Sensorineural hearing loss following tympanoplasty surgery: a prospective cohort study

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Objectives
Sensorineural hearing loss (SNHL) subsequent to middle-ear surgery is an important yet under-reported complication. Our aim is to assess the prevalence of this complication and to identify the risk factors for SNHL after type 1 tympanoplasties.

Materials and methods
In this prospective cohort study, a total of 312 patients with tubotympanic chronic suppurative otitis media and pure conductive hearing loss were included. The patients were evaluated using case histories, clinical examinations, preoperative and postoperative (3, 6, and 12 months) audiograms, and laboratory investigations. All patients underwent type 1 tympanoplasties, the surgical details were noted, and the prevalence of SNHL as a consequence of the surgical procedure was recorded.

Results
Sixteen patients (5.1%) developed SNHL. Fifteen operations were performed by residents, and one was performed by a consultant.

Conclusion
We concluded that the most important factor in the development of SNHL after a type 1 tympanoplasty is the surgeon's experience.

Keywords:
sensorineural hearing loss, surgeon's experience, tympanoplasty

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Introduction

Chronic suppurative otitis media (CSOM) without cholesteatoma is defined as a persistent ear infection in the presence of a tympanic membrane perforation and continuous or recurrent ear discharge, usually with conductive hearing loss (CHL). When medical management fails, surgery (tympanoplasty) is generally indicated to repair the perforated eardrum and improve hearing.

Although tympanoplasty is typically a straightforward procedure with a high rate of successful tympanic membrane closure, the rates reported in the literature vary greatly (35–98%) but are generally greater than 80% [1,2].

Intraoperative complications, including injury to the cochlea with partial or total sensorineural hearing loss (SNHL), can occur.

The risk of partial or total SNHL after tympanoplasty type 1 has been reported to range from 1 to 5% [3]. Although the conductive loss can be corrected through surgery, SNHL is permanent and treated only through the use of a hearing aid.

Many published studies have addressed the issue of SNHL after middle-ear surgery, but the majority of these studies included all types of middle-ear surgery in their evaluation, including canal wall down and canal wall up procedures for cholesteatoma, tympanosclerosis, otosclerosis congenital malformations, granulating otitis, and plain tympanoplasty. In addition, these studies were mostly conducted during the immediate postoperative period or during a short postoperative follow-up [4–6].

However, few studies have discussed the prevalence of SNHL after tympanoplasty type 1 procedure with extended patient follow-up [7]. To date, SNHL subsequent to tympanoplasty surgery is an important complication of middle-ear surgery. Lack of proper knowledge concerning this problem is attributed to under-reporting of the exact magnitude of SNHL.

The objectives of this prospective cohort study are to detect the prevalence of SNHL in patients undergoing tympanoplasty surgery, explore the factors contributing to SNHL following type 1 tympanoplasties,

and increase awareness of this under-reported complication.

Materials and methods

This cohort prospective study was conducted at the ENT Department of the Medical College at King Saud University, Riyadh, Saudi Arabia, from January 2002 to December 2012.

In total, 1367 patients who were referred to the otology clinic at our Tertiary Care Teaching Hospital from primary care or other referral centers with a history of ear discharge were subjected to a full history and clinical examination, including the use of an otomicroscope, by an otorhinolaryngologist. Patients from 15 to 45 years of age with CSOM and central perforations without a history of previous ear surgery, occupational noise exposure, use of systemic ototoxic medications, and medical problems such as diabetes mellitus and meningitis were selected. The selected patients were referred to the audiology clinic for a hearing assessment through conventional audiometry using a Beltone 2000 clinical audiometer (Beltone Electronics Corporation, Glenview, Illinois, USA) to measure hearing thresholds as low as 10 dB HL in the 125–8000 Hz range. All measurements were taken in an audiometric room and fulfilled the criteria of ISO/DIS 6189.2 (1982). All bone conduction testing was performed with masking applied to the opposite ear.

Only patients with pure CHL ranging from 20 to 40 dB HL were included in the study. With a mean age of 28.30 years, 312 patients (151 male and 161 female) met the inclusion criteria.

All 312 patients who met the inclusion criteria were scheduled for type 1 tympanoplasties. One week before surgery the patients were subjected to routine laboratory investigations, including full blood count, urea and creatinine levels, bleeding time, and preoperative audiogram.

All surgical procedures were performed under general anaesthesia. The operations were primarily performed by senior residents in training under the supervision of consultants. When the rotating residents were junior or unavailable because of educational courses or examinations, department consultants performed the surgery. All of the surgical details, including whether the surgery was performed by a consultant or resident, the type of surgical approach (postauricular, transcanal, or end aural), the graft type (temporalis fascia or homograft), ossicular chain status (fixed or disconnected) and ossicular manipulation during surgery, the use of drills, grafting technique (under or overlay), and the use of suctions, were noted.

