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The impact of tongue-deviating and tongue-depressing oral stents on long-term radiation-associated symptoms in oropharyngeal cancer survivors



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ABSTRACT

Objectives: To evaluate whether the use of oral stents during intensity modulated radiation therapy (IMRT) for oropharyngeal cancer (OPC) is associated with long-term patient reported symptoms.

Materials and methods: Data was obtained from a prospective observational study of disease-free head and neck cancer survivors. Radiation-associated patient reported symptoms were assessed using the MD Anderson Symptom Inventory Head and Neck module (MDASI-HN). Scores of ≥ 5 (11-point Likert scale, 0–10) were considered moderate/severe. Stratification was performed regarding IMRT volume (uni- versus bilateral neck) and stent utilization, with non-parametric analyses between groups.

Results: 462 OPC survivors formed the cohort (54% tonsil, 46% base of tongue primaries). A tongue-deviating stent was used in 17%, tongue-depressing stent in 46%, and no stent in 37%. Median prescribed dose to the high dose clinical target volume was 66.0 Gy. Median follow-up from RT to MDASI-HN assessment was 68 months. Twenty percent had received unilateral neck RT (all had tonsil primaries), in whom a significant improvement in the proportion of patients with moderate/severe taste impairment (2% vs. 15%, $p = 0.047$) and lack of appetite (0% vs. 9%, $p = 0.019$) was associated with the use of tongue-deviating stents compared to no oral stent. In those who had received bilateral neck RT, a significant improvement in the proportion of patients with moderate/severe difficulty swallowing/chewing was associated with use of a tongue-depressing stent (21% vs. 31% without oral stent, $p = 0.013$).

Conclusion: Disease-site specific select use of oral stents during IMRT was associated with reduced long-term patient reported symptoms in OPC survivors.

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1. Introduction

Xerostomia, taste impairment, and dysphagia are common late radiation-associated side effects that can negatively impact the quality of life of head and neck cancer (HNC) survivors [1–3], and the severity of these oral-related toxicities has been shown to be related in part to radiotherapy (RT) dose delivered to the oral

tongue and its associated mucosa, salivary glands, and musculature [4–6].

Oral stents can be used during RT for oropharyngeal cancer (OPC) to better position the oral tissues to facilitate normal tissue sparing and/or immobilize the tongue. For example, tongue-deviating oral stents can be used to displace the non-target oral tongue away from the target volume, such as in well-lateralized tonsil cancers treated with unilateral neck RT. Tongue-depressing oral stents can be used in base of tongue (BOT) cancers to displace the BOT target volume away from the non-target palate and help to

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immobilize the tongue to facilitate tongue/target position reproducibility [7] and accurate RT delivery.

While patient-specific custom oral stents, fabricated by our dental oncologists, are commonly used at our center for the treatment of OPC based on the aforementioned rationale and the demonstrated dosimetric advantages [8–14], the use of custom oral stents may not be routinely used in many radiation oncology practices owing to availability of dental expertise/resources or lack of studies demonstrating clinical benefit in terms of late toxicity reduction. In recent years, pre-fabricated commercial stent products became available and stent fabrication became easier and less time consuming with the innovation of 3D printers [15–17]. However, 3D printers in hospitals are still not common devices.

As part of an ongoing effort by our MD Anderson Head and Neck Cancer Symptom Working Group to profile patient reported symptoms and outcomes in HNC survivors and to advance clinical practice by developing strategies to reduce RT-associated toxicities, the specific aim of the present study was to assess whether the use of oral stents is associated with oral morbidity-related patient reported symptoms in OPC survivors after treatment with intensity modulated radiation therapy (IMRT).

2. Material and methods

2.1. Study procedure

Adult HNC patients who had received RT with curative intent, who were without evidence of active disease and had completed

initial therapy more than 6 months previously were eligible to participate in an Institutional Review Board (IRB)-approved, single institution, prospective longitudinal symptom assessment study. Study-specific informed consent was provided by all participants, who then either self-completed patient reported outcome questionnaires via pencil/paper during follow-up visit or via telephone interview conducted by study personnel using a study-specific IRB-approved script.

