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Clinical Phonetics to Residual Vowel Defects in Speech Communication Corpus of Adult Congenital Bilateral Profound SNHL with Analogue BTE Hearing Aid

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ABSTRACT

***Purpose**: To phonetically assess the vowels in a typical adult congenital bilateral profound sensori-neural hearing loss (SNHL) with analogue BTE (Behind the Ear) level hearing aid user post his completion of long term comprehensive oral aural speech language therapy (LT-CAOLST) in Kannada. To identify the nature of resdiual vowel misarticulations in the dynamics of natural speech communication tasks contexts and draw implications in similar community interaction tasks. **Method**: A natural conversation test TELS-HI in Kannada was administered. Simultaneous recording was done and phonetically transcribed for data generation of the communication speech corpora. This was examined to identify vowel defect patterns called as residual vowel errors. **Results**: Qualitative perceptual phonetic analyses yielded a list of residual multiple vowel defect patterns of all ten vowel of Kannada in word contexts in spite of potential for their normal vowel articulation post 16 years of LT-CAOLST. Further, the misarticulated residual vowel occurrences in speech corpus are in the range of 35.53% to 52.13% of corresponding total vowel occurrences. This has serious implications for his conversation in his community occupation and interactions. **Conclusion**: The analogue BTE level hearing aid use is ineffective for efficient vowel learning and its monitoring at speech communication in congenital bilateral congenital profound SNHL even after 18 years of LT-CAOSLT.*

***Keywords**: vowels, phonetics, misarticulation, residual, analogue BTE hearing aid, bilateral congenital sensori-neural*

hearing loss, articulation, speech disorder, variability, community interaction

INTRODUCTION

Congenital sensorineural hearing loss (SNHL) is a type of permanent hearing loss, or deafness at birth, in which the root cause lies in the inner ear or sensory organ (cochlea and associated structures) or the vestibulo-cochlear nerve (cranial nerve VIII). Incidence of congenital SNHL (Figure 1) is as high as 7% (Varsheney 2016). It has severe impact on speech and language development and subsequent educational achievements.

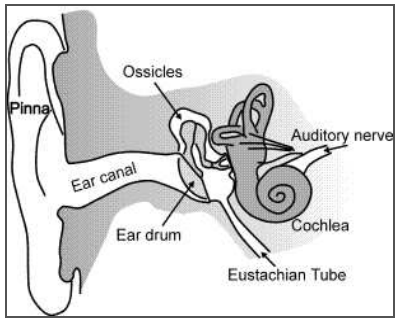

Figure 1. *Anatomy of the ear with inner ear illustrations*

Extensive community based early identification programmes are lacking for early identification with rehabilitation in critical period. Goal of rehabilitation of congenital SNHL is to normalize the speech and language development, main stream to normal schools, and good vocational placement with successful education. Since, sensory- neural hearing loss is irreversible, this population is fitted with hearing device for auditory access of speech information, followed by speech and language therapy. With technological revolutions in the world so far, India has seen a trail of hearing devices. These include the analogue body level hearing device (D0), analogue BTE hearing devise (D1), programmable digital BTE (D3) and the cochlear implantation (D4). The distribution of these devices to young children with

congenital SNHL is not uniform due to heterogonous policy making at large scale free hearing aid fitting by NGOs, or institutions and socio economic status of family of congenital SNHL.

