International Journal of Pediatric Otorhinolaryngology 82 (2016) 47–53

Contents lists available at ScienceDirect

International Journal of Pediatric Otorhinolaryngology

journal homepage: www.elsevier.com/locate/ijporl

Deeper insertion of electrode array result in better rehabilitation outcomes – Do we have evidence?☆

Gyanaranjan Nayak [a], Naresh K. Panda [a,*], N. Banumathy [a], Sanjay Munjal [a], N. Khandelwal [b], Akshay Saxena [b]

[a] Department of Otolaryngology Head and Neck Surgery, PGIMER, Chandigarh, India
[b] Department of Radiodiagnosis, PGIMER, Chandigarh, India

ARTICLE INFO

Article history:
Received 18 September 2015
Received in revised form 30 December 2015
Accepted 31 December 2015
Available online 7 January 2016

Keywords:
Cochlear implantation
Depth of insertion
Outcome analysis
Round window

ABSTRACT

Objective: To study the outcome analysis in cochlear implantees in relation to depth of insertion.
Methods: 30 patients of non-syndromic congenital profound hearing loss in the age range of 2–12 years received cochlear implantation by a posterior tympanotomy round window approach. Depth of insertion was calculated using post-operative X-rays (modified Stenver's view) and categorized into four groups, viz. fair insertion (Group A <180°), good insertion (Group B 180–<270°), very good insertion(Group C 270–360°), excellent insertion (Group D >360°). The outcome analysis of each implantee was carried out in a follow up interval of every 3 months using Meaningful Auditory Integration Scale (MAIS), Infant Toddler Meaningful Auditory Integration Scale (IT-MAIS), Category of Auditory Performance (CAP), and Speech Intelligibility Rating (SIR).
Results: Overall 30, 29, 25, and 22 patients have completed 3, 6, 9, and 12 months follow up respectively. The MAIS scores in Group C were significantly better than Group B at 6, 9, and 12 months ($P < 0.05$). The mean CAP score of Group C was more than rest of the groups with significant difference between Group C and Group D at 12 months ($P < 0.05$). The mean SIR scores were maximum in Group C with significant difference between Group C and Group B at 9 and 12 months ($P < 0.05$).
Conclusion: The study demonstrates that insertion from 270° to 360° gives optimum hearing outcomes as compared to deeper insertion, although larger sample and long term follow-up is warranted for definite conclusions.

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1. Introduction

Cochlear duct length estimation predicts the cochlear implant depth insertion which has been described either in terms of linear distance (in mm) or insertion angle (in degrees). Due to the small size of the apical turn, full insertion of the electrode array is hardly achievable. There are extensive individual anatomic variations in both size and shape of human cochlea and these variations will influence the position of cochlear implant arrays and also will affect the potential of hearing preservation surgery [1,2].

The diameter of cochlear duct decreases considerably from the basal turn to the apical turn. Insertions of more than 1 turn bear an increased risk of trauma to the basilar membrane, organ of Corti or the lateral wall structures, such as the stria vascularis. Inter-individual variation of size of the cochlea, results in variability of cochlear duct length [3].

The base of the cochlea is tuned for frequencies as high as 20 kHz and the apex is sensitive to frequency as low as 20 Hz. The benefit of deeper insertion is yet to be established in the clinical setting, despite the intuitive appeal that the deeper insertions should lead to improved speech and hearing understanding. Evidence supporting the fact of benefit of deeper insertion has come from individuals using experimental speech processors, where the place of stimulation within the cochlea has been moved from basal to apical regions with a corresponding improvement in speech perception [4]. Deep insertion is not necessary and may even be disadvantageous since the human ganglia extend only 1–3/4 turns [5,6].

William House originally used the round window as a route for the first pioneering electrode insertion [7]. To facilitate greater

☆ This paper was presented at the 12th Annual Conference of Cochlear Implant Group of India, New Delhi, November 2014.

* Corresponding author at: Department of Otolaryngology, PGIMER, Chandigarh, India. Tel.: +91 0172 2756760; fax: +91 172 2744401.
E-mail address: npanda59@yahoo.co.in (N.K. Panda).

http://dx.doi.org/10.1016/j.ijporl.2015.12.028
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insertion depth, the technique of scala tympani cochleostomy and removal of the crista fenestra was developed. However the major disadvantage of the cochleostomy approach is the trauma to the inner ear that causes loss of residual function. Also the depth of insertion is still limited and intra-cochlear trauma can occur when the electrode bands of the straight array contact the lateral wall of the scala tympani, spiral ligament and undersurface of the basilar membrane. Although the initial round window approach was abandoned in the early years of cochlear implantation, it has now regained its popularity in recent years among many surgeons. A pure round window approach avoids the trauma to the inner ear and bone dust associated with cochleostomy approach and also ensures entrance into the scala tympani [8,9].

