Research Paper: Investigating Quick Speech-in-Noise Comprehension in Adult Bimodal Users

Javad Fakhri[1], Nematollah Rouhbakhsh[1*], Reza Hoseinabadi[1], Farzaneh Fatahi[1], Mahsa Sepehernejad[2], Zohreh Roghani[1]

1. *Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.*
2. *Department of Audiology, School of Rehabilitation, Isfahan University of Medical Sciences, Isfahan, Iran.*

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ABSTRACT

Introduction: The use of cochlear implants, due to technological limitations, causes problems in speech comprehension in the presence of noise. This study aimed to evaluate the speech-in-noise (SIN) comprehension with emphasis on high-frequency components between users of different bimodal adult.

Materials and Methods: This study was conducted on 33 adult participants with a mean age of 36 years using bimodal (cochlear implant in one ear and hearing aid in another ear: CI/HA) style of different companies. Quick SIN with emphasis on high-frequency components was performed on the participants using an audiometer, an amplifier, and one speaker.

Results: Comparing the average percentage of correct answers from the word recognition test in the presence of noise in bimodal users showed that the Cochlear brand provides a better signal-to-noise (SNR) compare to other brands. Our result shows that bimodal users of Advance bionic and Med-El groups have better performance in speech recognition than other brands.

Conclusion: Bimodal users of Advance bionic and Med-El have better SNR loss than other brands. Besides, further studies on different ages can be helpful to make the right decision in this regard.

Keywords: Cochlear implant, Bimodal implantation, Speech recognition, Noisy backgrounds, Speech in noise perception.

*** Corresponding Author:**
Nematollah Rouhbakhsh, PhD.
Address: *Department of Audiology, School of Rehabilitation, Tehran University of Medical Sciences, Tehran, Iran.*
Tel: *+98 (21) 77530636*
E-mail: *rohbakhn@tums.ac.ir*

1. Introduction

Sense of hearing plays a vital role in communication, and its impairment has many adverse effects on communication skills and social interactions both for children and adults [1]. Hearing loss in the pre-language period can affect a child's learning, attention, and communication and cause varying degrees of disability. This disability delays the development of the child's language and speech, and other related skills compared to a healthy child. Studies have shown that these disorders increase with the increasing severity of hearing loss [2]. For adults, the effects of hearing loss are more pronounced in terms of their communications, social interaction, and occupational limitations. To overcome the consequences of hearing loss, hearing amplification, monaurally or binaurally, should be considered as early as possible. Binaural hearing amplification is essential for localization and understanding speech. To prevent communication and speech problems, a deaf child should use binaural amplification, such as hearing aids or cochlear implants [3, 4].

However, monaural hearing, especially in complex auditory situations, reduces auditory processing performance [5]. On the other hand, bimodal (Cochlear implant in one ear and hearing aid in another ear: CI/HA) hearing improves speech perception in noisy and quiet environments and improves voice localization. Studies have shown different results for understanding speech in a quiet environment in patients with bimodal (CI/HA) amplification [6]. Some studies have reported improvement in speech comprehension, and some even reported worsening of speech comprehension in these individuals compared to individuals with unilateral cochlear implants [7]. However, the information obtained is more stable for speech perception in a noisy environment [8, 9]. Many researchers have suggested that the low-frequency information is provided via a hearing aid, and this is important for maintaining the fundamental frequency of speech, and receiving this information provides essential acoustical cues for understanding speech and music [10]. Natural speech carries many spectral and temporal cues. In cochlear implant processors, only general spectral and temporal information of speech is transmitted, and the fine structure of speech information is not encoded, so patients with cochlear implants do not have access to all of this information. Also, encoding temporal information at very low frequencies, such as harmonics and fundamental frequency information are not encoded. Thus, these limitations lead to poor pitch perception and difficulty in patients with cochlear implant even in quiet situations. Especially, it becomes noticeable in noise situations where the noise source changes over time [11].

