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Otoendoscopy as a better preoperative predictor than pure tone audiometry for ossicular erosion in mucosal chronic otitis media

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Main Article

Manu Malhotra takes responsibility for the integrity of the content of the paper

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Abstract

Objective. To compare the diagnostic accuracy of angled otoendoscopy with pure tone audiometry in predicting ossicular discontinuity in patients of mucosal chronic otitis media.
Methods. Ninety-four patients were included in this prospective study. A 2.7-mm 30° otoendoscope was used to examine ossicular status preoperatively. Hearing thresholds were recorded by pure tone audiometry. Intraoperative ossicular status was recorded as the gold standard. Otoendoscopic findings were recorded as per the criteria has been devised by the authors of this manuscript.
Results. Otoendoscopy was conclusive in 56 (59.6 per cent) patients, with 100 per cent sensitivity, 95.56 per cent specificity, 84.62 per cent positive predictive value, and 100 per cent negative predictive value in the conclusive group. Overall (in 94 patients), diagnostic test values of otoendoscopy were 73.33 per cent sensitivity, 97.47 per cent specificity, 84.62 per cent positive predictive value, and 95.06 per cent negative predictive value. As per the ROC curve, air–bone gap > 38.12dB had the optimal diagnostic test values, with 73 per cent sensitivity, 72 per cent specificity, 33.3 per cent positive predictive value, and 93.4 per cent negative predictive value.
Conclusion. Angled otoendoscopy has better diagnostic accuracy (93.6 per cent) than pure tone audiometry (72.3 per cent; $p < 0.001$) for preoperative ossicular discontinuity prediction in patients of mucosal chronic otitis media.

Introduction

Mucosal chronic otitis media patients typically present with ear discharge and hearing loss. Assessing ossicular chain integrity and its reconstruction is integral to surgical management for chronic otitis media. In patients afflicted with chronic otitis media, disease eradication and tympanic membrane reconstruction are often prioritised over hearing reconstruction, which is often the primary grievance of the patient.[1,2]

Ossicular erosion is observed in chronic otitis media due to resorption osteitis. The long process of incus is the most commonly eroded ossicle, followed by the stapes crura, incudal body, and manubrium of malleus.[3–6] Ossicular erosion is confirmed only during surgery and is often surprising for the surgeon.[1,3]

Pure tone audiometry has been routinely used to predict ossicular erosion. However, it is not the definitive tool as different states and conditions of the middle ear may entail a variable range of hearing loss.[4,5,7] Inadequate masking also renders pure tone audiometry unreliable in assessing ossicular status.[7] However, high-resolution computed tomography (CT) with three-dimensional reconstructed images may aid in assessing ossicular integrity. Nevertheless, performing high-resolution CT in a mucosal chronic otitis media case is not cost-effective, along with the added disadvantage of radiation exposure for the patient. Cone-beam CT might be useful in such cases, but it also is associated with radiation exposure, albeit less than high-resolution CT. Despite being cost-intensive, the endoscope presents the advantage of no radiation exposure if used in routine ear evaluation.

Determining the ossicular status pre-operatively will aid surgeons and anaesthetists in anticipating surgery duration and arranging the required prosthesis for ossiculoplasty. Along with meticulously strategizing the operating procedure, physicians can counsel patients on expected hearing outcomes before undertaking the procedure.

Although endoscopes are used for ear examinations and ear surgeries,[8] we are unaware of their specific use in the pre-operative assessment of ossicular status in existing literature. A literature search on PubMed, Scopus, Web of Science, and Google Scholar by using "Chronic otitis media, tympanic perforation, hearing loss, endoscopic, ossicles, ossicular chain, and hearing loss" keywords did not find any existing study regarding the same. This study aims to evaluate the role of an angled endoscope in pre-operative

Table 1. Criteria to record ossicular status on endoscopy; IS = incudostapedial; OD = ossicular discontinuity: OD+ = patients with ossicular discontinuity; OD− = patients without ossicular discontinuity

Conclusive		Non-conclusive
OD +	OD −	A. Endoscope not negotiable through perforation (Figure 1K) B. Endoscope negotiable, but incus and stapes not visualised as perforation involved the anterior half of pars tensa (Figure 1L, 1M) C. Endoscope negotiable through a posterior quadrant perforation, but the long process of incus, IS joint, and stapes supra structure not clearly visualised to comment upon (Figure 1N)
Malleus: Handle of malleus is completely eroded (Figure 1A)	Malleus: A. Handle of malleus intact, not foreshortened (Figure 1F) B. Handle of malleus foreshortened and/or partially eroded (Figure 1G)	
Incus: A. Isolated lenticular process erosion (Figure 1B) B. Long process visualised, eroded (Figure 1C) C. Long process not visualised (Figure 1D)	Incus: A. Long and lenticular process intact (Figure 1H)	
Stapes: Suprastructure absent	Stapes: Suprastructure intact (Figure 2)	
IS joint: A. Visualisation of a fibrous band between the long process and stapes head (Figure 1C) B. Discontinuity between incus and stapes (Figure 1D) C. Visualisation of sclerosis and/or sclerotic patch at IS joint (Figure 1E)	IS joint: A. Visualisation of normal mucosa at apparently intact IS joint (Figure 1H) B. Visualisation of hypertrophied mucosa at apparently intact IS joint (Figure 1J)	

ossicular examination through tympanic membrane perforation and compare it with a pure tone audiogram for ossicular status assessment.

