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Research Article

Incidence and Risk Factors of Sensorineural Hearing Loss After Mastoidectomy for Chronic Otitis Media: A Prospective Study

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ABSTRACT

Objective: To evaluate the incidence, severity, and recovery of sensorineural hearing loss (SNHL) in patients undergoing mastoidectomy for chronic otitis media (COM), and to identify associated surgical risk factors.
Methods: A prospective comparative study was conducted at Upgraded Institute of Otorhinolaryngology, Madras Medical College, Chennai, India) from May 2017 to October 2018. One hundred adults aged 18–60 years with unilateral COM (tubotympanic or atticoantral type) requiring cortical or modified radical mastoidectomy. Patients with pre-existing SNHL, bilateral COM, prior otologic surgery, or systemic conditions affecting hearing were excluded. Preoperative and postoperative hearing was assessed using pure tone audiometry (PTA) and distortion product otoacoustic emissions (DPOAE) at 6 hours, 24 hours, 48 hours, 72 hours, 96 hours, 1 month, and 3 months post-surgery. Paired t-tests, independent t-tests, and chi-square tests were used for statistical analysis ($p<0.05$).
Results: SNHL occurred in 22% of patients (12% ipsilateral, 10% contralateral), with 16% experiencing temporary threshold shifts (TTS) recovering within 2 months and 6% showing permanent threshold shifts (PTS). Ipsilateral high-frequency (>2000 Hz) thresholds increased significantly post-surgery ($p=0.01$–0.03), with partial recovery by 3 months. Contralateral thresholds showed milder, non-significant shifts ($p>0.05$). Drilling duration >1 hour ($p=0.02$), cutting burr use ($p=0.04$), and ossicular manipulation ($p=0.01$) were associated with SNHL. DPOAE amplitudes decreased significantly in the ipsilateral ear ($p=0.04$).
Conclusions: Mastoidectomy for COM carries a 22% risk of SNHL, primarily temporary and high-frequency, with permanent loss in 6%. Prolonged drilling, cutting burrs, and ossicular manipulation increase risk.

***Keywords**: Chronic Otitis Media, Mastoidectomy, Sensorineural Hearing Loss, Pure Tone Audiometry, Otoacoustic Emissions, Surgical Complications.*

INTRODUCTION

Chronic otitis media (COM) is a prevalent condition in developing countries, characterized by chronic inflammation of the middle ear cleft, tympanic membrane perforation, and persistent ear discharge [1]. Previously termed chronic suppurative otitis media (CSOM), the nomenclature shifted to COM as infection is not consistently present [2]. COM is classified into tubotympanic (safe) and atticoantral (unsafe) types, with the latter often involving cholesteatoma, increasing the risk of complications such as ossicular necrosis and intracranial sequelae [3].

Mastoidectomy, a surgical procedure to remove diseased mastoid air cells, is a cornerstone treatment for COM when medical management fails or complications arise [4]. Despite its efficacy in controlling infection and preventing disease progression, mastoidectomy poses risks to auditory function, notably sensorineural hearing loss (SNHL) [5].

SNHL following mastoidectomy may result from multiple intraoperative factors, including drill-induced noise, vibration, suction irrigation, and ossicular manipulation [6]. High-speed microdrills generate noise levels exceeding 90 dB in the ipsilateral ear and 80–85 dB in the contralateral ear, potentially causing acoustic trauma to cochlear hair cells [7]. Vibrations from drilling may transmit through the temporal bone, disrupting cochlear fluid dynamics or damaging hair cells directly [8].

Thermal injury from the rotating burr, particularly near the labyrinth, can exacerbate cochlear damage, while suction irrigation may amplify noise and induce pressure changes [9]. Excessive ossicular manipulation, especially inadvertent contact with the stapes footplate, can lead to labyrinthine injury, resulting in temporary threshold shifts (TTS) or permanent threshold shifts (PTS) [10].

The pathophysiology of SNHL in this context is complex. Drill-induced noise primarily affects outer hair cells, which are more susceptible to high-intensity sound, leading to hearing loss, particularly at frequencies above 2000 Hz [11]. Vibration-induced trauma may cause mechanical stress on cochlear structures, while thermal injury can impair the stria vascularis, disrupting the endocochlear potential [12]. Contralateral SNHL, though less frequent, occurs due to skull-transmitted vibrations, highlighting the bilateral risk of otologic surgery [13].

Previous studies report SNHL incidences ranging from 0% to 31%, with most cases being temporary and resolving within days to weeks [14]. However, comprehensive evaluations of both ipsilateral and contralateral hearing using pure tone audiometry (PTA) and otoacoustic emissions (OAE) are limited, and factors such as drilling duration, burr type, and surgeon experience require further exploration [15].

