INTRODUCTION

Patients with a patulous eustachian tube (PET) can develop habitual sniffing to alleviate uncomfortable aural symptoms such as autophony [1]. Several studies have reported that habitual sniffing in patients with PET is closely related to the pathogenesis of cholesteatoma [2-9]. Its incidence in acquired middle ear cholesteatoma has been reported to be as high as 25.7% and 27.4% respectively [9,10]. The incidence of eustachian tube (ET) closing failure is much higher (54.8%) in cases with pars flaccida retraction cholesteatoma [11]. The middle-ear pressure created by habitual sniffing was considered to be an important initiator of cholesteatoma [12]. In addition, postoperative recurrence of cholesteatoma is significantly associated with continuing habitual sniffing after the surgery [10]. Therefore, it is important that cholesteatoma patients with PET stop habitual sniffing to prevent recurrence. However, the treatment of PET with habitual sniffing is not easy. Several studies have reported that surgical treatment that partially blocks the ET could help PET patients to stop sniffing [13-15]. Though the mechanical or functional
obstruction of the ET has been regarded as a major factor in the pathogenesis of middle ear diseases including cholesteatoma, this concept has not been widely accepted. In this study, we evaluate the safety and efficacy of additional ET catheter insertion performed simultaneously with cholesteatoma surgery (atticotomy or simple mastoidectomy) in acquired cholesteatoma patients associated with PET and habitual sniffing.

MATERIALS AND METHODS

We retrospectively analyzed patients with acquired cholesteatoma associated with PET and habitual sniffing, who underwent cholesteatoma surgery with simultaneous additional ET catheter insertion, between January 2015 and December 2017. The diagnosis of PET was based on the presence of aural symptoms such as autophony and/or fullness, decrease in symptoms by closing the ET (supine or prone position, or artificial obstruction of the pharyngeal orifice by maneuvers such as using cotton or jelly) and objective findings of an open ET (tympanic membrane movement upon respiration) [16,17]. Only patients who met all three criteria were diagnosed with definite PET and included for analysis. We also assessed the presence of habitual sniffing. Most patients were not conscious of their sniffing habits. The manner in which sniffing was performed to relieve aural symptoms such as aural fullness, autophony, or hyperacusis varied from patient to patient; so, before a simple yes or no question, demonstration of various sniffing actions by a doctor was necessary to help the patients to decide whether or not patients actually had a sniffing habit. The presence of habitual sniffing was confirmed when both uncomfortable aural symptoms (aural fullness, autophony, or hyperacusis) and a history of habitual sniffing to alleviate such aural symptoms were observed [12]. The judgement of habitual sniffing was based on both the habitual occurrence of sniffing and the fact that the patients themselves realized such sniffing was performed to relieve symptoms such as aural fullness, hyperacusis and autophony. Sniffing for nasal diseases such as allergic rhinitis and chronic sinusitis was excluded from this study.

Standard tonal audiometry for air (125, 250, 500, 1,000, 2,000, 4,000, and 8,000 Hz) was performed before and after surgery.

The patients were examined using a microscope and an endoscope for recurrence of postoperative cholesteatoma. Diffusion-weighted magnetic resonance imaging was performed in suspicious cases. The patient’s self-reporting of presence or absence of autophony was used as the outcome measure as (1) complete relief; (2) significant improvement, satisfied; (3) significant improvement, dissatisfied; (4) unchanged; and (5) worse [18]. The continuity of postoperative habitual sniffing was assessed in the same manner before surgery. To evaluate PET symptoms during the preoperative and postoperative periods, a PET handicap inventory-10 (PHI-10) scoring system was also used [16]. The postoperative PHI-10 outcome measurement was defined as: (1) complete relief (0–8 points); (2) significant improvement (10–16 points); (3) slight improvement (18–24 points); (4) unchanged (26–40 points) (Table 1) [19]. The study was approved by Insti-

Table 1. Patulous eustachian tube handicap inventory-10 (PHI-10) questionnaire [19]

| No. | Question | Never | Moderate | Severe |
|-----|----------|-------|----------|--------|
| 1   | Because of your symptom, is it difficult for you to concentrate? | 0 | 2 | 4 |
| 2   | Does the loudness of your symptom make it difficult for you to hear people? | 0 | 2 | 4 |
| 3   | Does your symptom make you angry? | 0 | 2 | 4 |
| 4   | Do you feel as though you cannot escape your symptom? | 0 | 2 | 4 |
| 5   | Does your symptom interfere with your ability to enjoy social activities? | 0 | 2 | 4 |
| 6   | Because of your symptom, do you feel frustrated? | 0 | 2 | 4 |
| 7   | Does your symptom interfere with your job or household responsibilities? | 0 | 2 | 4 |
| 8   | Do you feel that your symptom has replaced stress on your relationships with members of your family and friends? | 0 | 2 | 4 |
| 9   | Do you find it difficult to focus your attention away from your symptom and on to other things? | 0 | 2 | 4 |
| 10  | Does your symptom make you feel anxious? | 0 | 2 | 4 |

Fig. 1. Image of bone wax filled “tripod”-shaped catheter.

