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Derived Nasalance Measures of Nasality for Sentences in Children with Repaired Cleft Lip and Palate

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Abstract

***Context*:** Hypernasality is dominant characteristic of speech exhibited by individuals with cleft lip and palate. Hypernasality can be assessed by subjective and objective methods, Nasometer is one of the instrument widely used as a diagnostic and therapeutic tool to estimate nasality. Nasometer provides nasalance values and other two new derived nasalance measures.

***Aim*:** The aim of the present study is to explore the use of derived nasalance measures in differentiating the children with repaired cleft lip and palate (RCLP) with respect to severity and also from control group.

***Settings and design*:** Institutional setup and standard group's comparison design.

Methods and material: The study considered ninety children equally divided into three groups. Group Ia included children with repaired cleft lip and palate (RCLP) exhibiting mild hypernasal and group Ib included children with RCLP exhibiting moderate to severe hypernasal, and group II is typically developing age and gender matched children. The children with RCLP were divided into groups based on perceptual evaluation of hypernasality using a standardized four point rating scale. Nasometer II was used to measure the nasalance values, nasalance distance and ratio for oral and nasal sentences.

***Statistical analysis*:** SPSS, Descriptive statistics and Multivariate analysis (MANOVA) were used to analyze the data.

***Results*:** Increased nasalance value was seen in children with moderate to hypernasal than mild hypernasal and control group. The derived nasalance measures (nasalance distance and nasalance ratio) calculated from mean nasalance were significantly differentiating the children with RCLP based on severity and from the typically developing children.
***Conclusions*:** The new nasalance measures can be used potentially in clinical scenario and may be explored across the various methodological conditions to further evaluate the efficacy of these measures.

***Key-words*:** Nasalance distance, Nasalance ratio, Hypernasality.

Introduction

Nasality is one of the important parameters of resonance aspects related to speech production and perception. The varying shape of the vocal tract results in change of resonance characteristics of speech. Individuals with cleft of the lip or palate (CLP) have disorders in speech dominantly exhibiting hypernasality. They exhibit articulation, resonance and voice disorders leading to unintelligible speech. Among these hypernasality resonance disorder is frequently seen. Nasality is assessed through perceptual or instrumental method.

The speech of individuals with repaired cleft lip and palate and/ or velopharyngeal dysfunction can be evaluated primarily using perceptual evaluation (McWilliams, et al. 1990, Sell, et al. 1990). There is diversity across evaluations procedures in terms of reporting parameters and guidelines for usage, speech sampling procedures. The perceptual rating scales usually vary from four to nine points or even eleven points (Whitehill 2002). Most widely used is the ordinal scale with 5 categories (normal nasality, mild, moderate, severe and very severe hypernasality/ nasal emission). To build a consensus in evaluating, reporting and exchanging the information among the professions and for ease of communication Henningsson et al. (2007) developed a universally standardized speech protocol for reporting speech outcomes in individuals with CLP. However, the differences in inter and intra judge reliabilities are high and there found to be significant variations in the use of methodological procedures of using various test and rating scales to measure the speech and language abilities. Hence, subjective assessment procedures can be a supplement along with the objective measures.

The measure of nasalance using Nasometer is one to the most popular objective diagnostic measure of nasality for individual with CLP. Nasometer is developed by Kay Elemetrics (Pine Brook, NJ) based on the work done by Fletcher (1970, 1972, & 1978). Extensive studies have been reported using Nasometer Model No. 6200 and 6400 (Seaver, Dalston, Leeper, & Adams, 1991; Watterson, Lewis, & Brancamp, 2005). Various studies have focused on developing the normative data across the languages (Haapanen, 1991; Van Doorn & Purcell, 1998; Jayakumar & Pushpavathi, 2005; Devi & Pushpavathi, 2009). Studies have also focused in documenting nasalance values in clinical populations i.e., individuals with CLP or deformity of nose and compared with the perceptual studies (Keuning, Wieneke, Van Wijngaarden, and Dejonckere, 2002).

A study done by Hardin et al (1992) on cleft and non flap cleft subjects correlated the nasalance scores with the perceptual judgments of perceived nasality. Pharyngeal flap surgery was received by 29 of the 51 subjects with cleft palate. The efficiency, sensitivity and specificity of Nasometer as a screening instrument was evaluated using predictive analysis method. Nasal sentences for assessing hyponasality and zoo passage for assessing hypernasality were used as stimulus. The results indicated a good correlation and high sensitivity (0.87) and specificity (0.93) for non flap subjects, than subjects with cleft undergone pharyngeal flap surgery. Hence, the author concluded that efficiency was poorer in individuals who underwent flap surgery.

