

Surgical Treatment of Extensive Ossification over the Lateral Semicircular Canal in Otitis Media Surgery

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Abstract

Introduction: Extensive ossification over the semicircular canal is not common in the surgery of otitis media. This study aimed to reduce intraoperative and postoperative complications among patients with extensive ossification over the lateral semicircular canal and concomitant otitis media. **Methods:** The patients' clinical data were retrospectively reviewed to determine the preoperative imaging characteristics of perilyabyrinthine ossifications and key points of surgical operation. The data of 156 patients who underwent radical mastoidectomy or tympanoplasty between January 2016 and December 2018 due to chronic otitis media or cholesteatoma were reviewed. Seven patients with extensive ossification over the lateral semicircular canal were identified, and their preoperative imaging results, intraoperative procedures, and postoperative symptoms were evaluated. **Results:** The incidence of extensive ossification over the lateral semicircular canal among patients with chronic otitis media was 4.5% (7/156). Ossification occurred in the periphery of the lateral semicircular canal; the osseous tissue frequently fused with the osseous lateral semicircular canal, obscuring the boundaries between the two structures. A semicircular canal fistula was observed in two of the seven patients with extensive ossification over the lateral semicircular canal. The two patients underwent surgical patching or filling and symptomatic hormone treatment. Postoperative vertigo occurred in both patients and subsided within 1–3 months. There was no significant difference between preoperative and postoperative hearing thresholds. **Conclusion:** Extensive ossification over the lateral semicircular canal has a low incidence and may be discovered through preoperative imaging evaluation, enabling medical personnel to engage in adequate preoperative preparations. During the surgical procedure, navigational landmarks are required to determine the anatomical structures. The management of semicircular canal fistulas is essential to the reduction of intraoperative and postoperative complications.

Key points:

- Extensive ossification over the lateral semicircular canal has a low incidence.
- The osseous tissue frequently fused with the osseous lateral semicircular canal, obscuring the boundaries between the two structures.
- The incidence of iatrogenic fistula during surgery is extremely high.
- EC-LSC is essentially a form of heterotopic ossification; the resultant osseous tissue features an external morphology and texture similar to that of normal bone.
- Preoperative identification and intraoperative search for several location makers

are essential to the reduction of complications.

1 INTRODUCTION

Lateral semicircular canal prominences, which have relatively fixed positions, are key anatomical landmarks used to locate the facial nerve in middle ear surgery. The color and bone density of these prominences differ distinctly from those of the compact bone around the tympanic antrum, which enables easy identification of them during middle ear surgery. Hence, these prominences often serve as key structural landmarks during temporal bone dissection. Extensive ossification over the lateral semicircular canal (EC-LSC) is a complex

condition encountered by surgeons during middle ear surgery that usually occurs in patients with a long history of chronic otitis media or cholesteatoma. Clinical cases of EC-LSC were first reported by Fleury et al. in 1978,¹ who categorized EC-LSC into three types: massive, diffuse attic-antral, and localized.² However, the literature has since featured relatively scant reports on EC-LSC. Hoshino et al.³ performed surgeries on 89 patients with attic cholesteatoma over three and a half years. In eight patients, they identified bony tissue proliferation at the tympanic antrum or aditus ad antrum as typical characteristics of EC-LSC. A previous study suggested that infectious stimuli at an early stage of the disease might stimulate such osteoplastic activity,³ while another study indicated that EC-LSC might be induced by trauma.⁴ Regardless of its etiology, the membranous labyrinth are apparent in such patients. Notably, the bony lateral semicircular canal carina, a key landmark, is often encased in dense bone. Hence, difficulties usually arise upon encountering the facial nerve and membranous labyrinth, and – as the incidence of iatrogenic fistula during surgery is extremely high – inexperienced otologists may be prone to operating errors. In the present study, we retrospectively analyzed all the data of patients who underwent surgery for otitis media or cholesteatoma within the 3 years to elucidate the clinical characteristics of EC-LSC. Findings from this study will help inform preoperative planning, intraoperative procedures, and postoperative management of symptoms.

2 MATERIAL AND METHODS

2.1 Reporting guideline

A phenomenon of extensive ossification over the lateral semicircular canal was found in clinic. Due to the difficulty in intraoperative identification, iatrogenic injury was easy to occur. This phenomenon is not common in clinical practice by literature review. All surgical cases (156 cases) of chronic otitis media and cholesteatoma in the past 3 years were further reviewed and 7 of them were found. The clinical characteristics of these 7 cases were reviewed in order to provide clinical experience for preoperative recognition and intraoperative management.