The current study is based on a cross-sectional sample of the aforementioned study using the validated MD Anderson Symptom Inventory - Head and Neck module (MDASI-HN) [18]. In the current study we analyzed six potentially oral morbidity-related items of the MDASI-HN completed at a minimum of 12 months after completion of IMRT (including volumetric arc radiation therapy [VMAT]) for treatment of tonsil or BOT squamous cell carcinoma. These items were: problem tasting food, dry mouth, mucus in mouth/throat, difficulty swallowing/chewing, mouth/throat sores, and lack of appetite.

Since the patients' symptoms had been assessed at various time points in the post-RT follow-up period with the MDASI-HN, we used the last assessment for our analysis in patients who had no cancer events subsequent to treatment. The last MDASI-HN has been chosen, as our group previously showed, that even after years from RT there is still potential for improvement of late radiation-associated symptoms like taste impairment [19]. For patients who developed local/regional recurrence, received systemic therapy for distant metastases or second malignancy, or had oral surgery in the follow-up period, we used the last MDASI before this event or otherwise excluded the patient if this MDASI was

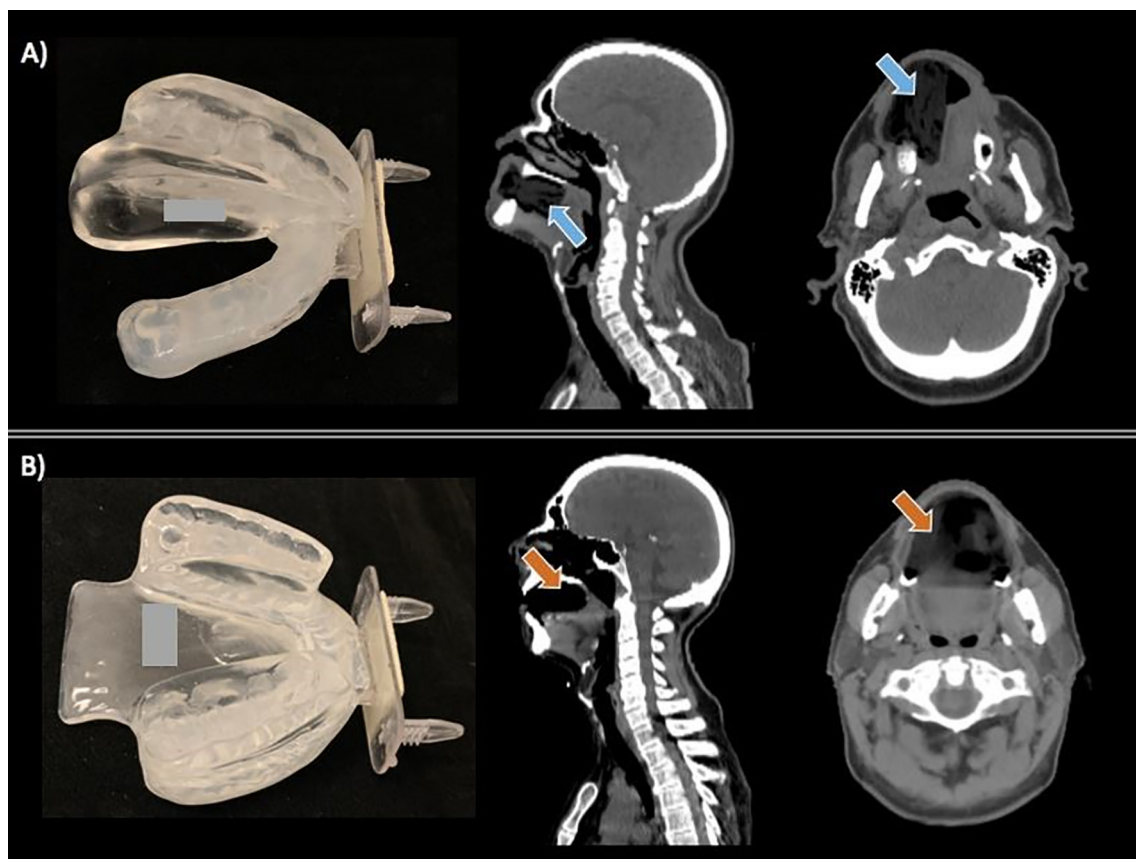


Fig. 1. Tongue-deviating stent (A/blue arrow) and tongue-depressing stent (B/orange arrow) with representative sagittal and axial CT simulation images of patients. (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

completed within the first year post-RT (Suppl. Table 1). Patients excluded from this analysis were those with missing information regarding oral immobilization.