Another study by Keuning, Wieneke, Van Wijngaarden, and Dejonckere (2002) correlated between the nasalance score and the perceptual rating of several aspects of speech in speakers with velopharyngeal dysfunction (VPD) by six experienced speech-language pathologists. The overall grade of severity, hypernasality, audible nasal emission, misarticulations, and intelligibility were rated on visual analog scales. Speech samples with a normal distribution of phonemes (11.67% of the consonants are nasal) called as normal text - NT and those free of nasal consonants (denasal text- DT) comparable to zoo passage were used for 43 individuals with VPD as stimulus for measuring nasalance. Mean nasalance scores were computed for the speech samples. Results revealed that the correlation coefficients between mean nasalance and perceptual rating of hypernasality ranged among judges from 0.31 to 0.56 for nasal text speech samples and 0.36 to 0.60 for denasal text speech samples.

Sweeney and Sell (2008) conducted a study to explore the correlation between acoustic measurements and perceptual assessment while using controlled speech stimuli. The Temple Street Scale was developed which is based on perceptual evaluation to describe perceived nasality. The study included 50 children with nasality were evaluated using Nasometer to derive nasalance values and perceptual evaluation was performed using Temple Street Scale. The relationship between the perceptual ratings and the Nasometry results were evaluated using correlation analysis, test sensitivity, specificity and overall efficiency. The findings of the study indicated correlation coefficients for perceived nasality and nasalance ranged from 0.69 to 0.74. The sensitivity and specificity of nasalance values ranged from 0.83 to 0.88 and from 0.78 to 0.95 respectively. Its efficiency was between 0.82 and 0.92. The study concluded that the existence of strong relationship studies related to correlation of speech based on nasalance value with perceptual judgments of nasality. This is due to the considerable variation in the magnitude of mean nasalance values of speakers with perceptually normal nasal resonance. This indicates the range of nasality used in speech by normal individuals can vary considerably. Hence it is difficult for judges to determine the limit for normal nasalance just based on perceptual evaluation.

To overcome this limitation, Bressmann, Sader, Whitehill, Awan, Zeilhofer, and Horch (2000) evaluated two measures which are derived from mean nasalance values. Those are nasalance distance (difference between maximum and minimum nasalance) and nasalance ratio (ratio of minimum nasalance to maximum nasalance). The study included 133 individuals with cleft lip and palate exhibiting hypernasality. Nasal view system was used to perform the oral and nasal acoustic measurements. The modified Heidelberg Rhinophonia Assessment Form was used to calculate nasalance distance and nasalance ratio for five non-nasal and three nasal sentences. Optimum cut-offs were derived from Receiver-Operating characteristics. Results revealed that, for the sentence stimuli sensitivity and specificity ranged from 64.4% to 89.6% and from 91.2% to 94.1% respectively. The study concluded that these two new measurements which are valuable in routine clinical examinations can becomes supplements for the nasalance mean value. Hence the present study is aimed to investigate the new derived nasalance measures using the standardized Kannada oral and nasal sentences in Kannada speaking children with repaired cleft lip and palate.

Objectives of the Study

1. To group the children with RCLP exhibiting hypernasality based on perceptual evaluation.
2. To investigate the mean and derived nasalance values (Nasalance Distance - ND and Nasalance Ratio – NR) for oral and nasal sentences in children with RCLP and control group.

Method

Participants: The present study considered ninety children (42 boys & 48 girls) as participants who were divided into three groups. Group I consisted of sixty children with 27 boys and 33 girls with RCLP age ranging from four to twelve years. Only children with repaired cleft lip and palate or cleft palate not exhibiting any associated syndromes, without any ear infections and neurological issues were considered for the study. The control group consisted of thirty age and gender matched typically developing children. All the children included in the study had passed hearing screening, exhibited normal cognitive abilities without any neuromotor dysfunction. The parents and care takers of the participants were requested to provide informed consent.

Table 1

Details of the subjects participated in the study.

Participants	**Mean Age**	**Gender**		**Severity of nasality**
		M	**F**	
Group Ia	8.2	14	16	Mild hypernasal
Group Ib	9.1	13	17	Moderate to severe hypernasal
Group II	8.7	16	14	Normal nasality.

Group Ia = mild hypernasal, Group Ib = moderate to severe hypernasal, Group II = control group, M = Male, F = Female.

