

Relationship between Electrically Evoked Compound Action Potential Thresholds and Auditory, Language, and Speech Progress after Cochlear Implant Surgery

Masoud Motasaddi Zarandy¹, Navid Nourizadeh², Farzad Mobedshahi³, *Sadegh Jafarzadeh⁴

Abstract

Introduction:

Electrically evoked compound action potential (ECAP) is an objective auditory response that can be used in the programming of cochlear implants. The aims of this study were to monitor ECAP thresholds and auditory, language and speech progress for 6 months after cochlear implant surgery and to evaluate any relationship between them.

Materials and Methods:

Ten children with a mean age of 4.2 (± 0.6) years and bilateral congenital and profound sensorineural hearing loss underwent cochlear implant surgery and post-operation auditory and speech training. The auditory, language, and speech abilities (Newsha level) and ECAP thresholds (for apical, medial and basal region of cochlea) were evaluated 1, 3 and 6 months after surgery.

Results:

ECAP threshold showed no significant improvement in any of the evaluated areas in the 6 months after surgery ($P > 0.05$); however, the Newsha level improved for all patients ($P = 0.00$).

Conclusion:

There was no relationship between ECAP thresholds and auditory, language, and speech abilities (Newsha level) in the first 6 months after surgery. ECAP thresholds may be a poor indicator of improvement in auditory, language, and speech abilities, and depend on many factors.

Keywords:

Cochlear implant, Electrically evoked compound action potential, Neural response telemetry, Newsha.

Received date: 4 Jan 2018

Accepted date: 21 Apr 2018

¹Department of Ear, Nose and Throat, Faculty of Medicine, Tehran University of Medical Sciences, Tehran, Iran.

²Sinus and Surgical Endoscopic Research Center, Mashhad University of Medical Sciences, Mashhad, Iran.

³Amir Alam Hospital, Tehran University of Medical Sciences, Tehran, Iran.

⁴Department of Audiology, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran.

*Corresponding Author:

Department of Audiology, School of Paramedical Sciences, Mashhad University of Medical Sciences, Mashhad, Iran. E-mail: jafarzadehs@mums.ac.ir

Introduction

Electrically evoked compound action potential (ECAP) is an objective auditory response that is achieved by the neural response telemetry (NRT) method and may be used in the programming of cochlear implants (1,2). This response shows the function of the cochlear implant and auditory nerve (3), and can be tested during and after surgery. The thresholds decrease after surgery (1,4), due to electrode interactions with the surrounding tissue. However, there is some disagreement about further improvement of ECAP thresholds over the subsequent months after surgery. This may be important, because improvement of ECAP thresholds show better synchronization in the auditory nerve and may relate to patients' auditory, language, and speech progress (5). Also, new thresholds may be used in the reprogramming of the device.

In this study, ECAP thresholds and scores on the Newsha developmental scale were recorded in the 6 months after surgery. The Newsha developmental scale is a Persian scale that evaluates the auditory, language, speech, and cognition ability of infants and children up to 6 years of age (6), and has good validity and reliability (7). The aims of this study were to monitor ECAP thresholds and investigate any relationship between ECAP thresholds and Newsha levels in the 6-month period after cochlear implant surgery.

Materials and Methods

Participants

Ten children, aged 3 to 5 years, participated in this study. All children had bilateral congenital and profound sensorineural hearing loss. The children were selected randomly and had no other abnormalities such as auditory neuropathy, mental retardation, or autism. Inclusion criteria were congenital profound sensorineural hearing loss in both ears, history of bilateral hearing aid use for at least 6 months, unsatisfactory improvement in auditory, language, and speech abilities despite rehabilitation before surgery, and normal radiologic evaluations for cochlear implant surgery. Auditory sensitivity was evaluated using behavioral audiometry (play audiometry, tympanometry, and acoustic reflex) and physiologic assessment including otoacoustic

emissions, auditory brainstem responses, and auditory steady state response.

The procedures were explained to the children and their parents, and all provided informed consent to participate in this study. All evaluations were free of charge. This study was approved by the ethics committee of Tehran University of Medical Sciences.

Procedure

Participants underwent cochlear implant surgery and received Freedom C5 (Nucleus) for one ear. All surgeries were performed under general anesthesia using mastoidectomy and round window insertion of electrodes, as this method shows better placement of electrodes than cochleostomy (8).

