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CORRELATION BETWEEN NEURAL RESPONSE TELEMETRY (NRT) MESUREMENT LEVEL AND BEHAVIORL (T-LEVEL AND C-LEVEL) IN PRELINGUAL COCHLEAR IMPLANT PATIENTS

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ABSTRACT

Objectives: To study the correlation between Neural Response Telemetry (NRT) measurement level and behavioral (Threshold level and Comfort level) in pre lingual cochlear implant patients age between 2 -10 years old at one and three months post implant.

Methods: A cross sectional study conducted at University Kebangsaan Malaysia Medical Center from September 2010 to January 2012. Total numbers of hundred patients were involved in this study.
All recipients implanted with Nucleus 24 cochlear implant and had full insertion and normal activation of the electrode array. Comparison between intra-operative NRT measurement level and behavioral (T-level and C-level) in cochlear implant patients at one month and three months post implantation were obtained respectively.

Results: This study showed the intra-operative NRT levels were seen to fall between the T and C levels in one and three months respectively. There was also a positive correlation between NRT value measurements and both T and C value measurements in both one and three months (*p* value 0.01). There is a fair strength of the linear relationship between NRT and behavioral level in both one and three month post implant as shown by the r value (0.4 at one month, 0.2 at three months)

Conclusion: It is useful to use the NRT values to predict the behavioral T and C values in prelingual children and an additional tool for the mapping.

Key words: Neural Response Telemetry (NRT); Threshold level; Comfort level; Nucleus 24 cochlear implant.

INTRODUCTION

A local study in Malaysia showed a prevalence of hearing loss is 0.42%. This invisible problem occurs more often then all other health problems in newborns that are screened for at birth. It is indisputable that early diagnosis and treatment of hearing impairment in newborns is of paramount importance [1]. The effects of early hearing loss on communication development, as well as social and educational development are well documented [2]. Early implantation provides exposure to sounds that can be helpful during the critical period when children learn speech and language skills. A substantial evidences and literatures now support the benefit of early detection of congenital hearing loss and the concomitant implementation of early intervention strategies [3]. With the introduction of universal newborn hearing screenings in worldwide, the average age of diagnosis of congenital hearing impairment has now decreased to 3-6 months of age, thereby increasing the likelihood for appropriate and successful early intervention in these infants [4].

Numerous changes continue to occur in cochlear implant candidacy. Programming the cochlear implant in young children is another challenge. Optimal use of CI technology requires an accurate assessment of threshold and comfort levels during the mapping session, obtained in older children and adults with behavioral testing. Neural response telemetry of Cochlear Corporation (Sydney, Australia), neural response imaging of Advanced Bionics (Valencia, Calif, USA), and auditory nerve response telemetry of Med-El (Innsbruk, Austria) use an electrode in each array to record a response from the auditory nerve in postoperative programming sessions [5].

The eventual hearing performance of cochlear implant recipients depends on various factors; age at implantation, duration of deafness, number of electrodes inserted in the cochlea, and the therapy of rehabilitation. The success of the implantation depends on the ability of the auditory system to extract useful auditory information from the electrical stimulation provided by the cochlear implants [6]. An additional consideration is learning to interpret the sounds created by an implant. This process takes time and practice. Speech-language pathologists and audiologists are involved in this learning process.

Availability of the NRT system allows easy and rapid electrophysiological estimate of the auditory sensitivity and provides a direct measure of the auditory nerve function without the need for surface recording electrodes. Intra-operative NRT in conjunction with electrode impedance data, help indicates the integrity of the implanted electrodes confirming that the implant is functioning correctly. The data can be collected easily for every electrode on the array in less than 10 min and can be done during flap closure. Various tools have been proposed in the literature for an objective study of the neural response, these include the electrical stapedius muscle reflex, the electrically evoked auditory brainstem response (EABR) [7, 8] and most recently the electrically evoked auditory action potential (EAP) [9]. Brown et al.2000 demonstrated that NRT might be used to define the maps based upon EAP thresholds rather than arbitrarily setting a T- or C-level. Thus, the EAP thresholds can provide an indication of “safe” levels of stimulation. He suggested that further research is needed in order to determine correlation between NRT and T- and C-level [10].

It is critical to ensure early and continued optimal auditory input to support development of speech and language in children. Consequently, it is important to determine whether NRT can provide reasonable estimates of T-levels based on consistent detection of soft sounds and C-levels ensuring comfort of loud sounds in most pediatric subjects. The main objective of this study is to study the correlation between the NRT thresholds and profile of T- and C-levels in children's who were fitted with cochlear implant.

