**Effects of suspension pharyngeal flap on speech in Filipino individuals with velopharyngeal insufficiency**

**Running title: suspension pharyngeal flaps in patients with cleft palate**

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**Abstract**

**Introduction.** This study investigated the effects of suspension pharyngeal flap surgery for velopharyngeal insufficiency (VPI) due to cleft palate.

**Methods.** Ten Filipino individuals (mean age = 20.63 years, range = 8.4 to 34.9 years) with a cleft palate who underwent suspension pharyngeal flap surgery for VPI were included in this study. Perceptual and instrumental speech assessments were conducted at two different time points: before surgery (data point 1) and after surgery (data point 2, range = 4 to 26 weeks post-operatively). Speech intelligibility in different contexts and satisfaction with speech were assessed by the participants themselves using a self-report questionnaire. Additionally, the risk for obstructive sleep apnea was assessed using the The Berlin Questionnaire.

**Results.** Velopharyngeal gap size significantly decreased after the surgery. Additionally, significant improvements in speech understandability and acceptability were observed following the suspension pharyngeal flap procedure. Besides, a significant reduction in hypernasality, nasal emission, and the occurrence of passive articulation errors was seen. No difference in the occurrence of active articulation errors was observed when comparing data pre- and post-surgery. The ten individuals reported to be significantly more intelligible in different contexts after surgery.

**Conclusion.** Improved speech was observed in individuals who received the suspension pharyngeal flap procedure. This procedure also positively influences an individual’s intelligibility in different contexts in daily life. In individuals with persisting active articulation errors, post-surgery speech therapy will still be necessary.

**Keywords.**

Cleft palate, velopharyngeal insufficiency, speech outcomes, pharyngeal flap

**Introduction**

Orofacial clefts are the most common congenital anomalies with high prevalence rates (1). The reported prevalences vary between 1.5 per 1000 births in high-income countries and 1 per 730 births in low- and middle-income countries (1). In South-East Asia, prevalence rates are reported up to 1 per 574 births (2). The goal of primary surgical repair of the palatal cleft is to restore functional anatomy by closing the defect (3). Consequently, successful primary palatal closure aims to positively impact speech development and Eustachian tube functioning (4). However, primary palatal repair is often not successful with the occurrence of post-operative oronasal fistula, poor speech outcomes, or velopharyngeal insufficiency (VPI) (5, 6). Velopharyngeal insufficiency (VPI), which can be described as the inability to achieve adequate velopharyngeal closure which results in an inadequate coupling between the oral and nasal cavities, is reported in 20-30% of the individuals with a cleft palate following primary palatal repair (3, 5, 7, 8). Typical hallmarks of VPI are hypernasality, nasal airflow errors, and passive articulation errors including nasalized productions of high-pressure consonants (4, 9). Children may also adopt active strategies to compensate for VPI by producing active articulation errors, for example, glottal productions of pressure consonants (9). A differential diagnosis between passive and active errors is important as they require a different treatment approach. Passive errors are directly caused by the structural deficit which means that surgery is usually to correct the VPI (9). In contrast, speech therapy is necessary to correct active compensatory-type strategies as these errors involve incorrect articulatory gestures (9).

As VPI negatively impacts an individual’s speech understandability (i.e., the degree to which the speaker’s message can be understood by the listener), speech acceptability (i.e., the degree to which speech calls attention to itself apart from the content of the spoken message) (10), and quality of life (11), there is often a need for secondary speech improving surgery. In the literature, different surgical techniques have been proposed for treatment of VPI, for example, posterior pharyngeal wall augmentation, pharyngeal flap, sphincter pharyngoplasty, and buccal myomucosal flaps (12-15). The decision to opt for one or another surgical procedure is multifactorial including the surgeon’s preference or experience (16) and velopharyngeal closing pattern or gap size (17).

