SOME TEMPORAL CHARACTERISTICS OF SPEECH OF CHILDREN WITH UNOPERATED CLEFT LIP AND PALATE

[1]Gopi Sankar R. & [2]Pushpavathi M.

Abstract

Analysis of speech of individuals with cleft palate provides an insight to understand the physiology of CLP speech. The present study was aimed to investigate some temporal characteristics of speech in individuals with unilateral unoperated cleft palate and to compare with typically developing children (non-cleft. A total of 20 children were divided into two different groups ten in each group. Speech stimuli consisted of sixteen bisyllabic meaningful Kannada words loaded with target phonemes combined with consonants in CVCV combination (e.g. /pata/, /bada/ etc) in initial and medial positions. Participants were asked to repeat the words thrice clearly Vowel duration, closure duration and total duration were analyzed using PRAAT software version 5.1.27. The results revealed that vowel duration, closure duration and total duration in children with unoperated cleft palate was found to be longer when compared to that of the control group. The results also indicated significant difference across the group in all the three parameters studied.

Key words*: vowel duration, closure duration and total duration, acoustic analysis, cleft palate.*

Communication is vital for both biological and social existence. Man's most distinct attribute is the ability to communicate by means of visible and audible codes. Human communication depends on a number of elements of which hearing, vision, cognition and normal oral structures are of prime importance. But many birth defects produce gross physical deformities that hamper the normal communication process. Cleft lip and palate (CLP) is one of the most frequently occurring birth defect.

The incidence of cleft lip and palate in India is estimated approximately one in 781 live births (Raju, 2000). It is also estimated that every year nearly 36,000 children with cleft palate are born in India. Tata Institute of Social Sciences conducted a survey, which revealed that only 25% of the individuals with cleft palate have undergone surgery and these individuals were predominantly from districts with higher socioeconomic status. This indicates that majority of the clients from rural areas or lower socio-economic status lack the awareness of the condition and facilities related to intervention of the condition. While surgical repair often takes care of normalizing the appearance in CLP, debilitating speech disorders frequently persist in these individuals with CLP. Speech is considered as one of the primary outcome measures of CLP management and yet its measurement is elusive and challenging for speech-language pathologists. Despite the challenges, there are no common consensuses for speech assessment and measurement approaches for CLP. Forner (1983) spectrographically analyzed the utterances of fifteen children with congenital cleft palate in the age range of 5 to 6 years with varying degrees of hypernasality and compared with fifteen normal children. The stimuli consisted of five consonants nonsense syllables using /p/, /t/, /k/, /tf/ /s/. The stopgap of the plosives and affricate consonants was found to be the most deviant individual acoustic segment.

Vasanthi (2001) studied a few spectral and temporal parameters of speech in two individuals with repaired cleft lip and palate and compared with that of normal adults. She found that, in the first subject, terminal frequency F2 (TF_2) was found to be lower than normals. The frication duration and affrication duration were found to be shorter in individuals with cleft palate. In the second subject, she found omission of initial plosive consonant in words. She reported that, the duration of the following vowel was increased to keep the syllable duration constant. The VOT was found to be longer for unvoiced stops. For plosives, burst duration was not clear and lower F_2 was observed in both speakers. Casal et al (2002) studied the speech of twenty-two children with repaired cleft lip and palate and matched with twenty-two non-cleft children spectrographically. They used Spanish vocalic stimuli /a/, /i/, /u/, /e/, /o/, stop consonants /p/, /t/, /k/ and nasal stimuli /m/. They analyzed first, second formant, burst, voice onset time and duration. Results revealed there was significant difference between the control group and cleft palate group in the first formant of /e/ and in the frequency of the /t/ burst. The results also showed significant difference in the second

[1]Research officer, All India Institute of Speech and Hearing (AIISH), Mysore-06, Email:sankaj2002@gmail.com & [2]Professor in Speech Pathology, AIISH, Mysore-06, Email: pushpa19@yahoo.co.in

formant of vocalic stimuli /a/, in the first formant of /o / and in the second formant of /o / across groups. Their results also indicated significant influence of the cleft lip or its repair on lip rounding for /o/ and /u/. In addition, the difference in tongue position was also attributed as responsible for the differences seen with /a/ and /e/.

