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ORIGINAL ARTICLE

Facial Nerve Dehiscence at Mastoidectomy for Cholesteatoma

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Objective: The incidence and localization of facial nerve dehiscence (FND) in patients undergoing mastoidectomy for middle ear cholesteatoma were determined. Various clinical factors predictive of FND preoperatively were also researched.

Materials and Methods: A retrospective review of 112 patients (115 ears) undergoing mastoidectomy by canal wall-up or canal wall-down methods during a five-year period was conducted, recording occurrence rates and sites of FND at the time of surgery. Correlations between FND and clinical features (age, sex and surgical technique) or intraoperative findings (dural exposure, labyrinthine fistula, and the absence of the stapedial suprastructure) were ascertained, based on Fisher's Exact or Chi-Square statistical analyses.

Results: FND occurred in 33 (28.7%) of 115 ears. Involvement of tympanic segment only (81.8%) predominated over mastoid segment alone (9.1%) or tympanic and mastoid segments together (9.1%). Intraoperative absence of stapedial suprastructure was significantly with FND (p=0.012), while dural exposure or labyrinthine fistula at surgery and FND showed no clear associations (p>0.05).

Conclusion: The incidence of FND was 28.7%, with preferential involvement of tympanic segment. Since the absence of stapedial suprastructure correlated with FND, lost integrity of the stapes may preoperatively predict FND. Therefore, otologic surgeons should be particularly cautious during mastoidectomy, given these conditions.

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Introduction

While mastoidectomy with middle ear disease is a common practice for the otologic surgeon, facial paralysis, as a postoperative complication, can be a devastating consequence of such surgery. The obvious facial deformity that ensues may have considerable psychologic impact, culminating in social isolation and diminished self-esteem for the affected patient. In addition, this particular complication is the second-most source of litigation within the otolaryngologic subspecialty.[1]

Historically, mastoid surgery performed without benefit of a microscope has been associated with rates of facial nerve injury was as high as 15% [1] but today, with the aid the modern technology (high-magnification microscopy, motorized drills, etc), that figure has been dramatically reduced. The risk is now between 0.6% and 3.6% for an initial procedure, although it escalates to 4%-10% for surgical revisions.[2]

Facial nerve dehiscence (FND) is a common anatomic variant that usually occurs in the tympanic segment above the oval window but is also encountered at the level of the geniculate ganglion and in the mastoid segment adjacent to the retrofacial cells. Published reports place the incidence of FND anywhere from 0.5% [3] to 74% [4], based on histologic studies of temporal bone and cumulative intraoperative findings. It has been noted that a gestational aberration during Weeks 21-26, generally involving failure of two ossification centers in the tympanic segment to fuse, is responsible for FND. One of these sites is anterior to

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the apical otic ossification center, while the other abuts the canalicular ossification center, near stapedius muscle.[5] Alternatively, FND may be attributable to longstanding middle ear inflammation with bony erosion of the facial canal such as cholesteatoma,[6] prior ear surgery or trauma, and the pressure effect of tumorous lesions.

Injury to the facial nerve may reflect disease-related insult, as well as a surgical sequela; and, in fact, both situations may contribute. FND may also be a predisposing factor. Patients with cholesteatoma often exhibit a higher incidence of FND than those with other middle ear pathologies.[6,7] When cholesteatoma and FND coexist, the risk of facial nerve injury during tympanomastoid surgery is heightened, because the natural bony overlay otherwise shielding the nerve from microdissection trauma is absent.[8] The risk posed by FND is increased when the nerve occasionally protrudes from the dehiscence, mimicking a middle ear mass (Figure 1), that is challenging to identify as nerve tissue. As for the mechanism of bony erosion induced by cholesteatomas, that point remains unclear. A combination of pressure effect and enzymatic destruction has the greatest evidentiary support to date.[9]

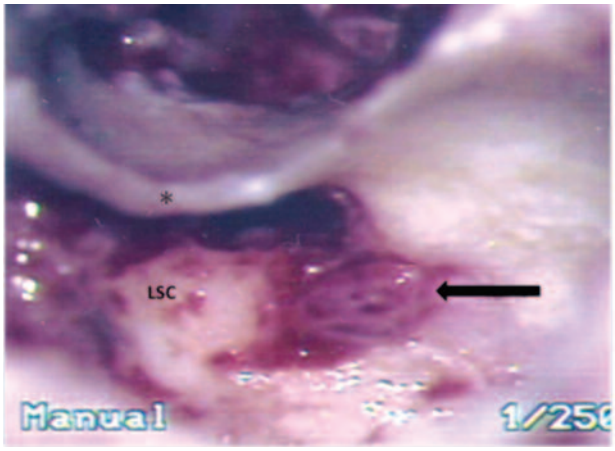

Figure 1- Dehiscence of the mastoid segment of the facial nerve with protruding (arrow) mimics a granuloma during a cholesteatoma surgery. LSC: lateral semicircular canal, * posterior canal wall.

