

# Measuring tongue strength in adults after partial glossectomy: a review

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W Shaw<sup>1</sup>, A Ismail<sup>2</sup>, BJ Vangu<sup>3</sup>, D Kimmie<sup>4</sup>, S Naidoo<sup>5</sup>, R Katulondi<sup>6</sup>, N Madikoa<sup>7</sup>, Z Cassim<sup>8</sup>, N Kana<sup>9</sup>, S Maharaj<sup>10</sup>

## ABSTRACT

### Objectives

The purpose of this study is to present a scoping review of the measurements of tongue strength available, particularly in adult patients, following partial glossectomy. The subsequent impact on functionality and quality of life were also explored.

### Materials and methods

This study used a scoping review and the study selection comprised two stages of screening: the review of the title and abstract followed by a full-text review. During the first stage of screening, the title and abstracts of all retrieved references were reviewed against the predetermined inclusion criteria. In the second stage of screening, all studies were reviewed at full-text level, utilising the Full-Text Screening Relevance measure. A total of 20 articles were reviewed as they met the inclusion criteria

### Results

The study found that subjective and quality-of-life measures may still be useful in measuring tongue strength in developing contexts as they closely approximate objective measures and are reliable as an interim measure. However, there is still a need for the development of other objective measures, should funding be available.

### Keywords

Swallowing, dysphagia, tongue, oral pathology, mouth, cancer, head and neck

## INTRODUCTION

The tongue is a vital muscle required for various oro-motor functions specifically for the oral preparatory phase of swallowing as well as the swallow trigger used to initiate the pharyngeal phase of swallowing. The tongue provides the medium through which speech is produced, as its swift yet well co-ordinated movements produce the complex sounds required for language production.<sup>1</sup> Those with cancer involving the tongue undergo aggressive surgery and multiple treatment regimens in an attempt to optimise patient survival<sup>1</sup>. This may include a complete or partial removal of the tongue tissue, known as a glossectomy<sup>1</sup>. Such procedures result in reduced tongue strength causing dysphagia, and difficulties with articulation and fluent speech production. This, in conjunction with the impact on patients' physical appearance, greatly impacts on psychosocial and emotional wellbeing<sup>1</sup>.

Those suffering from oral cancer experience life-altering deficits that greatly affect their quality of life (QoL) mostly due to the treatment effects on the tongue, jaw, throat and salivary glands.<sup>2</sup> QoL indicators have become increasingly important in patient treatment, given the positive change in life expectancy and road to recovery after treatment.<sup>3</sup> This is therefore an important component in treatment planning and the overall success of treatment.<sup>4</sup> The purpose of this study is to present a scoping review of the available measurements of tongue strength in adult patients following partial glossectomy. The subsequent impact on functionality and QoL was also explored.

## MATERIALS AND METHODS

A scoping review was the most appropriate method as it assesses the extent of literature available on a specific topic with an analysis of its importance.<sup>5</sup> It is exploratory in nature, especially when not much is known about the area of study, and is useful to systematically map the evidence, explain key concepts and findings, address knowledge gaps, and develop further areas for future research.<sup>5</sup> The methodological framework is a tool that provides a structured and practical approach for the researcher through a step-by-step process.<sup>6,7,8</sup> The seminal work by Arksey and O'Malley<sup>9</sup> was used in this review and was refined by Levac and Colleagues<sup>10</sup> as well as the Joanna Briggs Institute (JBI).<sup>8</sup> The final step of consultation was not considered in this review; thus, only five steps of the framework were used which included finding and selecting the relevant studies, and charting and reporting the results. The review was done over a period of six months

## SAMPLE

According to the literature the search strategy for a scoping review should be comprehensive in order to identify all literature specified by the inclusion criteria.<sup>9</sup> A three-step search strategy was employed to identify research

