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Functional considerations between flap and non-flap reconstruction in oral tongue cancer: A systematic review

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ABSTRACT

This systematic review aims to provide insight into the ideal reconstructive approach of the oral tongue in oral tongue cancer (OTC) by investigating the relationship between functional outcomes and the extent of tongue resection. A structured search was performed in Ovid MEDLINE, EMBASE, and Web of Science. Studies comparing patient-reported and objective measurements of the oral tongue function between flap vs. non-flap reconstruction were included. Functional outcomes of interest were speech production, deglutition efficiency, tongue mobility, overall quality of life, and postoperative complications. A total of nine studies were retrieved and critically appraised. Patients with 20 % or less of oral tongue resected had superior swallowing efficiency and speech intelligibility with a non-flap reconstruction while patients with a tongue defect of 40–50 % self-reported or demonstrated better swallowing function with a flap repair. The data in intermediate tongue defects (20–40 % tongue resected) was inconclusive, with several studies reporting comparable functional outcomes between approaches. A longitudinal multi-institutional prospective study that rigidly controls the extent of tongue resected and subsites involved is needed to determine the percentage of tongue resected at which a flap reconstruction yields a superior functional result in OTC.

Introduction

Surgery, with or without adjuvant therapy, is the standard of care for patients with oral tongue cancer (OTC). While oncological outcomes are favorable with surgery, the excision of tongue tissue may significantly impair a patient's postoperative speech production, tongue mobility, deglutition efficiency, and overall quality of life (QoL) [1–3]. In addition to these critical oral functions, restoration of oral competence is crucial as it has been shown to predict survival [4,5].

Depending on the extent and location of the tongue defect, reconstruction of the oral tongue can be performed with a non-flap approach such as primary closure, secondary intention, and skin graft, or with a more complex procedure such as a flap repair (distal or free flap). While the advent of vascularized tissue transfer has facilitated the restoration of tongue volume with less tethering to surrounding structures [6,7], flap repair is technically demanding and associated with significant donor-site morbidity [8]. Furthermore, there is no clear consensus as on whether flap reconstruction leads to a superior functional result compared to simpler non-flap procedures in certain tongue defects. In a national survey distributed across institutions, Akakpo and colleagues demonstrated that the decision to perform a flap reconstruction in specific tongue defects is primarily driven by surgeon preference [9]. High-quality evidence that guides the intraoperative decision-making of a flap reconstruction is currently lacking.

In this review, we evaluated the studies that compared functional outcomes by reconstructive approaches after the surgical management of OTC. Our goal is to synthesize a framework from the published literature to inform the decision for tissue transfer as well as to identify a tipping-point, extent of tongue excised, or lack thereof that is needed to optimize patient outcomes while minimizing treatment morbidity.

