

Semicircular Canal Fistulas and Hearing Loss. Single Surgeon's Experience

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Abstract

Fistulas of the lateral semicircular canal may occur mainly in cholesteatoma cases, both as consequence of the disease and an excessive or inadvertent drilling of the bone. The risk of significant hearing loss had been stressed, especially in the past. More recent experiences have shown that a careful approach allows to save the pre-operative hearing in the majority of the cases, even when the cholesteatoma matrix is removed from the fistula and the canal is plugged. The author presents his experience in 22 cases collected since year 1989.

Keywords: Labyrinthine Fistula; Hearing Loss; Cholesteatoma

Introduction

Fistulas of the semicircular canals may be primitive or follow an erosive process of the endochondral bone of the labyrinth. A type of primitive/malformation fistula involves the superior canal and may show up as Minor's Syndrome [1]. Also, the posterior semicircular canal may be involved, in rare cases associated with a high-riding jugular bulb and fibrous dysplasia [2]. Secondary fistulas generally follow a middle ear infection, most of the cases a cholesteatoma [3].

An iatrogenic origin should also be taken into account, as a consequence of an excessive drilling during a middle ear surgical procedure [4]. Because of its anatomical location, the lateral semicircular canal is normally involved. As reported in the literature, a fistula of the semicircular canal brings a variable, often high risk of hearing loss until anacusis, due to the damage to the membranous labyrinth [5]. The crucial point is the injury to the endosteum of the canal, while its blue lining is considered safe. When dealing with fistulas due to a bony erosion caused by a cholesteatoma, removal of the matrix may lead to open the endosteum. This is why, especially in the past, for fistulas of more than 2 mm, leaving a piece of matrix in place, over the fistula, used to be advised [6]. It had also been demonstrated that, at a second look operation, most of the time this piece of matrix disappears into normal mucosa.

Conversely, in the more recent literature there have been several suggestions for a careful but complete removal of the matrix, with immediate coverage of the fistula with autologous tissue, even until the obliteration of the canal itself [7,8,9].

The Author's attitude has always been a careful removal of the pathology and, in regards to the matrix, the decision of completely removing it or leaving a piece over the fistula was based upon the size of the fistula but also the easiness of detaching the matrix from the endosteum. When the detachment seemed to be too difficult, a piece of matrix and/or inflammatory mucosa was left over the fistula itself. The Author's series was revised mainly in the light of the audiologic outcome and the

results will be hereby reported.

Materials and Methods

From 1989 up to December 2019 the Author performed 111 tympanoplasties (TPLs) for cholesteatoma (65 males and 46 females), 39 TPLs for other diseases (28 males and 11 females) and 8 "radical" operations (4 males and 4 females). In 22 cases (15 males and 7 females), a fistula of the lateral semicircular canal was detected (18 cases) or provoked (4 iatrogenic cases). In Table I all these 22 cases are described. Several items have been taken into account: sex, age at operation, ear pathology, year of surgery, pre-operative imaging availability, state of the facial nerve (covered, exposed, pre-operative presence of palsy), state of the semicircular canal, in accordance with the classification of Dornhoffer and Milewski [10], simplified (simple bone erosion with presence of a "blue line", type I; bony fistula with endosteum exposed and closed, type II or open, type III), type of operation performed, pre-operative hearing (air conduction between 500 and 4000 Hz), post-operative hearing (air conduction between 500 and 4000 Hz) and post-operative bone conduction (0.5,1,2,4 kHz) as compared with the pre-operative one.

Results

The results will be hereby globally analyzed. Furthermore, six cases will be reported and documented, to illustrate the various scenarios. The series consists of 22 patients, 15 males (mean age 52 years) and 7 females (mean age 46 years).

Over the whole number of cases, the incidence of fistula is 14 % (22/158). All the cases but one had a middle ear cholesteatoma. The sole non-cholesteatoma case was an iatrogenic one. Thus, the percentage among the cholesteatoma cases is 21/111 (19 %). In 11/22 patients a pre-operative CT had been performed. In all cases but one (case n. 3 of the year 1991), where a complete fistula was present, with endosteum exposed, the exam was positive for fistula. For the three cases with bony

Table 1: Case series.

