

The Anatomical Relation of the Round Window and the Facial Recess in Thai Cadaveric Temporal Bone

Watchareporn Teeramatwanich MD*, Somchai Srirompotong MD*,
Pornthep Kasemsiri MD*, Kowit Chaisiwamongkhol MD**,
Suthee Kraitrakul MD*, Kwanchanok Yimtae MD*

* Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

** Department of Anatomy, Faculty of Medicine, Khon Kaen University, Khon Kaen, Thailand

Objective: To determine the anatomical relationship between the facial recess and the round window membrane and to measure the distance between the chorda tympani nerve and the facial nerve through the round window membrane.

Material and Method: A descriptive study of the embalmed Thai cadaveric temporal bones was conducted at the Department of Otorhinolaryngology, the Faculty of Medicine, Khon Kaen University.

Results: Thirty-seven Thai cadaveric temporal bones from 22 males and 15 females were included in the study. The length of the facial nerve from the crotch of the facial nerve and the chorda tympani nerve (CFC) to the fossa incudis was 13.52 mm (95% CI: 12.74-14.31), and the length from the CFC to the round window position was 10.28 mm (95% CI: 9.52-11.04). The length of the chorda tympani nerve from the CFC to the round window position was 9.34 mm (95% CI: 8.61-10.07). The width of the facial recess (the distance between the chorda tympani nerve to the facial nerve) through the round window was 2.89 mm (95% CI: 2.71-3.09). The round window was located at a ratio of 0.75 (95% CI: 0.72-0.79) of the facial nerve length from the CFC. The mean distance of the posterior crus of stapes footplate to the round window membrane was 2.24 mm (95% CI: 2.16-2.33). The diameter of the stapes footplate was 2.66 mm (95% CI: 2.58-2.76).

Conclusion: The round window could be identified at 3/4 the length of the facial nerve from the CFC to the fossa incudis or from the posterior crus of stapes at approximately the length of the stapes footplate. The width of the facial recess at the round window position was 2.89 mm.

Keywords: Facial recess, Facial nerve, Round window membrane, Posterior tympanostomy, Cochlear implantation

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Bilateral profound sensorineural hearing loss has many causes and could be treated using cochlear implantations. Cochlear implants are surgically implanted electronic devices that provide a sense of sound to people with bilateral profound sensorineural hearing loss that is not improved by hearing aids. Cochlear implantation is performed behind the ear; an opening is drilled in the mastoid bone, through which the cochlear implant is inserted into the cochlea. The operation might cause a number of complications including facial nerve paralysis, dysgeusia, vertigo, and intracranial complications⁽¹⁻³⁾. The boundary of the facial recess consists of the facial nerve, chorda tympani, and incus buttress. This corridor is used to approach the middle ear cavity and identify the position of the

round window membrane during cochlear implantation. The electrode of the implant is inserted into the scala tympani via a cochleostomy or round window approach. Auditory performance depends on atraumatic electrode insertion and the electrode location; device manufacturers generally suggest performing a cochleostomy antero-inferior to the round window. Placement more anterior to the round window might increase the risk of vestibule insertion and intracochlear trauma⁽⁴⁾. Recently, round window insertion has become an accepted approach for preserving hearing, particularly in the use of combined electric acoustic stimulation cochlear implant systems⁽⁵⁾. The position of the round window varies, and direct visualization of the round window is not always possible. Raine et al reported restricted access to the round window in 5 of 42 procedures (11.9%)⁽⁶⁾. The round window position is the most crucial landmark when performing this operation.

Bielamowicz et al compared the growth and dimensions of the facial recess and reported no

Correspondence to:

Yimtae K, Department of Otorhinolaryngology, Faculty of Medicine, Khon Kaen University, 123 Mittrapha Highway, Muang, Khon Kaen 40002, Thailand.

Phone: +66-43-368396, Fax: +66-43-202490

E-mail: kwayim@kku.ac.th

significant differences in the facial recess dimension between children and adults⁽⁷⁾. Additionally, the relationship between the facial and chorda tympani nerves exhibited no change after birth.

