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Original Article

Landmarks for Proper Round Window Electrode Insertion in Cochlear Implantation

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BACKGROUND: This study aimed to evaluate the role of landmarks for proper round window electrode insertion in cochlear implantation surgery.

METHODS: This is a case series study. We included 150 patients undergoing cochlear implantation in a tertiary medical center during the period from January to December 2019. Patients with inner ear malformations or ossification or revision surgery were excluded. Three surgeons participated in the study. During surgery, the round window electrode insertion was marked using 5 surgical landmarks: oval window, pyramid, fustis, round window membrane, and arborization of intracochlear blood vessels. Each surgeon reported on the identification of each landmark and its reliability for round window electrode insertion.

RESULTS: Oval window and round window membrane were clearly seen by the 3 surgeons in all cases. Pyramid was seen in 94% of cases, fustis in 85%, and intracochlear wall in 90% of cases. The postoperative transorbital x-ray confirmed the intracochlear position of electrodes in all cases.

CONCLUSION: Round window electrode insertion can be precisely performed using these 5 surgical landmarks in straight forwards cases as well as in difficult cases. These landmarks can also assist in teaching young surgeons, in a step-wise manner, how to properly do round window electrode insertion in cochlear implantation surgery.

KEYWORDS: Round window, fustis, pyramidal ridge, cochlear implantation compliance with ethical standards

INTRODUCTION

Cochlear implantation is the standard rehabilitation surgery for bilateral sensorineural hearing loss. The round window membrane is an important landmark during this surgery to localize the scala tympani whether the surgeon is contemplating classical promontory cochleostomy, round window (RW) membrane insertion, or extended RW cochleostomy.[1,2]

The RW membrane is not always apparent through the posterior tympanotomy with partial or complete coverage of the membrane with the tegmen of the RW niche. It can also be confused with hypotympanic structures such as the subcochlear canaliculus or hypotympanic air cells. This may pose some difficulties for many surgeons to properly localize the RW niche and may lead to the wrong insertion of the electrode.[3]

To prevent this problem, surgical landmarks through a classical posterior tympanotomy that help the proper localization of the RW membrane were chosen and marked until the full insertion of the electrode. We suggest the routine use of these landmarks during cochlear implantation, so we could identify the location of RW precisely. The primary aim of this study was to indicate easily fixed landmarks for proper identification of the RW membrane and the secondary aim was to allow proper insertion of the cochlear implant.

MATERIALS AND METHODS

This is a prospective study of 150 patients who underwent cochlear implantation during the period from January to December 2019 at our tertiary referral center. Patients with inner ear malformations or ossification (determined radiologically) or revision surgery were excluded. All cases were operated on using the mastoidectomy posterior tympanotomy approach by 3 surgeons.

The study was approved by our Ethics Review Board and was in accordance with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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Each surgeon was asked to locate the following 5 surgical landmarks: oval window, pyramid, fustis, RW membrane, and inner wall of the cochlea. These landmarks were identified as follows:

1. The oval window: the oval window can be easily identified by the stapes footplate. The first depression on the promontory below the oval window indicates the RW niche (Figure 1). The RW membrane is also present on the same level as the oval window.
2. The pyramidal eminence: visualization of the pyramid medial to the facial nerve in the posterior wall of the mesotympanum was used to localize the RW niche. The posterior part of the RW niche is parallel, anterior, and medial to the pyramid (Figure 2).
3. The fustis: it is a hard bone extending anteriorly from the styloid complex in the retrotympanum, pointing to the anterior attachment of the RW membrane (Figure 2). Surgically by the posterior tympanotomy, the RW membrane should always be lateral to the fustis.
4 The RW membrane: it should always be visualized in every case. This can be done indirectly by eliciting the RW shadow with some irrigation fluid which can reflect the shadow of the membrane, even if it is completely covered, before seeing it. The membrane itself should be seen in all cases by slowly burring the tegmen of the RW niche uncovering all or most of the dark RW membrane (Figure 2).
5 The intracochlear wall visualization: from there, the surgeon can proceed for cochleostomy. In cases of RW insertion or extended RW cochleostomy, the membrane is first incised, preferably from anterior to posterior. The last landmark is the arborizing vessels over the inner wall of the cochlea (Figure 3). The surgeon can visualize the first bent of the basal turn of the cochlea and this can help in axis determination of the proper insertion of the electrode.

