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Revisiting the Anatomy of the Facial Recess: The Boundaries of the Round Window Exposure

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Background: The exposure of the round window (RW) through the facial recess (FR) is sometimes partial. The anatomic variations that alter RW exposure during cochleostomy have not been clearly defined to date.

Aims: The aim of this study was to assess the best FR position in which to achieve the widest exposure of the RW niche and to define the topographic relationship between two other important anatomical structures, the facial nerve (FN) and the chorda tympani (CT).

Study Design: Cadaver study.

Methods: Twenty-four temporal bones were included in the study. Anterior and posterior epitympanectomy and posterior tympanotomy were performed after mastoidectomy. Bone was removed until the FN and CT were skeletonized and the CT branching point was visible. Two pictures were taken. The first was taken when the facial recess was at its widest exposure, while the second was taken when the RW niche was maximally exposed through the facial recess. Various measurements were taken.

Results: The RW niche was totally visible in 19 temporal bones (79.2%). The RW was partially visible in the remaining five bones (20.8%). The unexposed part of the RW lay posteromedial to the FN in these five bones. While the branching point of the CT could be visualized in all cases at the widest exposure of RW, the part of the FN distal to the branching point was hidden in eight subjects (33.3%) under the posterior wall of the external ear canal.

Conclusions: The RW niche was totally visible in most of the temporal bones. The RW lay posteromedial to the FN in some cases and total exposure was impossible.

Keywords: Round window, facial recess, chorda tympani, cochlear implantation

The facial recess (FR) is the route used in posterior tympanotomy to perform cochlear implantation surgery (1,2). The major boundaries of the FR are the facial nerve (FN) and chorda tympani (CT). Several major and minor complications of posterior tympanotomy and cochlear implantation have been described previously (3). Two of the most important complications are facial paralysis and taste disorders.

It has been established that the scala tympani is the optimal region of the cochlea for electrode insertion of a cochlear implant (4). Round window (RW) insertion has some advantages over promontory cochleostomy (5,6). With the help of RW electrode insertion, one may prevent inadvertent scala vestibuli insertion of the electrodes (7). However, the exposure of the RW through the FR is sometimes partial and RW insertion is impossible. The boundaries of the facial recess and awareness of the related anatomy are crucial in the prevention of complications such as facial paralysis and CT injury. There are few clinical and anatomical data with which to determine how one may try to further increase the exposure of the RW without any major complications. Is it possible to establish RW insertion in all cases? One previous report advocated the anteplacement of CT to increase the exposure of the RW (8). There are some cadaver studies about FR anatomy; however, there are limited data focusing on RW exposure through the FR and its limitations (9,10).

This study has been presented at the 34th Turkish National Congress of Otorhinolaryngology Neck and Head Surgery 2012, Antalya, Turkey.

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The aim of this study was to assess RW niche visibility after maximally exposing the facial recess and to define the topographic relationship between two other important anatomical structures, the FN and CT.

MATERIALS AND METHODS

This study was conducted between 2010 and 2012. Twenty-four temporal bones from 18 donated cadavers preserved in formalin were examined in the Anatomy Department cadaver dissection laboratory. All cadavers were male. Ten temporal bones were from the left and 14 were from the right. The study was conducted in accordance with international ethical standards. Local ethics commitee approval was obtained.

The surgical procedure was carried out under a surgical microscope (Möller-Wedel Optical; Hamburg, Germany), and the specimens were dissected with the help of a mobile motor drill starting from the mastoid cortex. Anterior and posterior epitympanectomy and posterior tympanotomy were performed after mastoidectomy. The bony lamella covering the FN and CT was thinned so that the FN and CT were skeletonized and the CT branching point could be made visible. The incus, incudostapedial joint, stapes, stapedius tendon, lateral semicircular canal, RW niche, promontory, Jacobson nerve and cochleariform process were made visible by the completion of dissection.

