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FUNCTIONAL OUTCOMES AFTER TORS FOR OROPHARYNGEAL CANCER: A SYSTEMATIC REVIEW

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Abstract

OBJECTIVE—Summarize functional outcomes after transoral robotic surgery (TORS) ± adjuvant therapy for oropharyngeal cancer (OPC).

STUDY DESIGN—A systematic review was conducted. The MEDLINE database was searched (MeSH terms: transoral robotic surgery, pharyngeal neoplasms, oropharyngeal neoplasms).

METHODS—Peer-reviewed human subject papers published through December, 2013 were included. Exclusion criteria were: 1) case report design (n<10), 2) review article, or 3) technical, animal or cadaver studies. Functional outcomes extracted included feeding tube dependence, swallow examination findings, speech ratings, velopharyngeal insufficiency, pneumonia, and oral intake measures.

RESULTS—Twelve papers comprising 441 patients with OPC treated with TORS ± adjuvant therapy were included. Feeding tube rates were the most commonly reported functional outcome. Excluding prophylactic placement, 18% to 39% of patients required gastrostomy placement, typically during adjuvant therapy. Chronic gastrostomy dependence ranged from 0% to 7% (mean follow-up: 11–26 months), regardless of disease stage. Composite MD Anderson Dysphagia Inventory (MDADI) scores ranged from 65.2 to 78 (89 patients, 3 series, mean follow-up: 12–13 months). Videofluoroscopic swallowing studies were not systematically reported. Incidence of postoperative pneumonia was 0% to 7%. Predictors of swallowing function included baseline function, T-stage, N-stage, tongue base primary tumors, and adjuvant chemoradiation. Rates of transient hyponasality were 4% to 9%. A single study suggested dose-dependent effects of adjuvant therapy (none, radiation alone, chemoradiation) on diet scores at 6- and 12-months.

CONCLUSIONS—Crude endpoints of functional recovery after TORS ± adjuvant therapy suggest promising swallowing outcomes, depending on the functional measure reported.

Keywords

Transoral robotic surgery; Oropharyngeal cancer; Functional outcome; Swallowing

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INTRODUCTION

The incidence of oropharyngeal cancer (OPC) is rising precipitously, and the annual number of cases in the US is projected to almost double by the year 2030.¹ Contemporary OPC survivors, who predominantly present with HPV-associated disease, are younger, commonly diagnosed in the 5th decade, and have favorable prognosis for long-term survival. Treatment paradigms for OPC have shifted in recent decades, coincident with changes in the epidemiology of the disease. The use of “open” transmandibular surgery has declined as organ preservation regimens using radiotherapy and chemoradiotherapy have become the core modalities of treatment for OPC. Pooled data from observational studies over 40 years (1970–2000) support this practice, citing equivalent locoregional control and survival with lower rates of severe (including gastrostomy and tracheostomy) or fatal complications after non-surgical therapy compared with definitive open surgery.² Meta-analyses also demonstrate survival benefits of chemoradiation over radiotherapy alone, and so concurrent chemoradiation regimens are now the mainstay of current treatment for OPC.³

Swallowing is the primary functional priority of OPC survivors,⁴ with claims of superior swallowing function after nonsurgical therapy compared with open surgery and post-operative adjuvant radiation. For instance, a cross-sectional comparison of chemoradiation versus open surgery with adjuvant radiotherapy reported roughly 20% to 30% better swallowing-related quality of life scores in long-term survivors after non-surgical therapy despite more advanced stage tumors in the chemoradiation group.⁵ Nonetheless, chemoradiation can be associated with significant toxicity and adverse functional effects. Dysphagia is among the most commonly cited functional impairments in OPC survivors.⁴ Gastrostomy placement is required in up to 62% of oropharyngeal cancer patients during definitive radiotherapy due to the acute toxicities of treatment, and as many as 23% are still dependent on feeding tubes 6 months after treatment.⁶

Dysphagia is also an important late complication. Severe (grade 3–4) late laryngopharyngeal toxicity was reported in 35% of 101 OPC survivors who had adequate baseline function in a pooled analysis of 3 RTOG trials of concomitant chemoradiotherapy,⁷ and the 3-year prevalence of dysphagia approached 50% in a population level analysis of OPC survivors in the SEER-Medicare database.⁸ In addition, late onset of radiation-associated dysphagia (late-RAD) is a rare but particularly devastating delayed toxicity of nonsurgical organ preservation among OPC survivors, associated with progressive functional deterioration even decades after treatment.⁹ Thus, current data strongly suggest both early and long-term swallowing outcomes are a key metric of successful organ preservation after OPC.

