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Effect of furlow double opposing z - plasty on nasalance measures in individuals with velopharyngeal dysfunction: a pre-post operative comparison

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Abstract

Objective: To evaluate the Effect of Furlow double opposing Z- Plasty on nasalance scores of individuals with Velopharyngeal dysfunction (VPD) and to correlate the perceptual and instrumental evaluation after surgery.**Materials and method**: Fifteen individuals with VPD in the age range of 7 to 25 years were considered. Preoperatively, the subjects underwent detail speech and cineradiographic evaluation. All the subjects underwent Furlow double opposing Z- Plasty. The speech samples consisted of sentences and spontaneous speech. The resonance was assessed by using nasometer II (6450) for vowels, consonant-vowel combinations, nasal and oral sentences. Post-operative speech evaluations were carried out after three months for the same tasks prior to speech therapy. The speech samples were perceptually rated by three speech language pathologists using 4 point rating scale (0 to 3). **Results:** There was a significant reduction in nasalance values ($p=0.009<0.05$) and hypernasality ($p=0.025<0.05$) post operatively. Moderate positive correlation ($r= 0.465$) was seen between perceptual rating and nasalance scores of oral sentences. **Conclusion:** This study highlights the need for surgical correction of VPD. However the surgical correction of velopharyngeal port does not necessarily change its function. The articulation problems may persist following surgery in some individuals and this suggests the need for speech therapy following surgical correction of VPD.

Key words: Velopharyngeal dysfunction (VPD), Nasalance, Cineradiographic Evaluation , Furlow double opposing Z- Plasty

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INTRODUCTION

Resonance is defined as a vibratory response of air in the vocal tract set in motion by a source of phonation [1,2]. Normal resonance is the quality of voice which is achieved by the size and shape of the pharyngeal, oral, nasal cavities and normal velopharyngeal function. Velopharyngeal closure is the closure of the nasal airway by the elevation of the soft palate and contraction of the posterior and lateral pharyngeal wall [3-7]. The velopharyngeal valve is important for normal speech as it is responsible for regulating and directing the transmission of sound energy and air pressures in the cavities of the vocal tract. When this valve does not function adequately it leads to velopharyngeal dysfunction (VPD) which has a significant effect on speech and resonance characteristics.

Velopharyngeal Dysfunction (VPD) can result in hypernasal speech, audible nasal air emission/nasal turbulence, short utterance length, compensatory speech errors and weak pressure consonants distortion [8]. The assessment of nasality is a key task for the speech–language pathologist (SLP) working with individuals with VPD. The assessment of speech in individuals with velopharyngeal dysfunction is grouped under two major categories such as perceptual and instrumental assessment procedures. Perceptual assessment of speech is an essential part in the diagnosis of velopharyngeal dysfunction, along with physical examination and clinical history [9-13]. Perceptual speech evaluation, especially regarding resonance, is the cardinal method of assessing VPD.

Through perceptual evaluation of resonance in individuals with velopharyngeal dysfunction, assessment can be made for the presence or absence of hypernasality, nasal air emission and compensatory articulation during speech. It is also possible to rate the velopharyngeal function.The instrumental evaluation of speech includes indirect assessment and direct visualization techniques. Nasometry is an indirect computer-based procedure that provides information regarding the acoustic analysis of velopharyngeal function. Nasometer provides nasalance value (in percentage) that reflects the relative amount of nasal acoustic energy in a subject's speech [5]. Excessively high nasalance scores typically reflect hypernasality, while excessively low scores typically reflect hypo-nasality or de-nasality.

The combined use of perceptual and instrumental assessment tools is important for diagnosis of VPD. Velopharynegal Dysfunction (VPD) is one of the most common adverse sequelae of cleft palate. Although the incidence of VPD following cleft palate repair may vary with age at repair, operative technique, cleft severity, and surgical experience, 10 to 25% of patients with cleft palate will ultimately require secondary surgical management .Better speech outcome is considered as the success of the secondary surgery in individuals with VPD.

