# EFFECT OF PALATAL LIFT PROSTHESIS ON LARYNGEAL AERODYNAMICS AND VOICE QUALITY IN SUB-MUCOUS CLEFT PALATE

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**Abstract**

*The closure of velopharyngeal port is essential for normal resonance in speech. The abnormality of velopharyngeal port (VPP) in persons with cleft palate leads to compensatory changes in laryngeal valving and higher prevalence of voice disorder. Palatal lift prosthesis is one of the rehabilitation options for individuals with submucous cleft palate (SMCP). The present study investigates the influence of velopharyngeal dynamics on laryngeal airway dynamics and voice quality in an individual with SMCP using palatal lift prosthesis. Laryngeal aerodynamic parameters such as Sub-Glottic Pressure (SGP), Laryngeal Airway Resistance (LAR), Mean Air Flow Rate (MAFR) and Dysphonia Severity Index (DSI) were obtained with and without using prosthesis before and after 20 minutes of vocal loading task. Age and gender matched subjects served as controls. The results indicated variations in the laryngeal aerodynamics (LAR) and voice quality following vocal loading in individual with SMCP than compared to normal subjects. The reduction in the measures of the laryngeal resistance and subglottic pressure in the individual with SMCP was noticed with the use of palatal lift prosthesis. These variations indicate the influence of palatal lift prosthesis in reducing the laryngeal compensatory behavior.*

**Keywords:** *Palatal Lift, Dysphonia Severity Index, Laryngeal Resistance, Sub Glottal Pressure.*

Voice is one of the most important parameters of speech production. Production of normal speech requires coordination between the phonatory, respiratory, articulatory and resonatory systems. Individuals with cleft lip and palate (CLP) exhibit anatomical deformities of oral structures leading to the voice disorders. The voice characteristics in individuals with CLP are characterized as breathy, hoarse, and soft. This is usually due to increased respiratory, muscular effort, and hyper-adduction of the vocal folds while attempting to close the velopharyngeal valve (Kummer, 2008). The prevalence of hoarseness in the cleft palate population is reported as 5.5% (Robison & Otteson, 2011).

The hoarseness in individuals with cleft lip and palate is explained with different hypothesis, the most common being laryngeal compensation for abnormal velopharyngeal valving. The laryngeal aerodynamic parameters have been found to be a useful tool in discriminating normal vocal function from pathologic voice. Aerodynamic parameters are influenced by a number of anatomical features and physiological events, such as the driving pressure arising from the respiratory system, the constriction, size and timing of movements of the vocal cords, together with the size, shape and biomechanical properties of the vocal tract as a whole (Miller & Daniloff 1993). Based on relationship that exists between laryngeal aerodynamics, laryngeal structure and physiology, it would be expected that aerodynamic parameter values would vary with respect to the different types of cleft and compensatory strategies used by individuals with cleft lip and palate.

The importance of aerodynamic measures in the assessment and treatment of individuals with voice disorders is increasingly being recognized (Baken, 1987). Grillo and Verdolini (2008) investigated the efficacy of laryngeal aerodynamic parameters such as laryngeal resistance and vocal efficiency in distinguishing pressed, normal, resonant, and breathy voice qualities in vocally trained subjects. The authors concluded that, out of the two parameters the laryngeal resistance was efficient in distinguishing the pressed from normal and breathy voice qualities. In a similar study by Grillo, Perta, and Smith (2009) laryngeal resistance was found to be successful in distinguishing the pressed, normal, and breathy voice qualities in vocally untrained females.

Mc Williams, Bluestone, and Musgrave (1969) reported that some children with velopharyngeal inadequacy may use “generalized laryngeal tension” as a compensatory valving strategy, “even in the absence of glottal fricatives and plosives”.

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They believed that children with borderline velopharyngeal function would be most likely to engage in this type of compensatory laryngeal activity (McWilliams, Bluestone, & Musgrave, 1969). Leeper, Macrae, and Mcknight (1994) compared the transglottal airflow in children with inadequate VPI and with adequate VP closure. They reported higher transglottal airflow in the group with inadequate closure.