Although high-resolution computed tomography (CT) can delineate large defects or bony dehiscence of the facial canal, the layer of bone along tympanic segments of the facial nerve is so delicate that visualization by CT may be impossible. Moreover, the facial nerve characteristically runs a tortuous course through temporal bone, so minor defects of the facial nerve largely go undetected on imaging. Preoperative CT scans of the temporal bone therefore fail to provide sufficient surgical guidance at the point where the facial nerve is most vulnerable in cases of cholesteatoma.

Thorough knowledge of facial anatomy and innervation is essential for middle ear surgery to be safely conducted. The ability to preoperatively anticipate FND could conceivably lower the risk of facial nerve injury and the morbidity it entails. In this regard, we endeavored to assess the incidence and site predilection of FND in a large cohort of patients having mastoidectomy for middle ear cholesteatoma. We also explored the relationship between FND and pertinent clinical parameters.

Materials and Methods

During a five-year period (July, 2005 to June, 2010), medical records of patients with middle ear cholesteatoma, opting for either canal wall-up or canal wall-down mastoidectomy, were obtained and analyzed retrospectively. To comply expressly with goals of the study, patients having tympanoplasty, atticotomy, or atticoantrotomy were excluded. Subjects were further restricted to those treated by the first author (K-C.C.) for the sake of data uniformity, and repetitive surgeries on ears operated upon previously were eliminated. Pertinent patient demographics were also collected, as well as whether procedures were primary or revisional. A total of 112 patients (age ranged from 5 to 77 yrs; median, 37.1 yrs) with a total of 115 surgical ears were examined, of which 55 were males (56 ears) and 57 were females (59 ears). Surgeries were bilateral for one male and two female patients. There were 10 patients (10 ears) in the pediatric group (age <18 years) and 102 patients (105 ears) in the adult group (age ≥18 years). Of 115 ears reviewed, 96 (83.5%) primary and 19 (16.5%) revisional surgeries were performed. The study was approved by the Medical Ethics and the Human Clinical Trials Committee of Chang Gung Memorial Hospital, Taiwan.

FND was defined as any discontinuity in the bony structure of the fallopian canal producing abnormal communication between the middle ear space or

mastoid air cell system and facial nerve.[9] Facial nerves were systematically and consistently monitored intraoperatively via microscopy to identify affected tympanic or mastoid segments, either singly or in combination. Concomitant intraoperative labyrinthine fistulas or dural exposure, and integrity of the stapes, were simultaneously recorded. However, intraoperative electomyographic facial nerve monitoring was not available in our institute until 2009, so was only used in later cases.

Postoperative facial nerve function was noted as well. Statistical analyses relied on SPSS software (version 17, SPSS Inc, Chicago, Illinois, USA). Using Chi-square or Fisher's exact tests, the relationships between FND and specific clinical variables (age, sex, surgical procedure, intraoperative findings) were explored, as was the association between FND and postoperative facial nerve injury. A p-value <0.05 signalled statistical significance, and for each comparison above, an odds ratio (OR) was calculated.

Results

The incidence of FND was 28.7% (33/115 ears), with tympanic segment alone (81.8% [27/33]) most frequently involved. FND of the mastoid segment alone and the tympanic/mastoid segments combined were found in three ears each (9.1%). The predominance of tympanic FND was consistence within subgroups categorized by gender, age group, surgical procedure, the presence of labyrinthine fistula and exposed dura, and the absence of stapedial suprastructure (Table 1). The frequency of FND did not differ by gender, surgical group or the finding of dural exposure (Table 2). However a trend towards a greater incidence of FND was observed in the pediatric group (five of 10 ears, 50%, p=0.233, OR=2.75, 95% CI: 0.74-10.22) and in patients with labyrinthine fistula (five of 10 ears, 50% p=0.147, OR=2.75, 95% CI: 0.74-10.22) (Table 2).

