Comparison of the impedance measurements and neural response threshold with and without stylet in the nucleus contour cochlear implant

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ABSTRACT

Objective: To compare the impedance and neural response threshold levels in freedom contour advance nucleus cochlear implant before and after removal of stylet.

Material: Fifty patients aged 1 to 12 years old of both sexes who were profoundly deaf in both ears with no benefit of hearing aids were included in the present study.

Methods: Impedance threshold levels and neural response telemetry thresholds were recorded for each patient intra operatively before and after removal of stylet.

Results: There were significant differences ($p < 0.05$) between impedance measurements and neural response telemetry threshold levels before and after removal of stylet.

Conclusion: Withdrawing the stylet results in a favorable position change of the electrode array within the scala tympani, so that it comes closer to the auditory nerve endings, a finding which is important in clinical setting when programming the system. Removal of stylet results in lower impedance threshold and lower neural response telemetry threshold levels compared to results while stylet is inserted. Therefore we recommend recording the impedances and neural response telemetry before removal of stylet to avoid displacement of electrode arrays before ensuring that the array is in the correct place, and to adopt the impedance and neural response telemetry thresholds after the removal of stylet for the purpose of programming the speech processor.

Keywords: impedance, neural response telemetry, stylet off, freedom cochlear implant

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Introduction

The cochlear implant is a remarkable combination of science, technology and medicine that brings functional hearing to severely and profoundly deaf individuals. In 2005, Cochlear (cochlear implant device manufacturer) released Nucleus freedom, the fourth generation of cochlear implant systems that was characterized by a new electrode array type using an advanced off-stylet technique insertion. [(1)]

The off-stylet technique has two effects; first, the soft, flexible tip leads, and because the stylet has been withdrawn from the tip, the distal electrode is no longer stiff, avoiding penetration of the basilar membrane or spiral ligament; second , it allows the electrode to take up its pre coiled shape and hug the modiolus.[(2)]

There is always a big concern when attempting to slide off the stylet, care should be taken not to result in an incorrect insertion or an intra operative extrusion of the array, thus causing difficulties to reinsert the array and a big chance of losing the device; therefore to avoid such difficulties or undesirable results when using the off-stylet technique and to assure that the insertion is in the correct position, we recommend performing the impedance measurements and neural response telemetry before removal of the stylet .

Neural response telemetry (NRT), based on the work of Brown and colleagues, is a useful method for functional evaluation of the Integrity of the cochlear implants and the cochlear nerve, and is useful both intraoperatively and after the patient is discharged from hospital. [(3)]

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Tsuji *et al* 2009 studied the neural response telemetry in the nucleus contour cochlear implant before and after stylet removal. The result of their study showed a significant reduction in the impedance values of an average 1.5 komega in common ground mode and 1.3 komega for all monoplolar modes after stylet removal ($p<0.001$), and there was a significant reduction in the neural response thresholds after stylet removal only in the apical electrodes.

Seidman *et al*. 2005 studied NRT thresholds in 12 adult patients before and after stylet removal and recorded lower thresholds following removal of the stylet; they concluded that the curved array assumes a perimodiolar position. [5]

Weert et al. 2005 studied NRT in 14 subjects and reported no significant reduction in the stimulus thresholds before and after stylet removal.[6]

Hgar 2011 evaluated the Contour Advance in–stylet technique compared to Contour Advance of off-stylet technique and concluded that the modiolus-hugging do not seem to result in large differences in electrical stimulation thresholds , so in difficult cases the stylet may be left in place without significantly changing the thresholds, except perhaps at the apical turn.[2]

Rajati et al 2014 analyzed the changes in neural response telemetry (NRT) and electrically evoked stapedial reflex thresholds (ESRT) before and after stylet withdrawal during cochlear implant surgery in a group of Thirty children implanted with Nucleus Contour Advance, they concluded that Withdrawing the stylet results in better NRT and ESRT responses, most probably due to a favorable position change of the electrode array within the scala tympani. [7]

The present study was designed to compare the impedance measurements and neural response telemetry levels before and after removal of the stylet.

Methods

This is a prospective study in which the impedance measurements threshold levels and neural response threshold levels were recorded for each patient who received the nucleus freedom contour advance cochlear implant system between July 2011 and August 2013 before and after removal of the stylet. Analysis was done using Excel program for analysis (Microsoft corp 2010). The statistical analysis was performed using Anova one way t- test on each patient group at each point of time. $P<0.05$ was considered statistically significant

All the patients underwent cochlear implantation using the Nucleus Freedom cochlear implant system, (Nucleus 24 Contour Advance (CI24RE)), at Queen Rania Al-Abdallah Hospital for children. After full insertion of the electrode array into the scala tympani, impedance measurements and neural response telemetry measurements were performed before and after withdrawing the stylet.

Auto NRT system intraoperative mode (Cochlear custom sound EP 4.0 software) was used for neural response telemetry.

