Combined Transmastoid/Middle Fossa Approach for Intracranial Extension of Middle Ear Cholesteatoma

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Abstract

A retrospective review was performed of patients treated for middle ear cholesteatoma with bone defects of the skull base via a combined transmastoid/middle fossa approach at the University of Tsukuba Hospital from 2006 through 2011 to determine the safety and effectiveness of a combined transmastoid/middle fossa approach for the treatment of cholesteatoma involving the middle cranial fossa. The bone defects of the skull base were reconstructed with a galeal flap pedicled with a parietal branch of the superficial temporal artery and an autologous bone flap. The clinical and radiological data were analyzed. This series included 8 patients (6 men and 2 women) with a mean age of 46.3 years (range 10–67 years). One of the patients preoperatively exhibited meningoencephalocele of the middle fossa skull base, and in the remaining 7 patients, petrous bone involvement such as involvement of the supralabyrinthine cells was observed. The cholesteatoma lesion was totally removed and inner ear function preserved in all the patients. Cerebrospinal fluid leakage was observed in 1 patient during and after the surgery. Neither meningitis nor recurrence was observed in any patient during the follow-up periods (mean 29.4 months, range 6–64 months). The combined transmastoid/middle fossa approach allowed complete removal of cholesteatoma with middle cranial fossa involvement while preserving hearing and preventing postoperative cerebrospinal fluid leakage and meningitis.

Key words: cholesteatoma, skull base, complication, transmastoid/middle fossa approach, middle cranial fossa

Introduction

Cholesteatoma, an epidermal inclusion cyst of the middle ear or mastoid, contains debris generated from its keratinizing, squamous epithelial lining. Cholesteatoma shows a propensity to erode the middle ear bone and sometimes encases vital structures such as the internal carotid artery, jugular bulb, and sigmoid sinus, with further extension into the clivus, sphenoid sinus, or rhinopharynx.1) The therapeutic goal of cholesteatoma is primarily complete removal of the debris and epithelium, which is accomplished through a translabyrinthine, transcochlear, retrolabyrinthine, or middle cranial fossa approach, or through an approach that is a combination of any of these routes.

Cholesteatoma of the petrous bone has been reported to destroy the floor of the middle or posterior cranial fossa and thereby to extend into the intracranial structure. The common pathway for intracranial extension is from the supralabyrinthine region through the supratubal recess and into the middle cranial fossa; an alternative pathway is from the retrofacial air cells into the posterior fossa.2) Given the involvement of the middle cranial fossa, repair of the dura and/or reconstruction of the skull base are considered to prevent postoperative cerebrospinal fluid (CSF) leakage, meningitis, temporal seizures, and brain herniation.3) We present a series of patients with middle cranial fossa extension of cholesteatoma who underwent removal of the cholesteatoma and repair of the cranial base through a combined transmastoid/middle fossa approach for hearing preservation. The bony defects of the skull base were repaired using the vascularized galeal and free bone flaps.
Materials and Methods

Among the 176 patients who underwent cholesteatoma removal at the University of Tsukuba Hospital between January 2006 and April 2011, 8 (4.5%) with middle cranial fossa extension were retrospectively analyzed. The hearing level was evaluated using a pure-tone audiometer (AA-75; Rion, Tokyo) before and 6 months after the surgery. Hearing thresholds were examined at 250, 500, 1000, 2000, 4000, and 8000 Hz, and the mean values at 500, 1000, and 2000 Hz preoperatively and postoperatively were evaluated. As for hearing preservation, the postoperative hearing level was determined to be good if the postoperative air-bone gap was equal to or less than 15 dB without significant deterioration of bone conduction; the hearing gain was equal to or greater than 15 dB as compared with the preoperative level; or the postoperative hearing level was equal to or less than 30 dB (according to Japan Otological Society guidelines). Hearing outcome was considered to be bad if the postoperative hearing level was not within the “good” range and had worsened by more than 10 dB. Otherwise, hearing outcome was judged to be moderate. Conditions of the temporal bone and dura mater were preoperatively evaluated by computed tomography (CT) and magnetic resonance (MR) imaging. Postoperative CT scans were first assessed within 2 days of surgery to check for intracranial complications, and subsequently CT scans or MR images were assessed every 6 months for 3 years after the surgery.