MATERIAL AND METHODS:

Initially the candidates was assessed by ENT consultants and audiologist and if he / she was found to be a suitable candidate a comprehensive audiological evaluation including BERA / OAE / PTA / Speech Audiometry/ aided audiogram and hearing aid trial was done. The candidate also underwent radiological procedures like high resolution CT scan and MRI scan to detect any congenital deformities of the cochlea and eighth cranial nerve. A cross sectional study was conducted at Universiti Kebangsaan Malaysia Medical Center (UKMMC) from September 2010 to January 2012. Only the non-syndromic pre-lingual cochlear implant recipients' age between 2 and 10 year were included. Those syndromic SNHL and bilateral CI recipients were excluded from the study. Subjects included in the analysis only if both NRT and behavioral measurements were available. Neural Response Telemetry (NRT) recordings were obtained in operating rooms. The recordings obtained at the end of the implant operation after the surgeon placed the skin over the implanted device using software (custom sound EP v 3.0) with the speech processor to capture, process, store and display the measurement data on a personal computer.

The switch on and speech processor tuning was done 3 weeks after surgery. Mapping is done at periodic intervals till a stable map is achieved. The data of NRT at all electrodes as well as the behavioral levels of the electrodes at one month and three months after surgery were collected from Cochlear implant database and analyzed using SPSS v.13. The Pearson Correlation coefficients of a *p* value less than 0.05 indicated statistical significance.

RESULTS:

Comparison between intra-operative NRT measurement level and behavioral (T level and C level) levels in cochlear implant patients at one month and three months post implantation were obtained respectively.(Table 1),(Table 2). The data were normally distributed and showed a significant correlation between both NRT and behavioral levels in one and three months (*p* value 0.01) as shown in (table 1, 2).There was a fair strength of the linear relationship ($r=0.415$ at one month and r=0.268 at three months).

Table1. Mean, standard deviation and correlation between intra-operative NRT measurement level and behavioral (T level and C level) levels at one month post implantation.

	MEAN	SD	Correlation coefficient(*r*)	*P* value	N
NRT	164.2300	20.22904			100
T-level	124.3100	28.56030	0.415	0.01	100
C-level	183.9200	25.42634	0.436	0.01	100

Table 2. The mean, standard deviation and correlation between intra-operative NRT measurement level and behavioral (T level and C level) levels in at three months post implantation

	MEAN	SD	Correlation coefficient(*r*)	*P* value	N
NRT	164.2300	20.22904			100
T-level	128.2900	25.57907	0.268	0.01	100
C-level	201.3500	22.07443	0.275	0.01	100

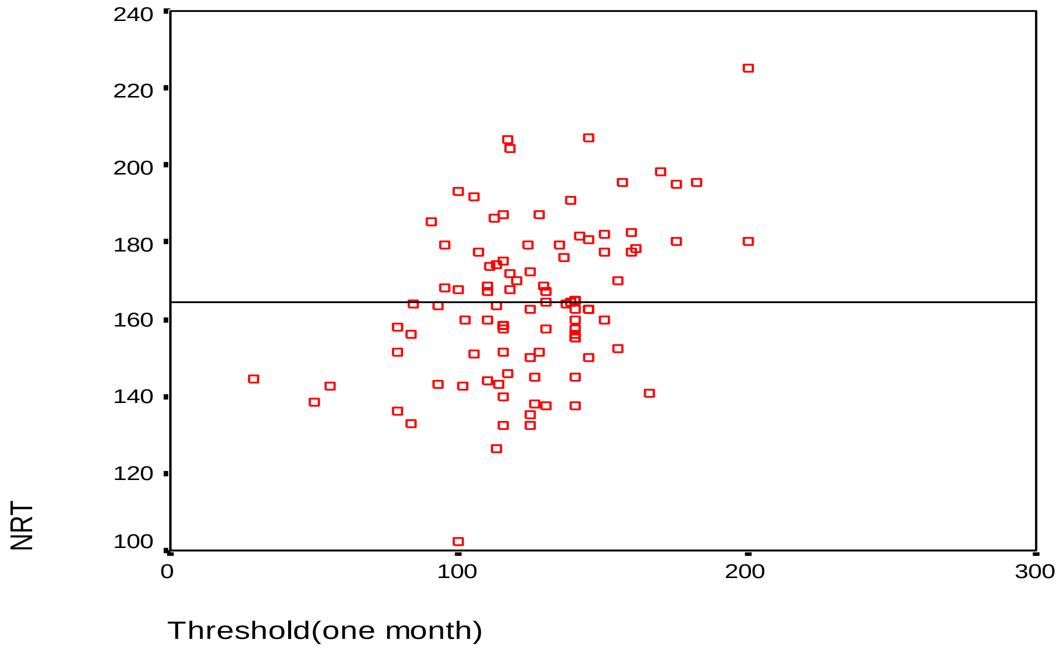

Figure.1a. Graph shows the correlation between NRT measurement levels and threshold level (red dots) at one month.