In individuals who present a large velopharyngeal gap (but with lateral pharyngeal wall movement), a pharyngeal flap is often recommended (17). A common side-effect of pharyngeal flap surgery is hyponasality or obstructive sleep apnea especially when the airway is too small or even obstructed following the procedure (18). Failure of the pharyngeal flaps in restoring adequate velopharyngeal functioning is often caused by a low placement of the flaps or an incomplete motion of the lateral pharyngeal walls to close the velopharyngeal gap (4). To overcome this issue, some authors proposed a superior based pharyngeal flap (17, 19-21). Using such superior based flap, the pharyngeal flap base is positioned slightly above the level of the hard palate or where the palatopharyngeal muscle joins the lateral pharyngeal wall (21). This procedure allows for good lateral pharyngeal wall movement preventing airway complications (17). Two recent studies have evaluated speech outcomes following a superior based pharyngeal flap (Lee et al., 2020; Rabah et al., 2022). A retrospective study by Lee et al. (2020) investigated the effect of superior based pharyngeal flap surgery in 72 patients with VPI (age range at the time of pharyngeal flap surgery = 4 to 52 years) (22). Speech (hypernasality and the production of plosives, fricatives, laterals, and nasal consonants) was assessed using a Korean articulation test assessed by five doctors (specialization not mentioned) and five medical students. The results demonstrated statistically significant improvements in speech outcomes following the superior based pharyngeal flap surgery (22). More recently, Rabah, Alkahtani (23) determined speech outcomes of the superiorly based pharyngeal flap to treat VPI following cleft palate repair. The authors also used a retrospective cohort study including 35 patients with VPI (age range at the time of pharyngeal flap surgery = 5 to 56 years). Before the surgery, 25.7% of the patients had severe hypernasality, 68.6% had moderate hypernasality, and 5.7% had mild hypernasality. After the surgery, only 8.6% of the patients still had severe hypernasality, 22.9% had moderate hypernasality, 57.1% had mild hypernasality, and hypernasality became absent in 11.4%. Articulation errors were present in 91.4% of patients before surgery, and decreased to 71.4% postoperatively. The authors concluded that the superiorly based pharyngeal flap was successful in treating VPI following initial cleft palate repair. It must be noted that the two outlined studies used no standardized and validated protocol for speech assessment. It was unclear what speech sounds were targeted and which speech samples were assessed (e.g., spontaneous speech, sentence repetition, or word production). This is important as it is known that the phonetic content of speech materials needs to be controlled especially in terms of the occurrence of high-pressure consonants and high vowels, sounds that are vulnerable to cleft-related speech errors (24).

The superior based pharyngeal flap still relies on lateral pharyngeal wall movement. A more recent innovation in pharyngeal flap surgery is the suspension pharyngeal flap. Such a procedure has been reported by Mann (19) and Mukunda (20). This technique raises a narrow pharyngeal flap and insets the flap anteriorly to the levator muscles. The aim of the suspension pharyngeal flap is to increase the soft palate by drawing the soft palate to the pharynx at the point of normal velopharyngeal closure. In other words, this procedure does not rely on lateral wall movement but rather focuses on augmenting soft palate movement. Recently, Damalachervu, Yellinedi (25) described and evaluated the use of suspension palatoplasty (i.e., suspension flaps) in the context of primary palatal closure. Ninety-four patients were included in the study (age range = 6 to 45 years). Out of the 94 patients, 59 patients had normal speech (62.8%) and 12 patients (12.8%) had articulation errors but with no features suggestive of VPI following the procedure. Twenty-three patients (24.4%) still presented with hypernasality or nasal emission following the procedure, signs of possible persisting VPI post-surgery. Unfortunately, these results are difficult to interpret as no pre-operative speech assessments were performed. Additionally, even though 62.8% of the patients were reported to have normal speech, normal speech was not defined by the authors. The effects of the surgical technique are also questionable as 24.4% of the patients still presented with signs of VPI.

Even though some studies investigated the effect of suspension pharyngeal flap surgery in the context of primary palatal closure, the effect of this technique as a method for secondary speech improving surgery has not yet been studied. Therefore, the aim of this study was to investigate the effect of a suspension pharyngeal flap on speech outcomes in Filipino individuals who presented with VPI following primary palatal closure using a pre-post design. Speech outcomes were assessed in terms of speech understandability and acceptability, resonance, nasal airflow, velopharyngeal functioning, the occurrence of active and passive cleft speech characteristics (CSCs), and consonant proficiency. Besides, self-reported speech intelligibility in different contexts and satisfaction with speech were assessed.