2.2 Study population

This retrospective study reviewed the clinical data of patients who underwent mastoidectomy between January 1, 2016, and December 31, 2018 in ** due to chronic otitis media or cholesteatoma. This study was approved by the ***. All patients were exempt from written informed consent.

2.3 Imaging and audiology

There were a total of 156 patients; 25 patients underwent revision mastoidectomy due to persistent discharge from the ear after a previous mastoidectomy. All of the patients' CT scans were reviewed. Seven cases of EC-LSC were identified from the CT scans. The preoperative CT image characteristics, intraoperative observations of lesions, and postoperative hearing thresholds and complications of these seven patients were evaluated to determine the clinical characteristics of EC-LSC.

Audiological parameters using three frequencies, 0.5, 1 and 2 kHz, were assessed pre and postoperatively. The Paired T test was used to compare the preoperative and postoperative changes of the hearing threshold. All analyses were performed using GraphPad Prism (version 5). Statistical significance was set at a two-tailed $P < .05$.

3 RESULTS

3.1 Characteristics of patients

All seven EC-LSC patients were women with a mean age of 45.9 years and a disease duration of 4–25 years. Two of the patients (patients ID5 and ID7) received revision surgery due to postoperative recurrence. All seven patients suffered from middle ear cholesteatoma. Three patients had concomitant tympanosclerosis and one patient had concomitant adhesive otitis media. Canal wall down mastoidectomy was performed in all patients, and concurrent ossicular chain reconstruction was performed in four patients (total ossicular replacement prosthesis [TORP], three; partial ossicular replacement prosthesis [PORP], one) (Table 1).

The most common site of ossification was the tympanic antrum (6/7 patients), followed by the attic. Complete ossicle damage occurred in two patients. The fusion of the osseous tissue and the ossicles was observed in the other five patients, resulting in abnormalities in ossicle morphologies. Fusion also occurred between the osseous tissue and lateral semicircular canal, which obstructed the aditus ad antrum and induced local drainage disorders in severe cases. The bone tissue was visible upon postoperative pathological examination. As the density of osseous tissue formed from ossification is close to or slightly lower than that of the normal bone, it is often difficult to distinguish between osseous tissue and the bone of the semicircular canal during surgery. Cholesteatoma tissue or granulation tissue is usually concealed between the osseous tissue and normal bone, as shown in Figure 1 (patient ID2) and Figure 2. In two of the seven patients, semicircular canal fistulas of differing degrees were found intraoperatively (Patient 1: the “blue line” of the lateral semicircular canal was exposed intraoperatively and the membranous semicircular canal was intact (Figure 1); Patient 2: a 2-mm semicircular canal fistula occurred intraoperatively during bone grinding). Fascial patching and temporal muscle filling were separately adopted for the closure of the lateral semicircular canal fistulas, and dexamethasone was administered intraoperatively and postoperatively. Both patients with lateral semicircular canal fistula experienced postoperative vertigo, which subsided at 1 month and 3 months postoperatively, respectively, with the administration of symptomatic treatment.

3.2 Postoperative hearing

Prior to surgery, all seven patients experienced a reduction in conductive hearing or a reduction in mixed hearing that was primarily conductive in nature. The preoperative pure-tone average values for air conduction (AC), bone conduction (BC), and the air-bone gap (ABG) were 60.2 dB, 25.5 dB, and 34.8 dB, respectively. Postoperative hearing tests were conducted between 3 and 6 months for all patients following the operation. The preoperative and postoperative hearing of the seven patients did not differ significantly. Among the two patients with lateral semicircular canal fistulas that were treated by patching or filling, one patient showed postoperative improvement in hearing, while another patient experienced a further reduction in hearing. Table 2 shows the preoperative and postoperative hearing threshold values of the seven patients.

4 DISCUSSION

EC-LSC is a rarely encountered phenomenon in clinical practice. In this study, we reviewed the data of 156 patients and found that seven patients exhibited varying degrees of ossification (incidence, 4.5%). The osseous tissue may hinder the further expansion of the cholesteatoma from the attic to the aditus ad antrum. However, the osseous tissue often fuses with key anatomical structures such as the semicircular canals and ossicles that may obstruct the aditus ad antrum in severe cases. This increases the difficulty of identifying the aforementioned anatomical structures during surgery, which may elevate the probability of intraoperative damage to the semicircular canals or to the ossicles and the facial nerve in some cases.

