

Association of ear-cleaning habits involving the deep bony portion with perilymph fistula of the oval window

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Background: Recent studies have reported non-traumatic inner ear disorders associated with ear-cleaning habits.

Objective: Examination of our patients with perilymph fistula (PLF) has frequently revealed cerumen accumulated on the deep bony external auditory canal (EAC) and transverse wrinkles on its posterior surface as a result of ear-cleaning habits. We aimed to determine a relation among the presence of wrinkles and the frequency of ear cleaning and the development of PLFs.

Methods: The records of 188 patients with PLFs, including 105 patients with wrinkles on the posterior surface of the deep bony EAC, were retrospectively reviewed. Labyrinthine windows were sealed only when fluid leaks, stapes abnormalities, and/or mucosal lesions were observed.

Results: Wrinkles and sealed oval windows were significantly associated with the practice of ear cleaning once or more a week. Patients who cleaned their ears once or more a week and had wrinkles had the highest proportion of sealed oval windows (Fisher's exact test, $P < 0.001$).

Conclusion: Habitually touching the posterior surface of the deep bony EAC by ear cleaning once or more a week is a risk factor for PLF of the oval window and inner ear disorders, including dizziness, vertigo, and acute sensorineural hearing loss.

Key words: stapes, cerumen, dizziness, vertigo, sensorineural hearing loss

Introduction

The cartilaginous external auditory canal (EAC) produces cerumen. Cleaning the EAC to remove cerumen with ear-cleaning tools and cotton swabs is believed to have no impact on the inner ear, except for perilymph fistula (PLF), due to penetrating ear injury. However, recent studies have reported episodes of ear fullness, tinnitus, vertigo, and hearing loss associated with ear-cleaning habits.^{1,2} It seems that some methods of ear cleaning can cause non-traumatic inner ear disorders.

Causes of inner ear disorders include PLF.³⁻¹⁰ The bony EAC, covered with smooth skin without cerumen, does not need to be cleaned. However, examinations of the EACs of patients with a PLF have frequently revealed accumulations of cerumen on the deep bony EAC and transverse wrinkles on its posterior surface as a result of ear-cleaning habits. Therefore, we hypothesized that

ear-cleaning habits with wrinkle formation may play a role in the development of PLFs.

Surgery for PLFs provides valuable information about the pathophysiology of PLFs. In this study, we analyzed the surgical findings of 188 PLFs to investigate the effects of habitually touching the posterior surface of the deep bony EAC and the relation to the risk of PLFs.

Materials and Methods

Patients

This retrospective study included 188 patients who underwent primary surgery for unilateral PLF repair at the Koga General Hospital between October 2013 and February 2021. PLFs that occurred after penetrating ear injuries were excluded. Patients' medical records were reviewed, paying especial attention to demographic characteristics, ear cleaning patterns, pre- and postoperative symptoms, and intraoperative findings

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(Table 1).

All the procedures in this study were in accordance with the Helsinki Declaration of 1975, as revised in 2008. The Institutional Review Board of Koga General Hospital approved this study (IRB No. 19–27). Written informed consent for surgery was obtained from all the patients.

Wrinkles on the deep bony EAC

The EAC was examined under an operating microscope at the first medical examination. Although the normal deep bony EAC is covered with smooth skin, 105 patients had transverse wrinkles on the posterior surface of the inner half of the bony EAC (Figure 1). Their deep EACs

had cerumen accumulated on the skin. For a number of years, they habitually cleaned their ears with ear-cleaning tools or cotton swabs to remove cerumen, to absorb water after swimming and bathing, and/or to scratch an itch. They were classified into the "wrinkles +" group. The upper wall of the outer half of the bony EAC presented a histological appearance similar to that of the cartilaginous EAC.¹¹ Therefore, patients without wrinkles and those with wrinkles in only the outer half of the bony EAC were classified in the "wrinkles -" group. No patients had an infection or trauma on the EAC or tympanic membrane. Table 2 shows the relationship between wrinkles and the reported frequency of ear cleaning.

