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Dysphagia profiles after primary transoral robotic surgery or radiation for oropharyngeal cancer: A registry analysis

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Abstract

Objective: To describe the physiologic swallowing impairments (MBSImP™©) associated with safety/efficiency impairments ($DIGEST_{safety}$/$DIGEST_{efficiency}$ grades) at 3–6 months after transoral robotic surgery (TORS) or radiation therapy (RT).

Study Design: Secondary analysis of registry data.

Setting: Single, academic institution.

Methods: Two hundred and fifty-seven patients with HPV+ oropharynx cancer were stratified by primary treatment (75 TORS, 182 RT). Modified barium swallow studies were analyzed at baseline and 3–6 months using MBSImP scores and $DIGEST_{safety}$/$DIGEST_{efficiency}$ grades. $DIGEST_{safety}$/$DIGEST_{efficiency}$ grades and MBSImP were compared groupwise and associations between $DIGEST_{safety}$/$DIGEST_{efficiency}$ grades and MBSImP were explored by ordinal logistic regression. Exploratory analyses were stratified by multimodality treatment.

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AUTHOR CONTRIBUTIONS

Concept and design: Barbon, Hutcheson; Acquisition, analysis, or interpretation of data: Barbon, Yao, Alvarez, Goepfert, Fuller, Lai, Gross, Hutcheson; Drafting of the manuscript: Barbon, Hutcheson; Critical revision of the manuscript for important intellectual content: Barbon, Yao, Goepfert, Fuller, Lai, Gross, Hutcheson; Statistical analysis: Barbon, Hutcheson; Obtained funding: Hutcheson; Administrative, technical, or material support: Yao, Goepfert, Fuller, Lai, Gross; Supervision: Hutcheson, Lai, Fuller. Drs Barbon and Hutcheson had full access to all data in the study and take full responsibility for the integrity of the data and the accuracy of the data analysis.

CONFLICT OF INTEREST

Dr Hutcheson reports receiving research grants and contracts from the National Institutes of Health and the Patient Centered Outcomes Research Institute and personal fees from MedBridge, ATOS Medical, and the American Speech-Language-Hearing Association (ASHA) outside of this work. Dr Lai reported receiving grants from the National Institutes of Health and the Cancer Prevention and Research Institute of Texas and personal fees from Cardinal Health outside the submitted work. Dr Fuller reported receiving grants and personal fees from the National Institutes of Health, grants and personal fees from Elekta AB, and personal fees from Greater Baltimore Medical Center, Tianjin Memorial Hospital, and the American Association of Physicists in Medicine outside the submitted work. Dr Gross reported receiving personal fees from Intuitive Surgical and non-financial support from MedRobotics outside the submitted work.

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Results: Neither $DIGEST_{safety}$/$DIGEST_{efficiency}$ differed significantly between groups at baseline or 3–6 months. Laryngeal vestibule closure was impaired more frequently in the RT group (RT: 41% vs. TORS: 27%; $p = 0.02$) while the TORS group had significantly more pharyngeal contraction impairment (63%; $p < 0.001$) compared to RT at 3–6 months.

Conclusion: The results suggest a focal injury associated with $DIGEST_{safety}$/$DIGEST_{efficiency}$ post-TORS in contrast to a low-level diffuse physiologic impairment associated with post-RT dysphagia.

Keywords

dysphagia; head and neck cancer; radiation; surgery

1 | INTRODUCTION

The recent increase in the incidence of oropharynx cancers (OPCs) is largely driven by human papilloma virus (HPV) associated tumors, which are rising in epidemic proportions.[1] Much of the cohort of OPC is composed of patients with low-to-intermediate risk stage of disease, based on tumor, nodal volume, HPV status, and smoking.[1] Patients with low to intermediate risk OPC present with favorable survival probability, thus likely to progress into lifelong survivorship.

Standard of care treatment for OPC over the past two decades has relied on radiotherapy (RT), with iterative advancements in conformal methods such as intensity modulated radiation therapy designed to sculpt dose to minimize normal tissue injury by sparing radiation dose to critical structures. Transoral robotic surgery (TORS) has been rapidly adopted as another primary treatment option for low-to-intermediate risk OPC.[2,3] The increase in TORS is driven by the potential to de-escalate or avoid postoperative, multimodality treatments altogether.[3]

There are conflicting findings regarding which primary treatment strategy results in the best swallowing outcomes in low-to-intermediate risk disease.[4,5] Neither TORS or RT is, however, dysphagia-free despite the function-preserving focus of both primary treatment methods.[4-6] Regardless of which modality is best to preserve swallow function, acute dysphagia is expected for either approach.[5,6] A current knowledge gap exists in understanding pathophysiology of functional impairment in early survivorship with modern treatment options as clinical observations, in fact, suggest that the mechanism of swallowing injury differs.

Pharyngeal swallowing function is two-fold, often broken into safety and efficiency. Swallow safety is commonly measured using the penetration-aspiration scale,[7] which captures depth and corresponding sensation or reaction to airway entry on an ordinal scale. Pathophysiology that drives any underlying swallowing safety impairment is commonly measured using parameters describing the completeness, timing, and duration of laryngeal vestibule closure (LVC).[8-10] Swallow efficiency is commonly measured using visuo-perceptual rater estimates[11,12] and more objective quantitative spatial measures of postswallow residue. Pathophysiology of swallow inefficiency is theoretically driven by

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factors such as poor pharyngeal constriction, pharyngeal cavity area, esophageal opening, and impaired lingual and tongue-base propulsion.[13,14] Knowledge of the underlying pathophysiology of impaired swallow safety and efficiency is needed to plan personalized treatment, select appropriate diagnostics, and inform patients regarding their post-treatment expectations.

