience more severe complications, such as esophageal stenosis requiring dilation and osteoradionecrosis [1]. Furthermore, RT may fail, necessitating secondary treatment. In one retrospective study of squamous cell larynx cancer cases in the National Cancer Database, approximately 7% of patients treated with primary RT for T1/T2 cancers required salvage surgery [6].

Furthermore, patient-specific considerations, such as the presence of medical hardware in irradiated fields, may contribute to failure or further complications of RT. It is estimated that approximately 4% of patients undergoing RT have metal implants in their spine, hip, or other areas of the body [7]. It has been theorized that metal hardware in an irradiated field diminishes treatment effects and may lead to increased side effects due to scatter [8]. This proposed effect is due to the scattering of photons or electrons when they come into contact with a metal implant, leading to an unintended change in the directionality and dose delivery of the radiation. When a radiation beam is directed at a metal implant, scattering results in an overdose on the front surface of the metal and the tissue anterior to it, and a decreased dose behind the implant. Depending on the location of the tumor relative to the hardware, the cells being targeted may be overdosed (leading to increased side effects) or underdosed (leading to diminished treatment effects) [8]. Furthermore, metal hardware causes artifacts in CT imaging, which renders the Houndsfield Unit (HU) values of the surrounding tissues inaccurate and can pose difficulties in calculating the proper dose of radiation [9]. The effects of metal hardware on RT have been studied in spinal, femur, jaw, pelvic, and esophageal cancers. Findings in these other fields have spurred further research into which radiation modalities reduce scatter effects and how treatment plans should be adjusted for the presence of hardware [8-10]. To our knowledge, the association between metal hardware in the cervical spine and outcomes of RT in laryngeal cancer is yet unstudied.

This study aims to: (1) explore the rates of cervical hardware in patients treated for T1/T2 laryngeal cancers (limiting to early-stage removes many of the confounding variables of treating larger tumors,) (2) determine the incidence of major and minor RT complications in each patient group, and (3) determine the need for secondary therapy, such as salvage laryngectomy, and the 5-year-survival of each group.

METHODS

A retrospective chart review was conducted on 245 patients treated with primary radiation for T1 and T2 laryngeal cancer at our quaternary care academic center. Using the electronic medical record (EMR), data were collected between November – January 2025 regarding baseline demographics, TNM stage, cancer site, details of radiation therapy, radiation complications, need for salvage laryngectomy, and five-year survival. The earliest recorded date of diagnosis for a patient included was 1999. Radiation complications were defined as major or minor [Table 1].

Table 1. Outcomes of interest in patients with and without cervical hardware.

Major Complications	• Osteoradionecrosis
	• Second primary cancers in the radiated field
	• Carotid blowout
	• Dysphagia *with* surgical intervention
	  o Dilation
	  o PEG dependence

Minor Complications	• Xerostomia • Fibrosis • Dysphagia *without* surgical intervention • Soft tissue necrosis • Carotid stenosis • Radiation myelopathy
Treatment Outcomes	• Five-year survival • Need for salvage laryngectomy

Patients were separated into groups for analysis based on presence or absence of cervical hardware. Patients with cervical hardware were identified by chart search for the words “hardware,” “fusion,” and “ACDF,” as well as a search for operative notes and review of imaging at the time of cancer diagnosis. To be included in this group, patients had to have hardware in place prior to undergoing radiation therapy.

Following data collection, categorical and continuous variables were evaluated using chi square analysis (with Fisher’s exact tests) and student’s t-tests, respectively. Missing data were evaluated in SPSS and determined to be missing at random (MAR). As such, multiple imputation was used to address missing values. Finally, a post-hoc power analysis was performed to assess the study population size and outcomes.

This project was reviewed and approved by IRB-I – Medical University of South Carolina (Pro00125501). In accordance with 45 CFR 46.104(d), this study was considered exempt from Human Research Subject Regulations.

RESULTS

245 total patients were included for analysis – 16 with cervical hardware, and 229 without. Basic demographics of the two groups were similar [Table 2]. 51.43% of patients overall had a diagnosis of T1 laryngeal cancer. The remaining 48.57% of patients had T2 cancer. Rates of comorbidities such as tobacco use (77% vs. 72% former smokers, p=0.50) and diabetes (19% vs. 23%, p=0.72) were comparable between groups.