All surgeries were performed by a single person. Participants underwent routine auditory and speech training after surgery, including auditory verbal therapy. The ECAP thresholds and Newsha level were evaluated 1, 3, and 6 months after surgery. ECAP thresholds were recorded by NRT for the apical (electrode number: 22), medial (electrode number: 11), and basal region (electrode number: 2) of the cochlea, and the Newsha level was determined by a trained audiologist and speech and language pathologist.

Data analysis

Data were analyzed with SPSS 19 software using descriptive analysis and analysis of variance (ANOVA) for ECAP thresholds and generalized estimating equations for the Newsha level.

Results

The mean (standard deviation) age of participants was 4.2 (0.6) years, and seven out of 10 were female. Surgeries were performed on the right side in all patients, and they attended regular rehabilitation sessions after surgery as scheduled.

Table 1 shows the results of ECAP responses and Table 2 shows Newsha levels 1, 3, and 6 months after surgery. These results show that the ECAP responses had no significant improvement over 6 months ($P > 0.05$), but the Newsha level improved significantly ($P = 0.00$).

Table 1: Mean ECAP thresholds (current level) 1, 3, and 6 months after surgery.

	ECAP responses		
	Apical	Medial	Basal
1 month after surgery	144.60 (31.54)	177.20 (17.76)	178.70 (25.87)
3 months after surgery	146.00 (25.94)	173.30 (14.61)	177.20 (18.41)
6 months after surgery	147.70 (25.11)	174.00 (12.06)	180.40 (11.75)

Table 2: Frequency (number of patients) in each Newsha levels 1, 3, and 6 months after surgery.

	Newsha level										
	1	2	3	4	5	6	7	8	9	10	11
1 month after surgery	6		1		2	1					
3 months after surgery					3	3	1	2	1		
6 months after surgery							2	5	1	1	1

Discussion

ECAP thresholds showed no significant improvement in any of the evaluated areas in the 6 months after surgery, but the Newsha level improved for all participants in the same period. This finding is similar to previous studies that found no change up to 12 months after surgery or only a small reversible change in ECAP threshold, but contrast with other studies that showed an improvement or increase of ECAP thresholds (1-14).

Studies that showed improvement of ECAP thresholds also have some inconsistencies; some showed improvement only in the basal area (11), or the basal and apical areas but not the medial area (13), or the apical and medial areas of the cochlea only in first 3 months after surgery (12).

The ECAP improvement may represent better neural connection and synchronization in the peripheral auditory system (5); however, it does not necessarily lead to better processing in the auditory system (15). Furthermore, ECAP thresholds depend on many pre- and post-surgery factors including the status of the nervous system before surgery, the type and amount of neural stimulation received, pathologic conditions of the inner ear such as stenosis of the cochlear nerve canal, electrode type, position, insertion method, device type, patient age (younger than 18 months), and presence of neural abnormalities such as auditory neuropathy (4,8,11,16-20). However, they do not relate to the insertion depth of the electrodes or the size of the cochlea (17).

On the other hand, improvement in Newsha levels show better auditory and speech

abilities and good neural stimulation through cochlear implantation. Therefore, it may be inferred that improvements of ECAP threshold depend on many factors, and some patients (including our participants) may show no improvement.

It has been reported that ECAP thresholds do not have a good correlation with behavioral thresholds (21), and the results of this study and related studies may suggest that ECAP is a poor indicator of patient improvements in auditory, language, and speech ability. One weakness of the current study is that it used only one type of cochlear implant device. The results may be different for other types of device, and our suggestion therefore is for further studies to be conducted using different devices.

Conclusion

There was no relationship between ECAP thresholds and auditory, language, and speech abilities (Newsha level) in the first 6 months after surgery. ECAP thresholds may be a poor indicator of improvement in auditory, language, and speech abilities and depend on many factors.

Acknowledgments

The authors are grateful to the study participants for their collaboration.

References

1. Telmesani LM, Said NM. Electrically evoked compound action potential (ECAP) in cochlear implant children: Changes in auditory nerve response in first year of cochlear implant use. *Int J Pediatr Otorhinolaryngol.* 2016;82:28–33.

