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Original Article

Evaluation of Saccular Function Pre-Post Cochlear Implant Surgery Using VEMPs

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Objectives: The aim of present study was evaluation of saccular function in cochlear implant candidates with severe to profound sensory neural hearing loss. Before and after cochlear implantation

Methods: In this study 35 Cochlear Implant (CI) candidates with bilateral severe to profound sensory neural hearing loss before and about 30 days after cochlear implantation and 20 normal-hearing cases as a control group underwent VEMP test. Both groups were matched based on gender and age.

Results: VEMP responses were absent bilaterally in 10 out of 35 patients. 4 patients were excluded from the study because they did not receive CI during present study. From 21 remaining patients, 5 cases lost VEMP response in their implanted ear after surgery. In control group, VEMP responses were present bilaterally.

Discussion: The results of present study show that saccular dysfunction in CI candidates is extremely probable and this is possible that saccule get impaired after CI.

Key words: cochlear implant, sensory neural hearing loss, saccule, VEMPs

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Introduction

In addition to anatomical proximity, the cochlear and vestibular system has close similarity in embryonic origin and development, microstructure, cellular and neuronal function. Therefore vestibular involvement is possible in patients with cochlear dysfunction and sensory neural hearing loss (SNHL) (1,2). Based on studies, there are vestibular dysfunctions in about 40 percent of children and adults with severe to profound SNHL (3,4). Cochlear Implant (CI) is a mean for patients with severe to profound hearing loss to retrieval of their hearing function. At least in preferable hearing conditions, most cases are able to understand speech only with CI device (5). Improved accessibility of auditory information which is absolutely vital for suitable speech and language development in children and for proper oral speech understanding in adults, has led to disregard studying side-effects and sometimes harmful effects of CI on other inner ear organs. Aside from hearing benefits, CI can make secondary damages to vestibular end organs especially saccule and these damages may lead to some extent of obscure or explicit vestibular dysfunction (6,7). In some studies the estimated risk for semicircular canal damage were from 6.3 to 93 percent (8) and this risk were from 21 to 100 percent for saccule (9). In spite of knowing these potential side-effects, the positive effects of CI on personal and social life have been so strong that vestibular function of CI candidates has been less appreciated.

The aim of present study was to evaluate saccular

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function as a part of vestibular end organs in CI candidates and determining percentage of saccular function after the surgery.

Methods

There were a control and an experimental group. The control group consisted of 35 patients with average age of 10.94 (SD=11.70) including 18 males (51 percent) and 17 females (49 percent). All of them had bilateral severe to profound SNHL and were CI candidates. The experimental group consisted of 20 normal-hearing cases including 9 males (45 percent) and 11 female (55 percent) with mean age of 13.15 (SD=10.32). This study was verified by university of welfare and rehabilitation sciences ethics committee. In both groups receiving written consent from patients was one key including criteria. Tests were conducted at Akhavan rehabilitation center of university of social welfare and rehabilitation sciences between April to November of 2012. The experimental group was selected from available samples in Tehran Loghman Hakim educational hospital and Baghiatallah azam hospital. Based on cochlear implant criteria, all cases in this group were CI candidates with bilateral severe to profound hearing loss (≥70 dBHL). They did not have tympanic membrane or middle ear abnormality based on normal otoscopy and a tympanometry. The hearing loss etiology was unknown and in all of them was congenital. Cases in control group had normal hearing (≤15 dBHL), normal otoscopy and a tympanogram, without any vestibular or neurologic disorder. The patients in both groups could maintain sufficient contraction of sternocleidomastoid muscles (SCM). In experimental group VEMP was carried out on all patients before surgery and cases without any response in both ears or in the selected ear for implantation were not re-tested after CI. The VEMP test was conducted on control group as well.

Test procedures: ICS charter EP2000 (made in Denmark) equipment was used for obtaining VEMP. All patients and their parents received complete explanation about the procedure before testing. For younger children, test procedure was described with performing a play for simplification. The patients were seated in a chair and their skin was cleaned with abrasive gel to reduce electrode impedance. We used disposal button electrodes. Electrode arrangement was as follows: non-inverting on ipsilateral 1.3 superior part of SCM, inverting on sternum and clavicle joint, and ground electrode on forehead. Acceptable impedance was below five kilo ohms and acceptable inter-impedance was lower than two kilo ohms. Another electrode placed on middle part of SCM for monitoring EMG during recording and verifying appropriate SCM contraction. The proper contraction was considered within 50 to 120 millivolts. Otherwise the recording was cancelled. For activating SCM, patients were asked to turn their head contralateraly to their test ear. There was about few seconds rest time between each tracing to avoid muscle fatigue. The stimulus was 500 HZ tone burst with rarefaction polarity, 2 milliseconds rise and fall time without plateau, with 5.1/s rate. The stimulus was delivered unilaterally through TDH 39p (Telephonic, NY, USA) without contralateral masking. The gain was set on 5000 and band pass filter was set between 10 to15000. The number of stimulation was 150 sweeps with time window of 100 milliseconds. 20 milliseconds were used as pre-stimulus time. Threshold tracing was started from 93 dBnHL (maximum output for the equipment with headphone) and stimulus level was decreased 10 dB or increased 5 dB according to presence or absence of the response. Threshold was considered as the lowest stimulus level in which clear and repeatable bi-phasic p13-n23 potential was seen. If there was not any reliable response, recording was reported as no response. Aside from threshold, p13-n23 amplitude and latency were calculated at 93 dBnHL as well.

