The Effectiveness of the Buccal Myomucosal Flap on Speech and Surgical Outcomes in Cleft Palate: A Systematic Review

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Abstract: *Purpose*: A systematic review was conducted to assess speech and velopharyngeal competence outcomes following the buccal myomucosal flap surgical approach used for primary palatoplasty and secondary surgery for velopharyngeal insufficiency (VPI) in individuals with cleft palate.

Methods: A systematic review was guided by the PRISMA guidelines. Articles were included if the patients received the surgical technique for primary cleft palate repair or secondary surgery for VPI and if the study provided detailed methods on the perceptual speech assessment or visualization of postoperative velopharyngeal anatomy.

Results: A total of 1013 patients were included from 11 studies. Post-surgery, normal resonance was achieved in 77.4% of patients and no nasal air emission was reported in 54.7% of patients. An improvement in velopharyngeal closure was reported in 81.8% of patients. A variety of perceptual speech assessment scales and methods for assessing velopharyngeal competence were used in the studies.

Conclusions: The review suggests that the buccal myomucosal flap procedure results in improved velopharyngeal closure as evidenced by physiologic observation and reported perceptual changes in speech intelligibility, resonance balance, and reduced nasal air emission. The development of an international, standardized method for assessing and reporting speech outcomes and velopharyngeal competency is recommended to ensure accurate comparisons between surgical techniques.

Keywords: Buccal flap, systematic review, perceptual speech assessment, speech outcomes, surgical outcomes.

INTRODUCTION

Orofacial clefting is one of the most common birth defects. A cleft palate occurs when the roof of the mouth does not fuse together properly during fetal development. This results in an opening between the nasal and oral cavity which can affect feeding, speech, and resonance. Individuals born with cleft palate typically undergo a primary palatoplasty between 6-12 months of age to reconstruct the palate and establish a normal velopharyngeal (VP) mechanism. The importance of the primary palatoplasty is to ensure normal speech and resonance post-surgery. There are various surgical procedures designed to repair a cleft palate which report different speech and surgical outcomes. In cleft palate care, the speech-language pathologist (SLP) is involved in the evaluation of the patient along his/her lifespan, particularly when primary palatoplasty fails to result in normal VP function. Given speech is the primary outcome measure for success of primary palatoplasty, examining surgical techniques from this perspective is critically important.

The goal of primary palatoplasty is to reconstruct the palate and achieve normal speech and resonance while not inhibiting maxillofacial growth. Primary palatoplasties aim to create a separation between the oral and nasal cavity and create proper elevation and retraction of the velum necessary for adequate VP closure during speech and swallowing. The success of a repair is based on normal resonance, assessed when speech develops, and normal maxillofacial growth, assessed after maxillofacial growth is complete. Although multiple techniques exist, the most commonly used methods for primary palatoplasty include the Furlow double opposing Z-Plasty, straight-line intravelarveloplasty, or V-Y pushback [1]. The effectiveness of these traditional surgical techniques resulting in normalized speech are reported to range from 80% to 95% [2, 3]. Secondary surgeries for velopharyngeal insufficiency (VPI) are performed to correct postoperative VPI and aim to achieve adequate VP closure necessary for speech. The goal of secondary surgery for VPI is to create a seal between the oral and nasal cavity while avoiding airway obstruction. Common surgical techniques include a pharyngeal flap, sphincter pharyngoplasty, palatal lengthening procedure, palate re-repair, or posterior pharyngeal wall augmentation. The effectiveness of these surgical techniques results in 70.7% of patients

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achieving normal resonance and approximately 8.7% requiring further surgery for speech [4].

