Experience on Treating Variations of Facial Nerve in Cochlear Implant with Endoscopic Assistant of Access to the Round Window

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Abstract

Objectives: Cochlear implant is the only solution of profound sensorineural hearing loss. The round window implant provides minimal injury to the inner ear, and may preserve the residual hearing, and the key to insert the electrode array is to expose the round window, but displaced facial nerve may hinder the visualization of the round window. The aim of the study was to expose the round window and preserve the full function of facial nerve with endoscopic assistant. Design: Cases with variant facial nerve were observed with rigid endoscopy. The locations of round window were assessed by endoscopy and we performed retrofacial approach, or using "suspended" facial nerve technology to expose the round window by shifting the facial nerve posteriorly. Paticipants: Three cases were collected with variant facial nerve, two cases performed retrofacial approach, one case performed "suspended" facial nerve technology. Results: All cases inserted electrode array in round window and preserve the residual hearing, and none of the cases suffered facial nerve injury, chorda tympani nerve injury, misplacement of the electrode array, and other complications. Conclusion: Rigid endoscopy can provide a clear vision of round window, and assistant the electric array insertion during cochlear implant surgery.

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Keywords

Endoscopic ear surgery, retrofacial approach, round window, facial nerve, cochlear implant

Keypoints

Cochlear implant through the round window provides minimal injury to the inner ear and preserve the residual hearing.

The facial nerve variation may hinder the visualization of round window and leads to misplacement of the electrode array.

The facial nerve monitoring during cochlear implant is necessary, especially when facial nerve variation is expected.

The facial nerve bone canal can be removed depending on the variation of facial nerve.

The rigid endoscopy may provide a clear vision of round window, and guide the electric array insertion during cochlear implant surgery.

Introduction

During cochlear implant surgery, facial nerve is an important anatomic landmark for visualization of posterior tympanic approach. In this approach, the facial recess is opened to get access to the round window through the mastoidotomy. The electrode array is then placed through the round window into the cochlear. Round window exposure is a crucial procedure during cochlear implant, unable to expose the round window may lead to misplacement of the electrode array, such as eustachian tube and hypotympanum[1]. However, the facial nerve may have variations, which may prevent to visualize the round window. These may result in the chorda tympani nerve dissection.

Endoscopic ear surgery has been rapidly increased in recent years. It enlarged surgical view to examine all structures with angled rigid endoscopy without difficulty. It allowed minimal invasive access to inspect the hidden recesses [2].

To preserve the full function of facial nerve and chorda tympani nerve, and place the electrode array, we hypothesize the operation can expose the round window by rigid endoscopy and avoid excessive dissection of the mastoid, and assistant to place the electrode array correctly without complications.

Methods

This study followed clinical practice. Patients were selected during 2018 January to 2020 December in <Blinded for review>. Three patients were selected from total of 946 patients. All the patients were evaluated preoperatively by CT scan to comfirm the facial nerve was anteriorly positioned in mastoid segment. All the patients were assessed by House-Brackmann facial nerve grading system as grade I.

In surgeries, all patients were underwent cochlear implant. All patients were accepted facial nerve monitoring during surgery (NIM-Neuro 3.0, Medtronic, USA), and surgeries were performed using endoscopic techniques assistant (0° and 30° 3mm diameter endoscope, Karl Storz, Germany).

Case 1

A 10-months-old boy patient with bilateral profound sensorineural hearing loss (SNHL) underwent right cochlear implantation. The CT scan had been estimated preoperatively that mastoid segment of facial nerve was anteriorly positioned. After mastoidectomy and opened the facial recess, the facial nerve was prevented to expose the round window. By reappraised the location of the round window, the endoscopy was used to observe around corners of the tympanic cavity, and the round window was visualized via retrofacial approach eventually. The electrode array was then placed into the round window.

Case 2

A 24-year-old patient with bilateral profound sensorineural hearing loss (SNHL) underwent right cochlear implant. The CT scan had been estimated preoperatively that vertical facial nerve was covered the round window. The facial nerve was monitored during the surgery. After the facial recess was opened, the facial nerve and chorda tympani nerve were skeletonized to exposed the round window. However, the round window could not be visualized. The round window was then observed with endoscopy assistant. Although the round

window could be observed by endoscopy, it was too narrow to place the electrode array. Then the sinus tympani attempted to open by retrofacial approach, until the variation branch of facial nerve was found to occupied the retrofacial space. As a result, the bone around the vertical facial nerve was totally removed and the facial nerve was 'suspended'. After that, the 'suspended facial nerve' was pulled posteriorly to expose the round window. The electrode array was then fully inserted into the round window with assistant of endoscopy.

Case 3

A 15-year-old male patient with large vestibular aqueduct syndrome (LVAS) suffered bilateral mixed hearing loss. The patient underwent bilateral cochlear implant. The CT scan indicated that the right vertical facial nerve was anteriorly positioned. The facial nerve was monitored during the surgery. During implant, the right round window could not been seen through the facial recess, so the retrofacial approach was performed to expose the round window. The electrode array was inserted with assistant of endoscopy guide. The left facial nerve had no variations. The postoperative CT scan showed full inserted of the electrode array.

