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Speech Understandability and Phonological Processes in Kannada Speaking Preschool Children with Repaired Cleft Lip and Palate

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Abstract: **Phonological processes are known to characterize unintelligible speech. The present study is aimed at identifying the type of phonological processes characteristic in children with repaired cleft lip and palate (RCLP) and their relation with speech understandability. The study consisted of ten native Kannada speaking children with RCLP between the ages of 3 to 4 years. A ten minute conversation sample was collected from each of the child which was rated by experienced speech pathologists for speech understandability. Based on their rating the children were grouped into mild and severe groups. Further Kannada Photo Diagnostic Articulation Test was administered and the responses were analyzed for the presence of phonological processes using sound by sound analysis. The guidelines in Computerized Assessment of Phonological Processes in Kannada was used to identify the phonological processes. Later the frequency of occurrence of the processes identified was calculated and its relationship with speech understandability rating was analyzed. The study revealed that there are specific phonological processes which characterize the speech of children with Kannada speaking children with RCLP viz., initial consonant deletion, medial consonant deletion, medial syllable deletion, cluster substitution, retroflex fronting, backing, gliding, progressive assimilation, regressive assimilation and idiosyncratic processes. Also, it was noted that the frequency of phonological processes was higher in the children with severe speech understandability rating compared to mild group. The reasons for such findings are discussed.**

Keywords: **Phonological processes, Kannada language, Speech Understandability.**

I. INTRODUCTION

Children with cleft of lip and palate (CLP) present with both speech and language disorders even post primary palatal surgery. There are various factors which characterize the speech disorder in children with CLP such as velopharyngeal dysfunction, poor articulatory competence and compensatory articulation. Due to these factors children with CLP often have poor speech intelligibility compared to their age matched typically developing peers.

Speech intelligibility is described as how well a speaker's acoustic signal can be accurately recovered by a listener [1]. Measures of speech intelligibility act as an index of severity and measure of functional outcome of the speaker's speech. Various studies in literature report extensive use of speech intelligibility as an outcome measure in children with CLP [2]. Different factors have been reported to influence speech intelligibility in individuals with CLP viz., number of articulatory errors, degree of nasality, stop errors, nasal emissions, presence of compensatory articulation etc., [2], [3], [4], [5], [6].

Use of traditional rating scales of intelligibility however has inherent limitations [7]. To overcome these drawbacks, and make it more applicable to CLP population, a more global outcome measure of speech understandability which is closely related to speech intelligibility has been proposed [8]. Speech understandability is described as the 'degree to which the speaker's message can be understood by the listener' and is rated using a 4-point (0 through 3) severity rating scale [8]. Speech understandability is rated using conversational speech sample alone.

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Speech intelligibility in children with CLP is not only influenced by poor articulatory competence but also by the influence of active, linguistically based phonological disorder [9], [10], [11]. Phonological disorder is identified in a child when he faces difficulty in comprehending the sound system and rules of speech used in his language. Children with such disorder often use patterns of sound errors called as phonological processes, which simplify their speech. Children with CLP have been reported to exhibit various phonological processes for protracted period of time [10]. Processes such as, final consonant deletion, initial consonant deletion, syllable reduction, stridency deletion, cluster simplification, backing, glottal replacement, stopping, velar assimilation, nasal assimilation, nasalization and deaffrication have been reported in children with CLP [10], [12], [13].

Review of literature has revealed that until recently there have not been many studies exploring the relationship between the global measure of speech understandability and phonological processes noted in the speech of children with CLP. Thus the current study is aimed at exploring the relationship between speech understandability and phonological processes in Kannada speaking 3 to 4 year old children with repaired cleft lip and palate (RCLP). The objectives of the study are

1) To investigate speech understandability in Kannada speaking 3 to 4 year old children with RCLP.

2) To identify the phonological processes which characterize the speech of Kannada speaking 3 to 4 year old children with RCLP.

3) To explore the relationship between speech understandability rating and phonological process.

II. METHOD

Participant selection:

Study consisted of ten Kannada speaking children with repaired complete cleft of lip and palate (RCLP). Children were between 3 to 4 years and with a mean age range of 3.7 years. All children considered in the study, reported to the institute with the complain of unclear speech. All the children had undergone surgery between one to one and a half years of age. None of the children had attended speech rehabilitation, post-surgery. Children with sub-mucus cleft, facial cleft, other associated syndromes, hearing loss, history of ear discharge, upper respiratory tract infection and poor intellectual ability were not included in the study. The study was carried out following the ethical rules of bio-behavioral research of the institute [14]. Accordingly, a written consent was obtained from the parents of all the children participating in the study. The details of the participants are given in Table 1.

