ORIGINAL ARTICLE

Facial Canal Dehiscence and Tympano-mastoid Surgery

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Objectives: We evaluated the incidence of facial canal dehiscence in patients with chronic otitis media with or without cholesteatoma, adhesive otitis and tympanosclerosis who underwent canal wall-down tympanomastoidectomy or canal wall-up tympanomastoidectomy.

Materials and Methods: We performed a retrospective study in a tertiary referral hospital of operated 228 patients between April 2008 and June 2013. Using intraoperative findings, data were collected regarding the patients' age upon presentation, gender, clinical diagnosis, presence of cholesteatoma, preopeartive and postoperative facial nerve function, presence or absence of facial canal dehiscence and its location, lateral semicircular canal fistula or dural exposure due to erosion of bony plate.

Results: The frequency of facial canal dehiscence in our patients was 28.1%. The most common site of dehiscence (68/228, 82.8%) was the tympanic segment (P<0.001) and the incidence of facial canal dehiscence in ears with cholesteatoma (92.2%) was distinctly higher than than other ears (P < 0.001). When the pediatric group (≤16 years of age) and the adult group (>16 years of age) were compared, 10.5% of the 38 pediatric age patients had facial canal dehiscence, while 31.6% of the 190 adult patients (P<0.05). The most common accompanying findings were respectively dural exposure (12.7%) and lateral semicircular canal fistula (11%). There was a statistically significant correlation between semisircular canal fistula and dehiscence (P<0.001) and in the ears with dural exposure and dehiscence (P<0.01). The dehiscence was was seen significantly more often in patients who had the canal wall-down tympanomastoidectomy than in those who had the canal wall-up tympanomastoidectomy (P<0.001). The incidence of dehiscence was more often in female patients and in primary surgery group but both results were not statistically significant.

Conclusions: Dehiscence of facial canal was mostly seen in patients with cholesteatoma and mostly located in the tympanic segment. Also, most common site for the facial nerve injury during otologic surgery is the tympanic segment and mechanical dissection is most often indicated in this region. The presence of semicircular canal fistula and dural exposure on preoperative computerized tomography of temporal region are invaluable clue for presence of dehiscence.

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Introduction

Anatomic variations of the temporal bone are of significant concern in the otological and neurotological surgery. Facial canal dehissence (FCD) is the most common variation about this issue that usually occurs in the tympanic segment, especially above the oval window[1,2].

Dehissence can make the facial nerve (FN) more vulnerable [3]. The cause of the FCD is still unclear. Incomplete fusion at the bony cover, lonstanding inflammation, the result of prior surgery or trauma, persistent stapedial artery and the pressure effect of tumorous lesions such as cholesteatoma are presumed factors [4,5]. So, this situation leaves the FN unprotected and increases the risk for unintended injuries during surgery [3]. FN injury during otologic surgery is uncommon but, when it occurs, it is the most frightening complication encountered at the postoperative period and it is destructive for the patient. Also, each control

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examination of such a patient might result in a severe psycological trauma for the otologic surgeon.

Therefore, it is necessary to evaluate the status of the facial canal in relation to otologic surgery and FCD is especially important issue in medical centers where the training of otologic surgery has routinely been made. In this study, we aimed to determine the incidence and the locations of FCD in patients operated for chronic otitis media with/without cholesteatoma. This study also aimed to analyze its association with semicircular canal fistula and with dural exposure due to erosion of bony plate.

