Incidence of Facial Nerve Canal Dehiscence in Primary and Revision Cholesteatoma Surgery

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Abstract The aim of this retrospective study was to determine the incidence of facial canal dehiscence (FCD) in primary and revision cholesteatoma surgery in a tertiary referral center. Moreover, our second goal was to identify association between FCD and other intra-operative pathological findings in a group of patients with cholesteatoma surgery. Inclusion criteria were primary and revision canal wall up and canal wall down tympanomastoidectomy in patients who suffers from chronic otitis media (COM) with cholesteatoma. An exclusion criterion was charts with inadequate documentation. In addition tympanoplasty cases were excluded due to evaluate both tympanic and mastoid segments of facial nerve canal. Preoperative clinical data and intra-operative findings were documented in a formatted questionnaire. We found the incidence of FCD in COM surgery was 18%. There was no difference between the primary and revision surgeries regarding its incidence. In addition, there was association between some preoperative or intra-operative findings of COM, such as middle fossa dural dehiscence, external auditory canal polyp, facial nerve paralysis, labyrinthine fistula, and FCD. In conclusions we found that there was no difference between primary and revision surgeries regarding the incidence of FCD. Surgeons should consider effective measures to prevent intra-operative facial nerve trauma in COM surgeries.

Keywords Dehiscence · Facial canal · Chronic otitis media · Cholesteatoma

Introduction

Chronic otitis media (COM) surgery is the most prevalent operation in the field of otology, particularly in developing countries. The incidence of intra-cranial and intra-temporal complications of COM in developing countries is about 0.24–0.45%, respectively [1]. One of the ominous intra-temporal complications is facial nerve paralysis which in a study by Lin et al. [2], it was observed in 0.43% of patients suffering from COM. Some researchers believe that from supportive COM is a predisposing factor for Facial nerve canal dehiscence (FCD) [3].

FCD increases the risk of facial nerve trauma in COM surgery. FCD may be an anatomical normal variation due to the congenital process or association with COM, particularly with cholesteatoma [4–6]. On the other hand, one of unpleasant intra-operative complications of COM surgery is facial nerve trauma. Its incidence in primary and revision surgery has been 0.6–3.6 to 4–10%, respectively [7]. It is identified relatively often during cholesteatoma surgery [8–11]. The tympanic segment and second genu of the facial nerve are most commonly involved by cholesteatoma. However, the mastoid portion of the nerve may be at risk, but the involvement of the geniculate ganglion is less common [12–15]. Selesnick and Lynn-Macrae [11] reported that fallopian canal dehiscence was seen in 33% of patients with cholesteatoma. Also, Yetiser et al. [16] reported 83.3% FCD in patients with facial paralysis who suffered from COM, and the most common sites were the second genu and horizontal segment. However, not all

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studies support this view. For example, in a temporal bone study by Nomiya et al. [17], no association was found between COM and FCD. In fact, about 69% of temporal bones with chronic otitis media and 72% of controls had FCD. In a recent histopathological study on temporal bone and in another study by the same authors, the incidence of facial canal dehiscence in the oval window area in otosclerosis was reported lower than normal controls (49.6 vs. 65.7%) [18]. But Li and Cao detected it as 11.4% in stapes surgery [19].

Whether there are any significant intra-operative findings that can assist clinicians in predicting FCD is open to question. On the basis of the framework published in the literature, in a retrospective review of 111 cases of COM surgery, Manolidis found that there is a higher incidence of facial paralysis, facial nerve involvement by cholesteatoma, encephaloceles, and dural dehiscences in patients with labyrinthine fistula [20]. Some authors have noted an increase in the number of other complications and also FCD following COM surgery [10, 21–23]. It has also been reported that 33.5% of patients suffering from COM referred with either one or two complications [24]. On the other hand, the accuracy of the CT scan for detection of FCD was not constant and sometimes it may be impossible to find it in the thin bone of the facial canal precisely [9, 25, 26]. The aim of this retrospective study was to determine the incidence of FCD in primary and revision cholesteatoma surgery. Moreover we explore more thoroughly the association between FCD and other intra-operative pathological findings in primary and revision surgeries in patients who suffer from COM with cholesteatoma.

