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Revisão Sistemática

Biomechanics of the tongue during swallowing after total laryngectomy: an integrative review

Biomecânica da língua durante a deglutição após laringectomia total: revisão integrativa

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Keywords

Tongue
Larynx
Laryngectomy
Laryngeal Neoplasms
Deglutition Disorders

ABSTRACT

Purpose: To synthesize the state of scientific knowledge about biomechanics of the tongue during swallowing after total laryngectomy. **Research strategy:** The PICO question and combinations of descriptors and single terms were formulated in the PubMed/Medline, EMBASE, LILACS, and SciELO databases. **Selection criteria:** Articles in Portuguese, English, or Spanish were included, without time limit, with results on the biomechanics of the tongue during swallowing and total laryngectomy, and studies on randomized or non-randomized clinical trials, cohort, case control, cross-sectional, case series, and case studies. **Data analysis:** year, country, population, objective, study design, assessment methods, main outcomes, and methodological quality were analyzed. **Results:** There were four studies in the United States, one in Australia, and one in Brazil, all published between 1986 and 2014. In all studies, the biomechanics of the tongue was the secondary outcome. Most articles had low methodological quality, small samples, predominance of the male gender, and a prevalent cross-sectional design. The assessment instruments were fluoroscopy, manometry, accelerometer or a device to capture tongue pressure. Main results indicated a higher propulsion force of the tongue base to overcome the high resistance of the neopharynx to the bolus flow, reduced contact and pressure between the base of the tongue and the posterior pharyngeal wall, residues in the tongue base after swallowing, increased pressure, and reduced resistance of the oral tongue. **Conclusion:** There are indications of compensatory tongue movements during swallowing after total laryngectomy; however, the scientific evidence is insufficient.

Descritores

Língua
Laringe
Laringectomia
Neoplasias Laríngeas
Deglutição
Transtornos de Deglutição

RESUMO

Objetivo: Sintetizar o estado do conhecimento científico sobre biomecânica da língua durante a deglutição após laringectomia total. **Estratégia de pesquisa:** Formulou-se a questão PICO e combinações de descritores e termos livres para busca nas bases de dados PubMed/Medline, EMBASE, LILACS e SciELO. **Critérios de seleção:** incluíram-se artigos nos idiomas português, inglês ou espanhol; sem limite de tempo; com resultados sobre a biomecânica da língua durante a deglutição em laringectomizados totais; e estudos do tipo ensaio clínico randomizado ou não randomizado, coorte, caso controle, transversal, série de casos e estudos de caso. **Análise dos dados:** analisou-se ano, país, população, objetivo, delineamento do estudo, instrumentos de avaliação, principais desfechos e qualidade metodológica. **Resultados:** Foram incluídos quatro estudos realizados nos Estados Unidos, um na Austrália e um no Brasil, publicados entre 1986 e 2014. Em todos os estudos incluídos a biomecânica da língua foi um desfecho secundário. A maioria dos artigos teve baixa qualidade metodológica, com amostras pequenas, predomínio do sexo masculino e desenho transversal prevalente. Os instrumentos de avaliação foram videofluoroscopia, manometria, acelerômetro ou dispositivo para captar pressão de língua. Resultados principais indicaram mais força de propulsão da base de língua para superar a alta resistência da neofaringe ao fluxo do bolo alimentar; redução do contato e pressão entre base de língua e parede posterior da faringe; resíduo em base de língua após deglutição; pressão aumentada e resistência reduzida da língua oral. **Conclusão:** Existem indícios de movimentos compensatórios de língua durante a deglutição após laringectomia total, porém, as evidências científicas são insuficientes.

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INTRODUCTION

Total laryngectomy is the complete removal of the laryngeal organ and requires a definitive separation between digestive and airways[1-3]. Thus, the passage of food, liquids or secretions into the respiratory tract occurs only in the presence of a fistula or a leakage in the tracheoesophageal prosthesis[1]. However, other possible complications may arise at any of the stages of swallowing, including restriction to some food consistencies[1,3-7], feeling of tightness during the passage of food through the neopharynx or the esophagus[3-5], residues in oral cavity or neopharynx[1,3-8], in addition to disturbances in the biomechanics of the tongue[8-10].