Table 1. Clinical characteristics of 188 patients

Characteristics	Wrinkles +	Wrinkles -	P value
	n = 105	n = 83	
Age (years)	58.2	57.4	0.707
Standard deviation	14.6	16.0	
Sex			
Male	48	43	0.463
Female	57	40	
Affected side			
Left	42	42	0.184
Right	63	41	
Chief complaints			
Acute sensorineural HL	58	40	0.512
Vestibular symptoms without HL	23	18	
Vestibular symptoms with chronic HL	24	25	
Outcome of acute sensorineural HL			
≥30 dB	23	16	1.000
<30 dB	35	24	

HL, hearing loss

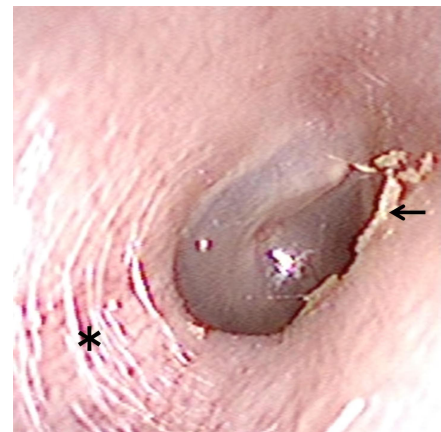


Figure 1. A representative image of the deep EAC from the "wrinkles +" group shows transverse wrinkles (asterisk) on the posterior surface and an accumulation of cerumen (arrow) on the bony portion near the tympanic membrane.

Table 2. Wrinkles, sealed labyrinthine windows, and ear-cleaning frequency in 188 patient

Frequency	Wrinkles +			Wrinkles -		
	Patients n = 105	Sealed OW 97 (92%)	Sealed RW 33 (31%)	Patients n = 83	Sealed OW 50 (60%)	Sealed RW 56 (67%)
7/week	44	42	10	2	1	1
3/week	14	13	4	1	1	1
2/week	16	15	4	4	2	2
1/week	22	20	12	6	3	4
2/month	5	4	2	11	8	7
1/month	3	3	0	4	2	3
<1/month	1	0	1	38	22	26
Unknown	0	0	0	17	11	12

OW, oval window; RW, round window

Patient examinations

In addition to pure-tone audiometry and nystagmus examinations, all patients underwent high-resolution axial computed tomography (CT) scanning. CT scanning was to identify a soft-tissue density mass in the oval window niche, the round window niche, and/or the tympanic sinus to support the diagnosis of PLF.¹⁰ Forty-seven patients underwent magnetic resonance imaging to exclude the presence of intracranial lesions.

Surgical indications

Indications for exploratory tympanotomy included deterioration or no improvement in acute sensorineural hearing loss, persistent dizziness, and recurrent or severe vertigo. All patients had persistent positional nystagmus in the supine position. Our indications for sealing the labyrinthine windows were the presence of fluid leaks, stapes abnormalities, or mucosal lesions. Of the 188 patients who underwent exploratory tympanotomy, sites of PLF accounted for 99 oval windows, 41 round windows, and 48 both labyrinthine windows. Thus, all 188 patients had surgical findings that met our criteria for an intraoperative diagnosis of PLF.

Operative procedure

Sealing of the labyrinthine windows with a retroauricular incision was performed under local anesthesia in 185 patients and under general anesthesia in 3 patients. The middle ear was examined under an operative microscope. Adequate curettage of the posterior superior canal wall was performed to visualize the oval and round window niches. Both niches were carefully inspected for fluid leaks, stapes abnormalities such as subluxation and hypermobility, and/or mucosal lesions including edema, adhesions, and scar tissue formation.

For these lesions, the oval window was sealed with areolar connective tissue, and the round window was packed with a fascia and subsequently covered with an absorbable gelatin sponge.

Surgical outcomes

All the patients underwent follow-up examinations for at least 1 month. There were 11 re-explorations. Complete resolution or substantial improvement occurred in 98% (88/90) of the patients whose chief complaint was dizziness or vertigo. Of those with unilateral acute sensorineural hearing loss, 40% (39/98) demonstrated hearing recovery of more than or equal to 30 dB on the 5 pure tone averages from 250 to 4,000 Hz (Table 1).

Statistical analyses

Continuous variables were analyzed using Student's *t*-test. Categorical variables were analyzed using Fisher's exact test. All P values were two-sided with $P < 0.01$ considered to indicate statistical significance. All statistical analyses were conducted using the R statistical software (Version 3.4.1) (The R Foundation for Statistical Computing, Vienna, Austria).

Results*Clinical characteristics*

Clinical characteristics were not significantly different between patients with and without wrinkles on the posterior surface of the deep bony EAC (Table 1).