In recent years, favorable post-operative speech and maxillofacial growth results have been reported with the use of the buccal myomucosal flap for primary palatoplasty, secondary surgery for VPI, and fistula repairs [5, 6, 7, 8, 9]. The buccal myomucosal flap approach consists of dividing the hard and soft palate junction and creating a defect that will be reconstructed using the buccal myomucosal flaps, which are raised from the inner aspects of the cheek. In the use of a bilateral buccal flap, the first flap is interposed in the opening between the hard and soft palate and sutured in the nasal layer with the mucosal side facing the nasal lumen. The second flap is then sutured in the oral layer, with the mucosal side facing the oral lumen [1, 10, 11]. The reported benefits of the buccal myomucosal flap are to close the palate without tension, lengthen the palate, reconstruct the levator veli palatini sling, achieve normal maxillofacial growth, and achieve normal resonance [5, 6, 7, 8]. The buccal myomucosal flap approach is different from more traditional surgeries in that it adds muscle to the defect between the hard and soft palate in an effort to decrease tension and lengthen the palate, while other surgical approaches rely on the existing palatal tissue to close the cleft.

Given the emerging number of publications on improved outcomes following the buccal myomucosal flap approach, the authors performed a systematic review of the current literature on the impact of the buccal myomucosal flap approach. The purpose of the study was to assess the effectiveness of the buccal myomucosal flap approach using the primary outcome measure of speech and secondary outcome measure of surgical complications. Outcomes following the use of the buccal myomucosal flap approach used for primary palatoplasty and secondary surgery for VPI are considered separately.

METHOD

Literature Search

This systematic review followed the checklist and guidelines outlined by the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) [12]. Specifically, PRISMA uses an evidence-based method including completion of a 27-item checklist and following a four-phase flow diagram to ensure transparent and comprehensive reporting methods. A meta-analysis and assessment of risk bias was not performed due to the heterogeneity in assessment and outcome measures. Electronic searches of the following databases were used to identify studies: Excerpta Medica Database (EMBASE), Pubmed, Scopus, Cumulative Index to Nursing and Allied Health Literature (CINAHL) and Cochrane on June 21, 2019. The search strategy included synonyms for the surgical procedure ((buccal flap OR buccinator flap OR buccal myomucosal flap) AND (cleft palate OR submucous cleft palate)). No limits were placed in the search criteria. Reference lists of all relevant publications were searched for additional papers.

Inclusion/Exclusion Criteria

Studies were screened for inclusion using the following inclusion criteria: (1) human study of patients undergoing the surgical technique for primary cleft palate repair or secondary surgery for VPI. Studies were also included if they contained one of the following inclusion criteria: (1) postoperative perceptual speech assessment reported and/or (2) visualization of postoperative VP anatomy. Studies were screened for exclusion using the following exclusion criteria: articles not published in the English language, had an inadequate description of methods used to analyze speech and surgical outcomes, as well as letters, presentations, case reports, technical notes, and cadaver studies.

Study Selection

A 3-stage screening process was used. In the first stage of screening, article titles were reviewed and excluded based on their lack of relevance to the review. Articles that were remaining were then reviewed at the abstract level and removed if found to be irrelevant to the review. At the third stage, the full-text articles were reviewed. To avoid overlapping patient populations, authorship and date of recruitment were compared. Articles with patient populations that were found to overlap were compared, and the article with the most comprehensive data were included. The PRISMA flow diagram is presented in Figure **1**.

Data Extraction

The following data were extracted from each article: author(s), year of publication, procedure name, reason for procedure, number of patients, syndrome diagnosis, mean age at surgery, mean length of follow-up for speech assessment, methods of speech assessment,