**HIGHLIGHTS**

- Eustachian tube catheter insertion performed simultaneously with cholesteatoma surgery could be helpful to reduce aural symptoms and stop habitual sniffing.
- Eustachian tube catheter insertion performed simultaneously with cholesteatoma surgery might help in preventing cholesteatoma recurrence.
- The presence of habitual sniffing and patulous eustachian tube must be evaluated before cholesteatoma surgery.
Institutional Review Board of Pusan National University Hospital (IRB No. H-1712-012-062) and informed consent was waived.

Surgical technique

All patients underwent atticotomy or simple mastoidectomy to remove acquired cholesteatoma. Additional ET catheter insertion was performed simultaneously with cholesteatoma surgery. The diameter and length of the ET was variable. We determined the diameter and length of the catheter based on previous studies [13,14]. To design the catheter which would be inserted, we

![Fig. 2](image1.png)

**Fig. 2.** The estimated length from the isthmus to the bony orifice of eustachian tube (ET) is 16.1 mm (red line). The estimated length from the isthmus to the nasopharyngeal orifice of ET is 23.2 mm (white line). Isthmus of ET is located between the dilated visualized segment and the undilated nonvisualized segment of ET (arrow).

![Fig. 3](image2.png)

**Fig. 3.** The length of the catheter was 25 mm. The tip of the catheter passed the isthmus of the eustachian tube and partially obstructed the eustachian tube.

| Patient | Sex/age | Habitual sniffing | PET-related aural symptom | PET side | Cholesteatoma side | Cholesteatoma type | Operation | Length from isthmus to bony orifice (mm) | Design of ET catheter | Follow-up (mo) | Preoperative mean dB HL | Postoperative mean dB HL |
|---------|---------|-------------------|--------------------------|----------|-------------------|------------------|-----------|----------------------------------------|-----------------------|---------------|-------------------------|-------------------------|
| 1       | F/65    | Yes               | Autophony pressure sensation | Both     | Both              | Pars flaccida    | SM+T4     | 17.0                                    | 20 G, 25 mm            | 37            | 63                      | 55                      |
| 2       | F/33    | Yes               | Autophony hyperacusis     | Both     | Right             | Pars flaccida    | SM+T4     | 14.3                                    | 18 G, 20 mm            | 35            | 22                      | 17                      |
| 3       | M/20    | Yes               | Autophony                 | Right    | Right             | Pars flaccida    | Aticochmy+T1 | 16.2                                    | 20 G, 25 mm            | 29            | 17                      | 9                       |
| 4       | F/32    | Yes               | Autophony hyperacusis     | Right    | Left              | Pars flaccida    | Aticochmy+T1 | 16.2                                    | 20 G, 25 mm            | 24            | 17                      | 10                      |
| 5       | F/51    | Yes               | Autophony hyperacusis     | Left     | Left              | Pars flaccida    | Aticochmy+T1 | 16.1                                    | 18 G, 25 mm            | 30            | 25                      | 12                      |
| 6       | F/39    | Yes               | Autophony pressure sensation | Right    | Right             | Pars flaccida    | Aticochmy+T1 | 16.1                                    | 18 G, 25 mm            | 20            | 16                      | 21                      |
| 7       | F/27    | Yes               | Autophony pressure sensation | Both     | Right             | Pars flaccida    | Aticochmy+T1 | 16.1                                    | 18 G, 25 mm            | 20            | 16                      | 17                      |
| 8       | F/38    | Yes               | Autophony                 | Right    | Left              | Pars flaccida    | Aticochmy+T1 | 16.1                                    | 18 G, 25 mm            | 19            | 16                      | 17                      |
| 9       | M/38    | Yes               | Autophony pressure sensation | Left     | Left              | Pars flaccida    | Aticochmy+T1 | 16.1                                    | 18 G, 25 mm            | 16            | 16                      | 17                      |

Table 2: Overview of all treated patients

PET, patulous eustachian tube; ET, eustachian tube; HL, hearing level; AC, air conduction; BC, bone conduction; F, female; M, male; SM, simple mastoidectomy; T, tympanoplasty.