Chen, Yang, Wu, Zang, and Wang (2005) have studied acoustic features of the consonant of sixty six individuals who underwent with post-palatoplasty velopharyngeal incompetence (VPI) with that of the normals. The speech stimuli consisted of /da/, /bo/, /ge/, /ji/, /ku/and /qu/ syllables were recorded and analyzed using computerized speech lab (CSL). They analyzed for duration of syllable (Dur), duration of the consonants (CD) and duration of the vowels (VD), voice onset time (VOT), first concentrated frequency of the consonants (F1), second and third concentrated frequency of the consonants (F2) and (F3). They found that significant difference in all the parameters across the group.

Gaylord and Zajac (2006) aimed to analyze the temporal characteristics in children with varying levels of velopharyngeal dysfunction. They considered speech stimuli consisted of ten /ta/ and /da/ phrases mainly consisting of alveolar stops. Stop gap and voice onset time were analyzed using CSL. Stop gap for /t/ was around 142.4 msec and for /d/ was around 153.7 msec. They found that stop gap duration decreased as level of VPD increased in English during production of aspirated. They hypothesized that this may have been a strategy adapted by the child in an effort to minimize the presence of nasal air emission.

Subramaniyam, Savitha and Biji (2011) studied to identify the distribution of glottal stops in individuals with repaired unilateral cleft lip and palate across different voiceless stop consonants in Tamil language. They found following rank order /k/ followed by /t/, /th/and /p/. Based on the wave form pattern they have sub classified in class A and class B glottal stops. In class A glottal stops wave form showed simultaneous voicing without release burst. In class B glottal stop wave form showed lag voicing with release burst. Closure duration for class A glottal stop was reported to be longer (259.4 msec) compared to that of normal subjects. Closure duration for class B glottal stop was reported to be longer (260.4 msec) compared to that of normal subjects. Burst duration of class B glottal stop was 7.3msec) within the range of normal burst duration of the stop consonants.

To summarize, there are very few studies on acoustic analysis of unoperated cleft palate speech. As a part of acoustic analysis, most of the studies are limited only to study the formant frequencies of vowels in individuals with cleft palate. However, there are no studies, which provide insight on detailed acoustic analyses of temporal characteristics of unoperated cleft palate speech. Hence, there is a need to study the temporal characteristics of speech in individuals with unoperated CLP.

The aim of the present study was to investigate, and compare the Vowel duration, Closure duration and Total duration among typically developing children (TDC) and children with unoperated cleft palate.

Method

Participants: Participants for the present study included two groups- Group I consisted of ten typically developing children (TDC) with normal oro-facial structures (normal/control group) and group II consisted of ten children with unilateral unoperated cleft palate (UnCP) (clinical/experimental group)details of the participants is given in table 1.

Table 1: *Details of the Subjects*

Subject No	Children with unrepaired cleft palate group	
	Age/gender	Diagnosis
1	7/F	Cleft of hard and soft palate
2	14/F	Cleft of soft palate
3	6/F	Cleft of hard and soft palate
4	5/F	Submucous cleft palate
5	6/F	Cleft of soft palate
6	5/M	Submucous cleft
7	6/M	Cleft of hard and soft palate
8	9/M	Cleft of soft palate
9	14/M	Submucous cleft palate
10	7/M	Submucous cleft palate

In which, 3 children had unrepaired hard and soft palate, 4 children had submucous cleft and 3 had cleft of the soft palate. All the participants were native speakers of Kannada language and they were in the age range of 5 -14 years. The mean age was around 8.7 years. Control group was screened using WHO ten disability checklists (Singhi, Kumar, Malhi & Kumar, 2007) for sensory and motor development.

Stimuli & Procedure: Speech stimuli consisted of eight bisyllabic meaningful Kannada words loaded with stop consonants (/p/, /ʈ/, /t/, /k/, /b/, /ɖ/, /d/and /g/). Stop consonants in the initial position followed by short vowel/a/ and those in the medial positions preceded by low mid open vowel /a:/ in CVCV combination (e.g. /pata/, /bada/, /a:ta/ etc). Participants were asked to

repeat the words thrice clearly. The data was recorded using PRAAT software version 5.1.27(Boersma & Weenink, 2010) which was installed in the computer for both the groups. To confirm that the individuals with cleft palate uttered the target word, these words were given to Speech language pathologist who is experienced in analyzing cleft palate speech. The judge was asked to identify whether the subject was attempted to utter the target words correctly. The identified samples were considered for further acoustic analysis.

