

# Preoperative HRCT temporal bone measurement useful for cochlear implantation in children: correlation between pre-op HRCT and surgical measurement

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## Abstract

**Objective:** The purpose of this study was to compare pre-operative High Resolution Computed Tomography (HRCT) temporal bone measurement and surgical measurement taken between the oval window and round window niche and correlate the reliability of measurement intra-operatively during cochlear implantation procedure. **Materials and Methods:** This is a prospective study of 50 Cochlear implant candidates aged between 1-6 (mean  $-3.4 \pm 0.7$ ) years who underwent HRCT temporal bone as preoperative evaluation during the period December 2013 to September 2014. Cochlear implantation was done in 50 children (34 in right ear, 16 in left ear). The distance between oval window and round window niche was measured in preoperative HRCT temporal bone and it was correlated with measurement during surgical procedure. We classified the position of Round window niche as seen through Facial recess during surgery in to two types: Type 1: Normal in position and Type 2: Rotated in position. **Results:** The mean and standard deviation for the distance between oval window and round window niche for types 1 and 2 were  $3.2 \pm 0.2$  mm,  $3.9 \pm 0.2$  mm. The distance oval window and round window niche showed significant correlation between pre-operative HRCT temporal bone measurement and Surgical measurement for two types (Type 1,  $r=0.934$ , Type 2,  $r=0.731$ ). **Conclusion:** This study shows that pre-op HRCT measurement of the temporal bone was useful in planning the safe surgery for cochlear implantation and also reliable in identifying the variations in position of the round window niche and thereby reducing surgical complications.

**Keywords:** Cochlear Implantation, round window, oval window, temporal bone.

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## INTRODUCTION

In Cochlear implantation surgery the visualization of the Round window niche and round window membrane is required for inserting the electrode array in to the scala tympani of the cochlea. In some cases the round window is obscured due to overhang or placed posterior<sup>1</sup>. These variations in position of the round window niche are caused due to rotation of cochlea which can make it challenging for the otologists in finding it. The surgeon uses the stapes covering the oval window as land mark for identifying Round window niche. Prior Knowledge about the approximate location of the round window niche from this land mark will be helpful in planning

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surgery. So in our study we measured the distance between the oval window and round window niche preoperatively on HRCT and correlated during surgery

## MATERIALS AND METHODS

Institutional ethical committee approval was obtained. Informed consent was obtained from the parents. We performed a prospective study on consecutive HRCT temporal bone scans done from December 2013 to September 2014. This study include children with bilateral sensory neural hearing loss aged between 1 and 6 (mean -  $3.4 \pm 0.7$ ) years. A total of 50 ears (34 of the right ear, 16 of the left ear; 29 male, 21 female) were included in the study.

### Computed tomography protocol

Imaging was performed using Philips Brilliance 16-slice CT scanner (Brilliance CT, Philips medical systems, OH, Cleveland, USA). The axial sections of temporal bone were acquired at 120 kVp, 250 mA, with thickness of 0.7 mm. and matrix of 512x512. The axial sections were obtained parallel to orbito-meatal base line.

### Pre-operative HRCT measurement

Distance between oval window and round window niche [cranio-caudal] is defined as the distance between midpoint of oval window to the edge of tegmen of round window niche at the mid-point of anterior and posterior border. The oblique axial image showing the incus and malleus head was chosen [Figure 1a]. On axial image a plane passing through the body of incus and round window was used to obtain oblique coronal image [Figure 1b]. The distance between oval window and round window was measured on the obtained oblique Coronal image [Figure 1b]. The measurement was noted in millimeters. The Pre-op HRCT measurement was done by two readers. Reader A (Ph.D. Research scholar) who is expert in reading temporal bone scans and repeated them at two different sessions. Reader B (Radiologist) who has experience of more than 10 years has read these measurements again.

### Surgical Measurement

The Cochlear implantation surgery was done using Carl Zeiss microscope and a standard trans mastoid, posterior tympanotomy approach. A total magnification of 125x (magnification of objective lens is 12.5x and magnification of ocular lens is 10 times) was used to obtain the surgical view showing fossa incudis, stapedial tendon inserting in to stapes and round window niche. The photos were taken from the monitor without changing the magnification using the digital camera. The measurements were done on the photos using measurement software which was calibrated by entering

the total magnification used. As the oval window cannot be visualized during surgery we have approximately taken the distance between the stapes covering the oval window to the inferior border of round window niche on the surgical images. The surgical measurements were performed by the surgeon who has experience of more than 5 years in performing the cochlear implant surgery. The surgeon also measured the distance between stapes covering the oval window to round window using right angle pick with a tips of 3, 4 and 5 mm during live surgery. We compared the measurements done on the photos and measurements done live surgery both showed good correlation ( $r=0.928$ ,  $p<0.01$ )

We classified the round window position as seen through the Facial recess in to two types:

**Type 1:** Normal in position [Figure 2]

**Type 2:** Rotated in position [Figure 3]

Rotated in position is considered as an anatomic variation of Round window niche.