The symptom items are rated by patients on an 11-point Likert scale from 0 (“not present”) to 10 (“as bad as you can imagine”), indicating the presence and severity of the symptoms over the past 24 hours. Symptom ratings were considered mild with a score of 1–4, moderate 5–6 and severe 7–10. Patient demographics and tumor and treatment characteristics were extracted from the electronic medical record. Tumor category is described according to the current cancer staging manual of the American Joint Committee on Cancer (AJCC) at the time of the initial diagnosis.

2.2. Patient treatment

All patients had undergone CT simulation and were immobilized for simulation and treatment using a customized thermoplastic head, neck and shoulder mask with or without a customized oral stent at the discretion of the treating radiation oncologist. Use of stent was considered for patients who could safely and reliably tolerate stent use and achieve oral immobilization and/or displacement. A customized mouth-opening and tongue-depressing oral stent was generally used for patients with BOT primaries and a tongue-deviating oral stent for patients with small tonsil primaries or those confined to the tonsillar fossa (Fig. 1).

All patients had received IMRT (or VMAT) with 6 MV photons. Patients with well-lateralized T1-T2 tonsil primaries without evidence of contralateral nodal disease were generally treated with unilateral neck RT [20]; all others were generally treated with bilateral neck RT.

2.3. Statistical analysis

All statistical analyses were performed with IBM SPSS Statistics 24 (IBM, Armonk, NY) and JMP Pro 14 (SAS Institute, Cary, NC). Descriptive statistics were used for description of patient population and symptom ratings. Mann-Whitney U and Kruskal-Wallis test were performed for non-parametric group comparison analyses. Spearman rho test was applied to test for correlation between symptoms. Univariate analysis was used for selection of confounding factors on symptoms (no/mild vs. moderate/severe), which were then investigated in the multivariate analysis if more than one factor had a p-value below 0.1 (both nominal logistic regression). A non-Bonferroni corrected p-value of <0.05 was considered as significant for this hypothesis generating study.

3. Results

Four hundred sixty-two OPC survivors formed the cohort. Eighty-three percent were male, 17% female, with a median age of 55 years. The median follow-up from end of RT (2001–2015) to MDASI-HN assessment (collected from 2010 to 2019) was 68 months (range 13–158).

Two hundred forty-eight patients (54%) had tonsil primaries and 214 (46%) BOT. Most had T1 (36%) –T2 (39%) tumors and 91% were node positive. The most common radiation treatment fractionation schedules were 66 Gy in 30 fractions (48%), and 70 Gy in 33 fractions (36%). Chemotherapy was used in 45% of patients (including induction, concurrent and/or adjuvant chemotherapy) and 13% received concurrent targeted therapy. Details of the patient population are displayed in Table 1.

Unilateral neck RT was delivered in 94 patients with tonsil cancer (20% of the whole cohort; 38% of the tonsil cancer patients). In these, 49 (53%) were treated with a tongue-deviating stent. Bilateral RT was received by 364 patients; 152 with tonsil cancer

Table 1

Patient and treatment characteristics of the study cohort (n = 462 patients).

	n (%) [*]
Sex	
Male	385 (83.3%)
Female	77 (16.7%)
Age at RT start [years]	
Mean/SD	56/9
Median	55
Range	29–84
Race	
Caucasian	448 (97.0%)
Asian	3 (0.6%)
Black or African American	7 (1.5%)
American Indian or Alaska Native	2 (0.4%)
Unavailable	2 (0.4%)
Primary tumor site	
Tonsil	248 (53.7%)
BOT	214 (46.3%)
Tumor category	
Tis	1 (0.2%)
T1	168 (36.4%)
T2	181 (39.2%)
T3	72 (15.6%)
T4	35 (7.6%)
Unavailable	5 (1.1%)
Nodal status	
N0	40 (8.7%)
N+	422 (91.3%)
Tumor HPV or p16	
Positive	222 (48.0%)
Negative	22 (4.8%)
Unknown	218 (47.2%)
PTV1 [Gy]	
Mean/SD	67.9/2.4
Median	66
Range	57.6–72.5
Number of fractions	
Mean/SD	31.9/2.6
Median	30
Range	27–40
Chemotherapy	
Any	256 (44.6%)
Induction	152 (32.9%)
Concurrent	156 (33.8%)
Adjuvant	5 (1.1%)
Targeted therapy	
Concurrent	58 (12.6%)
Smoking status at RT start	
Current smoker	31 (6.7%)
Former smoker	173 (37.4%)
Never smoker	204 (44.2%)
Unavailable	54 (11.7%)