Disorders in the tongue biomechanics after total laryngectomy may arise as an outcome to the procedures of the surgery, such as the fixation of the suprahyoid muscle after removal of the hyoid bone[11] or the type of pharyngeal closure depending on the size and extent of the surgical defect[3,12]. Transverse closure, for example, requires a suture on the basis of the tongue, which generates scarring or the need for reconstruction with other tissues[3,12], which may result in a reduction in the strength and range of movement of the tongue[10].

The tongue is essential in the preparation of the bolus in the oral cavity[13] and, together with the laryngeal elevation, contraction of the cricopharyngeal musculature and the negative pressure of the pharyngoesophageal segment, allows an adequate propulsion of the content prepared for the oropharynx[13,14]. In total laryngectomy, the propulsion force of the neopharynx decreases and there is an increase in resistance to the bolus flow in all segments of the pharynx[15,16]. Therefore, the tongue needs to expand its ejection action and create a pressure gradient sufficient to overcome pharyngeal resistance and allow the movement of the bolus[9]. Therefore, the absence of the larynx interferes with the biomechanics of the tongue during swallowing and may compromise the ability of oral ingestion, pleasure with food, and quality of life[4-6].

Oropharyngeal dysphagia after a total laryngectomy is common and has a multifactorial cause[17], referred to by about 70% of patients[5]. However, it is still an underestimated condition probably because the phonatory and respiratory impacts are more evident and the risk of laryngotracheal aspiration does not exist[8]. In addition, studies on oropharyngeal dysphagia in total laryngectomized patients show heterogeneous results and methodological limitations that make it difficult to propose more robust clinical practices[17]. This scenario contributes to an insufficient understanding of what happens during the swallowing of these patients after surgery, including possible sequelae in the biomechanics of the tongue. Understanding physiopathology is a fundamental requirement for planning appropriate therapeutic strategies for the rehabilitation process.

OBJECTIVE

The aim of this study is to synthesize the state of scientific knowledge on the biomechanics of the tongue during swallowing after total laryngectomy.

RESEARCH STRATEGY

This study is an integrative literature review. Because of its methodology, it was not necessary to submit it to evaluation by the institution's Research Ethics Committee on Humans.

This integrative literature review followed the phases[18]: (1) preparation of the research question, (2) definition of descriptors and keywords, (3) selection of articles according to eligibility criteria, (4) data collection, extraction, reading, and critical analysis of articles, (5) interpretation and discussion of results, and (6) synthesis of knowledge and presentation of the review.

To formulate the conductive question, the PICO strategy was used (abbreviation for *patient, intervention, comparison, outcomes*). The first element of the strategy (P) consists of the total laryngectomized patient, the second (I) is the total laryngectomy procedure, the third (C) was not used in this review, the fourth element (O) are changes in the biomechanics of the tongue during swallowing. Thus, the guiding question of this study was: "In patients undergoing total laryngectomy, what are the characteristics in the biomechanics of the tongue during swallowing after surgery?"

The search for articles took place in July 2020 in the PubMed/Medline, EMBASE, LILACS, and SciELO databases. In addition, an additional search was performed in the references of the selected articles. According to the search procedures of each database, combinations between keywords and descriptors were used in *Medical Subject Headings* (MeSH), Embase *Emtree Terms*, and Health Science Descriptors (DeCS) of the Virtual Health Library (VHL) (Appendix 1). In all databases, the search was for English, and Portuguese and Spanish articles specifically in LILACS and SciELO.

SELECTION CRITERIA

The selection criteria were defined based on the elements of population, intervention, results, and type of study. Chart 1 shows the inclusion and exclusion criteria.

