

Outcomes of Nasalance Scores in Children with Cochlear Implants in Ramathibodi Hospital

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Abstract:

Objective: The study compared the nasalance scores of Thai children with cochlear implants in Ramathibodi Hospital with normative data.

Material and Methods: From August 2021 to December 2022, a cross-sectional study was conducted in Ramathibodi Hospital. The participants were 20 children, ranging in age from 6.10 to 14.1 years, with severe to profound sensorineural hearing loss who received cochlear implants and were evaluated for nasalance using the Nasometer. They were instructed to read three standard Thai passages for nasalance assessment. Descriptive statistics and a sample t-test were employed to compare the nasalance scores with normative data.

Results: A significant difference in the mean nasalance scores between the Thai children with cochlear implants and the normative data for the oral passage in all three age groups. Furthermore, only the 12.1 to 15.0 age range in the nasal passage showed a significant difference in mean nasalance scores compared to the normative data. However, the remaining age of the nasal and oro-nasal passage showed no significant differences between the mean nasalance scores compared to the normative data (p -value<0.05).

Conclusion: Children with cochlear implants may have improved nasalance scores. Their scores were still higher than those of children with normal hearing, suggesting that even after cochlear implants are fitted, speech therapy is still necessary to rehabilitate nasal resonance in children with hearing impairment.

Keywords: cochlear implant, hearing impairment, nasalance scores

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Introduction

Human perception of the world is through sensory experiences. Among the senses, hearing is considered fundamental to communication. It allows people to build relationships, participate in daily activities, and experience life events. Hearing is key for children to learn spoken languages, perform academically, and participate in social activities. It is a prerequisite for normal speech and language development. Therefore, if children are hearing impaired, it will cause difficulty in learning spoken languages. According to the World Health Organization (WHO), more than 5% of the world's population, or approximately 466 million individuals, have a hearing disability. Of these, 432 million are adults and 34 million are children¹⁻².

Children who have a hearing impairment often experience articulation problems, voiced-voiceless errors, and nasalization³⁻⁴. Abnormal nasalization, which can be found in both vowels and consonants or perceived as hypernasality and hyponasality, is a significant problem that affects speech intelligibility^{3,5-6}. In particular, hypernasality is a common speech problem in adults and children who are hard-of-hearing⁷⁻¹³. However, several studies have shown that poor velopharyngeal valve control due to limitations in auditory feedback is related to hypernasality in hard-of-hearing people^{7-11,13}. Hassan et al. investigated the impact of cochlear implantation on hypernasality in 25 adults with hearing loss after language acquisition, compared with 25 adults with normal hearing. Nasalance scores were measured using the Nasometer at four time points: pre-implantation, 6, 12, and 24 months post-implantation. The study results show that adults with cochlear implants showed significantly higher nasalance scores compared to the normal hearing group. However, adults with cochlear implants showed statistically significant reductions in nasalance scores at 6, 12, and 24 months, reflecting improved resonance control. The results indicate that auditory feedback from cochlear implants supports improved control of velopharyngeal function, therefore reducing hypernasality in speech³.

Ysunza and Vazquez¹⁰ studied the speech characteristics in 53 children with hearing impairment and reported a lack of rhythm and strength in velopharyngeal movement, but no structural or neuromuscular abnormalities in the velopharyngeal anatomy.

Fletcher et al. conducted a study comparing nasalance scores using a nasometer between 30 children with profound hearing loss and 30 children with normal hearing through reading sentences and passages that contained nasal consonants and those without nasal consonants. The results of this study showed that the children with profound hearing loss had significantly higher nasalance scores compared to the children in the normal hearing group in passages without nasal consonants, which reflects hypernasality. In addition, the nasalance scores of the children with profound hearing loss were significantly lower than those in the normal hearing group in passages containing nasal consonants, which reflected hyponasality.⁸

Although the problem with speech sound disorders is much easier to notice, the researchers' experience found that most of these children have the characteristics of hypernasality and/or hyponasality. These characteristics come from only listening and observing and may not have been examined through a measuring device and then compared with the normative data. However, prior studies on nasalance scores in Thai children with cochlear implants are limited. Therefore, this research aimed to compare the nasalance scores of Thai children who use cochlear implants in Ramathibodi Hospital with normative data. Moreover, the result of this study can be used as a guideline for planning more appropriate and effective speech therapy, which could result in children with cochlear implants having a better quality of life because they can communicate clearly.

