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# Voice Onset Time (VOT) in Kannada Speaking Children with Cleft Palate: A Pre- and Post-Operative Comparison

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# Abstract

# **Background and Objective**

The speech of children with cleft lip and palate (CLP) is characterized by lack of abnormal intraoral pressure which leads to misarticulation of pressure consonants. This often results in unintelligible speech due to variable voice onset time (VOT) in pressure consonants. Surgical

procedures and speech therapy have often been found to bring adequate changes in the acoustic parameters in the speech of children with CLP. Hence the aim of the present study was to investigate the changes in VOT in children with CLP in the pre and post operative condition and to compare with typically developing children.

## Method

The study included subjects in Group I consisted of five children with unrepaired CLP and palate who underwent surgery later (group II) and group III consisted of age and gender matched typically developing children with normal oro-facial structures. All the subjects were native speakers of Kannada language (a Dravidian language spoken in south India) and were in the age range of 5 -14 years. Eight Kannada meaningful bisyllabic words loaded with stop consonants (/p/, /t/, /k/, /b/, /d/, and /g/) in CVCV combination were selected as stimuli and these words were repeated by the children, which were audio recorded and acoustically analyzed using Praat software.

#### Results

The VOT data was subjected to statistical analysis to compare the changes across and within group. Results showed that VOT in children with CLP was longer in the pre operative conditions compared to that of the control group and VOT in post-operative condition was longer compared to the VOT in pre-operative condition. The results also explore the differences in VOT for pressure consonants based on place/manner of articulation.

# Conclusions

The present study highlights the influence of the surgical correction of the palate on the acoustic characteristics and facilitates understanding the physiological changes in the oropharyngeal system

Key words: Cleft lip and palate, acoustic analysis, palatoplasty, voice onset time.

#### Introduction

Speech is a complex form of human behavior, which is dependent upon the organic framework of central nervous system and the structure of the speaking mechanism of the body. It is also depend upon numerous environmental, psychosocial, and developmental factors. There are many causes for disordered speech, one among them is cleft lip and palate. Speech production in children with cleft lip and palate (CLP) has been studied using various methods. Acoustic analysis of speech is one such method which is used along with perceptual method.

Voice onset time (VOT) is one of the temporal parameter used to study the feature of the production of stop consonants. VOT has been studied extensively in different languages in individuals with CLP. Warren & Mackler's (1968) speculated that, individuals with CLP may have prolonged speech segments such as VOT. This is to give more distinct acoustic cues for the listener.

D'Antonio (1982) reported that the durations of the acoustic-phonetic segments in CVC utterances were found to be longer in individual with CLP when compared that of normals. Forner (1983) studied VOT in children with unoperated CLP and compared with typically developing children. Results revealed that, VOT was found to be longer for voiceless plosives in children with CLP when compared with that of normal children. Shin, Ko, Hong, Suh, Ko & Kim (1998) aimed to develop an objective method of speech diagnostic evaluation for children with CLP in Korea. To assess the velopharyngeal function, they used objective methods, which included Nasometer, nasofiberscopy and computerized speech lab (CSL) for the acoustic analysis. Ten children with cleft palate and fifty one normal children were participated. The test words are composed of the sustained low vowel /a/ and high vowel /i/ for Visi-Pitch, Nasometer and Nasofiberscopy, and /pip/, /pep/, /pup/, /pop/, /pap/ and simple vowels /i, e, u, o. a/ for spectrographic analysis. VOT was analyzed using spectrogram for children with cleft palate. Their results revealed that, VOT in children with CLP was longer than that of control group.

Vasanthi (1999) studied some spectrographic parameters in adults with repaired CLP. VOT was measured in eight Kannada stop consonants in two adults with repaired cleft lip and palate and normal adults. She reported that, VOT for unvoiced stop constants were found to be longer in cleft palate, when compared with that of normals. The results also revealed that, within the unvoiced stops, dental stops had longer VOT in adults with CLP.

Gaylord and Zajac (2006) found that VOT decreased as level of VPD increased in English aspirated, long-lag VOT alveolar stop /t/ by children with unoperated cleft palate. They explained that, this may be a strategy adapted by the child to try to minimize the occurrence of nasal air emission. In contrast, Casal, Dominguez, Fernandez, Sarget,Martinez-Celdran, Sentis-Vilalta & Gay-Escoda (2002) found no significant difference in the VOT of unaspirated stops with short-lag VOT /p, t/ in Spanish-speaking two to three year old children with CLP, when compared to typically developing peers.