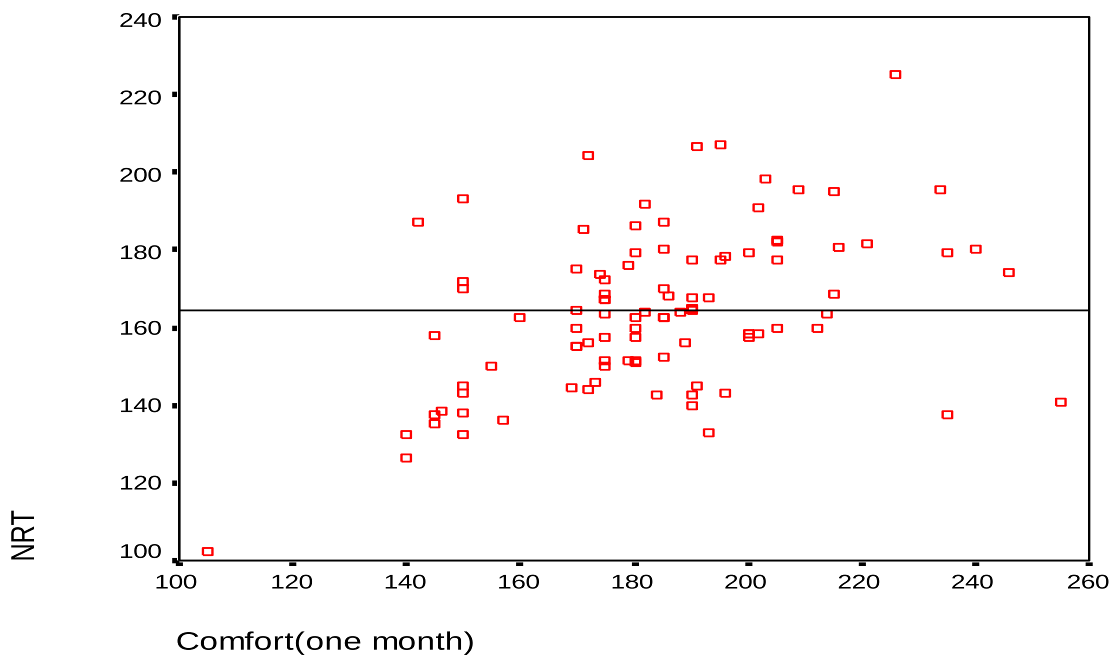

Figure.1b. Graph shows correlation between NRT measurement level and Comfort level at one month post implant.

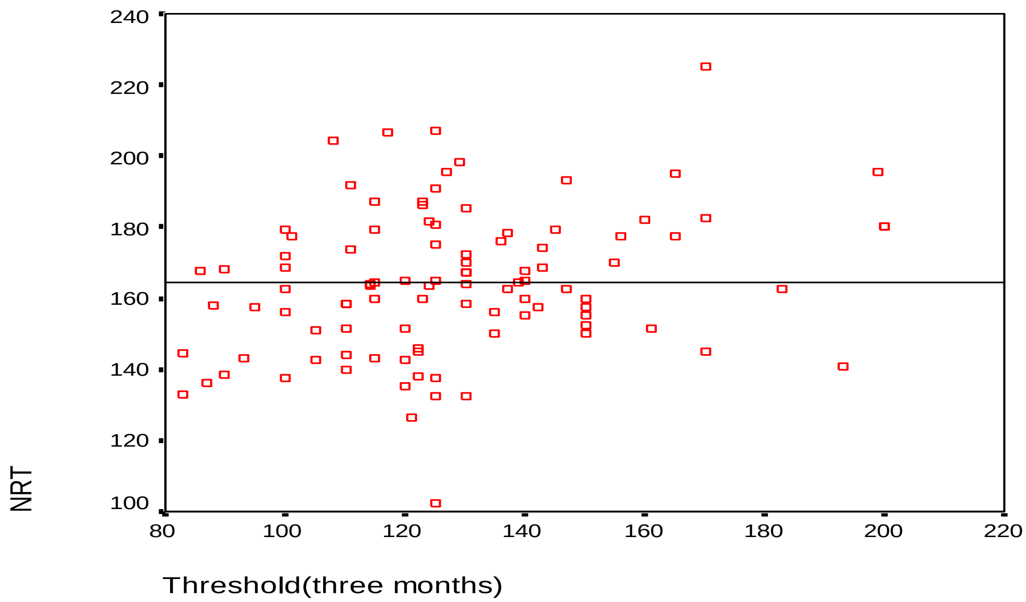

Figure.2a. Graph shows correlation between NRT measurement level and threshold level at three months.