Materials and Methods

A total of 228 patients with chronic otitis media (COM) with or without cholesteatoma, adhesive otitis (AO), tympanosclerosis (TS), who underwent canal wall-down tympanomastoidectomy (CWDT) or canal wall-up tympanomastoidectomy (CWUT), between April 2008 and June 2013 at the Afyon Kocatepe University, Medical Faculty, Department of Otolaryngology were reviewed retrospectively. Using intraoperative findings, data were collected regarding the patients' age upon presentation, gender, clinical diagnosis, presence of cholesteatoma, preopeartive and postoperative FN function, presence or absence of FCD and its location, lateral semicircular canal (LSC) fistula or dural exposure due to erosion of bony plate (DE). Furthermore, whether the patient had undergone revision or primary operation was also noted. For ears operated on for more than once, to avoid redundancy of the same data, only the data obtained for one of the operations were recorded. This study has not operated ears with malign tumors. FN was evaluated for dehiscence in all segments of the nerve at surgery by visual inspection under operating microscope with high magnification and also by palpation with a blunt pick. The locations of FCD were recorded depending on whether it was located in the geniculate ganglion (dehiscence is before the coq), tympanic segment (dehiscence is between the second genu and the coq), second genu (dehiscence is situated in the second genu region very close to the lateral semisircular canal), mastoid segment (dehiscence is after lower level of the oval window) or tympanic + mastoid segments. Pre- and postoperative facial functions were evaluated according to House-Brackmann classification. Statistical analyses were done using SPSS for Windows software (version 9.0, SPSS Inc, Chicago, Illinois, USA). Chi-square test were used to detect statistically significant differences for frequency and binary logistic regression was used to obtain the odds ratio. P value <0.05 was considered statistically significant.

Results

The distribution of the diagnoses for ears that were operated was as follows: 151 ears, cholesteatoma; 63 ears, COM, 8 ears, AO and 6 ears, TS. The gender distribution of the operated patients was 122 female (53.6%) and 106 male (46.4%). The mean age of the operated patients was 43.8 years (range 7–76 years). FCD was observed in 64 patients (28.1%) and it was the most common among ears with cholesteatoma (92.2%), followed by the patients with COM (7.8%) and was not seen among the patients with AO and TS. The incidence of FCD in ears with cholesteatoma was higher than were those of the ears with COM, AO and TS (P<0.001, chi square test). The 95% confidence interval for this odds ratio is 0,20–0,55. The distribution of FCD detected in different operations performed has been presented in Table 1.

Table 1. Incidence in different ear pathologies and distribution of gender in ears with dehiscence

Ear pathology	Facial canal dehiscence		Gender (ears with facial canal dehiscence)	
	+	-	Male	Female
Cholesteatoma	59	92	28	31
Adhesive otitis	0	8	0	0
Chronic otitis	5	58	1	4
Tympanosclerosis	0	6	0	0
Total	64	164	29	35

Of the 64 patients with FCD, 35 (54.7%) were female and 29 (45.3%) were male. FCD was observed in 35 (28.7%) of the 122 female patients, while in the male group the incidence of dehiscence was 27.4% (29 of the 106 male patients). The difference in the incidence of FCD between both genders was not statistically significant (P>0.05). The 95% confidence interval for this odds ratio is 0,03–2,63.

When the pediatric group (≤16 years of age) and the adult group (>16 years of age) were compared, 4 (10.5%) of the 38 pediatric age patients had FCD, while 60 (31.6%) of the 190 adult patients had FCD. The difference between the two groups was statistically significant (P<0.05). The 95% confidence interval for this odds ratio is 1.33–11.56. The relationship between pediatric–adult age groups and FCD is shown in Table 2.

The most common location for FCD was tympanic segment (n=53, 82.8%). The mastoid segment was dehiscent in four patients (6.3%); both tympanic and mastoid segment in four patient (6.3%); geniculate ganglion in 2 patient (3.1%) and second genu in a patient (1.6%). The difference between tympanic location and other locations of FCD was statistically significant (P<0.001). All of the ears with FCD in geniculate ganglion, second genu or mastoid segment had cholesteatoma. The distribution of the FCD according to locations is shown in Table 3.

The postoperative facial functions were intact in all the patients who had intact preoperative facial functions. Three patients had not preoperative intact facial functions. Two of them (House-Brackman 5/2) had cholesteatoma and FCD and were not also seen improvement in facial functions at postoperatively period. Other patient (House-Brackman 4), improved within a few weeks postoperatively had COM and FCD.

