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OTOLOGY

Ossicular chain erosion in chronic otitis media patients with cholesteatoma or granulation tissue or without those: analysis of 915 cases

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Abstract

Purpose The aim of this study was to evaluate the ossicular chain erosions (OCE) in chronic otitis media patients with cholesteatoma (COM-C) or without cholesteatoma (COM).

Materials and methods The OCE and preoperative hearing levels of a total of 915 patients were evaluated retrospectively. Patients were divided into three groups. Of the 915 patients, 615 (67.2%) had COM, 234 (25.6%) had COM-C, and 66 (7.2%) had chronic otitis media with granulation tissue (COM-G).

Results OCE was found in 291 (31.8%) of 915 patients. OCE was found in 192 (82%) of 234 patients with COM-C, 21 (31.8%) of 66 patients with COM-G, and 78 (12.7%) of 615 patients with COM.

Conclusion The most commonly seen OCE was incus erosion, followed by stapes and malleus erosions. The results of this study show that there are more OCE in the COM-C group than in the COM-G and COM groups. To our knowledge, this study has the widest patient population in the literature focused on the OCE relation with COM, COM-C, and COM-G and its effect on the preoperative hearing level.

Keywords Ossicle · Erosion · Chronic otitis media · Incus · Stapes · Malleus

Introduction

Some of the chronic otitis media (COM) patients have intense granulation tissue in the middle ear due to cholesteatoma or frequent infections, and some have dry perforations without such pathologies. The destructive effect of cholesteatoma, which occurs as a result of progression of the external ear canal skin that should not be in the middle ear, can lead to different complications, such as facial nerve paralysis, meningitis, and brain abscess through bone and ossicular chain erosion OCE, causing conductive type hearing loss. It has been argued that ossicular chain erosion is caused by osteoclast activation, pressure necrosis, acid lysis, inflammatory mediators, and some biomolecules [1]. This erosion mostly affects incus followed by stapes and malleus [2]. Multi-ossicular erosion is more common than single-ossicular erosion. Ossicular chain erosion is seen more frequently in COM patients with cholesteatoma, but can also be observed in patients without cholesteatoma.

In our large patient series, we aimed to classify and compare ossicular chain erosions in COM patients with middle ear cholesteatoma or granulation tissue or without any of them, with dry middle ear and tympanic membrane perforation. Considering the number of patients, it is hoped that the data obtained in our study may contribute significantly to the literature.

Materials and methods

In this retrospective study, starting with the approval of the local ethics committee, we reported the findings of 1121 COM patients who were operated by the senior author

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(MTK) between 2000 and 2016. Data were obtained from the database where all the data related to the patients were recorded in a computer database immediately after the operation. Preoperative audiological data obtained during the last month before the operation were evaluated. Audiometric findings at 0.5, 1, 2, and 4 kHz were taken as air conduction and bone conduction thresholds and air-bone gap while evaluating data. Patients who previously had an operation history for the same ear were excluded from the study, thinking that the ossicles might have been affected by previous operations. The cases were divided into three groups: Chronic otitis media with cholesteatoma (COM-C), chronic otitis media with granulation tissue (COM-G), and chronic otitis media (COM) with dry middle ear. Single or multi-ossicular erosions and preoperative audiological data of those cases were evaluated.

SPSS version 22.0 (SPSS, USA) was used for statistical analysis. To describe the qualitative data, frequency analysis was used. To compare them, Chi square test was used. Statistically significant level was accepted as $p < 0.05$.

Results

One hundred ninety-seven patients who had undergone ear surgery before were excluded, and the data of 924 patients who underwent surgery for the first time were evaluated. Nine patients were excluded from the study because of the lack of information in the database, and the remaining 915 cases were retrospectively reviewed. The mean age was 31 (4–79 years). Four hundred seventy-one (51%) of the cases were women, and 444 (49%) were men. OCE was detected in 291 (31.8%) of 915 patients in the study groups (Table 1). There were 615 (67.2%), 234 (25.6%), and 66 (7.2%) patients in COM, COM-C, and COM-G groups, respectively. Single and multi-ossicular erosions in all study groups are given separately in Table 1.

