ORIGINAL RESEARCH PAPER

Volume - 15 | Issue - 04 | April - 2026 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

THE EFFECT OF DRILLING ON THE HEARING OF CONTRALATERAL NORMAL EAR AFTER MASTOID SURGERY - A PROSPECTIVE STUDY

Otorhinolaryngology

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ABSTRACT

Background: Mastoidectomy requires extensive bone drilling that generates high-intensity noise and vibration capable of causing cochlear injury. While the operated ear is directly exposed, the contralateral normal ear may also be affected through bone-conducted and airborne transmission. **Objective:** To evaluate the incidence, type, degree, and reversibility of hearing changes in the contralateral normal ear following mastoid surgery and to analyze intraoperative factors influencing these changes. **Methods:** This prospective observational study included 57 patients undergoing unilateral mastoidectomy at a tertiary care center. Pure tone audiometry (PTA) and otoacoustic emissions (OAE) were performed preoperatively and postoperatively at fixed intervals up to 90 days. Intraoperative drilling duration, burr type, and noise levels were recorded. Statistical analysis was performed using GNU PSPP. **Results:** Five patients (8.8%) developed transient sensorineural hearing loss in the contralateral ear. Hearing changes predominantly involved high frequencies (2–6 kHz) and resolved completely by postoperative day 7. Prolonged drilling time and increased cutting burr usage were significantly associated with hearing loss ($p < 0.05$). Type of mastoidectomy was not significantly associated with contralateral hearing loss. **Conclusion:** Mastoid drilling can cause transient, reversible sensorineural hearing loss in the contralateral normal ear, particularly with prolonged drilling and extensive cutting burr use. Adoption of drilling strategies that minimize duration and vibration may reduce cochlear stress.

KEYWORDS

Mastoidectomy, Contralateral ear, Sensorineural hearing loss, Drill noise, Otoacoustic emissions

INTRODUCTION:

Mastoidectomy is a fundamental otologic procedure performed to eradicate disease from the temporal bone while preserving or reconstructing hearing. It may be carried out as canal wall up (CWU) or canal wall down (CWD) surgery, often combined with tympanoplasty and ossicular chain reconstruction. Although surgical outcomes are typically assessed based on disease clearance and hearing in the operated ear, overall hearing disability largely depends on the hearing status of the better-hearing ear. Therefore, preservation of hearing in the contralateral normal ear is of significant clinical importance[1,3].

Bone drilling is an essential component of mastoid surgery and generates high-intensity noise and vibration. These factors have been shown to cause sensorineural hearing loss (SNHL), particularly affecting high frequencies[4,7]. Drilling near the ossicular chain produces vibratory forces equivalent to hazardous sound pressure levels, which may lead to temporary or permanent cochlear damage depending on exposure duration and intensity[8,10]. The degree of injury is influenced by several factors, including drilling duration, burr type, rotational speed, and site of drilling. Cutting burrs have been reported to produce higher noise levels compared to diamond burrs[11,12].

Although the operated ear is directly exposed to drill-induced trauma, the contralateral ear is also subjected to significant acoustic energy through bone conduction and airborne transmission. Previous studies have reported that drill-generated noise in the non-operated ear may exceed 90 dB, posing a risk of cochlear injury[1,11,13].

Outer hair cells are the earliest structures affected in noise-induced cochlear injury. Otoacoustic emissions (OAEs), which reflect outer hair cell function, are sensitive tools for detecting early or subclinical damage not evident on pure tone audiometry[14,15]. Several studies have demonstrated transient auditory changes in the contralateral ear following mastoid surgery; however, the extent, severity, and clinical implications of these changes remain inadequately defined[1,3,7].

The present study aims to evaluate the effect of mastoid drilling on hearing in the contralateral normal ear using audiometric and otoacoustic emission parameters.

Aims and objectives:

AIM

To evaluate the effect of mastoid drilling on hearing in the contralateral normal ear following mastoid surgery.