Surgical findings

Sealed labyrinthine windows numbered 147 oval windows and 89 round windows. Fluid leaks, which were defined as fluid puddles in the labyrinthine niche and refilling within 1 minute after aspiration, were found in 84 (57%) of the 147 sealed oval windows and in 49 (55%) of the 89 sealed round windows, including 11 patients with fluid leaks in both labyrinthine windows. Stapes abnormalities occurred in 115 (78%) of the 147 sealed oval windows, with 87 (83%) of 105 patients with wrinkles, and 28 (34%) of 83 patients without wrinkles ($P < 0.001$). Stapes abnormalities could be classified into the following 3 types: (1) Outward subluxation of the anterior stapes footplate in 80 ears, including 15 ears with hypermobility of the stapes; (2) hypermobile stapes without subluxation in 21 ears; and (3) stapes inclined towards the promontory in 14 ears.

Ear-cleaning habits and sealed labyrinthine windows

Table 2 shows the number of sealed labyrinthine windows according to wrinkles and frequency of ear cleaning in 188 patients. The percentage of sealed oval windows in patients with wrinkles was higher than that of sealed round windows (92% vs. 31%, respectively). Contrastingly, the percentage of sealed oval windows in patients without wrinkles was lower than that of sealed round windows (60% vs. 67%, respectively).

Effects of ear-cleaning frequency on the sealed labyrinthine windows

Because the medical records of 17 patients without wrinkles did not reveal the frequency of ear cleaning, the remaining 171 patients were analyzed to determine the impact of the frequency of ear cleaning on the labyrinthine windows (Table 3). Patients who cleaned their ears once

or more a week had a significantly higher proportion of sealed oval windows (97/109 vs. 39/62, $P < 0.001$) and a significantly lower proportion of sealed round windows (38/109 vs. 39/62, $P < 0.001$) than did patients who cleaned their ears fewer than once a week. In addition, the proportion of wrinkles was significantly higher in patients who cleaned their ears once or more a week than that in patients who cleaned their ears fewer than once a week (96/109 vs. 9/62, $P < 0.001$).

Effects of wrinkles on the sealed labyrinthine windows

The proportion of sealed oval windows was significantly higher in patients with wrinkles than that in patients without wrinkles (97/105 vs. 39/66, $P < 0.001$) (Table 4). When 171 patients were classified into 2 groups according to the frequency of ear cleaning, 109 patients who cleaned their ears once or more a week showed that the proportion of sealed oval windows was significantly higher in patients with wrinkles than that in patients without wrinkles (90/96 vs. 7/13, $P < 0.001$). However, 62 patients who cleaned their ears less than once a week had no significant differences in sealed oval windows between the patients with and those without wrinkles (7/9 vs. 32/53, $P = 0.464$). Patients with wrinkles had a significantly lower proportion of sealed round windows than did those without wrinkles (33/105 vs. 44/66, $P < 0.001$) (Table 4). However, when 171 patients were classified into 2 groups according to the frequency of ear cleaning, neither group showed a significant difference in sealed round windows between patients with and without wrinkles ($P = 0.059$, P

= 0.066, respectively).

Discussion

This study investigated sealed oval and round windows in 188 patients with PLF in relation to the frequency of ear cleaning and wrinkles on the posterior surface of the deep bony EAC. Wrinkles and sealed oval windows were significantly associated with ear cleaning once or more a week. The highest increase in sealed oval windows was observed in patients with wrinkles who cleaned their ears at least once a week.

Wrinkles and ear cleaning of the deep bony EAC

Transverse wrinkles on the posterior surface of the deep bony EAC were always accompanied by an accumulation of cerumen on the deep bony EAC and were significantly associated with the habit of cleaning the ears once or more a week. Cerumen is formed in the cartilaginous EAC and is not found on the smooth skin lining of the bony EAC. Therefore, an accumulation of cerumen on the deep bony EAC is a sign of inserting ear-cleaning tools into the deep bony EAC. Because of the slightly curved EAC, the ear-cleaning tool inserted into the deep bony EAC predominantly touches its posterior surface. Thus, habitual contact with the deep bony EAC during ear cleaning is related to wrinkle formation on its posterior surface. We suggest that rubbing the thin skin covering the deep bony EAC inhibits its natural outward migration and forms wrinkles.

