

An Overview of Vowel and Consonant Production by Four Kannada Speaking Preschool Children with Repaired Cleft Lip and Palate



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Abstract

Greater number of pre-school children with cleft lip and palate (CLP) continue to exhibit atypical consonant production post-surgery. This is often described in terms of type and frequency of phonetic errors such as substitution, omission, distortion and addition. The present study aimed to investigate the phonetic features at word level, in four Kannada speaking preschool children with repaired cleft lip and palate (RCLP) and compare it with typically developing children (TDC). Each child considered in the study was asked to name/repeat age appropriate pictures from Kannada Diagnostic Photo Articulation Test (KDPAT). The responses were audio-video recorded and later transcribed by native Kannada speaking examiner using International Phonetic Alphabet (IPA) and extension IPA. Data thus obtained was analyzed. Results revealed that children with RCLP exhibited more phonetic errors than TDC, with substitution errors being most frequent, followed by omissions and distortions. Analysis of substitution errors further revealed that Kannada phonemes of all place of articulation were equally affected whereas in terms of manner of production, only nasals remained unaffected. Conclusions: The unique phonological features of Kannada do have an impact on the degree, type and frequency of errors noted in children with RCLP.

Keywords: SODA analysis, place and manner of articulation, Kannada language.

Abbreviations: TDC: Typically Developing Children; CLP: Cleft Lip and Palate; RCLP: Repaired Cleft Lip and Palate; IPA: International Phonetic Alphabet; KDPAT: Kannada Diagnostic Photo Articulation Test; SODA: Substitution, Omission, Distortion and Addition Errors; WHO: World Health Organization

Introduction

Phonetic errors in individuals with Cleft lip and palate (CLP) have often been reported in literature by describing the errors, listing the type-frequency of those errors and comparing the same with the typically developing children (TDC) [1]. They are often reported to exhibit substitution, distortion and omission errors in varying degree depending on the age and presence of velopharyngeal inadequacy [2-4]. India, with the second-largest population in the world has 24.5 million births per year, among which, 27,000 to 33,000 are reported with clefts [5]. The phonological features of Indian languages are unique. Kannada is one among the major south Indian languages. It is the official language of the state of Karnataka of India. It has around 35 million speakers [6]. It has five long and five short vowels with different height and placements within oral cavity

(Table 1) [7]. Also there are two diphthongs present in viz /ai/ and /au/ [7].

Table 1: Ten vowels present in Kannada language depicted according to their height and placement.

	Front	Central	Back
High	i i:		u u:
Mid	e e:		o o:
Low		a a:	

Additionally there are 34 consonants in Kannada language (Table 2) which are further grouped as 25 classified and nine unclassified consonants [7,8]. The classified consonants are further divided into groups of five depending on the place of articulation.

Each of these smaller groups consists of unaspirated-voiceless, aspirated voiceless, unaspirated voiced, aspirated voiced and nasal consonants. The remaining 9 unclassified consonants

consists of /j/, /r/, /l/, /w/ /s/, /ʃ/, /ʒ/, /h/and /ʌ/ [7,8]. Additionally consonant /f/ is borrowed form Urdu language is used mostly in loaned words [7].

Table 2: Consonants in Kannada Language depicted according to their place and manner of articulation.

		Labial	Dental	Retroflex	Palatal	Velar	Glottal
Stop	voiceless	p p ^h	t t ^h	ʈ ʈ ^h		k k ^h	
	voiced	b b ^h	d d ^h	ɖ ɖ ^h		g g ^h	
Affricate	voiceless				tʃ tʃ ^h		
	voiced				dʒ dʒ ^h		
Fricative	voiceless	f	s	ʂ	ʃ		h
Nasal		m	n	ɳ	ɲ	ŋ	
Liquid			l r	ɭ			
Glide		w			j		

Adopted from Guntman & Avanzati, 2013 [7]

There are handful of studies which reveal that the phonological development is complete around 4 years in TDC who are native speakers of Kannada [9-13]. However, review of literature revealed that, there are no studies reporting the phonetic errors in Kannada speaking children with CLP. On the contrary, there is availability of extensive research findings about phonetic characteristics of English speaking children with CLP [3,14,15]. These findings however do not warrant their generalization to Kannada speaking population. This is because the number of vowels, number and type of consonants, consonant cluster combinations, the occurrence of phonemes in different positions within a word, etc., vary between Kannada and English [16]. Hence there is a need to explore the phonetic features exhibited in Kannada speaking children with repaired cleft lip and palate (RCLP).

