Analysis of Mastoid Findings at Surgery to Treat Middle Ear Cholesteatoma

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Objectives: To analyze mastoid findings, such as facial nerve dehiscence (FND), labyrinthine fistula, and dural exposure; to review its incidence at cholesteatoma surgery; to analyze its association with semicircular canal fistula; and to elucidate its relationship with dural exposure.

Design: One hundred fifty-two patients (65 males and 87 females; 155 ears) were enrolled in a retrospective study of tympanoplasty with or without mastoidectomy.

Setting: Medical university center hospital.

Results: The incidence of FND after exenteration of disease was 29.7% (46/155 ears) for total surgical procedures, 29.7% (43/145 ears) for initial procedures, and 30% (3/10 ears) for revision procedures. The prevalence of FND in the tympanic segment only was 87%, with 8.7% in the vertical segment only and 4.3% in both segments. Three patients (2.0%) developed facial palsy postoperatively, with 8 lateral semicircular canal fistulas (5.2% of total ears operated on), half of these with concomitant FND. The incidence of dural exposure of the mastoid tegmen in the entire surgical group was 16.8% (26 ears), 38.5% with concomitant FND.

Conclusions: The overall incidence of FND in our sample was high at 29.7%, with rates of lateral semicircular canal fistula and dural exposure of 5.2% and 16.8%, respectively. The relationship between FND incidence and presence of lateral semicircular canal fistula was positive in our study. The surgeon should bear in mind that the location of FND with cholesteatoma coincides with the most common area of iatrogenic facial nerve injury during otologic surgery.


C H O L E S T E A T O M A I S A P O C K E T or cystic lesion lined by stratified squamous epithelium containing proliferative keratin within the temporal bone. It most frequently involves the middle ear cleft. The invasive expansion and the keratin accumulation may cause bony destruction, hearing impairment, facial nerve paralysis, and labyrinthine fistula, as well as intracranial complications such as brain abscess and meningitis. However, the mechanism of the bony destruction in cholesteatoma remains controversial. Most theories of the bony destruction or resorption in cholesteatoma with chronic otitis media involve pressure necrosis, osteolysis, or contact between the inflammatory granulation tissue and bone, which cause a series of enzymatic bony destructions.

The facial nerve is vulnerable to infection during chronic otitis media, and facial palsy may occur as a complication of cholesteatoma, although it may also be a complication of tympanomastoid surgery. In addition to the normal variations of the facial nerve, distortions from previous operations, tissue granulation, or cholesteatomas are of substantial concern to the otologic surgeon. The facial nerve follows a course within the temporal bone and may be considered as 3 segments: labyrinthine, tympanic, and mastoid. The tympanic and mastoid segments are mostly vulnerable to injury during otologic surgery. Although facial nerve injury is an iatrogenic complication, incidence has declined markedly, from 15% to 1%, because of improvements in surgical microscopy and with the use of motorized drills. Further, the introduction of effective antibiotic agents has dramatically decreased the complication rate of chronic otitis media. Although the advancements in otologic surgery and medical treatment have been encouraging, anatomical variations of the facial nerve from bony erosion caused by cholesteatoma may be the primary reason why current incidence remains unchanged.

Numerous otologists have reported cases with facial nerve dehiscence (FND), which is common in the human adult. According to the medical literature, the frequency of FND varies from 0.5% to 74%, and it typically occurs in the tympanic segment near the oval window. Destruction of the bony fallopian canal covering the nerve can occur as a result of pathologic or surgical invasions. Therefore, the risk...
Facial nerve dehiscence occurred in 15 male patients (40 ears) in the tympanoplasty with mastoidectomy group and in 6 male patients (26 ears) in the tympanoplasty without mastoidectomy group. The incidence of FND in the male patients with and without mastoidectomy subgroups was 37.5% and 23.1%, respectively. The total FND rate in male patients was 31.8%. Six ears operated on had undergone previous surgery, with FND diagnosed in 2 (33.3%) of these. Further, FND was identified in 19 (31.7%) of the remaining 60 ears in male patients during the initial middle ear surgery.

Facial nerve dehiscence was demonstrated in 13 (33.3%) of 39 ears with mastoidectomy and 12 (24%) of the remaining 50 ears without mastoidectomy. The rate of FND in total ears operated on in female patients was 28.1%; 85 female patients underwent the initial middle ear surgery, with FND identified in 24 ears (28.2%). Revision surgery was performed in only 4 ears in female patients, with FND diagnosed in only 1 ear.