Our combined transmastoid/middle fossa approach is shown in Fig. 1. A spinal drain was inserted after the induction of general anesthesia. A galeal flap vascularized with a parietal branch of the superficial temporal artery was elevated anteriorly, as was an inferiorly based flap of the superficial temporal muscle with its preserved fascia. Temporal craniotomy led to good visualization of the upper side of the skull base of the middle cranial fossa, and extradural dissection along the petrous bone was performed. Then, transcortical mastoidectomy and removal of the cholesteatoma were performed by the canal wall down technique at the entrance of the external auditory meatus. After removal from the mastoid side, residual epithelium adherent to the middle fossa dura was carefully removed from the transcranial side. In some cases, mild CSF leakage was observed from the dura mater that became considerably thinned during this procedure. In cases in which the cholesteatoma infiltrated medially to the semicircular canal, the residual epithelium was removed from the transcranial route, so that the inner ear function was preserved. After complete removal of the lesion, the middle ear and skull base were reconstructed. For the closure of the bony defects of the skull base, the bone on the cranietomy side (cortical bone of the temporal squama) was divided into 2 parts: the outer and inner layers. The inner layer of the cortical bone was used for closure of the bony defects of the skull base. After the bone flap was placed on the base of the middle cranial fossa, it was covered by the galeal flap.

Results

Patient demographics, radiographical findings, and functional outcomes are summarized in Table 1. All 8 patients, 6 men and 2 women, aged from 10 to 67
Table 1 Clinical and imaging details of the patients

<table>
<thead>
<tr>
<th>Case No.</th>
<th>Age (yrs)/Sex</th>
<th>Bone defect</th>
<th>Petrous bone involvement</th>
<th>Dura</th>
<th>Complete resection</th>
<th>Postoperative</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>TT</td>
<td>TM</td>
<td>PW</td>
<td>Enhancement</td>
<td>Thickening</td>
</tr>
<tr>
<td>1</td>
<td>10/female</td>
<td>-</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2</td>
<td>56/female</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>medial</td>
<td>+</td>
</tr>
<tr>
<td>3</td>
<td>67/male</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>anterior</td>
<td>± (weak)</td>
</tr>
<tr>
<td>4</td>
<td>45/male</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>medial</td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>64/male</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>medial</td>
<td>+</td>
</tr>
<tr>
<td>6</td>
<td>10/male</td>
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<td>-</td>
<td>+</td>
<td>medial</td>
<td>-</td>
</tr>
<tr>
<td>7</td>
<td>51/male</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>medial</td>
<td>-</td>
</tr>
<tr>
<td>8</td>
<td>67/male</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>anterior</td>
<td>+</td>
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</tbody>
</table>


Fig. 2 Case 1. A 10-year-old girl was referred to our clinic with a pulsatile mass in the right external auditory canal. She had undergone middle ear surgery 3 times for 4 years at another hospital for middle ear cholesteatoma and recurrent lesions. Physical examination revealed a pulsatile mass in the right external auditory canal, and neuroimaging revealed that the mass was a meningoencephalocele. Herniated brain tissue had risen into the middle cranial fossa through the combined transmastoid/middle fossa approach. Follow-up examination at 5 years after the surgery revealed no evidence of recurrence. A: Fiberscopic view of the right external auditory meatus. A pulsatile mass was noted in the external auditory meatus. B: Coronal T2-weighted magnetic resonance image showing brain herniation (arrows). C: Coronal computed tomography (CT) scan of the left temporal bone before surgery showing a tegmen defect and middle ear mass. D: Coronal 3 years after the surgery showing reconstruction of the bone defect of the skull base with the bone flap. Outer and inner layers of cortical bone were used for reconstruction of the craniotomy site and tegmen defect, respectively.

Fig. 3 Case 2. Computed tomography scans showing superior and posterior mastoid walls extensively destroyed by the cholesteatoma (A, C). Supralabyrinthine cells were involved in the cholesteatoma lesion, and medial extension of cholesteatoma was observed (B, arrow). Years (mean 46.3 years), had large bone defects at the skull base of the middle and/or posterior cranial fossa. Meningoencephalocele following repeated surgery for a recurrent cholesteatoma was found in 1 patient (Case 1, Fig. 2). Petrous bone involvement was observed in the remaining 7 patients. Five patients had medial extension of the cholesteatoma, including involvement of the supralabyrinthine or perilabyrinthine cells, while involvement of the anterior part of the petrous bone was observed in 2 patients (Fig. 3). Three and four patients showed thickening and enhancement by gadolinium on MR imaging of the dura mater, respectively (Fig. 4).

Complete resection was obtained in all patients. The mean postoperative follow-up period of these
Fig. 4 Case 5. T1-weighted magnetic resonance image with gadolinium of cholesteatoma. The epidermal cyst wall of cholesteatoma was often enhanced with gadolinium. The middle ear cholesteatoma had destroyed the skull base bone of the middle cranial fossa. Thickening and enhancement of the dura mater are noted (arrow).

patients was 29.4 months (range 6–64 months). There were no major complications except for CSF leakage in 1 patient (Case 3), which was cured after reinsertion of the spinal drain. The split calvarial bone was well grafted to the middle fossa skull base in all the patients, although partial absorption of the bone graft was noted in 1 patient (Case 2). Hearing was well preserved (average hearing level: 54.1 dB preoperatively versus 48.0 dB postoperatively), and no patient revealed definitive worsening of sensorineural hearing after the surgery. Recurrence was not observed in any patients during the follow-up period.