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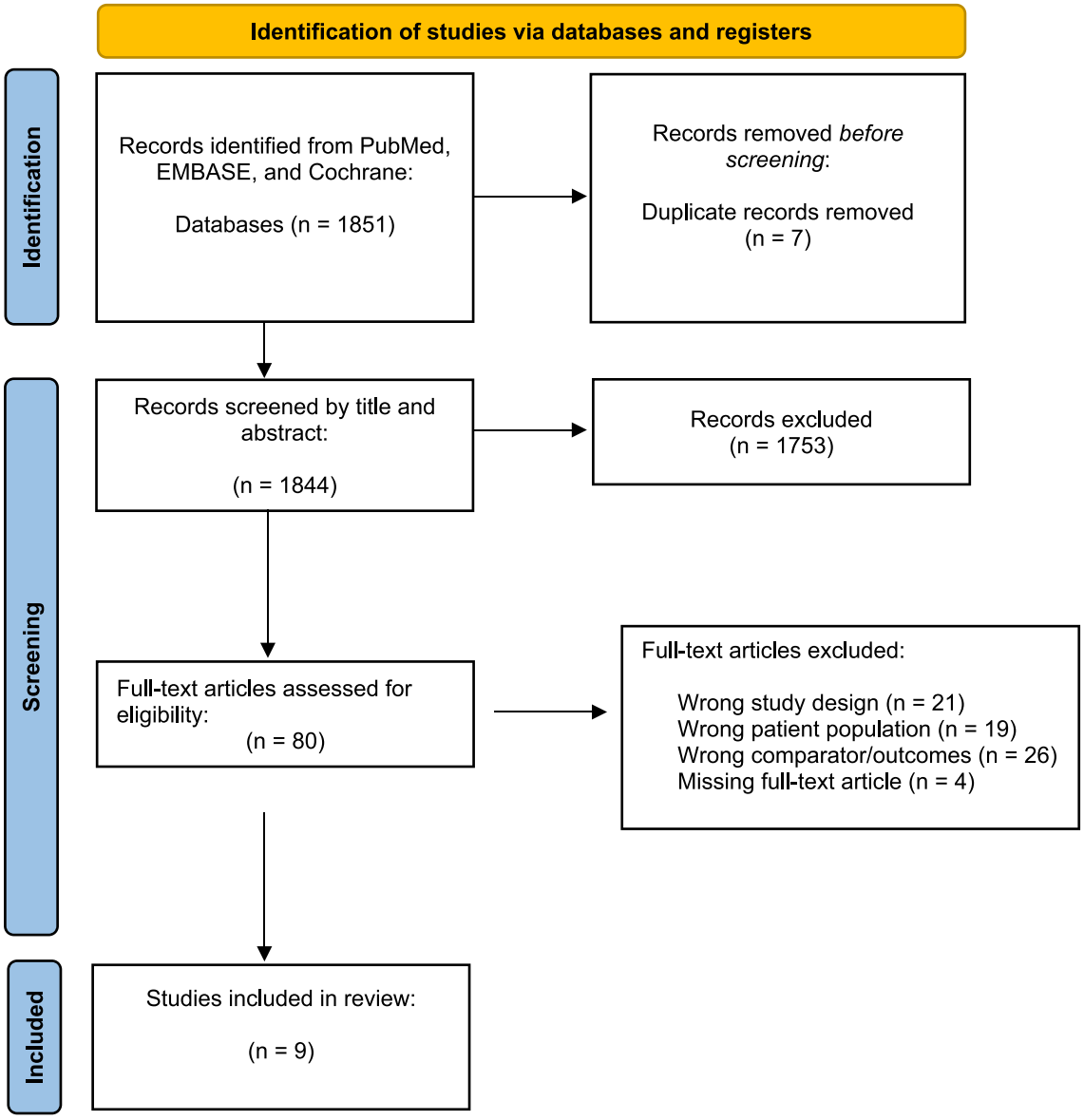

Figure 1. Flow diagram of study review process.

Methods

Initial search

A systematic review of the literature was designed and executed by a medical librarian (DG), and documented according to the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [10].

A search of published articles was performed on Ovid MEDLINE (1946-), Embase.com (1947-), and Web of Science (All Databases 1900-) on September 29, 2022, using a combination of controlled vocabulary and keywords focused on the concepts of oral tongue cancer surgery and quality of life. No filters for language, study design, date of publication, or country of origin were applied. All references were exported into Endnote 7.8 for deduplication and then to Covidence for further deduplication, study screening, selection, and data extraction. The search produced 3034 studies before deduplication, and 1844 after deduplication.

Inclusion and exclusion criteria

The eligibility criteria included observational cohort studies and randomized controlled trials with patients undergoing treatment of half of the oral tongue or less, with or without adjuvant therapy, and flap (*e.g.* pedicled or free tissue transfer) or non-flap reconstruction (*e.g.* primary closure, secondary intention, or skin graft). Studies evaluating and comparing functional subjective or objective outcomes between a flap or non-flap reconstruction were included. Reports that failed to compare functional outcomes among reconstructive approaches or included patients with mandible involvement, recurrence, or second primaries were excluded.

Screening process

The records identified in the initial search were screened and reviewed independently by two reviewers (LC and YZ) using the Covidence systematic review software (Veritas Health Innovation, Melbourne, Australia). All records were screened by title and abstracts, and a third reviewer (DM) arbitrated abstracts with disputes between the

Table 1
Studies were evaluated with the Newcastle-Ottawa Quality Assessment scale for cohort studies.