DATA ANALYSIS

After initial collection in the databases and exclusion of repeated articles, the articles were independently screened by two reviewers (LMA and TESF), who read the titles and abstracts. Then, the same reviewers read and analyzed the contents of the full text of the remaining articles. A third reviewer (LAP) was available for consensual decision-making along with the other two reviewers in cases of disagreement.

The eligible articles were submitted to the extraction of the following data to compose the analysis matrix: author, year of publication, country where the study was conducted, study objectives, sample characteristics, study design, instruments or exams used in the evaluations, and main outcomes related to the biomechanics of the tongue. The results were submitted to descriptive and integrative analyses, followed by discussion

Chart 1. Inclusion and exclusion criteria

	Inclusion Criteria	Exclusion Criteria
Population	Individuals undergoing total laryngectomy	Individuals undergoing other head and neck surgeries or with associated neurological conditions
Intervention	Total Laryngectomy	Total laryngectomy in individuals with associated neurological conditions
Results	Characteristics of the biomechanics of the tongue during swallowing after surgery	Studies that investigated swallowing after total laryngectomy, but did not mention tongue outcomes, or that studied the biomechanics of the tongue after total laryngectomy, but only in other functions
Type of study	Original articles, including randomized or non-randomized clinical trials, cohort, case control, cross-sectional studies, case series, and case studies	Experimental studies or those on cadavers, literature reviews, editorials, opinion articles, and annals of scientific events