Zajac (1995) studied the laryngeal airway resistance (LAR) levels with respect to the velopharyngeal closure in children with non cleft palate and 14 children with cleft palate grouped into incomplete and complete velopharyngeal closure. They were instructed to perform syllable repetition task while occluding the nostrils and targeting typical adult speech. Results indicated that children with incomplete VP closure exhibited significantly higher laryngeal resistance. Guyette, Sanchez and Smith (2000) conducted a study on thirty six children with cleft palate, ten with incomplete VP closure and twenty six with complete VP closure. They were asked to repeat /ipipipipipipipi/ at a rate of 1.5 syllables per second. The authors concluded that laryngeal airway resistance (LAR) and transglottal pressure were significantly higher and transglottal airflow was significantly lower in individuals with cleft palate exhibiting incomplete closure. They attributed this to the velopharyngeal insufficiency (VPI) which demands for increased muscular effort at the laryngeal level to compensate for the potential velopharyngeal (VP) air leak while speaking.

Brustello, Paula, and Yamashita (2010) conducted a study to explore whether individuals with marginal velopharyngeal dysfunction modify the laryngeal resistance as a strategy to achieve complete velopharyngeal closure during speech. The study was conducted on nineteen individuals with cleft palate and eighteen normal age and gender matched control group during the production of syllable /pa/ with and without nasal occlusion. They concluded that the individuals studied with marginal velopharyngeal closure did not modify laryngeal resistance. They had slightly lower laryngeal resistance values than individuals without cleft. They attributed this to the variations in the oro-nasal flow, resulting from the physiological adjustments occur as a compensatory strategy. This physiological adjustment is to maintain levels of intraoral air pressure for the stable production of speech, such as increased laryngeal airflow (Warren, 1986).

Most of the studies used the perceptual methods to describe the vocal behaviour in individuals with velopharyngeal disorder. Objective studies on vocal quality in subjects with cleft palate are sparse. Lewis, Andreassen, Leeper, Macrae, and Thomas (1993) reported higher frequency perturbation (jitter) in the voice of individuals with cleft lip and palate. Van Lierde, Claeys, De Bodt, and Van Cauwenberge (2004) used a multi parametric measure Dysphonia Severity Index (DSI) to analyze the voice quality in 21 children with cleft palate. The DSI is based on the weighted combination of the following selected set of voice measurements: highest frequency (F0-high in Hz), lowest intensity (I-low in dB), maximum phonation time (MPT in s), and jitter (%). The DSI ranges from +5 to -5 for, respectively, normal and severely dysphonic voices. The more negative the patient's index, the worse is the vocal quality (Wuyts, Bodt, Molenberghs, Remacle, Heylen, & Millet, 2000). The male children with cleft palate showed an overall vocal quality of +0.62 with the presence of a perceptual slight grade of hoarseness and roughness. The female children had a DSI value of +2.4 reflecting a perceptually normal voice. Results concluded that irrespective of the type of cleft, all subjects demonstrated a significantly lower DSI-value in comparison with the available normative data.

Vocal loading is one of the tasks to know the functioning of the laryngeal system and voice quality. Vocal loading is defined as prolonged loud use of voice and has four distinct phases: warm up (adapting to the voicing task), performance (continuance of the voicing task), vocal fatigue (perceived increase of physical effort associated with voicing, physical changes to the larynx), and rest or recovery (Jilek, Marienhagen, & Hacki, 2004; Vintturi, Alku, Sala, Sihvo, &Vilkman, 2003). Prolonged loud reading protocols vary with regard to loudness levels, tasks, and total reading times (20 min to 2 hr), making direct comparisons between study outcomes difficult. Most reported outcome data include some combination of before and after acoustic, aerodynamic, stroboscopic, and perceptual measures. Evidence suggests that for the healthy voice, a minimum of 1 hour is required to induce symptoms of fatigue (Gelfer, Andrews & Schmidt, 1991, 1996; Stemple, Stanley & Lee, 1995).