^{*}if not indicated otherwise; BOT: base of tongue, PTV1: high dose planning target volume, n: number of patients, N+: node positive, RT: radiotherapy, SD: standard deviation

(20% of them with tongue-deviating stent, 16% with tongue-depressing stent) and 212 with BOT primary (85% with tongue-depressing stent) (Suppl. Table 1).

3.1. Long-term patient reported symptoms

The topmost severe symptom was dry mouth (mean rating: 3.89), followed by difficulty swallowing/chewing (2.70), mucus in mouth/throat (2.15), problem tasting food (1.82), lack of appetite (0.90) and mouth/throat sores (0.49) (Suppl. Table 2). Moderate/severe symptom ratings were reported by 39% of the patients for dry mouth, 24% for difficulty swallowing/chewing, 19% for mucus in mouth/throat and 16% for problem tasting food; the percentage of patients with moderate/severe ratings for lack of appetite and mouth/throat sores was less than 10% (Fig. 2, Suppl. Table 2). There

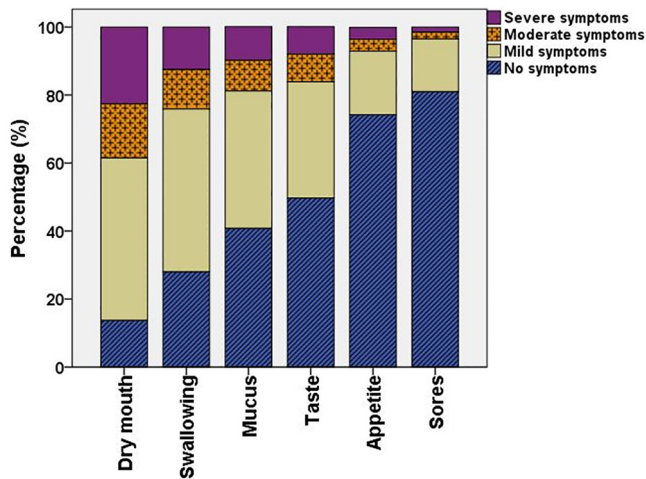


Fig. 2. Percentage of OPC survivors having no, mild, moderate and severe long-term symptoms according to the MDASI-HN questionnaire (n = 462).

was a highly significant correlation between all symptoms analyzed ($p < 0.001$) (Suppl. Table 3).

3.2. Effect of radiation technique

Patients with T1–2 tonsil cancer treated with unilateral neck RT had lower mean MDASI-HN scores compared to patients treated bilaterally for all the reported symptoms except for mouth/throat sores (Suppl. Table 4).

For problem tasting food, mouth/throat mucus, and lack of appetite, about half as many patients reported moderate/severe ratings treated with unilateral vs. bilateral neck RT (6.5 vs. 15.0%, 8.3 vs. 17.5%, 3.1 vs. 9.2%; respectively, Suppl. Table 4).

3.3. Effect of oral stent

For those patients who received unilateral neck RT, there was a significant difference in the number of patients in the different MDASI-HN categories (no, mild, moderate, severe) for taste impairment when comparing patients with tongue-deviating stent versus no stent ($p = 0.047$, Fig. 3). Thirteen percent of patients treated without stent reported severe taste impairment whereas no patient treated with a tongue-deviating stent had severe problems

tasting food. The mean MDASI-HN score for taste was 0.51 versus 1.74 in patients with and without stent, respectively (Table 2). Appetite was also significantly better in patients treated with a tongue-deviating stent (Table 2, Fig. 3). Both symptoms, taste impairment and lack of appetite, were significantly less with the oral stent when comparing the groups with no/mild versus moderate/severe symptoms (taste impairment: $p = 0.027$, lack of appetite: $p = 0.030$). Patients with a tongue-deviating stent had significantly earlier T-category than patients without stent (T1: 79% vs. 59%, respectively, Suppl. Table 5), but when subgrouping by T-category (T1 and T2) lower MDASI-HN taste impairment and lack of appetite scores for each stage were still observed (Suppl. Table 6).