A pre-operative assessment of the facial recess dimension and the spatial relationship between the facial recess and the round window was attempted by Bettman et al⁽⁸⁾. The study compared measurements from preoperative CT scans with operative findings. The width of the facial recess at the round window position was 4.5 ± 0.9 mm; there was no significant spatial relationship between the facial recess width and the round window feasibility. The pre-operative CT measurements were not consistent with the operative findings; the authors suggested a more detailed study to investigate the relationship between the operative direction and the orientation of the round window.

The aim of this research was to study the anatomical relationship between the round window and the facial recess and between the facial recess width at the round window position in Thai cadaveric temporal bones.

Material and Method

Formalin-embedded temporal bones were prepared from donated Thai cadavers at the Srinagarind Hospital, Faculty of Medicine, Khon Kaen University between August 2010 and August 2012. This research was granted an exemption from ethical review by the Khon Kaen University Ethics Committee in human research. Temporal bones were excluded from the study if the personal data of the donor as well as information regarding the cause of death of the donor or temporal bone injury were unknown. In accordance with the Bettman study⁽⁸⁾ a sample size at least 35 temporal bones was required to achieve 95% accuracy with a standard deviation of 0.9 mm and error of 0.3 mm.

The cadaveric temporal bones were drilled sequentially. First, a simple mastoidectomy was performed. Then, a posterior tympanostomy was performed through the facial recess. The chorda tympani, facial nerve, incus buttress, fossa incudis, and round window membrane were identified. The distances were measured three times using a caliper. The crotch of the facial nerve and the chorda tympani (CFC) was the landmark used to measure the length of the facial nerve and the chorda tympani. The perpendicular line from the center of the round window was used as the reference line of the round window, and the facial recess angle (FRA) was calculated by the Pythagorean formula. The width of the facial recess

was measured as the distance between the chorda tympani nerve and the facial nerve at the reference line of the center point of the round window. The diameter of the round window and the oval window were measured, and the distance between the two diameters was measured from their center points. The landmark and diagram measurements are presented in Fig. 1.

Results

Thirty-seven Thai cadaveric temporal bones from 22 males and 15 females were included in the study. There were 19 right temporal bones and 18 left temporal bones.

The average length of the facial nerve from the CFC to the fossa incudis was 13.52 mm (95% CI: 12.74-14.31). The average length of the facial nerve from the CFC to the reference line of the center of the round window was 10.28 mm (95% CI: 9.52-11.05). The length of the chorda nerve from the CFC to the reference line of the center of the round window was 9.34 mm (95% CI: 8.61-10.07), and the width of the facial recess at the round window position was 2.89 mm (95% CI: 2.70-3.09).

The facial recess angle was calculated by the

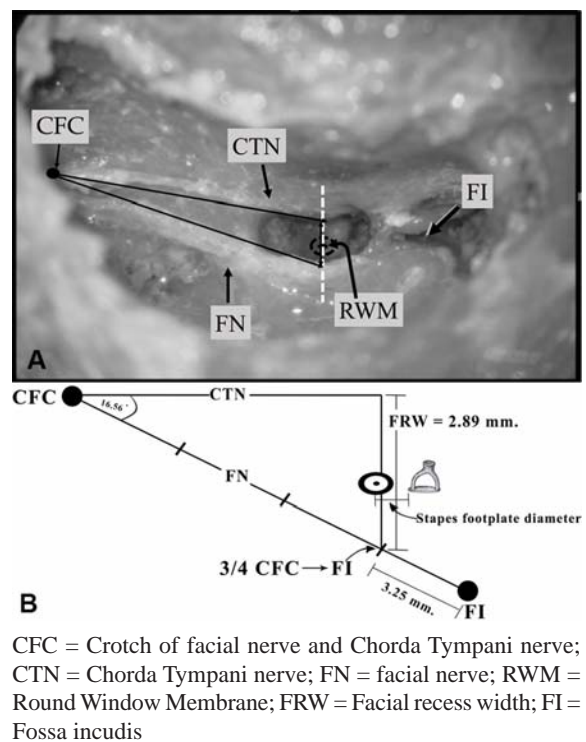


Fig. 1 A) Landmarks for measurement in a cadaveric specimen. B) Measurement diagram.

Pythagorean formula. The average angle was 16.56 degrees (95% CI: 14.68-18.45). The narrowest angle was 9.24 degrees, and the widest angle was 29.76 degrees.