Transoral robotic surgery (TORS) has emerged as a minimally-invasive approach of endoscopic head and neck surgery (eHNS) as an alternative to nonsurgical organ preservation regimens in OPC. The proposed functional advantages of TORS are many. TORS allows access for oropharyngeal resection without pharyngotomy or mandibulotomy, maintaining the critical muscular framework of the laryngopharynx necessary to preserve swallowing function. Tracheostomy, typically required for airway management after open resection, is also avoided in most (70% to 100%) TORS cases, regardless of adjuvant

therapy.^{10,11} Finally, proponents of a primary surgical approach with TORS cite the potential to de-escalate radiotherapy to postoperative doses, or to avoid concomitant chemotherapy or radiotherapy altogether as a major functional advantage of TORS. Collectively, published series suggest that 9% to 27% of patients treated with frontline TORS avoid postoperative radiotherapy, and 34% to 45% avoid chemoradiotherapy.^{10–14} These advantages are proposed to preserve swallowing function in properly selected patients treated with TORS. A number of authors have reported functional outcomes of TORS for OPC, but these data have not been comprehensively summarized. The purpose of this systematic review was to summarize functional outcomes after TORS ($\pm$ adjuvant therapy) for OPC in published literature, with particular emphasis on swallowing related outcomes.

METHODS

Search Methods

The primary search for this systematic review was conducted using the electronic MEDLINE database (data source: OVID). The search was limited to human subject research in peer-reviewed journal articles published through December, 2013. Medical subject heading (MeSH) terms were used to identify papers for 2 groups of terms: 1) transoral robotic surgery (MeSH term: transoral robotic surgery; 159 papers retrieved), and 2) pharyngeal neoplasms or oropharyngeal neoplasms (MeSH terms: pharyngeal neoplasms, oropharyngeal neoplasms; 25,329 papers retrieved). The final MEDLINE search identified 55 papers by cross-referencing the 2 groups of terms for common papers. The bibliographies of relevant articles were then hand-searched to identify additional manuscripts. Hand-searching identified 5 additional papers.

Selection Criteria and Data Collection

The abstracts of 60 peer-reviewed journal articles identified by electronic and hand searches were screened. Articles were excluded during the screening process according to the following exclusion criteria: 1) case report study design ($n < 10$), 2) review article, or 3) technical, animal or cadaver studies. The full-text of 27 articles was reviewed for the following data points: sample size, study methods, patient demographics, site and stage of disease, HPV or p16 status, prior treatment, adjuvant treatment, follow-up time, methods of functional assessment and rehabilitation, and functional outcomes. Functional outcomes extracted included measures of feeding tube dependence, instrumental and clinical swallow evaluations, patient reported outcome (PRO) measures, speech outcomes, velopharyngeal insufficiency, pneumonia, and diet. After full-text review, articles that reported any speech and/or swallowing-related outcomes among OPC patients treated with primary TORS (regardless of adjuvant treatment[s]) were included. Series comprised of $\geq 20\%$ of salvage cases were excluded to focus on functional outcomes after TORS as a primary therapeutic modality. Ten articles that met inclusion criteria after full-text review were summarized in this systematic review. Data from two overlapping cohorts were included because they reported complementary functional data and had varied inclusion criteria.^{11,14–16} Search results are illustrated in Figure 1. Results were summarized in descriptive format. Statistical analyses were performed using the STATA data analysis statistical software, version 10.0 (StataCorp LP, www.stata.com, College Station, TX).