DE was the most common accompanying finding. Defect in the bony plate at the mastoid tegmen, tegmen antri or posterior cranial fossa was detected in twenty nine patients. All of them, except two patients who had COM, had cholesteatoma. Also eight of these patients had FCD, DE and LSC fistula with cholesteatoma. The incidence of DE was 12.7% (n=29) in all of the operated ears. Among the ears with FCD, the incidence of DE was 25% (n=16), while it was 7.9% (n=13) in cases without dehiscence. Seventeen of the 29 patients with DE were male and twelve were female. One of these patients were of pediatric age group. There was a statistically significant correlation in the ears with DE and FCD (P<0.01). The 95% confidence interval for this odds ratio is 0,26–0,58. The correlation between FCD and DE presence has been presented in Table 4.

Table 2. Incidence of facial canal dehiscence in pediatric and adult groups

Age	Facial canal dehiscence		Total
	+	-	
≤16	4	34	38
>16	60	130	190
Total	64	164	228

Table 3. Site of facial canal dehiscence in different ear pathologies

	Cholesteatoma (59 patients)	Adhesive otitis (no patient)	Chronic otitis (5 patients)	Tympanosclerosis (no patient)	Total
Geniculate ganglion	2	0	0	0	2
Tympanic	48	0	5	0	53
Second genu	1	0	0	0	1
Mastoid	4	0	0	0	4
Tympanic+mastoid	4	0	0	0	4

Also a patient had temporomandibular joint erosion with cholesteatoma.

The second most common accompanying finding was LSC fistula following DE. Twenty three (92%) of the 25 patients with LSC fistula also had FCD. All of the patients with LSC fistula had cholesteatoma. Two patients, however, had LSC fistula without FCD and both of these patients were adult and male. The incidence of LSC fistula was 11% (*n*=25) in all of the operated ears. Among the ears with FCD, the incidence of fistula presence was 36% (*n*=23), while it was only 1.2% (*n*=2) in cases without dehiscence. Fifteen of the 25 patients with LSC fistula were male and ten were female. None of these patients were of pediatric age group. The correlation between LSC fistula and FCD was statistically significant (*P*<0.001). The 95% confidence interval for this odds ratio is 0,00–0,10. The correlation between FCD and LSC fistula presence has been presented in Table 4.

Of 64 patients with FCD, 57 (89%) were primary and 7 (11%) were revision operations. When all the ears were evaluated, 14 ears (6%) were revision cases, while 214 ears (94%) were primary cases (Table 5). The difference was not statistically significant (*P*>0.05). The 95% confidence interval for this odds ratio is 0,93–8,20.

All of the procedures included a mastoidectomy, performed either by the CWUT (83 patients, 36%) or by the CWDT (145 patients, 64%). The data on the incidence of FCD with these two procedures has been presented in Table 5. FCD was seen significantly more often in patients who had the CWDT than in those who had the CWUT (*P*<0.001). The 95% confidence interval for this odds ratio is 3,50–20,93.

Discussion

FN is different than all other nerves in the human body due to the length and tortuousity of its intratemporal 30-mm course which the longest bony-cover canal route of any cranial nerves and is more inclined to swelling comparing to other cranial nerves [6,7]. From clinical aspects, FN is the most vulnerable structure in the otologic surgery and the FCD is important anatomical variation for otologic surgeon.

FCD may be secondary due to developmentally incomplete ossification of the bony-cover canal surrounding the FN as well as denudation related to local osteitis (inflammatory granulation tissue theory) and chronic mechanical pressure due to COM and particularly cholesteatoma [2,8].

The mechanism of bone erosion was seen to be associated with pressure necrosis on the early theories. It now seems to occur via enzymatic activity with activated osteoclasts. Multiple enzymes, numerous cytokines and growth factors are thought to act a part on the removal of the organic and inorganic components of the bone, including acid phosphatase, collagenase, acid protease, interleukin (IL)-1, IL-6, colony stimulating factor-1,

Table 4. Incidence with respect to LSC fistula and dural exposure

Facial canal dehiscence	Lateral semicircular canal fistula		Dural exposure	
	+	-	+	-
+	23	41	16	48
-	2	162	13	151
Total	25	203	29	199

Table 5. Incidence with respect to surgery and type of procedure

Facial canal dehiscence	Surgery		Procedure type	
	Primary	Revision	Canal wall-up mastoidectomy	Canal wall-down mastoidectomy
+	57	7	6	58
-	157	7	77	87
Total	214	14	83	145

tumor necrosis factor-alpha, epidermal growth factor and transforming growth factor-beta [9]. This process is more likely in COM with cholesteatoma due to synergistic action. According to the many researchers, prolonged infectious discharge with suppuration cause the dehiscence or thinning of the bony canal over the nerve and also, cholesteatoma, occured in the course of time, extends with previously mentioned mechanism [10-12]. In our study, of the patients with FCD 94% were at the age over 16 years and also 92.2% of them had cholesteatoma.

