ORIGINAL ARTICLE

Anatomic Observations on Variations of the Round Window Niche and its Relationship to the Tympanic Membrane

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OBJECTIVE: To study the anatomic variations of the round window niche and its relationship to the tympanic membrane.

MATERIALS AND METHODS: Eleven dry temporal bones and 9 temporal bone specimens were studied. Visualization of the round window niche through external auditory canal, position of the round window niche opening, and relationship of the position of the round window niche to the posterior quadrant of the tympanic membrane were recorded.

RESULTS: If the round window niche was visible (75% of the bones) through the external auditory canal in otologic surgery position, it was located 2.2 mm posterior to the umbo, and the round window niche was located just at the level of midportion of the posterior tympanic annulus. Anteroinferior quadrant dimension (3.4 x 3.9 mm) of the tympanic membrane was found to be narrower than the posteroinferior dimension (4.8 x 3.9 mm).

CONCLUSION: From the surgical standpoint, these findings about the anatomic features of the round window niche might be important for several otologic interventions, such as ventilation tube insertions, intratympanic drug applications, and cochlear implantation.

The anatomic position of the round window (RW) niche and its relationship with the tympanic membrane (TM) is important in routine surgery, such as myringotomy and ventilation tube (VT) insertion, basic procedures in otology training. Although experienced ear surgeons are familiar with variations in the anatomy of the RW niche, inexperienced surgeons may experience difficulty in understanding its position and relationship to surrounding structures.

Some surgical approaches necessitate detailed knowledge of variations in the morphologic anatomy of RW niche. VT insertion is a good example. Because the RW is located behind the posteroinferior quadrant of the TM, myringotomy incisions on this quadrant may injure the RW membrane.[1,2] In addition, earlier reports indicate that determination of the position of the RW niche may also be essential in performing cochlear implant surgery through the posterior tympanotomy.[3,4] Finally, variations in RW morphology may influence the results of intratympanic therapy for several inner ear diseases. This therapy exposes the RW directly to the drug, considered the best way of obtaining high perilymphatic concentration. Nevertheless, it has been claimed that variations in RW anatomy may lead to inadequate exposure of RW to medication, which may account for some therapeutic failures.[5-12]

Although it is important in clinical settings, there is a lack of anatomic studies assessing the morphologic anatomy of the RW niche. Our study was designed to examine the anatomic variations of the RW niche and its relationships to the TM.

MATERIALS AND METHODS

Eleven dry temporal bones and 9 temporal bone specimens preserved in formalin were used in the study. No information was available on age and gender of the bones. Otomicroscopic examination of the TM and tympanic cavity was performed in the otologic surgery position. There was no sign of middle ear disease.

In the dry temporal bones, the following parameters were assessed (Figure 1):

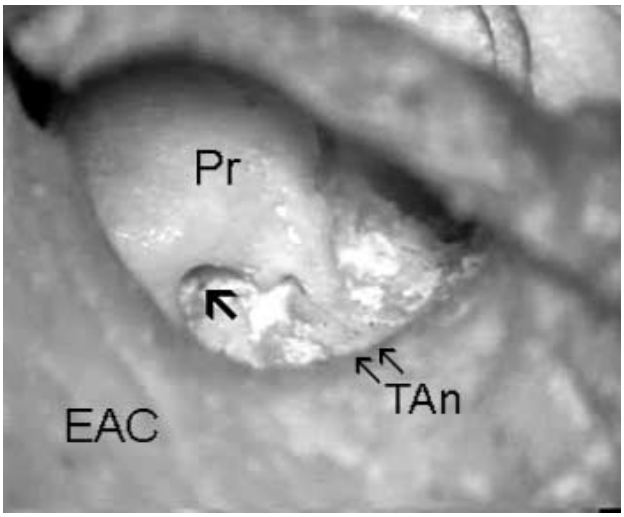

Figure 1: Visibility of round window niche (heavy black arrow) through external auditory canal (EAC) in the otologic surgery position (right ear). The position of the round window niche opening is inferior.
Pr = promontory, TAn = tympanic annulus.