Table 3. Effects of ear-cleaning frequency on sealed labyrinthine windows and wrinkles in 171 patients

Outcomes	Ear-cleaning frequency		P value
	≥1/week n = 109	<1/week n = 62	
Sealed OW	97	39	<0.001
Not sealed OW	12	23	
Sealed RW	38	39	<0.001
Not sealed RW	71	23	
Wrinkles +	96	9	<0.001
Wrinkles -	13	53	

Table 4. Effects of wrinkles and ear-cleaning frequency on sealed labyrinthine windows 171 patients

Outcomes	Wrinkles + n = 105	Wrinkles - n = 66	P value
Sealed OW	97	39	<0.001
Not sealed OW	8	27	
Ear cleaning ≥1/week			
Sealed OW	90 (94%)	7 (54%)	<0.001
Not sealed OW	6	6	
Ear cleaning <1/week			
Sealed OW	7 (78%)	32 (60%)	0.464
Not sealed OW	2	21	
Sealed RW	33	44	<0.001
Not sealed RW	72	22	
Ear cleaning ≥1/week			
Sealed RW	30 (31%)	8 (62%)	0.059
Not sealed RW	66	5	
Ear cleaning <1/week			
Sealed RW	3 (33%)	36 (68%)	0.066
Not sealed RW	6	17	

The intraoperative diagnosis of PLF

Current diagnostic criteria for PLF include fluid leaks in the labyrinthine window niche, fistulas of the labyrinthine window, and detection of the Cochlin tomo-protein (CTP). However, the CTP-positive rate in PLF-suspected cases is approximately 20%.³ Therefore, along with the fluid leaks in the labyrinthine window niche, two additional criteria were employed in this study. One was the presence of stapes abnormalities, which predispose PLFs of the oval window.⁴⁻⁶ And the other was mucosal lesions in the labyrinthine window niche, as these changes are observed in patients with PLFs.^{4,6-8}

In the present study, only the labyrinthine windows that met the above criteria for PLFs were sealed. Our surgical outcomes were better than those in previous reports, in which the surgical technique was sealing both labyrinthine windows, regardless of leakage,^{4,7,9} or only when PLF sites were unidentified.⁸ These results indicate that untreated labyrinthine windows in the present study were not PLF sites.

The effect of cleaning the deep bony EAC to the oval window

Cleaning the EAC with a soft object is usually considered harmless to the inner ear. However, we found that the habit of ear cleaning involving the posterior surface of the deep bony portion once or more a week significantly increased the risk of developing a PLF in the oval window. Although the underlying mechanism remains unknown.

Experimental studies of human beings have revealed the connection between nonacoustic stimulation of the external ear and stapedius muscle contraction. Tactile^{12,13} and electrocutaneous stimulation¹³ of the cavum conchae elicited stapedius muscle contractions in 84%¹² and 70%,¹³ respectively. The stapedius muscle contracted in response to electrocutaneous stimulation of cartilaginous EAC¹⁴ and bony EAC¹⁵ in 63% and 100%, respectively. The posterior surface of the bony EAC was the most sensitive to the electrocutaneous stimulation to cause the stapedius muscle to contract.¹⁵

The cavum conchae and inferior and posterior aspects of the EAC receive the sensory auricular branch of the facial nerve.¹⁶ The bony EAC receives abundant sensory innervation compared to the cartilaginous EAC, and the density of sensory nerve endings increases upon approaching the tympanic membrane.¹¹ Furthermore, the tensor tympani muscle contracted in response to tactile stimulation of the cavum conchae;¹² however, electrocutaneous stimulation of the cartilaginous EAC did not cause the tensor tympani muscle to contract.¹⁴

After reviewing the literature, we conjectured that

tactile stimulation of the posterior surface of the deep bony EAC elicits contraction of only the stapedius muscle. It is the most forceful contraction caused by tactile stimulation of the external ear. Pulling the stapes backward and outward because of contraction of only the stapedius muscle stretches the annular ligament of the stapes. Its repeated contraction caused by ear-cleaning habits compromises the integrity of the oval window. This suggestion coincides with our findings of a significant increase in stapes abnormalities in patients with wrinkles compared with patients without wrinkles.

Limitations

This study had a few limitations. First, ear-cleaning frequency was unknown for 17 patients in this study because it was not recorded on their medical records. Second, because a prophylactic patch was not applied to 140 labyrinthine windows in 188 ears, some labyrinthine windows may have been unpatched despite having a PLF or might have been prophylactically sealed. Third, when tactile stimulation was applied on the region of the EAC, a certain duration of the tactile stimulation was essential for the contraction of the stapedius muscle.¹⁵ Finally, the duration of the ear-cleaning practice was not examined in this study.

Conclusion

These findings showed that repeated contact with the posterior surface of the deep bony EAC due to ear-cleaning habits once or more a week was associated with an increased risk of a PLF in the oval window. Increased awareness of the harm of ear-cleaning methods involving the deep bony EAC may decrease the incidence of inner ear disorders, including ear fullness, tinnitus, dizziness, vertigo, and acute sensorineural hearing loss.

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Conflicts of Interest: None**References**

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