This study aims to address these gaps by evaluating the incidence, severity, and recovery of SNHL in patients undergoing cortical or modified radical mastoidectomy for COM. The primary objective was to compare pre- and postoperative hearing levels in both ears to quantify SNHL incidence. Secondary objectives included assessing recovery duration, identifying surgical risk factors (e.g., drilling time, burr type, suction irrigation), and evaluating the role of ossicular manipulation. Conducted at a tertiary care hospital in Chennai, India, this prospective study of 100 patients provides robust data to inform surgical practices and enhance patient outcomes. This manuscript presents the methodology, results, and implications, structured for submission to a high-impact otolaryngology journal.

MATERIALS AND METHODS

Study Setting: The study was conducted at the Upgraded Institute of Otorhinolaryngology, Madras Medical College, and Rajiv Gandhi Government General Hospital, Chennai, India, a tertiary referral center with specialized otologic services. Data were collected from May 2017 to October 2018.

Study Participants: Eligible participants were adults aged 18–60 years diagnosed with unilateral COM (tubotympanic or atticoantral type) requiring cortical or modified radical mastoidectomy. Inclusion criteria included persistent ear discharge, tympanic membrane perforation, or cholesteatoma confirmed by otoscopy and high-resolution computed tomography (HRCT) of the temporal bone, and willingness to comply with follow-up. Exclusion criteria comprised pre-existing SNHL (bone conduction thresholds >30 dB at 500–4000 Hz), bilateral COM, prior otologic surgery, congenital ear anomalies, systemic conditions affecting hearing (e.g., diabetes, ototoxic drug exposure), or refusal of informed consent.

Sample Size and Sampling Technique: Based on a prior study reporting a 10% SNHL incidence [14], a sample size of 100 was calculated to detect a 15 dB difference in bone conduction thresholds with 80% power, 5% significance level, and 10% attrition rate. Consecutive patients meeting inclusion criteria were enrolled using non-probability convenience sampling.

Study Tools: Audiological assessments included PTA to measure air and bone conduction thresholds at 250, 500, 1000, 2000, 4000, and 8000 Hz, conducted in a soundproof room using a calibrated audiometer. OAE, specifically distortion product otoacoustic emissions (DPOAE), assessed outer hair cell function. Additional tools included a structured proforma for demographic, clinical, and intraoperative data (e.g., drilling duration, burr type, ossicular status), HRCT of the temporal bone, and tuning fork tests (Rinne, Weber, absolute bone conduction) for clinical correlation.

Study Methodology: This prospective comparative study enrolled 100 patients undergoing mastoidectomy for COM. Preoperative PTA and OAE were performed within one week before surgery. Surgical procedures (cortical or modified radical mastoidectomy) were conducted under general anesthesia using a retroauricular approach, high-speed microdrill (tungsten or diamond burr), and continuous suction irrigation. Intraoperative findings, including drilling duration, burr type, and ossicular chain status, were recorded. Postoperative PTA and OAE were conducted at 6 hours, 24 hours, 48 hours, 72 hours, 96 hours, 1 month, and 3 months to detect TTS (recovery within 2 months) and PTS (persistent at 3 months). SNHL was defined as a bone conduction threshold shift of ≥15 dB at any frequency or a reduction in OAE amplitude.

Ethical Issues: The study received approval from the Institutional Ethics Committee of Madras Medical College. Written informed consent was obtained from all participants after explaining study objectives, procedures, and risks. Data were anonymized to ensure confidentiality, and participants could withdraw without impacting their care.

Statistical Analysis: Data were analyzed using SPSS version 22. Continuous variables (e.g., bone conduction thresholds, drilling duration) were reported as means ± standard deviations, and categorical variables (e.g., SNHL incidence, burr type) as frequencies and percentages. Paired t-tests compared pre- and postoperative bone conduction thresholds within groups, and independent t-tests assessed differences between ipsilateral and contralateral ears. Chi-square tests evaluated associations between SNHL and surgical factors (e.g., drilling duration >1 hour, ossicular manipulation). A p-value <0.05 was considered statistically significant.

RESULTS

All 100 enrolled patients completed the study with no attrition. The mean age was 34.6 ± 10.2 years, with 58% male and 42% female. Fifty-two patients underwent cortical mastoidectomy for tubotympanic COM, and 48 had modified radical mastoidectomy for atticoantral COM. Baseline bone conduction thresholds were comparable between groups, with no significant differences in age, sex, or disease duration (Table 1).