Study	Selection			Comparability			Outcome			Total
	Representativeness of the exposed cohort	Selection of the non-exposed cohort	Ascertainment of Exposure	Outcome of interest not present at start of study	Main Factor	Additional Factor	Assessment of outcomes	Sufficient follow-up time	Adequacy of follow-up	
Bressman et al. (2004)	*	*	*	*	*	0	*	*	*	(8/9) 89 %
Canis et al. (2015)	*	*	*	*	*	*	0	*	*	(8/9) 89 %
Hsaio et al. (2003)	*	*	*	*	*	0	*	*	*	(8/9) 89 %
Hsaio et al. (2002)	*	*	*	*	*	*	*	*	*	(9/9) 100 %
Ravindra et al. (2022)	*	*	*	*	*	*	*	*	*	(9/9) 100 %
Ji et al. (2017)	*	*	*	*	*	*	*	*	*	(9/9) 100 %
Gabriele et al. (2020)	*	*	*	*	*	0	*	*	*	(8/9) 89 %
Riva et al. (2021)	*	*	*	*	*	0	*	*	0	(7/9) 78 %
McConnel et al. (1998)	*	*	*	*	*	*	*	*	*	(9/9) 100 %

A study can be awarded a maximum of one star (*) for each numbered item within the Selection, Comparability, and Outcome categories. A zero (0) is given if a condition is not met for an item.

first two reviewers. After the title and abstract screening, the studies' full text was independently reviewed by two reviewers (LC and DM) for inclusion into the systematic review, with disputes arbitrated by a third reviewer (YZ).

Risk of bias and quality assessment

For the included studies, the level of evidence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach [11]. The GRADE scale considers the study design, risk of potential bias, consistency, and directness of evidence of each report. The risk of bias and quality assessment of included studies was assessed using the validated Newcastle-Ottawa Scale (NOS) [12] for nonrandomized cohort or case-control studies. On a numeric scale, studies were categorized as good, fair, and poor quality based on the selection of exposed and control participants, comparability of cohorts, and ascertainment of exposure.

Results

Studies included

A total of 1844 records were identified after the removal of duplicates. Records were then screened by title and abstract. From 1844 records, a total of 80 studies were identified as potential candidates for full-text evaluation. Following our inclusion criteria, nine studies were included in the systematic review. The remaining 71 articles were excluded due to incorrect study design (n = 21), wrong patient population (n = 19), and incorrect cohort comparisons or missing functional outcomes (n = 26), as well as four missing full-text articles. This information is further summarized in Figure 1.

Quality assessment of included studies

Our risk of bias assessment is displayed in Table 1. Across all studies, comparability between cohorts was highly variable, with several of the reports showing self-reported outcomes evaluated at distinct time periods. However, according to the NOS scale, all our studies were considered of high quality (6 or above out of 9 or 67 %). Most patients were lost to either recurrence of the primary tumor or death, introducing bias into the conclusions of the studies included. Based on the GRADE approach, most of our included studies ranked in the very low-quality rating with some in the low-quality rating.

Selected studies

Of the nine reports included, two had prospective study designs [7,13], while the rest were retrospective in nature [14–20]. Most studies (n = 8) evaluated functional outcomes between primary closure and pedicled/free flaps, while the last article compared functional results between secondary intention and free flap [14]. All studies included patients with adjuvant therapy. Five out of the nine studies included patients with hemiglossectomies (HG), with two studies comparing functional outcomes in HG patients only [17,18].

Across studies, functional outcomes were evaluated at different time points. One prospective report evaluated functional outcomes preoperatively and at 1 and 6 months [7], while the other prospective cohort study evaluated outcomes preoperatively and 3 months after treatment [13]. The evaluation of functional outcomes in the retrospective cohort studies varied considerably with a range of 6 to 36 months after treatment. This findings are summarized in Table 2.

Outcomes measured

PROMs: Four studies reported subjective swallow outcomes [13–15,20]. Subjective swallow was assessed with self-administered validated questionnaires: M.D. Anderson Dysphagia Inventory (MDADI) [21] and the Functional Outcome of Swallowing Scale (FOSS) [22]. Two of the nine studies reported subjective speech outcomes after surgical treatment [15,20]. Subjective speech production was evaluated

Table 2
Summary of studies included.