The incidence of FCD in literature varies from 0.5% to 74% (Table 6) that in our study, this rate was 28%. It is usually noted that the FCD is lower in surgical studies than in histologic studies. This situation may be the consequence of the destruction of the bone covering the FN during preparation of the the temporal bone from cadaver. Also, it can related to detection methods and the presence of the microdehissences which have no clinical relevance and on the inferior or underside of FN in the area of oval window. So, they may not affect the microdissection intraoperatively which is applied on the lateral surface of the tympanic segment of the FN [2,4,5]. Some studies on this issue is only related to the tympanic segment of FN. In our opinion, these studies present limited data to otologic surgeons who mainly operate COM with cholesteatoma.

The incidence of FCD significantly presented lower rate in dry ears without discharge. Daniels et al. presented an incidence of 2.8% dehiscence in their series of 3600 stapes operations [13]. Nomiya et al. reported that the histopathological incidence of FCD in otosclerosis was far lower than the non-otosclerotic control group in oval window region [14]. Moody and Lambert did not report any mastoid canal dehiscence in more than 300 cochlear implant procedures which is assumable as the largest serial [15]. Bayazit et al. and Ozbek et al. presented the lower incidence of FCD in their series of TS cases which had dry ears without discharge [8,16]. Discretely, Nomiya et al. recently presented that the histopathological incidence of FCD in temporal bone with COM was not statistically different compared to normal controls [17]. In our study, we have not detected any canal dehiscence in the ears with AO and TS. However, the incidence of FCD in ears with cholesteatoma was distinctly higher than the ears with COM, AO and TS (P<0.001) and also, patients with COM had higher incidence than the ears with AO and TS.

The location of FCD in patients operated for COM with/without cholesteatoma were mostly in the tympanic segment, especially located adjacent to the oval window[1,2]. In addition, the most commonest site for the FN injury during otologic surgery is the tympanic segment which has been stated by the authors that the main reasons for this occurrence are the dehiscent facial canal, very thin canal wall and close proximity of cholesteatoma found most frequently in this region [2,7,9,18]. So, mechanical dissection is most often indicated in this region. In our study, FCD in the tympanic segment was distinctly clustering -in comparison to other locations (geniculate ganglion, second genu and mastoid segment) which all of the FCD in these locations were detected in the ears with cholesteatoma.

Even though, two factor,cholesteatoma and male sex, were presented as predisposing to iatrogenic facial nerve injury, there was no consensus for gender dominance on the high incidenece of FCD in the literature [9,19]. In our study, female patients with FCD were more than the male patients, however, this result was not statistically significant (p>0.05). Cholesteatoma in the middle ear existed in the majority of patients who are with facial paralysis caused by COM [2]. The patients admitted to our clinic with intact facial functions had intact facial functions at postoperative period, except three patients who had not preoperative intact facial functions. Two of them (House-Brackmann 5/2) had cholesteatoma and FCD and were not also seen improvement in facial functions at postoperative period. Other patient (House-Brackmann 4) improved within a few weeks postoperatively had COM and FCD.

In our routine practice, we use preopeartive computerized tomography (CT) scan to detail the middle ear and mastoid structure of the FN, semicircular canals and bony plate at the mastoid tegmen, tegmen antri and posterior cranial fossa. To some authors, the bony canal of FN is very thin, especially in the tympanic segment and has multiplanar and tortuous route. So the diagnostic value of preoperative CT scan is very limited [3,9,18,20]. Discretely, Yu et al. recently presented that the diagnostic