Material and Methods

Ethical consideration and informed consent

Prior to data collection, the study was approved by the Faculty of Medicine Ramathibodi Hospital's Ethical

Clearance Committee (ID 4664). The participants, relatives, or caregivers were informed of the purposes and procedures of this study, and they all signed a consent form.

Design and participants

A cross-sectional study was conducted between August 2021 and December 2022 at the Speech Clinic in Ramathibodi Hospital. The 20 participants were children with severe to profound sensorineural hearing loss. The age range of participants was 6.1 to 15 years old. The inclusion criteria were as follows: spoke Thai as their primary language and had a cochlear implant with reasonable results while wearing it. Of the evaluation scores on the Thai version of the Early Speech Perception test (Thai ESP test)¹⁴, participants were classified in Category 4. In addition to this, the participants had received speech therapy for at least 1 year. For analysis, participants were divided into three groups based on age: 6.1–9.0 years, 9.1–12.0 years, and 12.1–15.0 years.

The researchers excluded any persons who had craniofacial abnormalities, cleft lip, cleft palate, cerebral palsy, or genetic disorders.

Instruments

Nasometer II, model 6450, made by PENTAX of America, Inc., was used in this study. There was a headset with a separator plate where the microphones were mounted. The headset was placed over the participant's head and then appropriately adjusted for each participant by the Velcro strip at the back and the band on top of the head. The separator plate should stay firmly in contact with the area between the nose and upper lip after the adjustment. The Nasometer could be used to display the acoustic speech parameters related to nasalance and assessed by analyzing the nasalance on standardized reading passages. The nasalance measurement was displayed as mean nasalance, minimum and maximum nasalance, and more.

The mean nasalance was compared with normative data for each age group.

For evaluating speech perception ability, the Thai version of the Early Speech Perception test (Thai ESP test)¹⁴ was used. The Thai ESP test comprises 3 sets of picture cards, a scoring sheet, and a manual. The three sets of picture cards: 1. pattern perception, 2. spondee identification, and 3. monosyllable identification. Each set of picture cards comprised 12 different pictures and was arranged in an 8x8-inch grid. The assessment was made by listening to each word from each set and then pointing to identify the picture according to the word. The total scores were organized into four categories: Category 1, no pattern perception; Category 2, pattern perception; Category 3, some word identification; and Category 4, consistent word identification.

Administrative procedure

All participants, relatives, or caregivers were requested to provide their personal data and medical history. Speech perception ability was assessed using the Thai version of the Early Speech Perception test.¹⁴ Participants had to be classified in Category 4 on the Thai ESP test. After that, they were evaluated for nasalance scores using the Nasometer II, model 6450, and instructed to read three standard Thai passages: the first passage contained oral consonants only, the second passage contained nasal sentences with about thirty-five percent nasal consonants, and the third passage contained both oral and nasal consonants with about twenty-two percent nasal consonants¹⁵. Each participant was asked to read each passage once.

Statistical analysis

The researchers used IBM SPSS Statistics for Windows version 24 to analyze the data. The nasalance scores were described for each passage using descriptive statistics such as averages and standard deviations.

Comparisons of the nasalance scores from each passage with normative data were made using a sample t-test. If the p-value was less than 0.05, statistical significance was indicated.

Results

Demographic data

The study included 20 participants with severe to profound sensorineural hearing loss, 10 of whom were male (50.0%) and 10 of whom were female (50.0%). They ranged in age from 6.10 to 14.1 years. In terms of the hearing loss characteristics, the majority of the participants (n=19) used a cochlear implant in one ear combined with a hearing aid in the other ear, representing a bimodal user group, while 1 participant used bilateral cochlear implants. Regarding the anatomical structures, 18 participants showed normal cochlear morphology and achieved full electrode insertion without intraoperative or postoperative complications, as confirmed by surgical reports. However, 2 participants presented with cochlear dysplasia (approximately one and a half turns) and underwent surgery at a different hospital; therefore, electrode insertion data were not available for these cases. Nevertheless, both participants demonstrated satisfactory aided responses, indicating functional benefit despite the absence of electrode insertion data. Of the implanted devices: 9 participants were fitted with Cochlear™ implants, 8 with Advanced Bionics (AB) implants, and 3 with MED-EL® implants. The participants' age at implantation or hearing age ranged from 1.4 to 10.7 years, with a mean age of 3.3 years. Speech therapy sessions varied from 3 to 59. Table 1 presents the demographic characteristics of the participants.