Patient	Sex	Age at oper.	Ear pathology	Year of surg.	Imag- ing	Facial nerve	Lateral semic. canal	Type of operation <i>Type of repair</i>	Pre-oper- ative hear- ing (AC 0.5,1,2,4 kHz)	Post- op ver- tigo	Post-oper- ative hear- ing (AC 0.5,1,2,4 kHz)	Post-operative bone conduction (0.5,1,2,4 kHz)
1 V.B.	M	42	cholest right ear	1989	CT + fistula	open	endosteum exposed, open	open TPL <i>fascia + fibrin glue</i>	conduc- tive HL 55,55,50,60 dB	no	---	---
2 R.G.	M	44	cholest left ear	1990	CT + fistula	closed	matrix removed endosteum closed	closed TPL I stage <i>blood clot</i>	conduc- tive HL 20,30,40,60 dB	---	conduc- tive HL 60,60,60,55 dB	as pre-op (8m p-o)
3 N.G.	F	58	cholest left ear	1991	CT - fistula	closed	endosteum exposed, closed	open TPL <i>fascia</i>	mixed HL 65,70,75,90 dB	no	mixed HL 70,85,80,80 dB	as pre-op (2m p-o); 40-60 dB in y 2000
4 B.A.	M	69	cholest right ear	1992	Tomograph ? fis- tula	open	matrix left in situ	open TPL <i>matrix in situ</i>	conduc- tive HL 65,70,45,45 dB	no	---	---
5 M.P.	F	30	cholest left ear	1992	---	closed	matrix removed; endosteum exposed, closed	open TPL <i>bone+ fascia</i>	conduc- tive HL 40,40,25,30 dB	no	conduc- tive HL 30,30,35,35 dB	as pre-op (2m p-o)
6 V.M.P.	F	64	cholest right ear	1994	---	open	endosteum exposed, closed	open TPL <i>fascia</i>	---	---	---	---
7 F.A.	F	31	cholest left ear	1995	---	closed	endosteum exposed, closed	closed TPL I stage <i>silastic+ fascia</i>	conductive HL 40-40-45-40 dB	no	conductive HL 55-60-60-55 dB	as pre-op (3m p-o)
8 M.P.	F	45	cholest right ear	1996	---	closed	bone ero- sion	closed TPL I stage <i>silastic+ fascia</i>	---	---	---	---
9 M.A.	M	69	cholest right ear re- current	1996	---	open	bone ero- sion	rev closed TPL → open TPL <i>fascia</i>	---	---	---	---
10 P.O.	M	78	cholest left ear recur- rent	1999	---	open	endosteum exposed, closed	rev closed TPL → open TPL <i>fascia</i>	---	---	---	---
11 BZ.EA.	M	42	cholest right ear	2002	---	open	endosteum exposed, open	open TPL <i>absorbable gelatin+ bone+ fascia</i>	conduc- tive HL 60,60,50,60 dB	---	conduc- tive HL 50,35,35,35 dB	as pre-op (2m p-o)
12 N.G.	F	48	cholest left ear	2002	---	closed	endosteum exposed, closed (a)	open TPL <i>fascia</i>	conduc- tive HL 60,65,40,40 dB	yes	mixed HL 65,80,85,120 dB	worsened at 35,45,60,-- dB
13 F.A. (b)	M	27	cholest right ear	2002	---	closed	matrix left in situ	closed TPL I stage <i>silastic+ fascia</i>	---	---	---	---
14 Z.T.	M	38	cholest right ear	2004	---	open	bone ero- sion (c)	open TPL <i>bone+ fascia</i>	conduc- tive HL 55,45,35,55 dB	---	conduc- tive HL 65,45,70,75 dB	as pre-op (2m p-o)

15 R.M.	M	69	cholest left ear	2005	CT + fistula	open	endosteum exposed, open	open TPL absorbable gelatin+ bone+ fascia	mixed HL 60,70,65,80 dB	no	---	as pre-op (48h p-o)
16 T.L.	M	76	cholest left ear	2007	CT - fistula	open	bone erosion	open TPL bone+ fascia	mixed HL 80--- dB	---	---	---
17 G.G.	M	62	cholest left ear	2008	CT + fistula	open	matrix left in situ	open TPL matrix in situ	mixed HL 70-95-80-95 dB	---	mixed HL 100-110-80-- dB	as pre-op (3m p-o)
18 L.C.	M	62	cholest right ear	2008	CT + fistula	open	endosteum + matrix cleaning + immediate obliteration	open TPL fascia+ bone	mixed HL 35,40,60,70 dB	no	mixed HL 30,50,50,65 dB	as pre-op (7m p-o)
19 F.D.	F	47	cholest right ear	2012	CT - fistula	open	endosteum exposed, closed (d)	open TPL + obliteration fascia	conductive HL 60,50,40,60 dB	no	conductive HL 65,50,40,50 dB	as pre-op (8y p-o)
20 S.G.	M	47	cholest right ear	2012	CT + fistula	closed	endosteum exposed, closed	open TPL fascia	conductive HL 30,45,30,40 dB	no	conductive HL 25,30,20,25 dB	as pre-op (2m p-o)
21 C.M. (e)	M	40	cholest right ear recurrent	2015	CT - fistula	open	endosteum exposed, closed	rev closed TPL → open TPL fascia	conductive HL 50,50,50,45 dB	no	conductive HL 50,50,50,45 dB	as pre-op (5y p-o)
22 M.S (f)	M	20	adenoma right ear	2020	CT - fistula	closed	endosteum exposed, closed (g)	closed TPL I stage bone + fascia	conductive HL 50,45,55,60 dB	yes	conductive HL 70,60,50,60 dB	as pre-op (4m p-o)