### Statistical analysis

The data were analyzed with SPSS (statistical package for the social sciences) version 16.0 (SPSS Inc., Chicago, IL, USA). A p-value of less than 0.01 was considered to be significant. Pearson's analysis was performed to find correlation between HRCT and surgical measurement. Intra class correlation coefficient (ICC) was calculated for preoperative HRCT measurement for inter-observer variability. Student's *t*-test was performed to assess intra-observer variability.

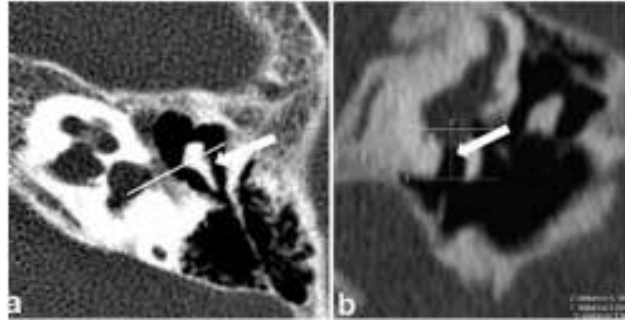
## RESULTS

In this study 50 cochlear implant candidates were studied. 38% (n=19) were classified as normal, 62 % (n=31) were classified as Rotated. Table 1 shows the means of pre operative HRCT and surgical measurement for the two types and correlation between them. The mean distance between oval window to round window niche for types 1, 2 measured during HRCT imaging were  $3.2 \pm 0.2$  mm;  $3.9 \pm 0.2$  mm respectively while it was  $3.2 \pm 0.2$  mm,  $3.9 \pm 0.2$  mm measured using surgery. The distance between oval window to round window niche showed significant correlation between HRCT and surgical measurements for the two types (Type 1,  $r=0.934$ , Type 2,  $r=0.731$ ,  $p<0.01$ ) Figure 4 a and b shows that the pre-operative HRCT measurement of distance between oval window correlated between the measurement done on intraoperative photograph for type 1. Figure 5 a and b shows that the pre-operative HRCT measurement of distance between oval window correlated between the measurement done on intraoperative photograph for type 2

**Table 1:** Showing the mean of preoperative HRCT and surgical measurements for the two types and correlation between them

	HRCT Measurement (mm)		Surgical Measurement (mm)		r value	
	Type 1	Type 2	Type 1	Type 2	Type 1	Type 2
Distance between OW to RWN	3.2±0.2	3.9±0.2	3.2±0.2	3.9±0.2	r=0.934	r=0.731

HRCT- High Resolution Computed Tomography, OW- Oval window, RWN- Round window niche



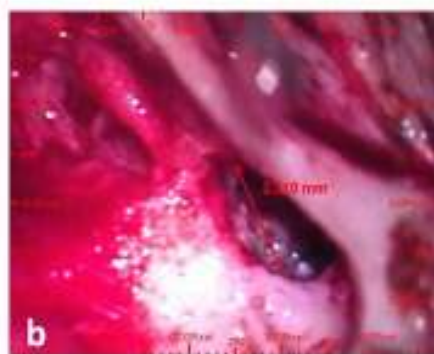
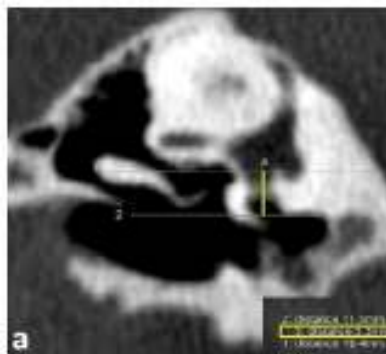
**Figure 1:** 2- year-old male with history of sensory neural hearing loss. (a) Oblique axial HRCT reconstructed image of the left ear shows incus and malleus head (white arrow) and also shows the plane passing through body of incus (white line). (b) Oblique coronal HRCT reformatted image (white arrow) shows the distance between oval window and round window niche.



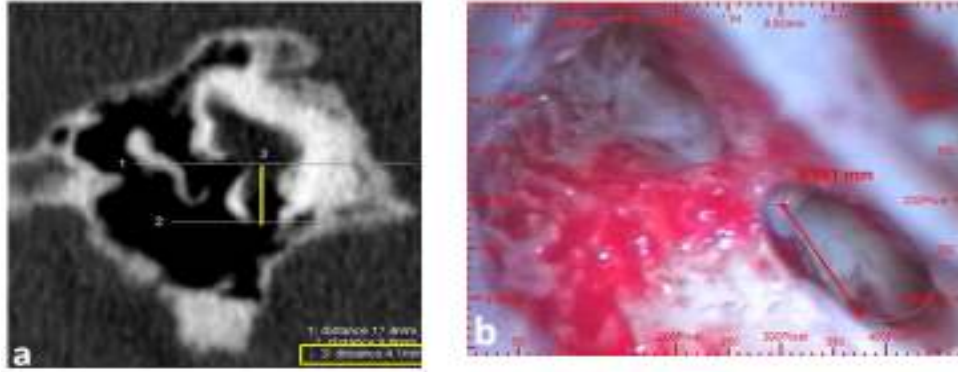
**Figure 2:** 4-year-old male with history of sensory neural hearing loss. Intraoperative photograph of cochlear implant surgery of the right ear shows Type 1 Round window normal in position (White Arrow)



