Our Experience of 4 Cases of Extended Endaural Incision for Cochlear Implantation in Ears After Canal Wall Down Mastoidectomy

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Abstract
There is no global consensus on the surgical technique of cochlear implantation (CI) in ears with an open cavity after canal wall down (CWD) mastoidectomy. Herein, we report CI surgery with an endaural incision for the ears after CWD mastoidectomy. The endaural incision was extended upward to obliterate the open cavity of the temporal fascial flap. The endaural incision was extended downwards to close the open cavity inlet. After inserting the implanted electrode, the open cavity was obliterated using a temporal fascial flap, and the cavity was closed at the inlet. We performed this type of CI surgery in four ears in three patients. This extended endaural incision provided an excellent view for pedicling the temporal fascial flap with the superficial temporal artery and for open cavity closure without any serious complications. This technique allowed us to opt for CI surgery of the ears after CWD mastoidectomy.

Introduction
Cochlear implantation (CI) is a remarkably effective treatment for patients with sensorineural hearing loss who meet the respective national criteria for cochlear implantation. In recent years, the number of CI surgeries performed has increased in Japan [1]. In the world, CI is recognized as the world's most successful sensory prosthesis, restoring hearing to over 800,000 individuals worldwide, with the majority experiencing enhanced speech perception. It is considered the gold standard for treating severe to profound bilateral sensorineural hearing loss, particularly in advanced economies [2]. Generally, the electrode of the CI is inserted into the cochlea after canal wall-up mastoidectomy and posterior tympanotomy. However, CI is occasionally conducted in patients who have undergone canal wall down (CWD) mastoidectomy for previous middle ear diseases, such as cholesteatoma. There is no global consensus on the management of open cavities during CI surgery. However, several authors have recommended removing the skin of the open cavity and closing its inlet [3]. The obliteration of the cavity has also been reported. Rambo et al. (1958) used a pedicled temporal fascial flap for cavity obliteration [4]. Herein, we report an extended endaural incision to perform CIs in ears after mastoidectomy. The open cavities were obliterated using pedicled temporal fascial flaps. This incision provides a good view to create a temporal fascial flap, including its pedicle, and to close the open cavity. We believe that with this relatively straightforward surgical technique, we can achieve a resilient defense against infection and prevent electrode extrusion. Furthermore, we anticipate obtaining an ear that does not necessitate outpatient visits for ear cleaning.

Technical Report
Materials and methods
Inclusion criteria were patients with CWD who underwent cochlear implant surgery at our institution between October 2020 and December 2022. Individuals with current or recurrent otitis media, those suspected of recurrent cholesteatoma, and those not desiring cochlear implantation are excluded from the study. CI surgery with this technique was performed in four ears in three patients. A 79-year-old man (case 1), a 68-year-old woman (case 2) and an 82-year-old woman (case 3) had undergone bilateral CWD mastoidectomy for cholesteatoma and had clean open cavities after CWD surgery. The CT scan of cases 1, 2 and 3 are shown in Figure 1. All patients exhibited severe bilateral sensorineural hearing loss. Depending on the patients' preferences, patients 1, 2 and 3 received bilateral, left and right CIs, respectively. I will present a concise profile of the patients in Table 1.
FIGURE 1: CT scan of cases 1, 2 and 3

A-D: Preoperative temporal bone CT of case 1. The right ear (A: axial, B: coronal). The left ear (C: axial, D: coronal).

E, F: Preoperative temporal bone CT in case 2. Left ear (E: axial, F: coronal)

G, H: Preoperative temporal bone CT in case 3. Right ear (G: axial, H: coronal)
### TABLE 1: characteristics of the patients

CWD: canal wall down

<table>
<thead>
<tr>
<th>Case</th>
<th>Age</th>
<th>Sex</th>
<th>Side</th>
<th>Reason for CWD</th>
<th>Open cavity health</th>
<th>reason for choosing bilateral/unilateral surgery</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79</td>
<td>Male</td>
<td>Right</td>
<td>Cholesteatoma</td>
<td>Good. No infection</td>
<td>Desire for simultaneous bilateral surgery</td>
</tr>
<tr>
<td>1</td>
<td>79</td>
<td>Male</td>
<td>Left</td>
<td>Cholesteatoma</td>
<td>Good. No infection</td>
<td>Desire for simultaneous bilateral surgery</td>
</tr>
<tr>
<td>2</td>
<td>68</td>
<td>Female</td>
<td>Left</td>
<td>Chronic otitis media</td>
<td>Good. No infection</td>
<td>Desire for surgery on the worse ear only</td>
</tr>
<tr>
<td>3</td>
<td>82</td>
<td>Female</td>
<td>Right</td>
<td>Chronic otitis media</td>
<td>Good. No infection</td>
<td>Desire for surgery on the worse ear only</td>
</tr>
</tbody>
</table>

**The extended endaural incision for the pedicled temporal fascial flap and the closure of the open cavity inlet**

An endaural incision was made and extended upward as illustrated as line A in Figure 2. The skin flap was elevated from the temporal fascia to provide a surgical view of the pedicled temporal fascial flap. The periosteum of the temporal region was elevated from the temporal bone to create the pocket (bed) for the CI body between the periosteum and bone. The incision was extended downward to the cavum conchae and tragus to close the open cavity inlet (Figure 2, lines B and C). Subsequently, all the skin covering the open cavity, including the tympanic membrane, external auditory canal and cavum conchae, was completely removed. The tympanic orifice of the eustachian tube was closed with small pieces of muscle to prevent the entry of infectious agents from the nasopharynx.