Dailey et al. [3] aimed at comparison of resonance outcomes after pharyngeal flap surgery and furlow double - opposing z- plasty in subjects with severe velopharyngeal incompetence (VPI). The pre- and post-operative speech assessments included single word articulation test, sentence

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repetition, and spontaneous speech. The hyponasality and hypernasality was perceptually assessed by a speech language pathologist using a six point rating scale. The results showed that both pharyngeal flap and Z-plasty groups benefited by significant reduction in the perceived hypernasality from surgery. The selection of the surgery was based on the preoperative ratings of perceived hypernasality and evaluation of velopharyngeal physiology. The authors concluded that severity of VPD is an important factor when considering the management of VPD and recommended detailed preoperative assessment which is essential for treatment planning for VPD. Even though the authors used the retrospective study design, they included perceptual and instrumental method for comparison[14-18].

Van Lierde et al.[19] studied speech outcome on intelligibility, articulation, resonance and voice characteristics in seven subjects in the age range from 4.7 to 9.1 years with a mean age of 6.9 years pre and postoperatively following pharyngeal flap surgery. The instrumental assessment procedures such as Nasometer, Dysphonia severity Index (DSI) and the perceptual assessments were carried out one week preoperative to pharyngeal flap and postoperatively for six weeks and one year. The speech samples used for perceptual evaluation of intelligibility and resonance were a five minute sample of connected speech on school and leisure activities and reading of nasometric sentences. The results revealed that statistically significant difference between pre-operative and two post-operative conditions in auditory perceptual ratings of intelligibility and nasality. The nasalance scores were measured using Nasometer (Model 6200). The subjects were asked to sustain three vowels /a/, /i /, /u/ and read two passages. The subjects were asked to read the passages once and the nasogram was obtained. The results showed statistically significant difference between the nasalance values preoperatively and age specific normative data[20].

Wojcicki et al.[21] evaluated the outcome of treatment of velopharyngeal dysfunction after simultaneous double Z-plasty and sphincter pharyngoplasty in 14 children with a mean age of 14 years. The pre and post-operative speech of the children were recorded for comparison after the surgical intervention. The evaluations of perceptual speech assessments for hypernasality, hyponasality and speech intelligibility were done. The nasometric recordings were performed for assessing the nasalance ratio and nasofibroscopy was done for assessing the length of the soft palate. The follow up examination was done 6 months after surgery and for three individuals it was three months after surgery. Before the surgery 9 individuals had velopharyngeal closure below 50% and for 5 subjects it ranged from 50 to 80 %. After surgery 4 individuals had 80-100% closure and 10 subjects had complete closure. Before operation all subjects had abnormal nasalance about mean value of 44% and after surgery it was between 26 to 30%. Ten subjects achieved full recovery (71%), and remaining 4 had improved recovery (29%).

The relationship between nasalance scores and perceptual nasality judgments has varied across studies from very good to poor. This inconsistency may be related to differences in design such as different subject populations, different machines, different stimuli, and different methods of obtaining nasality judgments. Dalston et al. [5] compared judgments of nasality versus nasalance scores in speech samples from 96 subjects. Nasality was rated on a six-point EAI scale by senior author of the study. They reported a high positive correlation of r = 0?82 between nasalance scores and nasality. They concluded that the perceptual judgement was done by a single judge and this study should be replicated with more number of listeners to evaluate interjudge reliability.

Brancamp et al.[1] evaluated the nasalance/nasality relationship when nasality ratings are obtained with both equal appearing interval (EAI) and direct magnitude estimation (DME) scaling procedures. Thirty nine participants in the age range of 3 to 17 years with their resonance ranging from normal to severely hypernasal were considered for the study. The subject's nasalance scores and audio recordings of turtle passage were obtained simultaneously. A single judge rated the speech samples using EAI and DME techniques. The result revealed that the degree of the correlation between nasalance scores and EAI ratings of nasality (r=.63) and between nasalance and DME ratings of nasality (r=.59) was not significantly different. They concluded that the both rating procedures were reliable and valid and had a statistical relationship to nasalance scores. Further investigations into the relationship between perceptual measurements and nasometric measurements and the effects of the speech stimuli on these relationships have to be studied in detail [12].