**Methods**

This study was approved by the ethics committee of the CURE Network Institutional Board (CNR/006/23).

***Study setting***

This study was conducted in the Philippines, a middle-income country in Southeast Asia (26). This study was part of a larger collaboration between Ghent University and the CURE Hospital in the Philippines.

***Participants and recruitment***

Individuals who were born with a cleft palate with or without a cleft lip (CP±L) and were scheduled to undergo a suspension pharyngeal flap procedure in the CURE Hospital in Davao were invited to participate in this study. Potential participants to be included in this study were contacted by phone by the SLPs of the hospital. They provided the individuals with information on this study and invited them to participate voluntarily.

In terms of ethical considerations, we did not postulate any inclusion or exclusion criteria based on age. Individuals had to be proficient in English so that they could complete questionnaires and a speech assessment in English. To avoid heterogeneity in the study group, individuals with syndromic CP±L, cognitive and/or related learning disabilities, and/or hearing disabilities were excluded. The hearing status of the patients was assessed immediately before the suspension pharyngeal flap procedure based on pure-tone audiometry (air conduction) (< 25 dB HL) performed at all octave frequencies between 250 and 8000 Hz using the modified Hughson-Westlake method performed by an experienced audiologist (K.K.).

Based on the above-mentioned criteria, ten individuals (*n* = 4 men and *n* = 6 women) were included in this study (Table 1). Eight of them had a cleft palate, one individual had a cleft palate with a cleft lip right, and one individual had a bilateral cleft lip and palate. All ten patients had previously received delayed primary palatal closure (range = 4.00 years to 33.00 years) using the Sommerlad palatoplasty technique (7). Nine of the patients had also previously received bilateral buccinator myomucosal flaps, at least 10 months before the suspension pharyngeal flap procedure. The mean age of the individuals at the moment of the suspension pharyngeal flap procedure was 20.63 years (range = 8.40 years to 34.90 years). This procedure was performed by the same experienced plastic surgeon (A.H.). None of the ten individuals reported post-operative complications. Besides, the individuals did not yet receive any speech therapy between the suspension pharyngeal flap and the post-operative speech assessment.

[Please, insert table 1 here]

***Operative technique for secondary speech improving surgery***

A narrow pharyngeal flap was raised and inset anteriorly to the apposed levator muscles. The aim of the suspension pharyngeal flap was to augment the soft palate function by drawing the soft palate to the pharynx at the point of normal velopharyngeal closure. If bilateral buccinator flaps had already been performed previously in the participant, the soft palate posterior to the bilateral buccinator myomucosal flaps was further lengthened with a double opposing Z-plasty (27). The oral mucosa was raised off the levator muscle which was further dissected and retroposed. The opposing Z-plasty was placed in the nasal layer. The suspension pharyngeal flap was designed with the base of the flap at the anterior margin of the apposed levator muscles. It has a width of 8mm and a length of approximately 2cm, with the tip extending down into the pharynx in the midline. The myomucosal flap was raised with meticulous haemostasis and the defect closed. The anterior nasal Z-plasty flap was sutured in position and then the suspension pharyngeal flap was inset into the posterior edge of this flap. The posterior nasal Z-plasty flap was then sutured so that the suspension pharyngeal flap sits between the two nasal Z-plasty flaps. The levator muscles were sutured together and the protruding suspension pharyngeal flap was sutured to the levator muscle thus drawing the levator muscle posteriorly to the pharyngeal wall. Finally, the oral mucosa was resutured. Surgery was performed by the same experienced plastic surgeon (A.H.) in the CURE Hospital in the Philippines.