Authors	Study design (No. patients)	Reconstructive comparison	%Oral tongue resected	Tongue subsites	Adjuvant treatment	Time after treatment (months)	Objective outcomes measured	PROMs measured
McConnel et al., 1998	Prospective cohort (81)	PC vs. distal/ free flap	<20 %	Anterior tongue w/ FOM	RT	3	Speech: Conversational speech intelligibility & Fisher-Logemann Test of Articulation Competence. Swallow: VFSS	X
Riva et al., 2021	Retrospective cohort study (22)	PC vs. pedicled flap	25–50 %	Not available	RT	12+	Speech: Intelligibility and articulation scales	Speech: SHI Swallow: MDADI, CTCAE QoL: EORTC QLQ-C30 & EORTC-QLQ-H&N35
Rivandra et al., 2021	Prospective cohort (47)	PC vs. SI vs. flap	<50 %	Lateral border & dorsum	RT/CRT	1 & 6	Speech: Intelligibility assessment	Swallow: MDADI
Ji et al., 2017	Retrospective cohort study (43)	SI vs. flap	≤50 %	Lateral border	RT	24–36	Speech: Korean Speech Mechanism Screening Test & Intelligibility assessment Tongue mobility: Korean Speech Mechanism Screening Test	Swallow: FOSS
Hsiao et al., 2002	Retrospective cohort study (12)	PC vs. RFFF	50 %	Not available	RT/CRT	6	Speech: Fletcher time-to-time, maximum repetition rate, and multiple rhyme test Swallow: Duration of swallow, bolus size, and ingestion rate	X
Hsiao et al., 2003	Retrospective cohort study (7)	PC vs. RFFF	50 %	Not available	RT/CRT	6	Swallow: VFSS	X
Gabriele et al., 2020	Retrospective case-control study (14)	PC/SI vs. free flap	≤50 %	Not available	RT	6+	Swallow: FEES & VFSS	Speech: PSS-HN. Swallow: MDADI. QoL: EORTC QLQ-C30 & EORTC-QLQ-H&N35
Canis et al., 2014	Retrospective (40)	PC vs. RFFF	40 %	Lateral border	RT/CRT	12	X	QoL: EORTC QLQ-C30 & EORTC-QLQ-H&N35
Bressmann et al., 2004	Retrospective (14)	PC vs. platysma flaps	Not available	Lateral, anterior +/- FOM, posterior	RT	6	Speech: Intelligibility assessment. Tongue mobility:	X

Abbreviations: Patient-reported outcomes = PROMs; Floor of mouth = FOM; Quality of life = QoL; Primary closure = PC; radial forearm free flap = RFFF; radiation = RT; chemotherapy = CRT; Speech Handicap Index = SHI; Videofluoroscopic Swallow Study = VFSS; Common Terminology Criteria for Adverse Events = CTCAE; Functional outcome swallowing score = FOSS.

with the validated questionnaires: Speech Handicap Index (SHI) [23] and Performance Status Scale for Head and Neck (PSS-HN) [24]. Finally, three of the nine studies [15,16,20] evaluated the health-related QoL of patients with two validated questionnaires: European Organization for Research and Treatment of Cancer (EORTC) Core Quality of Life Questionnaire C30 (EORTC QLQ-C30) and EORTC Head and Neck 35 (EORTC QLQ-H&N35) [25].

Objective measurements: Evaluation of objective functional outcomes were reported in eight of the nine included studies. Objective swallow efficiency was reported in four studies. Swallow function was assessed in two of the four studies with a Videofluoroscopic Study of Swallowing (VFSS) only [7,17]; one study used a combination of VFSS and Fiber-optic Endoscopic Evaluation of Swallowing (FEES) [20]; the final study evaluated swallowing by measuring the bolus volume, duration of a single swallow, and the rate of ingestion[18]. Six of the nine studies reported speech outcomes [7,13–15,18,19]. Objective speech production was assessed by perceptual evaluation of degree of intelligibility, articulation, type of speech errors, and verbal diadochokinesis. Two of these studies evaluated speech production using perceptual rating scales: the Korean Speech Mechanism Screening Test and Fletcher time-to-time maximum repetition of syllabus. Finally, tongue mobility was assessed in one study by nine lingual gestures, and another with the Korean Speech Mechanism Screening test (Table 2).

Results stratified by reconstructive approach

Partial glossectomy (<20 % of tongue resected): In the prospective multi-center cohort study, McConnell et al. showed that patients who were closed primarily and had <20 % of the tongue resected had higher conversational intelligibility and better objective swallow function compared to distal flaps at 3 months after treatment. Although Ravindra and colleagues did not report the extent of tongue defect, complementary to the findings in the McConell prospective study, T1 OTC lesions that were closed primarily had better long-term speech outcomes compared to free flaps [13] (Table 3).