When the cases were evaluated in terms of incus erosion alone or together with other ossicles, there were 71 (11.5%) of 615, 18 (27.2%) of 66, and 187 (79.9%) of 234 cases in COM, COM-G, and COM-C groups, respectively. There was stapes erosion in 22 (3.5%) of 615, 107 (45.7%) of 234, 7 (10.6%) of 66, and malleus erosion in 10 (1.6%) of 615, 69 (29.4%) of 234, and 10 (15.1%) of 66 cases in COM, COM-C, and COM-G groups, respectively.

Statistical analysis using Chi-square dependency test revealed a statistically significant difference between the groups for each of the three ossicles ($p < 0.001$).

When all three groups evaluated, there was a single-ossicle erosion in 142 of 915 cases, and there was a strong correlation between the 3 groups in single or multi-ossicular erosions ($p < 0.001$). The effect of cholesteatoma or granulation tissue on ossicular erosion was statistically significant in the COM-G and COM-K groups compared with the COM group when ossicle erosions were taken single or multiple. We also investigated the effect of sex on ossicle erosion. There was no statistically significant difference between men and women in terms of malleus and stapes erosion. However, incus erosion rate was statistically significant in men ($p < 0.05$). In our study, the number of male patients in the COM-C group was statistically significant ($p < 0.005$), but the difference was not significant in the other groups ($p > 0.05$). Incus was the most commonly eroded ossicle in 276 (30.1%) of the cases. Of those cases, 127 (13.8%) were single and 149 (16.3%) were together with malleus and/or stapes. The second common eroded ossicle was stapes found in 136 (14.9%) cases. The number of cases with eroded stapes alone was 8 (0.9%), and 128 (14%) cases had stapes erosion with other ossicles. Malleus was the least eroded ossicle in 89 (9.8%) cases. Malleus was the only eroded ossicle in 7 (0.8%) and with other ossicles in 82 (9%) of cases (Table 2).

In the current study, we found single-ossicular erosion in 142 (15.5%) and multi-ossicular erosion in 149 (16.3%) of cases. As a multiple ossicular erosion, the incidence of

Table 1 Ossicular chain erosions in all study group (915 cases)

Ossicular erosion	M		I		S		M and I		I and S		M and S		M, I, and S		Total number of ossicular erosion		None		All cases	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
COM	2	0.3	51	8.3	5	0.81	3	0.5	12	1.6	0	0	5	0.8	78	12.7	537	87.3	615	67.2
COM-C	3	1.3	67	28.6	2	0.85	15	6.4	54	23.0	0	0	51	21.8	192	82.1	42	18.0	234	25.6
COM-G	2	3.0	9	13.6	1	1.52	3	4.6	1	1.5	0	0	5	7.6	21	31.8	45	68.2	66	7.2
Total	7	0.8	127	13.9	8	0.87	21	2.3	67	7.3	0	0	61	6.7	291	31.8				
	291 (31.8%)																624	68.2	915	100

M malleus, *I* incus, *S* stapes, *COM* chronic otitis media without cholesteatoma or granulation tissue, *COM-C* chronic otitis media with cholesteatoma, *COM-G* chronic otitis media with granulation tissue and without cholesteatoma

Table 2 Erosion rates with M, I and S singlet or other ossicles in the entire study group

Ossicular erosion	M		I		S	
	n	%	*n*	%	*n*	%
COM (*n* = 615)	10	1.6	71	11.5	22	3.6
COM-C (*n* = 234)	69	29.5	187	80.0	107	45.7
COM-G (*n* = 66)	10	15.2	18	27.3	7	10.6
TOTAL (*n* = 915)	89	9.7	276	30.1	136	14.9

M malleus, *I* incus, *S* stapes, *COM* chronic otitis media without cholesteatoma or granulation tissue, *COM-C* chronic otitis media with cholesteatoma, *COM-G* chronic otitis media with granulation tissue and without cholesteatoma

