Int. Adv. Otol. 2009; 5:(3) 361-364

ORIGINAL ARTICLE

Alterations in Electrode Impedance Values in Response to Electrode Stimulation in the First Mapping Session of Children Using Clarion Cochlear Implant

Motasaddi Zarandy Masoud, Abbasalipour Pavaneh, Borghei Hebetadin, Khorsandi Muhammed Taghi, Moubedshahi Farzad

Department of Cochlear Implantation, ENT Research Center, Amir Alam Hospital, Tehran University of Medical Sciences, Tehran, Iran

Objective: Commencement of electrical stimulation in initial fitting session can decrease electrode impedance values in whole electrode array of Clarion cochlear implant system. Previous studies showed that commencement of electrical stimulation in Nucleus 24 cochlear implant system decreased in electrode impedance values.

Materials and Methods: For this purpose, 26 pre-lingually deaf patients (10 Clarion CII and 16 Clarion HiRes 90K users) were studied. Electrode impedance changes before and after conditioning were determined with SoundWave software. Paired t-test and one-way ANOVA were used for comparing the values between groups and among the impedance values within the electrode numbers, respectively.

Results: Electrode impedance values did not show significant difference between before and after conditioning in CII Clarion cochlear implant users. However, a significant difference was shown in electrode impedance values of HiRes 90K system between before and after conditioning.

Conclusion: The results showed that commencement of electrical stimulation in initial fitting day resulted in decreasing of electrode impedance values in whole electrode array in HiRes 90K system. However such decrease was not observed in CII system.

Submitted : 12 September 2008 *Revised : 26 May 2009* *Accepted : 25 June 2009*

Measurement of electrical impedance can give useful information about the status of individual electrode of a cochlear implant. In this respect, low impedance measurements may suggest a short circuit in a particular electrode. On the other hand, high impedance values may show a broken electrode wire or an electrode in contact with air [1].

It has been reported that the interface between the cochlear implant electrode and the spiral ganglion cells is critical to the passage of information via electrical stimulation [2, 3]. It has been shown that passage of electrical current through a tissue medium was governed by stimulus parameters such as current, voltage, stimulus width, the particular characteristics of the electrode surface and the nature of the medium through which the electrical current is passed. The principal transmission effect measured clinically is impedance, i.e., the measure of resistance to the flow of electrical current through any particular medium [4]. The impedance of an electrode reflects the electrical status of the electrode and its adjacent tissue environment [2-4].

Clinically, during cochlear implantation, the impedance of all electrodes along the array is tested using telemetry while the patient is still on the operating table. Those impedance measurements are used not only to confirm the functionality of the implanted electrodes but also to give guidance for subsequent setting (mapping) of the device [4]. Electrical impedance comprises resistance, capacitance and inductance. [1] According to Tykocinski et al. (2005) several factors may effect postoperative electrical impedances. They have shown that, patients who implanted with a Nucleus 24

Corresponding address:
Masoud Motasaddi Zarandy
Department of Cochlear Implantation, ENT Research Center, Amir Alam Hospital, Tehran University of Medical Sciences, Tehran, Iran
Phone: + 98 21 66 72 47 77; Fax: + 98 21 66 72 96 72; E-mail: motesadi@sina.tums.ac.ir

Contour electrode array positioned closer to the modiolus had lower threshold (T) and comfortable (C) levels when compared to the patients who underwent implantation with a straight Nucleus electrode array. However, electrode impedance of the Nucleus 24 Contour array was significantly higher than the Nucleus straight electrode array [4]. These researchers believed half-banded electrodes of Nucleus 24 Contour array have 60% of the surface area of the full-banded electrodes in Nucleus straight array. Their findings indicated the inversely relation between electrode impedance and geometric surface area of the electrodes. Other reports showed that intra-cochlear changes occur after cochlear implantation, resulting in an increase in electrode impedance in the post-implantation period. Studied on animals showed that this increase generally continued until electrical stimulation commencement and frequently leveled off thereafter or decreased [5, 6]. In this regard, it was showed an increase in the electrode impedance from the time of implantation until commencement of electrical stimulation about 2 weeks after surgery [4].

The aim of the present study was to compare the effect of electrical stimulation in the first programming session on the changes of the electrode impedance between two different implants of 16 full-banded electrodes (CII) and 16 half-banded electrodes (HiRes 90K) Clarion cochlear implantation system. Meanwhile, we followed to find out which part of the electrode array can be influenced due to such electrical commencement.

Materials and Methods

The CII electrode array is an array carrying 16 full-banded electrodes which positioned on the medial wall of the scala tympani after insertion to the cochlea. On the other hand, the HiRes 90K electrode array carries 16 half-banded electrodes on its medial side, facing the modiolus and neural elements.