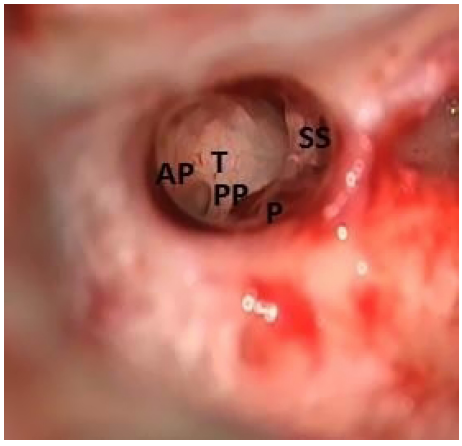

Figure 1. View from the classical posterior tympanotomy (left side). AP, anterior postis; T, tegmen; PP, posterior postis; P, pyramid; SS, stapes superstructure.

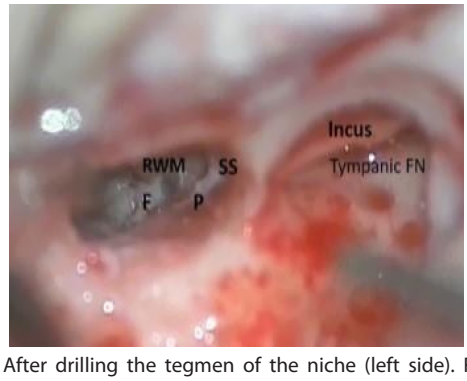

Figure 2. After drilling the tegmen of the niche (left side). RWM, round window membrane; F, fustis; FN, facial nerve.

Figure 3. Blood vessels arborization on the inner wall of the scala tympani.

The reliability of each landmark as observed by the surgeon was given a score: 0, not seen and 1, seen. The correct insertion was confirmed with intraoperatively evoked action potential at the end of the procedure and a post-operative transorbital plain x-ray for the localization of the electrode.

RESULTS

The study population included 150 patients. Their ages ranged from 2 to 55 years old. There were 125 children (2-14 years, mean age of 3.8 years) and 25 adults (18-55 years, mean age of 26.5 years). All patients had bilateral profound sensorineural hearing loss. In 117 cases, an extended RW cochleostomy was done, and in 33 cases, an RW membrane was done. Different devices and electrodes from different manufacturers were used (Table 1).

The surgeons were asked to tag the selected landmarks and report their identification:

1. The oval window could be located by visualizing the stapedius tendon and the stapes superstructure in all cases by all surgeons (score = 150).
2. The pyramid was clearly seen after posterior rotation of the head of the patient in 141 cases. In 9 cases, the position of the mastoid facial nerve and the curve of the posterior bony meatal wall made the visualization of the pyramid difficult.
3. The fustis was variable in size and configuration and it was clearly seen in 128 cases. In the remaining 22 cases, it was not reliably seen. In 11 cases, it was covered by mucosa; in 6 cases, it was covered by an overhanging Round Window Niche (RWN), and

Table 1. List of Devices and Electrodes Used

Device	Type of Electrode	Number of Cases
Medel Concerto	Flex 28	66
	FORM 24	24
Profile Cochlear	Slim straight	27
	Contour advance	20
Oticon ZTi	EVO	13

Table 2. Scoring for the 5 Landmarks

Landmark	Score 0	Score 1	Reliability (%)
Oval window	0	150	100
Pyramid	9	141	94
Fustis	22	128	85.3
RWM	0	150	100
Intracochlear wall visualization	15	135	90

RWM, round window membrane.

in the remaining 5 cases, it could not be distinguished within a well-pneumatized concomerata area..