The Dynamic Imaging Grade of Swallowing Toxicity (DIGEST™) and the Modified Barium Swallow Impairment Profile (MBSImP ™©) are two methods commonly used to grade dysphagia severity, per safety and efficiency of bolus clearance, and to characterize the physiological impairments of the swallow in patients with head and neck cancer. DIGEST is a validated method used to grade the severity of pharyngeal dysphagia from MBS and is based on the interaction of both swallow safety (per the penetration-aspiration scale[7]) and efficiency (per estimated amount of pharyngeal residue).[12] MBSImP is a standardized approach for visuo-perceptual ordinal grading of 17 oral and pharyngeal swallowing physiology components from the MBS.[15]

The authors have previously characterized the prevalence and severity of subacute dysphagia after primary TORS or RT for OPCs using the DIGEST grading method.[6] Approximately 7% of TORS and 16% of RT patients presented with DIGEST grades of 2 or higher, indicating moderate-to-severe dysphagia 3–6 months persisting after treatment. DIGEST analysis enabled the characterization of dysphagia severity among treatment subgroups and by tumor location. Alternatively, prospective, cross-sectional studies have applied an MBSImP component analysis to compare swallow physiology among OPC patients treated with surgery or RT to age-matched controls.[16] Specific MBSImP components, such as *initiation of pharyngeal swallow* (100%, 19/19), *decreased hyolaryngeal excursion* (53%, 10/19), and *decreased tongue base retraction* (74%, 14/19), were highly prevalent approximately 12 months post-treatment. These published data confirm the presence and pattern of dysphagia in OPCs after surgery or RT, yet we lack data that detail the underlying pathophysiological components that contribute to the swallowing safety and efficiency impairment, or differences in these relationships by primary treatment strategy (i.e., TORS or RT).

Therefore, the overall objective of the present study was to compare MBSImP profiles of swallowing physiology at subacute recovery (3–6 months) after primary treatment to determine which physiologic impairments are associated with safety (per $DIGEST_{safety}$) and efficiency (per $DIGEST_{efficiency}$) grades after two primary oncologic treatment strategies: TORS versus RT. Specific aims included a comparison between primary TORS and RT groups:

1. Patterns of functional impairment ($DIGEST_{safety}$ and $DIGEST_{efficiency}$ grades),
2. Physiologic impairment profiles (per MBSImP), and
3. Associations between MBSImP physiologic impairments with functional impairments ($DIGEST_{safety}$ and $DIGEST_{efficiency}$).

Finally, as most studies aggregate swallowing outcomes of all cases after TORS regardless of adjuvant therapies, we know very little regarding the cumulative effects of treatment

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as it relates to impairment profiles after single versus multimodality regimens.[6] Therefore, exploratory subgroup analyses were conducted for patients who received single (TORS alone, RT alone) versus multimodality treatments (TORS with adjuvant RT/chemoRT, RT with chemotherapy).

2 | METHODS

2.1 | Setting and study design

This is a secondary analysis of prospective registry data from the M. D. Anderson Oropharynx Cancer Registry (PA14-0947) Patient-Reported Outcomes and Function (PROF) Core. The registry enrolls all consenting patients with oropharyngeal malignancies of the head and neck at the University of Texas M. D. Anderson Cancer Center (MDACC) beginning in March 2015. The sample for this analysis comprised those enrolled on PA14-0914 from March 2015 to September 2019. Eligibility criteria were (1) cancer of the oropharynx, and (2) TORS or RT as primary treatment approach at MDACC. Primary treatment was determined by Multidisciplinary Tumor Board presentation of all cases in accordance with standard institutional practices.[17-19] Data analysis occurred under approval of the Institutional Review Board (protocol PA11-0809). Study data were collected and managed using Research Electronic Data Capture (REDCap) electronic data capture tools hosted at MDACC.[20,21] REDCap is a secure, web-based software platform designed to support data capture for research studies.

2.2 | Patient inclusion and eligibility

Two hundred and fifty-seven patients with HPV-associated low to intermediate risk OPC were sampled from a prospective registry and stratified by primary treatment of either TORS (n = 75) or RT (n = 182; Table 1). The full database sampling consort has been published elsewhere.[6]

2.3 | Swallowing outcome assessment

Patients enrolled in the prospective registry (PA14-0914) undergo standardized modified barium swallow (MBS) studies at regular timepoints including baseline and 3–6 months after locoregional treatment. Dysphagia was graded using DIGEST and MBSImP criterion.[11,15] MBS acquisition followed a standard protocol by a speech pathologist (SLP).[11] The MBS were recorded using 30 frames/s and archived via the TIMS DICOM System©.

The MBS bolus protocol included six trials thin liquid (5 cc, 10 cc, cup sip), and two trials each of pudding and cracker with barium pudding (Varibar® oropharyngeal contrast, Bracco Diagnostics, Inc.). Independent review of MBS DICOM files for DIGEST and MBSImP analyses were conducted by registered MBSImP clinicians who met >80 exact agreement reliability standard.[11,15] Rating SLPs were blinded to all clinical details.

