

Original Article

Radiologic Evaluation of the Round Window Niche Configuration: A One-Stop Approach

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BACKGROUND: Preoperative radiological prediction of the round window niche configuration.

METHODS: Fifty patients were evaluated. A single-axial high-resolution computed tomography image at the level of the cochlear aqueduct was compared to the intraoperative surgical images. Radiological configuration was classified as open, hooded, or covered depending on the extent of bony overhang. Surgical images were processed using Image J software to determine the amount of drilling required before the round window membrane is exposed. These images were classified according to the St. Thomas classification into 3 grades.

RESULTS: In all patients, the axial cut showing the cochlear aqueduct was obtained. There were 12 cases in the open category, 17 in the hooded category, and 21 in the covered one. Intraoperatively, the actual findings were type I 12, type II 18, and type III 20. The correspondence between the expected and actual classification was correct in 8, 12, and 18 cases, respectively. Comparing the intraoperative findings with the expected radiological configuration, there was a good concordance with a statistically non-significant difference (χ^2 =0.2613; *P*=.87751).

CONCLUSION: It is possible to predict the configuration of the round window niche on a single-axial computed tomography cut and plan the most suitable axis of approach and predict the amount of drilling expected to expose the round window membrane.

KEYWORDS: Cochlear implants, radiology, round window membrane, round window niche, sensorineural hearing loss

INTRODUCTION

During cochlear implantation, atraumatic round window (RW) insertion of the electrode array is highly recommended.¹⁻³ Adequate exposure and visualization of the round window membrane (RWM) depends on the configuration of the RW niche. The RWM is partially hidden behind an overhanging oblique ridge from the promontory, which regularly limits its visibility during surgery.^{4,5} The overhang is narrowest at its free edge and widens medially, measuring about 2.1 mm (range 1.9-2.4 mm).⁶ The orientation and size of the RW niche and the amount of exposure of the true membrane by the different approaches are extremely variable due to the uneven growth of different walls of the RW niche which alters the shape of the entrance.⁷ The ductus reuniens is closely related to the posterior margin of the RWM, whereas the inferior cochlear vein and cochlear aqueduct are closely related to its inferior margin.^{8,9} The internal aperture of the cochlear aqueduct is almost always situated at the base of the internal surface of the crista falciformis. It can thus give a presumptive location of the anteroinferior attachment of the RWM.⁹

Preoperative radiological evaluation of the anatomical peculiarities of each patient is mandatory to plan the surgery. Imaging of the RW and its orientation is difficult, and various methods were devised to predict the accessibility to the membrane, but very few address the issue of the configuration of the RW niche.¹⁰⁻¹⁴

The aim of this article is to correlate the appearance of the RW using a single-axial computed tomography cut at the level of the cochlear aqueduct, with the intraoperative findings. This might help the surgeon in predicting the expected amount of drilling of the niche before encountering the true RWM.



PATIENTS AND METHODS

This prospective study was conducted on 50 consecutive patients undergoing cochlear implantation. All had a preoperative CT scan using a dedicated cochlear implant (CI) imaging protocol.¹⁵ A single-axial bone window high-resolution CT image at the level of the cochlear aqueduct was selected. We set forth the hypothesis and compared the preoperative CT cut and the actual intraoperative images. The study was approved by our institutional review board (Ethics approval: ASUENT 24/2020).

Radiologically, the configuration of the RW niche was classified depending on the amount of bony overhang as open, hooded, or enclosed (Figure 1).

All patients were operated by the mastoidectomy/posterior tympanotomy approach. The selected axial cut was compared to the intraoperative surgical images at 2 operative epochs: the RW niche when it is first exposed and then after drilling until the membrane was visible. The visibility of the membrane was classified by the St. Thomas classification.¹⁶ The extent of drilling was judged by superimposing the 2 pictures and measuring the linear length from the base of the postis anterior to the posterior edge of the RWM along a horizontal line. We used Image J software (ImageJ bundled with 64-bit Java 1.8.0_112, NIH) (Figures 2 and 3). The assumption was that an open configuration should correspond to a type I, a hooded to a type II, and an enclosed to a type III class.

RESULTS

Patient Demographics

There were 31 males and 19 females aged 2-5 years (mean 2.7 years). All were unilaterally implanted, 40 on the right side and 10 on the left. None had any congenital inner ear anomalies or any recognizable syndrome.