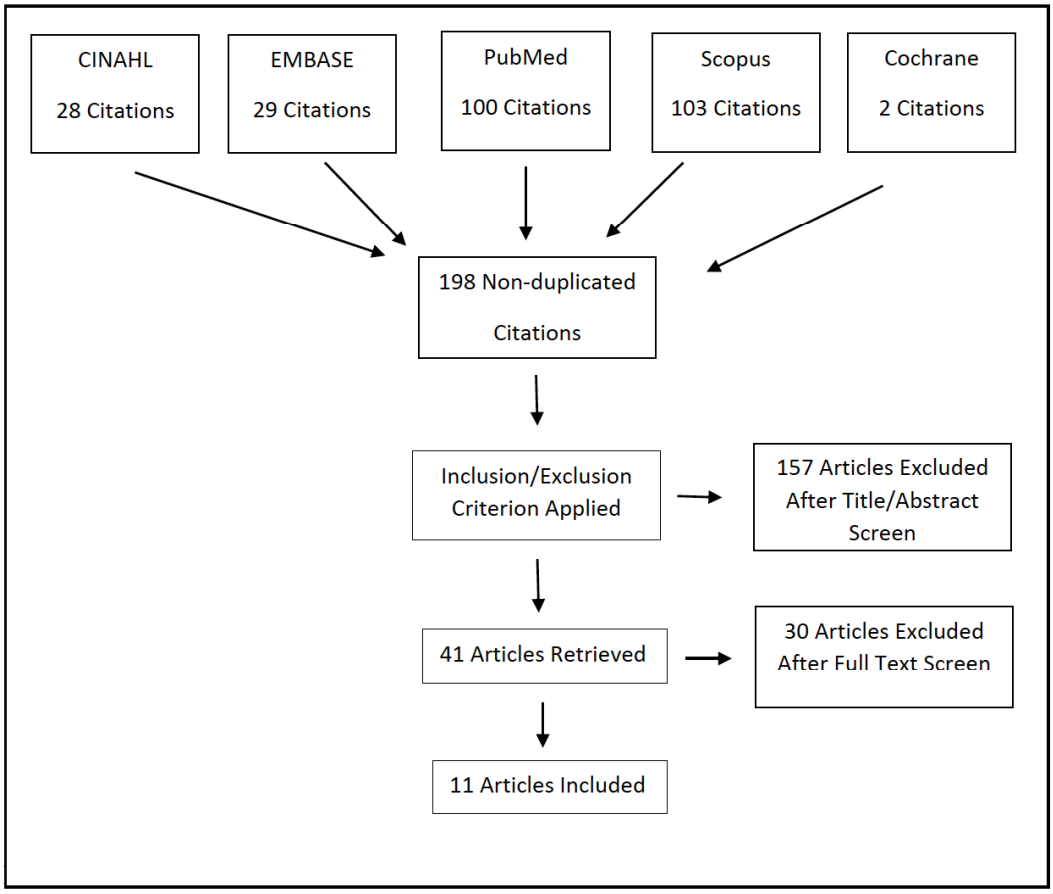

Figure 1: Study selection PRISMA flow diagram.

resonance pre- and postoperatively, nasal air emission pre- and postoperatively, methods for VP assessment, VP function pre- and postoperatively, postoperative complications, and need for further surgery. The data was further divided and reviewed based on the surgery type, i.e., primary palatoplasty or secondary surgery for VPI.

Outcomes of Interest

The primary outcome variable evaluated was speech. Speech outcomes were subdivided into nasal air emission, resonance, and intelligibility. The methodology used for assessing speech outcomes was extracted and included speech assessment carried out by a SLP, blinded speech assessment, speech assessment by more than one SLP, and use of a validated perceptual speech assessment. Outcomes of interest pertaining to the VP function include the methodology used for imaging, the assessment scale used to rate VP gap and competency and the post-operative VP gap size using the specified scale in the study. The secondary outcome measure was surgical complications.

Data Analysis

A formal meta-analysis of the study data was not possible due to the variability in methods of speech and VP assessment and reporting of results among the studies. Tables were constructed to summarize and explain the findings of the included studies. For each study, the number of patients reported in each outcome of interest was recorded. Individual percentages were calculated using the number of patients in each study as the denominator. Average percentages were calculated manually by adding the total patients reported in each outcome of interest and using the total number of patients from all of the studies as the denominator.