The DIGEST method follows a standard decision tree to derive safety and efficiency grades that converge on an overall grade of 1 (mild), 2 (moderate), 3 (severe), and 4 (life threatening/profound) pharyngeal dysphagia aligned to the NCI's CTCAE toxicity

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grading framework.[11] MBSImP provides 17 measures of swallowing physiology parsed out by swallow stage: oral (items 1–6), pharyngeal (items 7–16), and esophageal (item 17). MBSImP components are ordinal, with select components varying from 0 (normal function) to 3 or 4 (Table 2). MBS were graded for $DIGEST_{safety}$ and $DIGEST_{efficiency}$ grades in addition to all MBSImP pharyngeal items. Oral component 6, *initiation of the pharyngeal swallow*, was included as it has been identified as a potential impairment in the head and neck cancer (HNC) dysphagia profile.[16]

Patients completed the MD Anderson Dysphagia Inventory (MDADI) prior to primary treatment and at their 3–6 months MBS. The MDADI is a patient-administered questionnaire that indicates the swallowing related quality of life.[22] The questions include 19 items pertaining to various aspects of swallowing (emotional, functional, physical) in addition to one item related to overall function. Results from all three subscales are pooled and averaged to yield a composite score, which was used in this analysis. Data were unavailable for one participant in the surgical group who was deceased at subacute follow-up.

2.4 | Statistical analysis

$DIGEST_{safety}$ and $DIGEST_{efficiency}$ grades and MBSImP profiles were compared between groups (primary TORS and primary RT) using chi-square (Fisher's exact, twosided) and Kruskall-Wallis with post hoc Dunn's test and Šidák correction, respectively (Aims 1 and 2). Associations of MDADI scores MBSImP components with feeding tube placement at 3–6 months (yes/no) between groups were explored using the Wilcoxon signed-rank test and chi-square (Fisher's exact). Correlations between MDADI composite scores and dichotomized MBSImP components 6–15 were explored using point biserial correlations with multiple comparison correction. MBSImP components for each group (primary TORS and primary RT) associated with $DIGEST_{safety}$ (TORS vs. RT) and $DIGEST_{efficiency}$ (TORS vs. RT) were then explored further by ordinal logistic regression with Bonferroni correction (Aim 3) controlled for baseline DIGEST. Furthermore, exploratory analyses by treatment modality (single vs. multiple) involved descriptive summaries with stratification by four groups: TORS alone and RT alone (single modality), versus TORS with adjuvant treatment (TORS+), and RT with induction chemotherapy/concurrent chemotherapy (RT+; multimodality).

3 | RESULTS

A total of 257 patients (mean age, 59) were included in this study (29%, 75/257 underwent primary TORS and 71%, 182/257 received primary RT) as briefly summarized in Table 1; populations details are previously published.[6] The primary TORS group had significantly lower N classification and RT dose. All TORS patients received upfront neck dissection, in contrast with only 10% of those with primary RT receiving neck dissection. Multimodality treatment was common: 49% (37/75) TORS patients required adjuvant treatment and 84% (152/182) primary RT patients received chemo/systemic therapy.

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3.1 | Differences in $DIGEST_{safety}$ and $DIGEST_{efficiency}$ grades (Aim 1)

Neither $DIGEST_{safety}$ [X^2 (1) = 0.4, p = 0.51], nor $DIGEST_{efficiency}$[X^2 (1) = 2.7, p = 0.10] differed significantly between the two groups at baseline or at the subacute, 3–6 month timepoint post-treatment ($DIGEST_{safety}$: X^2 (1) = 0.4, p = 0.53; and $DIGEST_{efficiency}$: X^2 (1) = 0.1; p = 0.72). Dysphagia prevalence between groups at 3–6 months did not differ between the two primary treatment methods (DIGEST >0; TORS: 45%, 34/75; RT: 42%, 76/182; p = 0.44; Table 2).

3.2 | Differences in MBSImP physiologic impairment profiles (Aim 2)

MBSImP components at baseline significantly differed only for the laryngeal elevation component score with higher frequency of impairment in the RT group [X^2 (1) = 6.4, p = 0.01] but the laryngeal elevation component scores did not significantly differ at 3–6 months between the groups (p = 0.25). When comparing the two treatment groups at 3–6 months, only severity of laryngeal vestibular closure [X^2 (1) = 5.4, p = 0.02] and pharyngeal contraction [X^2 (1) = 10.5, p = 0.001] differed between the two groups. When dichotomized, MBSImP scores reveal greater LVC impairment in the RT group and an increased impairment in pharyngeal contraction in the TORS group (Figure 1).

3.3 | Associations between $DIGEST_{safety}$/$DIGEST_{efficiency}$ and physiologic MBSImP components (Aim 3)

Controlling for baseline DIGEST, we found significant correlates of post-treatment $DIGEST_{safety}$ in the TORS group including *laryngeal vestibule closure* (odds ratio [OR] 16.1, p < 0.001); while significant associations with $DIGEST_{safety}$ grades for the RT group included all MBSImP components with the exception of *initiation of pharyngeal swallow, anterior hyoid excursion*, and *PE opening* (p = 0.23, respectively; Figure 2). Significant correlates of $DIGEST_{efficiency}$ for the TORS group included *epiglottic movement* (OR 5.4, p = 0.003), *PE opening* (OR 11.2, p = 0.004), and *tongue base retraction* (OR 32.6, p < 0.001), while all MBSImP components were significant in the RT group, with the exception of *initiation of pharyngeal swallow* (OR 1, p = 0.84) and *anterior hyoid movement* (OR 1.7, p = 0.29).