Table 6. Reported Studies of Facial Canal Dehiscence

Authors	Date	Source	No. Of Ears	Incidence of FCD and sites
Baxter[22]	1971	Histologic study	535	55% (91% tympanic, 9% mastoid segment)
Sheehy et al.[23]	1977	Surgical study (cholesteatoma surgery)	1024	17%
Takahashi and Sando[24]	1992	Histologic Study	160	74% (tympanic segment)
Moreano et al.[25]	1994	Histologic Study	1000	56% (74% tympanic segment)
Li and Cao[5]	1996	Surgical study (stapes surgery)	1465	11.4% (tympanic segment)
Tange and Brujin[26]	1997	Surgical study (stapes surgery)	427	3.3% (tympanic segment)
Harvey and Fox[27]	1999	Surgical study (cholesteatoma surgery)	47	6%
Selesnick and Lynn-Macrae[9]	2001	Surgical study (cholesteatoma surgery)	67	33%
Daniels et al.[13]	2001	Surgical study (stapes surgery)	3600	2.8% (tympanic segment)
Bayazit et al.[16]	2002	Surgical study (surgery of COM)	202	8.9% (tympanic segment, second genu and mastoid segment)
Lin et al.[2]	2004	Surgical study (cholesteatoma surgery)	117	33.3% (87.2% tympanic, 7.7% mastoid and 5.1% timpanic and mastoid segment)
Di Martino et al.[3]	2005	Anatomical study	300	19.7% (tympanic segment)
		Surgical study (surgery of COM)	357	6.4% (labyrinthine, tympanic segment, second genu and mastoid segment)
Wang et al.[20]	2006	Surgical study (cholesteatoma surgery)	155	29.7% (87% tympanic, 8.7% mastoid and 4.3% timpanic and mastoid segment)
Moody and Lambert[15]	2007	Surgical study (cholesteatoma surgery)	416	18.8% (74% tympanic and 5% mastoid segment)
Kim et al.[4]	2008	Surgical study (surgery of COM)	152	8.6% (84.6% tympanic segment and 7.6% mastoid segment and 7.6% geniculate ganglion)
Ozbek et al.[8]	2009	Surgical study (surgery of COM)	265	21.1% (89.2% tympanic, 8.9% mastoid and 1.9% timpanic and mastoid segment)
Chan et al.[19]	2011	Surgical study (cholesteatoma surgery)	115	28.7% (81.8% tympanic, 9.1% mastoid and 9.1% timpanic and mastoid segment)
Magliulo et al.[28]	2011	Surgical study (cholesteatoma surgery)	336	27.1% (92.3% tympanic, 6.5% mastoid and 1.1% labyrinthine segment)
Yetiser[18]	2012	Surgical study (surgery of COM)	144	11% (63.6% tympanic segment, 45.4% second genu, 27.2 % geniculate ganglion and tympanic segment, 9% second genu and mastoid segment)

value of high resolution CT, that can clearly show the FN in majority of cases with COM [21]. Evaluation of LSC and bony plate are easier than bony cover of fallopian canal on preoperative CT. Also, the presence of LSC fistula or erosion of bony plate on preoperative CT scan can be invaluable clue for surgeon in regard to presence of FCD. In our study, of the patients with LSC fistula had FCD (92%), and the ears with DE had also FCD (55.2%). In our study, DE was found to have noteworthily higher incidence than the other series. There was a statistically significant correlation between LSC fistula and FCD (P<0.001) as well as the ears with DE and FCD (P<0.01).

In our country, especially in our pronvince, the number of the ears operated for delayed COM and extensive cholesteatoma is high as appearedin our series. The common consensus of our clinic is that the preservation of the bridge (posterior wall of external ear canal) in patients with cholesteatoma can be a risk for recurrence and residue. So our routine practice for the treatment of ears with cholesteatoma is CWDT which provides advantage for better evaluation of facial canal, especially the mastoid segment. Also, we can evaluate the extend of the disease and the presence of associated destructions such as; LSC fistula and DE.

In conclusion, dehiscence of facial canal was mostly seen in patients with cholesteatoma and mostly located in the tympanic segment. Also, most common site for the facial nerve injury during otologic surgery is the tympanic segment and mechanical dissection is most often indicated in this region. The presence of semicircular canal fistula and dural exposure on preoperative computerized tomography of temporal region are invaluable clue for presence of dehiscence.

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