Materials and Methods

This prospective study was carried out in a tertiary referral hospital in the south of Iran (Dastgheib Hospital of Shiraz University of Medical Sciences) over a two year period from March 2010 to April 2014. Dastgheib Hospital is a tertiary referral centre in the field of otology in south of Iran. Inclusion criteria was primary and revision canal wall up and canal wall down tympanomastoidectomy in patients who suffers from COM with cholesteatoma. An exclusion criterion was charts with inadequate documentation. In addition In order to evaluate both segment (tympanic and mastoid) course of facial nerve canal and associations of some preoperative findings and intra-operative complications with FCD, we excluded tympanoplasty cases.

Preoperative clinical data and intra-operative findings were documented in a specially formatted questionnaire. Preoperative clinical data means sign and symptoms before operation such as: hearing loss, otorrhea, otalgia, vertigo,

and facial nerve paralysis, external auditory canal polyp and postauricular abscess. Intra-operative findings mean abnormal or pathologic detections during surgery such as: labyrinthine fistula, dural plate or sigmoid sinus dehiscence. All patients were visited and operated by the first author. FCD was defined as the lack of bony covering over the facial nerve in tympanic and mastoid segment of the facial nerve. Assessments were performed by visual inspection under operating microscope with high magnification and also by palpation with a blunt pick. We modified the Moody and Lempert's classification of facial nerve segments [8]. The locations of FCD were recorded depending on whether it was located in (1) proximal tympanic segment, i.e. anterior to the cochleariform process including the distal geniculate ganglion, (2) middle tympanic segment, i.e. posterior to the cochleariform process and anterior to the pyramidal process, i.e. the nerve above the oval window, (3) the pyramidal part (distal tympanic segment), and (4) the vertical or mastoid segment. Chi-square and Fisher exact test were used to analyze the data. *p* values less than 0.05 were considered significant.

Results

A total of 499 ears underwent tympanomastoidectomy which belong to 431 patients met the inclusion criteria for this study. The age of patients ranged from 10 to 73 years with a mean of 29.69 (SD 12.46) years. From a total of 359 patients (400 ears) in the primary surgery group, there were 183 females (51.0%) and 176 males (49.0%). The population of the revision surgery group consisted of 72 patients (99 ears) with 37 (51.4%) females and 35 (48.6%) males.

In all 499 ears undergoing COM surgery, the most common chief complains were hearing loss (89%), otorrhea (76.6%), otalgia (7.1%), vertigo (5%) and facial nerve paralysis (2.1%). We detected preoperative otologic signs of external auditory canal polyp (9%), postauricular abscess (1%), and postauricular fistula (0.6). The ratio of canal wall down to canal wall up procedures was equal to 1.9 and 2.89 in the primary and revision groups, respectively.

Table 1 displays the distribution of FCD. The most common site of FCD was superior to the oval window (middle part of tympanic segment; 11.8% and 12.1% in the primary and revision groups, respectively). Also, there was no difference between the primary and revision surgeries regarding the incidence of FCD ($p > 0.05$).

We compared FCD, intra-operative bone dehiscence and some pre-operative findings between the primary and revision COM surgeries (Table 2). The most common intra-operative findings were middle fossa dural dehiscence 43 (8.62%). Also we found external auditory canal polyp in 56

Table 1 Locations of the FCD in tympanomastoid surgery

	Primary (N = 400)	Revision (N = 99)	Total (N = 499)	p value
Overall FCD	69 (17.3)*	21 (21.2)	90 (18)	0.36
Tympanic segment	62 (15.5)	18 (18.2)	80 (16)	0.51
Proximal	5 (1.3)	3 (3.0)	8 (1.6)	0.20
Middle	47 (11.8)	12 (12.1)	59 (11.8)	0.92
Pyramidal bend	5 (1.3)	2 (2.0)	7 (1.4)	0.63
All course of tympanic segment	5 (1.3)	1 (1.0)	6 (1.2)	1
Mastoid segment	5 (1.3)	2 (2.0)	7 (1.4)	0.63
Tympanic and mastoid segment	2 (0.5)	1 (1.0)	3 (0.6)	0.49

* Values are N (%)

(11.22%) ears as the most common pre-operative finding. We show that there was only middle fossa dural dehiscence between revision 26 (26.26%) and primary 17 (4.25%) surgeries. But there was no statistically significant difference in the incidence of other findings between two groups.