The above review highlighted the need for documenting the pre and post-operative condition using perceptual and instrumental method. Some studies used the perceptual method while others combined the perceptual and instrumental methods. Detailed assessment protocol was not used for the speech outcome measures. Most of the studies compare the mean percentage scores of the rating done by the listeners across the pre and post-operative conditions and not the relationship between perceptual and instrumental methods of evaluating the resonance pre and post operatively following velopharyngeal surgery. The present study is aimed to study the resonance outcome following secondary velopharyngeal surgery in individuals with velopharyngeal dysfunction and to evaluate the relationship between perceptual rating of nasality and nasalance scores of these individuals for pre and post-operative conditions.

SUBJECTS AND METHODS

Subjects

15 Kannada speaking individuals in the age range of 7 to 25 yrs (Mean age 14 yrs) who have undergone primary palatal repair (cleft of hard palate and soft palate, cleft of the soft palate) for the closure of the cleft after consultation with plastic surgeon were considered for the present study. All the participants were evaluated by team members including plastic surgeon, speech language pathologists, orthodontist, prosthodontist and a psychologist. These individuals underwent cineradiographic evaluation and were diagnosed to have velopharyngeal dysfunction by the craniofacial team. Individuals with poor intelligence and associated syndromic conditions were not considered for the study. This study was conducted with the understanding and with the written consent of the participants or their parents. The subjects who have not attended speech therapy for more than 15 sessions were considered for this study.

Methods

The individuals diagnosed by the craniofacial team as having velopharyngeal dysfunction (VPD) were subjected to detail perceptual and instrumental assessments. All the subjects underwent Furlow's double opposing Z Plasty surgery for their VPD correction. The perceptual evaluation of the speech was considered as the subjective assessment procedure. The resonance characteristics of the individuals with velopharyngeal dysfunction

were assessed using spontaneous speech sample and repetition of audio recorded sentences. A three minutes sample of spontaneous speech about the school and leisure activities in Kannada language was audio and video recorded. The subjects were asked to repeat audio recorded sentences (5 nasal and 5 oral) in Kannada which was presented through headphones. The speech samples were recorded one week pre operatively and 3 months post-operatively. The speech samples were blindfolded between the two conditions (pre and post-operative) and presented in a randomized order across speakers and oral/nasal conditions. The blindfolded speech samples were perceptually judged for hypernasality three trained speech language pathologists based on a five point rating scale (0-4) by Henningsson et al.9 (0 = Normal – acceptable/normal, 1 = Mild - unacceptable distortion evident on high vowels, 2= Moderate- evident on high and low vowels, 3 = Severe- evident on all vowels and some consonants, 4= Very severe- evident on all vowels and consonants).

For instrumental assessment of the resonance outcome in individuals with velopharyngeal dysfunction, Nasometer II (Model 6450) a microcomputer based system manufactured by Kay Elemetrics (2003) was used. The stimuli include repetition of isolated vowels (/a/, /i/ and /u/), CV syllable repetition which includes voiced (/b/, /d/ and /g/) and unvoiced (/p/, /t/, and /k/) consonants with different vowel combinations (/a/, /i/ and /u/), repetition of standardized audio recorded five oral sentences and five nasal sentences 10 Then the subjects were instructed to repeat the stimulus after the audio recorded stimuli by a native speaker played through the speakers in a quiet room situation. After the recording of each stimulus a two second interval was given so that the instrument acquires the each stimulus with a separation. After completion of each sample the recording was saved in the computer and subjected to analysis. The speech samples collected were analyzed for mean, minimum and maximum nasalance scores for each sample.