***Perceptual speech assessment***

Due to practical reasons, speech samples were collected by three different SLPs: one SLP from Ghent University (C.A.) and two Filipino SLPs from the CURE Hospital (R.A. and R.M.T.). Spontaneous speech (individuals tell about their free time, work, school, etc.), automatic rote speech (counting from 1 to 20, from 60 to 70, and reciting the days of the week), and sentence repetition using the sentences from the American-English version of the Cleft Audit Protocol for Speech- Augmented (CAPS-A-AM) (28). The speech samples were audio- and video-recorded at two different time points: immediately before the surgery (data point 1), and after the surgery (data point 2). The mean time between the suspension pharyngeal flap procedure and the post-surgery data collection was 11 weeks (range = 4 to 26 weeks). For the collection of audio and video materials, a Sony Handycam with a high-quality built-in microphone was used. In each audiovisual recording, the participant’s head and shoulders were framed.

Two experienced cleft SLPs (C.A. who had 5 years of experience in cleft palate speech and K.B. who had 10 years of experience in cleft palate speech) perceptually assessed the collected speech recordings. The samples were presented randomly and the raters were blinded for pre- or post-surgical treatment status. The definitions and ordinal rating scales of the CAPS-A-AM (28) were used. According to this protocol, different speech variables were rated: active articulation errors (anterior oral cleft speech characteristics (CSCs), posterior oral CSCs, non-oral CSCs) and passive articulation errors (score 0 – no consonants affected, score 1 – one or two consonants affected, score 2 – 3 or more consonants affected), hypernasality (score 0 – absent, score 4 – severe), hyponasality (score 0 – absent, score 2 – clearly present), audible nasal emission (score 0 – absent, score 1 – frequently present), nasal turbulence (score 0 – absent, score 1 – frequently present), voice (score 0 – normal voice quality, score 1 – disturbed voice quality), grimace (score 0 – absent, score 1 – present), and need for speech-language intervention for CSCs (score 0 – no, score 1 – yes). In addition, speech understandability and speech acceptability were evaluated using the definitions and ordinal rating scales described by Henningsson, Kuehn (10) (score 0 – within normal limits, 1 – mildly disturbed speech understandability/acceptability, 2 – moderately disturbed, 3 - severely disturbed). These parameters were chosen as Sell, John (29) cautioned against reporting speech intelligibility as this parameter is difficult to assess in a reliable way and given that Whitehill (30) recommended rating intelligibility and acceptability separately, both speech understandability and acceptability were rated. Speech understandability was assessed first based on the audio recordings of the spontaneous speech sample (31). Secondly, the raters listened to the audio recordings of the sentences to perform a first evaluation of the consonant productions in terms of CSCs and hypernasality. Thirdly, based on the video-recorded sentences, a revision of the visual aspects of the consonant productions was performed. Speech acceptability and the need for speech-language intervention for CSCs were assessed based on the raters’ overall judgment of all audio- and video-recorded speech samples (28, 31).

To assess consonant proficiency, the raters were asked to transcribe the sentences using the International Phonetic Alphabet (IPA) (32) and additional symbols to describe specific cleft-related articulation errors (33). Target consonants were based on thirteen high-pressure consonants that were present in English as well as in the local Bisaya language (also spoken by all the participants): /p/, /b/, /t/, /d/, /s/, /z/, /ʃ/, /ʒ/, /f/, /v/, /k/, /x/, /ɣ/). These high-pressure targets were supplemented by sentences with s-clusters (i.e., /sp-/, /st-/, /-ks/) (28). Based on the transcriptions, the Percentage Correct Consonants-Revised (PCC-R) (34), the Percentage Correct Places (PCP), and the Percentage Correct Manners (PCM) (35) were calculated. The PCC-R was calculated by dividing the number of target consonants elicited by the number of correctly produced target consonants, multiplied by 100 (34). Consonants produced with a correct place, manner, and voicing but with an (inter)dental quality, weak realization, or accompanying nasal airflow were considered to be correct (34, 36). The PCPs and PCMs were calculated similarly to the PCC-R following the guidelines described by Klintö, Salameh (35)*.*

The speech samples (*n* = 20) were randomized and pseudonymized. The first rater (C.A.) perceptually assessed 100% of the speech samples. She re-assessed 20% of the speech samples (*n* = 4) after one week to assess intra-rater reliability. The second rater (K.B.) assessed 25% of the speech samples (*n* = 5) to assess the inter-rater reliability with the first rater. The assessments of the first rater were used for further analyses.