Partial glossectomy (Between 21 and *49 % of tongue resected):* Six out of nine studies reported swallowing, speech, and QoL outcomes in patients with partial glossectomy with more than a quarter of tongue involved but less than a HG. Three of these studies reported higher speech intelligibility and degree of articulation in patients with primary closure compared to flap reconstruction [13,14,18]; however, the remaining three studies that compared speech outcomes showed no significant differences between approaches [15,19,20]. For swallowing outcomes, patients with T3 primary OTC lesions reconstructed with flap repair showed better swallowing efficiency than patients closed primarily [13]; however, one study that compared objective swallow outcomes showed no differences between approaches [20].

Three studies probed patients postoperative QoL after treatment. All three studies found comparable QoL outcomes between reconstructive

Table 3
Summary of functional outcomes stratified by % of tongue resected with proffered reconstructive approach.

Outcomes	PG (<20 %)	PG (20–49 %)	HG
Speech	PC – Higher speech intelligibility with pC (*McConnel et al., 1998*) as well as long-term speech (*Rivandra et al., 2021)*	Mixed – Patients showed better articulation and speech intelligibility with PC (*Rivandra et al., 2021; Ji et al., 2017*, *Hsiao et al., 2002*); other studies have reported no differences between approaches (*Riva et al., 2021*, *Gabriele et al., 2020; Bressmann et al., 2004*)	Mixed – One study showed better articulation and speech intelligibility with PC (*Hsiao et al., 2002*), while another studied showed better articulation and speech intelligibility with flap repair (*Ji et al., 2017*)
Swallow	PC – Patients with PC had a more efficient swallowing of thin liquids with less pharyngeal residue (*McConnel et al., 1998*)	Mixed – Better swallow in patients with T3 or smaller defects with flap repair (*Riva et al., 2021; Rivandra et al., 2021*); however, a study also reported no differences between approaches (*Gabriele et al., 2020*)	Flap reconstruction – Better pharyngeal clearance, reduced oral transit time, and improved contact with palate in flap repair (*Hsiao et al., 2002; Hsiao et al., 2003*)
QoL	N/A	Mixed– No differences between approaches (*Gabriele et al., 2020; Riva et al., 2021);* however, flap reconstruction appears to lead to significantly fewer problems with swallowing, speech, and social eating when the defect is 40 % or higher (*Canis et al., 2014*).	N/A
Tongue mobility	N/A	Mixed – Studies have reported higher mobility with PC/SI (*Ji et al., 2017*) as well as no differences between approaches (*Bressmann et al., 2004*)	Flap reconstruction – Better tongue mobility with flap repair (*Ji et al., 2017*)

Abbreviations: Partial glossectomy = PG; Hemiglossectomy = HG; Quality of life = QoL; Primary closure = PC; Secondary intention = SI.

approaches. However, flap reconstruction led to significantly fewer problems with self-reported swallow, speech, and social eating when the defect involved 40 % of the tongue [16]. Finally, tongue mobility was higher with primary closure in one study [14] while others reported no differences between approaches [19] (Table 3).

Hemiglossectomy: Patients with flap reconstruction had improved pharyngeal clearance, tongue contact with the soft palate, and improved oral transit compared with patients closed primarily [17]. The results for speech production were inconclusive with one study showing better articulation and intelligibility in primary closure [18] while another report showed better speech outcomes with a flap reconstruction [14]. Only one study evaluated tongue mobility in patients with HG and showed that patients had better tongue mobility with a flap reconstruction compared to non-flap repair [14] (Table 3).

Postoperative complications

Complications after tongue reconstruction were only reported in two of the included studies. Within the flap reconstructive cohort (n = 7) of the first report, one patient required a revision of the flap for venous congestion while two other patients experienced neck infections [20]. Within the non-flap reconstruction cohort (n = 7), one patient experienced a neck infection while another had an episode of aspiration pneumonia. All neck infections were treated with antibiotics with no further sequelae.

Within the reconstructive cohort of the second study (n = 20), one patient experienced partial necrosis of the free flap with revision; one patient had postoperative bleeding of the donor site with revision; half of the patients required temporary tracheotomy due to swelling. Within the non-flap reconstructive group (n = 20), one patient experienced postoperative bleeding in the oral cavity; one patient had a cervical hematoma; two patients required temporary tracheostomy due to swelling. No differences in postoperative feeding tube requirements were reported in this study among reconstructive approaches [16].