RESULTS

Population characteristics

A total of 441 patients in 12 papers were systematically reviewed. Sample sizes ranged from 12 to 66 OPC patients among individual studies. All were single-institution case series (level 4 evidence). Three studies reported on TORS for advanced (III–IV),^{11,14,17} and one reported outcomes for early (T1–T2) OPC tumors.¹⁰ The remaining 8 studies reported outcomes after TORS for all stages of disease (AJCC I–IV). Adjuvant radiotherapy was delivered in 63% to 100% of cases, with chemoradiation in 18% to 63%. Neck dissections were performed in 41% to 100% of TORS cases. Only 2 of 12 papers reported HPV status of patients, both of which reported the majority of TORS cases were HPV+ (72% to 80%). None stratified functional outcomes by HPV status.

Feeding Tubes

Feeding tube rates were reported in all 12 studies. Table 1 outlines rates of perioperative feeding tube placement, PEG placement, and chronic PEG dependence. Rates of perioperative feeding tube placement varied widely by disease stage and institutional practices (3% to 100%), and the average duration of perioperative nasogastric tubes was 2 to 13 days.^{11,13,17,18} Excluding prophylactic placement,¹⁵ 18% to 39% of patients required gastrostomy placement, typically during adjuvant therapy. A single study of radical tonsillectomy reported the placement of gastrostomy tubes intraoperatively in all patients.¹⁵ PEG placement did not differ significantly when stratified by AJCC stage,¹² but one series reported PEG placement exclusively in patients with T3 or T4 tumors and mostly in patients with tongue base primaries.¹¹ Chronic gastrostomy dependence was reported in 11 of 12 studies, and ranged from 0% to 7% (mean follow-up: 11–32 months), regardless of disease stage. Postoperative chemotherapy was found to independently predict for prolonged gastrostomy (>3 months) after TORS.¹⁰

PEG utilization was compared as a marker of acute swallowing morbidity among primary TORS ($\pm$ adjuvant therapy) series and definitive intensity modulated radiotherapy (IMRT $\pm$ systemic therapy) series. Excluding studies that restricted inclusion to early stage disease and those that routinely prophylactically placed PEG tubes, 18% to 39% required PEG tubes in TORS series^{11–13,16,18–19} compared with 29% to 60% of patients in definitive IMRT series^{6,20–25} (Figure 2).

Oral Intake

Measures of oral intake or dietary outcomes were reported in 8 studies. Time to oral intake varied by T-stage (Table 2). Oral intake was earlier among 3 series that excluded T4 tumors;^{12,13} 96% of patients began oral intake on POD #1 after TORS for T1–T2 tumors¹² and mean time to oral intake was 2 days after TORS for T1–T3 OPC tumors.¹³ In contrast, only 51% of patients began oral intake on POD #1 after TORS when data were reported for patients of all T-stages (T1–T4).¹¹ Among series including all T-stages, 69%–73% began oral intake by discharge,^{18,26} 83% by week 2,²⁵ and 89% by week 4.¹¹

Two studies longitudinally assessed dietary outcomes per the standardized Performance Status Scale–Head & Neck (PSS-HN).^{13,19} Leonhardt et al. reported a statistically significant drop in normalcy of diet scores from baseline (96.1 ± 17.0) to 6-months (74.4 ± 34.0); diet scores improved thereafter and were no longer significantly depressed at 12-months (84.2 ± 26.3).¹⁹ These diet scores reflect, on average, a change from unrestricted solids preoperatively to restricted solids (e.g., avoiding certain meats or dry foods) at post-TORS intervals. Similarly, Genden et al. reported that mean PSS-HN diet scores reached a nadir near 25 points (equivalent to a liquid/blended diet) 2-months after TORS and rose precipitously to near-normal levels (approximately 90 points) by 12-months.¹³ Significant drops in dietary scores 2 to 6 months after TORS in these series were likely in part attributed to acute toxicities of adjuvant therapy.

Swallowing Outcomes

Beyond feeding tube data, measures of swallowing-related outcomes varied widely among the 12 studies included in this review (Table 3). Outcomes of instrumental swallowing studies were rarely reported. Fiberoptic endoscopic evaluations of swallowing (FEES) were performed longitudinally from baseline through 1-year after TORS (postoperatively at 2 weeks, 2-, 6-, 9-, and 12-months) in a single study.¹³ Discrete data were not reported, but the authors reported that no patients developed aspiration or velopharyngeal reflux per FEES. Videofluoroscopic swallowing assessments were not systematically performed among the 10 studies. Thus, MBS outcomes could not be analyzed in this systematic review.