1. Direct visibility of the RW niche through external auditory canal (EAC; visible/not visible)

2. The position of the niche opening. If the RW niche faced completely to the posterior mesotympanum, it was defined as posterior; if it faced completely downward, it was defined as inferior; if it was between these, it was defined as posteroinferior

In the temporal bone specimens, the TM dimensions were measured on vertical and horizontal planes determined by 2 imaginary lines, one passing through the malleus handle and the other perpendicular to it at the level of the umbo (Figure 2). The nearest distance from the most anterior portion of the TM to the umbo (A) and from the most posterior portion of the TM to the umbo (B) were noted on the horizontal plane while the nearest distance from the most superior portion of the TM to the umbo (C) and from the most inferior portion of the TM to the umbo (D) were recorded on the vertical plane.

After that, TM and the skin of the posterior EAC were removed. RW niche morphology and variations were noted as they had been in the dry bones. In addition, the following measurements were performed:

1. Location of the RW niche along the horizontal line. If it was located just on the horizontal line, it was

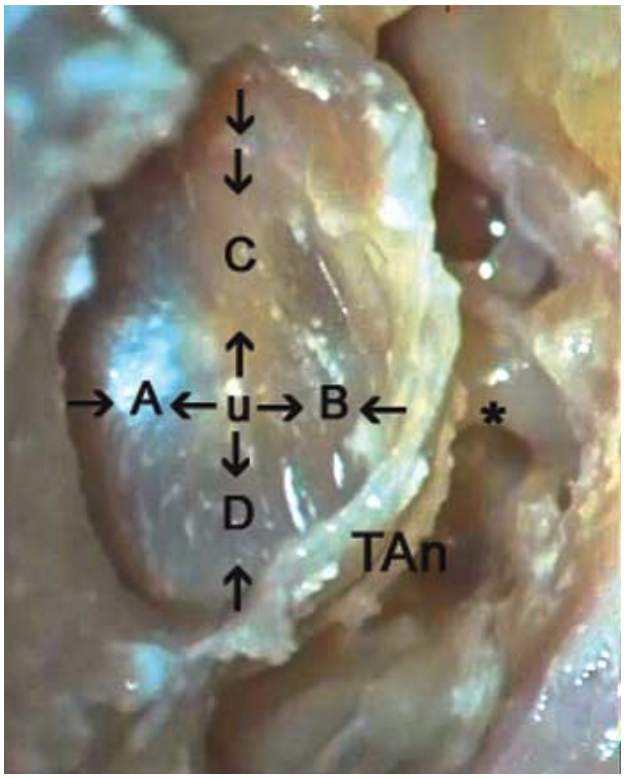

Figure 2: Orientation of the round window niche in relationship to the TM in the upright position (left ear, posterior bony canal wall of the external ear was removed).
TM = tympanic membrane; U = umbo; A = TM anterior portion; B = TM posterior portion; C = TM superior portion; D = TM inferior portion; TAn = tympanic annulus.
*Bony overhang of the round window niche.

defined as middle; if the inferior bony overhang of the RW niche was just above the horizontal line, it was defined as superior; if the superior bony overhang of the RW niche was just below the horizontal line, it was defined as inferior

2. Nearest distance between the umbo and RW niche on the horizontal plane

3. Nearest distance between the projection of the posterior tympanic annulus (TAn) and RW niche on the horizontal plane

RESULTS

Measurements of RW niche and TM morphology are listed in Tables 1 and 2.

We visualized the RW niche in 15 temporal bones (75%). The position of the niche opening was posterior in 3 (15%), inferior in 9 (45%), and posteroinferior in 8 (40%) temporal bones. The RW niche was located at the projection of the point where the posterior TAn was dissected by the horizontal line passing through the umbo. However, the RW niche was observed just superior to the horizontal line in one (5%) specimen, just inferior in 11 (55%), and on the horizontal line (middle) in 8 (40%) specimens.

The mean distance between the umbo and RW niche on the horizontal plane was 2.2 mm (range, 1-3 mm) while the mean distance between the projection of the posterior TAn and RW niche on the horizontal plane was 1.5 mm (range, 0.5-2.5 mm).