Table 1: Baseline Characteristics of Study Participants

Variable	Cortical Mastoidectomy (n=52)	Modified Radical Mastoidectomy (n=48)	p-value
Age (years)	33.8 ± 9.7	35.5 ± 10.8	0.38
Male, n (%)	29 (56%)	29 (60%)	0.69
Disease Duration (years)	4.2 ± 2.1	5.1 ± 2.4	0.07
Bone Conduction (dB)	18.4 ± 5.3	19.1 ± 5.7	0.54

Postoperative SNHL occurred in 22 (22%) patients, with 12 (12%) in the ipsilateral ear and 10 (10%) in the contralateral ear. Of these, 16 (16%) had TTS, recovering within 2 months, and 6 (6%) had PTS at 3 months (Table 2). Among PTS cases, 4 (4%) exhibited total hearing loss (>100 dB) in the ipsilateral ear.

Table 2: Incidence of Sensorineural Hearing Loss Post-Mastoidectomy

Hearing Loss Type	Ipsilateral Ear (n=100)	Contralateral Ear (n=100)	Total (n=100)
Temporary (TTS), n (%)	7 (7%)	9 (9%)	16 (16%)
Permanent (PTS), n (%)	5 (5%)	1 (1%)	6 (6%)
Total SNHL, n (%)	12 (12%)	10 (10%)	22 (22%)

Table 3 shows ipsilateral ear bone conduction thresholds across three frequencies. At 2000 Hz, thresholds increased from 18.2 dB preoperatively to 25.6 dB at 6 hours, recovering to 20.4 dB at 1 month and 19.1 dB at 3 months (p=0.12, non-significant). At 4000 Hz, thresholds rose from 19.4 dB to 28.3 dB, recovering to 22.7 dB and 21.3 dB (p=0.03, significant). At 8000 Hz, thresholds increased from 20.1 dB to 30.5 dB, recovering to 24.1 dB and 22.8 dB (p=0.01, significant). Significant persistent shifts at higher frequencies indicate greater susceptibility to surgical trauma.

Table 3: Bone Conduction Thresholds in Ipsilateral Ear (dB)

Frequency (Hz)	Preoperative	6 Hours Postop	1 Month Postop	3 Months Postop	p-value (Pre vs. 3 Months)
2000	18.2 ± 5.1	25.6 ± 7.3	20.4 ± 5.8	19.1 ± 5.4	0.12
4000	19.4 ± 5.5	28.3 ± 8.1	22.7 ± 6.4	21.3 ± 5.9	0.03
8000	20.1 ± 5.8	30.5 ± 9.2	24.1 ± 7.0	22.8 ± 6.3	0.01

Table 4 details contralateral ear thresholds. At 2000 Hz, thresholds increased from 17.9 dB to 20.3 dB at 6 hours, recovering to 18.5 dB and 18.1 dB (p=0.65). At 4000 Hz, thresholds rose from 18.7 dB to 23.1 dB, recovering to 19.6 dB and 19.0 dB (p=0.71). At 8000 Hz, thresholds increased from 19.3 dB to 25.4 dB, recovering to 20.2 dB and 19.7 dB (p=0.82). Non-significant p-values indicate near-complete recovery, suggesting milder trauma to the contralateral ear.

Table 4: Bone Conduction Thresholds in Contralateral Ear (dB)

Frequency (Hz)	Preoperative	6 Hours Postop	1 Month Postop	3 Months Postop	p-value (Pre vs. 3 Months)
2000	17.9 ± 4.9	20.3 ± 5.6	18.5 ± 5.1	18.1 ± 5.0	0.65
4000	18.7 ± 5.2	23.1 ± 6.5	19.6 ± 5.4	19.0 ± 5.3	0.71
8000	19.3 ± 5.6	25.4 ± 7.1	20.2 ± 5.9	19.7 ± 5.7	0.82

Table 5 presents OAE amplitudes. Ipsilateral amplitudes decreased from 12.4 dB SPL preoperatively to 8.1 dB SPL at 6 hours, recovering to 10.9 dB SPL at 1 month and 11.2 dB SPL at 3 months (p=0.04, significant), indicating persistent outer hair cell dysfunction in some cases. Contralateral amplitudes dropped from 12.7 dB SPL to 9.3 dB SPL, recovering to 11.8 dB SPL and 12.3 dB SPL (p=0.35, non-significant), reflecting transient effects.

Table 5: Otoacoustic Emission Amplitudes (dB SPL)

Ear	Preoperative	6 Hours Postop	1 Month Postop	3 Months Postop	p-value (Pre vs. 3 Months)
Ipsilateral	12.4 ± 3.2	8.1 ± 2.7	10.9 ± 3.0	11.2 ± 3.1	0.04
Contralateral	12.7 ± 3.1	9.3 ± 2.9	11.8 ± 3.2	12.3 ± 3.0	0.35

Drilling duration >1 hour (p=0.02), use of cutting burr (p=0.04), and ossicular chain manipulation (p=0.01) were significantly associated with SNHL. Among PTS cases, 4 of 6 involved accidental drilling on the intact ossicular chain, and 3 had drilling durations exceeding 90 minutes.

