Journal of Communication Disorders, Deaf Studies & Hearing Aids

Lertsukprasert et al., Commun Disord Deaf Stud Hearing Aids 2018, 6:2
DOI: 10.4172/2375-4427.1000186

Research Article Open Access

Tonal Perception Ability of Thai Children with Cochlear Implants and Hearing Aids

Lertsukprasert K*, Suvanich R, Wattanawongsawang W and Kasemkosin N

Department of Communication Sciences and Disorders, Mahidol University, Faculty of Medicine, Ramathibodi Hospital, Bangkok, Thailand

***Corresponding author:** Krisna Lertsukprasert, Department of Communication Sciences and Disorders, Mahidol University, Faculty of Medicine Ramathibodi Hospital, Bangkok, Thailand, Tel: + 6622012769; E-mail: krisna44@hotmail.com

Received date: October 20, 2018; **Accepted date:**November 21, 2018; **Published date:**December 01, 2018

Abstract

Background: Thai is one of several tonal languages. Accordingly, words spoken with different tones will change their meaning. Sensorineural hearing loss children have difficulty in perceiving tones which is directly related to a low level of speech understanding and intelligibility.

Objectives: This study compared the tonal perception ability of severe-to-profound hearing loss children and profound hearing loss children who used hearing aids and cochlear implants respectively.

Material and methods: Sixteen pre-lingual sensorineural hearing loss children from a preschoolaural rehabilitation program at Ramathibodi Hospital, Mahidol University, were selected. Subjects consisted of 8 bilateral hearing aid children and 8 unilateral cochlear implant children who were trained in the program for more than 3 years and able to produce speech recognition scores. All subjects demonstrated reasonable aided responses with their hearing devices. A Thai tone identification and discrimination test was used in this study. These tests were conducted by an experienced audiologist in a quiet room. The scores of the hearing aid group and the cochlear implant group were compared.

Results: There were significant differences in tonal identification scores and tonal discrimination scores for the cochlear implant group when compared to the hearing aid group ($p<0.05$)

Conclusion: Cochlear implantation provided better tonal perception of Thai lexical tone identification and discrimination of profound hearing loss children than severe-to-profound hearing loss children who used bilateral hearing aids.

Keywords: Cochlear implant; Hearing aids; Hearing impaired children; Tonal perception

Introduction

Thai is a national language spoken by approximately 65 million people. It is classified as a contour –tone language. When the tone changes within the same phonemic segment in tonal languages, the lexical meaning changes. There are five contrastive tones which are defined by the change in pitch level, contour and direction [1]. Each tone yields a different meaning. The characteristics of five tones include three static tones (low, middle, and high) and two contour tones (rising and falling), with average fundamental frequencies [2] as shown in Figure 1. Patients with sensorineural hearing loss have difficulty in the identification of phonemic tones [3] which is one of the most important factors in Thai speech recognition. The ability to identify phonemic tones also depends on the severity of hearing impairment [4]. In cases of severe sensorineural hearing loss, the use of hearing aids and lip reading become less efficient because patients can hear better but they are unable to discriminate between distinctive sounds [1]. Some studies reported that cochlear implantation improves hearing ability and even the detection of speech sounds [5,6]. However, some researchers reported less beneficial tonal perception in cochlear implant patients [7,8].

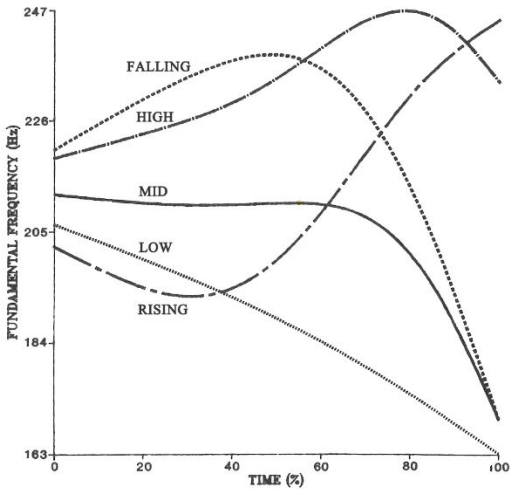

Figure 1: Average fundamental frequency contours of Thai tones on double vowels in word-final Position.

