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**Research Article**

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# Auditory Temporal Processing Performance in Cochlear Implant Users

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**ABSTRACT**

*Auditory temporal resolution is the main feature of speech processing abilities. Gap in noise test (GIN) is the one of the new tests for assessing auditory temporal resolution. This study aimed to compare temporal resolution ability of subjects who wear cochlear implant (CI) and normal-hearing listeners. In this cross sectional study, GIN was performed on 9 postlingually cochlear implanted patients with mean age of 31.77±6.6 and 17 controls with mean age of 32.76±6.5 years. Following a training period (8 sessions on the average), the cochlear implant users were re-evaluated by the same test. Data were analyzed by independent and paired t-test using SPSS software version 18. There was significant difference in approximate threshold and percent of corrected answers between cochlear implant users and normal-hearing controls ($p<0.05$). The mean approximate threshold and percent of corrected answers of cochlear implant users after training period, was significantly improved ($p<0.05$). The results demonstrated that patients with cochlear implant have some ability of auditory temporal resolution, and that this ability may be improved by regular training.*

**Keywords:** Cochlear implant, Auditory temporal resolution, Noise

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## INTRODUCTION

Central auditory processing has an important role in recognizing and interpretation of auditory information received from the peripheral auditory system (1, 2). Temporal processing is one of the main capabilities of the central auditory system (3). Short or very rapid sequential processing of acoustic stimuli is called auditory temporal processing (4). Studies have reported that the auditory temporal processing can be underlying many processing abilities such as the acoustic verbal and nonverbal signals, music perception, rhythm, pitch differentiation, duration and phoneme signal processing (5). Temporal processing includes temporal resolution, temporal ordering, temporal ordering and temporal integration (6). Temporal resolution refers to detecting short rapid changes in the sounds. The recognition of speech information depends on some factors such as the auditory temporal resolution function (7). Temporal resolution proves to be necessitous for speech perception, because of providing the information about the vowels, consonants, syllables and expression boundaries that for discernment the speech and language evolution is incumbent (8, 9). Gap in noise (GIN) test that developed by musiek et al. (2005) evaluates the auditory temporal resolution (10, 11). The peripheral auditory system is the main way of transferring information. Interfere at this level may have a significant impact on central auditory processing abilities such as auditory temporal resolution. Since the peripheral part of the auditory system was compensated by cochlear implantation. Therefore, this study was aimed to evaluate the ability of the central auditory temporal processing in cochlear implant patients using the GIN test.

## MATERIALS AND METHODS

This cross sectional non-interventional study was conducted on 9 postlingually cochlear implanted patients with mean age of 31.77±6.6 and 17 individuals with normal hearing (audiometric thresholds of 20 dB HL or better at octave frequencies between 250 and 8000 Hz) as controls with mean age of 32.76±6.5 years at Khoozestan cochlear implant center, speech and hearing research center of Ahvaz Jondishapoor University of Medical Sciences. The entire cochlear implanted group was fitted with the Advance Bionic device.

All subjects were informed about the nature and purpose of the study before consenting to participate. The inclusion criteria were age ranged between 20 to 50, right handedness and no previous history of depression, trauma that might affect the nervous system, coma, brain and brainstem surgery. All participants signed a consent form after informed about the nature and purpose of the study.

GIN test were done in sound-treated room. Stimuli were routed via a CD and AC 40 diagnostic audiometer. GIN test composed of a series of 6-second white noise segments. The test administered at the 50dBSL compared to speech recognition threshold. Approximate gap threshold and percentage of the correct responses are two criteria for this test (12).

Following a training period (8 sessions on the average), the cochlear implant users were re-evaluated by the same test.

Data were analyzed by t-test because the distribution of data was normal by Kolmogrov – smirnov test and $p<0.05$ was statistically considered significant. SPSS software version 18 was used in this study.

## RESULTS

Patient characteristics are shown in Table 1. The mean percentage of correct responses and mean approximate gap thresholds of GIN test in normal subjects and patients with cochlear implant in initial test have been shown in Table 2.