Materials and Methods

The study was conducted at our tertiary care centre between January 2019 and June 2022. This study enrolled patients diagnosed with mucosal chronic otitis media and prescribed for tympanoplasty who were cooperative for endoscopic ear examination. Non-consenting patients and those with marginal perforation, a history of surgery, or retraction in pars flaccida were excluded. Pure tone audiometry was performed in the final cohort of patients pre-operatively and recorded. Endoscopic assessment, pure tone audiometry, and surgery were performed for each patient within one week to circumvent possible changes due to disease.

Assessment criteria

Patients enrolled in the study were subjected to endoscopic ear examination using a 2.7-mm 30° endoscope a day before surgery. The procedure was performed by either of three surgeons, each with at least three years of experience performing ear surgery and endoscopic examination of the ear. The location and size of the perforation and tympanosclerotic patch were noted. If feasible, the endoscope was negotiated through the perforation, and the ossicular chain was examined. Per the planned protocol, the surgery and endoscopy (a day before surgery) were scheduled for the patients at a phase with no active middle-ear inflammation.

A criterion was developed to record the endoscopic findings for ossicular status (Table 1). The criterion was framed through a thorough literature search and brainstorming, followed by content- and face-validity computation by experts specialising in the subject. Endoscopic findings were broadly categorized as conclusive or non-conclusive. A conclusive interpretation meant that the endoscopic examination could definitely interpret the status of ossicles. In contrast, a non-conclusive interpretation meant that the examiners could not definitely interpret the ossicular status. A non-conclusive interpretation was based on an assessment by at least two examiners. The conclusive group was further categorised into patients with ossicular discontinuity (+) and patients without ossicular discontinuity (-).

Intra-operative findings as the gold standard

The surgeon assessing intra-operative ossicular status was unaware of the findings of the pre-operative endoscopic assessment. Considering the outcomes of intra-operative assessment as the gold standard, the diagnostic test results of the endoscopic assessment and the pre-operative air–bone gap (ABG) in predicting ossicular discontinuity were evaluated using sensitivity analysis.

Results and analysis

Of the 94 patients enrolled in this study, 15 were diagnosed with ossicular discontinuity through intra-operative assessment. There were three cases of isolated lenticular process erosion, nine cases of long process erosion, and six cases of malleus erosion; there was not a single case of stapes suprastructure erosion that was noted.

Table 2. Comparison of endoscopic assessment (as a test) with intra-operative assessment as the gold standard; OD = ossicular discontinuity: a = OD absent as per endoscopic assessment; b = endoscopic assessment non-conclusive

	Intra-operative assessment outcome	
Endoscopic assessment outcome	OD present	OD absent
OD present	11	2
OD absent or non-conclusive	4: ($0^a + 4^b$)	77: ($43^a + 34^b$)

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Table 3. Diagnostic test values of otoendoscopy; CI = confidence interval; LR = likelihood ratio

Metric	Overall	Only conclusive group
Sensitivity (95% CI)	73.33% (44.90–92.21%)	100.00% (71.51–100.00%)
Specificity (95% CI)	97.47% (91.15–99.69%)	95.56% (84.85–99.46%)
Positive LR (95% CI)	28.97 (7.13–117.69)	22.50 (5.81–87.21)
Negative LR (95% CI)	0.27 (0.12–0.63)	0.00
Positive predictive value (95% CI)	84.62% (57.51–95.72%)	84.62% (58.66–95.52%)
Negative predictive value (95% CI)	95.06% (89.26–97.81%)	100.00%
Accuracy (95% CI)	93.62% (86.62–97.62%)	96.43% (87.69–99.56%)

Endoscopic assessment for ossicular erosion was non-conclusive in 38 patients (Table 2). The most common reason for non-conclusive assessment was a small-sized perforation, which made the endoscope non-negotiable (seen in 22 of 38 patients). In 12 of 38 patients, perforation did not involve the posterior quadrant of pars tensa, resulting in a non-conclusive endoscopic assessment. In 4 of 38 patients, the incudo-stapedial joint zone could not be visualised despite the perforation being posterior and negotiable for the endoscope.

The overall sensitivity of otoendoscopy in detecting ossicular discontinuity was 73.3 per cent, and the specificity was 97.47 per cent. The observed positive predictive value was 84.62 per cent, with a 95 per cent confidence interval (CI). Among the 56 participants whose endoscopic assessment was conclusive, the sensitivity analysis showed 100 per cent sensitivity and approximately 96 per cent specificity for detecting ossicular discontinuity through otoendoscopy (Table 3).