3.4 | Single versus multiple modality exploratory comparisons

Exploratory descriptive analysis found relatively similar prevalence in LVC impairment between all treatment subgroups except single modality TORS (single modality TORS: 21%, all other groups: 32%–43%). While prevalence of impaired pharyngeal contraction was similar between the four subgroups, inspection of ordinal severity of the pharyngeal contraction component revealed a noteworthy increase in the proportion of TORS+ patients who presented with lateralized pharyngeal constriction impairment (unilateral bulging on MBSImP; 27%, 10/37) versus those patients who underwent TORS alone (8%, 3/38). Proportion of patients with MBSImP component scores ≥1 by treatment combination can be found in Figure 3.

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3.5 | Functional and patient reported outcome by MBSImP component analysis

There were no significant differences between MDADI composite scores between TORS or RT groups at either baseline of 3–6 months; $p = 0.28, 0.47$. MDADI composite scores were not significantly correlated with MBSImP components for either group or timepoint (Table 3). At 3–6 months, the RT group had significantly higher feeding tube rates (5%, 14/257) than the TORS group, $p = 0.009$. One MBSImP component, *pharyngeal contraction* was significantly associated with feeding tube at 3–6 months, $p = 0.05$.

4 | DISCUSSION

Given favorable response to current therapies, as the incidence of low-to-intermediate risk OPCs rises, so will the increase in survivors with dysphagia. While previous studies confirm the persistence of dysphagia after primary TORS or RT for low-to-intermediate risk OPC,[6] the patterns of functional and physiologic deficits are largely unknown. Clinicians should be mindful of the pathophysiological factors related to different primary treatment modalities for OPC. Differences in the pathophysiology and dysphagia profiles after primary TORS and RT represent key targets in rehabilitation planning and clinical decision making. Our results demonstrate differences in the pathophysiology of dysphagia between primary TORS and primary RT. Specifically, there are distinctions in LVC and pharyngeal contraction as well as different patterns of pathophysiology associated with swallowing safety and efficiency. While DIGEST grade of safety and efficiency impairments did not significantly differ between primary TORS or RT groups, physiological correlates of $DIGEST_{safety}$ and $DIGEST_{efficiency}$ impairments did differ. Our findings support the necessity for individualized approach to dysphagia management because of the distinct underlying pathophysiology of dysphagia depending upon the primary treatment method.

Despite dysphagia prevalence in almost half of survivors at 3–6 months per gold-standard MBS, it is encouraging to report a low severity of subacute dysphagia after primary RT for low-intermediate risk OPC. While diffuse, low-grade physiologic impairments appeared to contribute to radiation-associated dysphagia severity (per DIGEST), impaired LVC stood out as more prevalent in the RT group and most strongly correlated with safety impairment.

This result is supported by previous studies attempting to characterize swallow physiology in OPC patients treated with RT.[8,10,23] Based on the available data, laryngeal deficits are highly prevalent among individuals treated with radiation therapy. Specifically, Starmer et al. and Barbon et al. found measures related to degree of laryngeal closure (LVC mechanisms, laryngeal elevation) or timing of the laryngeal vestibule to be impaired in irradiated OPC patients.[8,10] It is postulated that edema and neuromuscular damage to the laryngeal framework in the radiation field manifest sensory and motor impairments within the laryngeal complex that are recognized as impaired LVC in these patients. These results have the potential to influence RT planning priorities that may mitigate post-RT dysphagia in the subacute stage post-treatment.

Despite studies demonstrating similarly favorable early post-TORS swallowing outcomes,[5,6,24-26] little is published regarding the physiologic impairments that contribute to post-TORS dysphagia.[27] The authors previously reported 23% prevalence of

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radiographically confirmed moderate to severe dysphagia in the acute postoperative period.[6] The current results further detail the prevalence of (any grade) dysphagia at the subacute period (3–6 months) and newly identified impaired pharyngeal contraction/base of tongue retraction as significant efficiency-based pathophysiologic features and likely drivers of subacute post-TORS dysphagia. This result aligns with aspects of swallowing decompensation reported post-TORS in a prospective case series of 10 patients,[24] wherein MBS conducted approximately 1-month post-TORS revealed unilateral pharyngeal weakness and impaired base of tongue motion in patients whose $DIGEST_{efficiency}$ scores were >0. The current data suggest that impaired pharyngeal constriction remains prevalent during the subacute period post-TORS, as pharyngeal contraction proved significant prior to Bonferroni correction and retained a large odds ratio (OR 3.4, $p = 0.10$). These results are aligned with the between-group analysis (Aim 2), which identified pharyngeal constriction impairment more prevalent post-TORS compared with primary RT. Oncologic resection of the pharyngeal constrictors and/or associated pharyngeal musculature along with resection of, or injury to the glossopharyngeal nerve in TORS are likely explanations for the impaired pharyngeal constriction identified in these data. Interestingly, our results also indicate increased pharyngeal impairment related to the presence of feeding tube at 3–6 months, although feeding tube dependence was extremely low at this time in both groups.