As shown in Table 2, the incidence of labyrinthine fistula in all 499 ears was 5.8% (29 ears). In the primary group, true labyrinthine fistula was found at surgery in 24 (6%) ears. The most common location of labyrinthine fistulas was in the lateral semicircular canal 22 (91.7%) and then the posterior semicircular canal 2 (8.3%). We detected that two ears had more than one fistula (8.3%). Of the total 24 ears with fistula, the size of fistula less than 2 mm was detected in 5 ears (20.8%) and more than 2 mm was found in 19 ears (79.2%). In the revision group, all of five labyrinthine fistulas were detected in lateral semicircular canal. Of the total of five ears with fistula, the size of fistula less than 2 mm was found in 4 (80%) and more than 2 mm was found in one (20%). Regarding the incidence, size, location of fistula and history of vertigo, there was no significant statistical difference between the primary and revision surgeries (not shown, $p > 0.05$).

In this study, the associations of some preoperative findings and intra-operative bone dehiscence with FCD were evaluated (Table 3). In 56 ears with external auditory canal polyp, FCD was detected in 36 ears (64.3%). We found a statistically significant association between FCD and middle fossa dural dehiscence, External auditory canal polyp, Facial nerve paralysis, Labyrinthine fistula, Posterior fossa dural dehiscence and Sigmoid sinus dehiscence ($p < 0.05$). But, there was no statistically significant association between FCD and post-auricular fistula and abscess ($p = 0.74$).

Discussion

Our research with a relatively high population under study, revealed that the incidence of FCD in COM surgery was 18%. In addition, its incidence there was no difference

Table 2 Comparison between primary and revision COM surgery regarding FCD, other pre-operative findings and intra-operative bone dehiscence

	Primary (N = 400)	Revision (N = 99)	Total (N = 499)	p value
Pre-operative findings				
<i>External auditory canal polyp</i>				
n	40	16	56	0.08**
FCD	25 (62.5)*	9 (56)	36 (64.3)	0.66***
<i>Facial nerve paralysis</i>				
n	10	3	13	0.72
FCD	6 (60)	3 (100)	9 (69.2)	0.50
<i>Post auricular fistula and abscess</i>				
n	8	1	9	1
FCD	2 (25)	0 (0)	2 (22.2)	1
Bone dehiscence				
<i>Middle fossa dural dehiscence</i>				
n	17	26	43	0.00
FCD	12 (70.6)	18 (69.2)	30 (69.8)	0.92
<i>Posterior fossa dural dehiscence</i>				
n	5	2	7	0.63
FCD	5 (100)	1 (50)	6 (85.7)	0.29
<i>Sigmoid sinus dehiscence</i>				
n	12	3	15	1
FCD	5 (41.7)	3 (100)	8 (53.3)	0.20
<i>Labyrinthine fistula</i>				
n	24	5	29	0.72
FCD	15 (3.8)	3 (3)	18 (62.1)	1

* Values are N (%)

** p value for comparison pre-operative findings and Bone dehiscence between primary and revision groups

*** p value for comparison FCD percentage by pre-operative findings and Bone dehiscence between primary and revision groups

Table 3 Associations of some pre-operative findings and intra-operative bone dehiscence with FCD

	FCD	<i>p</i> value**	OR (95%CI)
Pre-operative findings			
<i>External auditory canal polyp</i>			
+	36 (64.3)*	0.00	12.9 (7.0–24.0)
–	54 (12.2)		
<i>Facial nerve paralysis</i>			
+	9 (69.2)	0.00	11.2 (3.4–37.4)
–	81 (16.7)		
<i>Post auricular fistula and abscess</i>			
+	2 (22.2)	0.74	1.3 (0.3–6.4)
–	88 (18)		
Bone dehiscence			
<i>Middle fossa dural dehiscence</i>			
+	30 (69.8)	0.00	15.2 (7.5–30.8)
–	60 (13.2)		
<i>Posterior fossa dural dehiscence</i>			
+	6 (85.7)	0.00	29.1 (3.5–245.2)
–	84 (17.1)		
<i>Sigmoid sinus dehiscence</i>			
+	8 (53.3)	0.00	5.6 (1.9–15.8)
–	82 (16.9)		
<i>Labyrinthine fistula</i>			
+	18 (62.1)	0.00	9.0 (4.1–19.9)
–	72 (15.3)		