For the present study, twenty-six cochlear implanted children were recruited. Sixteen patients (10 males and 6 females) underwent implantation with the Clarion HiRes 90K electrode array and ten (4 males and 6 females) with Clarion CII electrode array (Advanced Bionics Corporation, CA, United States). Forty days after operation, in the first session of mapping, electrode impedance was measured by telemetry (SoundWave software, advanced Bionics Corporation, CA, United States). After then, we applied “conditioning” according to the manual instruction. (SoundWave software, Advanced Bionics, CA, United States). “Conditioning” is a biphasic pulse which applied to the whole electrode array to reduce the impedances. Once again, electrode impedances were measured by telemetry as post-conditioning values. Finally, mapping was done. This study was approved by the Ethics Committee of the ENT Research Center, Tehran University of Medical Sciences, Tehran, Iran.

For examining the distribution of data, the raw data or log transformed data was analyzed by means of Kolmogorov-Smirnov test using Sigma Stat statistical software. Alterations in electrode impedance values were compared between post-conditioning and pre-conditioning states of the corresponding electrodes using paired-t-test. Moreover, electrode impedance values among electrodes in both pre and post conditioning states for both CII and HiRes 90K were determined by means of repeated measures one-way ANOVA. Alfa in all cases was 5% ($p<0.05$).

Results

Electrode impedance values of CII and HiRes 90K Clarion cochlear implanted patients were shown in Table 1. The distribution of data was normal when checked by means of Kolmogorov-Smirnov test using Sigma Stat statistical software.

We have shown that there was no difference between corresponding electrode impedances of post-conditioning and pre-conditioning in CII cochlear implanted patients ($p>0.05$). However, our analysis revealed significant differences in the values of electrode impedances between pre-conditioning and post-conditioning status in HiRes 90K cochlear implanted patients. For example apical electrode (No: 1), middle electrode (No: 8) and basal electrode (No:

Table 1. Electrode impedance values in cochlear implanted patients for CII and HiRes90K Clarion cochlear implant. Values are expressed as mean ± SD for 10 patients of CII and 16 patients of HiRes 90K cochlear implant.

Electrode number	Impedance values of HiRes90K (kohm) Pre-condition	Postcondition	p-values differences between conditions	Impedance values of CII (kohm) Pre-condition	Postcondition	p-values differences between conditions
1	9.20±1.05	8.33±0.93	<0.001	7.77±0.53	7.61±0.56	0.545
2	9.04±1.05	8.11±0.95	<0.001	9.33±1.33	9.75±1.33	0.101
3	9.18±1.13	7.88±1.03	<0.001	8.06±0.55	7.76±0.48	0.246
4	8.58 ±1.00	7.69±0.91	<0.001	8.65±1.24	7.92±1.00	0.159
5	8.55±0.96	7.77±0.87	0.002	8.12±0.62	7.76±0.59	0.217
6	9.15±1.05	8.16±0.93	<0.001	10.20±1.72	9.22±1.25	0.145
7	8.78±0.93	8.05±0.88	<0.001	9.06±0.78	8.75±0.58	0.289
8	8.93±0.69	7.98±0.64	<0.001	10.81±2.05	9.94±1.72	0.081
9	8.44±0.68	7.63±0.58	<0.001	8.72±1.11	8.52±0.92	0.368
10	8.65±0.95	7.82±0.90	<0.001	10.03±1.52	9.31±1.22	0.118
11	8.88±0.79	7.83±0.77	<0.001	8.13±1.15	7.91±0.98	0.293
12	8.61±0.79	7.52±0.68	<0.001	10.01±1.53	9.38±1.29	0.070
13	8.41±0.89	7.64±0.72	0.002	8.92±1.34	8.57±1.20	0.190
14	8.28±0.68	7.37±0.58	<0.001	9.31±1.45	8.92±1.28	0.181
15	8.18±0.63	7.21±0.57	<0.001	8.50±1.22	8.17±1.05	0.207
16	8.05±0.85	7.03±0.70	<0.001	10.55±1.86	9.88±1.60	0.060

16) of HiRes 90K system had less impedance values (about 10%, 11%, 13%) in the post-conditioning status when compared to the pre-conditioning status. On the other hand, impedance values of HiRes 90K cochlear implants in both pre-conditioning and post-conditioning states did not show any difference among electrodes (p>0.05). Our findings showed that basal electrode impedance values of CII cochlear implant were higher than the other electrodes (p<0.001).

Discussion

The results of the present study indicated significant decrease in electrode impedance values after commencement of electrical stimulation in HiRes 90K Clarion cochlear implant. Our findings are in good agreement with the findings of Tykocinsky et al [4]. In this regard, previous studies showed a drop in electrode impedance values after the first mapping session and commencement of electrical stimulation. Moreover, they showed that values of electrode impedance remained essentially stable thereafter [7, 8]. Furthermore, a decrease in the electrical stimulation levels and electrode impedance values was observed in first mapping in children who had been implantedwith a Clarion cochlear implant (programmed with CIS strategy), and values were stabilized after 3 months of implant use [9].

