

Original Research Article

Comparison of residual hearing preservation and auditory based performance after paediatric cochlear implantation by round window insertion versus cochleostomy technique: an ambispective cohort study

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ABSTRACT

Background: Cochlear implantation (CI) has revolutionized the treatment of sensorineural deafness. The aim of the study was to compare auditory based performance in cochlear implants who underwent round window insertion and cochleostomy.

Methods: Ambispective cohort study was done among the children who underwent perilingual cochlear implant in a tertiary care hospital for period of 1 year. Children who satisfied the inclusion criteria were selected and randomly subdivided into 2 groups: group A- round window insertion and group B-cochleostomy. Pre- and post-operative pure tone average (PTA) and residual hearing preserved were evaluated among the cochleostomy and round window insertion groups separately. Post-operatively, children were evaluated, from three months to 1 year from the activation of cochlear implant, with the use of scores such as Category of Auditory Performance (CAP), Meaningful Auditory Integration Scale (MAIS), Speech Intelligibility rating (SIR) and Meaningful use of speech scale (MUSS score) to measure speech production skills by auditory verbal therapist.

Results: A total of 80 patients were included in the study. Complete hearing preservation (within 10 dB) was significantly high in round window insertion group compared to cochleostomy technique ($p < 0.001$). None the subjects had complete loss of residual hearing. On evaluating the post CI performance, MAIS score in the round window insertion group (9.34, 18.21, 27.79) were significantly better compared to cochleostomy group during the 3 months, 6 months and 12 months follow-up.

Conclusions: Round window insertion technique is significantly more successful in complete hearing preservation at low frequencies compared to cochleostomy technique. Among the auditory scores, only MAIS in the round window insertion group was found to be significantly better compared to cochleostomy group.

Keywords: Cochleostomy, Round window insertion, Sensorineural deafness

INTRODUCTION

Cochlear implantation has revolutionized the treatment of sensorineural deafness. The introduction of cochlear implants has made it possible to successfully rehabilitate profoundly deaf adults and children who did not derive any benefit from conventional hearing aids. It is shown that

preoperative residual hearing is a positive predictor of good performance with a cochlear implant.¹⁻³ Candidates with residual hearing are being progressively implanted across the world. Great success has been achieved with hearing preservation technique in conservation of residual hearing after cochlear implantation. This has attributed to improved word understanding, music appreciation and low

frequency speech recognition in these candidates. It also allows the possibility of combining electro-acoustic stimulation of same ear.

Thus, its preservation carries great significance. Lehnhardt introduced the 'soft surgery' concept for cochlear implantation to avoid as much damage as possible in the inner ear.⁴ 'Soft surgery' led to preservation of residual hearing in more than about 70% of the patients after cochlear implantation.⁵⁻⁷

The aim of the study was to evaluate the preservation of residual hearing after cochlear implantation using electrode array insertion via round window and cochleostomy. Besides, the effect of the preservation of residual hearing after cochlear implantation on speech and language acquisition was also evaluated.

METHODS

Study design and sampling

Ambispective cohort study was done among perilingual cochlear implantees from November 2013 to December 2014 at department of ENT, and auditory verbal therapy clinic MIMS after ethical committee clearance. Children (1-7 years) with clinically documented pre-operative residual hearing 90 dB or better at 250 Hz and 110 dB or better at 500 Hz were randomly selected and included for the study.

Exclusion criteria were subjects in post lingual category, with mental retardation/central auditory processing disorders, demyelinating disease osteogenesis imperfecta. Informed consent was taken before conducting the study.

Study procedure

The data was collected from the medical records department. Preoperative audiogram results were computed from records. All audiometric testing's were performed using calibrated audiometers using the modified Hughson-Westlake procedure.

A pre-operative low-frequency pure tone average (PTA) is calculated by averaging thresholds at 250, 500 and 1kHz. In children below 30 months, BOA /ASSR reports were obtained. Children were subdivided randomly into 2 groups: group A- for round window insertion (Figure 1) and group B- for cochleostomy (Figure 2), according to surgical technique chosen for cochlear implantation, which were again sorted into two sub-groups on account of age (<36 months and >36 months) to reduce the effect of a possible loss of plasticity in the brain's ability to listen, process, and recognize sound in older children.

Electrode insertion technique (Figure 3) (cochleostomy/round window insertion) was done as per the standard procedure.⁵



Figure 1: Round window insertion.