* Values are N (%)

** *p* value for associations of pre-operative findings and bone dehiscence with FCD

between the primary and revision surgeries. Various investigations have explored the subject, in a study of 67 cholesteatoma cases, Selesnick and Lynn-Macrae showed the incidence of 30% in the primary and 35% in the revision surgery (11). In the research by Lin et al. [10] on 117 tympanoplasties (with or without mastoidectomy), they reported its incidence as 33% in the primary, and 37.5% in the revision procedures. Also, in a study by Ozbek et al. [3] on 265 cases of mastoid surgery, the incidence of FCD was 1.26 times higher in the revision surgeries, and the difference was not statistically significant. In this study, the dehiscence rate was a little higher in the revision procedures (21.2%) than the initial operations (17.3%). However, the incidence of FCD was 1.22 times higher in the

revision operations and our result is similar to the other published study which reported incidence of 1.1 times higher in the revision operations [5]. But there was no statistically significant difference between the primary and revision groups ($p = 0.36$).

We found a significant association between FCD and some intra-operative findings such as labyrinthine fistula, external auditory canal polyp, dural plate dehiscence and sigmoid sinus exposure. A possible interpretation of these findings is that it will presumably take some time for development of such destructive complications; therefore, time is essential. As time passes, genesis of cholesteatoma or bacterial infiltrations may leads to osteitis and harmful destructive bone processes.

Some researchers believe that ears suffering from supportive COM are a predisposing factor for FCD [3]. The reported prevalence of intra-operative FCD in COM with cholesteatoma is in a wide range from 8.8 to 64% [3, 4, 10, 11, 27]. Recently in a retrospective study by Sun et al., on 212 patients, who underwent tympanomastoidectomy, they reported the prevalence of FCD in was 27.7% in patients without cholesteatoma and 64.0% in patients with cholesteatoma [27].

In other study by Genc et al., it was found that the rate of FCD was about 32% in COM with Cholesteatoma; also, about 88% of the patients with FCD who had undergone tympanomastoidectomy suffered from chronic otitis with cholesteatoma. In addition, they reported that the rate of FCD was higher in patients with scutum defect than those without defect (55.55 vs. 8.25%) [28]. Harvey and Fox have shown the rate of FCD as 6% [29] and Kim et al. [7] identified 8.6% FCD.

In a study on 202 patients who had undergone mastoidectomy, Bayazit et al. [4] reported the incidence of 8.9 and 18.4% of FCD in patients without and with cholesteatoma, respectively. In another retrospective study by Kim et al. [7] on 152 patients who underwent tympanoplasty with mastoidectomy for COM, they found that the rate of FCD was 8.6%. Also, in a prospective study by Jaswal et al. [5] on 146 cases that underwent radical and modified radical mastoidectomy, the rate was reported as 16.4%. Lin et al. conducted a trospective research on 117 tympanoplasties with or without mastoidectomy. They found the FCD rate as 33.3%. However, in a recent research by Shinnabe et al. [30], it was revealed that the incidence of FCD was higher in ears with pars tensa cholesteatoma (55.6%) than those with pars flaccid cholesteatoma (26.5%), but they reported an association between labyrinthine fistulas and dural exposure with FCD in patients with pars flaccid cholesteatoma.

Sheehy et al. [31] reviewed 1024 mastoid surgeries for cholesteatoma and reported the rate of 15% as congenitally exposed, and 17% due to affliction with cholesteatoma.

After Sheehy et al.'s study, our article is the largest scale one; we determined the incidence of 18%, it is near to Sheehy et al.'s study and similar to Moody and Lambert's paper [8] with 416 ear surgery and an incidence of 18.8%. The difference between the dehiscence rates at first may be due to the form of the extension and type of pathology in COM. Secondly, it can be attributed to the individual differences between research surgeons as assessors. The merit of this study is that all of COM surgeries were performed by one surgeon.