Discussion

In this work, we performed a systematic review of studies that compared postoperative functional outcomes between flap and non-flap reconstruction after the surgical management of OTC. Across studies, functional outcomes, such as deglutition, speech production, tongue mobility, and overall QoL, were assessed either as self-reported responses or as objective measurements of tongue function. Our evaluation showed that small tongue defects (<20 % of tongue resected) yielded superior swallowing efficiency and speech intelligibility with a non-flap reconstruction while larger tongue defects (>40 %) benefitted functionally from the additional tissue bulk. High quality evidence, however, guiding the intraoperative decision to perform a flap repair over a simpler non-flap reconstruction for intermediate tongue defects (20–40 % of tongue resected) is lacking.

A total of nine studies met our inclusion criteria. From these reports, two were prospective cohort studies, while the remaining seven were retrospective. The nine cohort studies included patients with small to HG tongue defects with varying yet representative oncological stages. Functional outcomes were evaluated from 1 to 36 months after treatment. There was still, however, large degree of heterogeneity in the functional outcomes assessed, methodological design, and cohort comparisons to perform an appropriate meta-analysis. Further, due to ethical reasons, there was no prospective randomized controlled trial to assess functional outcomes between reconstructive approaches.

Four of nine studies compared reconstructive approaches (flap vs. non-flap) while controlling for the extent of tongue resected. In the multi-institutional prospective cohort study, McConell et al. matched patients by the percentage of tongue resected and defect location. The results showed that patients with small tongue defects (<20 % of tongue resected) closed primarily had better swallowing efficiency and speech intelligibility than patients with a flap repair. Within our reports, Hsaio et al. also showed that flap reconstruction might be necessary for patients with a hemiglossectomy defect as the additional tissue volume helped with tongue contact with soft palate and bolus movement. These studies demonstrate that for large tongue defects (50 % of tongue resected), volume is the deterministic factor that guides a superior postoperative function; however, if the tongue defect is small, especially under 20 %, the additional non-motile tissue bulk may impede with the mobility and function of the remnant tongue. Our observations in small and large tongue defects align with the current practice of surgeons across institutions [9].

For intermediate tongue defects (20 to 40 % of tongue resected), however, there is a lack of conclusive evidence as to whether a flap repair yields a superior functional result compared to a simpler reconstruction. Data shows that within these tongue defects, the decision to

perform a free flap is driven by surgeon experience [9]. Evidence guiding this decision is critical for patients and surgeons as flap reconstructions are technically demanding, associated with donor-site morbidity, and may have a higher propensity for temporary tracheostomy compared to non-flap reconstructions.

Reports included in this review for intermediate defects showed that the functional outcomes between reconstructive approaches may be comparable. While this information may indicate that the additional vascularized tissue is not necessary for the recovery of oral competence, most of the comparisons did not control for the extent of resection or subsites involved. The included studies in this review primarily compared patients with similar pathological tumor stages. However, the tumor stage does not necessarily correlate to the extent of resection, thus limiting the validity of the conclusions.

Only two studies with intermediate tongue defects adjusted for percentage of tongue resected. Canis et al. showed that patients with 40 % of tongue resected self-reported significantly fewer problems with swallow function, speech, and social eating with a flap reconstruction compared to patients with a primary closure [16]. The second study showed comparable functional outcomes between reconstructive approaches [20]. However, the defect volumes in this study are sharply different between flap and non-flap reconstruction. The flap repair group had a much larger tongue defect compared to that of the primary closure group. Several published case series included in this review may likely have encountered a similar methodological flaw in their comparisons. Therefore, the extent of resection and location of defect must be controlled for accurate and informative observations between reconstructive approaches.

Conclusion

Small tongue defects (<20 % of tongue resected) have a superior functional outcome with a non-flap reconstruction while larger defects (>40 %) may benefit from a flap repair. The data for intermediate tongue defects is inconclusive, with several studies reporting comparable functional results. Postoperative complications vary among reconstructive approaches with a lower rate of temporary tracheostomy in non-flap reconstruction. A longitudinal multi-institutional prospective study that rigidly controls for the extent of tongue resection and subsites involved is needed to determine the percentage of tongue resected at which a flap reconstruction yields a superior functional result in OTC.

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Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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