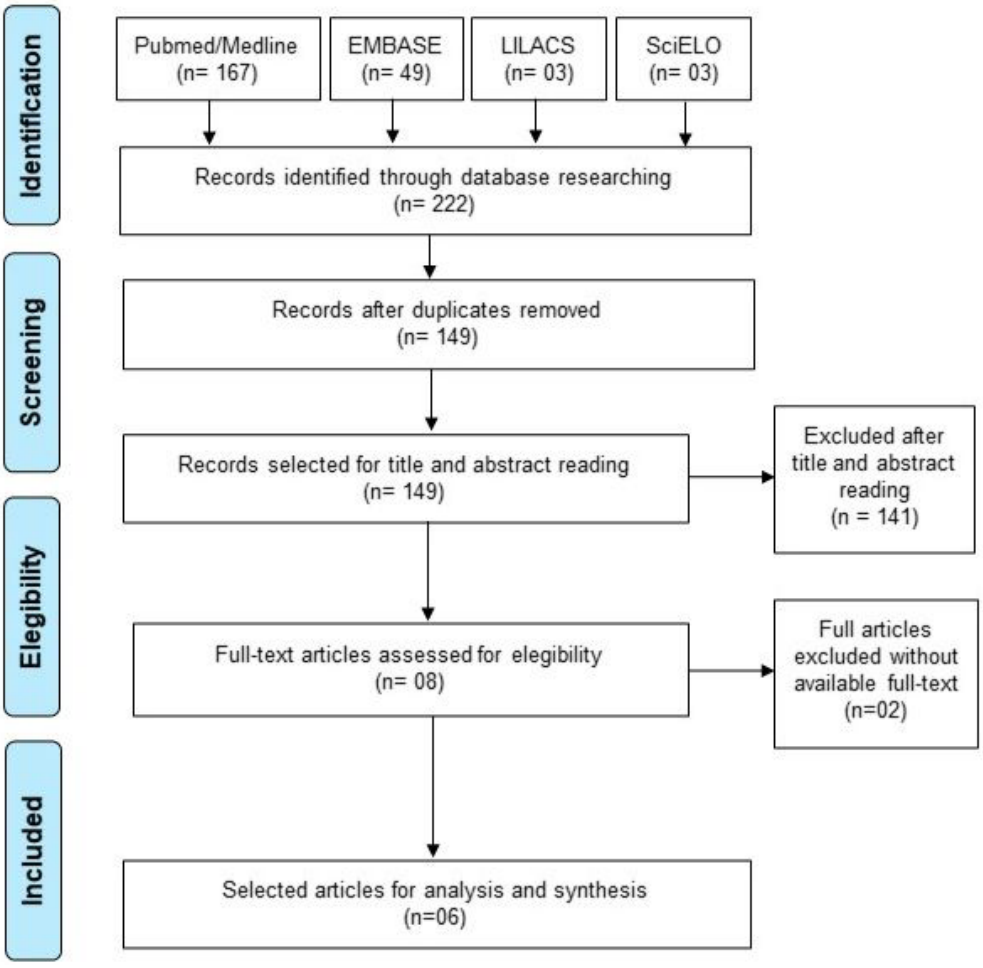

Figure 1. Flowchart of the selection of studies

to synthesize knowledge and present the review. In addition, the selected articles were submitted to methodological quality analysis using the instruments *Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross Sectional Studies*[19] and *JBI Critical Appraisal Checklist for Case Reports*([19]).

RESULTS

The search initially tracked 222 articles. Of these, eight were read in full, and six were selected for analysis after meeting the eligibility criteria, according to the flowchart that Figure 1 shows. There was no divergence between the reviewers who carried out the search and the screening of articles; therefore, the participation of the third reviewer was not necessary.

The analysis of results was performed according to the variables of interest in this review in a descriptive way. Chart 2 shows the analysis matrix listing the results.

The publications have long time intervals. Of the six selected studies[7,9,14,15,20,21], four were carried out in the United States[9,14,20,21], one in Australia[15], and one in Brazil[7]. In general, the studies

Chart 2. Analysis matrix of studies that investigated the biomechanics of the tongue during swallowing after total laryngectomy

Author, year, location	Objective	Sample	Type of study	Instrument or exam	Main outcomes related to the biomechanics of the tongue
McConnel, Mendelsohn, Logemann, 1986; United States[9]	To analyze the role of different anatomical components of the swallowing process in TL patients with and without tongue impairment.	Group 1 (G1): nine TL without tongue impairment (eight men and one woman);	Transversal	Manofluorography (manometry + videofluoroscopy); questionnaire on swallowing and speech; physical exam.	G1: voluntary control of the food bolus in the oral cavity with minimal residues; greater amplitudes of base pressure gauge waves of the tongue than those of the G2, and non-laryngectomized patients; two patients complaining of dysphagia.
		Group 2 (G2): five TL with tongue impairment due to associated partial/ total glossectomy or hypoglossal nerve injury (four men and one woman)			G2: difficulties in containing the food bolus in the oral cavity, presence of residues, and multiple swallows for cleaning; more difficulties in those who underwent glossectomy than in those with hypoglossal nerve damage; low amplitudes of base pressure gauge waves of the tongue than those of G1 and non-laryngectomized patients; head extension as a compensatory strategy; difficulties in initiating the pharyngeal phase of swallowing; all patients complaining of dysphagia.
		There is no information about the participants' age.			
McConnel, 1988; United States[14]	To investigate the mechanisms of generation of pharyngeal pressure and its relationship with the transit of the bolus in normal individuals who underwent surgery.	Group 1 (G1): 36 not TL (median age: 32 years)	Transversal	Manofluorography (manometry + videofluoroscopy); questionnaire on swallowing and speech; physical exam.	The amplitudes of manometric waves of tongue pressure of G2 are greater than those of G1 and G3; however, those of G3 are lower than those of G1.
		Group 2 (G2): 15 TL without tongue impairment			The motor force of the tongue (pressure produced by the tongue base directly on the bolus) is greater in G2 than in G1.
		Group 3 (G3): five TL with tongue impairment			In TL, although there is an increase in the motor strength of the tongue, there is a decrease in the pharyngeal pressure gradient, especially in the hypopharynx, in addition to a decrease in the time and speed of pharyngeal transit.
		Median age of G2 + G3: 54 years			
		Total sample: 33 men and 23 women			
Hamlet *et al*., 1992 United States[20]	To identify which acoustic dimensions of swallowing sounds distinguish TL patients from non-TL patients and suggest a causal interpretation.	EG: 13 TL (13 men and one woman). Ages between 41 and 71 years.	Transversal	Videofluoroscopy + accelerometer, simultaneously.	The time between the end of the tongue propulsion gesture and the abrupt spectral change expected shortly thereafter was shorter in the EG than in the CG in swallowing both liquid and pasty substances.
		CG: 17 non-TL (14 men and three women). Ages between 36 and 68 years.			