***Instrumental speech assessment***

Nasalance values were measured using a Nasometer (model II 6450). Since a Nasometric assessment was not part of clinical routine care at the CURE Hospital, Nasometric data were only collected following the surgery (i.e., at the moment when the SLPs from the Ghent University Team visited the hospital). The mean time between the suspension pharyngeal flap procedure and this instrumental data collection was 11 weeks (range = 4 to 26 weeks).

Two types of speech samples were used: (1) the 4 sentence groups (sentences with bilabial sounds, velar sounds, sibilants, and nasals) from the MacKay-Kummer Simplified Nasometric Assessment Procedures (SNAP) test (37), and (2) the oral Zoo Passage (38) and the oronasal Rainbow Passage (39). The sentences of the SNAP test and the oronasal and nasal passages were elicited by sentence repetition. The nasalance values were compared descriptively with normative data for English speakers retrieved from Alfwaress, Kummer and Weinrich (40) as we could only obtain data following the surgery.

**Assessment of velopharyngeal functioning**

The CURE Hospital has a radiology department which made it possible to assess velopharyngeal functioning using a videofluoroscopic examination. Similar to the perceptual speech assessment, data were collected at two different time points: immediately before the surgery (data point 1), and after the surgery (data point 2). The mean time between the suspension pharyngeal flap procedure and the post-surgery data collection was 11 weeks (range = 4 to 26 weeks).

The videofluoroscopic data were assessed using the scale by Youssefa and Alkhajab (41) which is an adapted form of the scale proposed by Golding-Kushner, Argamaso (42). Four sentences of the CAPS-A-AM were used to evoke speech during the videofluoroscopic assessment (28). Target consonants of these four sentences were /p, t, s, ɡ/. Palate movement (0.0 - no movement, 1.0 – velar contact with the posterior pharyngeal wall), lateral wall movement (0.0 - no movement, 0.5 - movement to the midline), and posterior pharyngeal wall motion (0.0 - no movement, 1.0 – anterior movement to meet the velum) were assessed. Additionally, the presence or absence of aberrant pharyngeal wall pulsations, the Passavant ridge, and palatal notching were determined. Velopharyngeal gap size was also classified: large (closure less than 50% - score 3), moderate (closure between 50% and 80% - score 2), small (closure greater than 80% - score 1), or normal (complete velopharyngeal closure – score 0) (41, 42). The videofluoroscopic data were assessed by one SLP (C.A.) and the plastic surgeon (A.H.). The SLP assessed 100% of the samples (*n* = 20). The second rater (A.H.) assessed 25% of the samples (*n* = 5) to calculate inter-rater reliability. The values for the videofluoroscopic assessments of the first rater are presented in the results section.

***Self-reported satisfaction with speech and speech intelligibility in different contexts***

A questionnaire, which was developed for this study, was administered to the participants to assess their self-reported satisfaction with speech and speech intelligibility in different contexts before and after the surgery. However, both questionnaires were administered at the data collection point after the surgery implicating that the participants’ self-reported satisfaction and speech intelligibility before the surgery was assessed retrospectively. The questionnaire was administered in absence of the treating surgeon by an SLP who had no previous relationship with the participants (K.V.L.).

Each questionnaire consisted of 9 identical questions. These questions were scored on a visual analog scale (VAS) of 10 cm. The VAS assessed the following topics: (1) “How satisfied were you with your speech before surgery/after surgery?” (“1” – not at all satisfied, “10” – very satisfied), (2) “Was your speech intelligible for immediate members of your family before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), (3) “Was your speech intelligible for extended members of your family before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), (4) “Was your speech intelligible for your friends before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), (5) “Was your speech intelligible for acquaintances before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), (6) “Was your speech intelligible for your teacher/employer before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), (7) “Was your speech intelligible for your colleagues before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), (8) “Was your speech intelligible for strangers before surgery/after surgery?” (“1” – completely not intelligible, “10” – very intelligible”), and (9) “Did liquids or solid food came from your nose while drinking or eating before surgery/after surgery?) (options: yes liquids, yes solid foods, yes both, no, I don’t know).

