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Original Article

Predicting Round Window Visibility During Cochlear Implantation Using High Resolution CT Scan

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OBJECTIVES: To predict round window niche (RWN) visibility using high-resolution computed tomography (HRCT).

MATERIALS and METHODS: We retrospectively reviewed the pre-surgical axial HRCT scan of 110 patients who underwent cochlear implantation and compared the CT visibility of RWN with the intraoperative findings by reviewing the operative notes and replaying the surgical video recording. The shape of RWN was determined using the HRCT slice with maximum RWN visibility. Accordingly, it was classified as the O-shaped or C-shaped RWN. Based on the surgical view, RWN visibility was classified as clearly visible or difficult to visualize. Radiological findings were correlated with the surgical view.

RESULTS: Seventy-six cases (69%) showed clear RWN visibility; of them, 66 correlated with the HRCT finding C-shaped RWN. Of the other 34 cases (31%) with difficult RWN visualization, 26 correlated with the HRCT finding O-shaped RWN. The sensitivity and specificity of the HRCT finding in predicting the difficulty in visualization of RWN were 79.4% and 86.8%, respectively.

Conclusion: The RWN shape on HRCT can be a simple and useful method in predicting RWN visibility through posterior tympanotomy approach in cochlear implantation.

KEYWORDS: Cochlear implant, round window visibility, computed tomography

INTRODUCTION

Posterior tympanotomy is the primary surgical approach used in cochlear implantation for accessing the middle ear and exposing the round window niche (RWN) [1, 2]. It is a well-known otologic approach that was first described by Jansen in 1958 and is achieved by opening of the facial recess, which is a triangular space defined medially by the mastoid segment of the facial nerve, laterally by the chorda tympani nerve, and superiorly by the incudal fossa [3].

Clear visualization of RWN and round window membrane (RWM) through the facial recess is a prime prerequisite for the surgeon to properly localize the scala tympani, which represents an optimal target for the inserted electrode. Due to the variations in the position of the round window, the visualization of the RWM can be difficult. Moreover, round window visualization may be hindered by various factors as abnormally positioned facial nerve, rotation of the cochlea in the axial, or even in the parasagittal planes [4].

In this study, we propose a simple method to predict RWN visibility through the facial recess by axial high-resolution computed tomography (HRCT).

MATERIALS AND METHODS

Ethical Considerations

Both the research project and patient record retrieval were approved by the institutional review board. Patients' consent for using their data in the research project was also obtained. The study was conducted according to the Declaration of Helsinki and a written

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informed consent was obtained from every patient who agreed to participate in the study.

We retrospectively reviewed the radiographic and surgical records of 110 patients who underwent cochlear implantation between December 2012 and December 2015. All patients underwent unilateral cochlear implantation through a cochlear implant program at tertiary referral institutions.

Pre-operative CT scans of the temporal bone were analyzed by a subspecialized radiologist who was blinded to the intra-operative scoring of the surgical difficulties. HRCT scans of the temporal bone were obtained at a slice thickness of 1.0 mm. They were acquired at 120 kVp, 250 mA, and imaging matrix of 512×512. The CT scans were viewed in the standard bone window setting.

Slices with maximum visibility of RWN and RWM were selected to determine the shape of RWN at its axial cross-section. If the bony overhang that shields RWM and constitutes the area concamerata appeared as a complete closed circular structure, i.e., "O-shaped," it was assigned as "invisible/barely visible RWM" (Figure 1). However, if the area concamerata appeared as an incomplete bony overhang, i.e., "C- shaped," it was assigned as "visible RWM" (Figure 2).

Two senior ENT surgeons, who were blinded to the HRCT images, reviewed the operative notes and surgical videos. All cases at our program undergo standard CI surgical reporting process in the form of a checklist including RWM visibility. Moreover, surgical videos of all cases were reviewed, and RWM was assessed to be either clearly visible or difficult to visualize, i.e., "slit-like orifice/invisible" (Figure 3 and 4). Decision was made by evaluating the true RWM visibility at the surgical stage after maximally optimizing the posterior tympanotomy and before starting the drilling of RWN.