Legend: TL = total laryngectomy.

Chart 2. Continued...

Author, year, location	Objective	Sample	Type of study	Instrument or exam	Main outcomes related to the biomechanics of the tongue
Lazarus *et al*., 2002; United States[21]	To assess swallowing, oral tongue pressure, and tongue base pressure towards the pharynx in an TL patient to improve dysphagia resulting from chemoradiotherapy for the treatment of a tumor in the hypopharynx.	Case: 72 years old, male.	Case report	Videofluoroscopy of swallowing + concomitant manometry.	Incomplete contact and reduced pressure between the base of the tongue and the posterior pharyngeal wall;
		Control: a non-TL individual matched for age and gender.		*Iowa Oral Performance Instrument* (IOPI) to assess tongue pressure and resistance.	Higher maximum isometric pressure of the tongue in this case, but within normal limits for healthy elderly people;
					Tongue resistance time was shorter in this case, but in both cases, it was lower than the normal limits for healthy elderly people;
					Oral tongue pressure during dry swallowing with no significant difference, but both with lower than expected values;
					Increased pressure of the oral tongue during swallowing, with effort in both.
Maclean *et al*. 2011; Australia[15]	To determine whether TL changes the pharyngeal pressure and whether such changes, if they occur, correlate with the surgical technique(s) or severity of dysphagia.	24 TL (19 men and five women).	Transversal	Videomanometry; questionnaire with swallowing scale of the *Australian Therapy Outcome Measures (Aus-TOMs)*.	There was no significant difference between TL with and without swallowing complaints regarding the maximum peak pressure of the tongue base.
		Ages between 46 and 82 years.			
Morandi *et al.*, 2014; Brazil[7]	To describe the results of videofluoroscopic analysis of swallowing in TL.	22 videofluoroscopy exams of TL patients who underwent bilateral neck dissection with primary closure (n = 20), pectoral muscle flap (n = 1), and jejunum microsurgical flap (n = 1), followed by radiotherapy.	Transversal	Videofluoroscopy of swallowing.	Reduced movement of posteriorization of the tongue base: 48%;
					Stasis on the base of the tongue: 76%.

Legend: TL = total laryngectomy.

aimed to understand the physiopathology of oropharyngeal dysphagia in total laryngectomy patients. They analyzed aspects of tongue biomechanics. However, this was not the primary outcome of any of the six studies.

The sample size ranged from two[21] to 30[20] patients. Age, when described, was between 36[20] and 82[15] years old. Five[7,9,14,15,20] studies were cross-sectional studies and only one[7] did not have a comparison group. The studies used different instruments or exams as a tongue assessment resource, some at the same time, namely: videofluoroscopy[7,9,14,20,21], manometry[9,14,15,21], accelerometer[20], and the *Iowa Oral Performance Instrument* (IOPI)[21], a device to assess pressure and endurance of the oral tongue.

The main outcomes related to the biomechanics of the tongue during swallowing in TL patients were: 1) after surgery, patients need to increase the propulsion force of the bolus with the tongue to overcome the high resistance of the neopharynx to the bolus flow[9,14,20]; 2) the pressure of the tongue base in the TL does not depend on a complaint of dysphagia[15]; 3) there is a reduction in contact and pressure between the tongue base and the posterior pharyngeal wall during swallowing;[7.21] 4) there is residue on the tongue base after swallowing[7]; and 5) there is evidence of increased oral tongue pressure and reduced tongue resistance after surgery[21].

Finally, the methodological quality of the studies was low (Table 1 and Table 2). The main weaknesses were related to inclusion criteria, description of the sample, sample allocation, and identification of confounding factors.