### Authors' information

1. Wade Shaw, BA Psychology, BA (Hons) Psychology, *MBBCh V*, University of the Witwatersrand
2. Azra Ismail, *MBBCh V*, University of the Witwatersrand
3. Baka Jolyne Vangu, *BHSc* (Hons), *MBBCh V*, University of the Witwatersrand
4. Deen Kimmie, *MBBCh V*, University of the Witwatersrand
5. Saijal Naidoo, *MBBCh V*, University of the Witwatersrand
6. Rosy Katulondi, *BHSc* (Hons), *MBBCh V*, University of the Witwatersrand
7. Nkoe Madikoa, *MBBCh V*, University of the Witwatersrand
8. Zarreen Cassim, BA Speech Therapy & Audiology, MA Audiology, University of the Witwatersrand
9. Nadir Kana, MBChB, MMED, FCORL, University of the Witwatersrand
10. Shivesh Maharaj, MBBCh, MMED, FCORL, Academic Head, Department of Otorhinolaryngology, University of the Witwatersrand

### Corresponding authors

1. Z Cassim, BA Speech Therapy & Audiology, MA Audiology, University of the Witwatersrand  
Tel: +27 716 739 755  
Email: zarreen56@gmail.com  
ORCID: 0000-0001-8075-335X
2. Dr N Kana, MBChB, MMED, FCORL, University of the Witwatersrand  
ORCID: 0000-0001-8902-2684
3. Prof S Maharaj, MBBCh, MMED, FCORL, Academic Head, Department of Otorhinolaryngology, University of Witwatersrand  
ORCID: 0000-0002-2118-2400

studies, which included (i) electronic database search for peer-reviewed studies (ii) Grey Literature search to identify available or ongoing systematic reviews, clinical trials and theses and dissertations and (iii) ancestry searching of included studies utilising snowball sampling.<sup>10</sup> The inclusion and exclusion criteria used the “PCC” (Population [or participants]/Concept/Context) guide recommended by the JBI<sup>10,11</sup> to identify the main concepts and inform the search strategy. The PCC framework also provided a clear context for the research review and assisted in aligning the title, review question and the criteria for inclusion.<sup>5</sup> This also included a list of the articles from the databases used, namely Google Scholar, Scopus® and PubMed® (using medical subject headings/MeSH terms). The same search terms listed above were utilised. For certain databases, Boolean operators, truncation and wildcards were used with the most common being “AND” or “OR”. A multipronged strategy was used to avoid potential bias.<sup>11</sup> The authors wanted articles specifically pertaining to tongue strength and, hence, Boolean operators were not used on all databases as this would have created an overlap of articles.

The following search terms and search strings were used:

- “IOPI and glossectomy”
- “Iowa Oral Performance Instrument and glossectomy”
- “Tongue strength after glossectomy”
- “Tongue strength measurement”
- “Tongue strength instrument”
- “SwallowSTRONG”
- “JMS”
- “Oropress”
- “Tongue-o-meter”

A total of 1,863 records were identified and after the screening process 74 were assessed for eligibility and, finally, 20 articles met the study inclusion criteria. The exclusion criteria were articles that were not in English.

### Pilot

Piloting was done during the screening phase as noted above and consisted of two distinct stages: (1) the pre-inclusion stage and (2) a post-inclusion stage. The pre-inclusion stage involved (i) piloting the search terms within databases and (ii) piloting of the abstract and full-text screening tools. The post-inclusion stage involved (i) obtaining a purposive sample from the total number of included studies to pilot up to the synthesis stage and (ii) extracting data from the sample using the data extraction tool. After the pilot was completed, the decision was made to include subjective measures and quality-of-life measures. This led to an adjustment of the search terms to include these variables, and the data extraction sheet was amended to include the additional objectives. The search strategy used was a scoping review.

Study selection within the review process comprised two stages of screening: (i) review of the title and abstract and (ii) full-text review.<sup>12</sup> During the first stage of screening, the title and abstracts of all retrieved references were reviewed against the pre-determined inclusion criteria.<sup>12</sup> To streamline the first stage of study selection, a simple tool was developed to assist screening of study titles and abstracts. This made it possible to determine the eligibility for inclusion. The title and abstract review were conducted using Microsoft Excel. Each reviewer was required to indicate “YES”, “NO” or

“CAN’T TELL” related to the inclusion and exclusion criteria. The following questions based on the inclusion criteria for the review were included:

- Does the abstract report on tongue strength and partial glossectomy?
- Does the abstract report on adults?
- Does the abstract report that qualitative, quantitative or mixed research design was employed?
- Is the abstract published in English?