Cochlear implantation has been available to profound hearing loss patients at Ramathibodi Hospital since 1999, but prior research on the tonal perceptions of cochlear implant patients had not been conducted. The present authors developed Thai tonal perception tests which consisted of natural speech tokens of the same root /k^h aa/ with five different tones. Five pictures and words were presented in color and random order on an A4 card. These tests were standardized by measurements of 480 normal Thai children, aged 2 years to 5 years 11 months, from four different areas in Thailand. The purpose of this study was to compare the tonal perception ability of severe-to-profound hearing loss children and profound hearing loss children who used hearing aids and cochlear implants respectively.

Material and Methods

The subjects in this study were 8 severe-to-profound sensorineural hearing loss children with binaural behind-the-ear hearing aids and 8 profound sensorineural hearing loss children with unilateral multichannel cochlear implants. These subjects met the following selection criteria:

- Pre-lingually hearing impaired children, native Thai speakers, and older than 5 years of age.
- At least 3 years of experience using hearing devices and trained in the preschool aural rehabilitation program at Ramathibodi Hospital.
- Demonstrated reasonable aided responses with their hearing devices and were able to produce speech recognition scores.
- No additional handicaps.
- Used oral communication and studied in normal classes
- Parents allowed their children to participate in the study.

Tonal perception tests included a tonal identification test and a tonal discrimination test. There were 10 items for tone identification. The words were sequenced in the test by random draws, twice for each tone. To be significant, a score had to have at least five correct words. Test stimuli for tonal discrimination consisted of four identical tone pairs and six contrastive tone pairs which were randomly selected in each draw. To be significant, a score had to have at least nine correct responses. Instructions and examples were given to subjects prior to testing by a qualified senior audiologist. Subjects were tested with live voices in a quiet room. For tone identification, subjects were asked to point to a corresponding picture when they heard a test tone. For tone discrimination, subjects answered "same" or "different" when they heard the test tone pairs. The scores were collected and analyzed.

Statistical analysis

A Mann-Whitney U test was used to compare the ages between the two groups and a t-test was used to compare the unaided and aided thresholds, the time duration of using hearing devices, and tonal perception scores.

Results

There were 2 girls and 6 boys in the hearing aid group, and 7 girls and 1 boy in the cochlear implant group. The mean age of the hearing aid group was 100.25 ± 40.34 months, while the cochlear implant group was 130.25 ± 46.19 months. The differences in ages between the groups was non-significant (p>0.05) (Table 1).

group	subjects		Mean age ± SD (months)	U	p
	male	female			
Hearing aid	6	2	100.25 ± 40.34	-1.472	0.141
Cochlear implant	1	7	130.25 ± 46.19		

Table 1: Descriptive statistics and age differences of the two groups of subjects.

The differences in mean hearing thresholds of the better ears (unaided) between the two groups was significant (p<0.05) while there was a nonsignificant difference in aided threshold levels between the two groups (Table 2). Nevertheless, this statistically nonsignificant result may be meaningful.

Threshold	group	Mean PTA ± SD (500-2000Hz)(dB)	t	p
Unaided ear	Hearing aid	85 ± 12	-2.796	0.0143*
	Cochlear implant	101.25 ± 11.23		
Aided ear	Hearing aid	30 ± 5.98	-2.000	0.0653
	Cochlear implant	25 ± 3.78		

Table 2: Differences in the unaided and aided thresholds of the two groups of subjects.