Postoperatively, patients underwent follow-up testing at 3, 6, and 12 months using pure-tone audiometry from 250 to 8000 Hz. Improvements in hearing by at least 10 dB and air-bone gaps of less than 25 dB at the 12-month follow-up were considered successes [8].

Bone conduction audiometric thresholds were calculated and compared preoperatively and postoperatively. Worsening of bone conduction thresholds by 10 dB or more through the frequencies of 500 to 4000 Hz was considered indicative of SNHL resulting from the surgical procedure [6].

Statistical analyses were performed using statistical package for social sciences, version 19 (SPSS Inc., Chicago, Illinois, USA). Data for nominal variables are expressed as percentages and were compared using the χ^2-tests or Fisher's exact tests. The results were considered statistically significant if the *P*-value was less than 0.05.

This study was approved by the Institutional Review Board at our hospital, and all patients consented to surgery after the procedure and its complications had been explained to them.

Results

Out of 1367 patients, 312 patients who met our inclusion and exclusion criteria underwent type 1 tympanoplasties for the first time, and four patients lost to follow-up were excluded from the study. The clinical presentations of those patients are presented in Table 1.

A postauricular approach was employed in 303 patients (98%), and a transcanal approach was used in five patients (2%). A drill was used in 47 patients (15%) to drill the spine of Henle, the prominent posterior external auditory canal that obscures views. In total, ossicular movement was assessed during surgery in

Table 1 Clinical presentations of the patients

Age	Sex		Site of perforation			Hearing loss		Ear discharge		Tinnitus		Vertigo	
15–45 years	Male	Female	Right	Left	Bilateral	Yes	No	Yes	No	Yes	No	Yes	No
	151	161	111	106	95	299	13	278	34	72	240	20	292

252 patients (82%). In addition, 304 patients (99%) received a temporalis fascia graft, and four patients (1%) received a homograft. Eighty-one (26%) of the cases were performed by consultants with a success rate of 88%, and 227 (74%) cases were performed by residents with a success rate of 84% (Table 2).

Regarding graft uptake, our study revealed an overall success rate of 85% after 1 year of follow-up.

Improvements in hearing were observed in 69% of the cases. The criteria for successful hearing improvement after the 12-month follow-up were an improvement of at least 10 dB and air-bone gaps of less than 25 dB.

Sixteen patients (5%) developed SNHL in the range of 500–4000 Hz. A change greater than 10 dB between the preoperative and postoperative average bone conduction thresholds at 0.5, 1, 2, and 4 kHz was considered significant. All of them were noticed in the first audiogram postoperatively.

Table 2 Surgical details of the patients

Surgeon	
Consultant	81
Resident	227
Surgical approach	
Postauricular	303
Transcanal	5
Type of graft	
Temporalis fascia	304
Homograft	4
Use of drill	
Yes	47
No	259
Not reported	2
Graft placement	
Underlay	301
Overlay	2
Not reported	5
Ossicular movement check-up	
Yes	252
No	32
Not reported	24

When considering higher thresholds from 4000 to 8000 Hz, we did not detect SNHL. However, we did not measure frequencies greater than 8000 Hz.

With regard to the causes of SNHL in those patients, we found that the use of a drill, assessment of ossicular movement, graft placement technique, and type of graft and surgical approach had no effect statistically on SNHL development in our patients (Table 3). However, of 81 surgeries performed by consultants, only one patient developed SNHL. In contrast, of 227 surgeries performed by residents, 15 patients developed SNHL ($P < 0.05$; Table 4). Thus, the surgeon's experience was a significant factor in our study, although no specific technical mistakes were noticed or documented in the cases managed by residents.

Discussion

SNHL after tympanoplasty surgery is a well-known complication. Despite its occurrence, we believe this complication is under-reported.

In this prospective cohort study of 308 patients experiencing CHL due to CSOM and undergoing tympanoplasty, we explored the factors contributing to SNHL following tympanoplasty surgery.

We studied the effects of the following factors: use of drills and suctions, ossicular movement, surgical approach, graft placement technique, graft type, and the surgeon's experience.

Many studies have discussed the effect of drills and suction on hearing [8–13], with contradicting results; however, many of these studies suggested that drilling contributes to SNHL after surgery [9,11].

Parkin and Wood [11] reported that sound levels above 115 dB can cause sensorineural damage if sustained for more than 15 min. In addition, the noise from aspiration also appears to be significant, adding 10–31 dB to the noise from drilling alone. Chen *et al.* [12] investigated the effect of noise generated during tympanoplasty

Table 3 Parameters used to assess the prevalence of post-tympanoplasty SNHL

Factors	Total patients	Patients with SNHL	*P*-value
Surgeon/residents	227	15	0.047
Surgeon/consultants	81	1	
Drill use	46	1	0.269
Failure of surgery	42	0	0.076
Ossicular movement	252	15	0.441
Graft placement technique	Overlay used in only two patients (in the remainder of the patients underlay was used)		
Type of graft	Temporalis facia was used in all patients, except four cases in which homograft was used		
Surgical approach	Postauricular approach was used in all patients, except five patients in which the transcanal approach was used		

SNHL, sensorineural hearing loss.