Table 1. Descriptive data of FND sites（33 ears）

Variable	Segment			
	Tympanic	Mastoid	Tympanic + Mastoid	Total
	N（%）	N（%）	N（%）	N（%）
Gender				
Male	14 (42.4)	0 (0)	0 (0)	14 (42.4)
Female	13 (39.4)	3 (9.1)	3 (9.1)	19 (59.6)
Age				
< 18yr	4 (12.1)	1 (3.0)	0 (0)	5 (15.1)
≥18yr	23 (69.7)	2 (6.1)	3 (9.1)	28 (84.9)
Surgical procedure				
Revision	5 (15.1)	0 (0)	1 (3.0)	6 (18.1)
Primary	22 (66.7)	3 (9.1)	2 (6.1)	27 (81.9)
Labyrinthine Fistula				
Yes	2 (6.1)	1 (3.0)	2 (6.1)	5 (15.1)
No	25 (75.8)	2 (6.1)	1 (3.0)	28 (84.9)
Dural exposure				
Yes	4 (12.1)	0 (0)	1 (3.0)	5 (15.1)
No	23 (69.7)	3 (9.1)	2 (6.1)	28 (84.9)
Absence of stapedial suprastructure				
Yes	13 (39.4)	1 (3.0)	1 (3.0)	15 (45.4)
No	14 (42.4)	2 (6.1)	2 (6.1)	18 (54.6)

Table 2. FND Rates Stratified Clinically (115 ears).

Clinical variables		Total number of ears	Number (%) of ears with FND		p-value	OR (95% C.I.)
			Yes	No		
Sex	Male	56	14 (25.0)	42 (75.0)	0.729 [a]	0.70 (0.31-1.59)
	Female	59	19 (32.2)	40 (67.8)		
Age	<18 y	10	5 (50.0)	5 (50.0)	0.233[b]	2.75 (0.74-10.22)
	≥18 y	105	28 (26.7)	77 (73.3)		
Surgical procedure	Revision	19	6 (31.6)	13 (68.4)	0.761[a]	1.18 (0.41-3.42)
	Primary	96	27 (28.1)	69 (71.9)		
Dural exposure	Yes	19	5 (26.3)	14 (73.7)	0.802 [a]	0.87 (0.29-2.64)
	No	96	28 (29.2)	68 (70.8)		
Labyrinthine fistula	Yes	10	5 (50.0)	5 (50.0)	0.147[b]	2.75 (0.74-10.22)
	No	105	28 (26.7)	77 (73.3)		
Absence of stapedial suprastructure	Yes	33	15 (45.5)	18 (54.5)	0.012[a]*	2.96 (1.25-7.02)
	No	82	18 (22.0)	64 (78.0)		
Postoperative facial paralysis	Yes	3	2 (66.7)	1 (33.3)	0.197[b]	8.1 (0.81-80.92)
	No	112	31 (27.7)	81 (72.3)		

*[a]Chi-square test, [b]Fisher's exact test, OR: odds ratio, C.I.: confidence interval. *Statistically significant, p<0.05.*

The stapedial suprastructure was absent in 15 ears (28.7%). Of these, 15 had concomitant FND (45.5%; Table 1). The loss of stapedial suprastructure was strongly associated with FND (p=0.012) and an increased incidence of FND (OR=2.96; CI: 1.25-7.02; Table 2).

In our cohort, three cases (2.6%, 3/115 ears) developed facial paralysis postoperatively. For two, (one male and one female) the surgery performed was their first. The other male patient had undergone a prior surgery. Two of these three cases (66.7%) had concomitant FND (both in tympanic segment alone), so the likelihood of postoperative facial paralysis was considerably greater with FND (OR=8.1; CI: 0.81-80.92; Table 2) than without it, although the association lacked statistical significance (p=0.197).

Discussion

In this five-year retrospective study, the incidence of FND was 28.7 %; similar rates of FND, from 8.8% to 37.3%, were observed in reported series of cholesteatoma surgery.[6-8, 10-16] According to Wang et al.[16] in 2006, the overall incidence of FND for 155 ears with middle ear cholesteatoma in Kaohsiung (Southern Taiwan) was 29.7%. This agrees with our findings (Northern Taiwan) and underscores a notable stability in the incidence of FND throughout this island.