OBJECTIVES

To determine the incidence of hearing loss in the contralateral normal ear after mastoid surgery.

To assess the degree and type of hearing loss (conductive, sensorineural, or mixed) in the contralateral normal ear.

To evaluate the duration and reversibility of hearing changes in the contralateral normal ear.

To analyze factors influencing hearing loss, including the type of mastoidectomy, duration of drilling, and type of burr used.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Otorhinolaryngology, Government Bundelkhand Medical College, Sagar, Madhya Pradesh, India, over a period of 18 months from September 2023 to February 2025, following approval from the Institutional Ethics Committee. Written informed consent was obtained from all participants prior to enrolment.

Study Population and Sample Size

The sample size was calculated using the formula: n= z2 pq /d2 where p represents prevalence, q = 100 − p, absolute precision (d) was set at 5%, and z value was 1.96 corresponding to a 95% confidence interval. The calculated sample size was 47. After accounting for a 10% attrition rate, the final sample size was 57 patients.

Inclusion Criteria:

Patients aged 10–60 years of either sex
Unilateral chronic otitis media requiring mastoidectomy
Normal hearing in the contralateral ear
Willingness to participate with informed consent

Exclusion Criteria:

Bilateral chronic otitis media
Previous history of mastoid surgery
Age below 10 years or above 60 years
Patients with systemic comorbidities such as tuberculosis, diabetes mellitus, or hypertension

PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

Patients unwilling to provide consent

Preoperative Assessment

All patients underwent detailed history taking and otoscopic examination. Examination under microscope was performed to assess the tympanic membrane status on the diseased side, while the contralateral ear was confirmed to be disease free.

Audiological evaluation included:

Pure Tone Audiometry (PTA): Air and bone conduction thresholds were measured at 0.25, 0.5, 1, 2, 4, and 6 kHz. Bone conduction thresholds exceeding 20 dB were considered abnormal.

Otoacoustic Emissions (OAE): OAE testing was performed using Echo Lab OAE system (ECL, model no. 14028) at frequencies ranging from 1 to 6 kHz. An emission threshold of <6 dB at any frequency was considered abnormal. All tests were conducted in a sound-proof room by the same examiner.

Radiological investigations included X-ray mastoid (Schüller's view) of both ears and high-resolution computed tomography (HRCT) of the temporal bone in axial and coronal planes. Routine hematological investigations were performed for all patients.

Surgical Procedure and Intraoperative Parameters

All patients underwent tympanomastoid surgery under general anaesthesia following standard pre-anaesthetic evaluation. Surgeries were performed by the same surgeon to eliminate inter-operator variability.

Of the 57 patients, 52 underwent cortical mastoidectomy and 5 underwent modified radical mastoidectomy. A single drill machine (Marathon Micromotor ECO-450; maximum speed 45,000 rpm) was used for all procedures. Fresh burr tips of the same manufacturer were used for each patient. Both cutting burrs and diamond burrs (D+Z Germany; stainless steel; sizes 1–6 mm) were employed as required intraoperatively.

Intraoperative noise levels were recorded using a digital sound level meter placed near the drill machine. Total drilling time as well as individual drilling duration for each burr type were recorded using a stopwatch by an assisting staff member.

Postoperative Audiological Assessment

PTA and OAE were performed on the contralateral ear on postoperative days 1, 3, 5, 7, 15, 30, 60, and 90. PTA thresholds were assessed at the same frequencies as preoperatively, and bone conduction thresholds >20 dB were considered abnormal. OAEs were evaluated at 1, 2, 4, and 6 kHz, with thresholds >6 dB at any frequency considered abnormal.

Outcome Measures

The primary outcome measure was the incidence and degree of hearing loss in the contralateral normal ear following mastoid surgery as assessed by PTA and OAE. Secondary outcome measures included the type (conductive, sensorineural, or mixed) and duration of hearing loss.

Statistical Analysis

Data were tabulated and analysed using GNU PSPP software. Appropriate statistical tests were applied, and a p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with ethical guidelines and was approved by the Institutional Ethics Committee.