4. The round window membrane (RWM) was seen in 78 cases. After slowly removing the tegmen, the membrane was seen in the rest of the cases (n = 72).
5. Intracochlear examination for blood vessels arborization was seen in all cases of extended RW cochleostomy and in 18 cases of RWM insertion. In the remaining 15 cases of RWM insertion, these blood vessels could not be visualized.

In all cases, Electrically Evoked Compound Action Potential (ECAP) and plain x-rays confirmed the proper positioning of the electrode.

Scoring of the landmarks' reliability by different surgeons was tabulated (Table 2).

DISCUSSION

Round window insertion is considered nowadays the most recommended technique for cochlear implantation. It ensures the proper direction of the electrode as it serves as a direct conduit to the scala tympani.[3] It also prevents any intracochlear damage or injury to the basilar membrane. Minimal drilling including drilling speed reduces acoustic trauma and dust entry into scala tympani compared to other types of cochleostomy.[2,3] To facilitate electrode insertion, adequate exposure of RWM must be achieved.[4,5] However, the niche and its constituent boundaries show variations in position, direction, shape, and size of the walls.[1] Different patterns of growth of RW niche could lead to great variations in the configuration of the RWN and shapes of the RWM.[3,6-8] Also, false RWM can be found in nearly 55% of temporal bones.[9]

The cochlear hook region is the interface between the middle ear and lateral skull base including the inner ear and contains the most basal part of the cochlea including RWN, the stapes footplate, and the vestibule.[10,11]

In our study, we introduce a step-wise approach to ensure proper RW electrode insertion by relying on 5 fixed surgical landmarks. To our knowledge, it is the first study to precisely define and localize the RW by these surgically fixed and reliable landmarks during surgery for cochlear implantation.

The oval window is one of the most reliable and constant landmarks for the identification of the RWN. However, you can rely on the stapedial tendon and the posterior crus of the stapes visualization without further exposure to the footplate. The pyramid can be identified in 98.5% of cases according to Sahin et al 2020.[12] If we consider the oval window to be at the 12 o'clock in the surgical position, the RW would be at the 7 o'clock in the right ear and the 5 o'clock position in the left ear. In our series, the pyramid was identified in 141 cases (94%). In 9 cases, the position of the mastoid facial nerve and the curve of the posterior bony meatal wall made the visualization of the pyramid difficult.

The fustis is a constant landmark for RW and may be pneumatized in 43% of cases.[8,13] In type A, it points like a finger to RWM. In our study, it was clearly seen in 128 cases (85.3%). In 11 cases, it was covered by mucosa; in 6 cases, it was covered by an overhanging RWN; and in the remaining 5 cases, it could not be well distinguished within a well-pneumatized concomerata area.

After completion of the posterior tympanotomy, the first 3 landmarks can be readily identified to precisely locate the RWN. After drilling the niche, the fourth landmark, the RWM, is identified. It may be absent only in difficult cases such as labyrinthitis ossificans or congenital anomalies, but in other cases, it is always there. After opening the RWM, we should visualize the arborization of the blood vessels inside the scala tympani of the cochlea, and this is the last sure sign of being in the correct location. We could visualize the intracochlear wall clearly in 90% of cases. This step helps in the proper insertion of the electrode in the proper axis without intracochlear damage.

CONCLUSION

Round window electrode insertion can be precisely performed using these 5 surgical landmarks in straight forwards cases as well as in difficult cases. These landmarks can also assist in teaching young surgeons, in a step-wise manner, how to properly do RW electrode insertion in cochlear implantation surgery.

Ethics Committee Approval: Ethical committee approval was received from the Ethics Committee of Ain Shams University Faculty of Medicine University (ASU-MED3852).

Informed Consent: Written informed consent was obtained from all participants who participated in this study.

Peer-review: Externally peer-reviewed.

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