**Table 1. Characteristics of the patients**

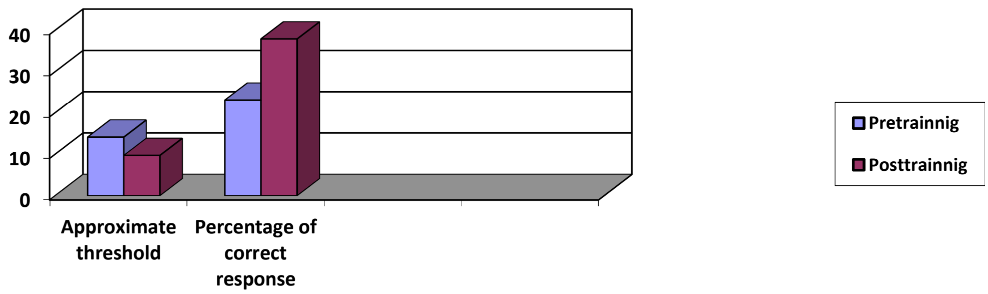
| No. | Implanted ear | Age | Device Type |
|---|---|---|---|
| 1 | Right | 23 | Advance Bionic |
| 2 | Right | 25 | Advance Bionic |
| 3 | Left | 31 | Advance Bionic |
| 4 | Right | 43 | Advance Bionic |
| 5 | Right | 29 | Advance Bionic |
| 6 | Right | 36 | Advance Bionic |
| 7 | Left | 27 | Advance Bionic |
| 8 | Right | 33 | Advance Bionic |
| 9 | Right | 39 | Advance Bionic |

**Table 2. Approximate gap threshold and percentage of the correct in cochlear implant users and normal-hearing listeners**

| Test measures | Mean (SD) in normal group (n=17) | Mean (SD) in CI group (n=17) |
|---|---|---|
| Approximate threshold | 4.81 (0.57) | 14.1 (0.82) |
| Percentage of correct response | 69.8 (7.1) | 23.1 (5.3) |

Figure 1 shows the mean percentage of correct responses and mean approximate gap thresholds of GIN test in cochlear implant patients in initial test and post- training tests.

Statistical analysis showed that in the initial test, approximate gap threshold and percentage of the correct responses of cochlear implant users was significantly poor when compared with that of normal-hearing controls (p= 0.00). The mean approximate gap threshold and percentage of the correct responses of cochlear implant users after training period, was significantly improved (p= 0.00).




**Graph 2. Pre and post training approximate gap threshold and percentage of the correct responses in cochlear implant users**

## DISCUSSION

The aim of this study was to compare temporal processing performance of central auditory system in cochlear implant users and normal-hearing listeners by using GIN test.

We found that cochlear implant users in our study did not discriminate gap in noise as well as normally hearing individuals. The results from this study showed that cochlear implant users somewhat were able to identify silent gap duration and this ability may be improved by regular training.

The present study has shown that there is a significant difference between percentage of the correct responses and approximate gap threshold of controls and cochlear implant users. Upon the obtained results, we observed lower percentage of the correct responses and larger approximate gap threshold in cochlear implant users. In other word temporal resolution ability in cochlear implant users poorer than normally hearing individuals. These findings are in accordance with the results of other studies such as the study conducted by Muchnik et al. (1994). They found absolute values of gap detection threshold (GDT) in the cochlear implant group were longer compared with those obtained from normal-hearing subjects (13).

In normal-hearing listeners, cues embedded in the temporal structure of the stimulus envelope contribute to speech recognition (14). For cochlear implant listeners who have only limited spectral discrimination, such temporal cues are especially important (15). For this reason, efforts to optimize the accurate transmission of the temporal features of the acoustic envelope have the potential to improve speech reception. As electric pulse rates increase, interpulse intervals shorten to less than the refractory periods of auditory fibers. In that condition, auditory-nerve responses become stochastic, exhibiting firing patterns more similar to those evoked by acoustic stimulation and, in particular, showing broadened dynamic ranges. These more physiological, neural response patterns have been hypothesized to enhance transmission of temporal details (16). Thus any effect of increased electric pulse rate should be particularly evident in sensitivity to the stimulus envelope (17).

Moore and Oxenham (1998) reported that cochlear hearing loss provokes basilar membrane responses that are more linear, which results in lower temporal resolution (18). The abilities of mammalian auditory nerve fibers to encode temporal gaps in wideband noise stimuli have been investigated by Zhang et al. (1990) (19). Taking into account reductions in firing rate during the gap and increases in spike counts immediately after the gap. They found that gap encoding improved with gap duration and sound level (30-80 dB SPL). In normally hearing individuals, varying firing rate of hair cells of the cochlea allows for the temporal coding and the auditory pathway transfer information to auditory cortex. Cochlear damage would provoke a series of changes in auditory input, reflecting alterations along the auditory pathway, and such alterations might also be related to temporal resolution. This series of auditory pathway alterations might influence auditory processing during temporal resolution tasks. Cochlear implants, however, bypass the cochlea and electrically stimulate auditory nerve fibers directly. Thus, cochlear implant users must rely on computerized processing strategies to encode sound, which may be insufficient. Furthermore, cochlear implants encode sound based primarily on place pattern and are limited by the number of channels available. In cochlear implants users a number of factors have been shown to affect auditory information such as electrode configuration (20), proximity to the modiolus (21), and electrode position (21). It has also been found that characteristics of the stimulus or complexity of the stimulus can affect discrimination. These factors, combined with spiral ganglion cell degeneration resulting from auditory deprivation and the possibility of electrode insertion trauma may explain the poorer performance by cochlear implant users in the present study.