Aim

The present study aimed to investigate the phonetic features in Kannada speaking preschool children with repaired cleft lip and palate (RCLP) and compare with age and gender-matched typically developing children (TDC).

Objectives

- a) To investigate the mean percentage of phonetic (vowels and consonants) errors in children with RCLP and compare it with TDC.
- b) To investigate the mean percentage of substitution, omission, distortion and addition errors (SODA) in children with RCLP and compare it with TDC.
- c) To analyze the errors related to substitutions, based on place and manner of articulation across groups.

Methodology

Participant selection

The study consisted of two groups of Kannada speaking children between three to four years of age. The first group, RCLP, consisted of three boys and a girl with a mean age of 3.25 years. All the children had undergone surgery for unilateral complete cleft lip and palate between one to one and a half years of age. These children had not attended speech therapy post surgery, and were selected by convenience sampling when they reported to the institute for speech evaluation. Presence of submucous cleft, facial cleft or any concomittant syndromes, hearing loss, frequent ear discharge, upper respiratory tract infection and intellectual disability were ruled out using standard clinical protocols.

The second group consisted of age and gender-matched typically developing children (TDC). These children were selected from play-homes in and around the institute. The presence of any disability was ruled out by administering World Health Organization (WHO) checklist [17]. A written consent was taken from the parents of all the children before including them in the study. The study was carried out by following the ethical guidelines of the institute for bio-behavioral research involving human beings [18]. The study was based on comparative design.

Speech sampling procedure

Each child was made to sit comfortably on a chair inside a quiet room with a handy-cam (Sony DCR-SR88) mounted on a tripod stand at a distance of one meter, for the purpose of audio-video recording. Also, a unidirectional microphone was kept at a distance of 10cm from the mouth of the participant, so that the speech sample could be simultaneously audio recorded by

Adobe Audition 3.0. This arrangement was made as there was a potential of losing key acoustic cues required for perceptual analysis with the use of handy camera alone due to fidelity and distance factors. Later each participant was asked to name age appropriate pictures displayed on the computer screen from computerized version of Kannada Diagnostic Photo Articulation Test (KDPAT) [19]. This is a standerdised articulation test in Kannada, which assess the production of phonemes using two to three syllable words. This test assesses ten vowels and two diphthongs in word initial positions only (using 23 pictures). Rest of the consonats are tested in initial and medial positions (using 72 pictures) except /l/ and /r/ which are assessed in word medial positions (using 4 pictures) as words in Kannada do not begin with these consonants. The phonemes are tested based on the age of acqisiton between the age of two to 5.6 years. Thus each child named 99 pictures in total to test these sounds. If the participant failed to name the picture, examiner named the picture and asked the participant to repeat the same. Two repetitions by the examiner were thus given for each child if he failed to name the picture. When the child named the picture or repeated after the examiner, he was asked to repeat the same to check for consistency.

Analysis of speech sample collected

The samples thus obtained were initially transcribed by the first examiner, a native speaker of Kannada using International Phonetic Alphabet (IPA) and extensions of IPA [20,21]. Twenty percent of the entire data was analyzed for inter-rater reliability by the second examiner who was also a native speaker of Kannada. This was further analyzed for the presence of substitutions, omissions, distortions and additions errors (SODA errors). An articulatory error was considered as substitution error if there was a “replacement of an incorrect sound for a target segment (correct sound)” [22] (e.g. /tattari/ for /kattari/ or /ʔattari/ for /kattari/). Substitution of an intended oral consonant by a nasal consonant was also considered under the broad category of substitution [23] (e.g. /mekku/ for bekku/).

An error was considered as omission when “segments that should have been included in standard pronunciations but were absent” [24] (e.g. /o:ti/ for /ko:ti/). Distortion error considered was similar to substitution error, but the substituted sound was

Table 4: Mean percentage of substitution, omission, distortion and addition errors across groups.

	TDC				Mean Percentage	RCLP				Mean Percentage
	T1	T2	T3	T4		R1	R2	R3	R4	
Substitution	1	5	-	1	1.76	56	47	40	40	46.21
Omissions	-	-	-	-	-	3	10	21	3	9.34
Distortions	-	-	-	-	-	5	5	0	13	5.80
Additions	-	-	-	-	-	0	0	0	0	0

“an unacceptable variation within the perceptual boundary of a target phoneme” [22]. If a phoneme was added to the target phoneme in the intended word then it was considered as an addition error (e.g: /nallɖi/ for /nalli/). The mean percentage of SODA was obtained by calculating the ratio of “the number of errors in each type (SODA) to the total number of target words”.