One hundred eighty patients (88%) with BOT cancers were treated with bilateral RT and a tongue-depressing stent compared with only 25 patients (12%) with tonsillar cancer ($p < 0.001$, Suppl. Table 5).

Patients with bilateral radiotherapy treated with a tongue-depressing stent reported significantly less swallowing/chewing difficulty and fewer mouth/throat sores (Table 2): Ten percent of patients treated with a tongue-depressing stent reported severe dysphagia after therapy, compared to 18% treated without an oral stent ($p = 0.013$ for comparison of the severity categories). Regarding mouth/throat sores, 84% of patients had no symptoms if treated with a tongue-depressing stent compared to 75% of patients treated without a stent ($p = 0.028$ for comparison of the severity categories). When the symptom severity groups were merged together to no/mild versus moderate/severe toxicity, swallowing/chewing difficulty remained significantly different between patients treated with or without stent ($p = 0.049$).

3.4. Multivariate analysis of patient and treatment factors on oral morbidity-related symptoms

The use of a stent was significantly associated with lower taste impairment, difficulty swallowing/chewing and lack of appetite in patients irradiated with unilateral radiotherapy in univariate analysis and remained significant for taste and appetite in multivariate analysis (Table 3).

In patients irradiated with bilateral neck RT, current smoking at RT start had a significant negative influence on all oral morbidity-related symptoms (no/mild vs. moderate/severe). Positive lymph node status was associated with increased taste impairment in these patients (Table 3).

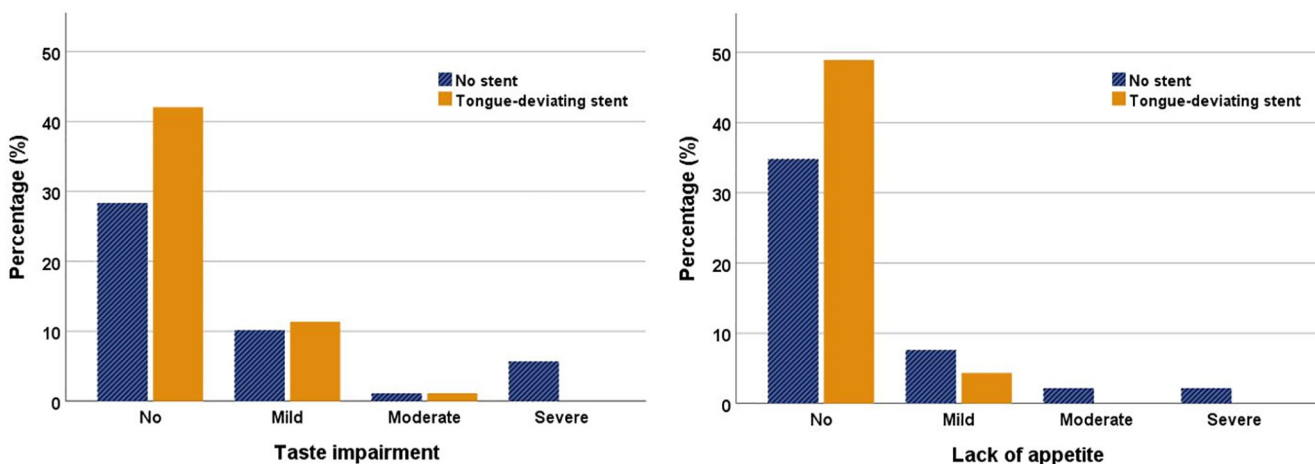


Fig. 3. Severity of taste impairment and lack of appetite for patients treated with unilateral radiotherapy with and without tongue-deviating stent.

Table 2MDASI-HN symptom ratings according to neck RT laterality and stent use. MDASI-HN scores of ≥ 1 and ≤ 4 are considered as mild, ≥ 5 and ≤ 6 moderate and ≥ 7 severe symptoms.