Table 2. Demographics of patients with and without cervical hardware

	Without Cervical Hardware	With Cervical Hardware	Total
N	229	16	245
Sex[a]			
Male	46	6	52
Female	183	10	193
Race			
Black or African American	57	4	61
White or Caucasian	163	11	174
Other	3	1	4
Unknown	6	0	6
Age Group (years)[b]			
25-55	47	5	52
56-75	152	7	159
75-85	25	4	29
>85	5	0	5
T Stage at diagnosis			
1	117	9	126
2	112	7	119

a. 60% male in the cervical hardware group vs. 25% male in the non-hardware group, p = 0.012
b. Mean average age was similar between hardware and non-hardware groups (63.1 vs. 63.4, p = 0.45)

The hardware and non-hardware groups received similar total doses of radiation (65.01 vs. 65.24 Gy, p = 0.83). Complete comparisons of treatment success as well as rates of major and minor complications can be viewed in Table 3.

Treatment Success

Proportion of patients needing salvage laryngectomy and recurrence rates were comparable between the two groups. The cervical hardware group had a slightly lower five-year survival rate, but this difference was not statistically significant (0.856 vs. 0.863, p = 1.00).

Minor Complications

There were no statistically significant differences between the two groups in terms of minor complications. The most common minor complication in both groups was dysphagia (not requiring surgical intervention). Dysphagia was marked present if it was noted as a patient problem in clinic or speech language pathology notes. Dysphagia was assessed in variable ways in our population: whether by validated surveys, functional endoscopic evaluation of swallow, or formal imaging (modified barium swallow study). The dysphagia rate was higher in the cervical hardware group, but not significant (0.750 vs. 0.653, p = 0.43). Severity of dysphagia was defined based on whether patients required surgical intervention. Rates of soft tissue necrosis, carotid stenosis, and radiation myelopathy were exceedingly low in both groups.

Table 3. Comparison of observed rates of various radiation outcomes in patients with and without cervical hardware, assessed with two-sided Pearson chi-square or Fisher's exact test

Outcome	Hardware	No Hardware	P value
Treatment success			
Five-year survival	0.856	0.863	P = 1.00
Proportion needing salvage laryngectomy	0.313	0.403	P = 0.48
Recurrence	0.375	0.425	P = 0.70
Major Complications			
Osteoradionecrosis	0.00	0.022	P = 1.00
Second primary	0.125	0.087	P = 0.64
Carotid blowout	0.00	0.009	P = 1.00
PEG dependence	0.438	0.343	P = 0.34
Dysphagia needing dilation	0.313	0.207	P = 0.35
Minor Complications			
Xerostomia	0.438	0.380	P = 0.86
Fibrosis	0.375	0.364	P = 0.96
Dysphagia without surgical intervention	0.750	0.653	P = 0.43
Soft Tissue Necrosis	0.00	0.017	P = 1.00
Carotid Stenosis	0.00	0.114	P = 0.23
Radiation Myelopathy	0.00	0.004	P = 1.00

Major Complications

In both groups, few to none of the patients experienced osteoradionecrosis, carotid blowout, or development of a second primary. Similarly to the pattern seen in the minor complications, patients with cervical hardware experienced higher rates of dysphagia requiring dilation or causing PEG dependence (0.313 vs. 0.207, p = 0.35; 0.438 vs. 0.343, p = 0.34). Neither of these trends reached significance. Of patients who required surgical interventions for dysphagia, 34% had dysphagia assessed via modified barium swallow study (MBSS).

DISCUSSION

Overall, there were no statistically significant differences in treatment outcomes or complication rates between patients with and without cervical hardware treated with radiation. There are several potential explanations for this finding. The most likely of these is that our study was not sufficiently powered to capture differences between the two groups. For example, post-hoc power analysis generated a 19.6% power to find a difference in dysphagia incidence between our two groups. Despite this study being underpowered and thus unable to decisively refute an effect of cervical hardware on radiation, we found it worthy to report as the first study assessing this question. This topic merits further research with a larger sample size in order to better characterize outcomes of laryngeal cancer radiation in cervical hardware patients [11].