RESULTS

The literature search identified 262 potential articles (Figure **1**). After removing duplicated articles and the application of the inclusion and exclusion criteria to titles and abstracts, 41 articles progressed to the next level of screening. The remaining articles were reviewed in their entirety and a total of 11 studies met the inclusion criteria. The studies included were

Table 1: Study Characteristics and Speech Outcomes, Sorted Alphabetically by Procedure

Study	Procedure	N; Mean age at surgery (range)	syndrome (%)	Post-surgery follow-up (range)	Normal resonance	Normal nasal emission	Intelligibility/ normal speech improved	Postoperative complications	Need further surgery for VPD	VP Assessment & Criteria	VP Gap Pre-op	VP Gap Post-op
Primary Palatoplasty												
Chen (2003)	Bilateral musculomucosal buccal flap	26; 6.4 years (3-12)	0	2-8 years	-	-	-	-	-	Nasopharyngoscopy; Good VP closure: <5mm; Poor VP closure: <5 and <10mm	-	20/24 (83%) had good VP closure; 4/24 (17%) had poor VP closure
Mann (2017)	Double opposing Z-plasty ± buccal flap	505; -	69 (14.1%)	7.76 years	I	-	I	8.78%	7.1%	-	-	-
Jackson (2004)	Buccal myomucosal flap	156; 6.3 ± 2 months	0	36 months	91.10%	-	89% normal speech	3.60%	10 (6.4%)	Videofluoroscopy; Competent: no gap; Minimally competent: 0-5mm; Moderately competent: 6 to 10 mm; Grossly incompetent: >10mm	-	91.1% Competent; 6.2% Marginal; 2.7% Incompetent
Secondary Surgery for VPI												
Ahl (2016)	Buccinator mucomuscular flap	103; 5.5 years	19 (18.4%)	14 months (5-23)	I	I	I	10 (9.7%)	14 (13.6%)	-	-	-
Denadai (2017)	Bilateral buccinator myomucosal flaps	53; 19.3 years (5-50)	0	3,6,12,15 months	72%	83%	85% normal speech	11 (21%)	8 (15%)	Nasopharyngoscopy; Complete; Pinhole (bubbling); Small (<80, >100% closure); moderate (50-80% closure); large (<50% closure)	Moderate: 19/53 (36%); Large: 34/53 (64%)	Complete: 41/53 (77%); Pinhole: 7/53 (13%); Small: 5/53 (10%)
Dias (2016)	Buccinator myomucosal flap	34; -	0	6 months-1 year	24 (70.6%)	29(85%)	I	-	-	-	-	-
Hens (2013)	Bilateral buccinator myomucosal flaps	32; 8 years (3-28)	16 (50)	9.2 months (5.7-17.2)	21 (81%)	No notable difference	-	4 (12.5%)	6 (19%)	Lateral videofluroscopies; Presence or absence	27/30 patients with a gap	20/30 (66.7%) no gap; 7/30 (23.3%) patients with a gap
Hill (2004)	Bilateral buccinator musculomucosal flap	16; 8.5 years (4-19)	0	3, 6, 12 months	87%	I	93%	4 (25%)	Not noted	-	-	-
Logjes (2017)	Unilateral myomucosal buccinator flap	42; 4.9 years (2.6-17.6)	8 (19%)	1.2 years (.5-2.1 years)	I	-	32 (80%)	1 (.02%)	7 (16.7%)	Nasopharyngoscopy; Adequate VP closure; Subadequate VP closure; Inadequate VP closure	-	Improvement in 24/29 (83%)
Mann (2011)	Buccinator flaps	24; 10.3 years (3-16)	6 (25)	58 months	I	I	I	2 (7%)	1 (.04%)	-	-	-
Robertson (2008)	Unilateral buccal myomucosal flap	22; 8.5 years (1-23)	4 (18)	-	14 (47%)	13 (65%)	I	-	5 (23%)	Videofluoroscopy; Competent: no gap; Minimally competent: 0-5mm; Moderately competent: 6 to 10 mm; Grossly incompetent: >10mm	17/20 had VPI	16/20 no VPI