For data analysis, SPSS16 (Chicago IL, USA) was used. Data were described using descriptive analysis including mean and standard deviation. Kolmogorov-Smirnov test was used for checking normal statistic distribution and Levene test was used for checking variance equality. Due to normal distribution we used independent t-test for comparing means between control and experimental group before CI, and paired t-test for comparing means before and after CI.

Results

Before CI: VEMP was absent bilaterally in 10 out of 35 patients (28.57 percent). In 25 remaining patients, VEMP response (threshold, latency and amplitude) was compared with control group. The mean of p13-n23 amplitude and threshold was significantly ($p < 0.05$) different but p13-n23 latency was not statistically different in these two groups (table 1).

Table 1. Comparing VEMP parameters between experimental group before CI and control group

VEMP parameters	experimental group before CI	control group	p
Threshold	81.00(6.12)	71.25(4.25)	0.001
Amplitude	94.41(28.12)	113.79(26.22)	0.022
Latency p13	14.27(0.38)	14.17(0.29)	0.36
Latency n23	23.26(0.46)	23.31(0.63)	0.76

One month after CI: VEMP response in 5 out of 21 patients (23.80 percent) was disappeared after CI. In remaining patients p13-n23 amplitude and latency were compared before and after CI. Mean threshold and p13-n23 amplitude was significantly different (p value<0.05) but latency was not different. In non-implanted ear VEMP parameters (threshold, amplitude and latency) were not significantly different before and after CI (table 2).

Table 2. Comparing VEMP parameters before and after CI

VEMP parameters	before CI	after CI	p
Threshold	80.00(6.32)	87.00(5.72)	0.001
Amplitude	98.16(25.01)	73.92(32.03)	0.022
Latency p13	14.19(0.45)	14.15(0.50)	0.66
Latency n23	23.15(0.45)	23.17(0.54)	0.88

Age and gender effects on VEMP parameters were studied in both groups. Gender had no effect on any of VEMP parameters (p value>0.05) and correlation between age and VEMP parameters was not significant. Prosthesis type (type A and B) and surgery procedure was studied as well. 8 patients (38 percent) used type A prosthesis and 13 patients (62 percent) used type B prosthesis. There were not any prosthesis effects on VEMP parameters. Round window surgery was used in 19 patients and cochleostomy procedure was performed in 2 cases. As there were not enough patients with cochleostomy procedure, we could not compare surgery effects statistically.

Discussion

As CI can provide suitable access to auditory environment, it is a useful and effective way for children and adults with severe to profound hearing loss (10). Based on studies CI surgery can make structural changes in vestibular end organs especially saccule (4,6). In present study there were differences between VEMP in CI candidates before surgery and control group. 28.57 percent of CI candidates had not any VEMP response and in the remaining patients VEMP parameters including threshold and amplitude were significantly different from control group. Prevalence of VEMP abnormality in CI candidates has been reported 30 to 40 percent (11-13). The reason for this variety is difference of sample size and VEMP test procedure in different studies.

In present study VEMP response was disappeared in 5 patients after CI. In others, VEMP amplitude and threshold was significantly abnormal. Other studies have shown VEMP changes after CI and the amount of changes has been from 30 to 50 percent (12-15). This variety in changes can be related to parameters such as middle ear function (12,15), the amount of SCM contraction (16), the time period after CI for re-test (12,15), surgical procedure (9,17), prosthesis type (17), age (18,19) and gender (16,17). These factors can make VEMP response absent. To rule out middle ear pathology, tympanometery was performed before VEMP test and to control muscle contraction, the SCM contraction was monitored during the test.