All these parameters were assessed in the individuals with velopharyngeal dysfunction one week prior to the surgery and three months after the surgery for measuring the speech outcome. Wilcoxon's signed rank test was done to evaluate the resonance outcomes in individuals with velopharyngeal dysfunction for both perceptual and instrumental assessment procedures. Pearsons Correlation co-efficient analysis was done to evaluate how best is the relationship between instrumental and perceptual assessment in evaluating the resonance outcomes after velopharyngeal surgery.

RESULTS

The results of the study were stated in the following three subsections

Perceptual Evaluation of Resonance in Individuals with VPD

The mean scores for perceptual rating of hypernasality done by three experienced speech language pathologists (SLP) were calculated for spontaneous speech and oral sentences which was shown in the above Figure 1. The perceptual evaluation of degree of hypernasality reduced from severe to moderate continuum and moderate to mild continuum after VPD surgery. The Wilcoxon signed ranks test was done to find statistically significant difference across pre and post-surgical scores across stimuli. The test results revealed a statistically significant difference ($p=0.025<0.05$) across pre and post-surgery (3 months) condition in perceptual rating of hypernasality for spontaneous speech and oral sentences ($p =0.011<0.05$) in

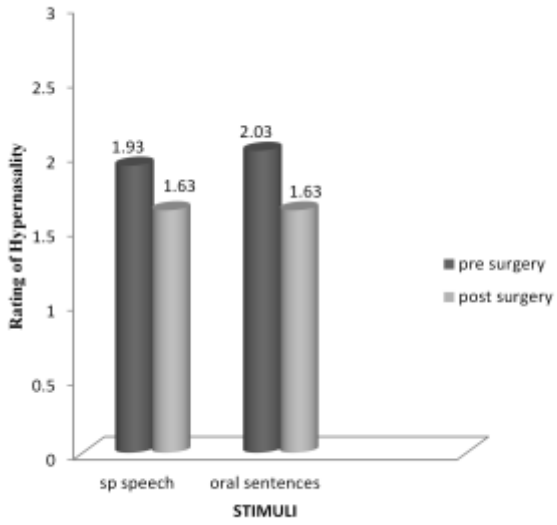

Fig.1 Perceptual Assessment of Hypernasality in Individuals with VPD

individuals with velopharyngeal dysfunction

Instrumental Assessment (Nasometer II 6450) of Resonance in Individuals with VPD

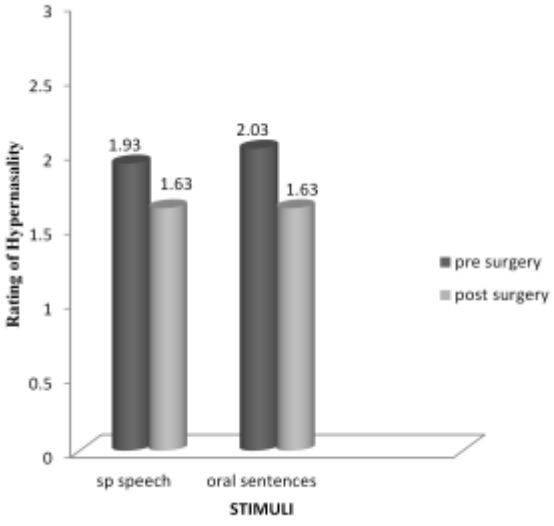

Fig. 2 Mean Nasalance values for Vowels

The mean nasalance scores for the vowels (/a/, /i/, /u/) before and after velopharyngeal surgery was shown in the above Figure 2. The mean nasalance score for vowel /i/ was higher followed by /u/ and /a/ vowels for both pre and post-operative condition. Wilcoxon signed ranks test was done to find statistically significant difference across pre and post-surgical scores for three vowels. The results showed a statistically significant difference ($p<0.05$) across pre and post-surgery (3 months) in nasalance values of vowels (/a/ and/i/) and not for vowel /u/ ($p>0.05$).