Webb, Starr, and Moller (1992) have conducted a study to measure the effects of extended speaking on resonance and voice quality of eight individuals with cleft palate and eight age and gender matched normal individuals using a five point rating scale for perceptual measurement. Results revealed that five cleft subjects became more nasal, two less nasals, and one did not change. Three normal subjects became more nasal and five did not change. The two cleft subjects who changed the most became less nasal. The mean of the vocal quality change ratings was higher for the normal. However, quality improved for three cleft and six normal subjects, and did not change for two cleft and one normal subject. From the results they interpret that resonance changes were greater and voice quality changes less, for the cleft group, but that changes were not significant nor always in the direction of increased hypernasality or decreased vocal quality.

The management of these individuals requires multidisciplinary team approach which includes an active role of the prosthodontist and speech pathologist. Considerable attention is focused on documenting the efficacy of prosthesis (Pinto, Dalben & Krook, 2007; Seunghee, Hyunsub, Zhi, & Kuehn, 2003). Palatal lifts are used as non - surgical interventions for management of velopharyngeal dysfunction (VPD) (Marsh & Wray, 1980). Palatal lift prosthesis aims to move the soft palate in a posterior and superior direction to aid in the closure of the velopharyngeal gap. Use of palatal lift prosthesis is considered as an effective method of treatment in improving articulation in individuals with velopharyngeal dysfunction (La Velle & Hardy 1979).

Pushpavathi and Sreedevi (2004) reported increased formants frequencies and better velopharyngeal closure with the use of palatal lift prosthesis in an individual with submucous cleft palate. Tachimura, Kotani, and Wada (2004) studied the effect of palatal lift prosthesis on children with repaired cleft palates exhibiting hypernasality and nasal emission with increased nasalance scores. They reported that individuals with repaired cleft palate exhibited decreased nasalance scores while using palatal lift prosthesis.

Despite of high prevalence of voice disorders, in individuals with CLP only few studies have documented the aerodynamic aspects of vocal functions. It is essential to explore the aerodynamic characteristics in individuals who have undergone prosthodontic management as this parameter provides insight into the physiological aspects of the laryngeal aerodynamics. As there are no studies on laryngeal aerodynamics using prosthesis, the present study is an exploratory study to analyze the laryngeal dynamics in prosthodontic management. Hence, this study is aimed to study the effect of velopharyngeal mechanism on laryngeal aerodynamics and voice quality of speech in an individual with submucous cleft palate using palatal lift prosthesis.

The objectives of the study were to investigate (a) The Sub Glottic Pressure (SGP), Mean Airflow Rate (MAFR), Laryngeal Airflow Resistance (LAR), and Dysphonia Severity Index (DSI) in open (without palatal lift) versus closed (with palatal lift) velopharyngeal port (VPP) conditions between subject and controls, (b) The combined effects of velopharyngeal port (VPP) dynamics and vocal loading on Sub Glottic Pressure (SGP), Mean Airflow Rate (MAFR), Laryngeal Airflow Resistance (LAR), and Dysphonia Severity Index (DSI) in the subject and controls and (c) Compare velopharyngeal closure with and without prosthesis conditions using nasoendoscopy.

## Method

### Subject

A female aged 35 years with unrepaired submucous cleft palate served as subject of in the present study. The cleft palate rehabilitation team (plastic surgeon, prosthodontist, orthodontist, psychologist & speech-language pathologist) was involved in the evaluation and management of the subject. The evaluation included oral peripheral examination, speech analysis using perceptual rating scales and objective methods. Based on the assessment, the participant was diagnosed as having velopharyngeal dysfunction with unrepaired submucous cleft palate exhibiting hypernasality and misarticulations. The plastic surgeon recommended surgical management of SMCP. However, the client was not motivated to undergo the surgery. Hence, she was recommended to use palatal lift prosthesis by the prosthodontist.

An impression of the palate was obtained and palatal lift prosthesis was prepared by the prosthodontist. Initially the participant was provided with the anterior portion of the palatal obturator and she was counseled to use consistently for two weeks to get adapted to the prosthesis. Following this period, the prosthesis was extended to the velar portion of the palate and the subject was provided one month time to get adapted to the prosthesis. The subject was recommended to attend speech therapy regularly. However, she was able to attend twice in a week (total 6 sessions, 45 minutes each session). Speech assessment was done using Kannada articulation test (Babu, Ratna, & Betagiri, 1972). She was diagnosed as normal articulation with hypernasality. Hence, the speech therapy goals were aimed at reducing the nasality and improving the oral resonance. Based on the feedback from the participant and perceptual analysis of speech, prosthodontist made suitable modifications to the velar section of the prosthesis until adequate velopharyngeal closure was achieved. Nasoendoscopy was done with and without palatal lift prosthesis in situ to examine the velopharyngeal closure. All the acoustic recordings with prosthesis condition were done after confirming adequate velopharyngeal port closure through the nasoendoscopy images.