One of the most challenging aspects of hearing loss is speech perception in noise (SPIN). Those with normal audiograms have impaired speech perception in a noisy environment. These people include persons with a central auditory processing disorder, patients with learning disability, patients affected by attention-deficit/hyperactivity disorder, and older people (generally over 60 years) [12-14]. Aged people who suffer from difficulty understanding speech in high-noise (SIN) environments complain of tiredness listening, meaningless hearing, hearing impairment despite background noise, and lack of conversation comprehension in the main competitive presence. SPIN is the biggest problem in children because one step of learning is done in noisy environments during childhood. But even normal children need more signal-to-noise ratio (SNR) to understand speech than adults [15]. Hence, this study aimed to evaluate the Persian version of the quick speech-in-noise (Quick SIN) with emphasis on a high-frequency component in bimodal users.

2. Materials and Methods

After reviewing the medical records of the Isfahan cochlear implant (CI) center, Isfahan City, Iran, 45 patients were found with a bimodal style of different CI brands. Of whom, 33 had the inclusion criteria and were invited to the implant center for nominating as study participants. The inclusion criteria were profound hearing loss in the implanted ear, a minimum age of 18 years, with educated parents (can read and write at least), filling out the consent form, and without neurologic complications (by checking history record form). The exclusion criteria were unwillingness to continue the study and losing any inclusion criteria during the study.

The basic information about the subjects (such as age, gender, background disease, auditory symptoms, etc.) was first collected. The patients who had taken a specific drug, blood circulation problems, neurological disorders, inner ear disorders, and head trauma were excluded from this study. After obtaining the consent of the participants, we performed otoscopic examination and tympanometry to make sure the ear was healthy.

The quick speech-in-noise (QSIN) test outcome, quantified as the signal-to-noise ratio (SNR) loss, was used as the metric of speech understanding in noise [16]. The QSIN test was designed so that audiologists can quickly

Table 1. Demographic characteristics of the participants

Variables	Grouping	No. (%)
Gender	Male	18 (54.5)
	Female	15 (45.5)
Age (y)	18-60	12 (100)
Implant side	Right	22 (66.7)
	Left	11 (33.3)
Total	-	33 (100)

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found a listener's ability to understand speech in noise as an SNR rather than a percent correct score [17]. The score is determined by using the formula of SNR Loss = 25.5 – total words correct. The SNR Loss score represents the SNR a listener with hearing loss requires above the SNR that an average hearing listener requires to achieve 50% correct sentence identification [18].

The Quick SIN user's manual supplies step-by-step guidelines for explicate performance on the mentioned test based on elements that describe the amount of SNR loss. Specifically, the SNR Loss score consideration is as follow: a score of 0-2 dB is normal; 2-7 dB indicates a mild SNR loss, while a score of 7-15 dB is associated with a moderate SNR loss and suggests that a directional mic should be considered. A score of >15 dB indicates a severe SNR Loss which would lead an audiologist to consider an FM system. These categories of SNR Loss (normal, mild, etc.) and their relation recommendation (directional mic or FM system) are suggestions. No recognized scale of SNR loss classifications or their appropriate interventions exist.

Then, a quick SIN test with an emphasis on high-frequency components was performed. The listeners were instructed via a tangible example. They were asked to imagine that they are at a party, a female is talking, and a lot of other people are talking at the same time. The lady's voice was easy to hear at first because her voice was louder than others. The participants have to repeat every sentence verbatim that lady says. Other people's voices will gradually increase and make it harder to hear the woman's voice, but please guess and repeat the sentences as much as possible [13]. There are several Quick SIN lists. The 13, 15, 16, and 18 lists, with high-pass filters were applied in a sound-field condition in an acoustically-treated chamber at a zero-degree azimuth. The test of recorded voice was used.

The data were analyzed using descriptive statistics, and tests such as the Chi-square and Exact Fisher test at 95% confidence interval. We used to the Persian version of the Quick SIN comprehension with emphasis on a high-frequency component in bimodal users.

3. Results

The total number of participants in the present study was 33 (18 men and 15 women), aged 18-60 years (Table 1). The results showed that bimodal users in this study mostly used Phonak hearing aid 10 (24.9) (Table 2). Regarding the frequency using of the CI brands, the results showed that bimodal users in this study mostly used Advance bionic cochlear implant 15 (27.5) (Table 3).

A 1-way analysis of variance (ANOVA) conducted on three-brand CI users while performing Quick SIN. The results showed that Cochlear brand users provide more SNR Loss than other brands (Table 4). The mean differences between Cochlear and Med-El, Cochlear and AB, and Med-El and AB were 3.8 ($P<0.01$), 6.7 ($P<0.01$), and 3 ($P>0.2$), respectively.