Swallowing outcomes were summarized according to the clinician-rated Functional Outcome Swallowing Score (FOSS)²⁷ pre- and post-TORS (4 weeks) in one series;¹¹ median FOSS scores were 1 indicative of “compensated abnormal swallow function” at both intervals. In addition, FOSS scores returned to normal (FOSS=0) by the 4-week assessment interval in all patients who had normal baseline swallows (FOSS=0) and avoided adjuvant radiotherapy.¹¹ Swallowing-related quality of life was measured in three studies using the validated MD Anderson Dysphagia Inventory (MDADI); 19-item composite summary scores were calculated per Chen et al.²⁸ Composite MDADI scores reported among 89 patients in 3 studies at a mean follow-up of 12 to 13 months ranged from 65.2 to 78.^{10,17, 26} Finally, the incidence of postoperative pneumonia was reported in 3 studies and ranged from 0% to 7%.^{14,15,18}

Predictors of Swallowing Function

Predictors of swallowing function included baseline function, T-stage, nodal status, base of tongue primary tumors, and adjuvant chemoradiation. T3 or T4 primary tumors were found to differentiate FOSS scores and PEG utilization in one study,¹¹ whereas N-stage independently predicted persistently poor long-term swallowing-related quality of life per MDADI scores in another study.¹⁰ Similarly, resections of >50% of the base of tongue predicted poorly compensated dysphagia (per FOSS >2) and prolonged PEG dependence.¹¹

A single study stratified functional outcomes by adjuvant treatment (none, RT alone, chemoRT), reporting near-normal speech, diet, and eating 6 months after TORS alone per the Performance Status Scale-Head and Neck (PSS-HN). Dose-dependent effects of

adjuvant therapy were apparent in diet scores at 6- and 12-months. Relative to TORS alone, diet scores were 23% and 16% lower in patients who received adjuvant RT, and 53% and 36% lower in patients who received adjuvant chemoRT at 6- and 12-months, respectively.¹⁹

Tracheostomy

Rates of tracheostomy were reported in 11 of 12 studies, ranging from 0% to 31%. Two institutions reported tracheostomy rates in excess of 20%, presumably in cases with advanced stage tumors but this stratification was not specified.^{11,13,16} Among all papers (pooled n=411 cases reporting tracheostomy rates), only two patients were permanently tracheostomy dependent.^{14,16} When reported, mean tracheostomy dependence ranged from 7 to 8 days.^{11,14}

Speech

Speech-related outcomes were described in 5 series.^{11,13,15,19,29} Summary speech ratings were taken longitudinally in 3 studies, according to the clinician-rated PSS-HN Understandability of Speech scale³⁰ in 2 series^{13,19} and using an ordinal, non-validated speech grade (normal, minor, gross) in the remaining.¹¹ The former reported PSS-HN speech scores above 75 (indicating “understandable most of the time” or better) at all post-TORS intervals, and speech received “normal” ratings on the initial post-TORS rating in the latter series. Transient hypernasality was reported in 3% to 9% of patients in 3 studies.^{11,15,29}

Long-term function after TORS

Long-term gastrostomy tube rates were reported in 426 patients from 11 studies and ranged from 0% to 7%, with mean follow-up in most studies between 1 and 2 years (Table 1). Long-term outcomes data from instrumental swallowing studies were not quantified in any of the 12 studies. Longitudinal studies only quantified functional outcomes with standardized metrics to 1 year after TORS, and reported near baseline diet levels per the PSS-HN (mean diet scores >80, reflecting solid diet with few restrictions) at 1 year.^{13,19} Similarly favorable outcomes were reported with regard to long-term airway and speech functioning. Only two patients among the total 411 pooled (reporting tracheostomy rates) from all studies were permanently tracheostomy dependent, and both were in series that included advanced stage tumors.