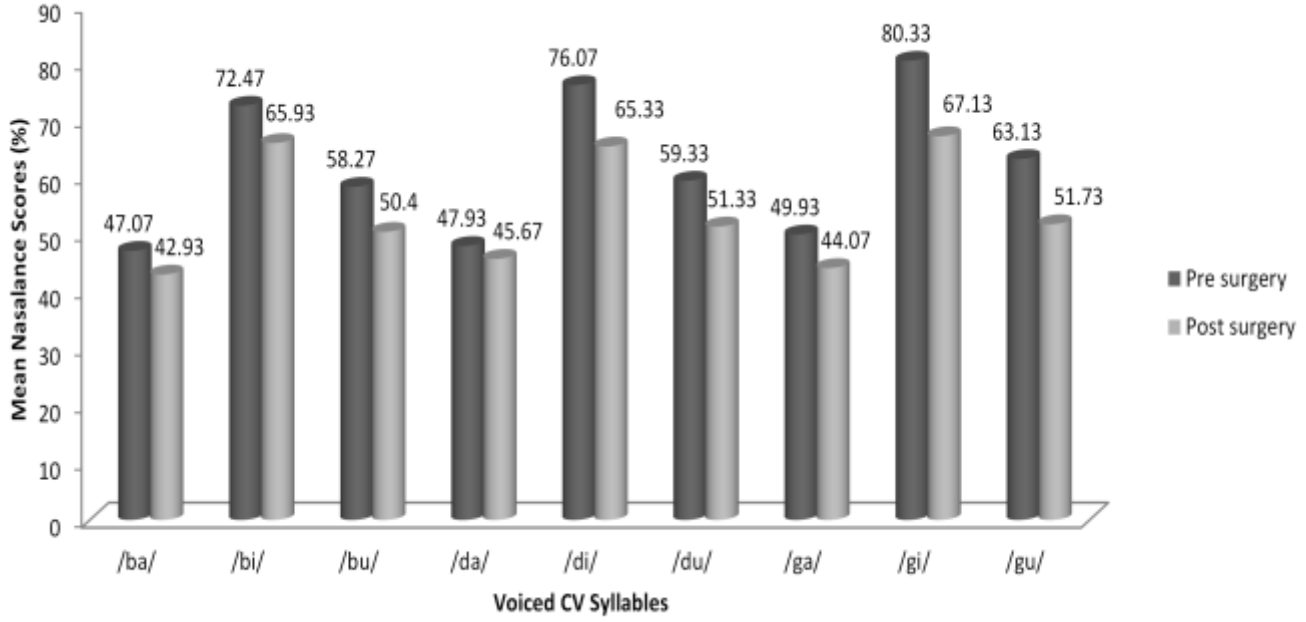

Fig. 3 Mean nasalance Values for Voiced CV syllables

The mean nasalance scores for voiced CV syllables before and after velopharyngeal surgery was shown in the above Figure 4. The mean nasalance scores for voiced syllables (/b/, /d/, /g/) in context of /i/ vowel were higher followed by /u/ and /a/ vowel for both pre and post-operative condition. Wilcoxon signed ranks test was done to find out if there is any statistically significant difference across pre and post-surgical scores for voiced CV syllables. The results showed that there was a statistically significant difference ($p<0.05$) across pre and post-surgery (3 months) in nasalance values of voiced CV syllables