(a): Iatrogenic maneuver

(b): The patient was operated on, twelve month later, for the II stage. The zone of the fistula appeared closed with neo-bone

(c): Iatrogenic maneuver

(d): Iatrogenic maneuver

(e): The patient had been operated on for closed TPL I stage in 2013, for intact TM cholesteatoma. At that time the facial nerve was closed and no lateral scc erosion was present

(f): The patient presented with a right facial paralysis grade V, not related to the ear pathology. He completely recovered three months after the operation

(g): Iatrogenic maneuver

erosion (blue-lined canal) caused by the pathology, imaging was not available. In the iatrogenic cases the CT was negative. In regards to the facial nerve, it was exposed in 13/22 cases and closed in the remaining 9/22. In all the four cases where the endosteum was open, the facial nerve was exposed. None of the cases had a pre-operative palsy, neither post-operative. The case n. 22 presented with a facial palsy grade V which was confirmed not to be due to the pathology (adenoma of the middle ear), but to be incidental. The palsy completely recovered after three months.

Coming to the conditions of the semicircular canal, in 4/22 cases (18 %) there was a complete fistula with the endosteum open. The presence of the matrix of the cholesteatoma onto the canal was mentioned in only one of these four cases (case n. 18), where it was removed, in presence of an open endosteum (see description of the case). In 9/22 cases (41 %) the endosteum was exposed, closed. For these cases the operation report did not mention if the fistula was covered by the matrix of the cholesteatoma. Conversely, the presence of the matrix over the canal was reported in further 5/22 cases besides the case n. 18 (see before), for a percentage of 27 % (6/22). It was removed in 3/6 cases, leaving an intact endosteum in two cases and an open one in the case n. 18, and left in situ in 3/5 cases. Finally, in 3 cases (n. 8, 9 and 16), there was a simple erosion of the bone with a blue-lined canal. The "iatrogenic cases" are 4/22 (18 %): the n. 12 (endosteum exposed, closed, due to excessive drilling); the n. 14 (bone erosion due to the curette-removal of hyperostotic bone over the lateral semicircular canal); the n. 19 (endosteum exposed, closed, due to excessive drilling); the n. 22 (bony fistula with endosteum intact, due to delayed anatomical recognition).

In 14/22 cases (64 %) an open TPL was performed, while a closed TPL was carried out in 5/22 cases (23 %). In the remaining 3/22 cases (14 %) the fistula was detected during a revision of closed TPL which was converted to an open one. Post-operative audiological data were available for 14/22 patients. Among

these 14 patients there were 3 of the four patients with a fistula with open endosteum. None of them had a worsening of the bone conduction. Only in 1/14 patients with post-operative hearing data, there was a deterioration of the bone conduction curve. It was the case n. 12, iatrogenic, with endosteum exposed, closed. Furthermore, the author does not remember a case of total hearing loss in this group of patients.

Clinical Cases

Case n. 15

(Fig. 1)

R.M., male, 69-year-old. Long history of left hearing loss. In September 2005 he suffered for an acute episode of vertigo. The ENT workout confirmed a significant left mixed hearing loss. The CT of the ear showed an opacification of the whole middle ear with erosion of the lateral semicircular canal. He underwent surgery in November 2005 and a huge bony fistula, with endosteum open, was confirmed. The facial nerve was exposed in the tympanic segment and covered by the cholesteatoma matrix. An open TPL was performed and the fistula was cleaned and then repaired with absorbable gelatin+ bone+ fascia. The operation was uneventful, with no vertigo and the 48-hour post-operative bone conduction curve was unchanged. The patient recovered well and was lost to follow-up. Information acquired for this paper says that the patient is still alive and his ear situation is stable with no further problems.

