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Perceptual and instrumental analysis of hypernasality in children with repaired cleft palate

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ABSTRACT

Context: Hypernasality is a frequently encountered problem in the speech of individuals with cleft palate with/without cleft lip (CP ± L). **Aims:** The aim of the present study was to explore the relation between perceptual and instrumental analysis of hypernasality in children with repaired CP ± L. **Settings and Design:** Comparative. **Subjects and Methods:** Children were divided into two groups. Group I included of 30 children operated for CP ± L and Group II included children in the age group of 4 -11 years in the age range of 4–11 years were included in the study. Specially constructed oral sentences in Marathi were used for the perceptual and instrumental analysis of speech. In addition, a number counting task and picture description was recorded for perceptual assessment. Nasal view Dr. Speech "Version 4 was used for instrumental assessment. Perceptual assessment for hypernasality was carried out by listening to the prerecorded speech samples by two experienced speech language pathologists. **Statistical Analysis Used:** Kappa coefficient, Pearson's product moment correlation. **Results:** The results of the study indicated a strong relationship between perceptual rating of nasality and nasalance scores for oral sentences. **Conclusions:** Nasal view was able to distinguish between normal resonance and hypernasality in speech of children with CP ± L.

Key words: Hypernasality, instrumental, perceptual

INTRODUCTION

Hypernasality is most commonly associated with the speech of individuals with cleft palate with/without cleft lip (CP ± L). It is considered as their signature characteristic. Hypernasality is perceived when there is an increase in the nasal resonance which is caused due to coupling of oral and nasal cavities either due to cleft of palate which is unoperated, fistula which may be either anterior or posterior in postoperative palate or due to velopharyngeal dysfunction. Perceptual assessment is the most common and frequently used assessment tool in clinical setup for the evaluation of hypernasality. It is considered as the "Gold standard" against which instrumental measures are evaluated.[1] Perceptual assessment can be done live or may include audio and/or video recording of the speech samples of the individuals. Equally appearing interval scales are most commonly used in clinical settings.

Controversial findings have been reported in the literature regarding the intra- as well as inter-tester reliability of perceptual assessment; with some studies indicating low inter and intra rater reliability;[2-5] whereas others indicating better reliability.[6-11] The reliability may be influenced by a number of factors; most important being the training and experience of the rater. Thus, instruments were developed to quantify the measurement of nasality. The two instruments commonly used are the Nasometer (Kay Elemetrics) and nasal view of "Dr. Speech" (Tiger DRS).

In India, instrumental assessment in spite of being "objective" is not as frequently used as the perceptual assessment due to its nonavailability in clinical settings, monetary constraints, and higher level of

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patient co-operation required, especially for children. It is predominantly used for research purpose and only sometimes clinically for supplementing the perceptual assessments especially for surgical decision making. At the same time, there is also a dearth of "trained ears" to obtain reliable and valid assessment of hypernasality in individuals with CP ± L. Although studies have been done in India and abroad, no study to author's current knowledge has been conducted using sentence stimuli in Marathi language. Hence, there was a need to study the correlation between the perceptual rating of hypernasality and its instrumental measure (Nasalance score) in individuals with repaired CP ± L speaking Marathi.

Aim

The aim of the present study was to explore the relation between the perceptual rating of hypernasality with its acoustic measure (nasalance) in children with repaired CP ± L.

SUBJECTS AND METHODS

Participant selection

The study included 30 children with CP ± L (Group I) and 30 typically developing children (Group II) who were age- and sex-matched to the children in Group I in the age range of 4–11 years. Parental consent was obtained for the inclusion of their children in the study.

Group I

Inclusion criteria

- Children with operated CP ± L with evidence of hypernasality (as judged perceptually by the researcher) with/without articulatory errors
- Children with language age >36 months (as judged informally), i.e., those who could repeat 3–4 word sentences for assessment.

Exclusion criteria

- Children with evidence of normal resonance, hyponasality, mixed nasality or cul-de-sac resonance (as judged perceptually by the researcher)
- Children who had undergone pharyngoplasty
- Children with hearing loss more than moderate degree (as assessed by pure tone audiometry)
- Children with active upper respiratory tract infections at the time of data collection
- Children with known behavioral, sensory, or motor problem or any known syndrome.

Group II (control group)

Inclusion criteria

- Typically developing children from regular schools with no known speech and language delays or disorders who were age- and sex-matched to the children of Group I.

Exclusion criteria

- Children with known hearing loss
- Children with active upper respiratory tract infections at the time of data collection
- Children with known behavioral, sensory, or motor problem.

Participants in Group II were selected by the researcher from a Marathi medium standard school. The children who fulfilled the inclusion and exclusion criteria for Group II were included in the study. Details of the participants are presented in Table 1.