Materials: The stimuli used for perceptual analysis consists of spontaneous speech (on self-introduction, school, leisure activities and picture description). The stimuli used for nasalance measures were standardized oral and nasal sentences.

Procedure: The spontaneous speech of children was video recorded in sound treated room by placing the handycam at a distance of 2 feet in front of the child. The recorded speech was subjected to perceptual analysis of hypernasality by three experienced judges (qualified speech language pathologist). The standardized four point rating scale was used by the judges to rate the severity of nasality perceived. The scale is defined as 0 = within normal limits (WNL), 1 = mild, 2 = moderate, 3 = severe. Three reference samples were used prior to the actual perception task to provide familiarity to the judges. These reference samples represented examples of scale points 0, 1, 2, 3 that ranged from normal nasal resonance at 0 to severe hypernasal at 3. The reference samples were selected from the 10 samples based on the 3 experienced listeners' agreement before the perceptual experiment. Written instructions regarding the description given for each rating scale by Henningsson et al. (2007) was provided and reviewed vocally at the beginning of the task.

The calibration of the Nasometer II was carried out by adjusting the headgear according to the instructions provided by the manufacture every day prior to the data collection. Each subject was instructed to repeat the standardized five oral and nasal sentences of six to ten syllable length in Kannada. The standardized Kannada oral sentences (Jayakumar & Pushpavathi, 2005) were selected, where the oral sentences loaded with 90 % oral pressure consonants and nasal sentences with 85% of nasal consonants along with the vowels. Each stimulus was recorded and saved separately for further analysis. The subject was instructed to phonate /a/ and trail one was taken as practice trail, to let the subject get adapted to the procedure. The subject was instructed to repeat the sample with an interval of 2-3 minutes. The phonation of the child was recorded and saved for further evaluation. The analysis was performed by pointing the cursors on the screen from onset to the offset of the stimulus end. The average of the mean nasalance of two trials out of three was calculated. Sentences were recorded only once, as the variability was high in case of production of phonemes and the reliability of nasalance value was reported to be more if the length of the stimulus is around six syllables (Watterson, Lewis, Foley-Homan, 1999) and mean nasalance value was noted.

After obtaining the nasalance values for the five oral and five nasal sentences separately, the mean of the nasalance values for both sets of sentences were considered. The two measures of ND and NR were derived from these mean values using the following formulas: ND (sentences) = Mean nasalance of nasal sentences – Mean nasalance of oral sentences and NR (sentences) = Mean nasalance of oral sentences / Mean nasalance of nasal sentences (Bressmann, et al., 2000).

Instrumentation: For perceptual evaluation the speech of children is video recorded using *Sony handycam with 60 optical zoom, bearing Model no. DCR-SR88.* The standardized four point rating scale developed by Henningsson, Kuehn, Sell, Sweeny, Trost-Cardamone, Whitehill (2007) is used for perceived nasality rating by three experienced speech language pathologists. The nasalance measures were obtained using Nasometer (Model 6400 II, Kay Pentax, and New Jersey) in speech lab.

Statistical Analysis

The mean and standard deviation (SD) were calculated and multivariate analysis was performed using SPSS software to obtain the significance level of the variables in differentiating the groups. Cronbach's Alpha test was administered to measure inter judge reliability of perceived hypernasality between three judges on four point rating scale. Receiver operating curves were used to obtain the sensitivity and specificity of the mean and derived nasalance measures.

Results

a) Perceptual evaluation of hypernasality to group the subjects.

The study included sixty children with RCLP, exhibiting varying degrees of nasality in their speech. The recorded spontaneous speech of these children was subjected to perceptual evaluation of hypernasality by three experienced judges using standardized four point rating scale. The scale is defined as 0 = within normal limits (WNL), 1 = mild, 2 = moderate, 3 = severe (Henningsson, 2007). All these children were grouped on the basis of severity of nasality exhibited in spontaneous speech. Perceptual evaluation revealed, thirty mild, nineteen with moderate and eleven with severe hypernasality. The children with mild hypernasal were considered as Group Ia and children together with moderate and severe were

considered as Group Ib and typically developing children were considered as Group II. Twenty percent of the sample was considered for inter and intra judge reliability of the ratings. The interjudge reliability is 0.83 and intra judge reliability is 0.86 for the perceived hypernasality by three judges indicated high Cronbach's Alpha coefficient.

b) Nasalance measures for oral and nasal sentences.