The TM was oval shaped; its mean vertical length was about 9.4 mm, and its mean horizontal length was about 8.2 mm. The part of TM anterior to the umbo was found to be shorter than the posterior part (3.4 vs 4.8 mm, respectively). The inferior portion of the TM was shorter than the superior portion (3.9 vs 5.4 mm, respectively).

DISCUSSION

Anatomic variations of the RW niche are reportedly found in approximately 33% of human temporal bones.[12] This high incidence might have implications for some surgeries, such as VT insertion, cochlear implantation, and intratympanic treatment for Meniere's disease. Hence, the otologic surgeon must be familiar with the anatomic relationship of the RW niche with some easily identifiable landmarks, such as the malleus handle and TAn, and with its variations in morphologic appearance.

The RW niche is classically defined as formed by 2 bony overhangs: one anteroinferior and the other posterior.[3] The posterior overhang may be called the posterosuperior overhang because it also lies superior to the RW membrane. The posterosuperior and anteroinferior overhangs make it difficult to see the RW membrane. The RW is reported to be located on average 1.3 mm from the RW niche.[13]

The position of the RW niche may be important for cochlear implantation surgery, which is performed

Table 1. Relationship of tympanic membrane to round window niche

Bone	Side	Niche Opening	Niche Visualization	Niche Location	Niche-TAn† (mean, 1.5 mm [range, 0.5-2.5 mm])	Niche-Umbo† (mean, 2.2 mm [range, 1.0-3.0 mm])
1	R	P/Inf	–-	Inf	–0.5	—
2	R	P	+	Inf	1.0	—
3	R	P	+	Inf	1.0	—
4	L	P/Inf	+	Inf	1.5	—
5	L	P/Inf	+	M	1.0	—
6	R	Inf	+	M	1.0	—
7	R	Inf	+	Inf	2.0	—
8	R	P/Inf	+	M	2.5	—
9*	R	Inf	+	Inf	1.0	2.0
10*	L	Inf	+	M	1.5	1.0
11	R	P/Inf	+	M	2.0	—
12	R	P/Inf	+	M	2.0	—
13*	R	P/Inf	–	Inf	–0.5	3.0
14	R	P/Inf	–	Inf	–1.0	—
15*	L	P	–	Inf	–1.0	3.0
16*	L	Inf	+	M	1.0	2.5
17*	L	Inf	+	M	2.5	1.5
18*	L	Inf	+	Inf	1.5	2.0
19*	L	Inf	–	Inf	–2.5	2.5
20*	R	Inf	+	S	1.5	2.0

TAn = tympanic annulus; R = right; L = left; P/Inf = posteroinferior; P = posterior; Inf = inferior; + = visualized; – = not visualized; S = superior.

*Temporal bone specimens.

†Distance at which the round window niche was not visible through the external auditory canal.

Table 2. Morphometric measurements* of the tympanic membrane

TBS	Side	A	B	C	D	A + B	C + D
1	R	3.5	4.5	5.5	4.0	8.0	9.5
2	L	4.0	4.0	6.0	4.0	8.0	10.0
3	R	3.5	5.0	5.5	4.0	8.5	9.5
4	L	3.0	5.0	5.0	4.0	8.0	9.0
5	L	4.0	5.0	6.0	4.5	9.0	10.5
6	L	3.0	5.0	5.0	4.0	8.0	9.0
7	L	2.5	5.0	5.5	4.0	7.5	9.5
8	L	3.5	5.0	5.5	3.0	8.5	8.5
9	R	4.0	5.0	5.0	4.0	9.0	9.0
Mean	—	3.4	4.8	5.4	3.9	8.2	9.4
Range	—	2.5-4.0	4.0-5.0	5.0-6.0	3.0-4.5	7.5-9.0	8.5-10.5

TBS = temporal bone specimen; R = right; L = left.

*In millimeters.

through the posterior tympanotomy. In our bones, we found that the RW niche opening was posterior in only 15% and posteroinferior in 40%, positions favorable for electrode insertion. However, in 45% of the bones, the RW niche was inferior, which may complicate surgery and necessitate removal of bony overhangs.