If there was a “NO” to any of the questions, the study was not included. The article was included for full-text screening if the reviewers indicated a “YES”. For the “CAN’T TELL” option the articles were then included for further full-text screening. Disagreements between the seven independent reviewers were then discussed during a meeting.

In the second stage of screening, all included studies were reviewed at full-text level, with each reviewer independently utilising the Full-Text Screening Relevance when answering the same set of questions, to determine the applicability of the contents of the full-text to the inclusion/exclusion criteria.<sup>13</sup>

### Compliance with ethical standards

The study did not involve human participants as it was a review of the literature available. There was no conflict of interest. Permission to conduct the research was obtained from the Wits University Human Research Ethics Committee (Wits HREC) prior to commencing with the study.

## RESULTS

### Demographic information

Fifty percent (n=10; N=20) of the studies reviewed were conducted during the period from 2016 to 2021. Thirty-five percent were conducted in Europe (n=7; N=20) and 65% (n=13; N=20) were in Asia and North America. No studies were conducted on the African continent. Twenty-five percent (n=5; N=20) of reviewed studies were conducted retrospectively through record reviews while 20% (n=4; N=20) used a cross-sectional research method. A clinical trial was conducted in only one of the studies and this involved a single case experimental design.

### Data analysis

Descriptive statistics was used for subsequent analysis, as recommended by Peters and Colleagues.<sup>13,15</sup> The data was represented using frequency counts and percentages, as well as summarising the data in tables and figures for analysis purposes. Content analysis was conducted to identify themes or concepts that emerged from the studies that were reviewed. Once the conceptual analysis was done, the data was coded into the following categories: “objective measures”, “subjective measures”, “quality-of-life measures” and “effects of partial glossectomy on tongue function”. According to Bengtsson<sup>16</sup>, while content analysis is used mainly in qualitative design studies, it can also be used to analyse quantitative data. Since all included studies used quantitative methods, content analysis was included as statistical pooling was not possible due to the variability of the data found.

Merely 20% (n=4) of the studies used objective measures to assess tongue strength. These included the Iowa Oral Performance Instrument (IOPA) (n=2) and the JMS/

handy probe (Japan) (n=2).<sup>17,18,19</sup> The other 80% (n=16) of studies reported on subjective measures and other forms of establishing tongue strength. Studies did not include measurements of tongue strength pre- and post-surgery or therapy, rendering it difficult to draw conclusions regarding the changes in tongue strength over time. Various measures were used to assess speech articulation and swallow function and, subjectively, tongue strength. This included (but was not limited to) the Assessment of Intelligibility of Dysarthric Speech (AsIDS), the Frenchay Assessment of Dysarthria, Speech intelligibility assessment, the MD Andersen Dysphagia Inventory (MDADI) questionnaire and the Percentage Consonant Correct (PCC).<sup>14,20,21</sup> Swallowing was studied objectively using Fiberoptic Evaluation of Swallowing (FEES) and videofluoroscopy (VFS).<sup>5</sup>

The most common quality-of-life questionnaire mentioned was the European Organization for Research and Treatment of Cancer (EORTC) Questionnaire.<sup>22</sup> A Japanese version of the EORTC, the QLQ-C30 version 3.0 and QLQ-H&N35, were also mentioned. Another common scale was the University of Washington Quality of Life Questionnaire (UWQoL). A Finnish translation of the original version of the University Of Washington Quality Of Life Questionnaire (UWQOL) was also noted. Other scales included the Functional Assessment of Cancer Therapy-Head and Neck (FACT-H&N) and the Functional Oral Intake Scale. These scales all addressed the effects of tongue strength difficulties by exploring common themes in different ways. However, none of these was objective and relied primarily on patients' perceptions of their own limitations.