Gamiz, Calle, Amador & Mendoza (2006) have studied the factors that modify the measures of VOT as acoustic parameter in operated children with CLP. They aimed to study the VOT in children with operated CLP. Results revealed, an increased VOT, with abnormal teeth occlusion and a normal soft palate function. Also VOT measures were influenced by cleft lip and delay in beginning of ortodoncy. They have also reported of hearing loss associated with increased VOT.

Bechet, Ferbach-Hecker, Sock, Vaxelaire & Stierle (2008) examined the characteristic features of speech production in children with repaired CLP. Six French plosives were embedded in carrier words were recorded several times from eight children which served as stimuli. The recorded and analyzed data from children with repaired CLP were compared with that of four normal children of the same age. Results of their study revealed, significantly longer VOT in children with a posterior cleft palate, regardless of the place of articulation of the consonants.

Deepthi (2008) spectrographically analyzed the speech of children with repaired CLP in the age range of 5-11 years and compared with that of normal children. They were asked to Language in India <u>www.languageinindia.com</u> ISSN 1930-2940 14:2 February 2014 R. Gopi Sankar, M.Sc. (Speech & Hearing), M. Pushpavathi, Ph.D. (Speech & Hearing) and Sathish V.H., MS, DNB (Gen. Surgery), M.Ch., DNB (Plastic Surgery) Voice Onset Time (VOT) in Kannada Speaking Children with Cleft Palate: A Pre- and Post-Operative Comparison produce 12 words loaded with stop consonants. Results revealed that, children with CLP had longer VOT for both voiced and unvoiced stop plosives. Significant difference was not seen when compared with that of the normal children.

Eshghi, Bijankhan, Shirazi & Nourbakhsh (2011) studied the impact of place of articulation on VOT of Persian initial plosive productions for Iranian children with CLP. Fifteen children with CLP and twenty normal children were participated. They were asked to produce seven words in CVC syllabic pattern. The initial consonant of the syllable was a plosive, the vowel was the close, front vowel /i/ and the final consonant was a liquid /r/ or /l/. Results indicated that voiceless plosives /p,t,k/ in children with CLP and normal children followed the general pattern that VOT values increased as the place of articulation moved from anterior to posterior position in both children with CLP and normal children. For voiced plosives the effect of place of articulation on VOT was not significant in both the group. Many studies conducted on VOT in children with repaired CLP. But, very few studies aimed to study VOT in pre and post operative conditions. Hence, the present study was aimed to study the changes in VOT in pre and post operative conditions in children with CLP and to compare with typically developing normal children.

#### Method

*Subjects:* Subjects for the present study included three groups- Group I consisted of five children with unilateral unoperated cleft palate children (UnCP) and same children who underwent palatoplasty were considered as group II (OpCP) (Study group). Group III consisted of five typically developing normal children with normal oro-facial structures (Normal/Control group). The surgical correction was done by the same surgeon and at the same center. Amongst the group with CLP, one child had unrepaired cleft of the hard and soft palate, two children had cleft of the soft palate and two had submucous cleft. The mother tongue of the children was Kannada and they were in the age range of 5 -10 years (Mean age 6.8). WHO ten disability checklist (Singhi, Kumar, Malhi & Kumar, 2007) was used to screen the control group for sensory and motor development. Study group was assessed for following subject selection **Language in India** www.languageinindia.com **ISSN 1930-2940 14:2 February 2014** R. Gopi Sankar, M.Sc. (Speech & Hearing), M. Pushpavathi, Ph.D. (Speech & Hearing) and Sathish V.H., MS, DNB (Gen. Surgery), M.Ch., DNB (Plastic Surgery) Voice Onset Time (VOT) in Kannada Speaking Children with Cleft Palate: A Pre- and Post-Operative Comparison

criteria before and after surgery. They were screened for receptive and expressive language level and children with receptive and expressive levels above four years were considered. Children with average or above average intelligence were considered. Children with other associated neurological problems were not considered.

The same subjects considered in the pre operative condition were included for the postoperative group after they underwent successful palatal closure surgery. The subjects who underwent surgical correction successfully were considered for postoperative recordings. Success of the surgery was certified by a plastic surgeon /maxillofacial surgeon. Subjects with presence of fistula and children who attended more than ten sessions of speech therapy after surgery was not considered for the post sample recording.