Conclusion

The results of this study show that CI can affect VEMP and this is in agreement with other studies. As it has been shown that in CI surgery, saccule damage is more prevalent than other vestibular organs dysfunction, VEMP can become a part of CI tests and provide valuable information about saccule status before and after CI. Involvement of other parts of vestibular system such as utricle and semicircular canals is possible as well (8). So other vestibular tests including oVEMP (ocular VEMP), head thrust, ENG (electro nystagmography) are highly recommended. This test battery provides a comprehensive vestibular evaluation. Comparing vestibular function before and after CI is also useful. Therefore it is highly recommended that in addition to hearing status criteria, vestibular system status becomes an integral part of selecting an ear for implantation. This method prevents bilateral vestibular loss when there is only one functioning vestibular system. Of course when audiologic and anatomic indexes are more important, surgeon has to choose the ear regardless of vestibular function and after surgery, if any vestibular damage happened, rehabilitation is vital and can improve patient's quality of life.

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References

1. Angeli S. Value of vestibular testing in young children with sensorineural hearing loss. Archives of otolaryngology--head & neck surgery. 2003;129(4):478-82.
2. Telian SA. Comments about the value of vestibular testing in young children with sensorineural hearing loss. Archives of Otolaryngology-Head & Neck Surgery. 2003;129(4):483.
3. Buchman CA, Joy J, Hodges A, Telischi FF, Balkany TJ. Vestibular effects of cochlear implantation. Laryngoscope. 2004;114(10 Pt 2 Suppl 103):1-22.
4. Krause E, Wechtenbruch J, Rader T, Gurkov R. Influence of cochlear implantation on sacculus function. Otolaryngology--head and neck surgery: official journal of American Academy of Otolaryngology-Head and Neck Surgery. 2009;140(1):108-13.
5. Mc Dermott H, Sucher C, McKay C, editors. Speech intelligibility with a cochlear implant sound-processing scheme based on loudness models. Engineering in Medicine and Biology Society, 2003 Proceedings of the 25th Annual International Conference of the IEEE; 2003: IEEE.
6. Tien HC, Linthicum FH, Jr. Histopathologic changes in the vestibule after cochlear implantation. Otolaryngology--head and neck surgery: official journal of American Academy of Otolaryngology-Head and Neck Surgery. 2002;127(4):260-4.
7. Handzel O, Burgess BJ, Nadol JB, Jr. Histopathology of the peripheral vestibular system after cochlear implantation in the human. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 2006;27(1):57-64.
8. Fina M, Skinner M, Goebel JA, Piccirillo JF, Neely JG, Black O. Vestibular dysfunction after cochlear implantation. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 2003;24(2):234-42; discussion 42.
9. Todt I, Basta D, Ernst A. Does the surgical approach in cochlear implantation influence the occurrence of postoperative vertigo? Otolaryngology--Head and Neck Surgery. 2008;138(1):8-12.
10. Allen C, Nikolopoulos TP, Dyar D, O'Donoghue GM. Reliability of a rating scale for measuring speech intelligibility after pediatric cochlear implantation. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 2001;22(5):631-3.
11. Jacot E, Van Den Abbeele T, Debre HR, Wiener-Vacher SR. Vestibular impairments pre- and post-cochlear implant in children. Int J Pediatr Otorhinolaryngol. 2009;73(2):209-17.
12. Cowdrey L, Frazier H, King S, Lewis K. Changes in Saccular Function after Cochlear Implantation. 2009.
13. Melvin TA, Della Santina CC, Carey JP, Migliaccio AA. The effects of cochlear implantation on vestibular function. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 2009;30(1):87-94.
14. Bogle JMM. The effect of cochlear implantation on the vestibular evoked myogenic potential response in children and adult participants: University of Colorado at Boulder; 2011.
15. Katsiari E, Balatsouras DG, Sengas J, Riga M, Korres GS, Xenelis J. Influence of cochlear implantation on the vestibular function. European archives of oto-rhino-laryngology: official journal of the European Federation of Oto-Rhino-Laryngological Societies. 2013;270(2):489-95.
16. Akin FW, Murnane OD, Panus PC, Caruthers SK, Wilkinson AE, Proffitt TM. The influence of voluntary tonic EMG level on the vestibular-evoked myogenic potential. Journal of rehabilitation research and development. 2004;41(3B):473-80.
17. Enticott JC, Tari S, Koh SM, Dowell RC, O'Leary SJ. Cochlear implant and vestibular function. Otology & neurotology: official publication of the American Otological Society, American Neurotology Society [and] European Academy of Otology and Neurotology. 2006;27(6):824-30.
18. Rosengren SM, Welgampola MS, Colebatch JG. Vestibular evoked myogenic potentials: past, present and future. Clinical neurophysiology: official journal of the International Federation of Clinical Neurophysiology. 2010;121(5):636-51.
19. Nguyen Y, Miroir M, Vellin JF, Mazalaigue S, Bensimon JL, Bernardeschi D, et al. Minimally invasive computer-assisted approach for cochlear implantation: a human temporal bone study. Surg Innov. 2011;18(3):259-67.