Table 3 Distribution of ossicular erosion in 291 patients

Ossicular erosion	M		I		S		M+I		I+S		M+S		M+I+S		M+S		Total	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
COM	2	2.5	51	65.4	5	6.4	3	3.8	12	15.4	0	0	5	6.4	0	0	78	26.8
COM-C	3	1.5	67	34.9	2	1.0	15	7.8	54	28.1	0	0	51	26.6	0	0	192	66.0
COM-G	2	9.5	9	42.8	1	4.8	3	14.3	1	4.8	0	0	5	23.8	0	0	21	7.2
TOTAL	7	2.4	127	43.6	8	2.7	21	7.2	67	23.0	0	0	61	21.0	0	0	291	100

M malleus, *I* incus, *S* stapes, *COM* chronic otitis media without cholesteatoma or granulation tissue, *COM-C* chronic otitis media with cholesteatoma, *COM-G* chronic otitis media with granulation tissue and without cholesteatoma

incus and stapes erosion was found in 67 (7.3%) cases, followed by erosion of malleus, stapes, and incus together with in 61 (6.7%) and malleus and incus together with in 21 (2.3%) cases. Malleus and stapes erosion was not seen in any patient, whereas incus was intact. Of the 615 cases with COM, 78 (12.7%) had ossicular erosion, whereas 192 (82%) of 234 cases with COM-C and 21 (31.8%) of 66 cases with COM-G had ossicular erosion. Single or multiple erosion rates for incus, stapes and malleus in all groups were 30.1% (*n* = 276), 14.9% (*n* = 136), and 9.7% (*n* = 89), respectively, in all 915 cases (Table 2). Erosion rates alone or with other ossicles for each ossicle were 94.8% (*n* = 276), 46.7% (*n* = 136), and 30.6% (*n* = 89) for incus, stapes, and malleus, respectively, in 291 cases with ossicular erosion (Table 3). Single-ossicular erosion rate was 48.7% (*n* = 142), and multi-ossicular erosion rate was 51.3% (*n* = 149). Of those 291 cases, the rate of incus erosion alone was 43.6%. The most frequent multi-ossicular erosion type was incus + stapes with 67 (23%) cases followed by malleus + incus + stapes with 61 (21%) and malleus + incus with 21 (7.2%) cases. One hundred ninety-two (66%) of the cases with OCE were in the subgroup COM-C, 78 (26.8%) in the subgroup COM, and 21 (7.2%) in the subgroup COM-G. Preoperative mean air and bone conduction threshold values within the last 1 month before operation are given in Table 4.

Air-bone gap (ABG) was 34.70 dB, 31.10 dB, and 29.85 dB in the COM-C, COM-G, and COM subgroups, respectively. ABG was found to be higher in COM-C and COM-G compared with subgroup COM.

Table 4 Preoperative pure tone audio audiometry results

Preoperative pure tone audiometry results	COM-C (dB)	COM-G (dB)	COM (dB)
Air conduction	54.64	48.41	44.29
Bone conduction	9.94	17.31	14.44
Air-bone gap	34.70	31.10	29.85

COM chronic otitis media without cholesteatoma or granulation tissue, *COM-C* chronic otitis media with cholesteatoma, *COM-G* chronic otitis media with granulation tissue and without cholesteatoma

Discussion

OCE is frequently encountered by otolaryngologists especially in patients with chronic otitis media and cholesteatoma. Cholesteatoma is defined as hyperplastic keratinized layered squamous epithelium with osteoclastic activity in the middle ear and mastoid which capable of bone resorption. The destructive mechanisms of cholesteatoma on bone, such as osteoclast activation theory, pressure necrosis theory, acid lysis theory, enzyme-mediated theory, inflammatory mediator-mediated theory, and recent biomolecular progressions and mechanisms of ossicular injury, have been discussed in various studies [1, 3–5]. It is also possible that inflammatory mechanisms, enzyme activities, and lysis are responsible for bone destruction in cases of chronic otitis media without cholesteatoma.