Post hoc comparison using the ANOVA test showed a significant difference in both variables of hearing aid brand and group cochlear implant in bimodal user ($P<0.05$).

4. Discussion

This study was conducted to evaluate the Persian version of the Quick SIN comprehension with emphasis on high-frequency components in bimodal (CI/HA) users. Comparing the average percentage of correct word comprehension in noise among the participants' bimodal users showed that this group had the Mean±SD number of correctly understood words (35.34±23.75). Veugen per-

Table 2. Description of bimodal users according to the frequency of different types of hearing aid brands

Variables (Hearing aid brand)	No. (%)
Phonak	10 (29.4)
Widex	5 (17.6)
Unitron	5 (11.8)
Oticon	4 (17.6)
Bernafon	5 (11.8)
Other	5 (11.8)
Total	33 (100)

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formed a study similar To Ji Eun Choi's study that it was performed on 32 bimodal (CI/HA) and bilateral cochlear implant users to evaluate the speech comprehension test in situations where the speaker is at a zero-degree azimuth as well as from sides (±90º) at a distance of 1 m from the participants in four-speaker positions.

Two basic parameters that affected speech perception are encoding and decoding auditory. Individuals with low decoding ability receive less information from a speech in a noisy place than in a quiet environment. The Spectro-temporal of consonants that have low intensity is one of the acoustic facets affecting speech perception in a noisy environment. Thus, a neuron's ability to de-

Table 3. Description of bimodal users according to the frequency of different Cochlear implant brands

Variable	Species	No. (%)
	AB	15 (47.1)
Cochlear implant brand	Med-El	10 (27.5)
	Cochlear	8 (29.1)
	Total	33 (100)

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Table 4. The result of the ANOVA test between types of cochlear brands (n=33)

Types		Mean Difference	Std. Error	Sig.	95% Confidence Interval	
					Upper Bound	Lower Bound
Advance bionic	Med-El	-2.97692	1.55817	0.202	-7.0896	1.1358
	Cochlear	-6.74359	1.47614	0.001	-10.7095	-2.7777
Med-El	AB	2.97692	1.55817	0.202	-1.1358	7.0896
	Cochlear	-3.76667	0.86538	0.002	-6.0758	-1.4575
Cochlear	AB	6.74359	1.47614	0.001	2.7777	10.7095
	Med-El	3.76667	0.86538	0.002	1.4575	6.0758

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code this limited information is critical for identifying and recognizing speech [19, 20].

The basic speaker frequency (F0) is an essential parameter for SPIN because speech components can be grouping across frequency and over time helps in recognizing the speaker [21]. Researches have demonstrated that people would like to use F0 in the situation with background noise and to exert other data superimposed on that (pitch, formants). Several studies confirmed that pitch perception could be considered the main parameter in improving SPIN [22, 23]. But Cullington's study shows no significant differences between the mean scores of the bimodal and bilateral groups on any test, although the bimodal group did perform better than the bilateral group on almost all tests [24].

The results of Joseph D. Crew's (2016) study showed that sentence recognition was weaker with sung speech relative to spoken, with a few differences between sung speech with a constant or variable pitch; mean performance was better with CI-only relative to HA-only, and best with CI+HA. Melodic Contour Identification (MCI) performance was better with constant words versus variable words; mean performance was better with HA-only than with CI-only and was best with CI+HA. Regarding CI-only, a strong bimodal benefit was observed for speech and music perception. Regarding the better ear, bimodal benefits remained vital for sentence recognition but were marginal for MCI [25].

In this study, it was clearly shown that when stimuli were presented from the implanted side or in front of the face, people with bilateral implantation have a better understanding of speech than bimodal people. So, the two factors of head shadow and hearing in another side of the implanted ear reduce the performance of the bimodal group. This function is significantly reduced in bimodal users with masking by ear implant [26]. There is a significant difference between correct perceived words in noise among groups.

5. Conclusion

According to our results, bimodal users of Advance bionic and Med-El groups have better SNR Loss than other brands. In addition, further studies on different ages can be helpful to make the right decision in this regard.

Ethical Considerations

Compliance with ethical guidelines

This study was approved by the Ethics Committee of the TUMS (Code: IR.TUMS.FNM.REC.1399.014).

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Authors' contributions

All authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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