TABLE 1: Details of the children participating in the study

Groups	3-4 years			
	Female	Male	Total	Average age (years)
RCLP	6	4	10	3.7

Data Collection:

Testing was done individually by the examiner in a quiet room. Each child was seated comfortably on a chair, with a handy camera at a distance of one meter from the child's face, for the purpose of audio video recording. Child was then involved in a conversation with the examiner for ten minutes. The topics included on self-introduction, family members, leisure activities, narration of recent events, favourite play activity etc.,

Each child was given a break period depending on the temperament and later was asked to name age appropriate pictures from Kannada Photo Diagnostic Articulation Test (KDPAT) [15]. This is a standardized test of articulation available in Kannada language. It assesses five short and five long vowels and two diphthongs in word initial positions using 23 pictures. The consonants are tested in initial and medial positions using 72 pictures except /ɭ/ and /ɳ/ which are assessed in word medial positions using four pictures as words in Kannada language do not begin with these consonants. The phonemes tested are based on the age of acquisition. Thus each child considered in the study was made to name 99 pictures in total. If the child was not able to name the picture shown, examiner named the picture and asked the child to repeat the name. The examiner gave a second repetition if the child failed to repeat after her the first time. After the child named the picture or repeated after the examiner, he was asked to repeat the response to check for consistency.

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Analysis:

The samples thus collected were saved in the handy camera and transferred to a computer and labelled appropriately. Thus each child had two files, a conversation sample and recording of KDPAT. The conversation sample of each child was later played to three speech pathologists having more than two years of experience in the field of cleft lip and palate. The speech pathologists then rated the sample individually for speech understandability using a 4-point rating scale which was tabulated accordingly. Following this mode was obtained as the measure of central tendency for the ratings. Thus the ten subjects primarily included were grouped based on the rating into mild, moderate and severe speech understandability. Based on this rating the subjects with speech understanding rating of moderate (2) were eliminated and only subjects with rating of mild (1) and sever (3) were retained. This was done to have clear demarcated groups.

The KDPAT samples of each child belonging to mild group (MG) and severe group (SG) were later transcribed by the first examiner, a native Kannada speaker using International Phonetic Alphabet (IPA) and extension IPA [16], [17]. Twenty percent of the sample was later analysed for inter-rater reliability by second examiner who was also a native speaker of Kannada. It has been stated in literature that the type of processes noted varies depending on language [18]. Taking this into account, data was further analysed sound by sound and the processes identified were grouped into the 35 processes listed in Computerized Assessment of Phonological Processes in Kannada (CAPP-K) (Table 2) [19].

TABLE 2: Phonological processes listed in Computerized Assessment of Phonological Processes in Kannada.

Syllable Structure processes	Substitution Processes	Assimilation Processes
Initial Vowel Deletion	Stopping	Progressive Assimilation
Initial Consonant Deletion	Nasal Fronting	Regressive Assimilation
Medial Consonant Deletion	Dental Fronting	Prevocalic Devoicing
Initial Syllable Deletion	Palatal Fronting	Postvocalic Devoicing
Medial Syllable Deletion	Retroflex Fronting	
Final Syllable Deletion	Velar Fronting	
Epenthesis	Backing	
Reduplication	Affrication	
Metathesis	Palatalisation	
Cluster Simplification	Depalatalisation	
Cluster Deletion	Gliding	
Geminate Cluster Deletion	Vowelisation	
Cluster Substitution	Denasalization	
Cluster Reduction	Lateralisation	
	Delateralisation	
	Monophthongisation	
	Labialisation	

CAAP-K is the only standardized and published work listing the phonological processes in Kannada speaking children between the ages of 2 to 3.6 years. It is reported in CAAP-K that the type of processes noted across the age group remained same with only a decrease in their frequency of occurrence as age increases. Thus processes listed in CAAP-K were considered for the study considering this factor and also by considering the evidence that children with RCLP are delayed in phonological suppression [10]. Processes which were unusual and deviant from the 35 listed processes were classified as idiosyncratic processes. Each type of phonological process thus noted was listed and analysed systematically to see whether the process occurred more than once. Following this, overall percentage of occurrence of phonological processes was calculated for each process for each group separately using the formula "total number of the same processes exhibited by all the subjects in a group / total no of target words spoken by all the participants * 100" [20]. Later, the processes common to both groups were listed and the overall percentage of occurrence was compared across groups.

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III. RESULTS

Speech understandability rating of 3 to 4 year old Kannada speaking children with RCLP:

The modes of speech understandability rating of ten subjects considered for the study are tabulated in table 3. Among ten subjects three subjects viz., B, F and I had a speech understandability rating of mild and subjects A, G and J had a rating of severe and the rest of subjects had rating of moderate. Based on this rating the subjects with speech understanding rating of moderate were eliminated and only subjects with rating of mild and sever were retained and grouped as mild (MG) and severe (SG) respectively as shown in table 4.