The differences in the mean time duration of using hearing devices between the two groups was non-significant (p>0.05) (Table 3). The differences in mean scores on both the identification and discrimination tests of the cochlear implant group were higher than those of the hearing aid group and were significant at p<0.05 (Table 4).

Group	Mean time duration ± SD (yrs.)	t	p
Hearing aid	4.875 ± 1.356	-1.0121	0.329
Cochlear implant	5.625 ± 1.598		

Table 3: Differences in the time durations of use of hearing devices of the two groups of subjects.

Tonal perception	Group	Mean score ± SD	t	p
Identification	Hearing aid	5.25 ± 1.83	-4.66	0.0004*
	Cochlear implant	8.625 ± 0.92		
Discrimination	Hearing aid	5.5 ± 1.77	-5.5841	0.0001*
	Cochlear implant	9 ± 0.00		

Table 4: Differences in the tonal perception scores of children with hearing aids and cochlear implants.

On discrimination ability, both hearing aid group and the cochlear implant group had markedly lowest scores on the contrastive tone pair for the low-rising tone (Table 5). On identification ability, the cochlear

implant group had higher numbers of correct responses on all items while the hearing aid group had lower numbers of correct responses on identifying dynamic tones, and the lowest score was on high static tone perception (Table 6).

Tone discrimination test			Hearing aid group		Cochlear implant group	
			No. Correct	No. Incorrect	No. Correct	No. Incorrect
Identical tone pair	static-static	low-low	5	3	8	-
		high-high	5	3	8	-
	dynamic-dynamic	falling-falling	4	4	7	1
		rising-rising	4	4	8	-
Contrastive tone pair	static-static	mid-low	5	3	8	-
		high-mid	3	5	5	3
	dynamic-dynamic	rising-falling	7	1	8	-
	static-dynamic	low-rising	2	6	4	4
	dynamic-static	falling-low	4	4	8	-
		rising-mid	5	3	8	-

Table 5: Statistics pertaining to the tone discrimination test responses of the hearing aid and cochlear implant groups.

Tone identification test		Hearing aid group		Cochlear implant group	
		No. Correct	No. Incorrect	No. Correct	No. Incorrect
Static tone	low	7	9	14	2
	mid	8	8	13	3
	high	4	12	15	1
Dynamic tone	falling	10	6	11	5
	rising	13	3	16	0

Table 6: Statistics pertaining to the tone identification test response of the hearing aid and cochlear implant groups.

Discussion

The identification of phonemic tones was adversely affected by sensorineural hearing impairment, especially in case of severe loss [4]. Hearing devices help hearing-impaired children to hear better, but the benefits of hearing aid amplification are limited, especially at high frequencies [9]. The subjects in this study were matched by age, aided response and time duration of using hearing devices. The results showed that children with cochlear implants performed markedly better than children with hearing aids on both identification and discrimination tests. Although there were still other factors related to outcomes such as environmental effects and family and economic status, improvement in tonal perception after cochlear implantation was reported in many studies [10] whereas hearing aids were not practical for better tone perception of profound hearing loss children [11-13]. Although children with hearing aids were able to identify tones, their scores were significantly lower than those of the cochlear implant group. Both groups had the lowest discrimination scores on the contrastive tone pair for the low-rising tone. This is probably because the initial fundamental frequencies of tones are similar, which causes difficulty in the discrimination between low and rising tones. Moreover, the hearing aid group appeared to have the most difficulty in identifying high tones, which corresponds to the limitation of hearing aids [9], and the later development of high-tone perception in children. Another factor was the time duration of using implants which has also been reported to have a high very beneficial effect on the auditory performance of cochlear implant children [14-16], which may be associated with neural plasticity consisting of development, compensation, and learning [17,18]. In the present study, children with cochlear implants had experience in using this hearing device for more than 3 years on the average. This experience might help them perform better on both identification and discrimination tests.

Conclusion

Cochlear implantation provided better tonal perception for Thai lexical tone identification and discrimination in profound hearing loss children than in severe-to-profound hearing loss children who used bilateral hearing aids.