Acoustical Data Analysis

Vowel duration (VD), Closure duration (CD), Total duration (TD) and Voice onset time (VOT) were analyzed using the PRAAT software version 5.1.27 (Boersma & Weenink, 2010). Both spectrogram and wave form was used to analyze the sound segment durations. Each word was displayed on a broadband spectrogram with the pre emphasis factor of '0.80'. The analysis size and bandwidth was set 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, temporal parameters measured using cursor as follows,

- ***Vowel duration (VD):*** It is the time difference between the onset and offset of the vowel.

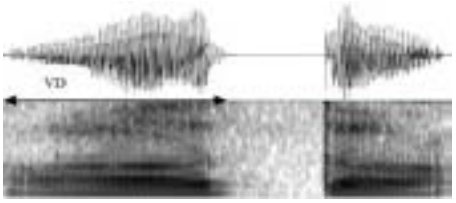


Figure 1: *Signal and Spectrogram of the word /a:ʈa/ (Vowel duration (VD)*

- **Closure *duration (CD):*** It is the time difference between the onset of the closure and the articulatory release in the production of a word-medial stop.

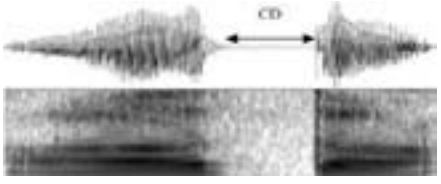


Figure 2: *Signal and Spectrogram of the word /a: ʈa/ (Closure duration (CD)*

- *Total duration (TD):* It is the time difference between the onset of the closure of stop consonants to the onset of the following vowel in word-medial position.

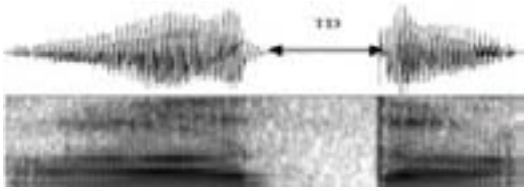


Figure 3: *Signal and Spectrogram of the word /a:ʈa/ (Total duration (TD)*

Statistical analysis: Analyzed data was subjected to statistical analysis using SPSS 17.0 version. Non parametric statistics and Mann-Whitney Test was used to analyze the data.

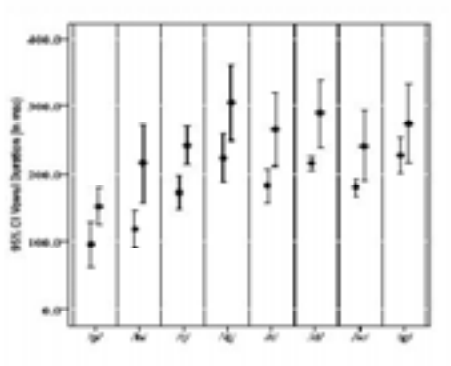
Results and Discussion

The aim of the present study was to study the temporal characteristics of speech in individuals with unilateral unoperated cleft palate conditions and to compare with typically developing children (non-cleft). Descriptive statistics was calculated for both groups based on the analyzed sample data.

Vowel duration (VD): Vowel duration was analyzed from the spectrogram. Table 2 shows the mean, SD and mod Z value for vowel duration for both normal and unoperated CP. It is evident that vowel duration for children with unoperated group was found to be longer when compared to that of the children with control group. Vowel duration was longer for voiced consonants compared to voiceless which was seen for all the stop consonants. Form the table it is evident that the vowel duration increased from /p/ (Normal 96.3msec, UnCP 152.2msec) to /g/ (Normal 227.5msec, UnCLP 274.1msec) same trend was observed for both groups.

Table 2: *Mean, SD and Mod Z value for Vowel Duration (VD) across the group*

VD	Normal		UnCP		Mod Z value	p value
	Mean	SD	Mean	SD		
/p/	98.4	47.1	153.4	37.3	2.34	<0.05
/b/	121.3	38.2	217.8	81	2.72	<0.001
/ʈ/	176.4	34.9	245.4	40.1	2.87	<0.001
/ɖ/	223.1	50.9	305.4	79.9	2.34	<0.05
/t/	182.5	35	265.7	76.2	3.02	<0.001
/d/	215.5	13.3	289.8	64.8	3.18	<0.001
/k/	179.9	16.7	241.4	72.2	3.09	<0.001
/g/	227.5	35.9	274.1	82	1.20	>0.05