The evidence supporting that early implantation and early restoration of hearing may yield better results than late implantation is building up. The reason behind is that it is arduous to assess the auditory performance in young children accurately. Pure tone audiometry (PTA) is widely acknowledged as reliable, but as an outcome measure of cochlear implantation it is not valid [10]. Therefore, various indirect outcome measures may have to be used in order to assess speech and language development viz. the Category of Auditory Perception (CAP) scores, etc. [11].

The MAIS (Meaningful Auditory Integration Scale) is designed to identify the meaning of hearing loss for a child that uses sound in daily life [12]. By using examples in three different hearing acquisition developmental areas which include (1) vocalization changes associated with using the device, (2) alertness to environmental sounds and (3) attribution of meaning to sounds, it analyses spontaneous auditory behaviors that children present in daily activities. IT-MAIS (Infant Toddler Meaningful Auditory Integration Scale) is designed for children less than 3 years of age [13].

The need to evaluate the hearing and speech outcomes in group of SNHL children after cochlear implantation is of vital importance. The results of this study may help in monitoring the development of hearing and speech perception after cochlear implantation.

Previous work by Escude et al. [14] suggested that the variation in cochlear size would produce >5 mm variation in the length of the lateral wall to the point consistent with insertion depth angle of 360°.

It remains unclear as to what extent the electrode length affects the risk of hearing loss post-implantation and how far the electrode array should be inserted into the cochlea is still a matter of debate. Various studies have shown that there is a large inter-subject variation in the size of cochlea and cochlear duct length. Because of this variation in size of cochlea and cochlear duct, the approximate electrode length may differ among the patients.

Yukawa et al. [15] have assessed whether depth of insertion of cochlear implant array affects postoperative speech perception in postlingually deaf adults and their findings suggested that deeper electrode insertion is associated with improved speech perception.

Hodges et al. [16] investigated the relationship of electrode insertion depth and speech recognition in Nucleus-22 cochlear implant recipients and concluded that insertion of electrode array beyond 22 rings does not improve performance in speech recognition.

According to Gstoettner et al. [17] and Hamzavi and Arnoldner [18], the anatomic variations of cochlear diameters may lead to significant variations in insertion degrees at constant surgical depth. A 360° insertion entering the 1 kHz region which is the endpoint of electric stimulation and starting of acoustic stimulation corresponds to 18–24 mm [19].

This study aimed to correlate the outcome analysis of cochlear implantation in relation to depth of electrode insertion with round window approach in pediatric age group.

2. Methods

The study was conducted in the Department of Otolaryngology and Head & Neck Surgery, Post Graduate Institute of Medical Education and Research, Chandigarh in collaboration with the Department of Radiodiagnosis. An institutional ethics committee approval was obtained before commencement of the study. The study investigated 30 children of bilateral severe to profound congenital sensorineural hearing loss of 2–12 years of age who underwent cochlear implantation by a standard posterior tympanotomy round window approach between the period 2012 and 2014. Children with any cochleovestibular anomaly, any syndrome, postoperative infection and those who underwent implantation via standard cochleostomy approach were excluded from the study.

Out of 30 children, 17 children received Nucleus CI24RE (ST), 6 received Nucleus Contour Advance (CA), 1 child received CI422 (ST) and 6 received Advanced Bionics HiFocus1j implants. The rationale for using different electrodes is that all these electrodes have variable length and thus serve the aim of our study. Postoperative radiographs (modified Stenver's view) of all the patients were studied as shown in Fig. 1. Modified Stenver's view radiography is routine after cochlear implantation to assess the position of the electrode. Computed tomography is not performed due to logistic reasons. Depth and Length of the electrode inserted was calculated in the postoperative radiograph according to Marsh and Xu et al. [20] as shown in Fig. 2. The bony cochlea was divided into various quadrants. The black line passes through the center of the superior semicircular canal and the center of the vestibule. This first vertical line is the baseline on which other lines are oriented. The first horizontal line shown by the red line drawn perpendicular to the first black line and is at the level of the lower level of the basal turn but more frequently it is suggested by the curvature of inserted array since the array rests on the outer wall of scala tympani. The second vertical line shown by the white line is drawn parallel to first vertical line, tangent to the ascending basal turn, but is usually marked by the electrode array along the outer wall of scala tympani. The second horizontal line shown by the yellow line is perpendicular to the first vertical black line and is drawn tangentially to superior-most part of basal turn, is usually marked by the electrode array if present to this point.

Distance between the first horizontal line (red line) and second horizontal line (yellow line) is measured and a line is drawn through the midpoint of these horizontal lines perpendicular to the

Fig. 1. Skull radiograph modified Stenver's view.

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