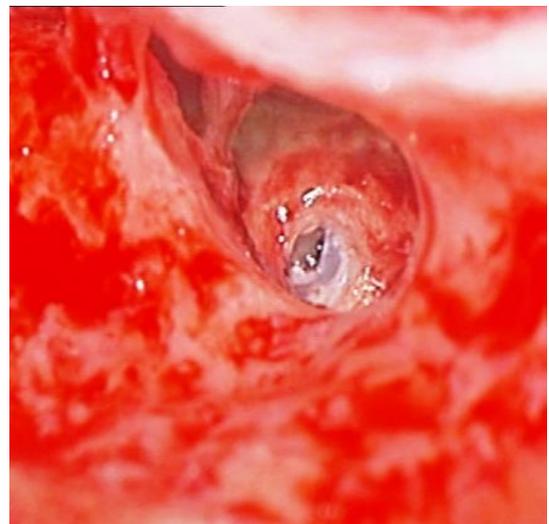


Figure 2: Cochleostomy.

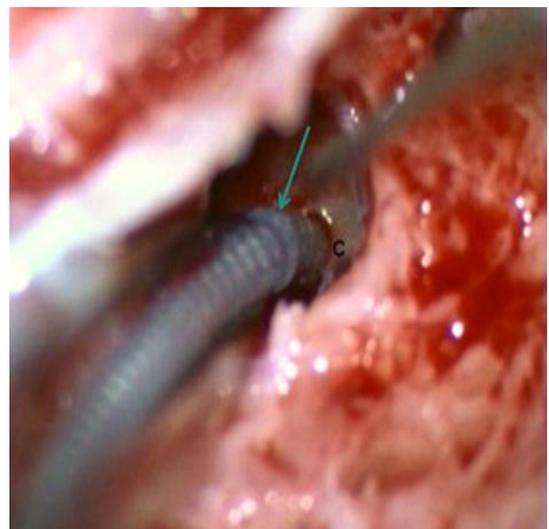


Figure 3: Electrode insertion.

Surgical procedure

Once the patient is properly anesthetized, the postauricular crease is infiltrated with 2% lignocaine with 1/2,00,000 adrenaline. Lazy 'S' shaped incision along the post auricular crease is made and extended to the level of 2 cm above attachment of pinna. Anteriorly based pericranial flap is raised. Using a conical burr, under high powered microscope cortical mastoidectomy is performed. Bony posterior canal is thinned and the antrum, opened and the horizontal semicircular canal is identified along with incus.

With a 2 mm diamond burr facial nerve was skeletonized in its descending portion, and chordai tympani identified to do posterior tympanotomy. Facial recess was widely opened with a 2 mm diamond burr and stapedial tendon, stapes suprastructure and round window niche inferiorly were identified. If visualization of round window was difficult, the bone anteriorly and medial to facial nerve was removed with a diamond burr and patient's bed towards surgeon was rotated.

Drilling out the bone well for cochlear implant receiver stimulator was done posterior and superior to the mastoidectomy site.

In group A patients, Round window insertion technique was used. When approaching the round window from the posterior tympanotomy hole, simple and safe procedure is removal of the anteroinferior overhang. The round window niche is usually covered either partially or completely by mucosal folds that should not be confused with the membrane itself. When in doubt, mobilization of the ossicular chain elicits a round window reflex. The depth and shape of the niche can vary considerably. The membrane may be easily visible or, at times, completely covered. Incision made at the very lateral part into the membrane.

In group B patients, Cochleostomy insertion was done. A small cochleostomy is performed 1 mm inferior and anterior to round window niche to avoid injury to scala media and spiral ligament, with a 1 mm diamond skelerator. The burr should not enter scalatympani. The endosteum is opened with a 0.2 mm foot plate hook. No suctioning of perilymph is permitted. Once basilar turn is visualized, any bone from ossification can be drilled out and further removed with stapes picks.

For the electrode insertion, the silastic receiver portion of the device was tucked under the temporalis or pericranial flap. Then the cochlear implant was secured within the well and tied it down with 1-0 prolene. Thereafter, the electrode was inserted along the outer wall of the basal turn of the cochlea. All insertions were stopped at the point of first resistance to minimize cochlear trauma. Actual insertion of the electrode is slow (30-45 s) to minimize intracochlear trauma. Use a temporalis fascia graft to pack the cochleostomy site. Using an intraoperative sterile

telemetry device, impedance testing for implant integrity was performed. The periosteal flap was closed over the mastoidectomy site, the cochlear implant with absorbable sutures and the skin flap with absorbable subcutaneous interrupted sutures with 3-0 monocryl and mattress suture with 3-0 ethilon. Mastoid dressing is applied.