Case n. 17

(Fig. 2)

G.G., male, 62-year-old. History of left hearing loss. Before referring to us, in the beginning of year 2008, he suffered for recurrent episodes of peripheral vertigo. A CT showed a diffuse involvement of the left middle ear with a probable fistula of the lateral semicircular canal. There was a significant mixed left hearing loss. The patient underwent surgery in April 2008. An erosion of the bony semicircular canal was confirmed. It was

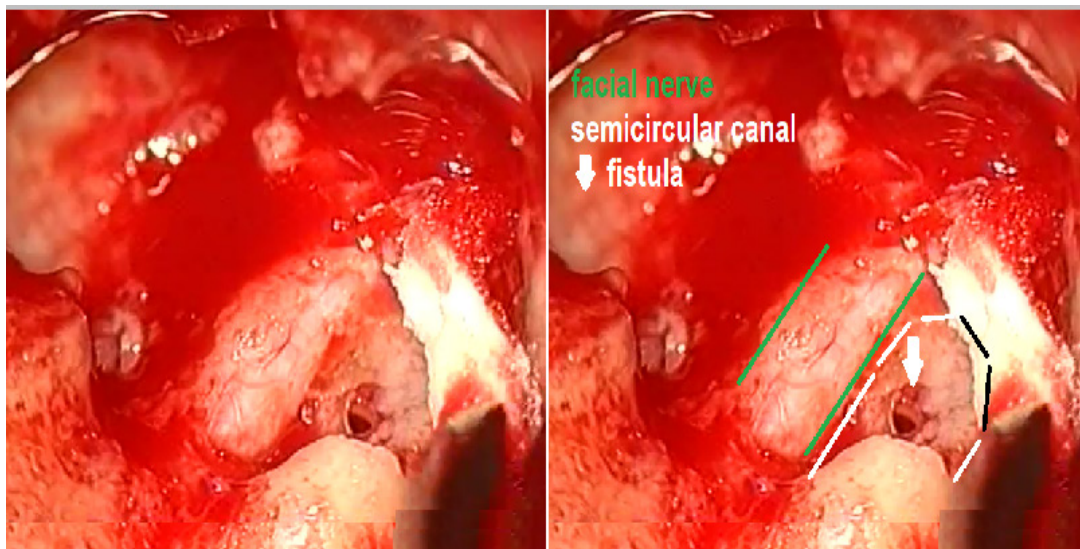


Figure 1: Case n. 15. The left lateral semicircular canal is absent in his superomedial aspect. The endosteum is exposed and open. A piece of absorbable gelatin is ready to seal the hole. The facial nerve is exposed.

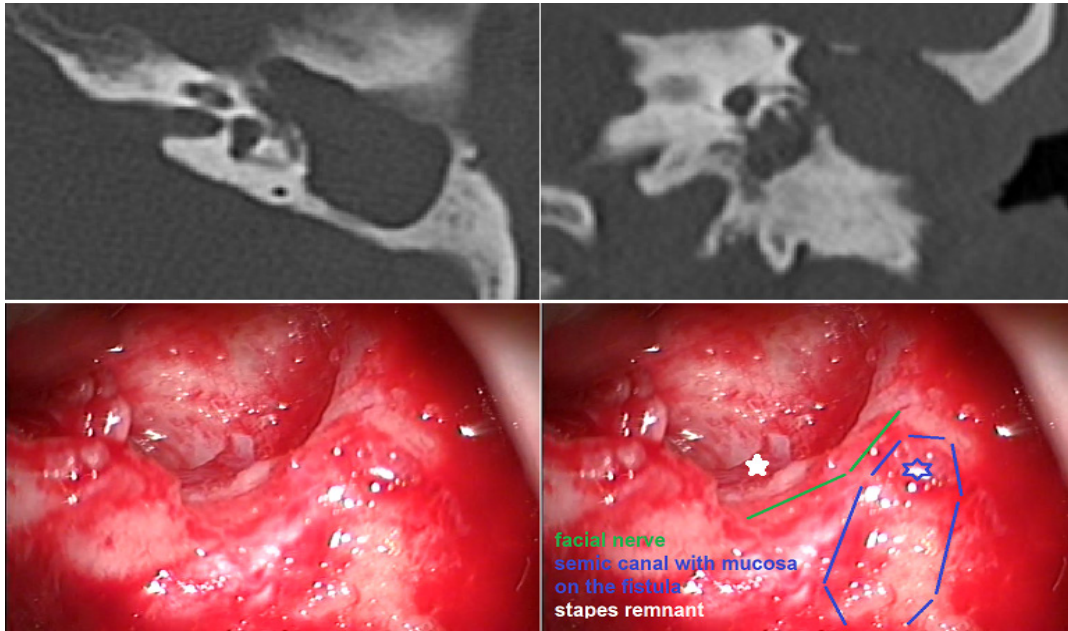


Figure 2: Case n. 17. Upper row: At the axial (left) and coronal (right) CT view, an erosion of the left lateral semicircular canal is evident. Lower row: A piece of mucosa is left over the semicircular canal bone erosion and also partially over the exposed facial nerve.