*Patient 5 failed to perform Valsalva maneuver simultaneously during computed tomography under supine position.*
used 18 G (length, 20 mm or 25 mm; diameter, 1.3 mm) and 20 G catheter (length, 20 mm or 25 mm; diameter, 1.1 mm). One end of the catheter was filled with bone-wax, the other end was divided into three sections with a length of 5 mm. Next, we spread the three arms to make a tripod (Fig. 1). The length from the isthmus to the bony orifice of ET was variable. We estimated the length preoperatively by temporal bone computed tomography while the patient was actively performing the Valsalva maneuver simultaneously [20]. Multiplanar reconstruction of the images in the axis of the ET was performed (Fig. 2). The length of the catheter covered the distance from the isthmus to the bony orifice of the ET. Using a 30°, 2.7-mm endoscope, the bony orifice of ET was visualized. The catheter tip filled with bone-wax was smoothly inserted into the bony orifice of ET until the resistance of the isthmus was felt (Fig. 3). The placement of catheter was confirmed with endoscopic visualization.

RESULTS

Additional ET catheter insertion was performed in nine ears of nine patients (two men and seven women; age, 20–65 years; average, 37.9 ± 12.0 years) with acquired cholesteatoma associated with PET and habitual sniffing who underwent cholesteatoma surgery (Table 2). In this study, all patients were confirmed PET preoperatively by symptoms together with directly observing

| Patient | Operation | Autophony          | PHI-10 score          |
|---------|-----------|--------------------|-----------------------|
|         |           | Preoperative | Postoperative | Preoperative | Postoperative |
| 1       | SM+T4     | Presence       | Significant improvement, satisfied | 16            | 8              |
| 2       | SM+T1     | Presence       | Significant improvement, satisfied | 20            | 10             |
| 3       | Atticotomy+T1 | Presence     | Complete relief        | 10            | 3              |
| 4       | Atticotomy+T1 | Presence     | Complete relief        | 2             | 0              |
| 5       | Atticotomy+T1 | Presence     | Significant improvement, satisfied | 8             | 5              |
| 6       | Atticotomy+T1 | Presence     | Significant improvement, satisfied | 12            | 2              |
| 7       | SM+atticotomy+T1 | Presence | Significant improvement, satisfied | 22            | 4              |
| 8       | Atticotomy+T1 | Presence     | Significant improvement, satisfied | 16            | 2              |
| 9       | SM+atticotomy+T3 | Presence | Complete relief        | 36            | 2              |

PHI-10, patulous eustachian tube handicap inventory-10; SM, simple mastoidectomy; T, tympanoplasty.

Fig. 4. (A) Temporal bone computed tomography 3 months after atticotomy and tympanoplasty type I with additional eustachian tube catheter insertion (right ear) showing good middle ear aeration and mastoid cavity pneumatization. Catheter (arrow) is located in the bony orifice of the eustachian tube. (B) Temporal bone computed tomography 12 months after atticotomy and tympanoplasty type I with additional eustachian tube catheter insertion (left ear) showing good middle ear aeration. Catheter (arrowhead) is located in the bony orifice of the eustachian tube.
the inward and outward movement of the TM at the same time as forced nasal breathing. Patients consisted of nine pars flaccida type (100%). Only one of nine sides had an air conduction hearing level worse than 60 dB in this study group. In contrast, eight of nine sides had a hearing level better than 60 dB. One patient had bilateral cholesteatoma. Cholesteatoma surgery with additional ET catheter insertion was performed sequentially in both ears. Three patients (three ears) had the bilateral PET with unilateral cholesteatoma. The same procedure was performed for the cholesteatoma side; in addition, we inserted the catheter through the myringotomy site and placed into the bony orifice of the other ET as well. The average duration of preoperative habitual sniffing was 17.8 years (range, 10 to 30 years). Follow-up duration ranged from 16 to 37 months, with an average of 25.4 months. During an average follow-up of 25.4 months, no cholesteatoma recurrence has occurred to date. All patients had improved aural symptoms such as autophony, and stopped sniffing. Outcomes with respect to relief from autophony are presented in Table 3. One case developed otitis media with effusion (OME) after postcatheterization; OME resolved spontaneously without treatment. We confirmed good middle ear aeration at 3 months and 12 months postoperatively (Fig. 4). The preoperative and postoperative PHI-10 scores were 15.8 ± 9.2 and 4.1 ± 3.0, respectively (P < 0.001) (Fig. 5). According to outcome measurement for relief of PET symptoms after surgery, complete relief was reported for eight ears (88.9%) and one ear (11.1%) experienced significant improvement (Table 3).