Despite similar proportions of dysphagia at 3–6 months evidenced by DIGEST grade and MDADI scores, underlying mechanistic differences exist between modalities. The results correlating physiologic impairments with swallow safety and efficiency suggest a more focal injury associated with $DIGEST_{safety}$ and $DIGEST_{efficiency}$ post-TORS in contrast to a low-level diffuse physiologic impairment associated with post-RT dysphagia (Figure 2). The diffuse physiologic impairment post-RT in OPC by Starmer et al. is aligned with our findings.[28] Impaired base of tongue retraction (35%), poor velopharyngeal closure (27%), and reduction in epiglottic tilt (70%) along with a reduction in hyoid excursion (42%) and velopharyngeal closure (27%) were all highly prevalent at 3–6 months post-RT. Wall et al. also reported nine pharyngeal phase deficits prevalent in a review of HNC patients treated with chemoRT; eight of which align with our findings.[29] The novelty of the present analysis is the demonstration of the independent significant associations between these previously reported physiologic impairments with impaired swallow safety and efficiency, and comparison between primary treatment strategies. Nevertheless, measurement variation in these publications limits direct comparison of findings.

There are trade-offs between surgical pharyngeal injury and RT dose that coexist in patients receiving multimodality treatment. The addition of postoperative RT or chemoRT augments the likelihood of a complicated toxicity profile that has yet to be examined with this degree of specificity on physiologic profiles. This is critical to our understanding as approximately half of TORS patients treated with primary surgery receive adjuvant radiation or chemoradiation.[3] Although we are unable to detect differences in swallow pathophysiology in the subgroup analysis stratifying on single versus multimodality treatments, trends emerged regarding significant differences in pharyngeal contraction among the groups (Figure 3). Observation of the ordinal pharyngeal contraction component revealed a large proportion of TORS+ patients with unilateral bulging, while patients with TORS alone were less impaired regarding pharyngeal contraction. There appears

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to be a difference in the severity pharyngeal contraction impairment between primary single modality TORS versus TORS plus adjuvant or RT that we posit reflects a loss of compensation for ipsilateral post-TORS pharyngeal injury after RT.

Our work demonstrates distinct pathophysiological underpinnings of functional impairment for patients with OPC who have been treated with primary TORS or RT. Strengths include the use of validated swallowing outcome measures and a large prospectively derived cohort. Limitations of this work include the lack of randomization between the groups with inherent imbalance of clinical factors relating to oncologic treatment selection and the low-to-intermediate risk sampling in our study, which provides an overall bias toward less severe dysphagia. Also, there were missing data that equated to approximately 20% at the subacute timepoint. These missing data are also attributed to the nature of the prospective registry. Additionally, measures of tumor location (e.g., proximity to midline or swallow critical structures) were not controlled for in our analyses representing a source of potential uncontrolled bias. Our data confirm the presence of subacute, mild dysphagia which has previously been reported in the literature. Targeting contributing pathophysiologic features early after treatment may be important in the mitigation of long-term dysphagia. Moving forward, future analysis aiming to characterize pathophysiology and swallow impairment should be stratified further for single versus multimodality treatment in larger cohorts.

5 | CONCLUSION

Although the dysphagia severity did not differ between primary TORS or RT for OPC at 3–6 months posttreatment, the pathophysiology of the dysphagia is distinct for each primary treatment strategy. These results may have particular implication on dysphagia-sparing adjuvant RT planning considerations. We have identified pharyngeal constriction impairment to be common among the post-TORS group, whereas impaired LVC was more common in the post-RT group. The results correlating physiologic impairments with swallow safety and efficiency suggest a more focal injury associated with $DIGEST_{safety}$ and $DIGEST_{efficiency}$ post-TORS in contrast to a low-level diffuse physiologic impairment associated with post-RT dysphagia. These nuances in swallowing profiles should be considered for targeted rehabilitative planning.

DATA AVAILABILITY STATEMENT

Data are available on request due to privacy/ethical restrictions.

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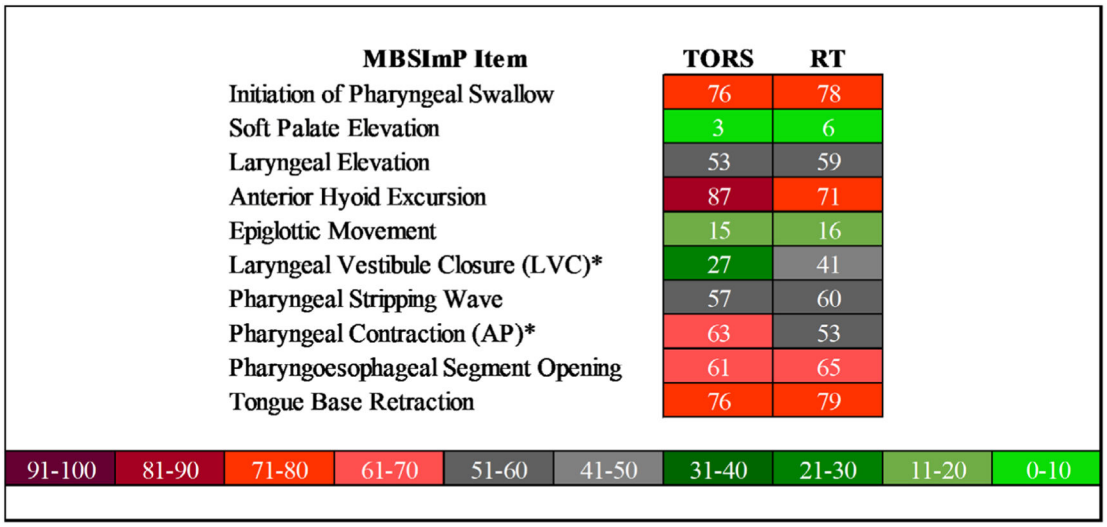

FIGURE 1.