Facial nerve dehiscence was diagnosed in 46 patients: tympanic segment only, 40 patients (87%); vertical segment only, 4 patients (8.7%); and both segments, 2 patients (4.3%). Tympanic FND predominated (91.3%), with 41 (89.2%) of the initial surgical procedures also involving this segment. Facial nerve dehiscence was identified in the vertical segment in 2 of 3 patients: tympanic segment only, 40 patients (87%); vertical segment; 3 of these patients had undergone mastoidectomy. A positive association was noted between FND and the presence of lateral semicircular canal fistula. This is higher than the overall FND incidence (29.7%); however, no significant difference between the incidence of FND and the presence of lateral semicircular canal fistula was demonstrated with the Fisher exact test (Table 3).

Concomitant lateral semicircular canal fistula was identified in only 8 (5.2%) of 155 ears. Of these 8 patients, 2 male and 2 female patients (50%) also had FND, all in the tympanic segment; 3 of these patients had undergone mastoidectomy. A positive association was noted between FND and the presence of lateral semicircular canal fistula. This is higher than the overall FND incidence (29.7%); however, no significant difference between the incidence of FND and the presence of lateral semicircular canal fistula was demonstrated with the Fisher exact test (Table 4).

Dural exposure of the mastoid tegmen was discovered intraoperatively in 26 (16.8%) of 155 ears operated on, with concomitant FND identified in 7 ears in male patients and 3 ears in female patients. However, no significant difference was demonstrated for the relationship between FND incidence and presence of dural exposure of the mastoid tegmen with the χ² test (Table 5). One female patient with dural exposure developed a brain abscess.

Postoperative facial paralysis occurred in 3 patients (2.0%); FND was found during middle ear surgery with

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**Table 1. Incidence of Facial Nerve Dehiscence in Tympanoplasty With and Without Mastoidectomy in 155 Ears**

<table>
<thead>
<tr>
<th>Surgical Procedure</th>
<th>Facial Nerve Dehiscence</th>
<th>Present</th>
<th>Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tympanoplasty with mastoidectomy</td>
<td></td>
<td>28 (35.4)</td>
<td>51 (64.6)</td>
<td>79 (100)</td>
</tr>
<tr>
<td>Tympanoplasty without mastoidectomy</td>
<td></td>
<td>18 (23.7)</td>
<td>58 (76.3)</td>
<td>76 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>46 (29.7)</td>
<td>109 (70.3)</td>
<td>155 (100)</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage). P = .17, χ² test.

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**Table 2. Incidence of Facial Nerve Dehiscence in Initial and Revision Surgical Procedures in 155 Ears**

<table>
<thead>
<tr>
<th>Surgical Procedure</th>
<th>Facial Nerve Dehiscence</th>
<th>Present</th>
<th>Absent</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Initial</td>
<td></td>
<td>43 (29.7)</td>
<td>102 (70.3)</td>
<td>145 (100)</td>
</tr>
<tr>
<td>Revision</td>
<td></td>
<td>3 (30.0)</td>
<td>7 (70.0)</td>
<td>10 (100)</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>46 (29.7)</td>
<td>109 (70.3)</td>
<td>155 (100)</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage). P = .28, Fisher exact test.

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No significant difference was demonstrated between the 2 groups using the χ² test (Table 1). Facial nerve dehiscence was identified in 43 (29.7%) of 145 ears after the initial procedure and 3 (30%) of 10 ears after the revision procedure. No significant difference was demonstrated between the initial and revision surgery groups using the Fisher exact test (Table 2).

Methods

One hundred fifty-two patients (65 males [66 ears] and 87 females [89 ears]) who underwent surgery to treat cholesteatoma, performed by the same senior surgeon (K.-Y.H.) at the Department of Otolaryngology, Kaohsiung Medical University Hospital, Taiwan, were enrolled in this retrospective study. All patients underwent tympanoplasty with or without mastoidectomy according to the involvement of the cholesteatoma. Patients who underwent tympanoplasty and complete mastoidectomy performed simultaneously comprised the tympanoplasty with mastoidectomy group, and those who underwent tympanoplasty and other procedures, such as atticotomy or atticoantrotomy, comprised the tympanoplasty without mastoidectomy group. One male patient and 2 female patients had undergone bilateral middle ear surgery. The age range was 5 through 80 years, with mean ages of 41.4 years for male patients and 42.9 years for female patients. Of 135 ears operated on, tympanoplasty with mastoidectomy was performed in 79 (40 male patients and 39 female patients) and tympanoplasty without mastoidectomy was performed in 76 (26 male patients and 50 female patients). The initial surgery was performed in 145 ears (60 male and 85 female patients), and revision surgery was performed in 10 ears (6 male and 4 female patients). The involved segment of the facial nerve was systematically and consistently evaluated using intraoperative microscopy to identify any possible dehiscence. Facial nerve dehiscence was found in 28 ears in the tympanoplasty with mastoidectomy group (n = 79; 33.4%) and 18 ears in the tympanoplasty without mastoidectomy group (n = 76; 23.7%). The intraoperative results for each surgical procedure were used to simultaneously establish the presence of FND, determine its location, and identify semicircular canal fistula and dural exposure.