DISCUSSION

HPV-associated cancers now account for roughly 70% of new OPC cases.¹ HPV-associated OPCs are clinically-distinct from tobacco-related cancers, diagnosed at a younger age with favorable prognosis for long-term survival. Thus, function-sparing treatment is a chief goal for this population. Unfortunately, dysphagia remains a significant toxicity of current organ preservation strategies that have intensified over time by the addition of concurrent chemotherapy and accelerated fractionation schedules of radiotherapy.^{31,32} Cooperative group trials and population-based data suggest an excess burden of dysphagia in HNC patients treated with chemoradiotherapy compared with other treatment modalities.^{7,8} Herein, we report promising early functional results of a frontline surgical organ

preservation strategy with TORS for OPC, with particular emphasis on swallowing outcomes. Early data are limited, however, by lack of systematic functional assessment using instrumental examinations and by short follow-up time.

Published endpoints of functional recovery after TORS suggest encouraging early outcomes. Rates of feeding tube placement and dependence after TORS were lower than published benchmarks in IMRT series of patients with oropharyngeal cancer. However, scores from PRO questionnaires reported in TORS series in this review had significant overlap with scores previously published in chemoradiation cohorts. Specifically, summary MDADI scores (based on 19-item composite scores) from TORS series ranged from 65.2 to 78,^{10,17,26} compared with 73.6 to 74.1 in published data in OPC patients treated with nonsurgical chemoradiation approach.^{5,33} Selection bias is a clear limitation when comparing outcomes of relatively small, single-institution TORS series to published benchmarks in larger, more inclusive IMRT series. Controlled comparisons are needed.

Direct comparisons of surgical and non-surgical approaches are limited in published literature, particularly with regard to functional outcomes. Two case-control studies support a swallowing-specific functional advantage of primary transoral surgery over primary chemoradiation for oropharyngeal cancers. An unmatched case-control study included this review reported better MDADI scores in the primary TORS cases compared to controls treated with chemoradiation. The authors found time-dependent significant differences in MDADI scores between treatment groups in favor of a primary TORS approach. No significant differences were observed in MDADI scores at 3-months but patients treated with TORS has significantly better scores at 6- and 12- months suggesting better long-term recovery after primary TORS compared with chemoradiation. Trends of better swallowing-related QOL in the TORS group were maintained when stratified by T-stage or oropharyngeal tumor subsite. Likewise, gastrostomy duration was shorter in the TORS (+adjuvant therapy) group compared with the primary chemoradiation group (mean duration gastrostomy: 3-months versus 6-months, respectively).³⁴ Similarly, a retrospective matched-pair comparison of primary transoral surgery (robotic or laser) to primary chemoradiation reported no difference in overall quality of life at 1 year between groups, but significantly better self-reported swallowing on the University of Washington Quality of Life scale. Notably, 74% of patients treated with primary transoral surgery reported swallowing “as well as ever” at 1-year compared with only 32% of patients in the chemoradiation group.³⁵ Findings from both of these case-control studies favor better long-term swallowing recovery with upfront transoral surgery (robotic or laser) and adjuvant radiation at postoperative doses. Nevertheless, retrospective and historical comparisons do not adequately account for confounding factors that influence functional outcomes. Regardless of treatment modality, swallowing outcomes are highly-dependent on baseline function and T-stage,^{11,34} and thus historical comparisons between TORS and radiation series should be interpreted with caution. Randomized, baseline-adjusted comparisons, as are currently planned in cooperative group trials, are needed to draw definitive conclusions.

Published data also suggest that swallowing physiology might be preserved for many patients after frontline TORS, as aspiration is rarely cited after this approach.¹³ This compares well to published estimates that suggest that up to 31% of patients develop chronic

aspiration after chemoIMRT for OPC.²⁵ This notion, however, is quite preliminary because a major limitation of functional data in the TORS series is that findings of instrumental swallowing assessments (e.g., modified barium swallow [MBS] studies, fiberoptic endoscopic evaluations [FEES]) are rarely reported. Future trials should include instrumental studies of swallowing function as a key component of multidimensional swallowing assessment, along with PRO measures. More specifically, physiologic impairment quantified from the MBS study has been shown to predict quality of life, and MBS endpoints of aspiration and pharyngeal residue significantly predict post-treatment pneumonia after treatment for OPC (p=0.017, Se 80%, Sp 60%).^{36,37} These data offer compelling support for inclusion of instrumental assessment, particularly the MBS, in TORS trials, as the data obtained from MBS cannot be reliably inferred from subjective, self-report of swallowing function obtained from PRO measures.