DISCUSSION

This study found a 22% incidence of SNHL post-mastoidectomy, with 12% in the ipsilateral ear and 10% in the contralateral ear, consistent with reported ranges of 0–31% [6, 14]. The predominance of TTS (16%) over PTS (6%) aligns with studies like Karatas et al., who reported transient contralateral SNHL recovering within 72–96 hours [13]. However, the prolonged recovery period (up to 2 months) in this study may reflect longer drilling durations and the inclusion of modified radical mastoidectomy, which requires extensive bone removal due to cholesteatoma [3]. High-frequency hearing loss (>2000 Hz) was most pronounced, corroborating the vulnerability of outer hair cells to acoustic trauma [11].

Drill-induced noise, generating levels up to 100 dB, was a primary contributor, as supported by Kylén and Arlinger [7]. The ipsilateral ear, exposed to higher noise intensities, exhibited greater threshold shifts, particularly at 4000 and 8000 Hz, consistent with outer hair cell damage [11]. Contralateral SNHL, observed in 10% of cases, likely resulted from skull-transmitted vibrations, as vibrations can propagate through the temporal bone to the contralateral cochlea [8]. This finding echoes Tos et al., who noted contralateral effects in translabyrinthine surgery [14]. The near-complete recovery in contralateral ears by 1 month suggests milder trauma, possibly due to lower noise transmission [13].

Drilling duration >1 hour significantly increased SNHL risk, aligning with Vijendra et al., who found greater hearing loss with extended drilling [15]. Cutting burrs, producing higher noise and vibration than diamond burrs, were associated with increased SNHL, supporting recommendations to prefer diamond burrs near critical structures [9]. Continuous suction irrigation likely amplified noise and induced pressure changes, contributing to cochlear trauma, as noted by Parkin et al. [10]. Ossicular manipulation, particularly inadvertent stapes contact, was a critical factor in PTS cases, with 4 of 6 patients experiencing total hearing loss (>100 dB) in the ipsilateral ear, highlighting the need for cautious surgical technique [6].

The study's comprehensive audiological assessment, including PTA and OAE, strengthens its findings. PTA detected threshold shifts, while OAE confirmed outer hair cell dysfunction, particularly in TTS cases [11]. The 100% retention rate enhances result reliability, and the evaluation of both ears provides a holistic perspective. However, limitations include the single-center design, potentially limiting generalizability, and the lack of intraoperative noise monitoring, which could quantify acoustic trauma. The study did not assess long-term outcomes beyond 3 months, which could reveal delayed recovery or progression of SNHL.

Comparative analysis with prior studies reveals variability in SNHL incidence. Urquhart et al. reported no SNHL in 40 patients, possibly due to shorter drilling times or less sensitive audiological measures [6]. In contrast, Mustafa et al. found a 31% incidence, likely reflecting more extensive surgeries [14]. The 22% incidence in this study may reflect a balance of cortical and modified radical procedures, with the latter posing greater risk due to cholesteatoma-related bone destruction. The absence of labyrinthine injury (e.g., inadvertent vestibule opening) in this study, unlike Souvik et al. [15], suggests surgeon experience mitigated severe complications.

Clinical implications are significant. Surgeons should minimize drilling time, use diamond burrs near the ossicles and labyrinth, and employ intermittent suction to reduce noise and pressure changes. Adequate irrigation prevents thermal injury, and gentle ossicular manipulation avoids stapes trauma [9]. Preoperative counseling should address SNHL risks, emphasizing the potential for temporary high-frequency loss and rare permanent deficits. Postoperative audiological monitoring should extend to 2 months to confirm recovery, particularly in contralateral ears. Avoiding routine mastoidectomy in dry ears and using high-quality instruments (e.g., micromotors, tungsten burrs) can further reduce risks [10].

Future research should incorporate intraoperative noise monitoring to quantify drill-related acoustic trauma and compare burr types systematically. Long-term follow-up beyond 3 months could elucidate delayed recovery patterns. Multicenter studies would enhance generalizability, and randomized trials comparing surgical techniques (e.g., diamond vs. cutting burrs) could refine best practices. Additionally, exploring patient-specific factors, such as mastoid pneumatization or preoperative hearing status, could identify high-risk groups for targeted interventions.

CONCLUSION

Mastoidectomy for COM carries a 22% risk of SNHL, predominantly temporary (16%) and high-frequency (>2000 Hz), with 6% experiencing permanent loss. Drill-induced noise, prolonged drilling, cutting burrs, suction irrigation, and ossicular manipulation are key contributors. Adopting noise-reducing techniques, careful surgical practices, and extended audiological monitoring can minimize iatrogenic hearing loss, improving patient outcomes in otologic surgery.

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