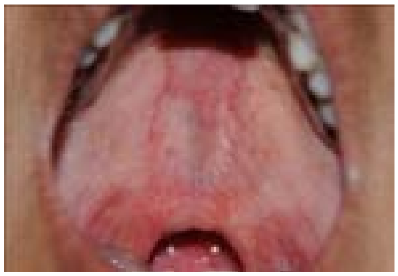


Figure 1: *Submucous cleft palate*

Figure 2: *Palatal lift Prosthesis*

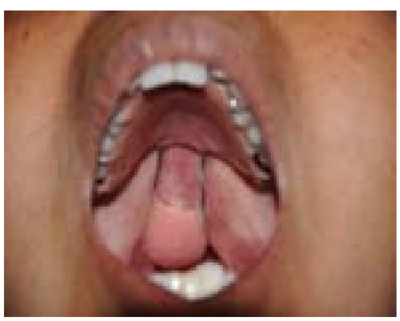


Figure 3: *Palatal lift prosthesis in Situ*

As the present study considered a single subject in the experimental group, the results have to be compared with control group. In order to analyze and compare the aerodynamic measures, five age and gender matched subjects were considered as the control group. The subjects with no history of smoking, laryngeal pathology under respiratory disorder and normal resonance were selected as control subjects .The control subjects were not using any medication

**Procedure**

To induce vocal loading effect, the subject was asked to read a story in Kannada from an elementary textbook. The subject was proficient in reading Kannada as it was her first language. The subject was instructed to read continuously for 20 minutes, as few studies (Remacle, Finck, Roche, & Morsomme, 2011; Niebudek-Bogusz, Kotylo, & Sliwinska-Kowalska, 2007) have reported 30minutes of continuous reading can induce vocal fatigue and lead to variations in acoustic characteristics of voice. Another study by Titze, Svec, and Popolo (2003) reported that beyond 17minutes of continuous vocalization or about 35 minutes of continuous reading can cause changes in the vocal fold tissue morphology and their response to vibrational pattern. As the previous studies have shown that 30 minutes of vocal loading task can induce variations in voices, the present study considered 20 minutes for vocal loading task at the level of 75-80 dB SPL. A practice trail helped her to monitor loudness (by visual feedback) during recording of the stimuli. All the recordings were obtained with a distance of 15cm between the microphone and subject. The Sub Glottic Pressure (SGP), Mean Airflow Rate (MAFR), Laryngeal Airflow Resistance (LAR), and Dysphonia Severity Index (DSI) were measured. The speech sample was recorded in four conditions a) without vocal loading and open velopharyngeal port (VPP) b) After inducing the effect of vocal loading and open VPP c) without vocal loading and closed VPP d) After inducing the effect of vocal loading and closed VPP. The recordings were made immediately after reading task for 20 minutes. The aerodynamic parameters were extracted from the above four recordings. The experiment was done before any actual vocal loading initiated by the subject. The subjects were instructed not to indulge with any vocal loading task or prolonged usage of voice prior to the data collection. The subjects were informed about few vocal hygiene tips after the experiments. Nasoendoscopy was done to analyze the velopharyngeal port closure only during the production of prolonged /a: / vowel with and without prosthesis condition. For the controls the below recordings were done before and after vocal loading task (Reading).

**Measuring SGP, MAFR, and LAR**

The instrument *Aeroview 1.4.4 version*, Glottal Enterprises was used to obtain the data related to aerodynamics of speech. The instrument consists of pressure and airflow transducers mounted onto the face mask, the computer interface and the dedicated application software for analyzing the data. The instrument was calibrated for air pressure and air flow transducers. The subjects were instructed to hold the mask firmly to cover nose and mouth with the intraoral tube placed between the lips and above the tongue. Then the subjects were instructed to produce the repetitions of nine CV syllables /papapapapapapapapa/ into the mask at a comfortable pitch and loudness with equal stress on each syllable. To ensure equal rhythm, subjects were trained until they produce the syllable trains at the appropriate pace and comfortable loudness level.