Ossicular erosion as a result of increased osteoclastic activity and lysis causes a functional consequence such as more hearing loss in the patient. This functional result significantly reduces the quality of life of the patient. It is, therefore, important to focus on it. There are various studies in the literature that are analyzing ossicular damage. Although these studies are providing important information in this subject, they are all made in a limited number of case series, and there is a need for studies with larger case series. In our study, which we performed on a large number of cases with ear surgery that was performed by the same author (MTK) due to standardization, we focused on ossicular chain erosions and hearing loss in patients with COM-C, COM-G, and COM. Similar to the literature, incus was found to be the most damaged, and malleus was found to be the least damaged ossicle in our study. Mohammadi et al. [6] reported that in the frequencies of single-ossicle erosions, the most frequent damaged ossicle was incus, and the least damaged ossicle was malleus in 166 cases. In a similar study, Varshney et al. [7] reported outcomes of 150 cases and reported that malleus was the most resistant, whereas incus was the most commonly eroded ossicle. Choi et al. [2] also found that the most frequently eroded ossicle was incus followed by stapes and malleus in 212 cases. The results of our study support this literature knowledge. It is expected that the destructive effect of cholesteatoma on ossicles is higher than the other cases without cholesteatoma. It has been reported that the prolongation of the cholesteatoma persistence increases the risk of ossicular chain damage [8]. However, it is necessary to know how long the cholesteatoma has been persisting in the middle ear to say something. The identification of cholesteatoma ethically necessitates the surgical intervention. Therefore, it is not rational and ethical to follow up the cholesteatoma and to note the ossicular erosion that will occur over time. It was not possible to obtain data on the relationship between cholesteatoma time and ossicular erosion. The time of initial onset of cholesteatoma was unknown, and surgical intervention was planned and performed when cholesteatoma was detected in our study. However, it is not wrong to say that the prolongation of the duration of cholesteatoma may lead to more erosion in the ossicular system because of the known destructive and lytic effect of cholesteatoma leading to ossicular erosion. Our study has the highest number of cases in terms of patient population compared with other studies in the literature. In our study, 915 patients were retrospectively reviewed, and the patients were classified as COM, COM-G, and COM-C and were examined separately for ossicular damage. The results of our study are similar to those of the other studies in the literature. However, in our study, patients were grouped as COM, COM-G, and COM-C, and the ossicular damage was assessed separately. Our results showed the presence of more ossicular erosion in cholesteatoma cases (Table 1).

The disruption of the normal ossicular structure in the middle ear leads to deterioration of the conduction of sound energy and hearing loss [9]. The conductive hearing loss associated with cholesteatoma is partly due to erosion of the ossicles and disruption of the ossicular chain. Similar destructive effects can develop in the presence of chronic infections and granulation tissue. However, this effect is expected to be more in the cholesteatoma. In this study, hearing thresholds and ABGs were noted by evaluating the audiological data in the preoperative period. The results show that the level of hearing loss in patients with COM-C is higher than those with COM-G and COM. This is an expected result. As seen in Table 4, airway thresholds are the lowest in COM-C, followed by COM-G and COM. A similar situation is also true for ABG results. The presence of middle ear cholesteatoma or granulation tissue increases the hearing loss in patients with COM. Martin et al. [10] reported an increase in ABGs because of ossicular erosion caused by cholesteatoma in 158 chronic otitis media patients. These findings support the results of our study.

Conclusion

OCE due to infection and destructive effect of cholesteatoma was observed in all chronic otitis media cases with or without cholesteatoma. Incus was the most affected bone followed by stapes and malleus. This study, which is conducted through a large case series, supports the knowledge in the literature. The results of our study show that ossicular chain erosion is more frequently encountered in cases with cholesteatoma than those with granulation tissue or tympanic membrane perforation alone. Hearing loss increases, and ABG becomes more pronounced in patients parallel to the frequency and severity of the resulting ossicular chain erosion.

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Compliance with ethical standards

Conflict of interest The authors declare that they have no competing interests.

Statement of human rights The study has been approved by the Ethical Committee of the University Hospital and has been performed according to the ethical standards of the Helsinki Declaration. Because of it was a retrospective study, formal consent was not required. We declare that all authors have contributed to, read and approved the final manuscript for submission.

Ethical approval This study was retrospectively data analysis study and it did not need to informed consent. This retrospective study was performed after approval of local ethic committee.

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