The nasalance was measured using standardized oral and nasal sentences across the groups. The mean and derived nasalance values for various stimulus is shown below. Table 2 and Figure 1 Illustrates the results for mean nasalance values of oral sentences, nasal sentences, nasalance distance and nasalance ratio with respect to three groups. Children with RCLP exhibited increased nasalance values across the stimuli compared than typically developing children. The difference between the groups was high for oral sentences than nasal sentences. Among the children with RCLP, group Ia (mild hypernasal) exhibited low mean nasalance values than group Ib (moderate-severe hypernasal). The nasalance distance was high for typically developing children (control group) than compared to children with RCLP. Among the groups the nasalance distance was reduced for moderate to severe hypernasal group than mild hypernasal group. The group with moderate to severe hypernasal exhibited increased nasalance ratio than the mild hypernasal group and control group as indicated in Figure 1.

Table 2

The mean and derived nasalance values for oral and nasal sentences across the groups.

Parameters	Oral sentences Mean (±SD)	Nasal sentences Mean (±SD)	Nasalance Distance Mean (±SD)	Nasalance Ratio Mean (±SD)
Group Ia	32.79 (9.7)	52.71 (9.31)	18.5 (8.98)	0.63 (0.15)
Group Ib	42.92 (10.9)	55.62 (9.38)	11.8 (7.21)	0.76 (0.10)
Group II	15.25 (5.2)	50.96 (6.26)	35.8 (4.43)	0.30 (0.081)

Notes.

Group Ia = mild hypernasal, Group Ib = moderate to severe hypernasal, Group II = control group, SD= standard deviation.

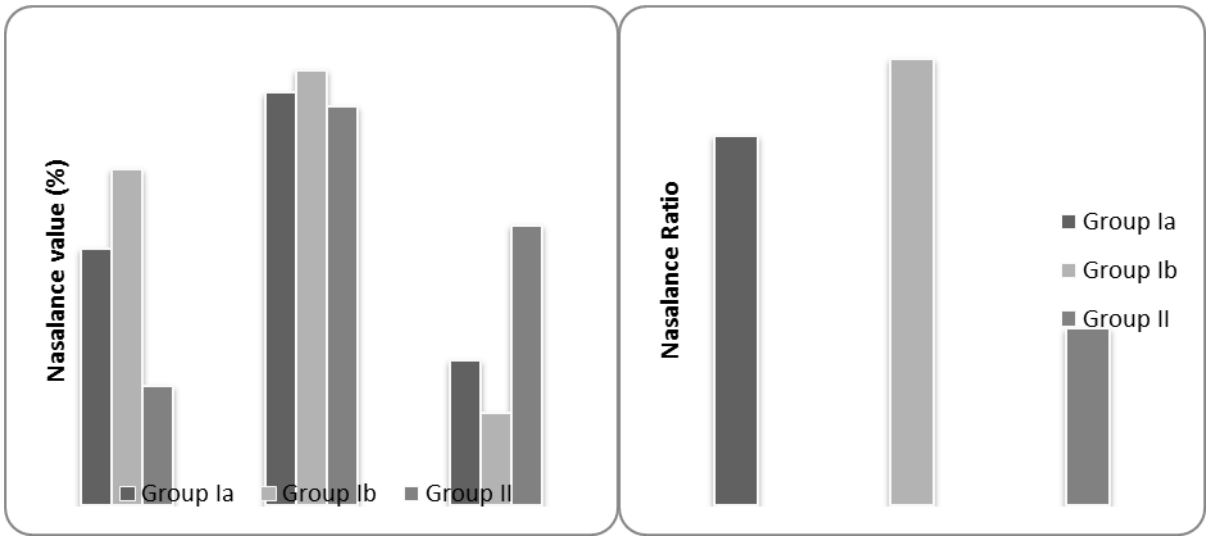

Figure 1: *The mean and derived nasalance values for oral and nasal sentences across the groups.*

Group Ia = mild hypernasal, Group Ib = moderate to severe hypernasal, Group II = control group, OS = oral sentences, NS = nasal sentences, ND = nasalance distance, NR = nasalance ratio.

MANOVA was used to find the differences in mean and derived nasalance measures between the three groups (mild hypernasal, moderate to severe hypernasal and normal) as shown in table 3. The significance values for oral sentences [$F(2,87) = 72.8$, $p < 0.001$] nasal sentences [$F(2.87) = 2.33$, $p < 0.10$], nasalance distance [$F(2,87) = 90.99$, $p < 0.001$], nasalance ratio [$F(2,87) = 116.38$, $p < 0.001$]. The results of MANOVA indicated highly significant ($P<0.01$) difference between the groups for oral sentences, nasalance distance and nasalance ratio. The MANOVA indicated no significant difference across the groups for mean nasalance values of nasal sentences at $p > 0.05$ level of significance.