Functional outcomes are most consistently studied in the first year after TORS. It is arguable, however, that the most salient functional advantage of TORS may be the potential to avoid late toxicities associated with definitive radiotherapy and chemoradiotherapy. Growing evidence suggests a risk of new onset or progressive dysphagia ("late-RAD") as a late effect of primary radiation-based organ preservation regimens in 5 and 10 year survivors. Late-RAD is associated with profound functional impairment, often accompanied by cranial neuropathies and a constellation of functional problems. Although rare, late RAD is a devastating delayed complication of therapy, refractory to exhaustive therapies, and should motivate investigation into alternative treatment paradigms in high-risk patients.⁹ A comprehensive assessment of long-term functional outcomes after a frontline TORS approach is not yet available in published literature. Transoral surgical methods (robotic or laser resection) are expected to have fairly comparable functional effects, although direct comparisons have not been reported. Five-year data after transoral laser microsurgery suggest favorable swallowing outcomes (per FOSS) in patients with T1–3 oropharyngeal disease, but suboptimal swallowing recovery in patients with T4 tumors.³⁴ Comparable long-term follow-up in TORS series is needed. Furthermore, current literature lacks consensus regarding the optimal assessment of functional outcomes in patients treated with TORS, and comparisons among published reports are challenging. Long-term functional data that clearly define physiology along with PROs are critical to fully understand the potential advantages of this modality. Most importantly, detailed functional analyses will ultimately help to define the salient group of patients most likely to benefit from a TORS approach.

CONCLUSIONS

Early studies of functional recovery after TORS ± adjuvant therapy suggest promising swallowing outcomes, depending on the endpoint measured. Gastrostomy utilization is lower in primary TORS series relative to published benchmarks in definitive IMRT cohorts. PRO data are less commonly studied and trends are less consistent using these outcome measures, but direct comparisons to nonsurgical therapy suggest favorable long-term PRO outcomes after upfront transoral surgery. Findings of instrumental swallowing assessments (MBS or FEES), and long-term outcomes have also not been widely used and reported. Functional outcomes after TORS are highly dependent on baseline function, T-stage, and

adjuvant treatment. Randomized, baseline-adjusted outcomes are needed to discern the functional differences between primary TORS versus nonsurgical approaches to organ preservation for OPC.

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Figure 1. Search strategy
n = number of papers

	N	Crude PEG rate
TORS ± adjuvant therapy		
Hurtuk et al (2011) ¹²	54	20%
Genden et al (2011) ¹³	28	23%
Moore et al (2009) ¹¹	45	18%
Moore et al (2012) ¹⁶	66	27%
Leonhardt et al (2012) ¹⁹	38	39%
IMRT± systemic therapy		
Bhayani et al (2013) ⁵	440	60%
May et al (2013) ²¹	170	55%
Hodge et al (2007) ²²	52	46%
Al-Mamgani et al (2013) ²³	191	49%
Mendenhall et al (2010) ²⁰	130	39%
Sanguinetti et al (2012) ²⁴	59	37%
Feng et al (2010) ²⁵	73	29%

Figure 2. Crude rates of gastrostomy utilization after primary TORS (±adjuvant therapy) compared with definitive IMRT (±systemic therapy)

Excluding studies that restricted inclusion to early stage disease and those that prophylactically placed PEG tubes in all patients, 18% to 39% (median: 23%) required gastrostomy tubes in TORS series compared with 29% to 60% (median: 46%) of patients in definitive IMRT series. Abbreviations: TORS, transoral robotic surgery; IMRT, intensity modulated radiotherapy