The subjects were allowed for two practice runs before the actual recording. The recordings in which the syllable production rate was between 2.0 – 3.5 per second were considered for further analysis. Three peak to peak measurements were made and their average was taken to obtain the Sub Glottic Pressure, Mean Air Flow Rate, and Laryngeal Airway Resistance values. Sub Glottal Pressure was estimated based on the measures of peak (intraoral air pressure) during the production of the consonant /p/. Mean Air Flow Rate was derived from the oral airflow measures recorded during the production of vowel segment of the /apapapapapapapa/. The measures (Sub Glottal Pressure & Mean Air Flow Rate during voicing) were subsequently used by the aerodynamic system to calculate Laryngeal Airway Resistance as shown in the figure 1 during comfortable sustained phonation.

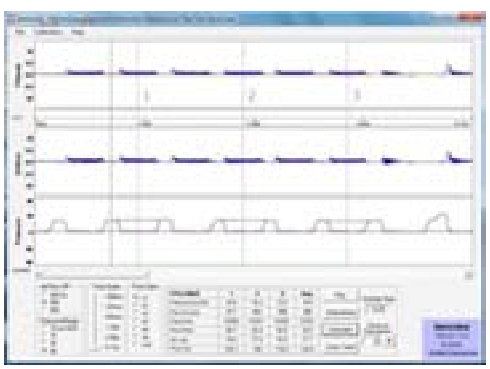


Figure 4: *The display of laryngeal parameters by Aeroview.*

**Calculating DSI**

Dysphonia severity index (DSI) was used to quantify the quality of voice. The raw scores required for DSI measurement are highest frequency (High F0), lowest intensity (low I), jitter % and maximum phonation time (MPT). The DSI scores were calculated from the raw scores using the regression equation - DSI=0.13xMPT+0.0053xF0 (high)-0.26xI (low)-1.18x jitter (%) +12.4. The more negative the patient's index is, the worse is his or her vocal quality (Wuyts, De Bodt, Molenberghs, Remacle, Heylen, & Millet, 2000). The results were analyzed and discussed in terms of graphical representation. These measures were obtained as described below.

*Measuring MPT*

MPT was measured for the vowel /a/, sustained at the subject's habitual pitch and loudness in free field (without any mouthpiece) and in sitting position. The experimenter instructed the subject on the task and also modeled the procedure demonstrating taking deep breath followed by phonation at a comfortable pitch as long as she could do. The length of sustained phonation was measured in seconds with the aid of the *Computerized Speech Lab (Kay Pentax, Model 4500)***.**

*Measuring high F0 and Low I*

The highest frequency and the lowest intensity were measured with the *Voice Range Profile* from the *CSL (Kay Pentax, Model 4500).* The procedure described by Heylen, Wuyts, Mertens, De Bodt, Pattyn, and Croux (1998) was used to measure the lowest intensity and highest frequency from the *Voice Range Profile*. After some vocal warm-up exercises, the subjects were instructed to inhale in a comfortable way and to sustain the vowel /a/ for at least 2 seconds using a "habitual pitch" and loudness. The subject vocalized at his or her lowest and highest frequencies using the softest and greatest intensities at each frequency extreme.

*Measuring Jitter %*

The acoustic parameters F0, jitter, and shimmer were obtained from the *Multi Dimensional Voice Program* (MDVP) of *CSL (Kay Pentax Corp, model 4500).* A mid vowel segment on a sustained /a/ at habitual loudness and pitch was used.

**Statistical Analysis**

Descriptive statistical analysis was used.

## Results and Discussion

**1) Effect of velopharyngeal mechanism on laryngeal aerodynamic parameters between the subject and controls.**

Sub-Glottic Pressure (SGP), Laryngeal Airway Resistance (LAR), Mean Airflow Resistance (MAFR) and Dysphonia Severity Index (DSI) were measured with and without prosthesis conditions in the subject and controls. The results are mentioned in table 1 and figure 5.