covered by the matrix of the cholesteatoma, which covered also the facial nerve, exposed along the whole tympanic segment and second genu. An open TPL was performed, leaving a piece of the cholesteatoma matrix/inflammatory mucosa onto the fistula. The post-operative evolution was good. No worsening of the bone conduction occurred. The patient has been recalled in the occasion of this paper. Under otomicroscopic examination a well done and healthy open TPL cavity was evident, with adequately-sized meatoplasty. There was a mixed hearing loss with the air conduction significantly better than after the operation, while the bone conduction had worsened, with a reduction of the air-bone gap. The patient was extremely satisfied, saying that after the operation he had no more problem, especially no more vertigo episodes nor dizziness. He mildly complained of the earing loss but does not require a hearing aid. He is still working.

Case n. 18

(Fig.3)

L.C., male, 62-year-old. Seen in the year 2008 for right chronic otitis media with discharge and evidence of cholesteatoma. The CT confirmed the involvement of the middle ear and showed an evident amputation of the lateral semicircular canal. He had a low-to-medium-grade mixed right hearing loss with a small air-bone gap. The patient was operated on in May 2008. A bony fistula, covered by the cholesteatoma matrix was detected. The matrix was carefully removed and an opening in the endosteum was found. This was immediately sealed with fascia + bone pate. The facial nerve was widely exposed, from the cog to the second genu. An open TPL with an ossicular reconstruction (titanium PORP) was performed. The post-operative outcome was good. The patient had no vertigo and a bone conduction control after 10 days showed no worsening of the curve. The patient recovered well and the hearing level remained as it was pre-operatively. He was strictly followed and ten months later a mastoid recurrence of the cholesteatoma was removed. Over the years the ear has remained stable, with a dry small perforation of the new-TM. As a piece of information, all the patients

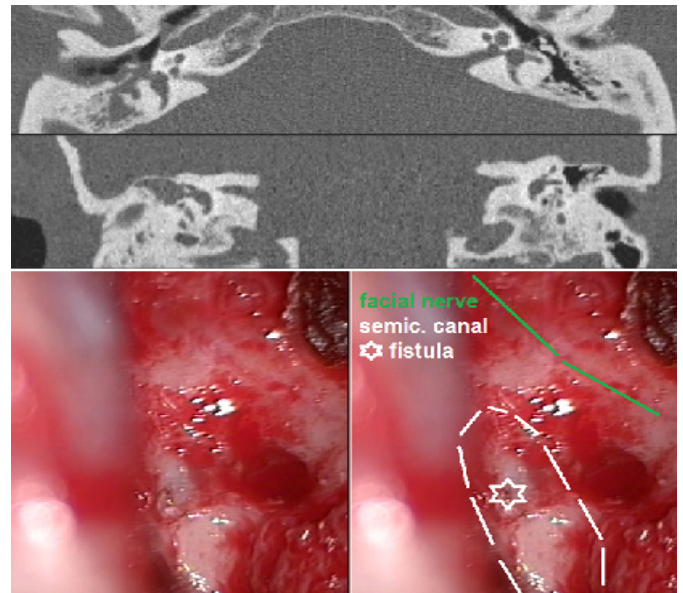


Figure 3: Case n. 18. Upper row: CT axial view. Middle row: CT coronal view. A wide opening of the right semicircular canal is evident. Inferior row: the superomedial half of the bony right lateral semicircular canal is absent. After careful matrix removal the endosteum is exposed and open.

operated by the Author for open TPL are advised to clean the operated ear, at least twice a week, with a warm boric or boric-salicylic solution [11]. In regards to the hearing, the bone curve was unchanged after seven months following the revision surgery, then started to deteriorate. At the most recent control, in April 2020, the ear is persistently stable but the hearing has worsened to a middle-to-high grade mixed hearing loss.