The distance between the posterior crus of stapes to the round window membrane was 2.24 mm (95% CI: 2.16-2.32). The average length of the stapes footplate was 2.67 mm (95% CI: 2.58-2.76).

Discussion

We found that the width of the facial recess at the round window position was 2.89 mm (95% CI: 2.708-3.088), whereas Bettman et al reported a width of the facial recess at the round window position of 4.5 mm (SD = 0.9 mm)⁽⁸⁾. This difference might be a result of the technique used to measure the distance or because of the ethnicity of the study subjects. Bettman et al measured the width of the facial recess using CT images. A study in China measured the width of the facial recess at the level of the round window using dissection and compared the results high-resolution computerized topography (HRCT) measurements⁽⁹⁾. They found that there was not a significant difference in the widths measured by dissection and by HRC3.T (3.13 ± 0.34 versus 3.20 ± 0.38 , respectively). Eby et al studied the width of the facial recess in 123 temporal bones from 73 individuals ranging in age from 8 weeks in utero to 7 years after birth and found that the width of the facial recess at the round window level was 2.62 mm, with no significant growth after birth⁽¹⁰⁾. His finding was consistent with the results reported by Bielamowicz et al. The width of the facial recess reported by Bettman et al is greater than those reported in other studies. This finding could be explained by the technique used to measure the distance rather than by the ethnicity of the study participants.

When drilling the facial recess, the chorda tympani nerve is typically used as a reference to avoid facial nerve injury. In our study, the average facial recess angle was 16.5 degrees (95% CI: 14.67-18.45). This finding is constructive for reminding surgeons that the facial nerve is nearby and that a small bur (1-1.4 mm) should be used to avoid injury to the facial nerve.

The average length of the facial nerve, measured from the CFC to the reference line of the center of the round window, was 10.28 mm (95% CI: 9.52-11.04); the length of the facial nerve from the CFC to the fossa incudis was 13.52 mm (95% CI: 12.74-14.31). Regarding the facial recess, the round window was located at 0.76-fold (95% CI: 0.72-0.79) or 3/4 of the distance of the facial nerve from the CFC to the fossa incudis. This result could be a reference for determining

the round window membrane position.

In the largest series, which evaluated 130 cochlear implantations, Gudis et al reported that the round window is easily approached in 85.4% of cases⁽¹¹⁾. The round window might be confused with the hypotympanic air cells. Another landmark for locating the round window is the correction between the round window and the stapes footplate. The results of our study indicate that the round window membrane was located 2.24 mm from the posterior crus of stapes (95% CI: 2.16-2.32). The length of the stapes footplate was 2.67 mm (95% CI: 2.58-2.76). This finding suggests that, in practice, the round window should be at an approximately one-fold length distance from the stapes footplate.

We suggest 3 ways to determine the round window position. First, the round window could be located in the tympanic cavity at 3/4 of the length of the facial nerve from the CFC to the fossa incudis. Second, the round window could be located at a distance of 1/4 the length of the facial nerve from the fossa incudis. Finally, the round window could be located from the posterior crus of stapes at a distance that is approximately the length of the stapes footplate.

Conclusion

The width of the facial recess at the round window position was 2.89 mm. and the facial recess angle was 16.56 degrees. The round window was located at 3/4 of the length of the facial nerve from the CFC and 1/4 of the length of the facial nerve from the fossa incudis. The round window was located at a distance of the stapes footplate length, approximately from the posterior crus of stapes. These parameters are useful references for identifying the round window when performing cochlear implantation.

What is already known on this topic?

The round window position is the most crucial landmark when performing the cochlear implantation. The position of the round window varies, and direct visualization of the round window is not always possible.

No studies have reported the anatomical relationship between the round window and the facial recess and between the facial recess width at the round window.

What this study adds?

The authors suggest 3 ways to determine the round window position. First, the round window could

be located in the tympanic cavity at 3/4 of the length of the facial nerve from the CFC to the fossa incudis. Second, the round window could be located at a distance of 1/4 the length of the facial nerve from the fossa incudis. Finally, the round window could be located from the posterior crus of stapes at a distance that is approximately the length of the stapes footplate.