Acknowledgements

Part of this study was presented at the Asia Pacific Conference on Speech Language and Hearing 2017, in Narita, Japan. The authors are grateful to all of the hearing impaired children who participated in this study. We also thank Mr. Werapat Punkhla, who provided assistance in statistical analysis of the data.

References

1. Nimitbunnasarn C (1984) Thai tonal perception in hearing-impaired patients (Unpublished master degree dissertation). Mahidol University, Bangkok, Thailand.
2. Gandour J (1979) Perceptual dimentions of tone: Thai. In: Liem N (Ed.) Southeast Asian linguistic studies. Canberra: Department of Linguistics, Australia National University.
3. Buss E, Hall J, Grose J (2004) Temporal fine-structure cues to speech and pure tone modulation in observers with sensorineural hearing loss. Ear Hear 25: 242–250.
4. Nimitbunnasarn C, Amatyakul P, Gandour J, Carney A, Nimitbunnasarn C, et al. (1984) Tonal confusionsin Thai patients with sensorineural hearing loss. J Speech Hear Res 27: 89-97.
5. Koch DB, Staller S, Jaax K, Martin E (2005) Bioengineering solutions for hearing loss and related disorders. Otolaryngol Clin North Am 38: 255-272.
6. Wong AO, Wong LL (2004) Tone perception of Cantonese-speaking prelingually hearing-impaired children with cochlear implants. Otolaryngol Head Neck Surg 130: 751-758.
7. Ciocca V, Francis AL, Aisha R, Wong L (2002) The perception of Cantonese lexical tones by early-deafened cochlear implantees. J Acoust Soc Am 111: 2250-2256.

8. Wu JL, Yang HM (2003) Speech perception of Mandarin Chinese speaking young children after cochlear implant use: effect of age at implantation. Int J Pediatr Otorhinolaryngol 67: 247-253.
9. Davidson LS, Firszt JB, Brenner C, Cadieux JH (2015) Evaluation of hearing aid frequency response fittings in pediatric and young adult bimodal recipients. J Am Acad Audiol 26: 393-407.
10. Mok M, Holt CM, Lee KYS, Dowell RC, Vogel AP (2017) Cantonese tone perception for children who use a hearing aid and a cochlear implant in opposite ears. Ear and hearing 38: e359-e368.
11. Huang TS, Wang NM, Liu SY (1996) Nucleus 22-channel cochlear mini-system implantations in Mandarin-speaking patients. Am J Otol 17: 46-52.
12. Lee KY, Van Hasselt CA, Tong MC (2008) Tone perception in Cantonese-speaking in children with hearing aids. Ann Otol Rhinol Laryngol 117: 313-316.
13. Tang SO, Luk WS, Lau CC, So KW, Wong CM, et al. (1990) Cochlear implant in Hong Kong Cantonese. Am J Otol 11: 421-426.
14. Fryauf-Bertschy H, Tyler RS, Kelsay DM, Gantz BJ (1992) Performance over time of congenitally deaf and postlingually deafened children using a multi-channel cochlear implant. J Speech Hear Res 35: 913-920.
15. Lee KYS, Van Hasselt CA, Chiu SN, Cheung DMC (2002) Cantonese tone perception ability of cochlear implant children in comparison with normal-hearing children. Int J Pediatr Otorhinolaryngol 63: 137–147.
16. Loizou PC (1999) Introduction to cochlear implants. Engineering in Medicine and Biology Magazine. IEEE 18: 32-42.
17. Lee KYS, Vakoch DA, Wurm LH (1996) Tone perception in Cantonese and Mandarin: a cross-linguistic comparison. J Psycholinguist Res 25: 527-542.
18. Scheich H (1991) Auditory cortex: comparative aspects of maps and plasticity. Curr Opin Neurobiol 1: 236-247.