Table 1

Rates of feeding tube placement and dependence after TORS for OPC

Cohort (n, follow-up time)	RT [*]	Percutaneous gastrostomy (PEG)			
		Perioperative feeding tube ^{**}		Ever PEG	
		Rate	Reason tube	Rate	Reason PEG
Early (I–II) OPC					
Sinclair et al. (n=42, $\bar{x}$ 17 mos.) ¹⁰	76%	3%	dysphagia	21%	adjuvant therapy
Advanced (III–IV) OPC					
Weinstein et al. (n=47, $\bar{x}$ 26 mos.) ¹⁴	85%	-	-	-	2%
Moore et al. (n=45, $\bar{x}$ 12 mos.) ¹¹	73%	29%	risk of dysphagia	18%	TORS or adjuvant
Weinstein et al. (n=27, min 6 mos.) ¹⁵	89%	100%	risk of dysphagia	100%	intraop (radical tonsil)
More et al. (n=19, median 14 mos.) ¹⁷	100%	80%	not specified	60%	adjuvant therapy ^{***}
All stage (I–IV) OPC					
Hurtuk et al. (n=54, $\bar{x}$ 11 mos) ¹²	91%	4%	fistula	20%	adjuvant therapy
Genden et al. (n=31, $\bar{x}$ 18 mos) ¹³	68%	11%	flap	23%	adjuvant therapy
Iseli et al. (n=33, $\bar{x}$ 13 mos) ²⁶	41%	-	-	-	6%
Leonhardt et al. (n=38, $\bar{x}$ 15 mos) ¹⁹	76%	-	-	39%	3%
Van abel et al. (n=15, not reported) ¹⁸	-	53%	risk of dysphagia	-	-
Moore (n=66, $\bar{x}$ 36 mos) ¹⁶	83%	47%	risk of dysphagia	27%	TORS or adjuvant
Weinstein (n=30, $\bar{x}$ 32 mos) ²⁹	0%	-	-	-	0%

Abbreviations: OPC, oropharyngeal cancer; TORS, transoral robotic surgery; PEG, percutaneous gastrostomy; $\bar{x}$, mean

- Not reported

* Percent of patients receiving adjuvant radiotherapy ($\pm$ chemotherapy)

** Perioperative tubes included nasogastric or gastrostomy tubes placed intraoperatively or in postsurgical recovery

includes tubes placed prophylactically in all patients receiving adjuvant chemoradiation

Table 2

Time to Oral Intake after TORS for OPC

T-stage	No. studies *	Time to oral intake after TORS	
		Time interval	% patients oral
T1-T2	1	POD1	96% ¹²
T1-T3	2	By discharge	100% ¹⁷
		By week 1	100% ¹³
T1-T4	3	POD1	51% ¹¹
		By discharge	69% ²⁶
		By week 2	73% ¹⁸
		By week 4	83% ²⁶
			89% ¹¹

* No. studies reporting time to oral intake by T-stage

Table 3

Measures of Swallowing-related Outcomes

T	Feeding tube rates			Instrumental swallow studies			Standardized functional scales				Pneumonia
	PeriOperative	PEG ever	PEG chronic	FEES	MBS	PSS-HN ³⁰	FOIS ³⁸	FOSS ²⁷	MDADI ²⁸		
Hurtuk ¹²		1-2									
Sinclair ¹⁰		1-2									
Weinstein ¹⁵		1-3									
Genden ¹³		1-3									
Weinstein ¹⁴		1-4									
Van Abel ¹⁸		1-4									
Iseli ²⁶		1-4									
Leonhardt ¹⁹		1-4									
Moore ¹¹		1-4									
Moore ¹⁶		1-4									
Weinstein ²⁹		1-4									
More ¹⁷		1-3									

Table 4

Tracheostomy Rates after TORS for OPC

Cohort (n, follow-up time)	Trach	
	Ever	Final
<i>Early (I-II) OPC</i>		
Sinclair (n=42, $\bar{x}$ 17M) ¹⁰	0%	0%
<i>Advanced (III-IV) OPC</i>		
Weinstein (n=47, $\bar{x}$ 26M) ¹⁴	11%	2%
Moore (n=45, $\bar{x}$ 12M) ¹¹	31%	0%
Weinstein (n=27, >6M) ¹⁵	7%	-
<i>All stage (I-IV) OPC</i>		
Hurtuk (n=54, $\bar{x}$ 11M) ¹²	0%	0%
Genden(n=31, $\bar{x}$ 18M) ¹³	23%	-
Iseli (n=33, $\bar{x}$ 13M) ²⁶	9%	0%
Leonhardt(n=38, $\bar{x}$ 15M) ¹⁹	3%	-
Van Abel(n=15, NR) ¹⁸	0%	0%
Moore (n=66, $\bar{x}$ 36M) ¹⁶	26%	2%
Weinstein (n=30, $\bar{x}$ 32M) ²⁹	3%	0%