Speech sampling

For perceptual assessment

Speech samples for all the participants were recorded in a quiet environment by the researcher using SONY NWZ-B152F audio recorder kept at a distance of 6 inches from the mouth of the speaker. Speech samples for perceptual assessment for all the children of both the groups were elicited by using the following tasks-picture description, repetition of the pre constructed sentences in Marathi (regional language of state of Maharashtra, India), which are attached as Appendix 1 and counting from 1 to 10, 61–70, and 90–99 in Marathi. The number counting task was used to confirm the presence of hypernasality and absence of other resonance issues. The sentences were especially constructed for the assessment of speech of individuals with CP + CL. They comprised 8 oral sentences completely devoid of nasal consonants. The oral sentences consisted of 4 sentences loaded with high-pressure consonants (p, t̪, ʈ, and k), 2 with low-pressure consonants (l and v), and 2 with pressure-sensitive consonants (s and ʃ).

For instrumental assessment

For instrumental assessment, each participant was seated comfortably with nasal view "Dr. Speech Version 4" head gear placed on the speaker's head with a sound separator. The sound separator had microphone on either side for measuring oral and nasal acoustic component in the participant's speech. The nasal view was calibrated before recording speech sample of each participant. Each participant was asked to repeat the same 8 test sentences which were used for perceptual assessment after the clinician. Output from each microphone was pre-amplified by the nasal view using a custom made dual channel amplification system, from which it was fed to the right (nasal) and left (oral) line input channel of a Sound Blaster 16. The Sound Blaster16 board allowed two channels recording at sample rate up to 44 kHz. Each

Table 1: Distribution of all the participants in Group I by age, sex, and type of cleft

Age range (years)	Number of participants	Sex		Type of cleft		
		Male	Female	Unilateral cleft lip and palate	Bilateral cleft lip and palate	Cleft palate only
4-5	8	4	4	6	1	1
5-6	7	4	3	5	2	-
6-7	7	3	4	4	1	2
7-8	2	2	-	1	-	1
8-9	1	-	1	1	-	-
9-10	1	-	1	-	1	-
10-11	4	2	2	1	2	1
Total		15	15	18	7	5

sentence was then recorded directly in the hard disk and then stored to WAV format. The nasal view had an inbuilt analysis system for the measurement of Nasalance which was displayed on the screen alongside the waveforms. The nasalance for each sentence for each participant was stored in the recording sheet prepared for the purpose. The sentences were recorded in the following order:

- Sentences 1–4: Sentences loaded with high-pressure consonants
- Sentences 5–6: Sentences loaded with pressure-sensitive consonants
- Sentences 7-8: Sentences loaded with low-pressure consonants.

Assessment of speech samples collected

Perceptual assessment

Two speech language pathologists (SLP) with a minimum experience of 5 years in perceptual assessment of cleft speech completed the assessments.

Prerecorded speech samples of the individuals of the two groups were mixed and randomized and played, under headphone condition in a quiet room. The SLPs, rated the nasality of the participant independently in two parts:

1. The SLPs analyzed the samples for the presence of normal resonance/hypernasality/hyponasality/mixed nasality/cul-de-sac resonance
2. Only the samples identified as having hyper nasality were rated on a 5-point rating scale.

The rating scale which was used in the department for clinical purposes was used for the present study. It was as follows:

0- Normal resonance
1- Minimal hypernasality
2- Mild hypernasality
3- Moderate hypernasality
4- Severe hypernasality.

One sample which was rated to be hypernasal by the researcher but rated as having mixed nasality by a rater was excluded from further analysis. Samples for which there was a discrepancy between the two primary raters were given to the third rater (SLP) with a minimum experience of 5 years in perceptual assessment of cleft speech. In such cases, rating of the third rater was considered for analysis. In all the samples, where there was a discrepancy, the rating of the third rater did match with one of the primary raters. The information on the type of resonance and rating of hypernasality was entered in the recording data sheet prepared for the purpose.

Twenty percent of the samples (Group I and Group II mixed) were given again to both the judges to determine the intrarater reliability after a minimum gap of 1 week post first assessment.

Instrumental assessment

The analysis of nasalance for all sentences as computed by the Nasal View software ('Dr Speech' Version 4 Tiger DRS) was recorded and stored in the recording sheet. The values considered for analysis was mean nasalance (as calculated by nasal view software). These were then tabulated for further statistical analysis.

Statistical analysis

For studying inter- and intra-rater reliability for the two judges, kappa coefficient was calculated.

Mean and standard deviation (SD) values of nasalance were calculated for each sentence types and all the sentences together for both the Groups. To compare the mean nasalance scores of both the groups, multivariate analysis of variance (MANOVA) was used.

The relationship between the perceptual assessment of hyper nasality and its instrumental measure, i.e., Nasalance was studied using the Pearson product moment correlation. SPSS for Windows, Version 17 was used for all the statistical analyses

RESULTS AND DISCUSSION

Perceptual ratings of nasality for Group I

All the speech samples of participants in Group I were

rated to be hypernasal. The distribution as per the degree of hypernasality was as given in Table 2, which indicates that more than 50% of the children had moderate hypernasality, whereas severe hypernasality was present in only one child with CP ± L.

Perceptual ratings of nasality for Group II

Speech of all age- and gender-matched typically developing children was found to have normal resonance.

Reliability of perceptual ratings

The Kappa coefficient was 0.64 for interrater reliability, which suggests substantial agreement between the raters.