## CONCLUSION

The results from this study showed that cochlear implant users have somewhat auditory temporal resolution ability, and this performance may be improved by regular training.

## REFERENCES

[1] Neijenhuis CAM. Auditory processing disorders: Development and evaluation of a test **battery2003**.
[2] Saki N, Karimi M, Mirahmadi S, Rostami MR, Nikakhlagh S. Evaluation of Loudness Perception Performance in Cochlear Implant Users.
[3] Katz J BR, Hood L. Handbook of clinical Audiology. Baltimore. **2009**;sixth ed:584-607.
[4] Musiek FE, Chermak GD, Weihing J. Handbook of Central Auditory Processing Disorder: ASHA; **2007**.
[5] Bellis TJ, Anzalone AM. Intervention approaches for individuals with (central) auditory processing disorder. Contemporary Issues in *Communication Sciences and Disorders*. **2008**;35:143-53.
[6] Shinn JB. Temporal processing: the basics. *The Hearing Journal. **2**0**03***;56(7):52.
[7] Musiek FE, Shinn J, Hare C, editors. Plasticity, auditory training, and auditory processing disorders. Seminars in hearing; **2002**: Copyright© 2002 by Thieme Medical Publishers, Inc., 333 Seventh Avenue, New York, NY 10001, USA. Tel.:+ 1 (212) 584-4662.
[8] Zatorre RJ, Belin P. Spectral and temporal processing in human auditory cortex. *Cerebral cortex.* **2001**;11(10):946-53.
[9] Geffner D, Ross-Swain D. Auditory processing disorders: Assessment, management and treatment: Plural Publishing; **2012**.
[10] Paulovicks J. The Gaps‐in‐Noise (GIN) Test and its diagnostic significance. *The Hearing Journal.* **2008**;61(3):67.
[11] Musiek FE, Shinn JB, Jirsa R, Bamiou D-E, Baran JA, Zaida E. GIN (Gaps-In-Noise) test performance in subjects with confirmed central auditory nervous system involvement. *Ear and hearing.* **2005**;26(6):608-18.
[12] Giannela Samelli A, Schochat E. The gaps-in-noise test: gap detection thresholds in normal-hearing young adults. *International Journal of Audiology.* **2008**;47(5):238-45.
[13] Muchnik C, Taitelbaum R, Tene S, Hildesheimer M. Auditory temporal resolution and open speech recognition in cochlear implant recipients. *Scandinavian audiology*. **1994**;23(2):105-9.
[14] Van Tasell DJ, Soli SD, Kirby VM, Widin GP. Speech waveform envelope cues for consonant recognition. The *Journal of the Acoustical Society of America.* **1987**;82(4):1152-61.
[15] Campos PD, Alvarenga KdF, Frederigue NB, Nascimento LTd, Sameshima K, Costa Filho OA, et al. Temporal organization skills in cochlear implants recipients. *Revista Brasileira de Otorrinolaringologia.* **2008**;74(6):884-9.
[16] Rubinstein J, Wilson B, Finley C, Abbas P. Pseudospontaneous activity: stochastic independence of auditory nerve fibers with electrical stimulation. *Hearing research.* **1999**;127(1):108-18.
[17] Fu Q-J. Temporal processing and speech recognition in cochlear implant users. *Neuroreport*. **2002**;13(13):1635-9.
[18] Arash Bayat, Akram Pourbakht, Nader Saki, Zuraida Zainun, Soheila Nikakhlagh, Golshan Mirmomeni. Vestibular rehabilitation outcomes in the elderly with chronic vestibular dysfunction. *Iranian Red Crescent Medical Journal*.**2012**;vol14(issue 11): 705-708.
[19] Delphi M, Zamiri Abdolahi F, Tyler R, Bakhit M, Saki N, Nazeri AR. Validity and reliability of the Persian version of spatial hearing questionnaire. *Medical Journal of the Islamic Republic of Iran*. **2015**;29:231..
[20] Drennan WR, Pfingst BE. Current-level discrimination using bipolar and monopolar electrode configurations in cochlear implants. *Hearing research*. **2005**;202(1):170-9.
[21] Sarafraz M, Saki N, Nikakhlagh S, Maleki M, Jonaky R. S. Distribution of Audiometric Findings in Patients with Presbycusis. *Biomed Pharmacol J* **2015**;8(March Spl Edition).