Data were analyzed using the χ² and Fisher exact tests.
Table 3. Location of Facial Nerve Dehiscence in 46 Ears*

<table>
<thead>
<tr>
<th>Segment</th>
<th>Mastoidectomy</th>
<th>Surgical Procedure</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Present</td>
<td>Absent</td>
</tr>
<tr>
<td>Tympagic</td>
<td>22 (47.9)</td>
<td>16 (39.1)</td>
</tr>
<tr>
<td>Vertical</td>
<td>4 (8.7)</td>
<td>0</td>
</tr>
<tr>
<td>Tympagic and vertical</td>
<td>2 (4.3)</td>
<td>0</td>
</tr>
</tbody>
</table>

*Data are given as number (percentage). Facial nerve paralysis after ear surgery was found in 1 male and 2 female patients.

Table 4. Correlation Between Incidence of Facial Nerve Dehiscence and Presence of Lateral Semicircular Canal Fistula in 155 Ears*

<table>
<thead>
<tr>
<th>Lateral Semicircular Canal Fistula</th>
<th>Facial Nerve Dehiscence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>4†</td>
<td>4</td>
</tr>
<tr>
<td>Absent</td>
<td>42</td>
<td>105</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>109</td>
</tr>
</tbody>
</table>

*P = .13, Fisher exact test.
†All in the tympanic segment; 3 with mastoidectomy; 2 male and 2 female patients.

Table 5. Correlation Between Incidence of Facial Nerve Dehiscence and Dural Exposure of Mastoid Tegmen in 155 Ears*

<table>
<thead>
<tr>
<th>Dural Exposure</th>
<th>Facial Nerve Dehiscence</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Present</td>
<td>10</td>
<td>16</td>
</tr>
<tr>
<td>Absent</td>
<td>36</td>
<td>93</td>
</tr>
<tr>
<td>Total</td>
<td>46</td>
<td>109</td>
</tr>
</tbody>
</table>

*P = .43, \( \chi^2 \) test.

Facial nerve dysfunction has been documented for many years, with studies focusing on understanding the associated clinical conditions and elaboration of surgical procedures for the temporal bone, as well as relevant histopathologic manifestations. Our study was based on estimation of FND using intraoperative microscopy.

Dehiscence of the fallopian facial canal is caused by congenital anatomical variation, inflammatory or infectious involvement, or iatrogenic procedures. The bony fallopian canal is defined as the portion of the facial nerve within the temporal bone, with ossification of the structure commencing in utero and ending about 1 year after birth.\(^4\) Ossification may not be complete in some parts of the fallopian canal, however, with resultant FND. The inflammation course with chronic otitis media or cholesteatoma involves local destruction, which induces dehiscence of the fallopian canal. Previous surgery, granulation tissue, and cholesteatoma distort normal anatomy and increase the risk of iatrogenic injury.

According to histologic and anatomical studies of the temporal bones, the prevalence of dehiscence ranges from 25% to 57%.\(^6\) In their anatomical study of 535 temporal bones, Baxter\(^9\) reported a dehiscence rate of 55%. Fallopian canal dehiscence was located in the tympanic and mastoid segments in 91% and 9% of their sample, respectively. Further, involvement of the inferior surface of the tympanic segment adjacent to the oval window predominated (85%). In the histopathologic study, Moreano et al\(^8\) demonstrated FND involvement in 56% of 1000 temporal bones, with dehiscence predominating (74%) in the tympanic segment, toward the oval window region.

The incidence of FND has been estimated in several studies based on intraoperative microscopic observation. In their retrospective study of 1465 stapes operations, Li and Cao\(^7\) reported an FND incidence of 11.4%, far less than in other histopathologic investigations. From retrospective analyses of 1024 mastoidectomies performed to treat cholesteatoma, Sheehy et al\(^10\) found that the facial nerve was exposed by disease in 17% of cases and by surgery in 44%. Harvey and Fox\(^11\) found significant FND in 3 (6%) of 47 mastoidectomies performed from the canal wall downward, an incidence far lower than that in our study. Selesnick and Lynn-Macrae\(^1\) found FND in 22 (33%) of 67 cholesteatoma surgery cases with involvement of the lateral surface of the facial canal. The overall incidence of FND was 29.7% (46 ears) in our sample.