RESULTS:

Gender Distribution

A total of 57 patients were included in the study, all of whom had normal hearing in the contralateral ear preoperatively. The mean age of the study population was 35.2 ± 15.7 years, with an age range of 10 to 60 years. Of the 57 participants, 30 (52.6%) were male and 27 (47.4%) were female, showing in figure1.

Age Distribution

The study population had a mean age of 35.2 ± 15.7 years (range: 10–60 years). The majority of participants belonged to the 21–30 years age group (52.6%), while the fewest participants were in the 51–60 years age group (3.5%). The youngest participant was 12 years old, and the oldest was 58 years old. (figure2)

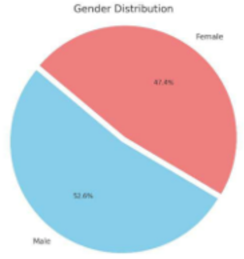

Figure1: pie chart of sex distribution in study population

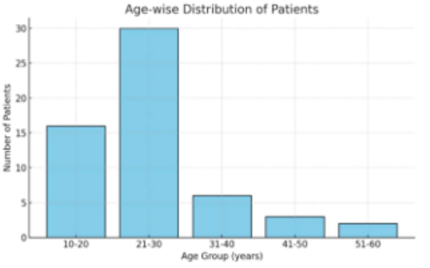

Figure2: age distribution in study population

Diagnosis Distribution

Among the 57 patients, 52 (91.2%) had squamosal type chronic otitis media (COM), of which 15 (26.3%) had active disease and 37 (64.9%) had inactive disease. The remaining 5 patients (8.8%) had mucosal type COM. (figure3)

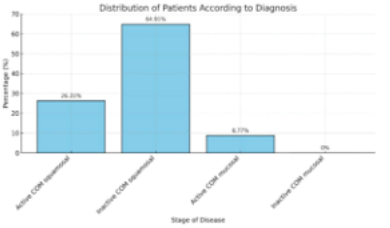

Figure3: distribution of patient according to diagnosis

Incidence of Hearing Loss in Contralateral Normal Ear

Among the 57 patients, 5 (8.8%) developed hearing loss in the contralateral normal ear following mastoidectomy, while 52 (91.2%) showed no hearing loss. (figure4)

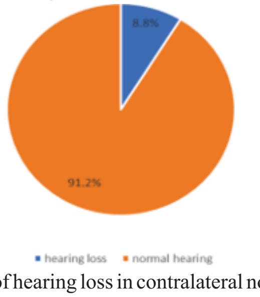

Figure4: incidence of hearing loss in contralateral normal ear

Distribution of Patients According to Type of Hearing Loss

A total of 57 patients were enrolled in the study. Among them, 5 patients (8.8%) developed hearing loss in the contralateral normal ear following mastoidectomy. Audiological evaluation revealed that all affected patients exhibited sensorineural hearing loss in the contralateral ear after surgery. (figure6)

Figure5: Distribution of Patients According to Type of Hearing Loss

Distribution by Type of Mastoidectomy with Hearing Loss

Cortical mastoidectomy was performed in 40 patients (70.17%), while modified radical mastoidectomy was carried out in the remaining 17 patients (29.82%). Following mastoidectomy, patients were categorized into two groups based on the status of the contralateral ear: those with hearing loss (HL) and those with no hearing loss (NHL).