TABLE 3: Speech understandability rating of ten subjects

Subject	A	B	C	D	E	F	G	H	I	J
Rating	3	1	2	2	2	1	3	2	1	3

TABLE 4: Subjects grouped into severe and mild based on the speech understandability rating

Speech Understandability Rating	**Severe Group (SG)**			**Mild Group (MG)**		
Subjects	A	G	J	B	F	I

Phonological processes characterizing the speech of Kannada speaking 3 to 4 year old children with RCLP:

The frequency of occurrence of each phonological process for every participant was tabulated (Table 5) following the grouping. It was noted that out of 36 processes there 21 processes noted among SG group and 23 noted in MG group. However, there were only ten processes which were common to all six subjects. Out of the ten, four processes belonged to the category of syllable structure processes viz., initial consonant deletion, medial consonant deletion, medial syllable deletion and cluster substitution; two belonged to category of substitution processes viz., retroflex fronting, backing, gliding; two more belonged to assimilation processes category viz., progressive assimilation and regressive assimilation and lastly idiosyncratic processes were also noted. Thus these ten processes characterized cleft speech among which, syllable structure processes were most often noted followed by substitution, assimilation and idiosyncratic processes.

Relationship between phonological process and speech understandability rating of children with RCLP:

The frequency of occurrence of each phonological process was utilized to calculate respective overall percentage of occurrence for both groups. It was noted that overall percentage of occurrence was higher in SG than the MG in all of the ten common processes except regressive assimilation; viz., initial consonant deletion (SG: 11.11%; MG: 6.06%), medial consonant deletion (SG: 5.72%; MG: 3.03%), medial syllable deletion (SG: 4.70%; MG: 4.04%), cluster substitution (SG: 5.38%; MG: 3.03%), retroflex fronting (SG: 10.77%; MG: 15.82%), backing (SG: 65.65%; MG: 20.20%), gliding (SG: 5.38%; MG: 2.35%), progressive assimilation (SG: 5.72%; MG: 5.05%), regressive assimilation (SG: 1.34%; MG: 4.04%), and idiosyncratic processes (SG: 54.54%; MG: 44.78%).

TABLE 5: Thirty six types of phonological processes as listed in CAAP-K and the type of processes identified in each child of both the groups with overall percentage of occurrence

PP	SG				MG			
	A	G	J	Overall %	B	F	I	Overall %
1	-	-	-					
2	3	17	13	11.11	5	9	4	6.06
3	5	1	11	5.72	5	3	1	3.03
4	1	-	-	0.33		-	-	
5	4	7	3	4.7	7	1	4	4.04
6	-	1	-	0.33		-	-	
7	-	-	-			-	-	
8	-	-	-		1	-	-	0.33
9	1	-	-	0.33	1	-	-	0.33

10	-	-	-			-	-	
11	-	-	-			-	-	
12	-	-	-		1	-	-	0.33
13	6	5	5	5.38	2	6	1	3.03
14	-	1	-	0.33	2	2	5	3.03
15	1	-	-	0.33	4	1	3	2.69
16	8	3	-	3.70	2	-	-	0.67
17	-	-	-			-	-	
18	-	-	3	1.01		-	-	
19	11	4	17	10.77	5	25	17	15.82
20	-	2	6	2.69	2	4	-	2.02
21	92	42	61	65.65	13	37	10	20.20
22	-	-	1	0.33	2	-	7	3.03
23	-	-	-			-	-	
24	-	-	-			-	-	
25	5	9	2	5.38	4	1	2	2.35
26	5	-	7	4.04	1	-	1	0.33
27	-	-	-		1	-	-	0.33
28	-	-	-		1	-	-	0.33
29	-	-	-			-	-	
30	-	-	-			-	-	
31	-	-	-			-	-	
32	7	6	4	5.72	7	3	5	5.05
33	1	1	2	1.34	4	6	2	4.04
34	2	-	-	0.67	1	-	4	1.68
35	-	-	-			-	1	0.33
36	60	30	72	54.54	20	85	28	44.78

PP- Phonological Processes; SG- Sever Group; MG- Mild Group

Syllable Structure processes : 1-Initial Vowel Deletion; 2- Initial Consonant Deletion; 3- Medial Consonant Deletion; 4-Initial Syllable Deletion; 5- Medial Syllable Deletion; 6- Final Syllable Deletion; 7- Epenthesis; 8- Reduplication; 9-Metathesis; 10- Cluster Simplification; 11- Cluster Deletion; 12- Geminate Cluster Deletion; 13- Cluster Substitution; 14-Cluster Reduction.