Of all phonetic segments the vowel are early acquired in normal population Banu (1977), Bassi (1983), Kumudavalli (1973). But, since its origin, the literature in hearing impaired which spans nearly a century has depicted vowel defects in the deaf (Numbers Jr (1936); Hudgins (1934); Hudgins & Numbers Jr (1942); Carr (1953); West & Weber (1973); Nober (1967); Smith (1975); Mangan (1961); Ling D (1976); Geffner (1980); Pratt & Tye-Murray (2008); Brannon (1966); Nataraja, Savithri, Sreedevi, Sangeetha (1998); Ramadevi (2006); Sfakianaki, Nicolaidis, Okalidou (2016); Svirsky, Chin (1998); Smith (1975); Ramadevi (2006); Carr (1953); Brannon Jr (1966); Mangan K (1961); Pratt, Tye-Murray (2008); Thirumalai & Gayathri (1980, 1988); Gayathri (2016). These studies have depicted varied vowel defects in their hearing impaired subjects. These comprise the prolongations, nasalizations, diphthongizations, centralizations, substitutions, omissions, additions and lastly are the restricted acoustic vowel space (Shukla 1989). Technological advancements in hearing aids and cochlear implants have emerged and disseminated to India, thus necessitating stratified findings on vowel acquisition in different types of hearing devices. While they specify different vowel segmental defects in the hearing impaired, very few studies have undertaken the studies of residual segmental defects after intervention with a specific hearing device to understand the outcome of treatment. Hardly, few studies are conducted in Indian languages in these directions while all four main types of hearing devices are in use in India. In addition, the impacts of intervention of these devices on segmental acquisition in Indian languages are lacking. Of crucial importance is the study of vowel phonetic behaviors which together contribute to higher proportion in percentages of overall segments in a language.

AIM

Previously, most studies have focused on patterns of vowel defect in developmental or school going deaf children. Aim of the current study is to address the residual vowel defects and performances in natural communication tasks in an adult congenital bilateral profound SNHL integrated into the community after the LT- CAOSLT for 16 years. The impact of analogue BTE hearing aid (Figure 2) for vowel articulation in natural conversation corpus is explored with qualitative clinical phonetics approach in Indian langauge Kannada.

METHODS

A qualitative and perceptual approach is designed for this ongoing study. A male profound adult SNHL with analogue BTE hearing aid whose age was 20 years running a small business in his community was selected for this study of vowels in his speech corpus. His audiogram in Figure 3 denotes only the Residual Hearing Responses in both the ears. There was no response in AC at 2 KHZ and beyond in both ears and absent bone conduction hearing responses throughout testing from 1 KHZ onwards in both ears. Due to vibro-tactile bone conduction responses in low frequencies, they are not a decisive parameter in this audiogram. Absence of BC responses from 1k to 4k is evident at maximum HLs. This participant has congenital bilateral profound SNHL. He has used analogue BTE (behind the ear) hearing aid for 16 years since his age 4 years (Figure 2). His mother tongue and regional tongue is Kannada. Since then, he has attended long term comprehensive oral aural speech and language therapy (LT-COASLT) in Kannada for 16 years. He was also main streamed to normal school upto class 9th and later is accommodated to a vocation of small business in his community.

The purpose of this study was to obtain conversational speech corpora by administering conversation section TELS HI/Kannada (Thirumalai & Gayathri 1980, 1988) and phonetically transcribe and analyze the vowel defects. Dyadic

conversation was recorded on alternate days in successive sessions. Each session ran a stretch of a maximum of 40minutes. A total of five data recording sessions was completed in ten days. The clinician made notes in her diary as the recording and testing were in progress. From these dyadic tasks were generated natural speech corpora for this participant. Hence, multiple phonetic and co articulation contexts for vowels in the spontaneous utterances participant were captured at data generation. Audio recording was performed in all test sessions with digital SONY high quality audio recorder with high quality microphone. Where possible and when the subject found the conversation interesting, prompts were applied at recording to elicit larger speech corpus.

Figure 2. *Behind the ear analogue hearing aids used by subject*

Phonetic transcription was performed by the clinician in sound treated Audiology room with head phones connected to the recording device at Bangalore. The recording was first played two to three times for familiarization and later fine transcriptions were done of defective speech units. A novel IPA transcription documentation is derived and adapted throughout the parent study, with fine attributions wherever needed (Gayathri 2016). Core unit at transcription was phon, placed within its contextual word unit marked by square brackets. Words in turn showed either isolated occurrence or they were parts of phrases, sentences and stretch of utterance. A total of 51 correctly articulated words and 324 misarticulated words are documented with fine phonetic transcriptions as shown in appendix below in Table 1. From this speech corpus is analyzed the phonetic vowel

behaviors in the data of his running speech. Some examples of his phonetically transcribed words are presented below. Their impacts at communication are inferred.