Impedance measurements using different modes of stimulation were recorded prior to NRT. The modes of the stimulation (Common Ground, MP1, MP2, and MP1 + 2) were used to check the integrity of the system, and to ensure correct placement of the electrode array. Impedance measurements and the NRT levels were recorded in all electrodes surfaces from 22 to 1 which cover the low, mid and high frequencies that are essential for speech recognition and production areas.

Results

Data was analyzed using t–test of variance between the means of impedance threshold levels and neural response telemetry thresholds before and after removal of stylet at $p< 0.05$ of significance. We used 5 electrodes for the purpose of analysis which represents the low, mid and high frequencies, although the measurements were recorded for all electrodes areas

Table (I) and figure (1) showed that the Impedance mean value measurements (Common Ground, MP1, MP2 and MP1 + 2), in all cases and all electrodes were less than 22 Ko (both before and after stylet removal). It is apparent that there was a significant difference before and after removal of the stylet. The mean value of impedance measurements were lower after the removal of stylet at all electrodes compared to before removal ($P < 0.05$).

Table (II) and figure (2) show the neural response telemetry mean value differences before and after removal of stylet. It is apparent that there was a significant difference between the mean value of NRT levels before and after removal of stylet.

The mean value of the NRT after removal of the stylet found to be less significant than that of before the removal ($P < 0.05$) at all measured electrodes

Table I: The means impedance levels (KO) of 5 electrodes in all cases before and after stylet withdrawal with stylet without stylet.

	Electrode 22		**Electrode 16**		**Electrode 11**		**Electrode 6**		**Electrode1**	
Mode of stimulation	With stylet	Without stylet	With stylet	Without stylet	With stylet	Without stylet	With stylet	Without stylet	With stylet	Without stylet
CG	16.3	10.5	18.2	11.7	17.6	12.8	20.1	12.8	20	13
MP1	16.3	10.5	18.2	11.7	17.6	12.8	20.1	12.8	20	13
MP2	16.1	10.1	17	11	17	12	19.8	12.3	19.8	13
MP1+2	16.2	10.2	17.5	11.3	17	12	19.9	12.2	19.4	12.8

Table II: The means threshold of NRT (current unit) for the 5 electrodes an all cases before and after removal of stylet

	Electrode 22		**Electrode 16**		**Electrode11**		**Electrode 6**		**Electrode 1**	
Mode of stimulation	With stylet	Without stylet	With stylet	Without stylet	With stylet	Without stylet	With stylet	Without stylet	With stylet	Without stylet
CG	182.23	161.33	188.22	176.11	190.12	180.23	199.1	189.2	200.23	192.12
MP1	181.23	160.2	187.24	177.19	189.12	179.34	198.12	188.2	190.8	179.2
MP2	181.32	161.2	187.4	176.23	188.4	178	199	189.3	189.7	178.2
MP1+2	180.8	161.8	187	176.9	187.9	178.9	198.7	189.5	189.5	179.56

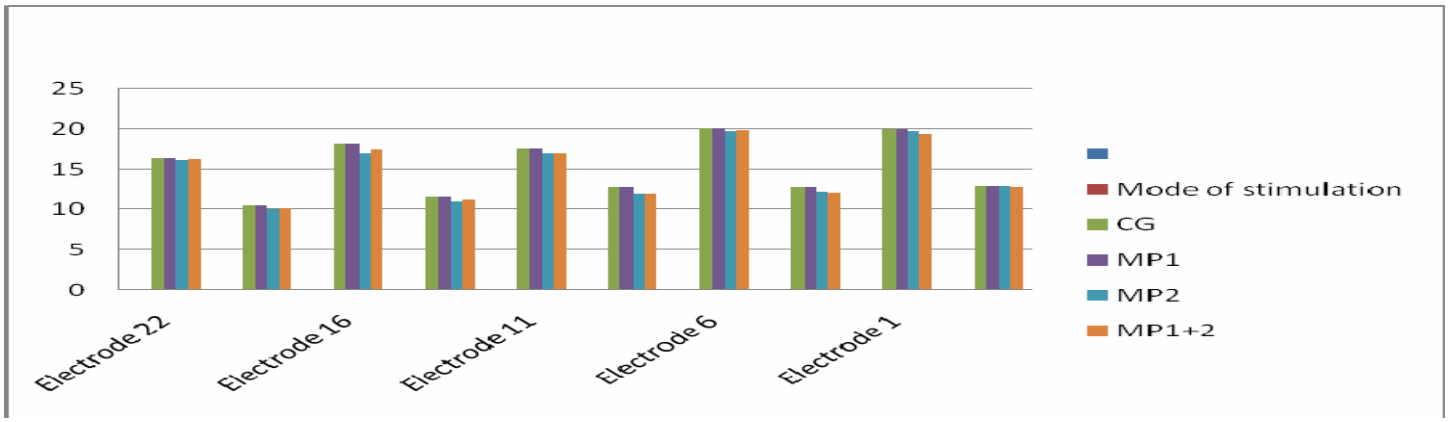

Fig (1): the means impedance levels (KO) of 5 electrodes in all cases before and after stylet withdrawal with stylet without stylet.