Computed Tomography

In all patients, the selected cut could be singled out and included. Findings were classified as follows:

- Open: 12 cases
- Hooded: 17 cases
- Enclosed: 21 cases

Intraoperative Findings

Type I: The RWM could be at least partially visible with no or minimal drilling in 12 cases.

Type II: The RWM could be visualized by minimal drilling of the anterior postis and tegmen in 18 cases.

Type III: The RWM could not be visualized except after extensive drilling in 20 cases (in 5, it could not be visualized and a cochleostomy was performed).



Figure 1. The 3 radiological configurations. (A) Open, (B) hooded, and (C) covered.



Figure 2. Open configuration. (A) CT scan at level of the ductus reuniens, (B) before drilling, and (C) after exposure of the RWM (drilling 12 units). CT, computed tomography; RWM, round window membrane.

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Figure 3. Hooded configuration. (A) CT scan at level of the ductus reuniens, (B) before drilling, and (C) after exposure of the RWM (drilling 27 units). CT, computed tomography; RWM, round window membrane.



Figure 4. Covered configuration. (A) CT scan at level of the ductus reuniens, (B) before drilling, and (C) after exposure of the RWM (drilling 64 units). CT, computed tomography; RWM, round window membrane.

Image Analysis

The amount of drilling ranged between 4 and 64 measuring units. The mean drilling depth for each category was open 8, hooded 30, and enclosed 48 (Figures 2-4).

Surgical/Radiological Correlation

In patients with the open configuration, 8 were type I, 3 type II, and 1 type III.

In patients with a hooded RW, 12 were type II, 4 type I, and 1 type III.

In patients with enclosed configuration, 18 were type III, and 3 type II.

Comparing the intraoperative findings with the expected radiological configuration, there was a good concordance with a statistically non-significant difference ($\chi^2 = 0.2613$; P = .87751) (Table 1).

DISCUSSION

Whatever the surgical approach for cochlear implantation, RW insertion of the electrodes is becoming a common practice.^{2,3,16,17}

 Table 1. Correspondence Between Computed Tomography and Surgical Findings

	Type I	Type II	Type III	Total
Open	8	3	1	12
Hooded	4	12	1	17
Covered	0	3	18	21
Total	12	18	20	50

However, exposure of the RW may be difficult to impossible due to the extreme anatomical variations. Proper insertion minimizes intracochlear trauma and optimizes hearing results.^{18,19} Preoperative radiological evaluation of patients gives an insight on the individual anatomical peculiarities and avoids surgical surprises. The mastoidectomy/posterior tympanotomy approach being the commonest, most publications address the angle of access to the RW through the posterior tympanotomy.^{20,21}

In this study, we tried to predict the anatomical variations of the RW niche area in order to predict how deep is the proper RWM buried within the niche. The internal opening of the cochlear aqueduct opens consistently just beyond the crista falciformis which is the insertion point of the RWM and is thus a guide to the proper level of the RWM. We selected a single-axial cut at the level of the cochlear aqueduct and classified the configuration into open, hooded, or covered. These images were compared to the intraoperative findings. There was a good correlation between the 3 radiological configurations and the intraoperative accessibility of the RWM. Similar correlations were obtained using more complex methods.^{10,13,14} In some studies, multiple contiguous cuts were analyzed to predict the depth of the RW,^{14,22,23} but this implies a standardized imaging technique for all patients which is not always possible. In other studies,¹⁰ analysis depends on drawing lines through the ossicles and reconstructed images to measure the distance between the tip of the short process of incus and the edge of tegmen of the RW niche at the midpoint of anterior and posterior borders. This implies complex reconstructions on a workstation and reproducible imaging techniques across all platforms. As our approach is simpler and uses a single-axial cut without complicated measurements, we suggest it as a practical method to predict the expected configuration of the RW region. The surgeon is thus less likely to be misled by a false membrane which can be superficial, or he/she would not be lured into deeper drilling.

CONCLUSION

It is possible to predict the configuration of the RW niche on a singleaxial CT cut and foresee the expected surgical difficulties in searching for the RWM.

Ethics Committee Approval: Ethical Committee approval was received for this study (ASU-MED- 6008/2019).

Informed Consent: Consent was not required as data is anonymous and there was no interference with standard techniques as part of the study.

Peer Review: Externally peer-reviewed.

Author Contributions: Idea, Data Collection , Image Analysis - B.E.M.; Data Collection, Literature Review – L.M.E.F.

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