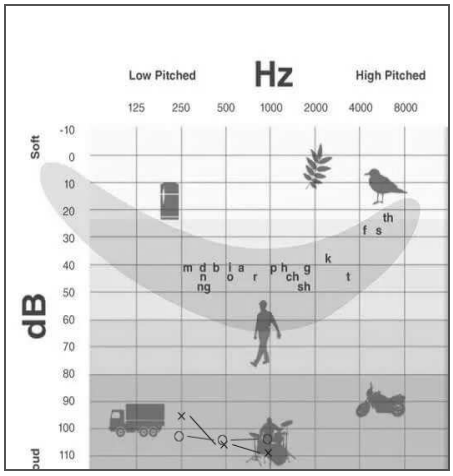

Figure 3. *Audiogram showing residual hearing of the subject*

RESULTS

Comparisons of phonetically transcribed vowels to phonetic characteristics of target vowels in Kannada reveals multiple residual vowel defects prevailing in participant's natural communication. There are a total of 10 vowels in Kannada language (Upadhyaya 1972). Articulation of all these vowels in this subject remains a persistent and prevalent problem, post completion of long term comprehensive aural oral speech and language therapy (LT-CAOSLT) for 14 years. His speech is characterized by the following phonetic vowel behaviors in word utterances in Kannada which is the regional and mother tongue and educational language of this participant.

1. All vowels are acquired – As mentioned above Kannada has ten vowels. In many contexts of participant's communication, it is noted that he has the potential to articulate all of them with accuracy.

2. Variability – but, at the same time all vowels are also misarticulated with high degree of variability in communication. This means that a vowel is articulated properly in some words, but misarticulated in some other words.
3. Substitution error – an alternate vowel is substituted for target vowel. This substituted vowel is either from within Kannada language or an alien one. E.g. [i] is substituted for [e] or by vowel [ae] which is not found in Kannada : *illa* for ella: *aeaenu* /*eenu*
4. Omission of vowels in words – *mane* is articulated as *man*
5. Two-vowel complex phon is substituted for pure vowels n Kannada sounding like diphthongs and hence is called as diphthongization defect ou/u in *monne* as *mounnee*. This particular defect causes immense conspicuousness in the listener of his speech.
6. Vowels get nasalized like in *kaNNu* is uttered as ka~*NNu*, wherein vowel [a] has become a nasal vowel (~)
7. 5 and 6 above also appears together, adding to the calling undue attention to manner of speech, at communication. *duo~*te for *dOse*
8. Same word also presents multiple vowel errors within it causing to difficulty in comprehension of his speech. *baayalli* as *beeyaeli*
9. Even though he has both short and long vowels in his speech they are not used appropriately in all word contexts. E.g.: *mara* as *maara*
10. A combination of vowel errors are also seen for e.g. 5 and 6 have occurred together as [ou~].
11. Frequency of occurrences of vowel errors: Percentage of vowel defects was calculated from total occurrences of respective vowels. This is tabulated in Table 2. Of all vowels, high mid back vowel [o] shows highest frequency of occurrence of errors to a little, more than 50% chance in its overall occurrences in transcribed speech corpus. This is followed by [a, i, u] and [e]. It is evident from the Table 2 that short vowels are more often defective than long vowels. The range of occurrences of vowel errors remains sustained

from 35.53% to 52.13% in 324 error word list. Overall, the vowel defects show a high percentage of occurrences of s post LT-CAOSLT for 16 years with analogue BTE hearing device. The implications of these high degree of occurrences of vowel errors can be understood in the contexts of total frequency of occurrences of target vowels in Kannada. The vowels in Kannada account for 52.18% of all phonetic segments in one lakh words (Ranganatha 1980, 1982; Ratna, Gopal, Gayathri 1980). This means that the vowel errors show possibility of occurrences from a chance of 35.53% to 52.13% in overall 52.12% of vowel phoneme occurrences in in conversation in Kannada. Thus, the vowel defects in this participant in current study have high degree of impact in conversation tasks.