4.1 Distinguishing EC-LSC from other lesions

4.1.1 Tympanosclerosis

Tympanosclerosis, a common sequela of chronic otitis media, is characterized by hyaline degeneration and the deposition of calcareous plaques in the connective tissue of the fibrous layer of the tympanic membrane and/or middle ear submucosa; it may result in local bone metaplasia during its late stages of development.⁵ As EC-LSC is essentially a form of heterotopic ossification; the resultant osseous tissue features an external morphology and texture similar to that of normal bone but – as revealed by pathological examination – also possesses the pathological characteristics of internal osseous structures and lacunae. Table 3 shows the differences between tympanosclerosis and EC-LSC. In some cases, EC-LSC may co-exist with tympanosclerosis. This is clearly demonstrated by the presence of concomitant EC-LSC and tympanosclerosis in three of the seven patients investigated in this study. The co-presentation posed a significant challenge during surgical operations.

4.1.2 Labyrinthitis ossificans

Labyrinthitis ossificans indicates the fibrosis or ossification of the membranous labyrinth. Tympanogenic,

meningogenic, and hematogenous etiologies are more common in cases of labyrinthitis ossificans than in those related to trauma.⁶ A report found the incidence of tympanogenic labyrinthitis ossificans to be 2%.⁷ The most common risk factors for labyrinthitis ossificans are chronic otitis media and temporal bone surgery. Regardless of etiology, labyrinthitis ossificans affects the semicircular canals with the greatest severity and the vestibules with the least severity.⁸ This study identified the bony semicircular canal as the ossification center of EC-LSC in all patients with growth mainly occurring in the direction of the tympanic antrum and attic. This may be different from the pathogenesis of labyrinthitis ossificans.

4.2 Key points to note during surgery for patients with EC-LSC

4.2.1 Dealing with osseous tissue

Determining whether the resection of osseous tissue is necessary requires particular attention during surgery. As the ossified tissue forms a relatively static lesion, it may be retained if it does not affect middle ear drainage or trigger secondary otitis media. However, the osseous tissue will require attention if one of the following occurs: (1) The osseous tissue occupies a relatively large volume and obstructs the aditus ad antrum, resulting in local aeration and drainage disorders of the middle ear; (2) in patients with middle ear cholesteatoma or chronic otitis media, lesion tissue usually grows along the gap between osseous and normal bone tissue, which necessitates the grinding of osseous tissue to eliminate residual lesions.

When treating osseous tissue, there are several matters that require attention. First, there are usually no clear boundaries that delineate the osseous tissue. Hence, adequate exposure of bone is necessary for removal. In the seven patients with EC-LSC investigated in the present study, canal wall down mastoidectomy was adopted for the complete saucerization of the surgical cavity to ensure adequate bone exposure. Second, the bone density of the osseous tissue is generally lower than that of the bony semicircular canals. Bone density should therefore be carefully distinguished, and the osseous tissue should be ground in a layer-wise manner during surgery. In some cases, the osseous tissue may form a concealed gap with normal bone tissue. Once this gap is exposed, the separation of osseous tissue from the normal structural surfaces can be performed.

4.2.2 Labyrinthine fistula

The incidence of a labyrinthine fistula during cholesteatoma surgery is approximately 7.5%.⁹ As osseous tissue mainly originates from or fuses with the lateral semicircular canal, difficulties may arise in the intraoperative identification of the semicircular canal. In such situations, other anatomical landmarks may be used for localizing the semicircular canal: (1) Navigational landmarks for identifying the pyramidal segment of the facial nerve, the stapes and pyramidal eminence also form the anteromedial boundary of the lateral semicircular canal; (2) the horizontal segment of the facial nerve, which passes anteriorly and inferior to the lateral semicircular canal; (3) situated between the sigmoid sinus and the middle cranial fossa dural plate, the sinodural angle also forms the posterior-superior edge of the saucerized mastoid cavity. By proceeding anteriorly from the sinodural angle, the posterior semicircular canal can be localized, enabling the exposure of the lateral semicircular canal. The osseous tissue on the surface of the semicircular canal must be ground layer by layer; (4) the “blue line” of the semicircular canal to confirm the direction of the passage and determine the location of the semicircular canal.