**FIGURE 2: Extended endaural incision (case 1)**

- **a:** Line A: Endaural incision is extended upward. This allows to harvest a sufficient amount of anteroinferior pedicled temporal fascial flap while keeping the superficial temporal artery in view. Line B: The incision is extended to the tip of the tragus. The skin of the external auditory canal (EAC) side of the tragus is removed with the skin of the open cavity. Line C: The incision is also extended on the cavum conchae. The skin of the cavum conchae should be also removed in addition to the skin of the open cavity.

- **b:** Photograph of the incision line. The incision line of the cavum conchae is represented by the dotted line.

As shown in Figure 3, a temporal fascial flap was created. The fascial flap was anteroinferiorly stemmed to ensure that it received an abundant blood flow from the superficial temporal artery (STA).
Electrode insertion and the wound closure

For the cochlear implant, the visor of the round window niche was removed using a small diamond bur. After the round window membrane was incised with a needle, the electrode array was inserted into the cochlea. The temporal fascial flap was then rotated into the open cavity to cover the electrode and obliterate the cavity. For wound closure, the tragal cartilage was rotated over the denuded cavum conchae and sutured to the conchae, thus closing the open cavity inlet.

Results

The patients, surgeries, and outcomes are summarized in Table 1. CI with an extended endaural incision provides a good view for the temporal fascial flap. It provides a particularly excellent surgical view of the STA. This approach also provides good access to the round window. After drilling the bone of the rim of the round window niche, all electrodes (CI632, Cochlear, Sydney, Australia) were smoothly inserted into the cochlea. The total operation time was 278 min for both ears in case 1, 78 min for left ear in case 2 and 136 min for right ear in case 3. The average duration was 123 min per ear (over the past decade, the average surgical duration for 97 cases of unilateral cochlear implant surgery performed by the same surgeon was 105 minutes). Two of the four ears exhibited a mild postoperative hematoma, that spontaneously resolved. Case 1 resolved in about two weeks, and Case 2 resolved in approximately one week. The surgeon provided feedback indicating that electrode insertion in an open cavity was easier compared to posterior tympanotomy or insertion through the external auditory canal. This was attributed to the broader surgical field and less restrictive maneuverability in open cavity procedures.
### Table 2: Case Summary (Age, Sex, Advantage, Operation Time, Complications)

<table>
<thead>
<tr>
<th>Case</th>
<th>Age and Sex</th>
<th>Side</th>
<th>STA view</th>
<th>Fascial flap view</th>
<th>Round window view</th>
<th>Electrode insertion</th>
<th>Operation time (minute)</th>
<th>Post-operative complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>79 Male</td>
<td>Right</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Round window</td>
<td>278 for both sides</td>
<td>Mild hematoma at cephalic side of the auricle</td>
</tr>
<tr>
<td>1</td>
<td>79 Male</td>
<td>Left</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Round window</td>
<td>278 for both sides</td>
<td>None</td>
</tr>
<tr>
<td>2</td>
<td>68 Female</td>
<td>Left</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Round window</td>
<td>78</td>
<td>Mild hematoma at cephalic side of the auricle</td>
</tr>
<tr>
<td>3</td>
<td>82 Female</td>
<td>Right</td>
<td>Good</td>
<td>Good</td>
<td>Good</td>
<td>Round window</td>
<td>136</td>
<td>None</td>
</tr>
</tbody>
</table>

STA: superficial temporal artery

### Discussion

Although CI is generally performed in the healthy temporal bone, there are cases in which cochlear implants must be placed in the open mastoid cavity because of previous middle ear diseases. In such cases, the treatment of the open cavity varies depending on the patient’s condition and the surgeon’s preference.

There are two main ways to treat an open cavity: (1) partially obliterating the open cavity or (2) closing the open cavity [5]. The advantage of partial obliteration is that it is easy to identify inflammatory middle ear diseases through the tympanic membrane after CI because the tympanic membrane remains in the post-CI ear. Conversely, the disadvantage of this method is the possibility of persistent infection through the external auditory canal and electrode array extrusion. In case of external auditory canal (EAC) closure, the advantage is that the frequency of infection and electrode array extrusion is less than that associated with previous methods [6, 7]. Another advantage is that it does not necessitate swimming restrictions. However, it is difficult to identify inflammatory middle ear diseases because the tympanic membrane is removed during surgery. Moreover, thorough removal of the squamous epithelium is required because residual squamous epithelium generates cholesteatomas.