12. In descedning order % misrtciulations of vowels can be arranged as [o,a,i,u,e]. This means that [o] is highly misariculated than all others and [e] is least misrticulated among five vowel sets of Kannada.
13. An examination of each vowel in speech corpus shows multiple types of vowel errors on each vowel phon. For example, vowel [a] in addition to normal vowel articulations in the data shows following patterns misarticulations in 82 of total [a] occurrences in the speech corpus contained in 324 misarticulated words. [a]= 82 ; {a<}(a) ;{a~}(a) ,{A~}(a){a~}(a) ; {a>}(a) ; {A}(a) ; {AA}(a); {AA>}(a) ; {A>}(a) ; {e>}(a) ; {e~}(a), {E}(a) ; {E">}(a); {EE}(a) ; {E>}(a); {EE">}(a) ; {e<}(a); {A">}(a) ; {ou<}(a); {I>}(a); {A.A}(anna) in k{A.A}(a)nnA((DA- shows multiple patters of vowel misarticulations. No vowel of Kannada is spared from misarticulations in this participant's communication data. The rest 51 correctly articulated words contained only Normal vowel articulation .This again comprised all vowels in Kannada.

Thus, it is inferred that vowels in congenital profound degree of bilateral congenital SNHL show persisting vowel misarticulations with their variability post completion of LT-CAOSLT. They are also highly prevalent as can be seen from

Table 2 and clause 11. Not a single vowel of Kannada is spared from vowel defects in their Kannada conversation data. This questions the sufficiency and efficiency of hearing device in use by the participant to manage vowels at articulation which show high frequency of occurrences in Kannada language.

DISCUSSION

The purpose of the parent study is to identify phonetic vowel performances and their defects at natural communication task in congenital adult profound SNHL who has completed 16 years of LT-CAOSLT. In this participant, residual vowel defects remains as a serious permanent phonetic disorder at 35.53% to 52.13% of the time interfering with his communication and in his occupation in his community interactions. Vowels demonstrate multiple patterns of phonetic defects. It is of concern that even the easy low central vowel set [a, A] stand out second ranking in this range of % vowel error. None of Kannada vowels is spared from misarticulations in this participant who is integrated into the community and hence this is a matter of serious concern.

The impact of the residual vowel errors at the participant's conversation task is discussed in this paragraph. This particular participant spoke word after word in at his conversation. His rate of speech was relatively slow than in normal speakers. It is clear from above sections 1 to 12 that he has persistent vowel articulation handicap in spite of having completed the LT-CAOSLT for 16 years. An examination of some words that he uttered in natural communication tasks explains how his speech interferes at semantic inferences of his spoken speech at conversation. Take for example 1. *illa* for *ella.* Here in, *illa means* "no" and *ella* means "all." Similarly in e.g. 2: *maara* for *mara* distorts the intended meaning by the subject from "tree" in *mara* to name or "ferocious man" in *maara* and lastly, *beeyaeli is more close to beeyali* in Kannada . This means "let it cook," *in place of intended word baayall* i which means inside mouth. These examples in current study show implications of misarticulated vowels in communication tasks. Such expressions impede fluent conversation between the speaker and the listener.

Hence, residual phonetic vowel defects sustain in congenital bilateral profound SNHL with analogue BTE hearing aid since his childhood. Vowel errors are also reported in analogue pocket level hearing aid users for more than a century now (Numbers (1936), Ling (1976), and Osberger (1980), Thirumalai & Gayathri 1980, 1988), Monsen (1980), Shukla (1982), Gayathri (2016). Like the analogue pocket hearing aid user Gayathri (2016) even the analogue BTE hearing aid user shows severe degree of multiple vowel defects in natural communication tasks. This study, however addresses continuing vowel errors after integration into the society. Even with analogue BTE hearing aid use and LT-CAOSLT for 16 years, the vowel disability remains in the communication of profound SNHL within his community interactions.

It is evident from this study that even though all vowels are also articulated correctly they are misarticulated in the dynamics of speech communication tasks in this participant drawn from a community occupation. A brief speculation for the high prevalence of persisting residual vowel errors in the context of his analogue BTE hearing device with his profound degree of congenital SNHL is presented in this paragraph. Vowel segments are articulated without constriction in oral cavity. The auditory supports provided by analogue BTE hearing aid are known to be insufficient. Hence, the demands on alternate sensory feedback at vowel articulation in bilateral profound degree of congenital SNHL with his analogue BTE hearing device are high. This is because, dependence on alternate sensory systems at vowels learning such, as visual feed back at learning is also ambiguous. In vowel learning sessions the participant faces ambiguity regarding tongue positioning from visual therapeutic model to his own speech mechanism due to lack of definitive point of articulation and articulatory contacts seen in consonants . He is then left to articulate without efficient auditory feed back with his device at therapy and in social contexts. At the latter juncture, he is devoid of visual feedback which had reinforced his vowel learning in therapy. With lack of efficient auditory feedback, and poor oro-sensory feedback that vowels provide in natural conversation contribute to the challenging nature of articulation