*Stimuli & Procedure:* Eight meaningful Kannada Bisyllabic words loaded with the stop consonants (/p/, /b/, /t/, /d/, /k/, and /g/) in the initial positions followed by short vowel /a/ in CVCV combination (e.g. /pata/, /bada/, etc) served as speech stimuli for the present study. Subjects were asked to produce/repeat the words thrice correctly. The sample was recorded using PRAAT software version 5.1.27 (Boersma & Weenink, 2010) which was installed in the computer. Study group samples were collected before and after the surgery. Post surgery sample was collected after three weeks from the date of the surgery. To confirm whether children with CLP uttered the target word correctly, samples were given to Speech language pathologist (SLP's) who is experienced in analyzing cleft palate speech. They were asked to identify whether the subject attempted to utter the target words correctly. The rating was done using four point rating scale. The correctly identified samples were considered for acoustic analysis.

#### **Acoustic Analysis**

The correctly identified speech samples were analyzed for VOT using the PRAAT software version 5.1.27 (Boersma & Weenink, 2010). Both spectrogram and wave form were used for the analysis. Broadband spectrogram with the pre emphasis factor of '0.80' was used to display the words. For the analysis size and bandwidth was fixed to 100 points and 160 Hz hamming

window was used. Spectrogram displayed using monochrome (black and white) in the linear scale. In reference to spectrographic analysis, VOT was measured using cursor as follows,

• *Voice onset time (VOT):* It is the time difference between the release of a complete articulatory constriction and onset of the quasi-periodic vocal fold vibration in a word-initial stop consonant (Lisker and Abramson 1964).



**Figure 1:** Signal and Spectrogram of the VOT for the unvoiced /p/ in the syllable/pa/ and VOT for the voiced /b/ in the syllable /ba/.

#### **Statistical Analysis**

Statistical analysis was done using SPSS 18 version. Descriptive statistics was calculated for the entire group based on the analyzed sample data. To check the significance between the pre and post surgical changes in the VOT, Mann–Whitney U test was used.

#### **Results & Discussion**

The present study was aimed to investigate the VOT in children with CLP before and after the surgical correction and comparing with that of typically developing children. Analyzed samples were subject to statistical analysis.

# a) VOT across pre- and post- operative conditions

The VOT was measured for all the stimuli across the conditions in children with CLP. Table 1 shows the mean and SD for stop consonants across the conditions. VOT for voiced stop Language in India www.languageinindia.com ISSN 1930-2940 14:2 February 2014 R. Gopi Sankar, M.Sc. (Speech & Hearing), M. Pushpavathi, Ph.D. (Speech & Hearing) and Sathish V.H., MS, DNB (Gen. Surgery), M.Ch., DNB (Plastic Surgery) Voice Onset Time (VOT) in Kannada Speaking Children with Cleft Palate: A Pre- and Post-Operative Comparison consonants /b/-49.58 (msec), /d/-60.14 (msec), /d/-70.02 (msec), and /g/ was 48.44 (msec). VOT for unvoiced stop /p/-20.90 (msec), /t/-17.78 (msec), /t/-24.82 (msec), /k/-23.36 (msec) consonants in pre operative conditions. The voiced consonants had longer VOT compared to voiceless consonants in both the conditions. The result of the present study supports the findings of the previous studies by Shin, Ko, & Hong et al 1998, Gamiz, Calle, Amador & Mendoza 2006, Bechet, Ferbach-Hecker, Sock, Vaxelaire & Stierle 2008, Deepthi 2008 who reported increase in VOT in children with CLP. The increase in VOT in unoperated children with CLP is due to the inability to occlude the airstream in the oral cavity.

Voice onset time (VOT)(m.sec)												
Target	CLP-Pre				CLP-Post							
consonants	N	Mean	S. D	N	Mean	S. D						
/p/	5	20.90	7.74	5	23.81	9.08						
/b/	5	49.58	20.69	5	69.52	51.85						
/t/	5	17.78	4.81	5	17.22	10.50						
/d/	5	60.14	37.93	5	65.07	69.07						
/t/	5	24.87	9.75	5	30.61	13.16						
/d/	5	70.02	47.91	5	75.64	25.64						
/k/	5	23.36	16.89	5	27.56	13.44						
/g/	5	48.44	42.32	5	66.60	74.73						

Table 1: Mean and SD of VOT in pre and post operative conditions.