Another potential explanation for the lack of significant differences between our groups could be that actual differences do exist, but they have small or clinically negligible effect sizes. This is especially likely to be the case for complications such as osteoradionecrosis, carotid blowout, soft tissue necrosis, and radiation myelopathy, which occurred at exceedingly low rates in both groups studied.

Additionally, it is possible that there is truly no difference in outcomes between patients with and without cervical hardware treated with radiation. While this would be discordant with evidence seen in treatment of other cancer types, there are several variables that make laryngeal cancer radiation unique. First, radiation dosage may differ for treatment of laryngeal cancer versus that of other malignancies. Studies on hardware and radiation therapy in the past have largely focused on treatment of spinal tumors. Patients with primary spinal tumors are given, on average, 74-85 Gy in total radiation [12], while our laryngeal cancer patients received 65 Gy total, on average. Additionally, in RT for spinal tumors, the hardware is more directly within the irradiated field. Irradiated laryngeal tumors, in contrast, are anterior to any existing hardware. However, one would not expect this to generate a large difference in outcomes, as conventional radiation does not boast the ability to spare normal tissue posterior to the tumor. Despite advances in target delineation, intensity-modulated radiation therapy, and volumetric-modulated arc therapy, conventional radiation with photon beams leads to the radiation dose being distributed throughout the entire path of the beam [13]. Future studies may assess whether the use of proton beam therapy, which has improved sparing of distal tissues [14], improves radiation outcomes in patients with spinal hardware. Additionally, given that this study focused primarily on smaller tumors [T1 and T2], the area treated was also much smaller as compared to tumors whose margins are treated more widely.

Despite overall lack of statistical significance, there was a slightly increased risk of dysphagia in the cervical hardware group. This included dysphagia with and without surgical intervention. This difference, if real, is consistent with theories surrounding hardware and radiation. Such theories state that tissues anterior to metal implants may get inadvertently overdosed, leading to increased side effects [8]. It is possible that the limitations of the retrospective chart review design lead to underestimation of true dysphagia prevalence, due to unpredictable lag times between radiation completion and development of complications. On average, patients in our study were diagnosed with laryngeal cancer 8.04 years prior to data collection taking place in 2025. Patients who underwent surgical interventions for dysphagia developed difficulty swallowing, on average, 1.92 years following completion of radiation (range: 0-16 years). While some patients (captured here) may develop radiation complications early, it is possible that patients will continue to develop post-radiation dysphagia many years after treatment. This concept of delayed complications could apply to other variables gathered in this study as well.

There are a few additional limitations to this study. First, we were unable to conduct logistic regression for multivariate analysis due to the large sample size discordance between the two groups. Few patients had cervical hardware (n = 16, 6.53%) in our sample. Based on the national PearlDiver database, approximately 1.2 million Americans underwent cervical spine surgery between 2010-2022, which represents about 0.5% of the United States population. Of these, ACDF was the most common surgery, closely followed by cervical disc arthroplasty (CDA) Both types of surgery involve the usage of titanium-coated hardware. Interestingly, then, our study population had a higher incidence of cervical spine hardware than anticipated given population-level data. This can most likely be attributed to patients with laryngeal cancer being older, on average, than the general population. Older adults are also more likely to have cervical hardware [11].

Additional study limitations include those intrinsic to retrospective chart reviews, such as inconsistent reporting between patient charts, missing data, and the possibility for selection bias. Some of our variables were not defined in precise detail – for example, presence or absence of dysphagia was assessed both by subjective reporting and more formal clinical assessments. Further, radiation complications may overall affect quality of life outcomes, which could be better assessed by a standardized patient survey.

One area for future research is to explore the outcomes of radiation therapy in patients with more advanced (T3 and T4) laryngeal cancers. We did not initially analyze these groups as they are more often treated with combined therapy (chemotherapy with radiation) or primary surgery with or without radiation. Additionally, patients with larger tumors often have pre-existing dysfunction, which has the potential to confound outcome findings. As discussed above, it would also be interesting to compare types of radiation used in patients with spinal hardware. Finally, patients could be assessed for morbidity and mortality at time points further out from radiation, as we only assessed survival up to five years.