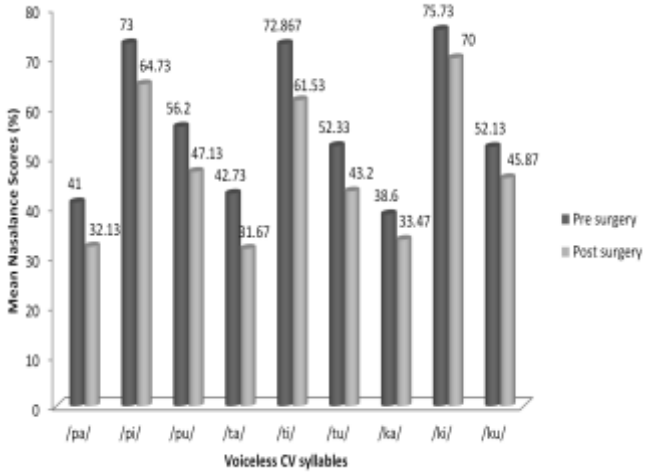

Fig. 4 Mean nasalance values for Voiceless CV Syllables

The mean nasalance scores for voiceless CV syllables before and after velopharyngeal surgery was shown in the above Figure 3. The mean nasalance scores for voiceless syllables (/p/, /t/, /k/) in context of vowel /i/ were higher followed by vowels /u/ and /a/ for both pre and post-operative condition. Wilcoxon signed ranks test was done to find any statistically significant

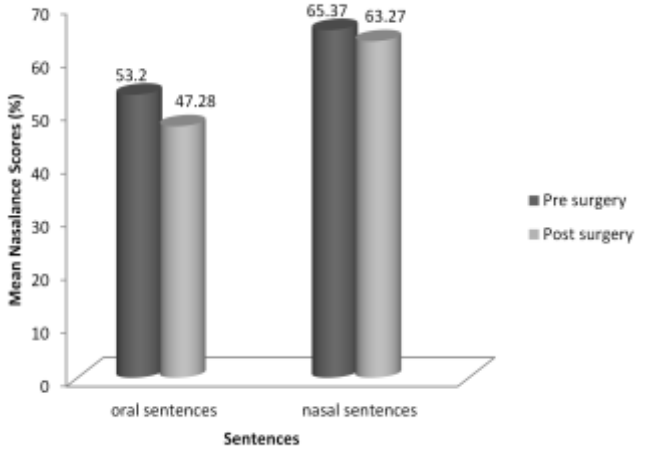

Fig. 5 Mean Nasalance values for Standardized Sentences

difference across pre and post-surgical scores for voiceless CV syllables. The results showed a statistically significant difference ($p<0.05$) across pre and post-surgery (3 months) in nasalance values of voiceless CV syllables.

The mean nasalance scores for standard sentences (oral and nasal) before and after velopharyngeal surgery was shown in the above Figure 5. The mean nasalance scores for oral sentences reduced more than the nasal sentences in the post-operative condition. Wilcoxon signed ranks test was done to find out if there is any statistically significant difference across pre and post-surgical scores for sentences. The results showed that there was a statistically significant difference ($p<0.05$) across pre and post-surgery (3 months) in nasalance values of oral sentences ($p=0.009<0.05$).

Correlation of perceptual and instrumental evaluation of resonance for high pressure sentences in Individuals with VPD

Pearson's correlation co-efficient (r) was calculated to find the relationship between perceptual and instrumental evaluation of resonance. The results showed that there was a fair or moderate

positive correlation for pre-operative scores (r = 0.518) and for post-operative scores (r= 0.465). The results showed that there was a positive moderate correlation between the perceptual rating of nasality and nasalance sores for oral sentences. The cronbach's alpha was calculated to find the internal consistency of the perceptual judgement done by three speech language pathologists. The results showed that alpha (a) value was 0.70 and this revealed that the reliability of the perceptual judgement done by the judges were in acceptable level.

DISCUSSION

The results of the present study showed that there was a better resonance outcome following velopharyngeal surgery. The instrumental and perceptual assessment of resonance was carried out prior to surgery and three months post operatively. The results showed that mean scores were statistically better postoperatively compared to preoperative scores.