***Assessment of risk for obstructive sleep apnea***

To assess the individual’s risk for obstructive sleep apnea, The Berlin Questionnaire was administered after the surgery by the two SLPs from the CURE Hospital (R.A. and R.M.T.) (43). This questionnaire is developed to identify individuals who are likely to have obstructive sleep apnea. It consists of three different categories assessing different symptoms related to obstructive sleep apnea: category 1 assesses snoring, category 2 assesses fatigue, and category 3 assesses self-reported presence/absence of high blood pressure and Body Mass Index (>30 or <30). Individuals can be classified into ‘high risk’ or ‘low risk’ based on their responses to the individual items and their overall scores in the symptom categories. When the score is positive on 2 or more categories, individuals have a ‘high risk’ for obstructive sleep apnea. Individuals have a low risk for obstructive sleep apnea when the score is positive on only 1 or no categories (43).

***Statistical analyses***

IBM SPSS Statistics software version 29.0 (IBM Corp., Armonk, NY) was used for the statistical analysis of the data. To assess intra- and inter-rater reliability, two-way random intraclass correlation coefficients (ICCs with absolute agreement) were calculated and interpreted following the classification of Altman (44) (ICC < .20: poor, .21–.40: fair, .41–.60: moderate, .61–.80: good, .81–1.00: very good). A two-way random effects model was chosen as this model is appropriate for evaluating rater-based clinical assessment methods designed for routine clinical use by clinicians with specific characteristics (e.g., years of experience) (45).

Descriptive statistics for the speech variables were calculated for data point 1 (before surgery) and data point 2 (after surgery). In addition, Wilcoxon paired-signed rank tests were used to compare the data between these two data points. This test was chosen because of the small sample size and the paired character of the data. Significance levels were set at α = 0.05.

***Results***

***Inter- and intra-rater reliability***

Results for the inter- and intra-rater reliability of the perceptual speech assessments are presented in Table 2. For the variables speech understandability, posterior oral CSCs, hypernasality, PCP, and PCM inter-rater reliability was good. For all other speech variables, very good inter-rater reliability was observed. Intra-rater reliability was good for poster oral CSCs, non-oral CSCs, PCP, and PCM. Very good intra-rater reliability was observed for all other speech variables.

***Perceptual speech outcomes***

Descriptive statistics for the different speech variables are displayed in Table 3. The Wilcoxon paired-signed rank test demonstrated a statistically significant difference when comparing values before and after the suspension pharyngeal flap procedure for different speech variables: speech understandability (*p* = .004), speech acceptability (*p* = .025), passive CSCs (*p* = .023), hypernasality (*p* = .010), and nasal emission (*p* = .023). With regard to consonant proficiency (Table 4), the Wilcoxon paired-signed rank test demonstrated no statistically significant differences when comparing values before and after the surgery (p > .05).

***Instrumental speech outcomes***

Post-operative nasalance values (Table 5) for the bilabial, apico-alveolar, velar, and sibilant sentences and oral passage were observed to be considerably higher compared to the normative data (40, 46).

***Assessment of velopharyngeal functioning***

Table 6 presents the data from the videofluoroscopic assessments. Statistically significant differences in lateral pharyngeal wall movement (*p* = .007), palatal movement (*p* = .006), and posterior pharyngeal wall movement (*p* = .007) were observed when comparing data before and after the suspension pharyngeal flap procedure based on the Wilcoxon paired-signed rank test.

***Self-reported satisfaction with speech and speech intelligibility in different contexts***

The results of the self-report questionnaires on satisfaction with speech and speech intelligibility in different contexts are displayed in Table 7. The Wilcoxon paired-signed rank test demonstrated statistically significant differences in the VAS-scores for the items “satisfaction with speech” (*p* = .018) and speech intelligibility for immediate members of the family (*p* = .027), extended members of the family (*p* = .018), friends (*p* = .017), acquaintances (*p* = .017), teacher/employer (*p* =.017), and strangers (*p* = .018) when comparing the values before and after the surgery.