Comparing the nasalance scores of Thai children who use cochlear implants with normative data: The three passages' mean nasalance scores and standard deviations are described in Table 2. For the first passage, the nasalance score of age group 6.1–9.0 ranged from 19

to 35%, with a mean nasalance score of 24.29 ± 5.56 ; 9.1–12.0 ranged from 20 to 53%, with a mean nasalance score of 30.33 ± 12.03 ; and 12.1–15.0 ranged from 19 to 43%, with a mean nasalance score of 32.29 ± 8.77 .

Table 1 Demographic characteristics of the participants (n=20)

Demographic data	Number (%)
Gender	
Male	10 (50.0)
Female	10 (50.0)
Frequency of speech therapy (sessions)	
Mean (S.D.)	23 (18.96)
Number of participants divided by age group	
6.1–9.0 years	7
9.1–12.0 years	6
12.1–15.0 years	7
Hearing devices	
Bimodal users	19
Bilateral Cochlear implant users	1
Cochlear anatomy	
Normal cochlear morphology	18
Cochlear dysplasia	2
Electrode insertion	
Full insertion (no complications)	18
Data unavailable (operated elsewhere)	2
Cochlear implant brand	
Cochlear™	9
Advanced Bionics (AB)	8
MED-EL®	3

S.D.=standard deviation

The second passage, the nasalance score of age group 6.1–9.0 ranged from 40 to 52%, with a mean nasalance score of 45.29 ± 4.89 ; 9.1–12.0 ranged from 42 to 63%, with a mean nasalance score of 50.67 ± 9.58 ; and 12.1–15.0 ranged from 23 to 52%, with a mean nasalance score of 42.00 ± 9.80 .

The third passage, the nasalance score of age group 6.1–9.0, ranged from 29 to 43%, with a mean nasalance score of 39.86 ± 5.05 ; 9.1–12.0 ranged from 34 to 54%, with a mean nasalance score of 44.83 ± 7.28 ; and 12.1–15.0 ranged from 30 to 47%, with a mean nasalance score of 40.14 ± 6.15 .

Table 2 also includes a comparison of the nasalance scores between the Thai children who use cochlear implants and the normative data. A t-test was used for the calculation. According to the t-test results, the mean nasalance scores of the Thai children who use cochlear implants and the normative data for oral passage in all three age groups showed a statistically significant difference.

Conversely, only the age range of 12.1 to 15.0 in the nasal passage showed a statistically significant difference in the mean nasalance scores compared to the normative data for each age group in the nasal and oro-nasal passage. No statistically significant differences were found between the mean nasalance scores compared to the normative data in the remaining age groups of the nasal and oro-nasal passage.

Discussion

Nasalization can be measured using a nasometer, and then a mean nasalance score can be given that interprets the characteristics of the nasal sound as hypernasality, hyponasality, or normal. Children with hearing

impairment frequently show nasalization in their speech, particularly hypernasality^{4, 7-13,16-18}.

This study compared the mean nasalance scores of 20 Thai children who use cochlear implants in Ramathibodi Hospital to normative data. The findings demonstrated a statistically significant difference in the mean nasalance scores between the Thai children who use cochlear implants and the normative data for oral passage in all three age groups. Including the nasal passage of the age range from 12.1 to 15.0 showed a statistically significant difference in the mean nasalance scores compared to the normative data for each age group in the nasal and oro-nasal passage. Few studies have been conducted on nasalance scores in children who use cochlear implants. Baudonck et al.⁵ reported investigating nasalance scores in children with cochlear implants, hearing aids, and normal hearing. They found that both the cochlear implants and the hearing aids group exhibited deviant nasalance scores compared to the normal hearing group. The investigation showed that both groups' speech sounds remained hypernasal, even if they had been using cochlear implants and hearing aids.