Table 1. Classification of methodological quality of studies according to criteria of *The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Analytical Cross Sectional Studies*

	McConnel, Mendelsohn, Logemann, 1986[9]	McConnel, 1988[14]	Hamlet *et al.*, 1992[20]	Maclean *et al.* (2011); Australia[15]	Morandi *et al.*, 2014[7]
1) Were the criteria for inclusion in the sample clearly defined?	N	N	N	Y	Y
2) Were the study subjects and the setting described in detail?	N	N	N	Y	N
3) Was the exposure measured in a valid and reliable way?	N	Y	Y	Y	Y
4) Were objective, standard criteria used for measurement of the condition?	Y	Y	Y	Y	Y
5) Were confounding factors identified?	N	N	N	Y	N
6) Were strategies to deal with confounding factors stated?	N	N	N	U	N
7) Were the outcomes measured in a valid and reliable way?	Y	Y	Y	Y	Y
8) Was appropriate statistical analysis used?	N	N	Y	Y	N
Adequate/Total	2/8	3/8	4/8	7/8	4/8

Y - Yes; N - No; U – Unclear.

Table 2. Classification of methodological quality of studies according to criteria of *The Joanna Briggs Institute (JBI) Critical Appraisal Checklist for Case Reports*

	Lazarus *et al*., 2002[21]
1) Were patient's demographic characteristics clearly described?	N
2) Was the patient's history clearly described and presented in a timeline?	Y
3) Was the current clinical condition of the patient on presentation clearly described?	Y
4) Were diagnostic tests or assessment methods and the results clearly described?	Y
5) Was the intervention(s) or treatment procedure(s) clearly described?	N
6) Was the post-intervention clinical condition clearly described?	Y
7) Were adverse events (harms) or unanticipated events identified and described?	Y
8) Does the case report provide takeaway lessons?	Y
Adequate/Total	6/8

Y - Yes; N - No; U – Unclear.

DISCUSSION

This review aimed to synthesize the scientific evidence on the characteristics of the biomechanics of the tongue during swallowing after TL given the growing interest in better understanding oropharyngeal dysphagia after complete removal of the larynx and considering the importance of the tongue for deglutition efficiency and safety.

The results show that, although relevant, the topic has been explored superficially in the literature and in studies, mostly conducted with a low methodological quality. The few studies found were published with a large time between them and the biomechanics of the tongue were studied as a secondary outcome, so that there is not enough support to attest to the existence of evidence on the topic. The case studies are few, the study designs are fragile, and the research centralizes in the United States.

The studies included sought to describe the pathophysiology of oropharyngeal dysphagia after TL using different assessment methods. Regarding the biomechanics of the tongue, emphasis was on the compensatory behavior of this structure during swallowing, which is characterized by an increase of its propelling force, especially at the tongue base, to overcome the absence of the larynx and the consequent increase in pharyngeal resistance[9,14,20]. The peak pressure at the tongue base does not depend on the presence or absence of swallowing complaints[15]. There is also a reduction in contact and pressure between the tongue base and the posterior pharyngeal wall[7,21] and swallowing functionality is worse in TL patients with associated tongue impairments[9]. Only one of the studies[21], a case report, evaluated characteristics of the oral portion of the tongue.

Among the instruments and exams used, videofluoroscopy was the only evaluation method present in almost all studies, either in isolation[7] or associated with other procedures[9,14,20,21]. The performance and analysis of videofluoroscopy exams were not standardized in the studies, which hinders an accurate comparison of results. Traditionally, videofluoroscopy is the gold standard for swallowing assessment[8,22], which may justify its frequent use in the studies included in this review. However, it is important to highlight that this exam

and the Fiberoptic Endoscopic Evaluation of Swallowing (FEES) did not show good indicators of reliability and agreement for cases of dysphagia after TL[1]. There has been an increasingly understanding that there is no superiority, rather a complementarity between instrumental exams such as manometry, videofluoroscopy, and FEES, and that the indication of one or more procedures must be in accordance with the patient's needs[8].