Proportion of patients with MBSImP component scores ≥1. "*" denotes significant MBSImP components between the groups

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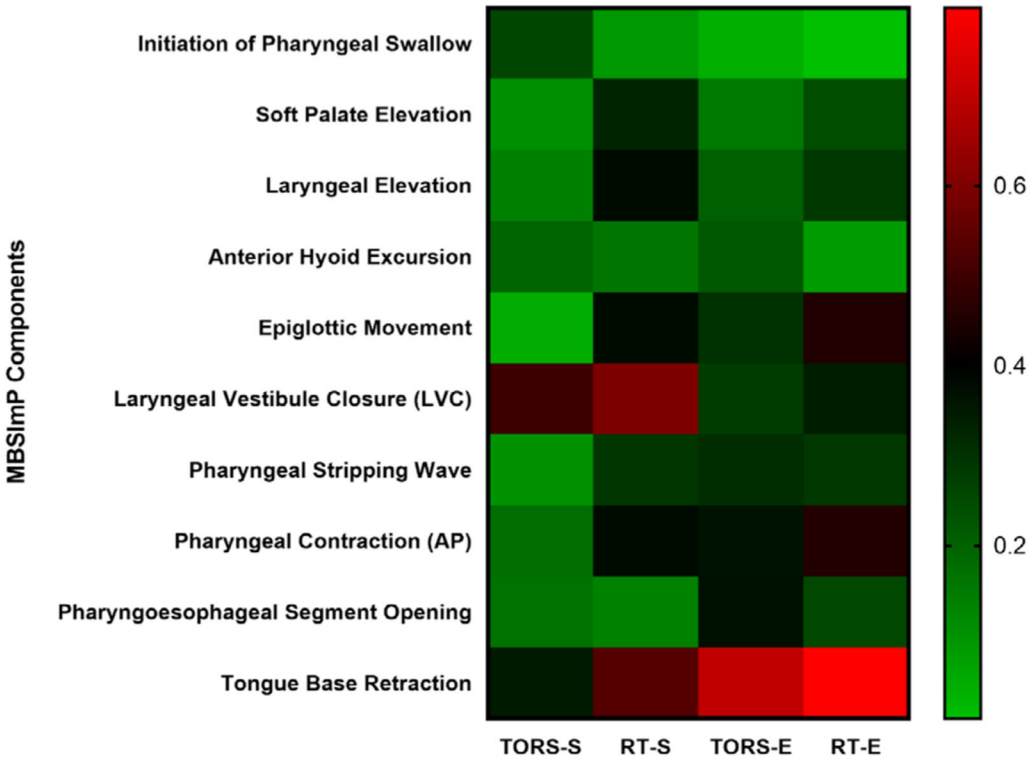

FIGURE 2.

Correlation between $DIGEST_{safety}$ and $DIGEST_{efficiency}$ with MBSImP pharyngeal components for TORS vs RT in low-to-intermediate risk OPC (n = 257). Red boxes depict stronger correlations

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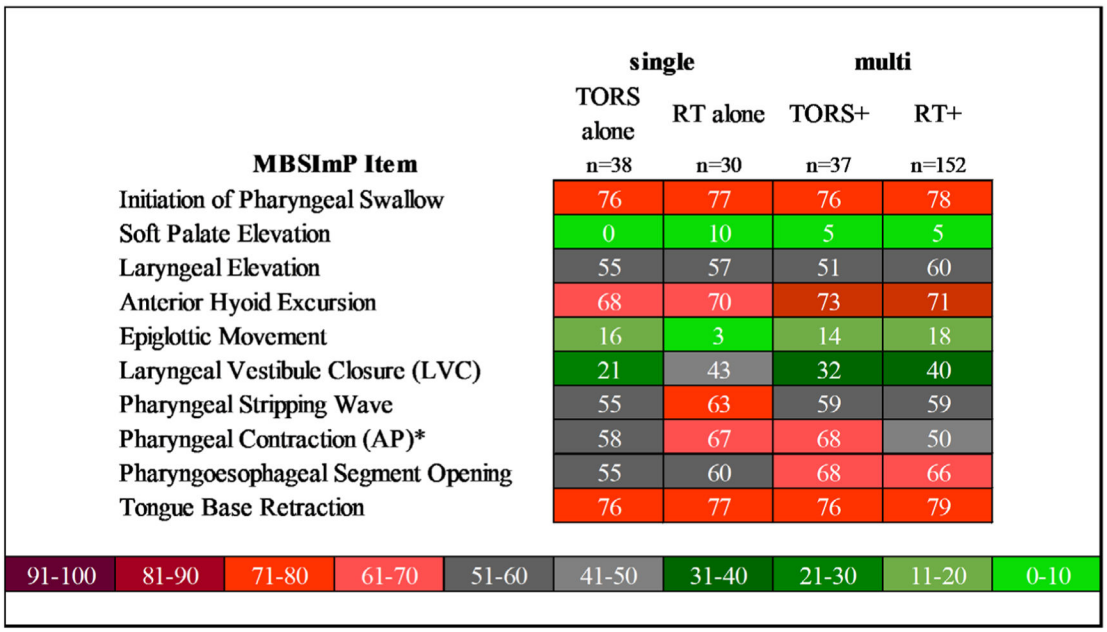

FIGURE 3.