Out of the 57 cases, 40 patients underwent cortical mastoidectomy, among whom only 2 patients (5%) developed hearing loss in the contralateral ear. Modified radical mastoidectomy (MRM) was performed in 17 patients, of whom 3 patients (17.64%) developed contralateral hearing loss. Statistical analysis using Fisher's exact test yielded a p value of 0.151 (>0.05), indicating that there is no statistically significant association between the type of mastoidectomy performed and the occurrence of hearing loss in the contralateral ear. (figure6)

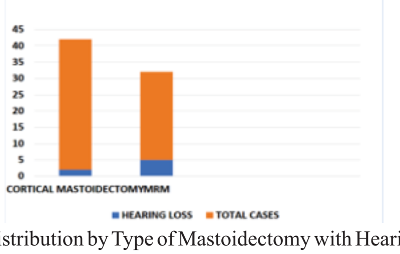

Figure6: Distribution by Type of Mastoidectomy with Hearing Loss

Distribution by Time of Drilling with Hearing Loss

For each case of mastoidectomy, various sizes of cutting as well as diamond burrs was used. The average time of drilling with a cutting burr was 42.1 minutes and that for a diamond burr was 12.5 minutes. The mean total duration of drilling was 54.7 minutes.

Of the total 57 patients 5 patients showed changes in at least one of the hearing parameters—PTA, DPOAE and TEOAE. Patients showing changes in hearing parameters had a cutting burr, diamond burr and total time was 42.1, 12.5, 54.7 respectively. However, patients without any hearing loss had a lesser mean drilling time of each of cutting, diamond, total respectively as shown in Figure7.

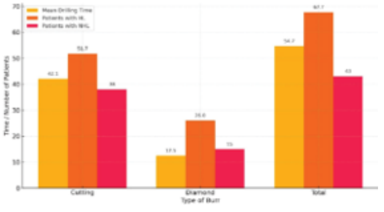

Figure7: Distribution by Time of Drilling with Hearing Loss

Audiological Parameters Over Time

Table given below shows the preoperative and postoperative values of Pure Tone Audiometry (PTA) and otoacoustic emissions (OAE). Both PTA and OAE demonstrated progressive improvement over the 7-day postoperative period.

Time Point	PTA (Mean ± SD)	OAE (Mean ± SD)
Pre-op	20 ± 8.4 dB HL	10 ± 5.6 dB HL
Day 1	22.9 ± 9.2 dB HL	6.6 ± 5.6 dB HL
Day 3	22.8 ± 10.1 dB HL	6 ± 2.5 dB HL
Day 5	21 ± 9.9 dB HL	6 ± 1.6 dB HL
Day 7	20.6 ± 9.6 dB HL	7± 0.8 dB HL
Day 15	20.0 ± 9.6 dB HL	12± 0.6 dB HL
Day 30	20.0 ± 9.8 dB HL	12 ± 0.4 dB HL
Day 60	20.0 ± 9.9 dB HL	12 ± 2.1 dB HL
Day 90	20.0 ± 9.9 dB HL	12 ± 0.3 dB HL

These line graphs (figure9) illustrate the postoperative improvement trend in both hearing parameters. Based on paired sample t-test analysis comparing preoperative PTA values with those obtained on postoperative day (POD) 1, 3, 5, 7, 30, 60, and 90, no statistically significant hearing loss was observed at 0.25 kHz and 0.5 kHz across all postoperative intervals.

At 3 kHz, 4 kHz, and for average PTA, a statistically significant temporary hearing loss was noted from POD 1 to POD 7, which normalized in all patients after POD 7. During the first postoperative week, a mean bone-conduction loss of 22.91 dB was observed in the 5 affected patients, which remained 22.8 dB on POD 3 and subsequently returned to baseline by POD 7.

Among the 57 patients, 5 patients demonstrated "refer" results on DPOAE during the first postoperative week. However, by the end of the first week, DPOAE values returned to normal in all patients. Additionally, a significant temporary threshold shift was observed at 2 kHz and 6 kHz from POD 1 to POD 5, with hearing sensitivity improving to preoperative levels by POD 7.

A significant temporary threshold shift was observed at 2 kHz and 6 kHz from postoperative day (POD) 1 to POD 5, with hearing sensitivity returning to preoperative levels by POD 7. ANOVA analysis revealed a statistically significant difference in PTA values across the postoperative time points ($p < 0.05$), which was attributable to the transient hearing loss observed in 5 of the 57 patients.