In our study, 80% of the FCD cases were located at the tympanic segment; the next most frequent site was the mastoid (vertical) segment (7%). We found that about 60% of FCDs were located at the oval window area (middle part of the tympanic portion). Our findings are in accordance with other previous reports [3, 5, 7–10, 27, 28, 32–34].

Next in frequency is the area anterior to the tensor tympani tendon (proximal) with a total of 9.5% FCD. The area of the pyramidal bend of the facial nerve (facial nerve genu) and dehiscences of all tympanic segments were in the next rank with 7.4%. Regarding the dehiscence rate in these two segments, our results agree with intra-operative findings in a study by Martino et al., on 357 ear surgeries, but the results are not in accordance with other studies reporting that in the tympanic segment the genu area was the second and the proximal part was the third frequent sites [4, 5]. This difference may be due to extension of cholesteatoma in the anterior attic recess in our patients.

In our study, overall incidence of labyrinthine fistula was about 6%. This incidence rate is just like Moody and Lambert's data in 416 ears with 6.5% fistula rate [8]. In the literature, the overall incidence of labyrinthine fistulas ranges from 3 to 13% [3, 21, 24, 31, 35]. On the whole, our results are within this range. Some researchers have found an increase in the incidence of COM complications in revision surgery [21–23]; nevertheless, we did not find a significant difference in the frequency of labyrinthine fistula in primary and revision COM surgeries. In a review article by Copeland and Buchman, they found that in extensive COM with cholesteatoma, 29% of cases with labyrinthine fistula also had FCD or preoperative facial weakness [36]. Similar to other studies, we found that the incidence of fistula was significantly higher in ears with FCD [3, 4, 8, 24, 37].

We detected 11% cases with external auditory canal polyp. This study revealed a significant association between external auditory canal polyp and facial nerve canal dehiscence. Our result is in the same line with those of Jaswal et al. study; they detected 12% polyp in 146 patients who underwent radical and modified radical mastoidectomy [5]. In a study by Prasannaraj et al. [38] on 42 cases with aural polyp, they found that in 19% of them there are other complications.

Some studies have focused on exploring the association between FCD and erosion of sigmoid sinus plates or dural plate dehiscence. Shinnabe et al. [30] studied 189 ears of patients with cholesteatoma, and found that dural exposure was significantly more frequent in cases with FCD. Jaswal et al. [5] found no significant association with FCD and erosion of sigmoid sinus plates and dural plate dehiscence. Some authors reported 19% sigmoid sinus dehiscence rate without any significant association between this finding and FCD [5]. We found an association between the presence of dural plate dehiscence and FCD. In our study, the incidence rate of middle and posterior fossa dural dehiscence was 8.6 and 1.4%, respectively. In the literature, the incidence of dural dehiscence is about 1.5–19% [3, 5, 39]. Therefore our result was within the above ranges.

In this study, we also showed that the incidence of sigmoid sinus exposure was 3% and there was a statistically significant association between sigmoid sinus exposure and facial nerve canal dehiscence. Because of inadequate number of cases, we could not make a clinical judgment about the association between the presences of posterior fossa dural dehiscence, sigmoid sinus dehiscence and FCD.

However, a limitation of the present analysis is its retrospective study; the retrospective nature of this investigation introduces the possibility of selection bias. Another limitation was inadequate number of some complications such as postauricular fistula and abscess and posterior fossa dural dehiscence. Therefore, we could not interpret the association of FCD with them. On the other hand, an important strength of this study was the relatively large population under the study. Also all operations were performed by one surgeon (the first author). The important clinical implication of our work is that the incidence of FCD in COM surgery was 18% and there was no difference between the primary and revision operations. Furthermore, some preoperative or intra-operative findings of COM, such as middle fossa dural dehiscence, external auditory canal polyp, facial nerve paralysis, and labyrinthine fistula, can assist clinicians in predicting FCD. Therefore, surgeons should consider effective measures to prevent intra-operative facial nerve trauma.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

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