Data were analyzed using the Statistical Package for Social Sciences (SPSS Inc., Chicago, IL, USA) version 16. The sensitivity and specificity of the HRCT finding in predicting difficulty in the visualization of RWN were calculated.

RESULTS

Of the 110 patients with cochlear implants, 73 (66.4%) were radiologically classified as visible "C-shaped RWN," and 37 (33.6%) were classified as invisible/barely visible "O-shaped RWN."

Surgical findings revealed that 76 cases (69%) showed clearly visible RWM through posterior tympanotomy; of them, 66 cases correlated with the HRCT findings of C-shaped RWN, while the remaining 10 cases were radiologically identified as O-shaped RWN and were assigned as "invisible/barely visible RWM."

On the other hand, 34 cases (31%) showed barely visible (n=24) or invisible (n=10) RWM intra-operatively; of them, 27 cases correlated with the HRCT finding of O-shaped RWN, while the remaining 7 cases were radiologically assigned as "visible RWM."

The sensitivity and specificity of the HRCT finding in predicting difficulty in the visualization of RWM were 79.4% and 86.8%, respectively.

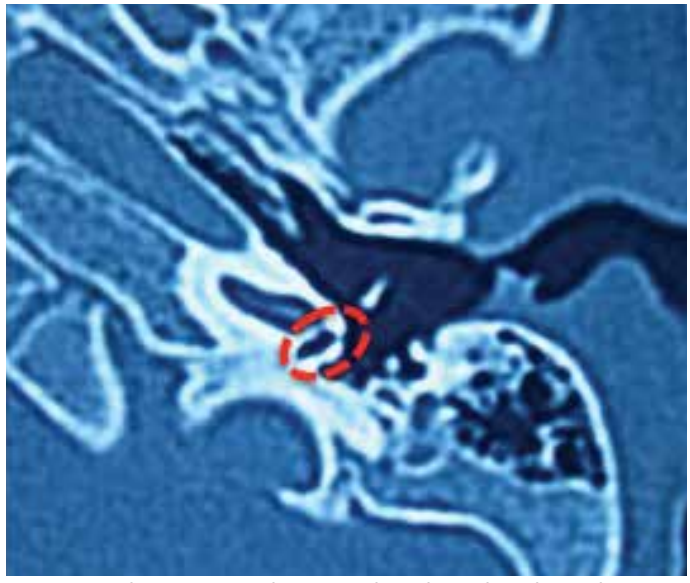

Figure 1. Axial HRCT section showing O-shaped round window niche (RWN). The dashed line represents the edge of RWN.

Figure 2. Axial HRCT section showing C-shaped round window niche (RWN). The dashed line represents the edge of RWN.

Positive predictive value was 72.97% [95% confidence interval (CI): 55.88%-86.21%], and negative predictive value was 90.41% (95% CI: 81.24%-96.06%).

DISCUSSION

In the present study, if RWN was C-shape conformation in the axial HRCT, we assumed that this indicates that its orifice faces postero-laterally and lies in an oblique vertical plane. Hence, we could expect a round window orifice to be visible through posterior tympanotomy. On the other hand, if RWN was O-shaped in the HRCT, this indicates that its orifice faces inferiorly and lies in a nearly horizontal plane parallel to the axial plane and would be difficult to visualize. Hence, it was considered as a radiological sign for difficult visualization of the RWN.

Accordingly, of the 110 cases in our study, RWM was classified as difficult to be visualized in 34 cases, based on surgical view. The HRCT finding could predict this difficulty in 27 cases (77.9%).