Discussion

We applied a combined transmastoid/middle fossa approach for the removal of middle ear cholesteatoma associated with large defects of the skull base. There is no single gold standard technique that is both simple and reliable for reducing the morbidity and mortality associated with operations involving the base of the middle cranial fossa. In our present series, middle ear cholesteatoma with middle cranial fossa extension was completely removed via a combined transmastoid/middle fossa approach. Inner ear function was preserved in all patients and the defect of the skull base was successfully reconstructed using autologous cranial bone.

Combined transmastoid/middle fossa approach can be selected for removal of middle ear cholesteatoma causing large defects of the skull base of the middle fossa. Especially, cholesteatoma with petrous bone involvement appeared to be a good indication for this approach. Several authors applied this approach to cholesteatoma with petrous bone involvement and suggested that this approach might provide an optimal route for the complete removal of these complex cholesteatomas in patients with intact sensorineural function. A transcochlear or transvestibular approach may also be applied to cholesteatoma with petrous bone involvement. However, these approaches lead to loss of inner ear function. On the other hand, as shown in our cases, cholesteatoma medial to the semicircular canals can be removed without compromising the inner ear function via a combined transmastoid/middle fossa approach. Infratemporal fossa approach type B has to be used for further extension of cholesteatoma into the clivus, sphenoid sinus, or rhinopharynx.

One of our cases had a meningoencephalocele after prior cholesteatoma resection without bone reconstruction, suggesting the importance of bony repair in cases with large defects of the skull base. Meningoencephalocele or meningocele with or without CSF leakage have also been reported. Therefore, reconstruction should be considered to avoid this postoperative complication when an extensive resection of a cholesteatoma results in a consequent defect of the skull base. Many reconstruction materials were applied for the repair of the middle cranial fossa after extensive removal of the skull base, such as temporal muscle fascia, autologous bone, conchal cartilage, titanium mesh, silicone, and hydroxyapatite cement. The incidence of infection and extrusion of the materials was higher when synthetic materials were used; therefore, we selected autologous divided calvarial bone to avoid postoperative infection because this operative site communicates with the middle ear and remains in substerile condition during and after the operation.

In our surgery, a galeal flap was elevated with preservation of the anteriorly based vascular pedicle (a parietal branch of the superficial temporal artery). A vascularized galeal flap is suitable for covering the bone graft and tegmen defect. Galeal flaps vascularized with the frontal branch of the superficial temporal artery have been used for closure of anterior craniofacial, oral, and pharyngeal defects. Galeal flaps have proven to be reliable when used as vascularized flaps. The middle fossa defect was reconstructed with a vascularized galeal flap in a recent case. The galeal flap was vascularized with the main trunk of the superficial temporal artery, and

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the flap might be useful for closure of defects of the middle fossa skull base. We used a galeal flap vascularized by the parietal branch of the superficial temporal artery, preserving the temporal fascia and muscle because the intraoperative CSF leakage was mild in all the cases. If the CSF leakage was moderate or severe, we would prefer covering with both galeal and temporal muscle fascia. Our method for skin incision provides a temporal fascial and temporal muscle flap with the pedicle placed inferiorly. These flaps can be alternatively used for the closure of middle or posterior fossa defects (from the middle ear cavity) to cover the sigmoid sinus or to obliterate the mastoid cavity.

Recurrence is a major problem in patients with cholesteatoma. The reported rates of recurrence vary from 5% to 63%, and the rates can be reduced by canal-wall-down procedures. A combined transmastoid/middle fossa approach facilitates excellent visualization of and access to the entire floor of the middle cranial fossa from the rostral and caudal routes. Therefore, the cholesteatoma epithelium can be completely removed from the surface of the dura mater and petrous bone under a wide surgical view. Even in cases of dura mater tearing during the removal of the cholesteatoma matrix, this approach also provides a wide working space for its repair. Surgeons should remove the cholesteatoma matrix not only from the dura mater but also from the edge and inside of the skull base bone defects to prevent recurrence. In our cases, recurrence was not observed during the postoperative period because the cholesteatoma matrix was thoroughly removed from the dura mater and bone.

We reported 8 cases of middle ear cholesteatoma with skull base defects of the middle cranial fossa successfully treated through a combined transmastoid/middle fossa approach. This approach afforded wide visualization of the tegmen defects and adequate working spaces, which facilitated certain complete extirpation of the cholesteatoma epithelium while preserving hearing and prevented CSF leakage or meningoencephalocoele. Our experience suggests that this approach could also be well adapted to carefully selected cholesteatoma cases with extension into the base of the skull. Separation of the cranial cavity from the middle ear cavity was achieved using the vascularized galeal and free bone flaps.

References


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