Results

The current study aimed at exploring the phonetic errors present in Kannada speaking preschool children with RCLP. The phonetic errors were further evaluated for mean percentage of substitution, omission, distortion and addition errors. Substitution errors were further analyzed based on place and manner of production in order to understand the articulatory proficiency of the participants. The first objective of the study was to investigate the mean percentage of phonetic errors and compare the same between both the groups. The mean percentage of phonetic errors noted in each group is tabulated in Table 3. It was noted that children in TDC group had a mean percentage of 1.76% whereas children in RCLP group had a mean percentage of 61.61%. Thus children with RCLP had more articulatory errors than their normal counterparts.

Table 3: Mean percentage of articulatory errors across groups.

	TDC				RCLP			
	T1	T2	T3	T4	R1	R2	R3	R4
Total errors	1	5	0	1	65	62	61	56
Mean Percentage	1.76				61.61			

The second objective of the study was to calculate the mean percentage of substitution, omission, distortion and addition errors (SODA analysis) and compare between the groups. The mean percentage of substitution, omission, distortion and addition errors for both the groups has been tabulated in Table 4. The results indicated that children in TDC group exhibited only substitution errors (1.76%) specifically in the medial position of the word list. However, children in RCLP group exhibited substitution (46.21%), omission (9.34%) and distortion (5.80%) errors, in both initial and medial positions equally. Amongst all the errors substitution errors were the most prominent in children with RCLP.

The third objective was to analyze the substitution errors noted in both the groups based on place and manner of production. This analysis would help identify any specific pattern in substitution errors which could be further termed as characteristic feature of children with RCLP. It was noted that children of both the groups did not exhibit any difficulty in producing vowels and diphthongs. Hence they were not explored further. However many substitution errors were exhibited by

consonants. For the ease of understanding, consonants were grouped as high and low pressure consonants. Table 5 shows the common substitutions noted for the high pressure consonants viz., plosives, fricatives, and affricates among children in TDC and RCLP group. Table 6 shows the common substitutions noted for low pressure consonants viz., nasals, approximants, lateral approximants and trills for both groups.

Table 5: Common substitutions noted for high pressure consonants across groups.

			TDC				Common substitutions	RCLP				Common substitutions
			T1	T2	T3	T4		R1	R2	R3	R4	
Plosives	Bilabial	p	-	-	-	-	-	m	-	ʔ	m	ʔ, m
		b	-	-	-	-	-	m	m	m,ʔ	m	ʔ, m
	Dental	t	-	ʈ	-	-	ʈ	h,ʔ	h	ʔ	h	ʔ, h
		d	-	ɖ	-	-	ɖ	h,ʔ	n	n,ʔ	n	ʔ, h, n
	Retroflex	ʈ	-	-	-	-	-	ʔ	ʔ	ʔ	t,h	ʔ, t, h
		ɖ	-	-	-	-	-	m,n	n, j	n, j	n,ɳ	n, m, j, ɳ
Velar	k	-	-	-	-	-	k ^ʰ ,ʔ	h,ʔ	ʔ	h,ʔ	ʔ, h, k ^ʰ	
	g	-	-	-	-	-	g ^ʰ ,ʔ	h	j	n	n, h, j, ʔ, g ^ʰ	
Fricatives	Alveolar	s	-	-	-	-	h	h	ʔ	h	ʔ, h	
	Postalveolar	ʃ	-	s	-	-	h	h	ʔ	h	ʔ, h	
Affricates		ʈʃ	-	-	-	-	ʈʃ ^ʰ	ʃ	-	ʔ	ʔ, ʃ, ʈʃ ^ʰ	
		ɖʒ	-	-	-	-	ʃ, ʔ	ɖʒ ^ʰ ,n	ʔ	n	ʃ, ʔ, n, ɖʒ ^ʰ	

Table 5 shows that only one child among TDC group (T2) exhibited substitution errors. These errors were noted for dental plosives /t/ and /d/ which were substituted by retroflex plosive /ʈ/ and /ɖ/ respectively. However, change in the manner of their production was not observed. In contrast, in children of RCLP group, phonemes of different place of articulations substituted the target high pressure consonants. Among them, the plosive consonants were more often substituted followed by affricates and fricatives. Within the plosives, velar consonants had the most number of substitutions (/g/ substituted by /n/, /h/, /j/, /ʔ/, /g^ʰ/ and /k/ substituted by /ʔ/, /h/, /k^ʰ/). This was followed by retroflex plosives (/d/ was substituted by /n/, /m/, /j/, /ɳ/ and /t/ by /ʔ/, /t/, /h/), dental plosives (/d/ by /ʔ/, /h/, /n/ and /t/ by /ʔ/, /h/) and bilabial plosives (/b/ and /p/ by /ʔ/, /m/). Affricates were also difficult to produce by the children with RCLP and were often substituted (/ɖʒ/ by /ʃ/, /ʔ/, /n/, /ɖʒ^ʰ