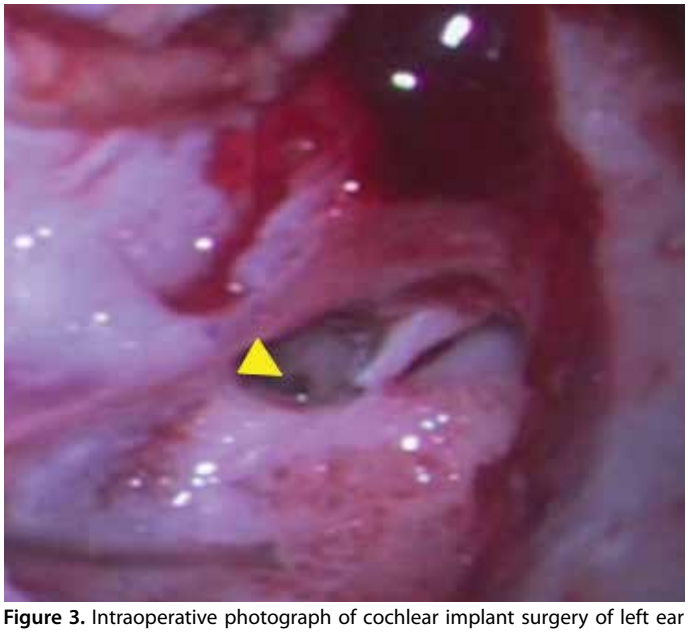

Figure 3. Intraoperative photograph of cochlear implant surgery of left ear showing clearly visualized round window niche (yellow arrow head)

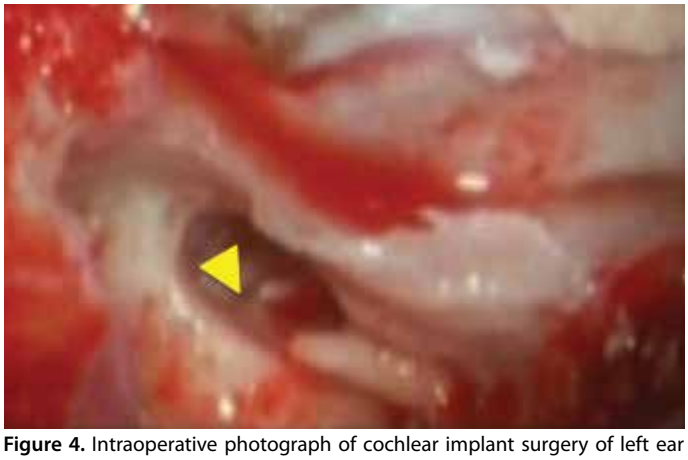

Figure 4. Intraoperative photograph of cochlear implant surgery of left ear showing difficult to be visualized round window niche (yellow arrow head)

We used the standard axial HRCT images to predict difficulty in visualization of the round window, which indicates a surgical difficulty requiring some modifications of our surgical technique/approach, such as drilling deeper into the facial recess or even using combined approach via the external auditory canal [4].

Multiple studies have attempted to use various HRCT measurements to predict RWN visibility. However, compared with our study, most used special reformatted radiological views. Moreover, those measurements were subjected to inter-observer and intra-observer variability.

Kashio et al. reported that intraoperative RWN visibility shows a high correlation with preoperative HRCT-based measurements of the EAC angle and FN location [5].

Pendem et al. utilized reformatted oblique coronal images to measure the distance between the short process of the incus and RWN and also the distance between the oval window and RWN to identify the variations in the position of the round window [4].

Furthermore, Hasaballah et al. [6] utilized oblique sagittal HRCT cuts of temporal bone to determine the accessibility of the posterior tympanotomy for either cochleostomy or the RWM approach. They found positive correlations between the posterior tympanotomy width and second genu angle, distance from facial bony canal to round window [6].

Our study showed that preoperative HRCT was highly specific (86.8%) in detecting difficult RWN visualization. The relative lower sensitivity might be explained by the fact that complete bony overhang of RWN, as determined radiologically as "O-shaped RWN," could be truly a result of its orifice being directed inferiorly and lying in a nearly horizontal plane with subsequent difficult visualization or it simply could be a result of improper visualization by HRCT due to technical issues such as volume averaging. However, statistically, it was a clinically useful method for predicting the visibility of RWM during surgery, as viewed through posterior tympanotomy.

CONCLUSION

Based on the study results, we conclude that the shape of RWN as determined by axial HRCT can help in predicting the extent of visibility of the round window during posterior tympanotomy approach in cochlear implantation.

Ethics Committee Approval: This study approved by the institutional review board.

Informed Consent: Written inform consent was obtained from the patients who participated in this study.

Peer-review: Externally peer-reviewed.

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