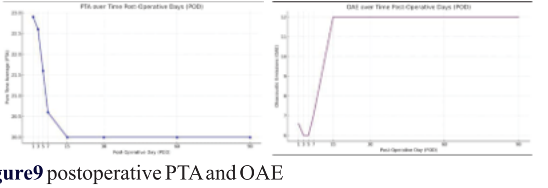

Figure9 postoperative PTA and OAE

Noise Level

The mean noise level during mastoidectomy was 92.8 dB HL in the no hearing loss (NHL) group and 98.7 dB HL in the hearing loss (HL) group. This paradoxical finding suggests that factors beyond decibel intensity—such as drilling duration, noise frequency, and individual cochlear susceptibility—may influence cochlear stress and postoperative hearing outcomes.

Scatter Plot: Drilling Time vs. Hearing Loss Outcome

The scatter plot (figure10) illustrates the relationship between drilling time and postoperative hearing loss. Green dots represent patients without hearing loss, while red dots indicate patients who developed hearing loss. A dashed gray line denotes the average drilling time across all patients.

Most cases of hearing loss occurred with longer drilling durations, even though their noise levels were not always the highest. Postoperatively, 5 out of 57 patients (8.77%) experienced sensorineural hearing loss in the contralateral ear. The hearing loss was temporary, with complete recovery by postoperative day 7. Overall, only a small fraction of patients developed transient hearing loss following mastoidectomy.

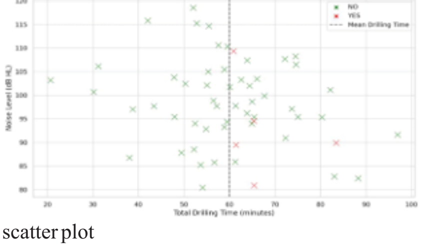

Figure10 scatter plot

DISCUSSION

This prospective observational study evaluated drill-induced hearing changes in the contralateral normal ear following mastoidectomy using pure tone audiometry (PTA) and otoacoustic emissions (OAE). Transient sensorineural hearing loss (SNHL) was observed in 5 out of 57 patients (8.8%), with complete recovery within 7 days, indicating a reversible cochlear insult. Similar transient contralateral auditory changes following mastoid drilling have been reported in previous studies.[16]

The mean age of patients (35.2 ± 15.7 years) was comparable to earlier studies by Karatas et al. and Vashishth et al., which reported peak incidence in the third to fourth decades.[17,18] Male predominance in the present study is also consistent with observations from other Indian studies.[19]

Squamosal chronic otitis media was the most common indication for surgery, and cortical mastoidectomy was the most frequently performed procedure. Although hearing loss was more frequently observed following modified radical mastoidectomy than cortical mastoidectomy, the difference was not statistically significant. A similar trend has been reported by Agrawal et al., suggesting that more extensive drilling may increase the risk of contralateral cochlear involvement.[20]

A statistically significant association was found between contralateral hearing loss and increased total drilling time as well as greater use of cutting burrs, whereas diamond burr usage was not significant. These findings support previous reports that prolonged drilling duration and higher vibration intensity contribute to cochlear stress.21

PTA demonstrated transient postoperative threshold elevation, most prominent on postoperative day 1, with recovery by day 7. OAE findings revealed temporary deterioration, particularly at higher frequencies (3000–4000 Hz), indicating reversible outer hair cell dysfunction. Similar high-frequency OAE changes have been reported in prior studies.[17,22,23]

The underlying mechanism is likely related to drill-generated noise and bone-conducted vibration transmitted across the skull, affecting cochlear outer hair cells. Thermal effects and mechanical trauma near the otic capsule may further contribute.[24,25] However, some studies, such as that by Urquhart et al., have not demonstrated significant contralateral changes, suggesting variability in susceptibility.[26]

Overall, the low incidence and reversible nature of hearing loss indicate a favorable prognosis. However, minimizing drilling duration, judicious use of cutting burrs, and consideration of contralateral ear protection may help reduce potential cochlear injury.[27]

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