Abbreviations: I, improved; VP, velopharyngeal; VPI, velopharyngeal insufficiency

published between 2003 and 2018 and were all retrospective reviews published in the Cleft Palate-Craniofacial Journal (n=4), Plastic and Reconstructive Surgery (n=3), Journal of Cranio-Maxillo-Facial Surgery (n=1), the Journal of Plastic, Reconstructive and Aesthetic Surgery (n=1), Ceyon Medical Journal (n=1) and the Journal of Oral Maxilliofacial Surgery (n=1). Studies originated from the United States (n=4), Europe (n=4), Asia (n=2), and South America (n=1). Comparison of the study characteristics revealed differences in the study populations (including the inclusion or exclusion of patients with syndromes), pre- and post-operative assessments for speech and VP function, and recorded outcomes. Details for each study are presented in Table **1**.

Study Participants

Study size ranged from 16 to 505 participants across research studies, with a mean of 92 patients and median of 34. Not all patients were included in the speech analysis in three studies due to age of the patient or absence of pre-and post-operative speech samples. The included studies were separated into two groups based on if the patients received a primary palatoplasty or secondary surgery for VPI. Three studies dealt with patients undergoing primary palate repair and eight studies examined secondary surgical findings. A total of 687 patients underwent the buccal myomucosal flap for primary palatoplasty and 326 patients underwent secondary surgery for VPI.

In all studies, cleft types were presented either descriptively or using the Veau classification system [13]. Participants with syndromes were included in six studies, for a total of 122 participants [1, 7, 8, 11, 14, 15].

Speech Assessments and Outcomes

Primary Palatoplasty Speech Outcomes

Resonance and speech intelligibility improved in the two studies that reported the variables following primary palatoplasty. Jackson *et al*. [6] reported normal resonance was achieved in 91.1% of patients and reported 89% of patients achieved normal speech with the use of the buccal myomucosal flap technique. Data related to normal nasal emission was not reported in either of the two studies.

Secondary Surgery for VPI Speech Outcomes

Following secondary surgery for VPI, 74% of patients achieved normal resonance with the use of the buccal myomucosal flap technique. Nasal emission data were collected in seven of 11 studies. The studies reported an improvement in nasal air emission, with 79% of patients presenting with no nasal air emission post-surgery. Normal speech was reported in 85% of patients and 80% of patient's achieved normal intelligibility.

Speech Assessments

Perceptual speech assessment scales varied widely between studies and are detailed in Table **2**. Five studies reported the perceptual speech assessment using an in-house scale. The other five studies, used previously published perceptual speech assessment scales, consisting of the Bzoch [16], the GOS.SP.ASS.'98 [17], and the Cleft Audit Protocol for Speech-Augmented (CAPS-A), which was derived from the GOS.SP.ASS.'98 [17]. Nasal air emission was rated using scales ranging from 3-point to 5-point scales. Resonance was rated using scales ranging for 3-point to 6-point scales. The speech assessments were carried out by SLPs in all the studies, however, not all studies included ratings by multiple SLPs to ensure reliability. The SLP was blinded to the study in six of the eight studies. Information about the experience level or training of the SLP for cleft palate speech errors was provided in six out of 11 studies.

Velopharyngeal Function Assessment and Outcomes

Overall, patients receiving the buccal flap approach for both primary palatoplasty and secondary surgery for VPI demonstrated an improvement in VP closure. "Good" VP closure was achieved in 87% of patients following primary palatoplasty, and 73% of patients following secondary surgery for VPI, across 2 studies. Post-operative imaging was included in six out of the 11 studies and is detailed in Table **1**. Imaging included nasopharyngoscopy in three out of the six studies [5, 15,18] and videofluorscopy in three out of the six studies [6, 7, 11]. Assessment of visual VP function scoring varied between studies with some using a 2-point scale to define the function of the VP mechanism, while other studies used a 4-point scale.