2. Bakhshinian VV. The current tendencies and prospects of the neural response telemetry in the rehabilitation of the patients after cochlear implantation. *Vestn Otorinolaringol.* 2014(2):21–5.
3. Wang Z, Li W, Tian Y, Jiang X. The clinical application of objective hearing monitoring technology in cochlear implants. *Lin Chung Er Bi Yan Hou Tou Jing Wai Ke Za Zhi.* 2014; 28(7): 435–9.
4. Christov F, Munder P, Berg L, Bagus H, Lang S, Arweiler-Harbeck D. ECAP analysis in cochlear implant patients as a function of patient's age and electrode-design. *Eur Ann Otorhinolaryngol Head Neck Dis.* 2016;133 Suppl 1:S1–3.
5. Caldas FF, Cardoso CC, Barreto MA, Teixeira MS, Hilgenberg AM, Serra LS, et al. Analysis of electrically evoked compound action potential of the auditory nerve in children with bilateral cochlear implants. *Braz J Otorhinolaryngol.* 2016; 82(2):123–30.
6. Jeddi Z, Jafari Z, Motasaddi Zarandy M, Kassani A. Aural rehabilitation in children with cochlear implants: a study of cognition, social communication, and motor skill development. *Cochlear Implants Int.* 2014;15(2):93–100.
7. Jafari Z, Asad-Malayeri S. The psychometric properties of newsha developmental scale: an integrated test for persian speaking children. *Iran J Pediatr.* 2012;22(1):28–34.
8. Poley M, Overmyer E, Craun P, Holcomb M, Reilly B, White D, et al. Does pediatric cochlear implant insertion technique affect intraoperative neural response telemetry thresholds? *Int J Pediatr Otorhinolaryngol.* 2015;79(9):1404–7.
9. Tanamati LF, Bevilacqua MC, Costa OA. Longitudinal study of the ecap measured in children with cochlear implants. *Braz J Otorhinolaryngol.* 2009;75(1):90–6.
10. Lai WK, Aksit M, Akdas F, Dillier N. Longitudinal behaviour of neural response telemetry (NRT) data and clinical implications. *Int J Audiol.* 2004;43(5):252–63.
11. Telmesani LM, Said NM. Effect of cochlear implant electrode array design on auditory nerve and behavioral response in children. *Int J Pediatr Otorhinolaryngol.* 2015;79(5):660–5.
12. Molisz A, Zarowski A, Vermeiren A, Theunen T, De Coninck L, Siebert J, et al. Postimplantation changes of electrophysiological parameters in patients with cochlear implants. *Audiol Neurootol.* 2015;20(4):222–8.
13. Spivak L, Auerbach C, Vambutas A, Geshkovich S, Wexler L, Popecki B. Electrical compound action potentials recorded with automated neural response telemetry: threshold changes as a function of time and electrode position. *Ear Hear.* 2011;32(1):104–13.
14. Hughes ML, Vander Werff KR, Brown CJ, Abbas PJ, Kelsay DM, Teagle HF, et al. A longitudinal study of electrode impedance, the electrically evoked compound action potential, and behavioral measures in nucleus 24 cochlear implant users. *Ear Hear.* 2001;22(6):471–86.
15. Thai-Van H, Chanal JM, Couderc C, Veuillet E, Truy E, Collet L. Relationship between NRT measurements and behavioral levels in children with the Nucleus 24 cochlear implant may change over time: preliminary report. *Int J Pediatr Otorhinolaryngol.* 2001;58(2):153–62.
16. Han S, Wang L, Zhang D, Peng K. Neural Response Telemetry Thresholds in Patients with Cochlear Nerve Canal Stenosis. *Otolaryngol Head Neck Surg.* 2015;153(3):447–51.
17. Mittmann P, Rademacher G, Mutze S, Hassepass F, Ernst A, Todt I. Evaluation of the Relationship between the NRT-Ratio, Cochlear Anatomy, and Insertions Depth of Perimodiolar Cochlear Implant Electrodes. *Biomed Res Int.* 2015; 2015:706253.
18. Muller A, Hocke T, Mir-Salim P. Intraoperative findings on ECAP-measurement: normal or special case? *Int J Audiol.* 2015;54(4):257–64.
19. Bakhshinyan VV, Fedoseev VI, Tavartkiladze GA. The new technologies for the intraoperative registration of the electrically evoked compound action potentials of the acoustical nerve by means of the neural response telemetry method. *Vestn Otorinolaringol.* 2015;80(3):14–7.
20. Ji F, Li JN, Liu K, Jiao QS, Sun L, Hong MD, et al. NRT test in auditory neuropathy patients with cochlear implants. *Acta Otolaryngol.* 2014; 134(9): 930–42.
21. McKay CM, Smale N. The relation between ECAP measurements and the effect of rate on behavioral thresholds in cochlear implant users. *Hear Res.* 2017;346:62–70.