Table 1: *SGP, MAFR, LAR and DSI with and without prosthesis across subjects.*

| Condition | SGP (cmH2O) | MAFR (L/sec) | LAR ( cmH2O / L/sec) | DSI (Index) |
|---|---|---|---|---|
| NP | 5.28 | 0.38 | 71 | 4.78 |
| WP | 3.87 | 0.39 | 9 | 5.05 |
| CSBR | 4.86 (1.83) | 0.31 (0.16) | 17.08 (4.06) | 4.26 (1.60) |

*(*standard deviations for control subjects are mentioned within the brackets, NP-No prosthesis, WP-With prosthesis, CSBR: Control Subject before reading)*

The laryngeal aerodynamic parameters were found to be increased in SMCP compared to normal subjects. However, the variation was observed in these values after using the prosthesis. The results depict reduction in the measures of the laryngeal resistance and subglottic pressure after using the prosthesis. The laryngeal airway resistance reduced more with respect to the subglottic pressure. The variation of these parameters was not consistent across the conditions. There were minimum differences in DSI, SGP and MAFR values with and without prosthesis conditions. The mean values of DSI and MAFR were higher in the experimental subject than control subject.

The present study reported the decrease in the laryngeal resistance and sub glottal pressures with prosthesis and this may be attributed to the reduction in the laryngeal involvement in the speech regulation mechanism, which appears to depend on velopharyngeal closure (Zajac, 1995). The results of the study is also in agreement with Guyette, Sanchez, and Smith (2000) findings who reported that individuals with cleft palate exhibit increased laryngeal airway resistance (LAR) and transglottal pressure and reduced transglottal airflow to achieve complete closure of the velopharyngeal valve. This may be due to velopharyngeal dysfunction (VPD) which demands for increased muscular effort at the laryngeal level to compensate for the potential velopharyngeal (VP) air leak while speaking. Hence, the use of prosthesis might have resulted in better velopharyngeal closure reducing the need of the respiratory and laryngeal system to compensate for the speech production. In the present study, the reduced laryngeal airway resistance reflects the reduced laryngeal compensatory mechanism for speech production.

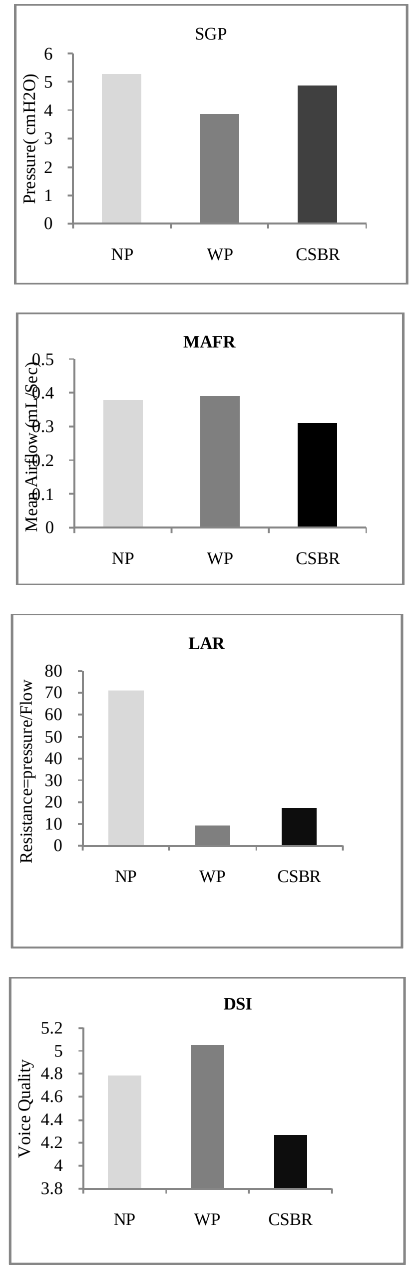



Figure 5*: SGP, MAFR, LAR and DSI with and without prosthesis across subjects.*

Van Lierde, Claeys, De Bodt, and Van Cauwenberge (2004) reported significant lower DSI values in cleft population than normal subjects. In the present study the DSI measures of the subject was at par with the controls. The contradicting results may be due to the dissimilarities or differences present in the methodological issues of the study. The study conducted by Van Lierde, Claeys, De Bodt, and Van Cauwenberge (2004) includes 28 children with unilateral or bilateral cleft palate and the present study included only an individual with submucous cleft palate and control subjects.