Surgical Outcomes

In terms of negative surgical outcomes, 7.5% of patients were reported to have complications and 7.7% required further surgery following primary palate repair. The only surgical complications reported following primary palatoplasty were fistulas. Following secondary

Table 2: Perceptual Speech Assessment Details

Study	Perceptual assessment tool	Assessment by SLP	Assessment by more than one SLP	Blinded speech assessment
Jackson (2004)	Bzoch, 1977	Yes	No	No
Mann (2017)	In-house scale	Yes	No	No
Ahl (2016)	Cleft Audit Protocol for Speech-Augmented (CAPS-A)	Yes	Yes	Yes
Denadai (2017)	In house-scale	Yes	Yes	Yes
Dias (2016)	GOS.SP.ASS.'98	Yes	No	Yes
Hens (2013)	Cleft Audit Protocol for Speech-Augmented (CAPS-A)	Yes	No	Yes
Hill (2004)	In house-scale	Yes	Yes	Yes
Logjes (2017)	In-house scale, Nasometry	Yes	Yes	No
Mann (2011)	In house-scale	Yes	No	No
Robertson (2008)	Bzoch, 1977	Yes	No	Yes

surgery for VPI, 12.6% of patients were reported to have complications and 14.5% required further surgery. The most common surgical complications reported following secondary surgery for VPI were fistulas, dehiscence, and partial flap necrosis.

DISCUSSION

The purpose of this systematic review was to determine the effectiveness of the buccal myomucosal flap in primary and secondary cleft palate repairs, as measured by speech outcomes (primary outcome) and rate of surgical complication (secondary outcome). The buccal myomucosal flap approach aims to close the palate without tension, lengthen the palate, reconstruct the levator muscular sling, not inhibit craniofacial growth and achieve proper oral-nasal resonance for speech [5, 6, 7, 8]. However, these claims have not been rigorously investigated, as more traditional primary and secondary techniques have previously been. The success of primary palate repairs and secondary surgery for VPI is measured by speech, the development of fistulas, the need for additional surgery, and proper craniofacial growth and development [19]. This review has noted wide heterogeneity across studies in the reported sample sizes, patient criteria, and methodologies used for measuring outcomes for both speech and VP competence.

Systematic reviews have previously been conducted on surgical interventions for primary palatoplasties, specifically on the Furlow double-opposing Z-plasty and straight line intravelarveloplasty [20]. Timbang *et al*. [20] reported hypernasality for 11.1-20% of individuals with an isolated cleft palate and 29.1-33.3% of individuals with a unilateral cleft lip-cleft palate following the straight line intravelarveloplasty. For individuals treated with the Furlow double opposing Z-plasty, 13-14.3% of individuals with an isolated cleft palate and 8.9-18.5% of individuals with a unilateral cleft lip-cleft palate presented with hypernasality post-surgery [20]. The percentage of individuals with hypernasality following the buccal myomucosal flap (8.9%) is lower than the percentage of individuals with hypernasality from the Timbang *et al*. [20] review.

Surgical success is typically measured by the patient's speech and resonance. In the current review, improvements in resonance, nasal emission, and intelligibility were reported in all studies with the use of buccal myomucosal flap approach when used as a secondary speech surgery to treat VPI. A systematic review by de Blacam *et al*. [4] reported normal resonance in 70.7% of individuals who received a posterior pharyngeal wall augmentation, palatoplasty, a pharyngeal flap, or a sphincter pharyngoplasty, while the current review reported 74% of patients achieved normal resonance following the buccal myomucosal flap approach. Normal nasal emission was reported in 65.3% of individuals and improved intelligibility was reported in 86.5% of individuals following traditional surgical techniques for VPI [4]. The current review reported 79% of patients presented with no nasal air emission, 85% with normal speech and 80% achieved normal intelligibility post-surgery following the buccal myomucosal flap repair. Based on these comparison literature reviews, the buccal myomucosal approach reported more successful speech outcomes for

resonance and nasal emission than the traditional surgical techniques for VPI. de Blacam *et al*. [4] reported an improvement in intelligibility while the current review reported normal speech and intelligibility. The results between the two reviews cannot be compared accurately due to the variability in the definition used for assessing overall intelligibility and normal speech.