The main outcome of videofluoroscopy in the included studies is related to the reduction in the movement of posteriorization of the tongue base. As the difficulties in the bolus flow through the pharyngeal transit are pointed out as one of the main changes in swallowing after TL[9,14,16,23], the emphasis on the basic movement of the tongue will possibly find support in its fundamental role in the ejection of the bolus during swallowing[9], since the tongue base is one of the main sources of pressure in the pharynx[14].

In the two oldest studies[9,14], published by the same research group, the authors assessed swallowing using videofluoroscopy and manometry. The results of these studies emphasize the tongue as one of the main pressure-generating components for a proper bolus flow. According to the authors, the tongue acts as a piston in the conduction of the bolus through the less compliant pharynx after TL[9]. The results, especially using manometry, show how the absence of the larynx requires adaptations in swallowing after TL and the primordial role of the tongue in overcoming the great resistance the neopharynx offers to the bolus flow. It is necessary to consider, however, that both studies do not mention possible confounding factors such as the postoperative time, the adjuvant treatments, and the primary location of the tumor.

These two studies[9,14] were pioneers in addressing the biomechanics of the tongue during swallowing after TL, but only 20 years later other researchers returned to using manometry[15]. The aim was to determine whether TL interferes with pharyngeal pressure during swallowing and whether this outcome correlates with surgical technique(s) or dysphagia severity[15]. The only result for the tongue showed that the peak pressure on the tongue base has no significant difference between TL patients with and without complaints of swallowing. The research found a correlation between the type of surgical technique and the peak pressure in the central area of the pharynx, but the authors did not develop this analysis on the tongue base.

Two more recent studies[16,23] resorted to a more sophisticated analysis using high-resolution manometry; however, they did not explore the participation of the tongue. One of these studies[16] also evidenced the influence of the type of surgical technique on the pharyngeal characteristics of dysphagia in TL. It is possible that this also occurs in relation to the biomechanics of the tongue, but as none of the studies included in this review considered this variable, this hypothesis should be investigated in further research.

One of the studies[9] also showed that TL patients with some associated tongue impairment has more difficulties compared to other TL patients without this condition, reinforcing that if there is a greater loss of tongue functionality, there is a decrease in swallowing performance. Still in that same study, the authors identified patients with pseudoepiglottis, a protuberance of the mucosa below the base of the tongue, which may be asymptomatic or act as a flap valve that accumulates residues and requires cleaning through multiple swallows.

Another study included in this review used an accelerometer to identify acoustic parameters of the sounds produced by swallowing[20]. Unlike non-laryngectomized volunteers, those who underwent surgery did not present distinct acoustic patterns between swallowing of liquid and pasty substances. The time interval between the sign representing tongue propulsion and the sign of abrupt spectral change, expected shortly thereafter, was significantly shorter in TL patients. In individuals with a preserved larynx, the sign of spectral change mentioned above is related to the passage of the bolus through the pharyngeal transit. However, in the case of TL patients, it is assumed that there is a link with the rapid entry of the bolus into the esophagus, although, according to the authors, it is not possible to state it precisely.

The researchers of the accelerometer study[20] argue that in TL patients, the food bolus is pumped directly into the esophagus by increasing the pressure of the tongue instead of being driven by the pharyngeal action, as occurs when the larynx is present. Although there was no subsequent study replicating the use of an accelerometer in TL patients, the results of this study ratify, in a way, the previous findings found using other assessment resources regarding the more vigorous propulsive action of the tongue during swallowing among that population[9,14].

Although changes in the oral cavity interfere with the pressure dynamics required for functional swallowing[7], only one case report study[21] evaluated the conditions of the oral portion of the tongue, specifically pressure and resistance. The authors justify that the highest isometric pressure of the tongue in TL is a compensatory mechanism that represents an attempt to swallow more efficiently. It is worth mentioning that in non-laryngectomized patients, the movement of posteriorization of the tongue base is preceded by the passage of the food bolus from the oral cavity to the vallecula in response to the pressure of the tongue against the palate[14]. This transition does not exist in TL, which reinforces the hypothesis of a compensatory use not only of the tongue base, as suggested in most studies, but also of its oral part in the increase in pressure during swallowing. This hypothesis needs to be further explored.