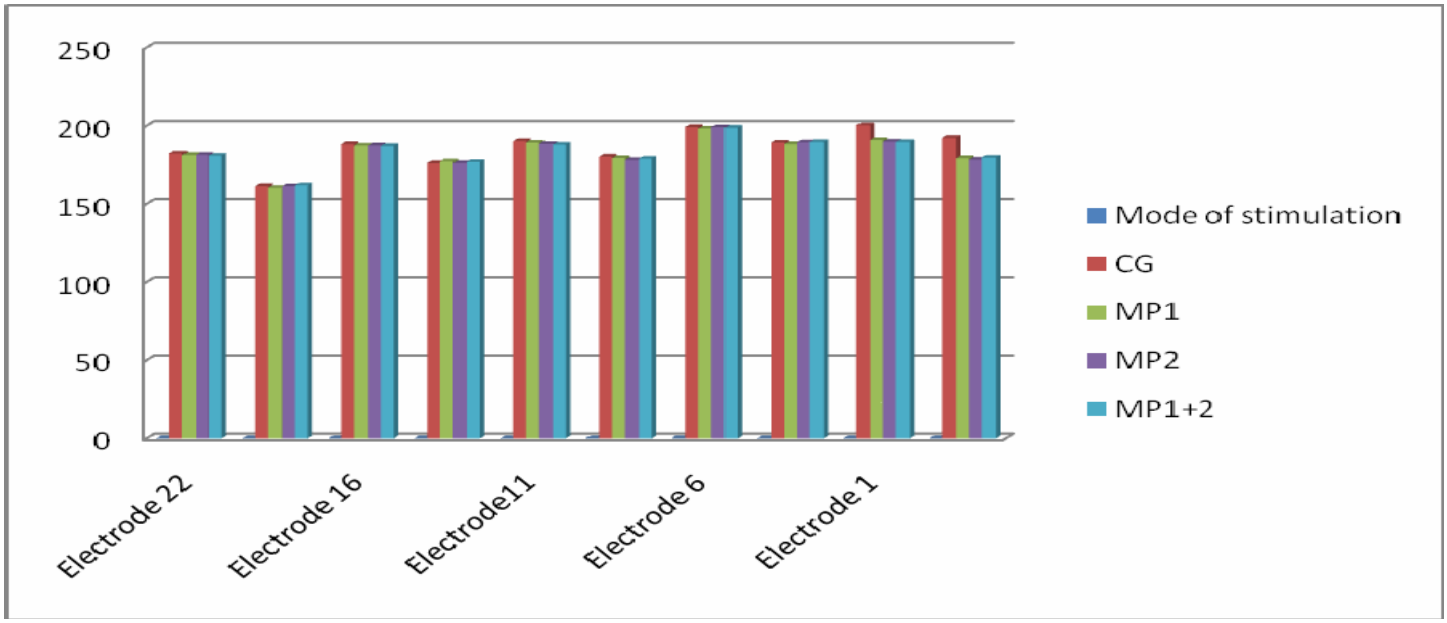

Fig (2): The means threshold of NRT (current unit) for the 5 electrodes an all cases before and after removal of stylet

Discussion

Theoretically, the closer position of the electrodes to the nerve endings has two main advantages, the first one is that the requirement for a lower level of stimulus current results in longer battery life and allows for the hopes for a fully implantable device.

The second benefit is more accurate activation of the ganglion cells, which prevents cross-stimulation of the facial nerve or the neighboring auditory neural cells and may result in improved speech perception. [(7)]

The results of the present study showed a significant difference in the mean threshold levels of impedance measurements and neural response telemetry threshold at all electrodes surfaces that cover the low mid and high areas , the impedances and neural response telemetry thresholds were lower after the removal of stylet compared to before the removal of stylet , the finding of the present study is consistent with the results found by Seidman *et al*. 2005 and Rajati et al 2014 and are inconsistent with the results obtained by Weert *et al* 2005 ,Tusiji 2009 and Hagar 2011 that no significant differences at all areas except perhaps for the apical region according to Tusiji *et al* 2009.

An explanation of the differences between the results obtained with and without removal of the stylet may be attributed to the fact that when the stylet is in place it may result in an increase in the impedances of the biological tissues and hence an increase in the neural response threshold as the stylet plays as a barrier to reach the spiral ganglion and prevents placing the soft tip of the electrode arrays closer to the apical area, in other words it prevents hugging.

Conclusion

Withdrawing the stylet results in a favorable position change of the electrode array within the scala tympani. The array comes closer to the auditory nerve endings, which is important in clinical settings when programming the system.

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