/ʃ/ and /ʈʃ/ by /ʔ/, /ʃ/, /ʈʃ^ʰ/) followed by fricatives (/s/ and /ʃ/ by /ʔ/, /h/). With respect to place of articulation, it was noted the children in RCLP group substituted target consonants with consonants in either anterior or posterior place of articulation compared to the target place of articulation. With respect to manner it was noted that children with RCLP often replaced plosives with a glottal stop (/ʔ/) or pharyngeal stops (/k^ʰ/ and /g^ʰ/) or glottal fricative (/h/), or their nasal counterparts (/n/, /m/ /ɳ/).

Affricates on the other hand were replaced by either glottal stops (/ʔ/), glottal fricative (/h/), nasals (/n/) or pharyngeal affricates (/ɖʒ^ʰ/ and ʈʃ^ʰ). Analysis of fricatives revealed that they were substituted by glottal stops (/ʔ/) or glottal fricatives (/h/). It was also noted that the voiced consonants were more often substituted than the un-voiced high pressure consonants.

Table 6: Common substitutions noted for low-pressure consonants across groups.

			TDC				RCLP			
			T1	T2	T3	T4	R1	R2	R3	R4
Nasals	Labial	m	-	-	-	-	-	-	-	-
	Dental	n	-	-	-	-	-	-	-	-
	Retroflex	ɳ	n	n	-	-	n	n	-	n
Approximants	Labiodental	v	-	-	-	-	-	-	ʔ	-
	Palatal	j	-	-	-	-	ʃ	-	v	-
Lateral approximant	Dental	l	-	-	-	-	n	n	n	n

	Retroflex	ɭ	-	l	-	-	n	n	-	n
Trill	Dental	r	-	-	-	ɖ	n	j,n	n	n

Table 6 reveals that three children in TDC group had occasional difficulty in producing three low pressure consonants. Retroflex nasal /ŋ/ by dental nasal /n/ by both T1 and T2, whereas retroflex lateral approximant /ɭ/ by dental lateral approximant /l/ by only T2. In both these condition place of articulation was compromised but manner was retained. T4 substituted dental trill /r/ with retroflex plosive /ɖ/ indicating a compromise in both place as well as manner of articulation.

On the contrary children in RCLP group substituted the target low pressure consonants with various other consonants. Among them, dental trill had most substitutions (/r/ by /n/ and /j/) followed by lateral approximants (/l/ and /ɭ/ by /n/), approximants (/j/ by /ʃ/ and /v/; /v/ by /ʔ/) and nasals (/ŋ/ by /n/). With respect to place of articulation, it was noted that most of the target low pressure consonants were often replaced by dental /n/ and occasionally by palatal /j/, labiodental /v/ and glottal /ʔ/. With respect to manner, nasal /n/ predominately substituted all the low pressure consonants. It was noted that children in RCLP group did not have any difficulty producing the labial and dental nasal consonants /m/ and /n/ respectively.

Discussion

The present study aimed at identifying and exploring the phonetic errors present in the speech of children with RCLP and comparing the same with TDC. SODA analysis and error analysis based on place and manner of articulation were done to understand the articulatory proficiency of children with RCLP. The results indicated several interesting points. The first point highlighted that the mean percentage of phonetic errors seen in children with RCLP was higher than that of TDC. This has also been reported by earlier studies [14,15,24-26]. Children in RCLP group had been operated between the age of one to one and a half i.e., after the initiation of verbal communication. They also had not availed the service of speech therapy post surgery and received less speech and language stimulation at home. These factors could have resulted in the increase in the mean percentage of phonetic errors in children with RCLP.

The second objective of the present study was to analyze the articulatory errors. These errors were broadly classified into substitution, distortions, omission and addition errors (SODA errors). Children in the TDC group exhibited only substitution errors whereas children in RCLP group exhibited substitution errors most frequently followed by omission and distortion errors. This finding is, however, contradicting the findings reported by various authors [2,14,27]. Presence of high substitution and omission errors than distortion errors indicate that the children with RCLP have lower articulatory proficiency [3,28]. The discrepancies between the previous

studies and current study could also be attributed to difference in the number of children considered for the study, the age range, methodological differences, language differences or a combination of these factors. It can also be speculated that number of consonants used in Kannada language and their place within the words (initial or medial positions of the word only) could also be a reason for this observation.