It was observed that there is substantial variation in the reporting of speech outcomes across the study reported as part of this systematic review, and therefore results should be interpreted with caution. Half of the articles included in the review used non-standardized in-house scales. The remaining five articles included published scales but varied in the scale used for the assessment. It is important for future studies to incorporate evidence-based metrices to assess speech outcomes. Evidence based-metrices are used to establish evidence-based practices which can be incorporated into clinical practice [21]. Not only does this allow for clinicians to properly assess speech and resonance for individuals with cleft palate, but also allows an accurate comparison of surgical outcomes across studies. Henningsson *et al*. [22] reported the need of consistent speech parameters and speech-sampling procedures across centers in order to accurately compare results across patient groups and languages. Henningsson and colleagues [22] provided a framework within which speech results can be reported in a consistent manner. To report speech outcomes, a set of five universal speech parameters are recommended including: hypernasality, hyponasality, audible nasal air emission and/or nasal turbulence, consonant production errors, and voice disorder. Two global parameters, speech understandability and speech acceptability, are also recommended. Allori *et al*. [23] also reported a standard set of outcome measures for comprehensive cleft care. Speech and communication were included as an outcome domain and included intelligibility, articulation, and VP competence as specific aspects for consideration. Validated instruments including the Intelligibility-in-Context scale, Percent Consonants Correct Scale, and VPC graded rating scale, are recommended to assess the speech and communication outcomes. It is important to note that seven articles were excluded during the search criteria because they reported an “improvement in speech” but included an inadequate description of the speech assessment used to reach that conclusion. In many cases, these appeared to be anecdotal statements that were not based on a formal method of review. The inadequate description of the speech assessment does not allow for an accurate comparison of the results to other studies. Data reporting methods varied across studies, with some only listing an improvement in speech, others reported the percentage of patients with an improvement following a statistical comparison between pre-and post-operative speech samples. In future studies, there is a need for additional statistical analysis of the results, including statistics between cleft groups and syndromes, to accurately compare results between institutions. Power analysis should also be included to ensure sample sizes contain enough power to detect differences among groups.

Four studies performed inter- or intra-reliability on the speech assessments and only six studies used speech language pathologists who were blinded to the study. The inconsistency in speech assessment methods make it difficult to draw meaningful comparisons between studies. Intra- and inter-rater reliability should be used with a standard protocol to ensure proper speech ratings. The studies originated in multiple countries which further limits comparisons as sounds vary between languages as well as the assessments typical used in each country.

Six studies assessed VP closure using videofluroscopies or nasopharyngoscopy. This assessment was used to determine if the surgery resulted in a competent VP mechanism. The scales used to assess the VP gap varied from a 2-point scale to a 4-point scale, therefore, making it difficult to make meaningful comparisons between studies. Although the patients were all assessed using a point scale, there was variability in the way the studies reported the outcomes. Some studies presented the data as an improvement in VP closure while others reported descriptive statistics for the closure for each point on the scale. All studies reported an increase in VP closure post-surgery, suggesting that the surgery is successful in altering the musculature necessary for the VP sphincter to function appropriately. However, the levator veli palatini muscle, the muscle that is altered in this surgical technique and is the primary muscle for velar elevation has not been assessed directly through use of imaging.

Surgical complications were reported in eight out of 11 studies, while the need for additional speech surgery was reported in nine out of 11 studies. Systematic reviews have previously been conducted on surgical interventions for primary palatoplasties,