## DISCUSSION

The reduction in tongue strength following partial glossectomy can lead to an increase in vulnerability to dysphagia, which in turn has been associated with further medical complications such as dehydration, malnutrition, aspiration pneumonia and, in severe cases, death.<sup>23</sup> The speech therapist plays a vital role in assessing for the safety of oral intake in order to prevent aspiration. During the assessment it is necessary to take into account the functionality of the tongue in terms of strength and range of movement, and how this may contribute to an oral phase of dysphagia. Together with the anatomical changes, the overall change in QoL must be considered, especially in patients who have undergone a glossectomy.<sup>24,25</sup>

Tongue pressure, precise articulation, speech intelligibility and level of food tolerated has been shown to decrease with the type of glossectomy.<sup>26,27,28</sup> Glossectomy has been linked to changes in the oral phase of swallowing and the consistency of food that can be tolerated. Nutritional monitoring was necessary in most patients in the studies reviewed and malnutrition was evident in about a quarter of patients, chiefly marasmus.<sup>29</sup> A positive correlation between swallowing and oral intake was found in relation to speech changes, demonstrating that the greater the change in food intake, the greater the speech changes. The most common speech disorders were distortion and misarticulations.<sup>30</sup> Intelligibility was not found to be a sensitive measure of speech change, but a study by Blyth and Colleagues<sup>31</sup> demonstrated considerable change in percentage of consonants correct for treated phonemes. Participants, however, demonstrated a reduced tongue range of movement using the Frenchay tool. These

showed no improvement following the articulation therapy protocol.<sup>32</sup> The site at which the cancer was present and the patients' gender had no significant effect on the outcomes of therapy.<sup>31</sup>

The reviewed studies revealed the negative impact that reduced tongue strength had on both the swallowing and QoL of patients. A study by Halczy-Kowalik and Colleagues<sup>33</sup> revealed decreased tongue mass, restricted movement of the tongue and epiglottis, and lax oral fissure during VFS evaluations for swallowing. Another study indicated impairment of the swallowing sequence both for the oral and pharyngeal phases following partial glossectomy.<sup>34</sup> In most studies, swallowing symptoms were worse in the first month after surgery with significant improvement by the third month after surgery.<sup>35</sup> Fifty-one percent of patients in a study by García-Peris and Colleagues<sup>26</sup> stated that their QoL suffered greatly due to dysphagia, thus illustrating that the impairments in swallowing negatively impacted on QoL. Patients had a median follow-up of nearly three years post glossectomy. In the study by Kazi and Colleagues<sup>5</sup>, there was no significant influence of "time since treatment" on swallowing function. Among patients who had long-term follow-ups, their subjective analysis of swallowing and articulation function revealed that they viewed their tongue function as acceptable after partial glossectomy. This illustrates that in formalised studies, no specific objective measurements were used to evaluate the tongue strength over time, and instead subjective reports and the correlation between tongue strength and dysphagia were used as indicators.

The Iowa Oral Performance Instrument (IOPI), a validated measurement device, is the most widely used tool for measuring tongue strength objectively. However, it is not affordable to all patients and practitioners due to budgetary and economical restraints.<sup>33</sup> In South Africa, the IOPI device cannot be easily imported into the country and patients often have limitations in resources. As such, other subjective and QoL measures need to be used to aid in determining tongue strength. Studies have shown a proportional correlation between oral function performance and patient self-perceived QoL measures.<sup>26</sup> It is complex to assess QoL given the multitude of variables that can impact on patients' self-perception, and thus a combination of measures including standardised and objective measures is necessary.<sup>36</sup> Several QoL scales exist in the literature including (but not limited to) the Speech Handicap index, Sydney Swallow questionnaire<sup>3</sup>, University of Washington Quality of life questionnaire (UWQOL) and the EORTC.<sup>22</sup>

The EORTC questionnaire and the PSS (Performance Status Scale) are used as measures of QoL for cancer patients but are not specific to tongue strength post glossectomy.<sup>22</sup> The majority of studies used EORTC as a measure of QoL in cancer patients. However, better suited for patients post glossectomy is the MD Anderson Dysphagia Inventory (MDADI) as it assesses the QoL of patients with head and neck cancers.<sup>36</sup> The MDADI questionnaire assesses patients' views of their swallowing ability following treatment, and how the change in swallowing function affects QoL.<sup>36</sup> Swallowing function is not only a QoL measure, as in several studies it is used as a measure of tongue strength. In the study by Halczy-Kowalik and Colleagues<sup>33</sup> the primary measurement for tongue strength was swallowing efficacy

which was assessed using a 100-point scale during VFS analysis of swallowing. Grammatica and Colleagues<sup>37</sup> measured swallowing function using FEES and VFS, testing various food consistencies. Hence, swallowing function can be assessed endoscopically, radiologically and by questionnaire. Thus, in countries where tongue pressure measurement devices are unavailable, a good alternative is measuring swallow function especially since this complex act requires good tongue strength and range of motion.