All CIs were activated after a period of around 30 days post-surgery.

Postoperatively, unaided audiogram was done and patients were reviewed sequentially for 1-year duration. The difference between the pre and post cochlear implantation PTA gave a measure of residual hearing preserved and were classified into four categories: category 1: ≤ 10 dB (complete hearing preservation); category 2: 11-20 dB (moderate hearing preservation); category 3: 21-40 dB (mild hearing preservation) and category 4: >40 dB (no hearing preservation).

All the participants attended identical post-operative rehabilitation program, with individualized intensive auditory training, conversation and speech stimulation. Postoperatively, all children were evaluated, from three months to 1 year from activation, by the auditory verbal therapist, and CAP score, for speech and language production skills; SIR score to measure the speech intelligibility of the implanted children and MAIS score for to examine auditory skills, MUSS score to measure speech production skills were opted.⁸⁻¹⁴

Statistical analysis

Data was analyzed using statistical software SPSS version 17. For the comparison of categorical variables Chi square test was used. Mann Whitney-U test was performed to compare MUSS, MAIS, CAP and SIR scores with respect to the two groups.

RESULTS

Eighty patients out of an overall 98 subjects who underwent CI surgery were enrolled for this study according to the selection criteria. Patient demographics details in the two groups were summarized in Table 1. Out of 80 subjects who underwent CI, 53 were males and 27 were females with mean age of 36.8 months (ranging from 12 months to 74 months). 11.3% had family history of sensorineural deafness. 73 subjects underwent CI in right ear, and 7 in the left ear. In which, four of them had dehiscent jugular bulb (right sided), 1 case was revision following CI infection (right), and 2 cases had H/O CSOM (right sided). 38 subjects underwent round window insertion technique (group A) and 42 subjects underwent cochleostomy technique (group B). As per category of hearing preservation complete hearing preservation was seen in 45% of subjects (both group A and group B), moderate preservation in 42.5% and marginal preservation 12.5%, and none of them had complete loss of residual hearing. It was found that complete hearing preservation

(<10 dB) was achieved in 68.4% (26/38) and 23.8% (10/42) respectively in Group A and Group B (Table 2). Thus complete hearing preservation was found to be significantly higher in round window insertion group (p<0.001). On evaluating the post CI performance, MAIS score was found to be better in round window insertion group (9.34, 18.21, 27.79) in 3 months, 6 months and 1 year follow up (Table 3) and was significantly higher in round window insertion group with p value<0.001 at 3

months and 6 months and p value<0.002 at 12 months. On CAP score assessment, distribution was significantly different between the two methods with higher scores in cochleostomy group (Table 4). SIR score showed no significant difference between the groups (p value=0.161) at 6 months, though significant difference observed at 12 months (p value=0.019) better for the cochleostomy group (Table 5). MUSS score did not show significant difference during the follow up between the two groups.

Table 1: Patient demographics.

Parameters	Group A (%)	Group B (%)	Total (%)
Age of CI (months)			
≤36	18 (47.4)	25 (59.5)	43 (53.8)
>36	20 (52.6)	17 (40.5)	37 (46.2)
Gender	38	42	80
Male	23 (60.5)	30 (71.4)	53 (66.3)
Female		12 (28.6)	27 (33.8)
Family history of deafness	15 (39.5)		
No	5 (92.1)	36 (85.7)	71 (88.8)
Yes	3 (7.9)	6 (14.3)	9 (11.3)
Side of CI			
Left	2 (5.3)	5 (11.9)	7 (8.8)
Right	36 (94.7)	37 (88.1)	73 (91.2)

Table 2: Categories of hearing preservation.

Hearing preservation	Methods		Total
	Group A	Group B	
Complete	26	10	36
	68.4%	23.8%	45.0%
Marginal	2	8	10
	5.3%	19.0%	12.5%
Moderate	10	24	34
	26.3%	57.1%	42.5%
Total	38	42	80

Table 3: Comparison of MAIS score.

Post-op evaluation		Treatment		P value
		Group A	Group B	
3 months	Mean±SD	9.34±0.88	7.74±1.01	<0.001
	Median	10	8	
	Inter quartile range	1	0	
6 months	Mean±SD	18.21±2.48	16.33±1.3	<0.001
	Median	18.5	16	
	Inter quartile range	4	3	
12 months	Mean±SD	27.79±2.22	26.40±1.42	<0.002
	Median	28	26	
	Inter quartile range	5	2	

Table 4: Comparison of CAP score.