The whole procedure was video recorded and two separate pictures were taken with a maximum magnification of 24x. The first one was taken when the FR was at its widest exposure, perpendicular to the Frankfort horizontal plane (Figure 1). The microscope head was readjusted and the second picture was taken while the RW was maximally exposed through the FR (Figure 2). The most superior point of the FN beneath the lateral semicircular canal, the most superior and anterior point of the CT and the acute angle at the branching point of the CT were exposed. Various measurements were taken with the help of these reference points.

The anatomical relations between the FN, CT (branching angle, width of FR) and cortex of the posterior wall of the external ear canal were evaluated on the first picture. The exposure status of the RW niche and the CT relative to the RW niche were assessed on the second picture.

Outcome measures were defined as follows: 1) length of the FN from the most superior point beneath the lateral semicircular canal (FNs) to the CT branching point; 2) length of CT from the branching point to the closest point to the FNs (CTs); 3) width of the FR as the distance between FNs and CTs; 4) angle between CT and FN on the branching point of CT; 5) exposure of round window (total, partial) (Figure 1).

Statistical analysis was conducted using computer software (SPSS version 17.0, SPSS Inc.; Chicago, IL, USA). Chi-square (X^2) tests were used for the comparison of categorical data while Student's t-test was used for the analysis of variables based on the distribution pattern of the data. Data were expressed as "mean (standard deviation; SD)", percent (%), minimum-maximum, Odds Ratio (OR) and 95% confidence interval (CI) as appropriate. $p<0.05$ was considered statistically significant.

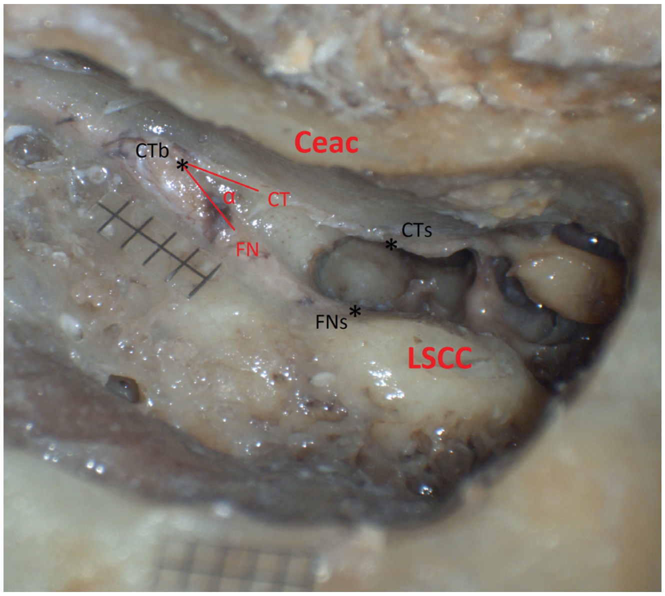

FIG. 1. Example of the first picture, which was taken when the FR was at its widest exposure, perpendicular to the Frankfort horizontal plane. (CTb: chorda tympani branching point; FNs: the most superior point of the FN beneath the lateral semicircular canal; CTs: the closest point on the CT to the FNs; α: branching angle of CT from FN; LSCC: lateral semicircular canal; FN: facial nerve; CT: chorda tympani; FR: facial recess; Ceac: cortex of external ear canal.)