	MDASI-HN scores/ symptom categories	Unilateral radiotherapy			Bilateral radiotherapy		
		Tongue- deviating stent	No stent	p-value (no vs. tongue- deviating stent)	Tongue-depressing stent	No stent	p-value (no vs. tongue- depressing stent)
Number of patients		49	43		205	129	
Taste impairment	Mean/SD	0.51/1.16	1.74/3.14	0.056	2.20/2.77	1.92/2.52	0.555
	Median	0	0		1	1	
	Range	0–5	0–10		0–10	0–10	
	No	77.10%	62.50%	0.047	43.00%	43.10%	0.773
	Mild	20.80%	22.50%		37.00%	39.00%	
Dry mouth	Moderate	2.10%	2.50%		9.00%	10.60%	
	Severe	0%	12.50%		11.00%	7.30%	
	Mean/SD	3.08/2.91	3.38/3.19	0.707	4.20/2.97	4.04/2.99	0.604
	Median	2	2.5		4	3	
	Range	0–10	0–10		0–10	0–10	
Mucus in mouth/throat	No	18.40%	20.90%	0.905	11.20%	10.20%	0.747
	Mild	55.10%	51.20%		44.40%	49.60%	
	Moderate	12.20%	9.30%		20.50%	15.70%	
	Severe	14.30%	18.60%		23.90%	24.40%	
	Mean/SD	1.54/2.14	1.33/2.41	0.373	2.25/2.59	2.58/2.81	0.335
Difficulty swallowing/ chewing	Median	0	0		1	2	
	Range	0–9	0–10		0–10	0–10	
	No	53.10%	62.80%	0.337	37.80%	33.90%	0.377
	Mild	34.70%	30.20%		41.80%	42.50%	
	Moderate	10.20%	0.00%		10.00%	10.20%	
Mouth/throat sores	Severe	2.00%	7.00%		10.40%	13.40%	
	Mean/SD	1.83/2.65	2.81/3.04	0.068	2.53/2.54	3.28/2.78	0.013
	Median	1	1.5		2	3	
	Range	0–10	0–10		0–10	0–10	
	No	44.90%	30.20%	0.085	28.80%	19.40%	0.013
Lack of appetite	Mild	38.80%	41.90%		50.20%	50.00%	
	Moderate	6.10%	16.30%		11.20%	12.90%	
	Severe	10.20%	11.60%		9.80%	17.70%	
	Mean/SD	0.65/1.77	0.69/1.63	0.606	0.37/1.24	0.55/1.26	0.023
	Median	0	0		0	0	
Lack of appetite	Range	0–9	0–10		0–8	0–7	
	No	81.60%	76.70%	0.577	84.40%	75.00%	0.028
	Mild	14.30%	18.60%		11.20%	22.70%	
	Moderate	0%	2.30%		2.40%	1.60%	
	Severe	4.10%	2.30%		1.00%	0.80%	
Lack of appetite	Mean/SD	0.17/0.66	1.02/2.27	0.018	0.96/2.05	1.12/2.17	0.242
	Median	0	0		0	0	
	Range	0–4	0–10		0–10	0–10	
	No	91.80%	74.40%	0.019	73.60%	66.70%	0.199
	Mild	8.20%	16.30%		18.90%	25.40%	
Lack of appetite	Moderate	0%	4.70%		4.00%	2.40%	
	Severe	0%	4.70%		3.50%	5.60%	

BOT: base of tongue, SD: standard deviation.

Significant p-values in bold.

4. Discussion

The dosimetric advantage of different oral stent types as well as the “stick-out” tongue technique for HNC RT has already been described in other studies [8–14,21] (Table 4). To our knowledge, this study of over 450 patients with OPC and long-term survival is the first to attempt to translate these dosimetric advantages of stent usage into a clinical benefit with regards to decreasing late symptoms in HNC patients. We found both a benefit to a tongue-deviating stent for patients treated with unilateral neck RT, and a tongue-depressing stent for patients treated with bilateral neck RT.

Patients treated with unilateral neck RT with a tongue-deviating oral stent for early tonsil cancer reported lower scores for taste impairment and lack of appetite. Although the difference in mean MDASI-HN score between the groups with and without oral stent might be low, there is a significant decreased proportion of patients who had moderate/severe symptoms. Less toxicity has already been reported for unilateral irradiation in cohorts of OPC

[22] and tonsil cancers only [23,24] compared to standard bilateral RT by other authors. Despite these patients having in general a lower toxicity profile, the addition of a tongue-deviating stent further decreases long-term patient reported symptoms.