Case n. 19

(Fig.4)

F.D., female, 47-year-old. She suffered for recurrent right ear discharge since her childhood, with hearing loss. In the year 2011 the situation worsened and the patient saw an ENT specialist who detected the presence of cholesteatoma, requested

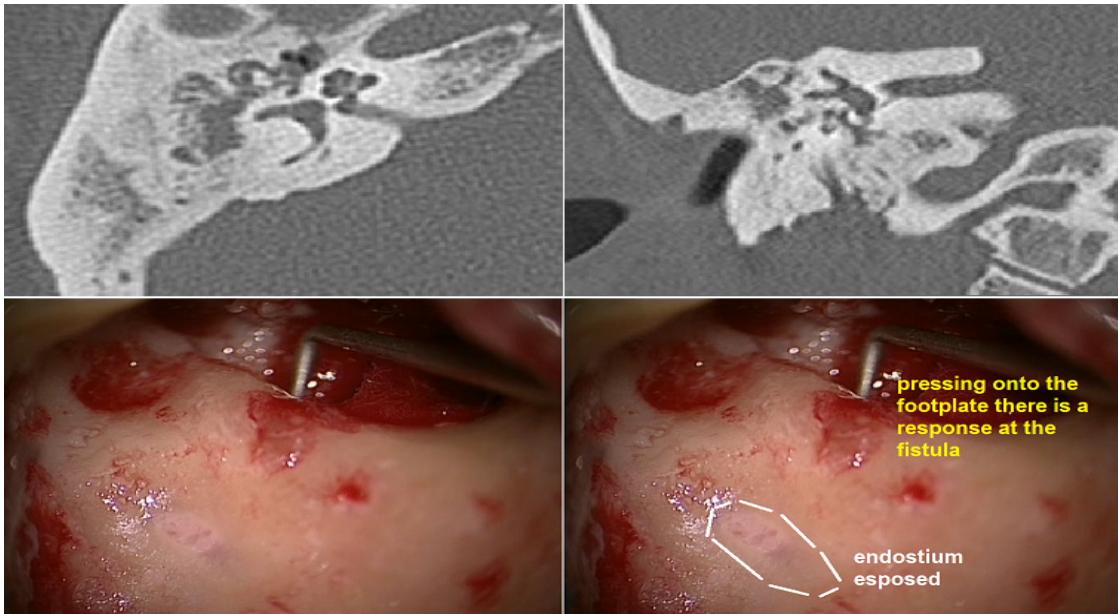


Figure 4: Case n. 19. Upper row. CT, axial view (left) and coronal view (right). The right semicircular canal is covered by bone. Lower row. The excessive drilling has exposed the endosteum of the right lateral semicircular canal. Pressing onto the footplate causes a movement of the endosteum itself.

a middle ear CT and referred her to the author. There was a conductive hearing loss with a substantially normal bone conduction. The patient underwent surgery in February 2012. A posterior-superior bony erosion with granulation tissue and cholesteatoma was detected. The ossicular chain was involved by the cholesteatoma and blocked. The mastoid was contracted and poorly pneumatized. The facial nerve was exposed at the second genu. An open TPL was planned and performed. During the bone-drilling, the endosteum of the lateral semicircular canal was exposed to a grade where the gently pushing on the stapes provoked a bulging of the endosteum itself. The bony erosion was immediately sealed with bone pate and the operation concluded uneventfully. No ossicular reconstruction was performed. The patient had no problem and she has been regularly followed. The hearing remained as it was before the operation. She always refused to undergo a reconstructive/functional operation. The most recent control was performed in February 2020.

Case n. 20

(Fig.5)

S.G., male, 47-year-old. Referred to the author in February 2012 with a history of recurrent right ear discharge for several years. A previous ENT examination showed an erosion of the scutum with granulation tissue and cholesteatoma. A CT confirmed the involvement of the middle ear and a probable fistula of the lateral semicircular canal. There was a mild conductive right hearing loss. The patient underwent operation in March 2012. There was a huge tympanic-mastoid cholesteatoma. After careful removal of the matrix, a bony erosion of the lateral semicircular canal was detected. The endosteum appeared to be covered by a minimum slice of bone and there was no mechanic transmission when gently pushing onto a mobile stapes. The facial nerve was covered/closed. An open TPL was performed with ossicular reconstruction (titanium PORP). The patient did well and post-operative hearing was improved and grossly normal. The patient was lost to follow-up and recalled for evaluation in June 2020. He reported a good and stable condition of his right ear for the first six post-operative years. In