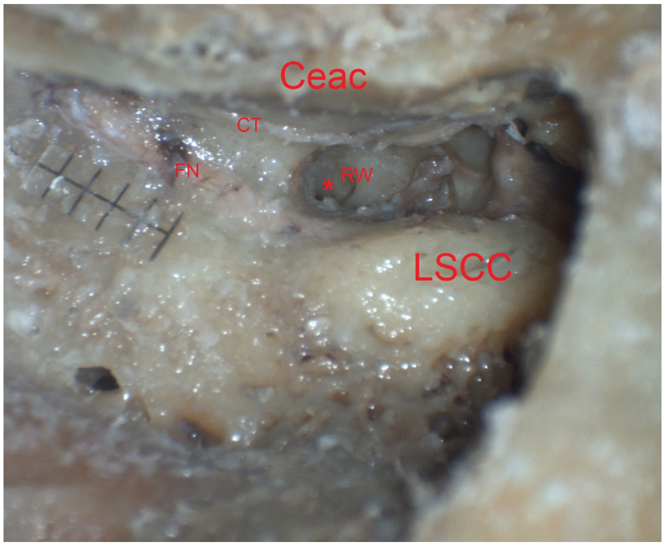

FIG. 2. Example of the second picture of the same cadaver as in Figure 1, which was taken when RW was maximally exposed. (LSCC: lateral semicircular canal; FN: facial nerve; CT: chorda tympani; RW: round window; Ceac: cortex of external ear canal.)

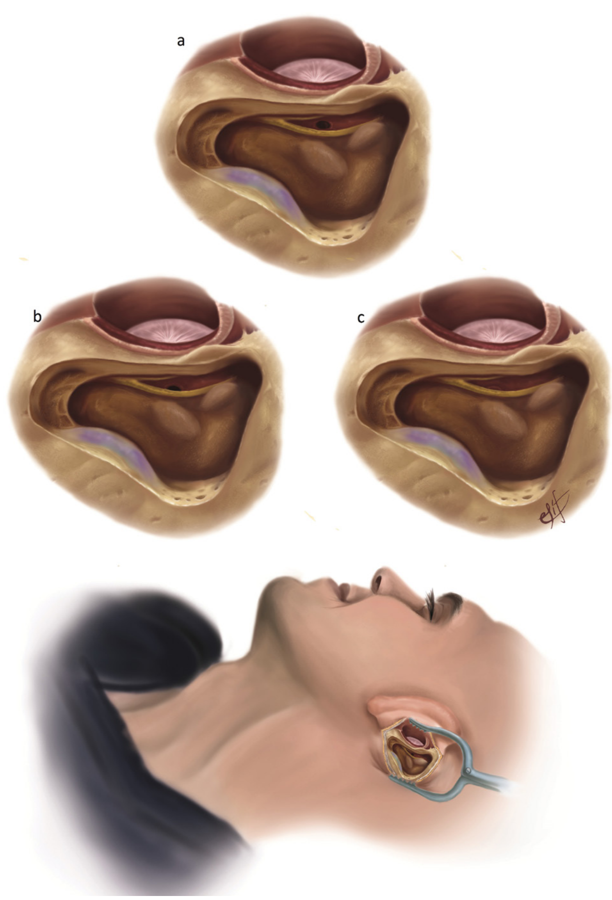

FIG. 3. The anatomical variations of round window (RW) exposure through posterior tympanotomy. RW is totally visible (a), partially visible (b) or completely invisible (c)

TABLE 1. Round window and chorda tympani exposure status in the second picture, which was taken when the RW was maximally exposed.

Exposure Status	RW total CT total	RW total CT partial	RW partial CT total	RW partial CT partial
Number	14	5	2	3
Per cent	58.3	20.8	8.3	12.6

RW: round window; CT: chorda tympani

RESULTS

Analysis of the data from the first picture revealed that the mean length of the FN from the most superior point beneath the lateral semicircular canal (FNs) to the CT branching point was 9.7 mm (5.4-15.1 mm, SD: 2.8 mm). The mean length of the CT from the branching point to the closest point to the FNs (CTs) was 11.4 mm (6.8-17.0 mm, SD: 2.9 mm). The width of the FR, which was defined as the distance between FNs and CTs, was 2.6 mm (1.1-4.2 mm, SD: 0.7 mm). The angle between the CT and FN on the branching point of the CT was 22.5 degrees (11.1-42.1 degrees, SD: 8.1 degrees).