All the aerodynamic and laryngeal parameters did not change after using the prosthesis but only few of these parameters (Laryngeal airway resistance and subglottic pressure) have shown variations after using the prosthesis. These results were supports the findings of Pushpavathi and Sreedevi (2004), Tachimura, Kotani, and Wada (2004) who reported decrease in nasality after using the palatal lift prosthesis in individuals with submucous cleft lip and palate.

**2) Comparison of SGP, MAFR, LAR and DSI with and without prosthesis before and after vocal loading across subjects.**

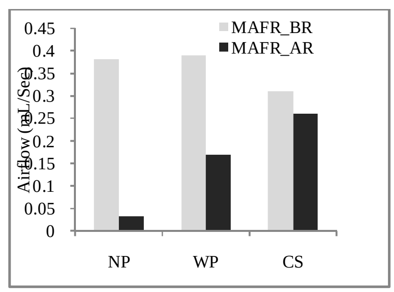
The Sub-Glottic Pressure (SGP), Laryngeal Airway Resistance (LAR), Mean Airflow Resistance (MAFR) and Dysphonia Severity Index (DSI) were measured with and without prosthesis before and after vocal loading in the subject and controls. The results are mentioned in table 2 & figure 6.

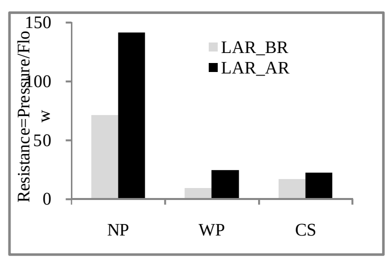
Table 2: *SGP, MAFR, LAR and DSI with and without prosthesis before and after vocal loading across subjects*

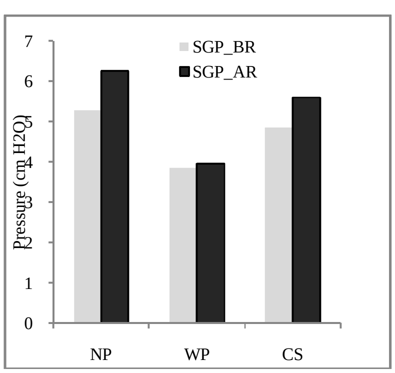
| Condition | SGP (cmH2O) | MAFR (L/sec) | LAR ( cmH2O / L/sec) | DSI (Index) |
|---|---|---|---|---|
| NPBR | 5.28 | 0.38 | 71 | 4.78 |
| NPAR | 6.25 | 0.033 | 142 | 2.48 |
| WPBR | 3.87 | 0.39 | 9 | 5.05 |
| WPAR | 3.95 | 0.17 | 24.8 | 3.88 |
| CSBR | 4.86<br>(1.83) | 0.31<br>(0.16) | 17.08<br>(4.06) | 4.26<br>(1.60) |
| CSAR | 5.59<br>(1.20) | 0.26<br>(0.11) | 22.75<br>(7.46) | 2.48<br>(1.25) |

**Note: NPBR-No prosthesis and before reading, NPAR- No prosthesis after reading, WPBR-with prosthesis before reading, WPAR-With prosthesis after reading, CSBR: Control Subject before reading, CSAR-With prosthesis after reading.*

The results illustrate that after vocal loading task the sub glottal pressure and laryngeal airway resistance increased. However, there was a decrease in the mean airflow rate and dysphonia severity index in all the conditions i.e., with and without prosthesis between the subject and controls. But, the increase in the laryngeal airway resistance was more in the subject than the controls while the other measures (SGP, MAFR & DSI) have shown less variation. The effect of vocal loading was reduced with the use of prosthesis as reflected in the laryngeal aerodynamic measures shown in the above table. With the use of prosthesis, differences in the laryngeal aerodynamic measures before and after vocal loading were less than that of the without prosthesis condition and also relatively similar to that of the controls.