Table 2 Comparison of the nasalance scores between Thai children who use cochlear implants and normative data

Comparison of the nasalance scores between Thai children who use cochlear implants and normative data						
Passages	n	Nasalance scores of children		Normative data		p-value<0.05
		Mean	S.D.	Mean	S.D.	
Oral						
6.1-9.0	7	24.29	5.56	13.56	5.38	0.002*
9.1-12.0	6	30.33	12.03	14.97	4.67	0.026*
12.1-15.0	7	32.29	8.77	18.81	8.56	0.007*
Nasal						
6.1-9.0	7	45.29	4.89	45.42	7.45	0.944
9.1-12.0	6	50.67	9.58	49.87	7.21	0.847
12.1-15.0	7	42.00	9.80	53.15	8.48	0.024*
Oro-nasal						
6.1-9.0	7	39.86	5.05	36.49	7.04	0.128
9.1-12.0	6	44.83	7.28	39.57	5.50	0.137
12.1-15.0	7	40.14	6.15	42.99	8.07	0.266

*p-value<0.05

Kamel et al.¹⁹ investigated resonance features in Egyptian children with hearing impairments. They focused on comparing nasalance scores among children with hearing aids, cochlear implants, and normal hearing. The results revealed that both the hearing aids and the cochlear implants group exhibited higher nasalance scores in oral speech tasks when compared to the normal hearing group, indicating hypernasality. In addition, Sebastian et al.¹⁷ examined how nasalance scores in children with hearing loss are affected by cochlear implantation and hearing aids. They reported that the cochlear implants group exhibited lower nasalance scores than the hearing aid group, suggesting improved speech quality. However, their nasalance scores remained higher than the normal-hearing group, indicating residual hypernasality. These findings were similar to what this study showed: children who use cochlear implants demonstrated higher mean nasalance scores in the oral passage compared to the normative data, indicating hypernasality.

A few of the studies mentioned above show that children with cochlear implants tend to have lower nasalance scores than those with hearing aids. However, nasalance scores of the children in the cochlear implant group were often still higher than the children with normal hearing. It may be suggested that the full normalization of nasality in children with hearing impairment does not always occur immediately after implantation. Nguyen et al.²⁰ examined how cochlear implantation influences nasality in children with hearing impairment. They concluded that cochlear implantation in children with hearing impairment can partially normalize increased nasalance measurements. The observed interference in children with hearing impairment affecting nasal resonance may be due to an inability to control velopharyngeal valving without auditory feedback. Therefore, the improvement in nasalance scores following implantation emphasizes how important auditory feedback is in regulating the function of the velopharynx. Supplementary

therapeutic strategies, such as speech therapy, should be undertaken after implantation to improve the quality of the speech outcome.

Collectively, the present study's findings suggest that auditory and speech performance play a critical role in influencing nasalance outcomes. Children with better auditory perception are more capable of monitoring their own speech and regulating the resonance system, in this way reducing abnormal nasalance scores. These findings are consistent with previous studies reporting that auditory feedback significantly impacts resonance quality in people with hearing impairment^{10,19}. Furthermore, following cochlear implantation, several investigations have demonstrated improvements in nasalance, indicating that enhanced auditory input contributes to improved resonance quality^{5,17,20}.

In addition to auditory performance, auditory milestones may represent an important factor influencing resonance outcomes. Children who achieve age-appropriate auditory milestones such as detection, discrimination, identification, and comprehension of non-speech or speech sounds tend to demonstrate more typical resonance control, likely due to improved auditory feedback and self-monitoring. Conversely, delayed auditory development may contribute to persistent hypernasality. This interpretation aligns with findings by Geal-Dor et al.²¹, who reported that children implanted before 24 months of age acquired early auditory milestones more rapidly and demonstrated enhanced speech perception and production abilities.

The limitation of this study was the small number of participants. Therefore, it could not demonstrate factors such as age at implantation, duration of cochlear implantation, and degree of hearing loss relating to nasalance scores. Further studies should be conducted with larger samples to explore factors such as age at implantation, duration of implantation, degree of hearing loss, and any appropriate speech therapy that affects nasal resonance in children who use cochlear implants.

Conclusion

This study compared the nasalance scores of Thai children who use cochlear implants with normative data. The results indicate a statistically significant difference in the mean nasalance scores between the Thai children who use cochlear implants and the normative data for the oral passage in all three age groups. However, statistical analysis revealed no significant differences between the mean nasalance scores compared to the normative data in the remaining age groups of the nasal and oro-nasal passage. These results indicate that the children who use cochlear implants may have improved nasalance scores. However, their nasalance scores were still higher than those of children with normal hearing. This indicates the need for speech therapy to address nasal resonance in children with hearing impairment, even after cochlear implants are fitted.

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Conflict of interest

The authors declare no conflict of interest.

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