The width of the facial recess at the round window position was 2.899 mm, and the facial recess angle was 16.5 degrees. These parameters are useful references for identifying the round window when performing cochlear implantation.

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Potential conflicts of interest

The authors have no personal financial or institutional interest in any of the materials or devices described in this article. We identified no conflicts of interest.

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ความสัมพันธ์เชิงกายวิภาคระหว่าง round window และ facial recess ของกระดูก temporal ในศพคนไทย

วัชรพร ศิริมาสวนิช, ขวัญชนก ยิ้มแต่, สมชาย ศรีรัมย์โพธิ์ทอง, พรเทพ เกษมศิริ, สุธี ไกรตระกูล, โกวิท ไชยศิวงมกล

วัตถุประสงค์: เพื่อศึกษาความสัมพันธ์เชิงกายวิภาคระหว่าง facial recess และ round window membrane ของกระดูก temporal ในศพคนไทยและวัดระยะห่างระหว่างเส้นประสาท chorda tympani และเส้นประสาท facial

วัสดุและวิธีการ: เป็นการศึกษาเชิงพรรณนาในศพคนไทยที่แช่ฟอร์มาลินที่ภาควิชาโสต ศอ นาสิกวิทยา คณะแพทยศาสตร์ มหาวิทยาลัยขอนแก่น

ผลการศึกษา: จากการศึกษาทั้งหมด 37 ศพ เป็นเพศชาย 22 ศพและเพศหญิง 15 ศพ วัดความยาวของเส้นประสาท facial ที่จุดแยกระหว่างเส้นประสาท facial และเส้นประสาท chorda tympani ถึง fossa incudis ได้ค่าเฉลี่ย 13.52 มิลลิเมตร (ช่วงความเชื่อมั่นร้อยละ 95 คือ 12.74-14.31) ความยาวของจุดแยกระหว่างเส้นประสาท facial และ เส้นประสาท chorda tympani ถึงตำแหน่งของ round window ได้ค่าเฉลี่ย 10.28 มิลลิเมตร (ช่วงความเชื่อมั่น ร้อยละ 95 คือ 9.52-11.04) ความยาวของเส้นประสาท chorda tympani จากจุดแยกจากเส้นประสาท facial ถึงตำแหน่งของ round window ได้ค่าเฉลี่ยยาว 9.34 มิลลิเมตร (ช่วงความเชื่อมั่นร้อยละ 95 คือ 8.61-10.07) ความกว้างของ facial recess โดยวัดระยะห่างระหว่างเส้นประสาท facial ถึงเส้นประสาท chorda tympani โดยลากผ่านตำแหน่งของ round window ได้ค่าเฉลี่ย 2.89 มิลลิเมตร (ช่วงความเชื่อมั่นร้อยละ 95 คือ 2.71-3.09) ได้คำนวณอัตราส่วนตำแหน่ง round window เมื่อเทียบกับความยาวของเส้นประสาท facial ถึง fossa incudis เป็น 0.76 (ช่วงความเชื่อมั่นร้อยละ 95 คือ 0.72-0.79) หรือประมาณ 3 ใน 4 ของความยาวของเส้นประสาท facial วัดค่าเฉลี่ยระยะระหว่าง posterior crus ของ stapes ถึง round window membrane ได้ค่าเฉลี่ย 2.24 มิลลิเมตร (ช่วงความเชื่อมั่นร้อยละ 95 คือ 2.16-2.33) โดยใกล้เคียงกับขนาดความยาวของ stapes footplate ที่วัดได้ค่าเฉลี่ย 2.66 มิลลิเมตร (ช่วงความเชื่อมั่นร้อยละ 95 คือ 2.58-2.76)

สรุป: จากผลการศึกษาพบว่าสามารถหาตำแหน่ง round window ได้ดังนี้คือ เมื่อเทียบกับความยาวของเส้นประสาท facial ถึง fossa incudis มีอัตราส่วนเป็น 3 ใน 4 ส่วน หรือ ระยะห่างจาก posterior crus ของ stapes เท่ากับความยาวของ stapes footplate และความกว้างของ facial recess ที่ตำแหน่งของ round window มีค่าเฉลี่ย 2.89 มิลลิเมตร