**Figure 3:** 4-year-old male with history of sensory neural hearing loss. Intraoperative photograph of cochlear implant surgery of the right ear shows Type 2 Round window rotated in position (White Arrow)



**Figure 4:** 4- year-old male with history of sensory neural hearing loss. (a) Oblique coronal HRCT reformatted image shows the preoperative distance between oval window and round window niche (yellow line) at the midpoint of anterior and posterior borders (3.3 mm). (b) Intraoperative photograph of cochlear implant surgery of the right ear shows measurement between stapes covering oval window and round window niche for type 1 i.e. round window is normal in position (3.3 mm)



**Figure 5:** 4- year-old male with history of sensory neural hearing loss. (a) Oblique coronal HRCT reformatted image shows the preoperative distance between oval window and round window niche (yellow line) at the midpoint of anterior and posterior borders (4.1 mm). (b) Intraoperative photograph of cochlear implant surgery of the right ear shows measurement between stapes covering oval window and round window niche for type 2 i.e. round window is rotated (4.1 mm).

### Inter-observer variability

Intra class correlation coefficients for pre-op HRCT measurement was 0.99 suggesting good reproducibility.

### Intra-observer variability

Student's *t*- test showed no significant difference between the measurements done by Reader A at two different sessions.

## DISCUSSION

In the present study we measured the distance between oval window and Round window niche were compared between preoperative HRCT and surgery. To our knowledge we did not find similar study in our literature search. In our study we found that as the pre-operative HRCT measurement between the oval window and round window increases the round window niche will become difficult to visualize during surgery. In the difficult cases (round window difficult to visualize) we observed that the round window niche was nearer to pyramid. The distance between oval window to round window niche showed significant correlation between preoperative HRCT and surgical measurement for the two types (Type 1,  $r=0.934$ ,  $p<0.01$ . Type 2,  $r=0.731$ ,  $p<0.01$ ) Ravi Goravalingappa<sup>1</sup> stated that the Jacobson's nerve can be used as a guide for inserting the electrode array in to basal turn in difficult cases where round window niche was obliterated. The preoperative HRCT scans of the temporal bone are useful in detecting anatomical variations of the temporal bone structures and thereby decreasing the surgical complications<sup>2</sup>. Miklos Toth *et al.*,<sup>3</sup> studied the development of the round window niche and described different shapes of the round window niche which are caused due to uneven growth of the walls of the round window niche. Mehmet sentürk *et al.*,<sup>4</sup> studied the distance between important land marks for facial canal such as Lateral semicircular canal, Cochleariformis process, eminentia pyramidalis and stated that these

measurements would provide additional information regarding the variations of the facial nerve during mastoid and middle ear surgery. In another study by Samar Pal Singh Yadav *et al.*,<sup>5</sup> studied the mean length of tympano mastoid segment of the facial nerve and stated that there are differences in length of facial nerve in Japanese, American compared to Indians. Jahanbaksh Hashemi *et al.*,<sup>6</sup> studied the comparison between CT and surgical measurements between the land marks useful for Mastoidectomy and said that measurements obtained from the CT are almost similar to measurements obtained during surgery. Antonio de Castro Rodrigues *et al.*,<sup>7</sup> said that these distance measurements done between anatomical structures in the middle ear are helpful in planning of safe surgery Anastacio Rodrigues Pereria Junior *et al.*,<sup>8</sup> said that the Computed Tomography measurements such as distance between the temporal meninges and the upper plane of petrous bone, the distance of the anterior border of the sigmoid sinus to posterior wall of external auditory canal predicted the surgical difficulties during mastoidectomy. Francesca Atturo *et al.*,<sup>9</sup> have studied the size, variations in the shape of the round window, round window membrane and its influence in surgical access. Mohamed S. Hasaballah *et al.*,<sup>10</sup> have studied the usefulness of oblique sagittal cuts of CT scan temporal bone in evaluation of the facial nerve course and anatomical factors that determine the field of view or the accessibility of the posterior tympanotomy for either cochleostomy or round window membrane approach and also said that preoperative HRCT measurement may influence the decision on which side to implant.

## CONCLUSION

From this study we conclude that the preoperative HRCT measurement between oval window and round window was reliable and can serve as useful roadmap for the

surgeon to access the round window niche. It also warns the surgeon about the possibility of a rotated cochlea so that adequate modifications can be made in the surgical technique to identify the round window niche.

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