Post-op evaluation		Treatment		P value
		Group A	Group B	
3 months	Mean±SD	2.55± 0.50	2.95±0.22	<0.001
	Median	3	3	

Continued.

Post-op evaluation	Treatment		P value	
	Group A	Group B		
6 months	Inter quartile range	1	0	<0.001
	Mean±SD	3.45±0.69	3.95±0.40	
	Median	3.5	4	
	Inter quartile range	1	0	
12 months	Mean±SD	4.32±0.74	5.43±0.70	<0.001
	Median	4	6	
	Inter quartile range	1	1	

Table 5: Comparison of SIR score.

Post-op evaluation	Treatment		P value	
	Group A	Group B		
6 months	Mean±SD	2.5±0.60	2.69±0.47	0.161
	Median	3	3	
	Inter quartile range	1	1	
12 months	Mean±SD	2.92±0.59	3.26±0.70	0.019
	Median	3	3	
	Inter quartile range	0	1	

DISCUSSION

There are two principal means of accessing the scala tympani for placement of the electrode array: via the round window membrane or via a basal turn cochleostomy. Lehnhardt initially rejected the round window approach because of its surgical anatomy, effect on intracochlear fluid dynamics, and potential to disrupt the cochlear aqueduct. Based on anatomical studies and clinical outcomes, the round window approach has emerged as a rational alternative to a cochleostomy.¹⁵ Correct placement of the cochleostomy, however, appears critical for avoiding damage to inner ear structures. A cochleostomy located anterior-inferior to the round window membrane avoids damage to the osseous spiral lamina as well as inadvertent entry into the scala media or scala vestibule.

Results of our study revealed that, in our subjects complete hearing preservation (within 10 dB) is significantly high in round window insertion group compared to cochleostomy group (p<0.001). None of our subjects had complete loss of residual hearing. Thus, this study revealed that round window insertion technique is significantly more successful in complete hearing preservation at low frequencies compared to cochleostomy technique.

Both parents and auditory verbal therapist have great role in assessing the post CI performance.

On evaluating the post CI performance, we found that in MAIS score, used for measuring auditory performance outcome round window insertion group performed significantly better compared to cochleostomy group at 3 months, 6 months and 12 months on follow up. CAP score (for assessing auditory skills) was better for cochleostomy group, though MUSS and SIR (for assessing speech and language) showed no significant difference between two groups.

Our study was in favour of prior studies conducted by, Skarzynski et al, who demonstrated that successful hearing preservation is possible in individuals in low frequency hearing using an atraumatic round window insertion technique and Usami et al, who showed that round window technique is less traumatic as it gives a guarantee of entrance into the scala tympani and does not expose the delicate structures of the cochlea to acoustic and vibration-induced trauma from the drilling of a cochleostomy, and hence better hearing preservation.¹⁶⁻¹⁸ Studies done by Kang et al also found that patients with favorable Superiority of the trans-fenestral (RW) anatomy, who underwent RW CI electrode insertion demonstrated higher auditory perception compared with the traditional cochleostomy group.¹⁹ Study conducted by Hytham et al also showed that round window insertion is associated with superior cochlear implantation outcomes regarding speech perception, language acquisition and speech production rather than the standard cochleostomy insertion.²⁰ RW approach in terms of hearing preservation was also demonstrated by Nasiff et al, Causon et al, and Adunka et al.²¹⁻²³ As a support to above studies, Briggs et al and Lenarz et al proposed that when using a custom short array, RW approach produces little intracochlear damage, as it's less traumatic and more direct approach to the scala tympani than the traditional cochleostomy.^{24,25} One-stage CI via the facial recess approach with round window insertion is safe and effective even in cochlear implant candidates with OME (in 24 children), in the study done by Hao et al and achieved improved auditory performance and speech intelligibility scores (MAIS, CAP and SIR) after CI.²⁶

In contrary, some clinical studies showed no significant differences among the two types of cochleostomies.²⁷

Small sample size was the limitation of the study. Since the study was retrospective, it was not able to evaluate

other 'soft surgical techniques' for hearing preservation. A possibility of post-operative residual hearing deterioration over years needs to be evaluated.

CONCLUSION

This study revealed that round window insertion technique is significantly more successful in complete hearing preservation at low frequencies compared to cochleostomy. On evaluating the post CI performance, MAIS score used for measuring auditory performance outcome round window insertion group performed significantly better compared to cochleostomy group at 3 months, 6 months and 12 months on follow up and the CAP score (for assessing auditory skills) was better for cochleostomy group, though MUSS and SIR (for assessing speech and language) showed no significant difference between two groups.

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