Labyrinthine fistulas can be classified into three types according to the classification system proposed by Dornhoffer and Milewski¹⁰: (1) Type I, an erosion of the bony labyrinth with an intact endosteum; (2) Type II, the concomitant involvement of the bony and membranous labyrinths that form a labyrinthine fistula, which features a depth of less than half of the diameter of the semicircular canal and causes lymphatic leakage; (3) Type III: the concomitant damage to the bony and membranous labyrinths that forms a fistula, which features a depth of more than half of the diameter of the semicircular canal and may induce dehiscence. Currently, there is no widely recognized standard for the repair of labyrinthine fistulas, and data do not demonstrate significant differences in postoperative hearing outcomes based on the surgical technique.¹¹ In the present study, patient 1 had a Type I labyrinthine fistula and patient 2 had a Type II labyrinthine fistulas; temporal fascial patching and muscle filling were adopted for the closure of the fistulas, and intravenous dexamethasone was administered for symptomatic treatment. The postoperative vertigo experienced by

patients 1 and 2 subsided at 1- and 3-months following surgery, respectively.

4.2.3. Influence of osseous tissue on hearing

This study found that the fusion and fixation of the malleus and incus occurred in five of the seven patients with EC-LSC. Ossicle fusion causes a loss of mixed hearing that is primarily conductive in nature. With the removal of the fused ossicles and the use of appropriate ossicular prostheses (PORP/TORP), the postoperative hearing of patients can be improved to varying extents.

Labyrinthine fistulas are also considered a key influencing factor for postoperative hearing. Geerse et al. found that the sizes of labyrinthine fistulas correlated with postoperative hearing loss.¹² Hence, opening the membranous labyrinth resulted in significantly worse postoperative BC threshold and can be seen as a predictive parameter. For the two cases of labyrinthine fistulas considered in this study, the timely discovery and patching of the fistulas during the surgery and the early administration of dexamethasone prevented the postoperative BC threshold levels from changing significantly. This suggests that the methods employed to address the fistulas helped to stabilize the patients' hearing.

4.3 Limitations

This study had some limitations. All data from the retrospective review were collected from medical records. While, the imaging data was reliable, the intraoperative findings relied on the accuracy of the original documentation. Additionally, the small sample size increased the likelihood of a Type II error skewing the results. In the future, we hope to expand the sample size of our center and increase multi-center research. We hope that this will provide not only accurate data for future analysis but also reference for the decision of the otologist.

In conclusion, EC-LSC has a low incidence and may be discovered in a timely manner through preoperative imaging evaluation, which enables medical personnel to engage in adequate preoperative communication and intraoperative preparation. During surgery, substantial reliance on navigational landmarks is required for the determination of anatomical structures. The timely and appropriate treatment of semicircular canal fistulas that have already formed is essential to the reduction of intraoperative and postoperative complications.

CONFLICT OF INTEREST

None declared.

ETHICAL APPROVAL

This study was approved by **. All patients were exempt from written informed consent.

DATA AVAILABILITY STATEMENT

Data may be made available on request.

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Table 1. Patient Data

ID	Sex	Age (years)	Duration of disease (years)	History of surgery	Surgical procedure	Site of ossification
1	Female	54	9	No	CWDM+TORP	Tympanic antrum
2	Female	60	10	No	CWDM	Tympanic antrum
3	Female	22	4	No	CWDM	Anterior attic
4	Female	35	10	No	CWDM+TORP	Tympanic antrum, attic
5	Female	25	5	Yes	CWDM+PORP	Attic
6	Female	68	10	Yes	CWDM+TORP	Tympanic antrum, attic
7	Female	57	25	Yes	CWDM	Periphery of labyrinth

Abbreviations: CWDM, canal wall-down mastoidectomy; TORP, total ossicular replacement prosthesis; PORP partial ossicular replacement prosthesis.

Table 2. Preoperative and postoperative hearing of the patients

	Preoperative	Postoperative	p	t
AC	60.2±12.4	53.1±16.1	0.276	1.200
BC	25.5±5.0	23.6±5.5	0.371	0.967
ABG	34.8±12.2	28.1±13.1	0.358	0.995

Abbreviations: AC, air conduction; BC, bone conduction; ABG, air-bone gap.

Table 3. Differences between Tympanosclerosis and Perilabyrinthine ossificans

	Observable by the naked eye	Commonly involved sites	Observable by
Tympanosclerosis	White sclerotic lesions	Attic, fenestra vestibuli, periphery of the ossicles	Ossified or calcified
Perilabyrinthine ossificans	Osseous tissue	Tympanic antrum	Osseous tissue

Figure Legends

Fig. 1. Surgery of patient ID2 (right ear). Extensive ossification was observed over the lateral semicircular canal. Triangle: Extensive ossification over the lateral semicircular canal. M: indicates the head of the malleus. Arrows indicate the fistula of the lateral semicircular canal. *: indicates the Cholesteatoma tissue.

Fig. 2. Preoperative imaging data of the patients. Arrows indicate the extensive ossification over the lateral semicircular canal.