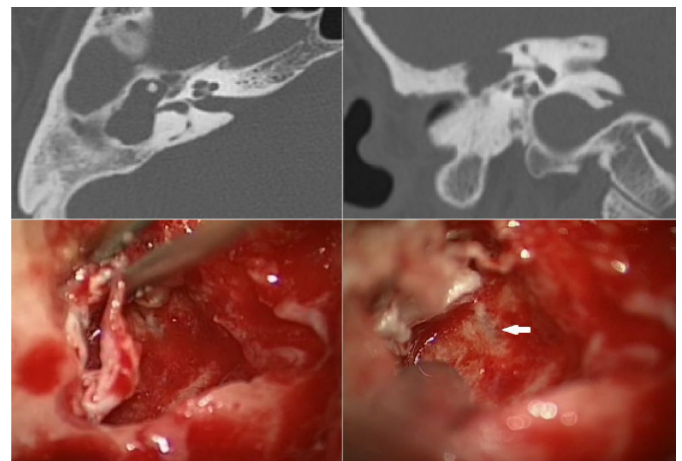


Figure 5: Case n. 20. Upper row: CT axial view (left) and coronal view (right). It seems to be a thin bony remnant over the right lateral semicircular canal. Lower row: after careful cholesteatoma matrix removal (left), a bony erosion is evident with nearly exposure of the endosteum (right, white arrow).

the last two years, instead, he suffered for recurrent inflammations and underwent ENT examinations without significant results. A CT was suggested and performed at the beginning of year 2020. Despite the surgical cavity was filled with crusts and epithelial debris, it seemed to observe a regeneration of the bone over the lateral semicircular canal. The patient was followed by the author and the local situation led to healing. An audiogram performed on August 24, 2020, showed a mild conductive right hearing loss (500 to 4000 Hz: 35,35,50,50), with bone conduction still normal.

Case n. 22

(Fig.6)

M.S., male, 22-year-old. In May 2017 the patient had a documented episode of pure conductive hearing loss (50-45 dB from 500 to 4000 Hz) and tinnitus, with a tympanogram type B, which completely recovered within a month after local and general steroid therapy, and was interpreted as serous otitis media. A further control in July 2017 confirmed a normal hear-

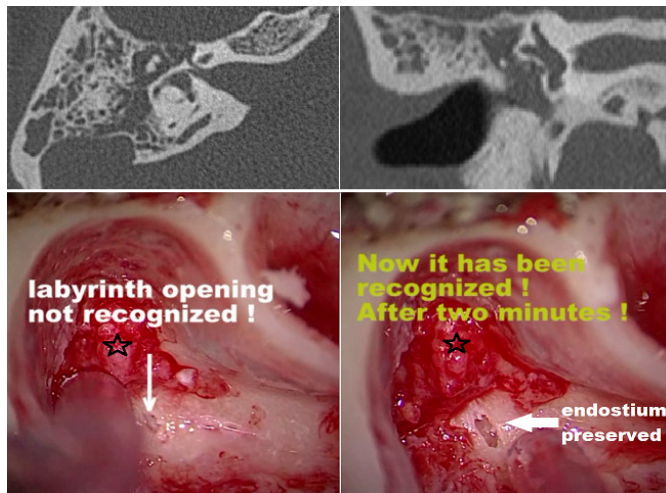


Figure 6: Case n. 22. Upper row: CT axial view (left) and coronal view (right). The right lateral semicircular canal is closed. Lower row: the excessive drilling over the right lateral semicircular canal has been recognized when the endosteum was already exposed. Black star: pathologic tissue (adenoma).

ing and a type A tympanogram. In February 2020 the patient was seen at the author's institution with an acute right facial palsy (grade V, House-Brackman scale). He complained of few symptoms in the ear but a hearing loss. At endoscopic and otomicroscopic examination, a posterior-superior bulging of the tympanic membrane (TM) was observed and an explorative myringotomy was performed which was substantially negative. Both a CT and MRI of the ear were obtained, showing a complete opacification of the middle ear with mastoid inflammation. Besides the suspect of a middle ear inflammation with subsequent irritation of a congenitally dehiscent facial nerve, the hypothesis of a tumor of the facial nerve was also taken into account. An explorative tympano-mastoidectomy was then performed on February 20, 2020. The facial nerve turned out to be closed and the antral-attic mass was histologically diagnosed as "adenoma". In order to remove this thick and adherent tissue, a posterior tympanotomy was planned. During the drilling, and because of the presence of the pathologic tissue, an excessive thinning of the bone over the lateral semicircular canal was realized only when a complete aperture of the bone had occurred. Fortunately, a thick endosteum was still intact and the bony fistula was immediately sealed with bone pate. In order to completely remove the pathology, the posterior bony wall was temporarily removed, then repositioned and stabilized with bone pate + fibrin glue. A first stage closed TPL was thus accomplished. The patient had mild vertigo for three days. A bone conduction control was performed 4 and 6 days post-operatively and it was as before the operation. The patient was then followed and the last control was at June 2020. The healing was completed with a well oriented and trophic tympanic membrane. A 50-60 dB conductive hearing loss was detected, as normal after first stage TPL. The facial palsy completely recovered. The patient still complains of episodic short spins of unbalance. An MRI control has been planned.