Results

The three cases took the CT scan preoperatively to estimate the facial nerve position, and all of the patients took the CT scan after the implant. The CT scan indicates that all three patients were completely inserted the electrode array into the cochlear. During the surgery, all three patients could not be visualized the round window by facial recess. Therefore, two of them were undertook retrofacial approach to expose the round window, see Figure 1, and one patient slightly move the facial nerve to visualize the round window, see Figure 2. The electrode array were placed with assistant of the endoscopy, see Video 1. The facial nerve were monitored during the surgery, and the function of facial nerve was preserved, see Figure 3. The LVAS patient took the pure tone audiometry after three days of implant, which indicated the residual hearing was preserved, see Figure 4.

Discussion

Cochlear implant is an effective treatment for profound sensorineural hearing loss (SNHL). Nowadays, many studies have proved round window approach as the minimal invasive approach and more likely to preserved the residual hearing[3]. The round window approach avoids drilling on the promontorium tympani, decreases the acoustic trauma by excessive bone removal or injury of the basilar membrane[4]. Besides, the inadequate exposure of the round window may lead to misplacement of the electrode array[1], including the eustachian tube, internal carotid artery canal, vestibule, internal auditory canal and semicircular canal[5]. Therefore, the round window visualization is necessary in cochlear implant.

The facial nerve is a crucial landmark for locate of the round window. The variations of the facial nerve are common, but most of the variations barely prevent placement of the electrode array to the round window. Marchioni et al. [6] studied 296 temporal bones HRCT and surgically related findings, and reported an incidence of 4.4% anteriorly positioned facial nerve which may prevent the visualization of the round window. Also, bifurcations of the facial nerve have been reported [7], which may leads to injury of the facial nerve in posterior tympanic approach. As a result, otologists should be estimate the facial nerve preoperatively by CT scan to avoid any possible damages. Also, the intraoperative facial nerve monitoring is necessary when facial nerve variation is predicted preoperatively[8].

The retrofacial approach was first described for cholesteatoma from sinus tympani [9]. Since then, otologists applied retrofacial approach to expose facial recess when facial nerve was variated. Rizk et al.[10] used retrofacial approach to get access to the round window for cochlear implant for two children with aberrant facial nerve. It is now a feasible approach and applied during cochlear implant [11]. In most of the cases, retrofacial approach helped to visualized the round window and insert the electrode array directly. Raine et al. [12] reported five cases of bifurcated facial nerve impeding access to the round window, and decompressed the nerve sufficiently to complete the operation. In our study, we confronted bifurcations of facial nerve lies in the mastoid segment which occupied the retrofacial space. To expose the round window, we entirely

dissected the nerve and operated it as 'suspended', inserting the array by shifting the facial nerve.

With the development of endoscopic ear surgery, it is now used widely in middle ear exploration. The endoscope can get full view of all the clefts in the middle ear, and may estimate the possibility of round window implant. Moreover, in this case, we used the endoscope to assistant of implant as well. In case 2, the microscopy can not provide full view and expose the round window, so we used endoscopy to guide the insertion by shifting the facial nerve of the electrode array. On the other hand, the rigid endoscope can hold the facial nerve posteriorly to provide space for the cochlear implant.

However, in endoscopic surgery, well-trained assistants are required to participate in the surgery to hold the endoscope, so the surgeon can use both hands for cochlear implant. Also, the use of endoscope may prolonged the time of operation, which may increase the risk of anesthesia for children with very young age. As a result, skilled experts are necessary for this kind of cochlear implant.

In summary, endoscopic assistant retrofacial approach provide a clear vision of round window, and the rigid endoscope can hold up the facial nerve 'suspended' to assistant cochlear implant. However, it requires technical expertise to perform the surgery and reduce operation time.

Conflict of interest

The authors declare no conflicts of interest.

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Fig1. Retrofacial approach to expose the round window

Fig1A: Preoperative CT scan showed the mastoid segment of facial nerve may prevent the exposure of the round window. Fig1B: Postoperative CT scan showed the retrofacial approach to expose the round window, the facial nerve canal was reserved. Fig1C: The round window was exposed by retrofacial approach. Red arrow: Facial nerve. Yellow arrow: Retrofacial approach. Black arrow: Round window.

Fig2. Exposure of the round window by the 'suspended facial nerve'

Fig2A: Preoperative CT scan showed the mastoid segment of facial nerve may prevent the exposure of the round window. Fig2B: Postoperative CT scan showed the facial nerve was pulled posteriorly to expose the round window. Fig2C: The facial nerve prevent the exposure of round window. Fig2D: The facial nerve canal was totally removed and the facial nerve was 'suspended', so the round window was visualized by the rigid endoscopy. Red arrow: Facial nerve. Black arrow: Round window. Blue arrow: the variation branch of facial nerve which occupied the retrofacial space.

Fig3. The preservation of function of facial nerve after the surgery

The patient is practicing the air-blowing movement and shuting eyes, the full function of facial nerve was preserved.

Fig4. Pure tone audiometry for LVAS patient

Fig4A: Pure tone audiometry result before cochlear implant surgery. Fig4B: Pure tone audiometry result three days after cochlear implant surgery.

Vid1. The round window was observed by endoscopy, and the electrode array were placed with assistant of the endoscopy