Before the suspension pharyngeal flap procedure, 5 participants reported nasal regurgitation on fluids. None of them reported any symptoms of nasal regurgitation after the surgery. Three participants reported nasal regurgitation on both fluids and solid foods before the surgery. Two of them reported no nasal regurgitation after the surgery, whereas one participant still reported occasional regurgitation on fluids. Two participants had no symptoms of nasal regurgitation neither before nor after the surgery.

***Assessment of obstructive sleep apnea risk***

Six of the ten included individuals completed The Berlin Questionnaire after the surgery. For five of these individuals, the tool revealed that they had a ‘low risk’ for obstructive sleep apnea. These individuals did not report any symptoms of snoring. One individual was considered to have a ‘high risk’ for obstructive sleep apnea. This participant did report snoring, which was assessed to have a loudness level that was louder than talking. This individual did also report a daily feeling of tiredness. For the other four individuals, data was missing.

**Discussion**

The present study examined the effect of a suspension pharyngeal flap on speech outcomes and self-reported speech intelligibility and satisfaction with speech in Filipino individuals who presented with VPI following primary palatal closure. We hypothesized that suspension pharyngeal flaps would result in an amelioration of the individuals’ speech understandability and acceptability (25). Besides, a reduction in the occurrence of hypernasality, nasal airflow errors, passive articulation errors, and velopharyngeal gap size was hypothesized (25). No differences in the occurrence of active CSCs nor consonant proficiency were expected when comparing pre- and post-surgical data.

Data derived from the ten individuals confirm the latter hypotheses. The participants’ speech was judged as significantly more understandable and more acceptable following the suspension pharyngeal flap procedure. A probable explanation for the improved speech understandability and acceptability may be the significant reduction in hypernasality, nasal emission, and passive CSCs. These perceptual improvements were confirmed by the data obtained with the videofluoroscopic assessments. Velopharyngeal gap size significantly decreased following the suspension pharyngeal flap. Before this surgery, the majority of the individuals presented with a large velopharyngeal gap. Following the suspension pharyngeal flap, 60% of the individuals presented with normal velopharyngeal functioning (i.e., no gap present). Even though there is no previous data available on the effect of suspension pharyngeal flaps in the literature, the present findings are in line with earlier research on the effects of superior based pharyngeal flaps (22, 23) or the use of suspension flaps as a method for primary palatal repair (25). Indeed, Damalachervu, Yellinedi (25) reported that 62.8% of the individuals who received this technique as a method for primary palatal repair had no signs of VPI post-surgery. Lee, Bae (22) and Rabah, Alkahtani (23) found significant improvements in hypernasality and articulation following superior based pharyngeal flaps. Our study did only find an improvement (i.e., reduction) in passive articulation errors. As we hypothesized, the results did not demonstrate an improvement in active articulation errors. In the previous literature on superior based pharyngeal flaps (22, 23), no clear distinction was made between active and passive articulation errors which makes a valid comparison with our data difficult. It is possible that the participants in the study from Lee, Bae (22) and Rabah, Alkahtani (23) had already followed speech therapy for the elimination of active articulation errors following the pharyngeal flap. In our study, individuals had not yet received any type of speech therapy following the surgery. The high amount of persisting active articulation errors highlights the need for speech therapy following suspension pharyngeal flap surgery as a method for secondary speech improvement.

Despite these promising perceptual results in terms of hypernasality, it must be noted that the obtained instrumental nasalance values following the suspension pharyngeal flap were considerably higher than normative data. This finding is in line with previous research on the combined effect of palatal repair, buccinator myomucosal flaps, and suspension pharyngeal flap in Filippino adults with unrepaired palatal clefts (47) and suggests that the degree of hypernasality was, for some individuals, not on the same level as peers without a cleft.