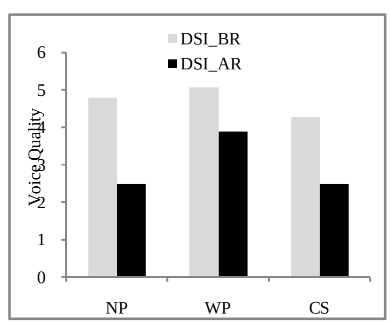




Figure 6: *SGP, MAFR, LAR and DSI with and without prosthesis before and after reading across subjects.*

The increased subglottal pressure and laryngeal resistance were observed across all the conditions in both subject and controls after vocal loading task. This can be due to the prolonged usage of the laryngeal mechanism (Webb, Starr, & Moller, 1992). The results also indicate reduction in the DSI and MAFR measures following vocal loading tasks in both the conditions of subject (with and without prosthesis) and controls. Webb, Starr, and Moller (1992) studied the effects of extended speaking on resonance and voice quality in eight adults with cleft palate exhibiting hypernasality and matched with non cleft adults. The results of the study were ambiguous. Hence, they concluded that resonance changes were greater and voice quality changes were less for the cleft group, but not indicating a consistent pattern of changes always. Whereas in the present study, consistently reduction in the MAFR and DSI across the subjects and conditions were seen. These contradictory results may be because of the variations in the methodology i.e., subject selection, number of subjects, method of analysis. The variations in the DSI values may be largely due to the variations in the jitter (frequency perturbations) after undergoing the vocal loading task. According to Vilkman, Lauri, Alku, Sala, and Shivo (1999) vocal loading task can lead to phonatory threshold shift and increased jitter percentage, which might reflect an impairment of the viscoelastic characteristics of the vocal folds.

This indicates that while using the prosthesis the effect of vocal loading was relatively less than without prosthesis condition. This can be attributed to the reduced physical effort on the vocal folds, which minimizes the vocal fatigue due to the better velopharyngeal closure. The study supports the findings of Warren (1986) who described that larynx has potential to regulate speech aerodynamic events in velopharyngeal dysfunction state

**3) Comparison of velopharyngeal closure with and without prosthesis conditions.**

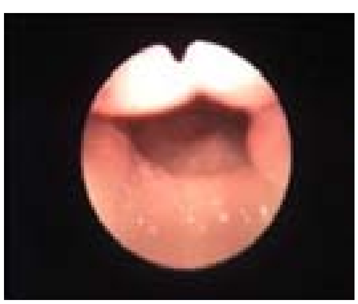


Figure 7: *Without Prosthesis*

Figure 8: *With Prosthesis*

The physiological assessment was done using the nasoendoscopy model number CS 400 to measure the velopharyngeal (VP) closure pattern with and without using prosthesis in individual with submucous cleft palate. Velasco, Ysunza, Hernandez, and Marquez (1988) point out that, individuals with velopharyngeal insufficiency are most likely to demonstrate a coronal closure pattern. Since the musculus uvulae occludes the major portion of the velopharyngeal sphincter in this pattern, its underdevelopment in submucous cleft palate would contribute significantly to the velopharyngeal insufficiency noted in these patients.

In the present study, nasoendoscopic images were taken when the subject phonated prolonged /a:/ in both the conditions (with & without prosthesis). The velopharyngeal closure without prosthesis (Fig. 7) showed gap while an improved closure was observed with prosthesis (Fig. 8). The improved velopharyngeal closure can be attributed to the effect of prosthesis and speech therapy. This result support the findings of Jian, Ningyi, and Guilan, (2002) who reported improvement in velopharyngeal closure by using a temporary oral prosthesis and speech training.

## Conclusions

The velopharyngeal port closure has an effect on the laryngeal airway dynamics and voice quality in an individual with unrepaired submucous cleft palate. The variations in laryngeal parameter were observed with and without prosthesis. The difference was also noticed in vocal loading condition. But the effect was more in subject than compared to controls. However, the results are preliminary in nature and to conclude further studies need to be carried out on the efficacy of using palatal lift prosthesis on laryngeal aerodynamics and voice quality of cleft lip and palate population.

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