Table 3

Mean and derived nasalance values differentiating the groups using MANOVA.

Parameters	Oral	Nasal	Nasalance	Nasalance

	sentences	sentences	Distance	Ratio
F (2,87)	72.8	2.33	90.99	116.38
Significance (*p*-value)	0.00	0.10	0.00	0.00

Post hoc multiple comparison using Duncan's test revealed significant differences between the three groups for mean nasalance values of oral sentences, derived nasalance measures (nasalance distance and nasalance ratio) at $p < 0.05$ level of significance. For nasal sentences, normal and moderate to severe groups were significantly different at $p < 0.05$ level of significance.

Discussion

The present study is aimed to evaluate, mean nasalance measures and derived nasalance measures for standardized oral and nasal sentences in Kannada to differentiate children with repaired cleft lip and palate from typically developing children. The perceptual evaluation of severity of hypernasality was conducted using a four point standardized rating scale developed by Henningsson et al (2007) resulted in differentiating the ninety children in to three groups; thirty children with mild hypernasal as Group Ia), nineteen with moderate and eleven with severe hypernasality together as group Ib. The interjudge reliability of perceptual rating among the judges resulted in Cronbach's alpha coefficient of 0.83. This indicates a high reliability among the judges in rating the samples. Even though hypernasality is one of the difficult variables to judge reliably because of the large number of variables influencing the internal standard of hypernasality, the high reliability in the present study was possible because of the experienced listeners and prior training to the listeners was provided using reference samples.

The results of the study support Laczi et al. (2005) who stated that expertise listeners in rating hypernasality were highly reliable than inexperienced listeners. The length of the stimulus (sentences used in present study) is one of the important factors effecting the reliability of the hypernasality ratings, as found by Counihan and Cullinan (1970). The reliability for nasality ratings was higher for sentences followed by single words and isolated vowels. Watterson (1999) on comparison of nasalance scores with the length of the stimuli,

they found that longer the stimulus, the stronger the correlation with the perceived nasality. The results of the study also agrees with by Redenbaugh and Reich (1985) who reported good intrasubject reliability for perceived hypernasality on equal appearing interval ratings for forward played sentences, reliability coefficient of 0.89 and backward played sentences, a coefficient of 0.96 was found.

Nasometry measures are useful in supplementing the perceptual ratings of hypernasality by speech language pathologists. Higher nasalance values were exhibited by group I (mild and moderate to severe hypernasal groups) for oral and nasal sentences than by group II (normal children). The increased nasalance values in children with repaired cleft lip and palate can be attributed to the oral – nasal imbalance due to velopharyngeal impairment. The measurement of oral – nasal acoustic balance (which in essence represents the physical measurement of nasality) has shown that the amplitude of oral nasal balance increases with greater velopharyngeal impairment (Jones, 2000).

The nasalance distance is significantly more for group II (35.8) i.e., typically developing children than group Ia (18.5) followed by group Ib (11.5). As the nasalance distance is the difference of mean nasalance values of oral and nasal sentences, the mild hypernasal and moderate hypernasal groups exhibited high mean values for oral sentences as the perceived nasality is increasing. This inturn reduces the difference between mean values for oral and nasal sentences than the typically developing children. The results are in accordance with the study by Bressmann et al., (2000) indicating high values of nasalance distance for normal resonance (27.31) followed by borderline hypernasality (23.41) and marked hypernasality (17.09). The inverse pattern was observed for values of nasalance ratio (NR) i.e., the NR value was less for group II (0.30) followed by group Ia (0.63) and group Ib (0.76). As nasalance ratio is the division of mean nasalance values for oral and nasal sentences, increased value in the numerator for children with RCLP lead to high nasalance ratio than typically developing children. Similar results were indicated by Bressman, et al. (2000) for nasalance ratio of normal resonance group (0.49), followed by group with borderline hypernasality (0.57) and group with marked hypernasality (0.69).

Conclusion

The study concludes that the derived nasalance measures (nasalance distance and nasalance ratio) calculated from the mean nasalance values of oral and nasal sentences are also significantly differentiating the children with repaired cleft lip and palate based on severity and from the typically developing children. Hence these measures can be used in the clinical scenario to evaluate the children with cleft lip and palate.

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