The individuals themselves were very satisfied with their speech following the surgery. Interestingly, a statistically significant improvement in their speech intelligibility in different contexts was found following the suspension pharyngeal flap. Even though the use of questionnaires always involves a certain risk for social desirability bias, these findings demonstrate that suspension pharyngeal flap surgery can positively influence an individual’s intelligibility in daily life. Besides, the study design actively tried to minimize the risk for social desirability bias as the questionnaires were not administered by the treating surgeons or involved SLPs.

In summary, these findings suggest promising speech outcomes after suspension pharyngeal flap surgery in individuals with VPI following (delayed) primary palatal repair. Our data adds further evidence to the ongoing question “Is there an upper age limit for cleft palate surgery?” (25, 47). As the literature and the present data suggest, surgery is still recommended in adults both in terms of primary palate repair as well as secondary speech improving surgery in individuals who had delayed primary palatal repair. Especially since our data revealed not only significant improvements in speech, but also an improved functioning in terms of eating and drinking (i.e., the majority of the individuals had no nasal regurgitation following the procedure).

The present study was the first to investigate the effect of suspension pharyngeal flaps on speech outcomes, self-reported speech intelligibility in different contexts, and risk of sleep apnea in individuals with VPI following (delayed) primary palatal closure. A standardized, internationally accepted speech protocol was used for the perceptual assessment of the collected speech data (48). An instrumental assessment, using both the Nasometer and a videofluoroscopic assessment of velopharyngeal functioning, supplemented the perceptual speech assessment. In contrast with previous retrospective studies, this prospective study included both pre- and post-operative speech data. As individuals are also known to be susceptible for obstructive sleep apnea after pharyngeal flap surgery (18), this study used The Berlin Questionnaire to assess the possible risk for obstructive sleep apnea. Data was obtained for six of the ten participants. Five of them had a low risk for obstructive sleep apnea. Possibly, the pharyngeal flap that was constructed using this suspension pharyngeal flap procedure was less obstructive compared to traditional pharyngeal flap approaches (25). Nevertheless, one participant did report symptoms related to snoring and fatigue. Considering the small sample size of this study, the occurrence of obstructive sleep apnea following suspension pharyngeal flap needs to be further investigated. Another limitation of this study was the large period in which post-operative speech data was collected (i.e., 4 to 26 weeks). Practical issues (i.e., the Ghent University team could only visit the Philippines for two weeks) caused this limitation. Also, no validity or reliability testing was performed for the questionnaire that assessed the participants’ self-reported satisfaction with speech and speech intelligibility in different contexts. Another limitation was the wide age range of the included participants (8.40 years to 34.90 years). Besides, most individuals had bilateral buccinator myomucosal flaps before the suspension pharyngeal flap procedure. In these cases, the soft palate was already lengthened by the buccinator flaps. Perhaps, different speech outcomes would be obtained in cases who had not undergone any soft palate lengthening procedure before the suspension pharyngeal flaps. This is an interesting topic for future research.

**The authors have no conflicts of interest to declare.**

**Consent statement**

Written and oral informed consent was obtained from all the participants. If they were aged under 18 years, an additional written informed consent was obtained from their legal guardian. Written informed consent was also obtained from the patient and their legal guardians (for participants aged under 18) for publication of the details of their medical case.

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**Author Contributions section**

C.A.: study idea, design, conceptualization, data collection, data analysis, drafting of the original manuscript

A.H.: study idea, design, conceptualization, data collection, approval of manuscript

K.K.: conceptualization, data collection, approval of manuscript

J.V.: study idea, design, conceptualization, data collection, approval of manuscript

K.B.: study idea, design, conceptualization, data analysis, approval of manuscript

R.M.T.: conceptualization, data collection, approval of manuscript

R.A.: conceptualization, data collection, approval of manuscript

K.V.L.: study idea, design, conceptualization, data collection, approval of manuscript

**Data availability statement**

Data is available upon request from the authors due to ethical reasons.

**Statement of Ethics**

This study was approved by the ethics committee of the CURE Network Institutional Board (CNR/006/23). Informed consent was obtained both orally and written from the participants.

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