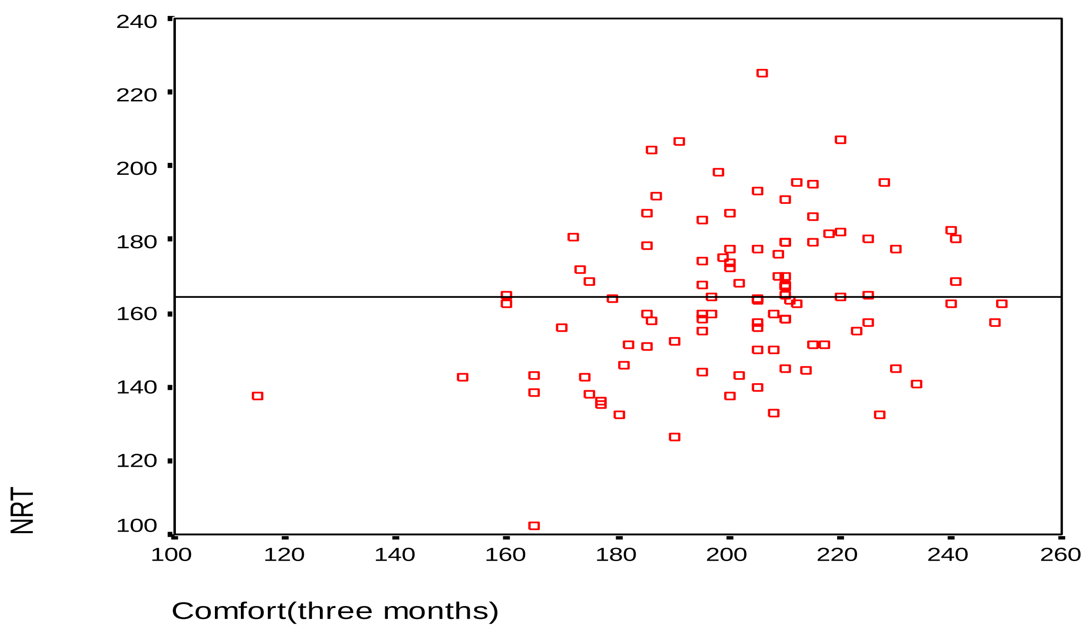

Figure.2b. Graph shows correlation between NRT measurement level and comfort level at three months post implant.

Figure.3a. Relation between the mean NRT and T-level and C-level at one month post implant.

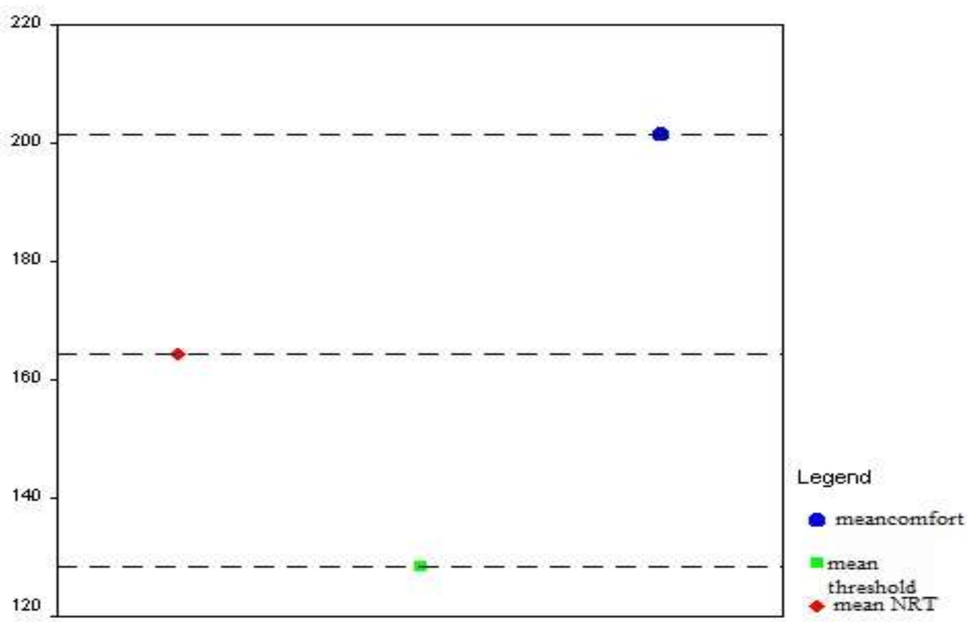

Figure.3b. Relation between the mean NRT and T-level and C-level at three months post implant.