Graph 1: *Vowel duration for normal and Unoperated CP group*

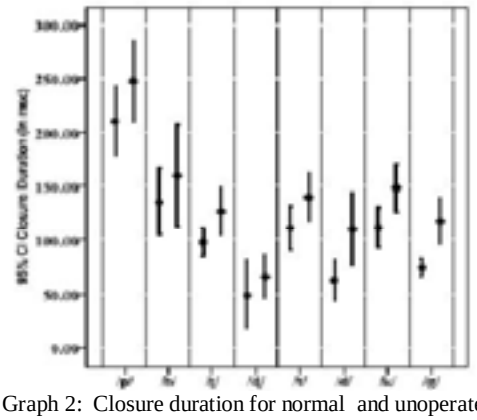
Graphs 1 shows error bar graph for vowel duration for preceded low mid open vowel /a: / for normal and children with unoperated cleft palate. Mann-Whitney Test results revealed significant difference in vowel duration for all the target consonants except /g/ when it is compared across the group. Findings of the of present study related to vowel duration is in support of Casal et al (2002) and Chen, Yang, Wu, Zang, and Wang (2005) they found that, vowel /a/ had longer duration when compared to that of control group. They also reported that, this is due to wider opening of the mouth which leads longer the duration. In children with cleft palate often used abnormal mouth opening and lengthen duration in order to be understood by the listener.

Closure duration (CD): Closure duration was analyzed from the spectrogram. Table 3 shows the mean, SD and mod Z value for Closure duration for both normal and unoperated CP. It is evident that closure duration for unoperated children group was found to be longer when compared to that of the control group. Closure duration was longer for voiceless consonants when compared that of voiced consonants the same trend was observed in both the groups

Table 3: *Mean, SD and Mod Z value for Closure Duration (CD) across the group*

CD	Normal		UnCLP		Mod Z Value	P value
	Mean	SD	Mean	SD		
/p/	210.7	44.7	247.7	52.3	1.361	>0.05
/b/	135.3	42.2	159.4	66.2	0.151	>0.05
/ʈ/	97.9	19	126.9	30.4	2.117	<0.05
/ɖ/	48.9	43.3	66.2	27.3	1.512	>0.05
/t/	111.3	28.3	139.9	30.1	1.816	<0.05
/d/	62.6	24.3	110	44.4	2.858	<0.001
/k/	111.4	25.8	148.2	29.9	2.419	<0.05
/g/	74	10.2	117.6	27.6	3.103	<0.001

From the table it is evident that the closure duration decreased from front /p/ (Normal 210.7msec, UnCP 247.7msec) to back /g/ (Normal 74 msec, UnCLP 117.6msec) same trend was observed for both groups.



Graph 2: Closure duration for normal and unoperated CP

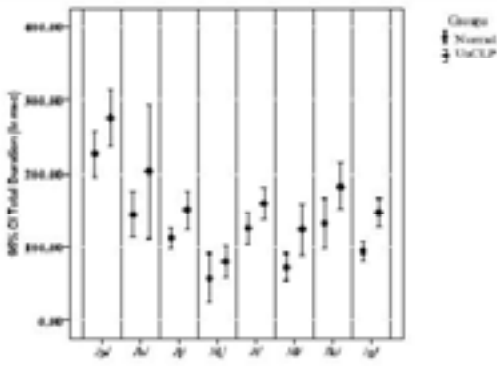
Graph 2 shows error bar graph for closure duration for normal and unoperated CP. From the graph is evident that closure duration for unoperated children group was found to be longer when compared to that of the control group. Mann-Whitney Test results revealed significant difference in closure duration for /ʈ/, /t/, /d/, /ɖ/, /k/, /g/ when it is compared across group. Findings of the present study related to closure duration are in support of Gaylord and Zajac (2006) & Subramaniyam, Savitha and Biji (2011). The overall longer closure duration in the stop consonants could be attributed to exaggerated laryngeal gestures used to compensate for a decrease in oral pressure in the individuals with CLP. Decreased closure duration from bilabials /p/ to velar/g/ may be attributed to involvement of the tongue to help in compensate production of stop consonants. It is reported that children with cleft palate have less mobility of the tongue that occupies a low

posterior portion. Gaylord and Zajac (2006) reported that children with cleft palate have attempt to shorten stop segments to reduce the temporal window for listeners to perceive nasal air emission .They have observed spectral noise in spectrographic analysis of the stop which is most likely resulting from nasal air escape. Hence, children with velopharyngeal dysfunction may be likely to reduce duration of the stop gap in order to avoid prolonged nasal air emission which can be a perceptually distracting speech quality.