In the most updated study included in this review, the authors collected 22 videofluoroscopy exams of TL patients for analysis[7]. Approximately half of the cases showed a reduction in the movement of posteriorization of the tongue base, as happened with a patient in another study[21]. It is assumed, therefore, that the increase in pressure in this region does not necessarily mean competence to produce a complete contact between the base of the tongue and the posterior pharyngeal

wall. The study also showed a high frequency of residues on the base of tongue[7], as it complements the records of a high occurrence of residues in the neopharynx, esophagus, and vocal prosthesis in TL patients[1].

In addition to the primary role in swallowing, the tongue also plays a crucial role in speech mechanisms. Two studies[11,24], although old and ineligible, call attention for relating the strength of the tongue to the type of speech rehabilitation the LT patient undergoes. The authors found that tongue strength is not significantly different between non-laryngectomized and LT patients who make use of the esophageal voice[11], but it is weaker in those who use an electronic larynx[24]. The authors argued that the production of esophageal voice requires an active use of the tongue to direct air into the esophagus, but the use of the electronic larynx does not provide this type of strengthening. In Brazil, speech rehabilitation by esophageal voice and electronic larynx is widespread. Therefore, the method of speech rehabilitation should be a variable considered in further studies on biomechanics of the tongue during swallowing in TL patients.

This review has some limitations. Regarding the eligibility criteria, the restriction of language and other types of scientific communication, such as annals of events, may have excluded studies with the potential to be included in the review. The results found should be interpreted with care, as some were published more than 30 years ago. Since then, there have been changes in surgical techniques, diagnostic tests, evaluation methods, and rehabilitation processes. Therefore, direct comparisons between the results of these studies and further studies may not be possible.

Despite this, the results presented in this review should stimulate the development of more robust evidence on the functionality of the tongue during swallowing in TL patients in order to collaborate with more accurate diagnoses and prognoses of the pathophysiology of oropharyngeal dysphagia in these patients, which are necessary elements to guide decision-making and clinical management of each case.

CONCLUSION

There is insufficient scientific evidence on the impacts of TL on the biomechanics of the tongue during swallowing. However, there are indications of reduction in the movement of posteriorization of the tongue base and of an increase in the compensatory increase in pressure in this region to ease the food bolus flow through the neopharynx. The possible repercussions of surgery on the functionality of the oral portion of the tongue need to be better understood.

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LMA contributed to collection, data analysis, writing, and final review of the article; TESF contributed to data collection and analysis; LP contributed to design, supervision, data analysis, writing, and final review of the article.

Appendix 1. Search strategies used in databases

Database	Descriptors
Pubmed/Medline	(((((laryngectomies[MeSH Terms]) OR (laryngectomy[MeSH Terms])) OR ("total laryngectomy"[Title/Abstract])) OR (laryngectomized[Title/Abstract])) AND (((((((deglutition[MeSH Terms]) OR (deglutition disorders[MeSH Terms])) OR (swallowing[MeSH Terms])) OR (swallowing disorders[MeSH Terms])) OR (deglutition[Title/Abstract])) OR (swallowing[Title/Abstract])) OR (dysphagia[Title/Abstract]))) AND (Tongue[Title/Abstract])
EMBASE	('total laryngectomy'/exp OR 'laryngectomy'/exp) AND ('dysphagia'/exp OR 'swallowing'/exp) AND 'tongue'/exp
LILACS	(("Total laryngectomy" OR laryngectomized) (Dysphagia OR Swallowing OR Deglutition OR "DeglutitionDisorders") Tongue)
SciELO	(("Total laryngectomy" OR laryngectomized) (Dysphagia OR Swallowing OR Deglutition OR "DeglutitionDisorders") Tongue)