Hunter et al. (2016) reported that the rates of surgical complications following CI in CWD mastoidectomy associated with EAC closure and residual open cavities were 14.6% and 30.0%, respectively [3]. Considering these data, we chose to close the open cavity.

Various materials are available for filling an open mastoid cavity, including the temporal fascia and autologous transplantation of abdominal fat and bone pate. In a study by Polo et al. (2016), which reported 110 cases of cochlear implantation (CI) following subtotal petrosectomy [8], abdominal fat grafting was employed in five cases, resulting in electrode extrusion observed in all five instances. The temporal muscle has also been reported as a material for cavity obliteration [9]. We believe that infection control and prevention of electrode extrusion are top priorities. In this regard, the pedicled temporal fascial flap is a good material because of its abundant blood flow. A potential drawback associated with the use of temporal fascia is the challenge in identifying acquired cholesteatoma through CT imaging. This difficulty arises due to the similarity in CT density between flaps, scars, and cholesteatoma. Moreover, the presence of post-cochlear implantation artifacts further complicates the accurate depiction of cholesteatoma lesions on magnetic resonance imaging (MRI). After CI, artifacts are so strong that it is almost impossible to evaluate middle ear lesions on MRI. Considering this disadvantage, it is necessary to thoroughly remove the squamous epithelium of the cavity. Additionally, it is necessary to pay particular attention to the increase in soft tissue density on CT scans and the progression of bone destruction for at least five years [10]. In this study, it goes without saying that the observation periods were relatively short (12 months, 36 months, and 37 months, respectively), leaving a potential risk for the occurrence of cholesteatoma.

Postoperative hematoma was the noted complication of the CI surgery. We consider that it may be beneficial to place drainage to prevent this complication. The handling of the superficial temporal artery during the execution of this technique is believed to elevate the risk of hematoma formation. It is our contention that meticulous care in managing this artery during flap creation is crucial to mitigate the potential for future hematoma recurrence.

The method of filling the open cavity with pedicled temporal muscle was first reported by Rambo in 1958 [4], who closed the EAC by dissecting and suturing its skin. Blind sac closure (BSC) is a well-known technique used to close the EAC and is usually adapted for retroaural incisions [11]. Using an endaural incision, it is easy to close the EAC using the tragal cartilage. The tragus was sewn into the cavum conchae, and the
rotated tragal cartilage provided a rigid wall. This closure of the external auditory canal with cartilage is considered an effective method that can prevent both electrode extrusion and disruption of the closure of the external auditory canal. The extended endaural incision technique seems reasonable for achieving a good field of view for both temporal fascial harvesting and EAC closure via the tragus.

Conclusions
In this study, we performed CI for the open cavity after canal wall-down mastoidectomy using an extended endaural incision. This surgical method of filling the open cavity with the anteroinferior pedicled temporal fascial flap and closing the cavity using the tragus may be an option for CI in an open mastoid cavity. This method is not entirely new or difficult but is easy and practical for everyone to adopt. In addition, closing the open cavity eliminates the need for outpatient visits for periodic ear cleaning. The surgical duration was extended by an average of approximately 20 minutes compared to standard cochlear implant surgery, and it was safely completed in all cases. Complications were minimal, with only two out of four cases experiencing mild hematomas that did not require specific interventions. Patients not recommended for this technique include those with infected ears or individuals who are averse to any alteration in appearance (due to the closure of the external auditory canal). Limitations of this study include a small sample size and a short observation period. Future efforts should involve accumulating more cases, collecting data on complication rates through long-term observation, and comparing outcomes with other surgical techniques. While the study focused on patients who had already undergone canal wall-down mastoidectomy, future considerations could explore the applicability of this technique in cases with middle ear anomalies or compromised temporal bone development. Validation of the method’s safety and absence of complications will necessitate a larger sample size and an extended follow-up period. However, we remain optimistic that this approach has the potential to encourage individuals with severe sensorineural hearing loss, who routinely seek open cavity cleaning from otolaryngologists or their attending physicians, to more actively contemplate cochlear implant surgery.

Additional Information
Disclosures
Human subjects: Consent was obtained or waived by all participants in this study. Tsukuba Clinical Research & Development Organization issued approval R03-250. Animal subjects: All authors have confirmed that this study did not involve animal subjects or tissue. Conflicts of interest: In compliance with the ICMJE uniform disclosure form, all authors declare the following: Payment/services info: All authors have declared that no financial support was received from any organization for the submitted work. Financial relationships: All authors have declared that they have no financial relationships at present or within the previous three years with any organizations that might have an interest in the submitted work. Other relationships: All authors have declared that there are no other relationships or activities that could appear to have influenced the submitted work.

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References