CONCLUSION

In this small series, there were no statistically significant differences in RT outcomes or complication rates for early-stage laryngeal cancer patients with and without cervical hardware. This does not definitively negate the presence of differences between groups, given the small sample size. Patients with cervical hardware had worse swallowing outcomes, disproportionately experiencing dysphagia both with and without intervention (requiring dilation or PEG). The difference in rates of dysphagia requiring intervention approached, but did not reach, significance. Furthermore, as patients have improved outcomes, it is important to assess patients for potential premorbid conditions when choosing treatment modalities as well as to counsel patients on potential treatment sequelae.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author, AC. The data are not publicly available in order to protect the privacy of patients studied.

Conflicts of Interest

Kejner: speaker honorarium Vioptix Inc, consultant for Cooper Surgical

ETHICS APPROVAL

This project was reviewed and approved by IRB-I – Medical University of South Carolina (Pro00125501). In accordance with 45 CFR 46.104(d), this study was considered exempt from Human Research Subject Regulations.

REFERENCES

1. Hrelec C. Management of Laryngeal Dysplasia and Early Invasive Cancer. Curr Treat Options Oncol. 2021; 22: 90.
2. Lee KC, Chuang SK. The nonsurgical management of early stage (T1/2 N0 M0) laryngeal cancer: A population analysis. Oral Surg Oral Med Oral Pathol Oral Radiol. 2020; 130: 18-24.
3. Obid R, Redlich M, Tomeh C. The Treatment of Laryngeal Cancer. Oral Maxillofac Surg Clin North Am. 2019; 31: 1-11.
4. Forastiere AA, Ismaila N, Lewin JS. Use of Larynx-Preservation Strategies in the Treatment of Laryngeal Cancer: American Society of Clinical Oncology Clinical Practice Guideline Update. J Clin Oncol. 2018; 36: 1143-1169.
5. Steuer CE, El-Deiry M, Parks JR, Higgins KA, Saba NF. An update on larynx cancer. CA Cancer J Clin. 2017; 67: 31-50.
6. Cheraghlou S, Kuo P, Mehra S, Yarbrough WG, Judson BL. Salvage Surgery after Radiation Failure in T1/T2 Larynx Cancer: Outcomes following Total versus Conservation Surgery. Otolaryngol Head Neck Surg. 2018; 158: 497-504.
7. Le Fèvre C, Lacornerie T, Noël G, Antoni D. Management of metallic implants in radiotherapy. Cancer Radiother. 2022; 26: 411-416.
8. Liang Y, Xu H, Tang W, Du X. The impact of metal implants on the dose and clinical outcome of radiotherapy (Review). Mol Clin Oncol. 2024; 21: 66.
9. Son SH, Kang YN, Ryu MR. The effect of metallic implants on radiation therapy in spinal tumor patients with metallic spinal implants. Med Dosim. 2012; 37: 98-107.
10. Li J, Yan L, Wang J, Cai L, Hu D. Influence of internal fixation systems on radiation therapy for spinal tumor. J Appl Clin Med Phys. 2015; 16: 279–289.
11. Ibrahim MT, Kirven JC, Kavuri V, Yu E, Singh VK. Trends in Cervical Spine Surgery in the United States: A National Database Analysis. World Neurosurg. 2025; 198: 123961.
12. Stieb S, Snider JW 3rd, Placidi L, et al. Long-Term Clinical Safety of High-Dose Proton Radiation Therapy Delivered With Pencil Beam Scanning Technique for Extracranial Chordomas and Chondrosarcomas in Adult Patients: Clinical Evidence of Spinal Cord Tolerance. Int J Radiat Oncol Biol Phys. 2018; 100: 218-225.
13. Citrin DE. Recent Developments in Radiotherapy. N Engl J Med. 2017; 377: 1065-1075.
14. Lideståhl A, Fredén E, Siegbahn A, Johansson G, Lind PA. Dosimetric Comparison of Conventional Radiotherapy, Volumetric Modulated Arc Therapy, and Proton Beam Therapy for Palliation of Thoracic Spine Metastases Secondary to Breast or Prostate Cancer. Cancers (Basel). 2023; 15: 5736.