DISCUSSION

In this study, we performed ET catheter insertion to partially occlude the ET simultaneously with cholesteatoma surgery (atticoctomy or simple mastoidectomy) in patients with acquired cholesteatoma associated with PET and habitual sniffing. The average duration of preoperative habitual sniffing of the patient was 17.8 years (range, 10 to 30 years). We hypothesized that the only detailed explanation of their symptoms and mechanism of sniffing were not sufficient for these patients.

Our results showed that 88.9% of patients were satisfied with the complete relief of PET symptoms after surgery. However, autophony grade showed complete relief in 33.3% and significant improvement, satisfied in 66.7% of patients. The difference between the PHI-10 score and the autophony grade is thought to be because the PHI-10 score is not a simple questionnaire but the sum of scores for each of the 10 symptoms. Moreover, no cholesteatoma recurrence has occurred in any patient to-date. Patients stopped sniffing with an aerated middle ear without tympanic retraction. Otologic surgeons have occasionally observed retraction of tympanic membrane that caused recurrent cholesteatoma after surgery. In most cases, the mechanical or functional obstruction of the ET has been regarded as a major factor in the pathogenesis of retraction-type middle ear diseases. However, otologic surgeons must carefully evaluate the patients from another perspective in case of acquired cholesteatoma associated with PET and habitual sniffing. Contrary to the widely accepted concept that the pathogenesis of cholesteatoma is caused by ET dilatory dysfunction, it is important to note that, although rare, that habitual sniffing in patients with ET patulous dysfunction is closely related to the pathogenesis of cholesteatoma.

Management of middle ear cholesteatoma is mostly surgical and aims to make a safe ear without residual or recurrent cholesteatoma. Optimizing hearing and creating a non-discharging, self-cleaning ear are also important goals of cholesteatoma surgery [21]. However, most otologic surgeons mainly concentrate on eradicating pathologic lesions and overlook important points to eliminate the triggering factor. Previous studies have reported that habitual sniffing in patients with PET is closely related to the pathogenesis of cholesteatoma [1-12]. In 1996, Kobayashi et al. [9] first reported that patients with cholesteatoma had a significantly higher prevalence of habitual sniffing (27.7%) than healthy subjects (1.5%) and that habitual sniffing was found to be more common in the pars flaccida type (32.3%) than in the pars tensa type (0%). Ohta et al. [10] reported that 25.7% of patients with cholesteatoma had a PET, and 27.4% of them were habitual sniffers. Ikeda reported that 23.4% of PET patients were found to possess evident sniffing habit and retraction-type middle ear diseases were significantly more common in PET patients with habitual sniffing (53.6%) compared with PET patients without habitual sniffing (12.8%) [1]. Habitual sniffing has been claimed to be a significant contributing factor to the development of postoperative retraction of the reconstructed posterior meatal wall and tympanic membrane [2]. Kawase et al. [22] reported severe retraction of the posterior meatal wall was found in 7 of 8 patients with habitual sniffing, but was significantly less (22 of 47) in ears without habitual sniffing. Yamamoto-Fukuda et al. [23] indicated that a tympanostomy tube was found to be effective in preventing the development of postop-
Habitual sniffing and PET may play a role in the pathogenesis of acquired cholesteatoma. When otologic surgeons decide to operate on cases with acquired cholesteatoma, the presence of habitual sniffing and PET must be evaluated. In case of acquired cholesteatoma associated with these issues, additional ET catheter insertion performed simultaneously with cholesteatoma surgery could be helpful in obviating habitual sniffing and preventing recurrence of cholesteatoma.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

ORCID

Sung-Won Choi https://orcid.org/0000-0002-7463-7720
Dong-Joo Lee https://orcid.org/0000-0001-6219-2384
Seok-Hwan Lee https://orcid.org/0000-0002-5044-6735
Se-Joon Oh https://orcid.org/0000-0001-8910-0064
Soo-Keun Kong https://orcid.org/0000-0002-6783-3766

AUTHOR CONTRIBUTIONS

Conceptualization: SKK. Data curation: DJL. Formal analysis: SHL. Methodology: SWC. Project administration: SKK. Visualization: SJO. Writing - original draft: SWC. Writing - review & editing: SKK.

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