Substitution Processes: 15- Stopping; 16- Nasal Fronting; 17- Dental Fronting; 18- Palatal Fronting; 19- Retroflex Fronting; 20- Velar Fronting; 21- Backing; 22- Affrication; 23- Palatalisation; 24- Depalatalisation; 25- Gliding; 26- Vowelisation; 27- Denasalization; 28- Lateralisation; 29- Delateralisation; 30- Monophthongisation; 31-Labialisation.

Assimilation Processes: 32- Progressive Assimilation; 33- Regressive Assimilation; 34- Prevocalic Devoicing; 35- Postvocalic Devoicing;

36- Idiosyncratic

IV. DISCUSSION

Speech understandability rating of 3 to 4 year old Kannada speaking children with RCLP:

The three speech pathologists were able to use the speech understandability rating scale with ease. They rated the speech of a child as mild when the speech was occasionally hard to understand and rated severe when speech was difficult to understand to the most part of the conversation. The speech understandability rating scale used in the current study was

proposed by Henningson et al., in 2008 with the intent of enabling speech pathologists all over the world to be more consistent and uniform while rating this perceptual parameter. The rating scale was developed in such a way that it is independent of language spoken by the subject. Therefore due to its universal applicability and language independent nature, the scale was found to be useful and applicable to Kannada speaking children with RCLP. Speech pathologists rating the samples had worked in the area of CLP for more than two years, which made the rating more reliable.

Phonological processes characterizing the speech of Kannada speaking 3 to 4 year old children with RCLP:

It was noted in the current study that there were ten phonological processes which were common to both SG and MG. Among the ten, four processes belonged to the category of syllable structure processes viz., initial consonant deletion, medial consonant deletion, medial syllable deletion and cluster substitution; two belonged to category of substitution processes viz., retroflex fronting, backing, gliding; two more belonged to assimilation processes category viz., progressive assimilation and regressive assimilation and idiosyncratic processes. Children with RCLP are reported to have articulatory incompetency even post-surgery. This in-turn leads to use of phonologic simplifications in their speech (Menn, 1979). Children in the current study had not availed speech therapy post-surgery which could have resulted in the persistence of the processes. Few of the processes noted in this study are similar to that noted by previous studies though the terms used for identifying the processes may vary, for example glottal replacement was also considered as backing in the current study [10], [12], [13].

It was also interesting to note that structure and rules of Kannada language had an influence on the type of phonological processes noted in children with RCLP. For example one of the processes retroflex fronting has not been reported in previous studies because very few languages in the world have retroflex phonemes, Kannada is one such language. Similarly final consonant deletion which is very often reported in European Languages such as English [21], Danish [22], and Swedish [23] is not seen in Kannada speaking children as words in Kannada do not end with consonants.

Relationship between phonological process and speech understandability rating of children with RCLP:

It was noted that the overall percentage of occurrence was higher for all the ten common processes in SG than MG. This finding suggested that the there is a definite correlation between overall percentage of occurrence phonological processes and speech understandability rating of children with RCLP i.e., an increased overall percentage of occurrence of phonological processes in RCLP children adversely affected speech understandability rating. This observation supports the finding of previous studies [9].

Phonological process is a natural phenomenon which occurs as a child is developing his speech and language skills. Nevertheless there are certain phonological processes which have been identified which contribute to unintelligibility such as, cluster reduction, stridency deletion, stopping, final consonant deletion, fronting of velars, backing, syllable reduction, prevocalic voicing and glottal replacement [9]. Presence of similar processes with significantly higher overall percentage of occurrence in SG group differentiated it from MG.

V. CONCLUSION

The current study was aimed at exploring the relationship between speech understandability and phonological processes in Kannada speaking 3 to 4 year old children with RCLP. It was observed that speech understandability rating scale used in the current study is reliable and applicable to Kannada speaking 3 to 4 year old children with RCLP as it is not language dependent. It was noted in the current study that there are ten phonological processes such as initial consonant deletion, medial consonant deletion, medial syllable deletion, cluster substitution, retroflex fronting, backing, gliding, progressive assimilation, regressive assimilation and lastly idiosyncratic processes which characterized the cleft speech of Kannada speaking 3 to 4 year old children with RCLP. It was also noted that overall percentage of phonological processes was quantitatively higher in children with severe speech understandability rating compared to the group with milder rating thus, establishing a positive relationship between the two i.e., as the overall percentage of phonological processes increases the severity of speech understandability rating increases. Thus a child exhibiting poor speech understandability rating warrants a through phonological processes analysis of their speech. Application of appropriate phonological intervention programs can be applied during therapy to improve speech understandability.

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