of vowels in this participant. This perhaps causes their phonetic variability and vowel defects in the dynamics of continuously varying phonetic contexts of spoken communication. Thus, difficulty in artciulatory control for vowel articulation in this participant for consistent vowel outcomes is speculated. This has serious impacts on firstly, the education and secondly, in efficacies of social vocational community interactions. A recent publication by Sfakianaki, Nicolaidis & Okalidou (2016), also report several vowel errors in adults with hearing aids.

It is inferred from the above evidences of vowels phonetics in lexicons of speech corpus that the hearing device (fig2) that is in use in this participant with congenital profound SNHL has not helped even the acquisition of trivial articulation of vowels to 100% accuracy even after 16 years of LT-CAOSLT. A similar finding is seen in an extensive preliminary study with analogue body level hearing aid user in congenital bilateral profound SNHL (Gayathri 2016). Congenital SNHL is a diverse population with different degrees and patterns of SNHL. Restraints on universal distribution of analogue hearing aids in large scale free camps in India to the young congenital profound SNHL should be held. It is evident that analogue hearing devices should then also be avoided during waiting time gap for cochlear implantation to avoid the circuitous wrong learning of vowels and re learning of vowels with accuracy in CAOSLT. A hearing aid bank with a repository of better auditory access versions of hearing aids should be considered during this time gap. This report helps in stratified decisions of policy makers for large scale hearing aid dispensing in the community welfare camps.

CONCLUSIONS

In this article is presented lasting vowel phonetic disorders in adult congenital SNHL (D1) with sustained vowel articulation disability even after completion of intensive long term CAOSLT. They remain as a handicap at societal interactions and at his occupation in small business. This has also a key implication to indiscriminate large scale hearing aid dispensing in the community and hearing aid fitting while the cochlear

implantation is awaited in young congenital bilateral profound SNHL population. Multiple residual vowel disorders persist with variability in adult congenital bilateral profound SNHL with analogue BTE hearing aid, post LT-CAOSLT for 16 long years.

IMPLICATIONS

Two main implications from the current study are that large scale dispensing of analogue hearing aids to the population of profound SNHL does not benefit even the vowel articulation. Kumar (2004) and Ray (1988) have pointed to high incidence of total dumbness in north east regions which also includes congenital SNHL in their National Census Studies .For the sake of community welfare and efficacies in subsequent speech language development post LT-CAOSLT indiscriminate dispensing of analogue hearing aids to the congenital profound SNHL should be restrained.

It is emphasized that in order to avoid defective speech learning with analogue hearing aids and re- learning the vowels again with cochlear implantation, analogue hearing aids should not be used in the waiting period for cochlear implantation in the critical period of speech and language development and in young profound SNHL children.

LIMITATIONS

In order to capture the virtual picture of vowel acquisition and to put the participant into the natural stress imposed by multiple linguistic demands the running speech communication data sampling was done. This is however highly time consuming at phonetic transcriptions and phonetic analyses. But this is justified in the context of 16 years of LT-CAOSLT that the participant has undergone and capturing of the realistic data that could happen in community that this study portrays. Parents of three female adolescent profound SNHL with analogue BTE in incidental sampling of this study had turned down on the issue of recording speech for their personal reasons. Hence, in this type of SNHL one participant is studied through his large speech corpora.

However linguistic studies permit single subject large speech corpus sampling as representative to its respective population.

This study is a part parent study undertaken in 2007 to compare the natural connected speech outcomes of the four major hearing devices users after completion of long term aural oral comprehensive speech and language therapy) .A series of heterogeneous results have emerged in this heterogeneous population which will be presented in a series of research papers. Initial analyses however are on vowel acquisition in this population.

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