VT insertion is one of the most frequently performed surgeries in ear, nose, and throat practice. It is used either in cases of chronic otitis media with effusion or for delivery of medicine in some inner ear pathologies. VTs are usually inserted into the anteroinferior quadrant of the TM.[1,2] The proponents of anterior quadrant incision maintain that placement of the myringotomy incision on the posteroinferior quadrant risks injury to the RW membrane.[1,2]

Nevertheless, there are several anatomic restrictions to this technique. The acute angle of approximately 20° between the TM and anteroinferior bony EAC causes difficulty in surgical manipulation, especially for inexperienced surgeons.[14] This difficulty further increases when the anterior bony wall of the EAC is prominent, obstructing the view of the TM. Hence, some physicians advocate that VT insertion in the posterior quadrant is safer and easier.[7,8] The anatomic findings of our study support this position.

The RW niche often can be directly seen within the tympanic cavity when the TM is removed.[6] However, this is not valid in every case. We found that it was visible in 75% of the bones after removal of the TM.

Silverstein and colleagues investigated whether it was possible to locate the RW niche using the malleus handle as a landmark.[6] They found that the mean distance between the umbo and the nearest edge of the RW niche was 3.44 mm. However, we found smaller dimensions (2.2 mm). This indicates variability in this distance. We hold that the use of this measure is not reliable in estimating the location of the RW niche. Therefore, we consider that it may be useful to examine the relationship of the RW niche to the posterior quadrant of the TM.

We measured the dimensions of the TM. However, our aim was not to repeat measuring these dimensions, because they are already known. It is believed that the risk of penetration of the RW membrane during incision on the posterior quadrant is possible, we tried to examine the location of the RW niche with regard to the posterior quadrant of the TM.

We found that the umbo was not situated midway between the vertical and horizontal dimensions of the TM. Instead, it was located slightly anterior and inferior. The anterior (B) and inferior (D) dimensions of the TM were shorter than the posterior (A) and superior (C) (Figure 2). This means that, in the TM, the anteroinferior quadrant dimension (3.4x3.9 mm) is narrower than the posteroinferior dimension (4.8x3.9 mm), which makes it difficult to manipulate.

Moreover, our results also showed that the location of the RW niche was just at midportion of the posterior TAn, which means that the RW niche is removed from the site of myringotomy incision. In addition, if it is assumed that the RW membrane is located approximately 1 mm inside the RW niche, it can also be assumed that the overhangs of the RW niche may play a protective role for the RW membrane during myringotomy incision.[13]

From the surgical standpoint, all these findings suggest that VT insertion into the posteroinferior quadrant may be much easier.

Determination of the RW niche position is also important for intratympanic treatment of Meniere's disease, tinnitus, or acute idiopathic sensorineural hearing loss.[5,7,9,11] In this treatment, the primary route of medication application into the inner ear is through the RW membrane. Hence, several medication delivery methods that will provide a sufficient dose of drugs to the RW have been proposed, including injection by needle through the TM or through tympanostomy tubes and/or catheters through the TM, and insertion of a wick through a tympanostomy tube into the RW niche.[5,7,9,11] However, a significant number of unsuccessful results have been reported; the primary reason for these failures is that the RW niche has not been exposed to an adequate dose of medication. RW niche variations may play a role here.[1,5,7-9,11] We found that the position of the RW niche

was just at the projection of the posterior TAn midportion. Therefore, it may be better to insert the needle for TM mediation delivery on the horizontal line passing through the umbo. If delivery is to be made through the VT, the needle can be placed in the posteroinferior quadrant safely. In addition, our findings on position of the niche opening (posterior, 15%; inferior, 45%; and posteroinferior, 40%) indicates that the patient should maintain a supine otologic position for more time after medication delivery to expose the RW sufficiently.

CONCLUSION

Our study demonstrated wider posteroinferior dimension of the TM, and almost stable location of the RW niche at the projection of the midportion of the posterior TAn. These results should be kept in mind during insertion of VT and administering intratympanic medication.

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