Discussion

Since it is not easy to obtain reliable behavioral responses in young children, Neural Response Telemetry (NRT) has been used worldwide to confirm the response to electrical stimulation, to guide initial programming, to monitor recipients over time and to create MAPs [7]. In this study, the mean NRT levels were not equal to the mean values either T- or C-levels it lie within the T and C mean levels on behavioral tests and were closer to C-level (Fig 3a, 3b). The profile of NRT levels as a function of electrode number resembles the profiles of T- and C-levels. In this study there was correlation between NRT levels and the behavioral T and C-levels. Additionally the study showed that there is a statistical significance (p 0.01) between NRT levels and both T and C-levels in one and three months post implant as shown in (Fig1a, 1b) and (Fig 2a, 2b) respectively. These finding are similar with those by Hughes et al 2000, who demonstrated that NRT thresholds show a significant correlation with T and C-levels [11]. Therefore, it is useful to use the NRT measurements to predict the behavioral T and C-levels. Hughes et al 2000 and Brown et al 1999 reported significant correlation between NRT and predicted T and C-levels as in our study [12]. Hughes et al 2000 and Brown et al 2000 again showed that the average map T-levels and C-levels were higher in children as compared to adults that may indicate that children have larger map dynamic ranges (difference between T and C levels)[11].

The correlation between the intra-operative NRT and behavioral T and C levels is affected by several factors. The number of auditory neurons contributing to a visible neural response may be more than the number of responding neurons for a perceptual hearing threshold. For that reason the NRT levels would be higher than those of the behavioral T and C levels. It is also known that temporal summation will affect the behavioral T and C levels and may therefore also affect the correlations [8].

It has been reported that the correlations between NRT level and the behavioral T and C-levels improved over time in children [13]. This improvement might reflect the improved accuracy in setting the T- and C-levels as the children become familiar with the auditory signal and better able to respond appropriately and this was seen in our study in three months post implant as compared to the one month results. (Fig 1a, 1b) and (Fig 2a, 2b) in which the T-level and C-level noted to be less than one month results. The other factors that affect the relation between the NRT and the behavioral levels is the age of the patient at which the cochlear implant performed and period of deafness because even though the electrical stimulation of cochlear implant elicits beginning of maturation of the auditory system in deaf children, this follows different patterns when compared to normal hearing children [9]. The intra-operative NRT levels in this research were seen to fall between the T and C levels(Fig 3a,3b) and a good correlation found between NRT and T and C levels(Fig 1a,1b and Fig 2a,2b). Although previous studies investigated the relation between NRT and behavioral levels used to create MAPs, methods varied substantially and results have been inconsistent making application difficult. This study showed that NRT can provide reasonable estimates of behavioral levels as found by Potts et al 2007 [13].The positions of NRT thresholds between T- and C-levels in this study agrees with those of previous studies with children [10, 11, 14, 15]. In addition, all of these studies have found large variability in the position of NRT threshold in relation to T- and C-levels as shown in our study as well. As Abbas et al. 2000 have indicated NRT thresholds obtained intra operative can serve as a valuable baseline with which to monitor the child's neural responsiveness at subsequent intervals [10]. The study showed large variability between the relation of NRT and behavioral levels in one and three months. Given the large variability of the overall level of NRT profile in relation to those of T- and C-level described in this study and by

Potts et al. 2007 [13]. It is important to progress beyond the NRT and to individualize and optimize the MAP using behavioral measures as quickly as possible. The present study therefore implies that NRT is not only a important clinical tool in providing information regarding integrity of the implant and status of peripheral auditory nerves but can also be used in programming the speech processor for young and difficult recipients.

Conclusion

NRT is used as an additional tool for the mapping. This study showed a close correlation between NRT and behaviorally T and C levels. The relationship between NRT and behavioral levels was better at one month was better than three month. The larger variability in T and C levels in one and three months post implant may have resulted from the differences in their auditory experiences.

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