Analysis of the data from the second picture revealed that the RW was entirely located in the FR in 79.2% (19/24) of the temporal bones, and partially located in the FR in 20.8% (5/24). The part of the RW that could not be visualized lay posteromedial to the FN in all five of these temporal bones. Table 1 shows the exposure status of the RW and CT on the second picture. While the mastoid portion of the FN proximal to the branching point of the CT was in the visible surgical field in all cadavers; most of the FN distal to the branching point of the CT was covered and hidden by the posterior wall of the external ear canal in 33.3% (8/24) of the cadavers. The anatomic variations of RW exposure through posterior tympanotomy are illustrated in Figure 3.

There was no statistically significant parameter predicting the total exposure of the RW ($p>0.05$). The most important parameter was the width of the FR; however, it did not reach a statistically significant level ($p>0.05$). The only positive correlation was found between FN and CT length ($p<0.05$).

DISCUSSION

Total exposure of the RW through the FR is very important in posterior tympanotomy performed in cochlear implant surgery. As described in the introduction, RW insertion of electrodes has some advantages over promontory cochleostomy. RW insertion of the electrodes secures the scala tympani localization of the cochlear implant and prevents inadvertent scala vestibuli insertion.

In a previous anatomical study, Hamamoto et al. (2) reported that reliable RW access cannot be achieved by posterior tympanotomy through the FR. However, our study found that total RW exposure can be achieved through the FR in most temporal bones (79.2%). Total exposure of the RW will allow RW insertion of the cochlear implant electrodes. Leong et al. (11) reported that the RW was visible in more than 50% to 89% of adult and 78% of paediatric cases after an optimal posterior tympanotomy. In cases in which the RW niche cannot be totally exposed, one must keep in mind that further dissection of the anatomic boundaries may cause complications such as facial paralysis and taste disorders. RW-related promontory cochleostomy might be preferred in such cases.

In a previous study, Wang et al. (8) reported 39 cases with a width of facial recess narrower than 1 mm. On the contrary, none of our cadavers had an FR width of less than 1 mm. This difference might be attributed to the dissection limits, which could be more advanced in a cadaver study than in real life. Wang et al. (8) described anteplacement of the CT in order to widen the narrow FR. However, we found that the RW was positioned posteromedial to the FN in all partially exposed cadavers. We believe that anteplacement of the CT will have little or no benefit in the case of a poorly exposed RW. One may enlarge the FR, whereas RW visibility may not be improved due to the posteromedial positioning of the RW to the FN.

The only correlations between branching angle, CT length, FN length and FR width were between FN and CT lengths. Additionally, there was no clear relation between FR borders and RW visibility. The RW visibility seemed to be independent from the anatomical structures that comprised the borders of the FR. In a previous study, Lee et al. (12) reported that the angle between the cortex of the external ear canal and the FN was highly correlated with visibility through posterior tympanotomy. We found no evidence of this correlation. They investigated the wide view from the FR, so they could not evaluate the detailed exposure status of the RW. The width of the facial recess was defined as the distance between the chorda tympani canal and sulcus of the stapedius muscle (13). Since we skeletonized the FN and CT, we did not use the intraoperative bony landmarks mentioned previously in the medical literature. A previous study investigated the position of the RW niche through posterior tympanotomy (14). Our study focused on the exposure of the RW niche and its variations. In a previous study, the authors reported that the CT branching point was in the stylomastoid foramen in 5% of cases (15). We did not encounter any case with a ramification in the stylomastoid foramen.

There are some limitations of this study. The first one was the small number of temporal bones included in the study, which might preclude a definitive conclusion. The second one is that it included six cadavers that each supplied two temporal bones. Two temporal bones from the same cadaver might resemble each other in some respects. The RW niche position is also important in RW insertion of cochlear implants. However the aim of this study was not to assess the RW insertion technique. Unfortunately RW niche position was not evaluated in relation to electrode insertion.

In conclusion, the RW niche was totally visible in most of the temporal bones. The RW lay posteromedial to the FN in some cases and total exposure was impossible.

Ethics Committee Approval: Ethics committee approval was received for this study from the ethics committee of Ege University School of Medicine.

Informed Consent: N/A.

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