Table 4 Cases performed by consultants and residents that resulted in SNHL

Post-operative SNHL	Surgery performed by		Total
	Consultant	Resident	
SNHL 500–4000			
Yes			
Count	1	15	16
With SNHL 500–4000 (%)	6.3	93.8	100
Within surgery (%)	1.2	6.6	5.2
No			
Count	80	212	292
With SNHL 500–4000 (%)	27.4	72.6	100
Within surgery (%)	98.8	93.4	94.8
Total			
Count	81	227	308
With SNHL 500–4000 (%)	26.3	73.7	100
Within surgery (%)	100	100	100

SNHL, sensorineural hearing loss.

by otologic drills and suctions on the cochlea in the operated and nonoperated ears. The results indicate no statistically significant difference between prenoise and 1-month postnoise bone conduction thresholds in both operated and nonoperated ears. Thus, the researchers concluded that otologic drills and suction are safe for the patients and that there is no apparent harmful effect on cochlear function in either ear after tympanoplasty.

Hüttenbrink [13] also studied the reaction of the cochlea after the trauma of middle-ear surgery using the following three surgical techniques: stapes surgery with the opening of the inner ear; mastoidectomy with drill-generated noise; and tympanoplasty with manipulations at the stapes. The researchers found that excessive drilling may result in a temporary threshold shift in hearing, but no signs of permanent hearing loss were evident.

Drills were used in 46 of our patients (15%). Only one patient developed SNHL involving frequencies from 2 to 4 kHz. A resident operated on this patient, making drills a nonsignificant factor.

Many authors cite ossicular manipulation as a contributing factor to SNHL caused by surgery [7–12]; these authors postulate that excessive manipulation can cause acoustic trauma to the inner ear, especially at high frequencies. However, other researchers [6,13] did not discover any signs of acoustic damage after ossicular manipulation even at the stapes. In our study, ossicular movement was assessed in 237 patients (77%); 15 of these patients (6%) developed SNHL, but it was not statistically significant.

In a study performed at our institute 18 years ago [14], a total of 2015 ears with CSOM but without cholesteatoma underwent operation during a 9-year period. In this study, the results of grafting and closure of air-bone gap to within 10 dB were enhanced using temporalis fascia compared with dura grafts. Postoperative SNHL at 4000 kHz was more prevalent in cases using dura graft (6%) compared with temporalis fascia (1.9%). However, in our current study, we observed that the graft placement technique, type of graft, and surgical approach did not affect postoperative SNHL development.

In our study, the tympanoplasty success rates were 88% when performed by consultants and 84% when performed by residents. In addition, we identified a surgeon's experience as the most important causative factor of SNHL in our cases. Among the 81 patients (26%) who underwent surgeries performed by consultants, only one patient (1%) developed SNHL. In contrast, 15 (7%) of 227 patients (74%) who underwent surgeries performed by residents developed SNHL.

Some authors have reported surgical experience as a factor affecting the results of surgery [7,15–18]. Fukuchi *et al.* [16] concluded that the low grafting success rates (65%) reported in their study were due to the procedures being performed by second-year medical residents.

Vartiainen and Nuutinen [17] studied the success of myringoplasty in 404 cases and found that the patient's age, the size or site of perforation, and the surgical technique (underlay or overlay) did not affect the success rate. In addition, the surgeon's experience was cited as the most decisive factor influencing the results.

Emir *et al.* [18] performed a study on 607 patients to identify the factors that influenced the success rate of type 1 tympanoplasty in a tertiary care center at which both residents and senior surgeons perform this operation. In this study, the senior surgeons had better results with large perforations and older patients.

Black and Wormald [7] described poor postoperative hearing results and SNHL in a study of 211 consecutive myringoplasties performed over 1 year. This study cited the experience of the surgeon and the size of the perforation as the most significant factors influencing the postoperative hearing results and SNHL. In addition, a 4.5% incidence of postoperative SNHL was reported in this study.

However, other studies report that the outcome of tympanoplasty is not affected by the surgeon's experience [19].

Despite surgical technical advances, SNHL remains an important under-reported complication associated with type 1 tympanoplasty. This complication causes permanent hearing loss that is only attenuated through use of a hearing aid. A surgeon's experience is an important factor in determining the likelihood of a successful surgical outcome; this illustrates the learning curve in tympanoplasty surgery.

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Conflicts of interest
There are no conflicts of interest.

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