The articles reviewed are varied in the parameters used to measure tongue strength such that a standard baseline of tongue strength post glossectomy cannot be made. However, the main parameters included tongue pressure and measurements of dysphagia, with a focus on swallowing function. A cost-effective measurement of dysphagia is the MDADI questionnaire. Other parameters of tongue strength include salivary flow assessment, tongue motility assessment, speech intelligibility and articulation. However, speech intelligibility can be open to variation and thus another cost-effective measure for evaluating tongue strength is speech articulation, by evaluating the production of specific sounds<sup>25</sup>. This study aimed to describe the available objective, subjective and quality-of-life measurements of tongue strength in adults after a partial glossectomy. The findings suggest that there are limited instances whereby objective measures are used to determine tongue strength in most contexts. Instead, clinicians have had to rely on subjective measures and other clinical factors such as the presence of dysphagia and the accuracy of speech production.

#### Limitations of the study

A frequently reported limitation of review studies is the inherent likelihood that a review may have missed some literature. This could be attributed to the database selection and the search period, as searching a greater number of databases over a longer search period may have resulted in more studies being identified. However, a saturation point must be established and, nonetheless, the possibility of missing studies due to the above-mentioned limitation cannot be ruled out. Scoping reviews are not exhaustive<sup>14</sup>, thus creating a challenge for researchers since relevant articles may not be included in the study, which will create a gap in the literature. The studies utilised for the review were in English only, and this could have introduced a language bias. Due to the disparity of the quantitative data in the included studies, statistical numerical analysis was not possible, and results were presented in a narrative form accompanied by graphical representation as recommended by JBI.

In terms of the studies themselves, a significant limitation was that most studies evaluated tongue strength subjectively via interviews or questionnaires, rather than relying on objective methods. This may have resulted in inaccuracies in the actual evaluation of the strength of the tongue, causing false conclusions to be drawn. Therefore, it is preferable to have at least one objective method utilised to confirm the findings of subjective measures and while this may not always be feasible, it has a significant impact on assessment and treatment procedures. Objective measures may include handheld instruments such as the IOPI and, if unavailable, then standardised measures to evaluate disorders related to reduced tongue strength should be used. These include FEES or VFS to objectively measure dysphagia or standardised articulation tests for speech production. Most studies had a sample size of less than 50 participants, thus reducing generalisability and increasing the margin of error. Future studies should then aim to have larger sample sizes to ensure that data is more representative of a wider

population.

There was occasionally a disparity in the ages of the healthy patients who were used as a control in the study and the patients who had undergone a glossectomy. As mentioned earlier in the review, a change in total swallowing function and tongue strength during swallowing becomes apparent as patients get older.<sup>26</sup> Thus, it is important to ensure that the age range of the control group matches that of the experimental group.

#### CONCLUSION

There was a significant relationship between improved QoL, reduced dysphagia severity and increase in Functional Oral Intake Scale scores.<sup>37</sup> As such, subjective and QoL measures may be useful in evaluating tongue strength within developing and under-resourced contexts. There is growing evidence that tongue strengthening exercises can improve tongue strength and swallowing function in both healthy and dysphagic patients<sup>38</sup>; however, additional insight is needed to develop effective and efficient tongue strengthening exercise procedures and protocols. This can only be done if there is a standardised and reliable method of assessing tongue strength that does not rely on expensive and hard to obtain objective measures, nor is reliant on subjective measures which are not always repeatable. Therapeutic intervention for those suffering from decreased tongue strength can only be successful if clinicians have access to a measurable value of tongue strength prior to treatment, during treatment and post treatment. This may help to further the field in developing therapeutic goals geared towards improving tongue strength in those post glossectomy.

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