Discussion

As easy to understand, erosions of the lateral semicircular canal with exposure of the membranous labyrinth (endosteum) and even rupture of it, happen in the great majority of cases when dealing with a cholesteatoma of the middle ear. An exposed facial nerve is also a common finding and its frequency

easy to understand as well.

Significant hearing loss has to be taken into account when dealing with a fistula of the lateral semicircular canal. It may happen also when the post-operative fistula test is negative. This is what reported by Yeho et al. (2004) [4], in the two cases of iatrogenic fistula they could observe. Besides the incomplete reliability of such maneuver, it may also mean that this negativity was caused by a hypofunction of the damaged labyrinth but, finally, also that the auditive (cochlear) partition is more sensible than the vestibular one. Surgically created (iatrogenic) fistulas have been reported to occur in 0.1% of the cases or less, with a good hearing outcome in the majority of such patients [12].

In the author's series the percentage of iatrogenic fistula is 2.5 % (4/22) and the good hearing outcome is confirmed. It is the author's opinion that the rate of occurrence is probably higher than reported in the literature, where the Authors generally present such cases without mentioning the number of their whole series [13]. The prevalence of the fistulas of the lateral semicircular canal, instead, in the author's series, is 14 % (22 cases over 158 patients), which rises to 19 % when considering the sole cholesteatoma cases (21/111). Naderpour et al. (2008) [14] examined series from the year 1978 to the year 2000 and the percentage varies from 2.9% to 21%.

More recently Meyer et al. (2016) [3] report a prevalence of 6 % in their series, with a huge number (16/42) of type I fistulas, that is a simple bone erosion, according to the classification of Dornhoffer and Milewski [10].

The percentage reported by Rosito et al. (2019) [5] is 2.7 %. These authors considered only the type II (endosteum exposed) and III (endosteum exposed and open). In the Author's series, when considering the sole cases with open endosteum (type III), the percentage is 2.5 % (whole series, 4/158) or to 3.6 % (cholesteatoma cases, 4/111). Adding the type II cases (9/22), the percentage rises to 8.2 % (whole series, 13/158) or 11.7 % (cholesteatoma cases, 13/111). Because the main purpose of this paper was to evaluate the audiological effects caused both by a spontaneous exposure of the membranous labyrinth or by its inadvertent uncovering by excessive bone removal, all the three types of fistula were considered. Indeed, the aim was to test the mechanical and noise effect that an excessive drilling and any manipulation (palpation, suctioning, cleaning), even careful, might cause. In regards to these effects, the results seem to be good. Even though the numbers are small, the sensorineural hearing outcome (bone conduction) was encouraging and a post-operative deterioration was observed in only one case.

Satisfactory hearing results seem also to confirm that a careful manipulation and removal of the cholesteatoma matrix is a significantly safe maneuver, as it is in regards to an exposed facial nerve. None of the author's patients with an exposed facial nerve, in fact, developed a post-operative palsy. The author has no experience of the complete obliteration of the semicircular canal, which too seems to be a safe maneuver in regards to hearing preservation.

Conclusion

When dealing with a middle ear cholesteatoma, the possibility of finding a fistula of the lateral semicircular canal, as well as an exposed facial nerve, has always to be kept in careful account. This was mandatory when imaging was not routinely

obtained and before the CT era. Nonetheless, even though high quality CTs allow an easier detection of the bony erosions, attention must constantly be paid as well. In regards to how to manage the fistula, the ongoing experience has validated the strategy of a careful removal and an immediate seal of an eventual open endosteum, with biologic means. Also, a complete obliteration of the canal has proved to be safe. As reported in the literature and also in the author's experience, such a careful attitude reduces the risk of sensorineural hearing loss to a minimum. Furthermore, in the author's opinion, the choice of leaving a piece of matrix on top of a wide bony erosion, which appears to be soft at a careful palpation, is still an advisable option (mandatory in the case of the only hearing ear), trusting in its mucosal transformation, as seen during second look operations.

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