Patients treated with tongue-depressing stents and bilateral neck RT showed significantly less moderate/severe dysphagia and mouth/throat sores. Besides the overall beneficial effect on long-term toxicity, the tongue-depressing stent has been previously shown to improve patient and oral immobilization during treatment [7]. This improvement in immobilization can lead to an improved image quality in MRI [7], which is often fused with the planning CT for better target and organ at risk delineation. Furthermore, the increased reproducibility of patient positioning during RT may possibly contribute to a higher local tumor control rate. However, that particular study [7] was conducted at baseline, mid-treatment and one month post-treatment only, and not at the end of the treatment when the radiation side effects are most severe, which could negatively impact patient tolerability of the

Table 3
Results (p-values) of univariate and multivariate (in brackets) analysis for different radiation-associated symptoms divided into groups with unilateral and bilateral radiation technique. Factors with p-values < 0.1 were included into the multivariate analysis.

	Taste impairment		Dry mouth		Mucus in mouth/throat	
	Unilateral	Bilateral	Unilateral	Bilateral	Unilateral	Bilateral
Sex	0.265	0.371	0.734	0.014 (0.021)	0.167	0.700
Age at RT start	0.053 (0.037)	0.088 (0.171)	0.674	0.617	0.834	0.521
Tumor site	–	0.789	–	0.303	–	0.762
Tis/T1/T2 vs. T3/T4	0.591	0.893	0.495	0.858	0.143	0.040 (0.163)
N0 vs. N+	0.788	0.032 (0.024)	0.107	0.677	0.124	0.160
PTV1 dose	0.851	0.081 (0.129)	0.881	0.890	0.409	0.598
Chemo yes vs. no	0.091 (0.085)	0.420	0.083	0.776	0.741	0.795
Current smoking at RT start	0.497	0.027 (0.016)	0.429	0.017 (0.014)	0.240	0.003 (0.006)
Stent yes vs. no	0.021 (0.018)	0.638	0.882	0.448	0.391	0.491
	Difficulty swallowing/chewing		Mouth/throat sores		Lack of appetite	
	Unilateral	Bilateral	Unilateral	Bilateral	Unilateral	Bilateral
Sex	0.230	0.470	0.980	0.567	0.430	0.552
Age at RT start	0.821	0.264	0.674	0.542	0.256	0.281
Tumor site	–	0.040 (0.192)	–	0.788	–	0.263
Tis/T1/T2 vs. T3/T4	0.356	0.216	0.051	0.245	0.051 (0.088)	0.594
N0 vs. N+	0.786	0.179	0.313	0.902	0.583	0.205
PTV1 dose	0.171	0.750	0.451	0.369	0.372	0.042 (0.141)
Chemo yes vs. no	0.804	0.302	0.201	0.573	0.910	0.260
Current smoking at RT start	0.069	0.016 (0.075)	0.441	0.013	0.441	0.006 (0.007)
Stent yes vs. no	0.179	0.050 (0.747)	0.894	0.561	0.012 (0.071)	0.876

PTV1: high dose planning target volume, N+: node positive, RT: radiotherapy

Table 4
Overview of published studies investigating oral stents for external beam head and neck radiotherapy.