Total duration (TD): Total duration was analyzed from the spectrogram. Table 4 shows the mean, SD and Mod Z value for total duration for both normal and unoperated CP. It is evident that total duration for all the target consonants were found to be longer when comparered to that of the control group. Total duration was longer for voiceless consonants when compared that of voiced consonants the same trend was observed in both the groups. Form the table it is evident that the closure duration decreased from front /p/ (Normal 226.4msec, UnCP 275.7msec) to back /g/ (Normal 94 msec, UnCLP 147.6msec) same trend was observed for both control and experimental groups.

Table 4: *Mean, SD and Mod Z value for Total Duration (TD) across the group*

TD	Normal		UnCLP		Mod Z Value	P value
	Mean	SD	Mean	SD		
/p/	226.4	44.7	275.7	54.2	1.588	>0.05
/b/	144.6	43.6	202.7	127.9	0.756	>0.05
/ʈ/	112.2	19.8	151.1	36	2.570	<0.05
/ɖ/	58.8	46.3	81.5	29.4	1.814	>0.05
/t/	126.1	29.8	159.9	31	2.343	<0.05
/d/	73.5	25	124.3	45	2.531	<0.05
/k/	132.4	47.5	182.5	42.7	2.193	<0.05
/g/	94.6	17.5	147	24.7	3.512	<0.001



Graph 3: *Total duration for normal and unoperated CP*

Graph 3 shows error bar graph for total duration of the target consonats for both normal and children with UnCP. Mann-Whitney Test results revealed significant difference in Total duration for /ʈ/, /t/, /d/, /k/, /g/ when it is compared across group. Findings of the present study related to total duration is in support of Chen, Yang, Wu, Zang, and Wang (2005) study. They have reported a significant difference in the duration of the consonants individual with CLP. The reason for increase in the total duration may be due to the prolongation of the phonemes in the target word especially in children with cleft palate. Cleft palate speaker use prolongation as a compensation strategy to achieve a normal production this leads to longer duration.

Conclusions

The results of the present study showed that, children with unoperated cleft group showed longer vowel duration, closure duration and total duration when compared that of the control group. These temporal parameters were compared with across the group results revealed a significant different. The present study also gives information about some temporal characteristics about stop consonants production of children with unoperated cleft palate in Kannada language.

Acknowledgements

We would like to thank The Director, AIISH for permitting us to carry out the study and subjects who have participated in the present study.

References

Boersma & Weenink. (2010) Praat software version 5.1.27. http://ww.fon.hum.uva.nl/praat.

Casal,C.,Dominguez,C., Fernandez,A., Sarget,R., Eugenio,M., Joan,S.,& Cosme,G (2002). Spectrographic measures of the speech of young children with cleft lip and cleft palate. *Folia Phoniatrica et Logopaedica*, 54,247-257.

Chen, Yang, Wu, Zang, and Wang (2005). The acoustic features of the consonants of the patients with post palatoplasty velopharyngeal incompetence. *China journal of oral and maxillofacial surgery*, 4, 279-284.

Forner (1983).Speech segment duration produced by five and six year old speakers with and without cleft palate. *Cleft palate Journal*, 20,185-198.

Gaylord and Zajac (2006). Temporal characteristics of alveolar stop consonants produced by children with varying levels of velopharyngeal dysfunction. Master's thesis submitted to the University of North Carolina.

Raju, S, S. (2000). Study of children born with cleft lip and palates in India. An Unpublished study by Tata Institute of Social Sciences, Mumbai. Cited in Sunitha, R., Monica, J., Manju, S, J., & Nagarajan, R (2004). Providing intervention services for communication deficits associated with cleft lip and/or palate –A retrospective analysis. *Asia pacific Disability Rehabilitation Journal*, 15, 2, 78-85.

Singhi, P., Kumar, M., Malhi, P., & Kumar, R. (2007). Utility of the "WHO Ten Questions Screen for Disability "detection in a rural community—the North Indian Experience. *Journal of Tropical Pediatrics*. 53, 6, 383-387.

Subramaniyam, Savitha & Biji (2011). Acoustic analysis of glottal stop in children with cleft lip and palate. *Proceedings of the 10th Annual meeting of Indian Society of cleft lip, palate and craniofacial anomalies*, 86-87.

Vasanthi (2001). Some acoustic aspects in the speech of cleft palate speakers. Unpublished Masters Dissertation, Submitted to the University of Mysore.