Our results agree with previous reports that the tympanic segment is most often involved (90.9% in our study; 74 % [11] and 92.8% [17] elsewhere). This may be due to with the tendency of cholesteatomas near tympanic segments of the facial nerve to invade more extensively and require mastoidectomy.[8] The bony covering of the fallopian canal at this point is relatively thin and simply more vulnerable to the mechanical trauma of surgical microdissection.

Our rate of mastoid segment FND, 5.2% (6/115), was comparable to prior reports in the 1.6% [11] to 9% [12] range. Additionally, FND of the mastoid segment was found more frequently at the inferior portion of the facial recess [18] or, in some instances, at the posterior portion of retrofacial cells.[12] Due to surgical field

restrictions, several studies, [8, 14-16] were unable to completely evaluate all middle ear segments of facial nerve, especially the mastoid portion. On the other hand, our mastoidectomy technique enabled full inspection of mastoid segment of the facial nerve and may have afforded a truer depiction of FND incidence.

We excluded surgical approaches such as, atticotomy or tympanoplasty, which differs from the canal wall-up or canal wall-down approach. Hence, distinguishing between congenital and pathologic FND in our series was not difficult. Furthermore, the direct abutment of cholesteatoma matrix or granulation to dehiscent facial nerve in most of our cases strongly suggested that bony erosion by cholesteatoma played a vital role in FND development.

Ossicular chain defects, which are frequent complications of cholesteatomas, include erosion of the incus, stapes, and malleus, in decreasing order of frequency. Because the malleus and incus are more vulnerable to prior surgical manipulation, they were not assessed for their relationship to FND. Therefore we relied on the integrity of the stapes, as a clinical marker for ossicular destruction, and explored its relationship with FND in cholesteatoma. Intraoperative absence of the stapedial suprastructure correlated statistically with FND. Both FND and altered stapedial suprastructure may result from bony erosion by cholesteatoma. Cholesteatomas at posterior epi- or mesotympanic sites are known for their spread along the ossicle chain, eroding the facial canal just above the oval window.[19] An eroded stapedial suprastructure should alert surgeons to the potential for FND and to facial canal involvement with cholesteatoma.

Some researchers have suggested that male gender [7] or adulthood [7, 14] are statistical correlates of FND in cholesteatoma. However, our data has not confirmed these associations. Similar to other data, [7, 15, 16] our study showed no difference between the frequency of FND with primary or revisional surgery. We have subsequently postulated that FND at revisional surgery may be anomalous or cholesteatoma-induced, rather than reflecting prior surgical trauma.

Previous studies have shown that the intraoperative discovery of labyrinthine fistula [7, 14] or dural exposure [7] correlated with FND; the former was partially supported by our study. Our patients with labyrinthine fistula were 2.75 times more likely to have FND, however the rarity of these fistulas precluded reaching statistical significance. Otologic surgeons should still consider the potential relationship of coincident labyrinthine fistula and FND (especially at the lateral semicircular canal), and be mindful of anatomic proximities during cholesteatoma surgery and the risk of traumatic injury to exposed facial nerve.

Iatrogenic facial paralysis, even now, remains a devastating complication of otologic surgery, although the incidence is low. Anatomic variants of the facial nerve, especially FND, may also increase intraoperative risks. In agreement with current reports, the incidence of postoperative facial paralysis was 2.6% in our study. All of our cases were grade II or III by House-Brackmann classification and completely resolved within 3 to 6 months. Despite a failure to statistically link FND with postoperative facial paralysis, the risk of paralysis was about 8-fold higher when FND existed.

In this series, the sole parameter found to be strongly associated with FND was the absence of the stapedial suprastructure. When Chee and Tan [20] evaluated high-resolution CT scans prior to cholesteatoma surgery, radiosurgical agreement was high for bony erosion of the stapes but low for the facial nerve. We believe these findings, taken together, can guide preoperative diagnostic imaging. The absence of the stapes on CT indicates greater potential for FND prior to cholesteatoma surgery, facilitating discussions with patients about the risk of facial nerve injury.

Conclusion

Our cohort of patients with cholesteatoma was predisposed to FND, with the tympanic segment of facial nerve frequently involved. We found that if the stapes was absent, there was a greater potential for FND. Hence, otologic surgeons should carefully dissect neighboring structures of the facial canal during mastoidectomy, particularly if there is preoperative evidence of damage to the stapedial suprastructure. As a further precaution, intraoperative facial nerve monitoring is advocated to reduce iatrogenic injury.

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