The substitution error analysis reveals few finer details of the speech production abilities of children with RCLP. Firstly phonemes produced at all possible place of articulation in Kannada language were effected. Secondly all phonemes were produced either with anterior place of articulation (labials or dentals or palatals) or posterior place of articulation (glottals or pharyngeals). Earlier studies have also reported that children with repaired cleft often prefer to produce phonemes in the extremities of the vocal tract such as labial / velar / glottal place of articulation [23,29,30]. This could be due to the persistence of velopharyngeal dysfunction (VPD) post surgery [31]. VPD is known to be a cause of compensatory articulation [32]. As the children in the current study were operated after they had gained some form of verbal communication, and did not receive speech therapy following surgery, compensatory articulation persisted in them resulting in the above observation. Thirdly with respect to manner of articulation nasal consonants were not affected. However, stops, affricates, fricatives, trill, lateral approximant, and approximants were found to be affected in decreasing order.

Stops were often alternatively substituted by fricatives or nasals and occasionally as approximant. Stops are phonemes which require sudden release of high intraoral pressure built behind a tight articulatory contact. Children in the current study attempted to imitate this manner of production but the place of articulatory contact was shifted to glottal due to the persistence of compensatory articulation. Thus when there was a release of the contact the air released produces a gottal fricative /h/. Stops were also produced as nasals by the children in the current study. Substitution of nasal for an oral stops by children with RCLP has also been reported by prior studies [33]. This could be due to the persistence of VPD leading to the nasalization of phonemes produced. Stops were also replaced by approximant in few occasions. It is speculated that this could be due to the influence of co-articulation.

Affricates were substituted either by fricatives or stops or nasals. Production of affricates involve sequential complex articulation where a stop is followed by a fricative [34]. Most of the affricates produced by the children with RCLP group were produced as fricatives i.e., eliminating the stop feature and maintaining only the frication feature. But in few instances the stop feature was retained and frication feature was eliminated. However it is important to note that the place of frication

and stopping were both at the different positions in the vocal tract. This observation indicates that children with RCLP have not mastered the complex consonant articulation required for production of affricates. The substitution of affricate by a stop produced at the level of glottis or by an affricate produced at the pharyngeal level as noted in the present study, could be due to the generalized laryngeal or pharyngeal constrictions, a lingering compensatory articulation, characteristic of children with RCLP [3,23,29,30].

Fricative consonants were often substituted by glottal fricatives and occasionally as glottal stops by children of RCLP group. Fricatives are high pressure consonants requiring high pressure build up behind articulatory contact within oral cavity followed by slow release of the air pressure between a small aperture creating turbulence. As children with RCLP in the current study might have had persistent VPD, the place of contact to build this pressure shifted to the glottis, resulting in the production of /h/. However, as these children might have not mastered the slow release of the articulators to produce turbulence, fricatives were sometimes substituted by glottal stops.

Lateral approximants and trill were substituted often by nasals and occasionally trill was substituted by approximant. Persistent use of nasals for lateral approximants and trill in the current study again points to the persistence of VPD. Substitution of a approximant for a trill could be attributed to unsuppressed phonological process [35]. Approximant consonants were one of the least affected class of consonants. They were substituted occasionally by fricative, stops (glottal) or by another approximant. This could be attributed to the developing phonemic use and the types of phonological processes employed which in turn get influenced by individual structural defects [36]. It is important to highlight in the study that though the nasals were retained as nasals the retroflex /ɳ/ was substituted by dental /n/. Children with RCLP have been reported to continue using dental-nasal phonemes for retroflex phonemes post surgery as well [3].

Conclusion

In conclusion, the data from the study revealed that Kannada speaking children with RCLP have more phonetic errors than their age matched counterparts. Findings also reveal that children with RCLP have more substitution errors followed by omissions and distortion errors. Further, substitution error analysis revealed that children with RCLP had difficulty producing phonemes in all place of articulation. However with respect to manner of articulation, nasals were found to be unaffected. The production of stops, affricates, fricatives, trill, lateral approximant, and approximants were found to be affected in decreasing order. The results of the current study imply that language does have an influence on the type of errors noted in children with RCLP. Thus initiation of early speech and language intervention for children with RCLP is important.

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