The perceptual evaluation revealed that the hypernasality was found to be reduced followed by surgery. This is due to the effect of surgery in which the muscle orientation is been focused to improve the velopharyngeal closure. These results were similar to that of the previous studies [3, 19, 21] done on assessing the resonance outcomes after VPD correction in individuals with repaired cleft lip and palate. These authors found significant reduction in the hypernasality after VPD surgery. The results of the previous studies showed that there significant reduction in the perceived hypernasality after surgery. The selection procedure of the surgery was based on the preoperative ratings of perceived hypernasality and evaluation of velopharyngeal function using direct visualization technique such as cineradiographic evaluation. The severity of velopharyngeal dysfunction is an important factor when considering the management of VPD and thorough preoperative assessment is essential for treatment planning for individuals with velopharyngeal dysfunction.

The instrumental evaluation showed that front high vowel /i/ had significantly higher nasalance value compared to low mid vowel /a/ and high back vowel /u/ in individuals with velopharyngeal dysfunction. Similar results were seen for speech samples consists of CV syllables in the context of vowels (/a/, /i/ and /u/). This study supports the findings of previous studies 17, 7. During the production of high vowels /i/ and /u/ the tongue tip is placed high in the oral cavity and imposes maximum resistance during the air flow through the oral cavity. But during the production of mid vowel /a/ which is an open vowel which creates less resistance to the air flow. The authors also reported that the greater degree of nasality on high vowels as the high vowels make greater demand upon the valving function and horizontal position of the tongue on the nasalance of vowels. Back vowels are reported to have lower nasalance values because some of the muscles that pull the body of the tongue back also pull the velum down resulting in tight velopharyngeal closure. The subjects considered for this study underwent furlow's Z plasty alone or it in combination with pharyngeal flap procedure. The surgical procedures considered for these subjects were equally effect in reducing the degree of nasality.

Further the results showed that there was a moderate positive correlation between the instrumental and perceptual assessment of nasality. These results were in consonance with the previous studies 18, 20 and the authors reported that the correlation coefficients were ranging from 0.49 to 0.66 for perceptual and instrumental evaluation of hypernasality for high pressure sentences. This improvement in relationship compared with previous studies may result from methodological differences between the studies [13,4,18]. Firstly, different speech stimuli had been used for the perceptual and nasometric assessments in previous studies. In the present study the speech sample used for nasometric assessment is the same as the speech sample used for perceptual assessment.

In a study by Keuning et al. [13] the judges rated hypernasality, nasal emission, misarticulations and intelligibility together at the time of analysis. This multi-tasking may have adversely influenced judges' perceptual ratings of each speech parameter. In the present study the judges perceptually rated the nasality only, thus possibly providing a more valid and reliable perceptual assessment. The previous studies have perceptually evaluated nasality using standardised oral sentences that completely devoid of nasal consonants. The present study has evaluated the spontaneous speech, which has greater face validity as it represents the natural conversational situation.

The results of the present study showed a moderate relationship between perceptual assessment of nasality and nasalance scores. The present results designated that high nasalance scores did not always reflect a high perceptual rating of hypernasality. Watterson et al. [21] stated that a lack of agreement between the Nasometer and perceptual ratings might be partly due to the Nasometer's limited measurements of hypernasality, relative to the information that may be used by the rater. They pointed out that the Nasometer uses a 300-Hz bandpass filter centred at this frequency range, although the acoustic effects of nasalization are not restricted to 500 Hz. This supports the need to supplement perceptual judgements using nasometry but not to replace them, as nasometry is assessing different aspects of speech.

CONCLUSION

The present study investigates the resonance outcomes after surgery in individuals with velopharyngeal dysfunction. Both perceptual and instrumental evaluations showed statistically significant difference between pre and post-operative (3months) conditions. Better results in perceptual and acoustic aspects may be attributed to improvement in velar elevation and length following surgery for improving velopharyngeal closure. The most of the subjects considered for the study underwent Furlow Double opposing z plasty. The generalization of the results of this study to all subjects is difficult as the sample size is very small. Thorough pre and post-operative evaluation, the subsequent follow ups of the subject's speech is very essential for evaluating the speech outcomes in individuals with VPD.

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