Proportion of patients with MBSImP components ≥1 among patients treated with TORS or RT (with and without adjuvant) in low-to-intermediate risk OPC (n = 257). "*" denotes significant MBSImP components between the groups

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TABLE 1

Participant demographic and clinical details

Variable	Value	All patients *n* = 257 No. of patients	Percentage	Primary TORS *n* = 75 No. of patients	Percentage	Primary RT *n* = 182 No. of patients	Percentage	*p* value
Age at primary treatment start	Mean (SD)	59	9	58	10	59	9	*0.32*
Sex	Female	35	14%	10	13%	25	14%	*0.55*
	Male	222	86%	65	87%	157	86%	
Primary tumor site	Tonsil	135	53%	38	51%	97	53%	*0.51*
	BOT	116	45%	34	45%	82	45%	
	GPS	6	2%	3	4%	3	2%	
Clinical T classification of primary, 7th edition	1	124	48%	40	53%	84	46%	*0.50*
	2	126	49%	34	45%	92	51%	
	3	7	3%	1	1%	6	3%	
Baseline primary tumor volume, median (range) (cm^3)		6.50 (0.30–29.30)		5.15 (0.30–21.90)		6.95 (0.50–29.30)		0.18 (0.04–0.29)[a]
Clinical N classification of primary, 7th edition	N0	50	19%	31	41%	19	10%	*<0.001*
	N1	35	14%	15	20%	20	11%	
	N2a	19	7%	4	5%	15	8%	
	N2b	153	60%	25	33%	128	70%	
Induction chemotherapy	Yes	21	8%	4	5%	17	9%	*0.21*
Radiation therapy	Yes	219	85%	37	49%	182	100%	*<0.001*
	No	38	15%	38	51%	0	—	
Concurrent chemotherapy and XRT	Yes	162	63%	15	20%	147	81%	*<0.001*
RT dose (Gy)	Mean (minimum, maximum)	6786	(5000, 7000)	6000	(5000, 6996)	6996	(6000, 7000)	*<0.001*
RT laterality	Unilateral	54	21%	17	23%	37	20%	*<0.001*
	Bilateral	164	64%	19	25%	145	80%	
Neck dissection	Yes	93	36%	75	100%	18	10%	*<0.001*
Baseline MDADI composite score	Mean (SD)	91.7	9.6	90.4	11.2	92.3	8.9	*0.285*
Subacute MDADI composite score		81.8	14.8	83.0	15.2	81.4	14.6	*0.474*
Subacute feeding tube	Yes	16	6%	2	1%	14	5%	*0.009*

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Variable	Value	All patients *n* = 257 No. of patients	Percentage	Primary TORS *n* = 75 No. of patients	Percentage	Primary RT *n* = 182 No. of patients	Percentage	*p* value
	No	234	91%	71	28%	163	63%	
	Missing	7	3%	2	1%	5	2%	

Note: The italic values indicate statistical significance ($p < 0.05$).

Abbreviations: BOT, base of tongue; CI, confidence interval; GPS, glossopharyngeal sulcus; MDADI, MD Anderson Dysphagia Inventory; RT, radiation therapy; TORS, transoral robotic surgery; XRT, radiation therapy.

[a]Effect size (95% CI).

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TABLE 2

MBSImP component scores, DIGEST grade, $DIGEST_{safety}$, and $DIGEST_{efficiency}$ at baseline and 3–6 months by primary treatment

	Baseline					3–6 Months				
	TORS (75)		RT (182)			TORS (75)		RT (182)		
Variable, Value	No. of patients	Percentage	No. of patients	Percentage	*p* value	No. of patients	Percentage	No. of patients	Percentage	*p* value
6_Initiation of Pharyngeal Swallow										
0	3	4%	6	3%	*0.69*	2	3%	3	2%	*0.73*
1	5	7%	18	10%		5	7%	10	5%	
2	36	48%	86	47%		27	36%	78	43%	
3	28	37%	65	36%		25	33%	54	30%	
4	0	—	0	—		0	—	0	—	
Missing	3	4%	7	4%		16	21%	37	20%	
7_Soft Palate Elevation					*0.45*					*0.28*
0	67	89%	167	92%		57	76%	134	74%	
1	5	7%	8	4%		1	1%	11	6%	
2	0	—	0	—		1	1%	0	—	
3	0	—	0	—		0	—	0	—	
4	0	—	0	—		0	—	0	—	
Missing	3	5%	7	4%		16	21%	37	20%	
8_Laryngeal Elevation					*0.01*					*0.25*
0	36	48%	58	15%		19	25%	37	20%	
1	35	47%	116	64%		40	53%	105	58%	
2	0	—	0	—		0	—	3	2%	
3	0	—	0	—		0	—	0	—	
Missing	4	5%	8	4%		16	21%	37	20%	
9_Anterior Hyoid Excursion					*0.64*					*0.86*
0	11	15%	31	17%		6	8%	16	9%	
1	61	81%	144	79%		53	71%	129	71%	
2	0	—	0	—		0	—	0	—	
Missing	3	4%	7	4%		16	21%	37	20%	
10_Epiglottic Movement					*0.77*					*0.78*