In post operative conditions VOT was found to be longer for both voiced and voiceless consonants the same have been depicted in table 1. To check the significant difference across the condition both the groups were compared using Mann–Whitney U test. Results revealed that there was no significant difference found across the group. Longer VOT seen in post operative condition may be due to the fact that children with CLP continue to use the compensatory

strategy adopted during the pre operative conditions. This may be speculated that, prolongation of segments is part to overdriving of the speech mechanism in CLP (Former 1983).

#### b) VOT across the conditions and groups

Table 2 shows the VOT for stop consonants across the conditions and groups. VOT for /b/-49.58 (msec), / d/-60.14 (msec), /d/-70.02 (msec) and /k/-23.36 (msec) found to be shorter pre operatively, when compared that of normal children. However VOT for /p/-20.90 (msec), /t/-17.78 (msec), /t/-24.87 (msec), /g/-48.44 (msec) was longer preoperatively when compared to that of normal children. This may be attributed that, children with CLP use this as a strategy to adapt in effort to minimize the presence of nasal air emission (Gaylord & Zajac 2006). To check the significant difference across the groups and condition Mann–Whitney U test was used. Results revealed that, there was no significant difference found across the conditions and groups.

Target consonants	Voice onset time (VOT)(m.sec)										
	Normals				CLP-Pre			CLP-Post			
	N	Mean	S. D	N	Mean	S. D	N	Mean	S. D		
/p/	5	16.38	4.21	5	20.90	7.74	5	23.81	9.08		
/b/	5	76.31	43.54	5	49.58	20.69	5	69.52	51.85		
/t/	5	16.72	3.81	5	17.78	4.81	5	17.22	10.50		
/d/	5	96.06	29.45	5	60.14	37.93	5	65.07	69.07		
/t/	5	23.13	5.93	5	24.87	9.75	5	30.61	13.16		
/d/	5	78.93	9.32	5	70.02	47.91	5	75.64	25.64		
/k/	5	33.15	3.41	5	23.36	16.89	5	27.56	13.44		
/g/	5	45.88	19.19	5	48.44	42.32	5	66.60	74.73		

 Table 2: Mean and SD of VOT in all the three conditions.

To investigate changes in the VOT postoperatively, VOT was compared with that of normal group and preoperative condition. Results revealed that VOT for post operative condition for the same children, was /b/-69.52 (msec), /d/-65.07 (msec), /d/-75.64 (msec) and /k/-27.56 (msec) found to be longer, when compared with that of preoperative conditions. Van Lierde et al.,2002; Mora et al., 2007 & 2009 stated that, soft palate and posterior pharyngeal wall approximation during speech can be affected by palatal surgery and these invasive procedures change the velar length, thickness, and consistency. Palatal surgery sometimes leaves scaring and tightening of soft palate muscles and tissue this may lead to shortening of the soft palate. Due to this children may take long time to build intra oral air pressure in the oral cavity which leads to longer VOT post-operatively.

VOT in post-operative condition was found to be shorter when compared to that of normal children the same have been depicted in the error bar graph 1.VOT for /p/-23.81 (msec), /t/-17.22 (msec), /t/-30.61 (msec), /g/-66.60 (msec) had longer VOT post operatively when compared to that unoperated conditions and normals. This may be due to the strategy adopted by the children to produce the words correctly. Even after the surgical correction they continue to use the compensatory articulation which may be a reason for having longer VOT post operatively. Harding and Gurnwell (1998) reported that, surgical correction can not change the passive speech processes. It is possible to change the passive patterns through speech therapy. They also reported, surgical correction alone is unlikely to modify active cleft-type processes, whereas speech therapy should be able to modify active processes. The finding of the present study also indicates the importance of speech therapy after the surgical correction to correct the compensatory articulatory behaviors.



Graph 1: VOT for across the group and conditions

# Conclusions

The present study is aimed to study the changes in VOT in pre and post operative conditions in children with cleft palate and to compare with that of the typically developing children. The results provided an insight in changes of VOT across the condition and groups. Consistent pattern was not observed based on place and manner of articulation. In future, changes in VOT across pre and post operatively could be studied on a larger sample. It would also be interesting to study the effect of speech therapy and measure the changes acoustically.

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