It has been previously shown that electrode impedance values in Nucleus 24M cochlear implant decreased after initial stimulation [10, 11]. On the other hand, it has been reported that in children using the Nucleus 24M cochlear implant, electrode impedance values decreased after initial stimulation, but then increased significantly from 1 to 12 months of post-initial stimulation. It has been suggested that the initial decrease in the values of electrode impedance may be attributed to the notion that stimulation of electrodes resulted in the formation of a hydride layer on the surface of the electrode, which creates a rougher, uneven surface resulting in lower electrode impedance values from 1-month of post initial stimulation [10]. Moreover, increase in the values of electrode impedances may be due to the presence of intra-cochlear fibrous tissue and new bone in the cochlea [12].

The initial increase in electrode impedance is thought to be caused by changes in electrode-electrolyte interface. In fact, commencement of electrical stimulation appears, at least partially, to reverse these changes.

Other researchers showed that at the end of the first mapping session and with commencement of electrical stimulation, the electrode impedance significantly reduced [4]. Although, increased basal impedance, which did not decline after commencement of electrical stimulation, has been observed previously in patients with Nucleus cochlear implant system, whose basal electrodes were not included in their maps and therefore not electrically stimulated. This is usually the case in patients using the SPEAK strategy [7].

At present study we have shown a significant decrease in electrode impedance values after commencement of electrical stimulation in all segments of electrode array in HiRes 90K Clarion cochlear implant. However, we have not found such changes in CII Clarion cochlear implant.

As mentioned before, half-banded electrodes in the Nucleus Contour array have higher impedance values in an inverse relation to the geometric surface area of the electrodes. It seems that in pre-conditioning states, the higher impedance values of half-banded electrodes in Clarion HiRes 90K resulted in more reduction of impedance values. However, this effect was not obvious in Clarion CII.

In conclusion, we observed that applying a biphasic pulse in HiRes 90K Clarion cochlear implant have resulted in better improving the stabilization of patients after programming. However, these findings need to be more clarified in future using different age groups of both sexes and several months after initial stimulation.

References

1. French ML. Electrical impedance measurements with the CI24M cochlear implant for a child with Mondini dysplasia. Br J Audiol 1999; 33(1):61-6

2. Agnew WF, McCreery DB, Bullara LA, Yuen TGH. Development and evaluation of safe methods of intracochlear and peripheral nerve stimulation. NIH progress Report October 1, 1983. NIH Contract NS-0-2319; Huntington Institute of Applied Medical Research, Pasadena, CA.

3. Shepherd RK, Franz BK, Clark GM. The biocompatibility and safety of cochlear prostheses. In: Clark GM, Tong YC, Patrick JF, eds. Cochlear Protheses. Edinburgh: Churchill Livingstone, 1990; 69-98.

4. Tykocinski M, Cohen LT, Cowan RS. Measurement and analysis of access resistance and polarization impedance in cochlear implant recipients. Otol Neurotol. 2005; 26(5):948-56

5. Charlet de Sauvage R, Lima da Costa D, Erre JP, Aran JM. Electrical and physiological changes during short term and chronic electrical stimulation of the normal cochlea. Hear Res 1997; 110: 119-34.

6. Tykocinski M, Duan Y, Tabor B. Chronic electrical stimulation of the auditory nerve using high surface (HiQ) platinum electrodes. Hear Res 2001; 159:53-68

7. Busby PA, Plank KL, Whitford LA. Electrode impedance in adults and children using the Nucleus 24 cochlear implant system. Cochl Impl Int 2002; 3:87-103

8. Henkin Y, Kaplan-Neeman R, Muchnik C, Kronenberg J, Hildesheimer M. Changes over time in electrical stimulation levels and electrode impedance in children using the Nucleus 24M cochlear implant. Int J Pediatr Otorhinolaryngol 2003; 67:873-80

9. Henkin Y, Kaplan-Neeman R, Kronenberg J, Migirov L,Hildesheimer M, Muchnik C. A longitudinal study of electrical stimulation levels and electrode impedance in children using the Clarion cochlear implant. Acta Otolaryngol 2006; 126(6):581-6

10. 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; 22:471-86

11. Saunder E, Cohen L, Aschendorff A, Shapiro W, Knight M, Stecker M. et al. Threshold, comfortable level and impedance changes as a function of electrode-modiolar distance. Ear Hear 2002; 23:28S-40S

12. Kawano A, Seldon HL, Clark GM, Ramsden RT, Raine CH. Intracochlear factors contributing to psychophysical percepts following cochlear implantation. Acta Otolaryngol (Stockh) 1998; 118:313-26