Author, year	Available publication	n	Tumor subsite	Stent type definition	Dosimetric result	Toxicity outcome
Feng, 2019 [8]	Original paper	60	Sinus, gingiva, nasal lymphoma, olfactory neuroblastoma	Bite block	Sign. lower Dmean and Dmax to the tongue, Dmax to submandibular gland and Dmean to mandible, bilateral PGs and SMGs. No difference for PTV.	15% G1 mucositis, 10% G2 mucositis during RT; no taste dysfunction or xerostomia (median follow-up 25 months).
Grant, 2019 [9]	Conference abstract	20	Tonsil	Tongue-deviating stent	Sign. lower Dmean and V30 to oral mucosa and tongue for IMRT. No difference for IMPT. No difference for both techniques for oral mucosa and tongue D3cc.	–
Kil, 2017 [10]	Case report	3	BOT	–	Sign. decrease in Dmean to ant. OC, oral tongue, SPC, MPC, supraglottic larynx; sign. reduced V30/V35 of ant. OC and oral tongue and V55/60 of SPC and MPC. PTV coverage same.	–
Kil, 2016 [11]	Original paper	13	Tonsil, larynx	“Stick-out” tongue	Sign. more distance between BOT/PC, tongue/hard palate and gingiva/lips. Sign. reduced Dmean to OC, tongue and lips (only for OPC). Lower V15/V30/V45 of tongue.	–
Nayar, 2016 [12]	Original paper	55 (24/31)*	HNC	Radiation-positioning stent	Sign. less dose to the maxilla in tumors of/near the mandible with stent. Also less dose to the mandible in tumors of/near the maxilla with stent, but not sign..	Sign. improvement of 78% in mouth-opening with stent 1–2 months post-RT.
Verrone, 2014 [13]	Original paper	33 (19/14)*	Tongue, floor of mouth	Mouth-opening, tongue-depressing stent	Sign. lower Dmean to the maxilla and ipsilat. PG with stent, but PTV dose in this group sign. lower.	Later onset of G3 mucositis with stent during RT.
Mall, 2016 [26]	Original paper	30 (15/15)*	Posterior tongue	Positioning stent	–	Sign. higher salivary flow rates (stimulated and unstimulated) and sign. better xerostomia-related QoL with stent at 3 and 6 months post-RT.
Verrone, 2013 [21]	Case report	1	Tongue	Mouth-opening, tongue-depressing stent	Lower Dmean to teeth, hard palate, PGs, left SMG with stent; target coverage similar.	G2 oral mucositis from day 13 of RT. Beginning of G3 xerostomia in first weeks of RT; at 6 months post-RT only G1 xerostomia
Goel, 2010 [27]	Original paper	48 (24/24)*	Tongue	Positional stents	–	Sign. lower palatal mucositis and xerostomia with stent at 30, 45 and 60 days post-RT.

Table 4 (continued)

Author, year	Available publication	n	Tumor subsite	Stent type definition	Dosimetric result	Toxicity outcome
Qin, 2007 [14]	Original paper	43 (19/24)*	NPC	Individual dental stent	Decrease in RT dose to the tip and body of tongue with stent.	Rate of G3 oral mucositis lower with stent, G1–2 higher. Sign. less taste dysfunction with stent.

*with/without oral stent. BOT: base of tongue, D: dose received by a certain treatment volume, Dmean: mean dose, G: grade, HNC: head and neck cancer, MPC: medial pharyngeal constrictor, n: number of patients, NPC: nasopharyngeal cancer, OC: oral cavity, OPC: oropharyngeal cancer, PC: pharyngeal constrictor, PG: parotid gland, PTV: planning target volume, QoL: quality of life, RT: radiotherapy, sign.: significant/ly, SMG: submandibular gland, SPC: superior pharyngeal constrictor, V: volume receiving a certain radiation dose

stents. Stent compliance or patient stent experience was not formally assessed as part of this study but would be worthy of future investigation.

A limitation of this study is the non-randomization of stent use and the non-standardization of clinical factors leading to stent use decision-making. Furthermore, due to the eligibility criteria of the parent study including only patients without active disease, any positive or negative association of stent use with local control could not be assessed. However, there is evidence that stent use is beneficial in terms of dosimetric parameters of the organs at risk [8–14,21], and we add data to suggest a clinical benefit with regards to patient reported long-term outcomes. This study is a retrospective analysis of prospectively collected data, and while randomized data is regarded as strongest from a scientific perspective, recognizing stents improve dosimetry with regards to avoidance of normal tissue, and treatment reproducibility, it is moot whether randomized data is an absolute necessity. Another limitation in our study is the wide range of individual MDASI-HN time points after RT. Although we excluded patients with only MDASI-HN assessments within the first 12 months from end of RT, others have shown there is further improvement of oral morbidity-related symptoms over time [25]. However, since the time points of analyzed MDASI-HN assessments did not vary much between the groups with or without stent (Suppl. Table 5), the impact of varying time points are likely at most of minor impact.

5. Conclusions

When safely and reliably tolerated, use of a tongue-deviating stent should be considered for selected tonsil cancer patients when treated with unilateral neck RT as it was significantly associated with improved long-term patient reported taste and appetite. Likewise, our data also suggest the select use of tongue-depressing stents for patients treated with bilateral neck RT for BOT cancers reduced long-term patient reported dysphagia and mouth/throat sores. Routine involvement of dental oncology specialists should be part of the multidisciplinary care of OPC patients.

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Declarations of Competing Interest

The authors declare no conflict of interest.

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