specifically on the Furlow double-opposing Z-plasty and straight line intravelarveloplasty [20] and VPD [4]. Timbang *et al*. [20] reported mean failure rates for individuals with an isolated cleft palate were 9.7% for the Furlow double opposing Z-plasty and 16.5% for the straight line intravelarveloplasty. In the unilateral cleft palate group, the authors reported mean failure rates of 11.1% for the Furlow double opposing Z-plasty and 17.1% for straight line intravelarveloplasty. The oronasal fistula rate was 7.87% in the Furlow repair group and 9.81% in the straight line intravelarveloplasty group in the Timbang *et al*. [20] review. Negative surgical outcomes for the buccal myomucosal flap for primary palate repair was 4.86% in the current review, suggesting the surgical technique may be more successful for primary palatoplasties. The most common surgical complications reported were fistulas, dehiscence and partial flap necrosis following the buccal myomucosal flap repair. Postoperative complications were noted in 3% of all patients undergoing a posterior pharyngeal wall augmentation, palatoplasty, pharyngeal flap or sphincter pharyngoplasty for secondary surgery for VPD [4]. However, the percentage of postoperative complications ranged from 0-6.4% between studies. The average percentage of surgical complications for the buccal myomucosal flap (12.75%) is higher than the mean (3%) for traditional secondary surgical methods for VPD from the de Blacam *et al*. [4] review. The interpretation of the surgical comparisons should be interpreted with caution. The systematic review by de Blacam *et al*. [4] included four categories of surgery for VPD including the pharyngeal flap, sphincter pharyngoplasty, palatoplasty and posterior pharyngeal wall augmentation. The systematic review consisted of 83 studies that reported perceptual speech assessment or obstructive sleep apnea while the current systematic review included only 11 studies. Both the buccal myomucosal flap studies and the studies included in the de Blacam *et al*. [4] review did not all include postoperative complications and also varied in the inclusion of syndromes, which would alter the overall percentage of surgical success in both reviews. de Blacam *et al*. [4] also reported that some studies included patients that had previously undergone surgery for speech. The differences between studies makes it difficult to draw comparisons between the surgical techniques.

Timbang *et al*. [20] reported the need for secondary surgery in the straight line intravelarveloplasty group to be 9.1-29.2% for the isolated cleft palate group and 6.7-19.4% for the unilateral cleft-lip-cleft palate group. The need for secondary surgery in the Furlow double opposing Z-plasty was reported to be 0-11.4% in the isolated cleft palate group and 0-6.7% in the unilateral cleft-lip-cleft palate group. In the current review, 6.5% of patients required secondary surgery following the buccal myomucosal flap for primary palate repair. This is similar to the percentage of patient's requiring surgery following the Furlow double opposing Z-plasty repair. In the systematic review of four categories for surgery for VPD (pharyngeal flap, sphincter pharyngoplasty, palatoplasty, and posterior pharyngeal wall augmentation), de Blacam *et al*. [4] reported 8.7% of patients required further surgery for speech. This is below the percentage of patients that needed further surgery following the buccal myomucosal flap for secondary surgery for VPD (14.5%). Results for the surgical comparisons should be interpreted with caution, as speech assessments varied greatly between studies in the systematic reviews, which alters the decision for secondary speech surgery.

There are limitations to the prior conclusions. There is a wide variability between the studies in the sample size, patient population, and assessment methodologies for speech and VP competence. The inconsistent use of published speech scales and VP closure ratings, as well as how data were reported may have impacted the outcome of the review. The exclusion criteria were used to control for variability between studies but all variability cannot be eliminated. The surgeon's experience and slight differences in the buccal flap surgical technique are factors that could not be eliminated in this systematic review. The studies included in the review contained cohorts including individuals with syndromes and individuals who were nonsyndromic, as well as individuals with different cleft types. With a wide range of features in the patient population, it was not possible to extract data separately.

CONCLUSION

This systematic review suggests that the buccal flap surgical approach for both primary palate repair and secondary repair for VPI may improve patients' resonance and nasal air emission as well as improve VP closure. The buccal flap surgery used to correct VPI has previously been reported to effectively improve or correct hypernasal speech and minimize the risk of obstructive sleep apnea and hyponasality [24]. The current systematic review and a systematic review for secondary surgery to correct VPI [24] both report

improvements in speech outcomes and VP function, suggesting the buccal flap can be beneficial for both primary palatoplasty and secondary surgery for VPI. Future studies should consist of randomized clinical trials to determine the efficacy of the buccal flap surgical approach for primary palatoplasty. There is a need for standardized methods to assess speech and VP competence to allow for precise comparisons between results at different institutions.

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