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	Baseline					3–6 Months				
	TORS (75)		RT (182)			TORS (75)		RT (182)		
Variable, Value	No. of patients	Percentage	No. of patients	Percentage	*p* value	No. of patients	Percentage	No. of patients	Percentage	*p* value
0	61	81%	151	83%		48	64%	116	64%	
1	10	17%	20	11%		9	12%	21	12%	
2	1	1%	4	2%		2	3%	8	4%	
Missing	3	5%	7	4%		16	21%	37	20%	
11_LVC					*0.48*					*0.02*
0	57	76%	147	81%		39	52%	70	38%	
1	14	19%	28	15%		20	27%	72	40%	
2	0	—	0	—		0	—	2	1%	
Missing	4	5%	7	4%		16	21%	38	21%	
12_Pharyngeal Stripping Wave					*0.69*					*0.73*
0	32	43%	73	40%		16	21%	36	20%	
1	40	53%	102	56%		43	57%	109	60%	
2	0	—	0	—		0	—	0	—	
Missing	3	4%	7	4%		16	21%	37	20%	
13_Pharyngeal Contraction (A/P)					*0.17*					*<0.001*
0	39	52%	109	60%		11	15%	45	25%	
1	28	37%	64	35%		34	45%	91	50%	
2	4	5%	1	1%		13	17%	3	2%	
3	0	—	0	—		0	—	2	1%	
Missing	4	5%	8	4%		17	23%	41	23%	
14_Pharyngoesophageal Segment Opening					*0.23*					*0.6*
0	18	24%	32	18%		13	17%	26	14%	
1	54	72%	143	79%		45	60%	118	65%	
2	0	—	0	—		1	1%	1	1%	
3	0	—	0	—		0	—	0	—	
Missing	3	4%	7	4%		16	21%	37	20%	
15_Tongue Base Retraction					*0.09*					*0.67*
0	0	—	4	2%		2	3%	2	1%	
1	46	61%	123	68%		19	25%	55	30%	

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Variable, Value	Baseline					3–6 Months				
	TORS (75)		RT (182)			TORS (75)		RT (182)		
	No. of patients	Percentage	No. of patients	Percentage	*p* value	No. of patients	Percentage	No. of patients	Percentage	*p* value
2	22	29%	45	25%		33	44%	62	34%	
3	4	5%	3	2%		5	7%	26	14%	
4	0	—	0	—		0	—	0	—	
Missing	3	4%	7	4%		16	21%	37	20%	
DIGEST grade					*0.06*					*0.93*
0	53	71%	147	81%		25	33%	72	40%	
1	16	21%	28	15%		29	39%	47	26%	
2	3	4%	1	1%		4	5%	23	13%	
3	0	—	0	—		1	1%	6	3%	
4	0	—	0	—		0	—	0	—	
Missing	3	4%	6	3%		16	21%	34	19%	
$DIGEST_{safety}$					*0.51*					*0.53*
0	64	85%	161	88%		44	59%	106	58%	
1	7	9%	15	8%		13	17%	29	16%	
2	1	1%	0	—		2	3%	8	4%	
3	0	—	0	—		0	—	4	2%	
4	0	—	0	—		0	—	1	1%	
$DIGEST_{efficiency}$					*0.10*					*0.72*
0	58	77%	155	85%		30	40%	79	43%	
1	10	13%	19	10%		24	32%	41	23%	
2	2	3%	1	1%		3	4%	16	9%	
3	2	3%	1	1%		2	3%	12	7%	
4	0	—	0	—		0	—	0	—	

Note: The italic values indicate statistical significance ($p < 0.05$).

Abbreviations: RT, radiation therapy; TORS, transoral robotic surgery.

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TABLE 3

Correlations between MDADI with MBSImP components for patients treated with primary TORS or RT for low-to-intermediate risk OPC (n=257).

	Baseline				3–6 Months			
	TORS (75)		RT (182)		TORS (75)		RT (182)	
	r_{pb}	*p* value	r_{pb}	*p* value	r_{pb}	*p* value	r_{pb}	*p* value
6_Initiation of Pharyngeal Swallow	−0.080	*0.531*	−0.122	*0.119*	−0.105	*0.451*	−0.041	*0.638*
7_Soft Palate Elevation	0.198	*0.116*	0.026	*0.743*	0.126	*0.365*	*−0.040*	*0.650*
8_Laryngeal Elevation	−0.150	*0.241*	−0.116	*0.139*	0.205	*0.137*	−0.016	*0.859*
9_Anterior Hyoid Excursion	−0.167	*0.189*	0.064	*0.417*	−0.137	*0.325*	−0.104	*0.234*
10_Epiglottic Movement	−0.163	*0.197*	−0.051	*0.514*	0.027	*0.848*	−0.200	*0.022*
11_LVC	−0.219	*0.085*	−0.100	*0.201*	−0.214	*0.120*	−0.168	*0.055*
12_Pharyngeal Stripping Wave	−0.008	*0.953*	−0.103	*0.190*	−0.178	*0.198*	−0.167	*0.056*
13_Pharyngeal Contraction (A/P)	0.019	*0.882*	−0.232	*0.003*	−0.075	*0.595*	−0.213	*0.016*
14_Pharyngoesophageal Segment Opening	0.077	*0.547*	−0.137	*0.079*	0.195	*0.157*	−0.058	*0.510*
15_Tongue Base Retraction	—	—	−0.006	*0.935*	−0.069	*0.623*	−0.060	*0.496*

Note: r_{pb} = point biserial correlations. The italic values indicate statistical significance (adjusted *p* value = 0.005).

Abbreviations: MDADI, MD Anderson Dysphagia Inventory; RT, radiation therapy; TORS, transoral robotic surgery.