Intrarater reliability was 0.65 for rater 1 and 0.84 for rater 2, which indicates a substantial agreement between the first and the second readings for both the raters for 20% of the samples.

The good inter- as well as intra-rater reliability obtained in the present study could have been due to the good quality of recordings with good listening conditions during analysis and experience of the raters in perceptual assessment of hyper nasality. Rater 1 had experience of more than 10 years, and rater 2 had experience of more than 20 years in perceptual analysis of cleft speech. Both these factors have been identified as contributing to better reliability.[7,12]

Research also indicates that a scale with less scale points increases the inter- and intra-rater reliability.[8,13] The rating scale used in the present study was a 5-point scale with rating solely of hypernasality. Simultaneous rating of various parameters such as hypernasality, nasal emission, misarticulation, and intelligibility by the listener reduces the reliability and efficiency of the readings.[3] Parameters other than hypernasality were not included in the present study.

Instrumental analysis

The mean nasalance and standard deviation were calculated for overall oral sentences, and also separately for the different types of oral sentences (high pressure, low pressure, and pressure sensitive). The mean and SD for the nasalance values for both the groups are given in Table 3.

MANOVA indicated than a significant difference was present in the nasalance scores across Group I and II where F (7, 52) - 93.52, $P = 0.00$, i.e., the nasalance as measured by the Nasal view for the typically developing children and children with cleft lip and palate was found to be different. Thus, the nasalance values obtained on Nasal view could be used to identify the presence of hypernasality.

Further analysis indicated that all the oral sentences were able to distinguish between normal resonance and hypernasality as depicted in Table 4. These results are in agreement with the previous studies.[14,15]

Correlation between perceptual rating of hypernasality and its instrumental measure (Nasalance scores)

Pearson correlation coefficients for the perceptual rating of hypernasality and nasalance scores for overall oral sentences and each sentence type (oral) and nasal sentences are given in Table 5.

Results revealed high correlation of the perceptual and acoustic measures for the overall oral sentences and all the oral sentence types.

Several other studies have also indicated a good correlation between perceptual rating of hypernasality

Table 2: Distribution of participants of Group I as per the degree of hypernasality

Rating of nasality	Degree of nasality	Number of children
0	Normal	0
1	Minimal	4
2	Mild	9
3	Moderate	16
4	Severe	1

Table 3: Mean and standard deviation of nasalance for Groups I and II

Sentence type	Group I		Group II	
	Mean percentage	SD	Mean percentage	SD
Overall oral	32.62	7.43	17.17	3.53
High pressure	34.60	7.63	17.64	3.78
Pressure sensitive	33.09	8.56	16.92	3.88
Low pressure	30.22	8.12	16.37	4.00

SD: Standard deviation

Table 4: Test of between subject effects for Groups I and II

Dependent variable	*F*	Significant
Overall oral	105.75	0.00
High pressure	118.84	0.00
Pressure sensitive	88.66	0.00
Low pressure	70.07	0.00

Table 5: Correlation between nasalance scores and nasality rating for all the type of sentences (oral)

	OA	HP	PS	LP
Correlation coefficient	0.81**	0.81**	0.79**	0.77**
Significant (two-tailed)	0.000	0.000	0.000	0.000

**Correlation is significant at 0.01 level (two-tailed). OA: Overall oral sentences, HP: High pressure, PS: Pressure sensitive, LP: Low pressure

and Nasalance scores ranging from 0.70,[16] 0.74,[10] to 0.82.[17] However, other studies have reported a weaker correlation ranging from 0.34,[18] 0.49,[19] to 0.66.[20] These contradictory findings seen in the literature could have been because of the methodological variability in the studies including thetype of stimuli used, type of instrumentation used, type of rating scale used by the rater, prerecorded versus live analysis of samples, among others.[18,20,21] The high correlation obtained in the present study may be attributed to the carefully constructed speech stimuli used with special emphasis on the phonetic content in the speech samples as the phonetic content may influence the perception of hypernasality.[22,23] The speech stimuli included specially constructed sentences (high pressure, pressure sensitive, and low pressure) and also picture description. The picture description sample is very similar to conversational sample that has been endorsed by researchers[4,24] since it provides important information about the consistency in resonance characteristics. Another factor that could have contributed to this high correlation includes good inter- and intra-rater reliability and use of less point rating scale for perceptual assessment.

CONCLUSIONS

Thus, a good correlation is present between the perceptual and nasalance assessment of hypernasality (using the nasal view) in children with CP ± L when specific speech stimuli are used. The results are however limited for Marathi language and further studies need to be conducted across different languages on larger study samples for the purpose of generalization of the findings.

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Conflicts of interest
There are no conflicts of interest.

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APPENDIX 1

High pressure sentences:
1. pappu papaI kap
2. ʈai ʃeʈeti dzaʈe
3. ʈIllU ʈaʈ vati ɖe
4. pakaʈ kaIrI ʈak

Pressure sensitive sentences:
5. sasa kasav basʈaʈ
6. ʃaʃi akaʃ bag^{h}

Low pressure sentences
7. valavar rava lav
8. ravivarI vaʃar lavlI