Perez et al\(^12\) reported that tympanic FND may have important clinical implications in terms of middle ear inflammation. In patients undergoing surgery because of chronic inflammatory middle ear disease, FND typically occurs in the tympanic segment. In our study, dehiscence in this segment predominated (91.6% [142 ears]) and the frequency of mastoidectomy was higher than that of tympanoplasty. Study data are in line with the growth patterns noted for cholesteatoma and closely approximate the tympanic segment of the facial nerve, which has more extensive invasion that requires mastoidectomy.\(^1\) Inasmuch as the bony covering of the facial nerve is also thinner in the tympanic segment than elsewhere,\(^9\) this segment of the facial nerve is more vulnerable to the mechanical trauma of dissection.

Facial nerve dysfunction is devastating to the patient and is a problem for the surgeon. In addition to direct invasion of the facial nerve caused by inflammatory diseases or fallopian canal erosion, previous operations and

mastoidectomy in 1 male patient and in 2 female patients. The overall rate of FND was 29.7% (n = 155 ears).
more destructive cholesteatomas increase the risk of intraoperative iatrogenic facial nerve injury. The frequency of facial paralysis is reportedly between 0.6% and 3.6% for all otologic surgical procedures, and increases to 4% to 10% in revision surgical procedures.\textsuperscript{13} Nilssen and Wormald\textsuperscript{6} found that the overall incidence of facial palsy was 1.7% in 1024 consecutive mastoidectomies during a 10-year period. In our study of 155 ears, the incidence of facial paralysis was 2.0%. The findings of our study and previous reports were compatible. Three patients (1 of 66 ears in male surgical patients and 2 of 89 ears in female surgical patients) had postoperative facial nerve paralysis. It has been demonstrated that cholesteatoma and male sex predispose to iatrogenic facial nerve injury.\textsuperscript{3} In our sample, however, the incidence of FND was similar between sexes (31.8% and 28.1%, respectively, for male and female patients), as was the incidence of facial nerve paralysis (1.5% and 2.2%, respectively). Therefore, in our study, male sex did not predispose to facial nerve paralysis. Our comparison of the groups undergoing initial and revision surgery was valid because there was no statistical variation in the frequency of FND. We conclude, therefore, that previous surgery was an unlikely cause of FND in the subgroup of patients who had undergone previous surgery.

Labyrinthine fistula is a common complication of cholesteatoma that coexists with FND.\textsuperscript{4,14} The most common site for this complication is the lateral semicircular canal because of its proximity to the facial nerve.\textsuperscript{7} The occurrence of labyrinthine fistula depends on the destruction of the otic capsule with perilymph leakage. Despite our failure to demonstrate statistical significance, the positive association noted between FND incidence and the presence of lateral semicircular fistula in this study confirm previous findings.

Intracranial complications of cholesteatoma are associated with high morbidity and can even be life threatening. Dural exposure of the mastoid tegmen was noted in 26 of 155 ears in our study, mostly attributable to cholesteatoma. Although the relationship between dural exposure and FND was not statistically significant in our sample population, the risk seems to be greater when cholesteatoma occurs with mastoid tegmen erosion and fallopian canal destruction.

High-resolution computed tomography can be used to detail the middle ear structures of the facial nerve and semicircular canals and the tegmen tympani.\textsuperscript{14} However, the bony covering over the tympanic segment of the facial nerve is so thin that it may not be seen on computed tomographic images. In contrast to evaluation of the semicircular canals and tegmen tympani, the radiosurgical agreement in cholesteatoma is excellent.\textsuperscript{15} Therefore, findings on computed tomographic images can alert the surgeon to potential intraoperative dangers and complications associated with middle ear surgery.

CONCLUSIONS

In this study, the intraoperative incidence of FND was 29.7% (46 ears), with the predominance of tympanic location (coinciding with the most common area of facial nerve injury. There was a positive association between FND and lateral semicircular fistula. Further, the delicate middle ear structures are vulnerable during expansive mastoidectomies performed to treat cholesteatoma. Thus, to decrease related complications and morbidity, the surgeon should be mindful of the risk of trauma or damage to the facial nerve canal, semicircular canal, and mastoid tegmen.

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Analysis and interpretation of data: H.-M. Wang, Lin, Lee, Tai, Chai, and Ho.

Drafting of the manuscript: H.-M. Wang, Lin, L.-F. Wang, Chang, Hsu, and Ho.

Critical revision of the manuscript for important intellectual content: Lee, Tai, Chai, and Ho.

Statistical analysis: Lin, L.-F. Wang, Chang, and Hsu.

Administrative, technical, and material support: H.-M. Wang, L.-F. Wang, and Ho.

Study supervision: Lee, Tai, Chai, and Ho.

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REFERENCES