The ABG threshold of greater than 37.5 dB had a sensitivity of 73 per cent, specificity of 67 per cent, and positive likelihood ratio of 2.23. The ABG threshold of greater than 40 dB demonstrated a lower sensitivity of 67 per cent but a higher specificity of 81 per cent and accuracy of 78 per cent compared to ABG greater than 37.5 dB (Table 4).

Table 4. Diagnostic test values at different ABG (air–bone gap) thresholds; CI = confidence interval; LR = likelihood ratio; negative predictive value = negative predictive value; PPV = positive predictive value

	ABG Threshold (dB)		
Metric	37.5	40	45
Sensitivity (95% CI)	73.33% (44.90–92.21%)	66.67% (38.38–88.18%)	46.67% (21.27–73.41%)
Specificity (95% CI)	67.09% (55.60–77.25%)	81.01% (70.62–88.97%)	91.14% (82.59–96.36%)
Positive LR (95% CI)	2.23 (1.44–3.45)	3.51 (1.97–6.27)	5.27 (2.16–12.83)
Negative LR (95% CI)	0.40 (0.17–0.93)	0.41 (0.20–0.85)	0.59 (0.36 –0.94)
PPV (95% CI)	29.73% (21.44–39.61%)	40.00% (27.20–54.33%)	50.00% (29.10–70.90%)
negative predictive value (95% CI)	92.98% (84.95–96.89%)	92.75% (86.13–96.35%)	90.00% (84.80–93.56%)
Accuracy (95% CI)	68.09% (57.67–77.33%	78.72% (69.07–86.49%)	84.04% (75.05–90.78%)

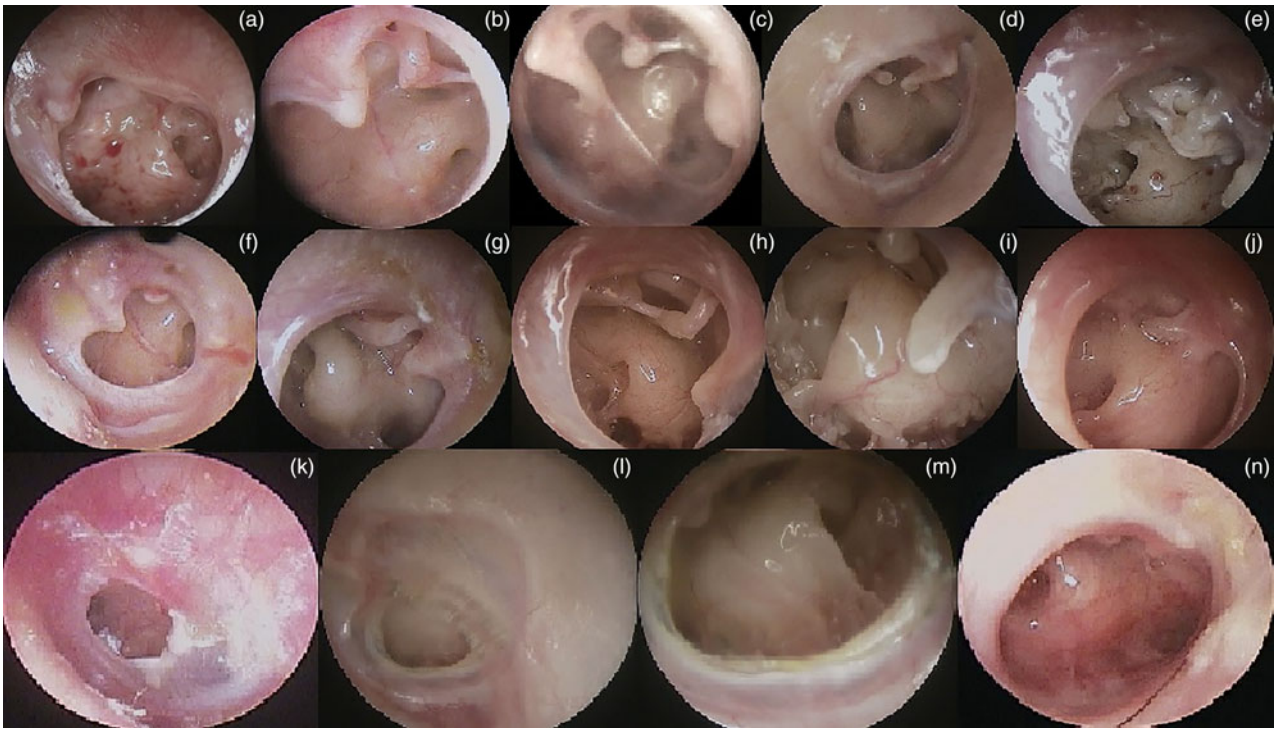

Figure 1. Otoendoscopy images as per the descriptions given in Table 1.

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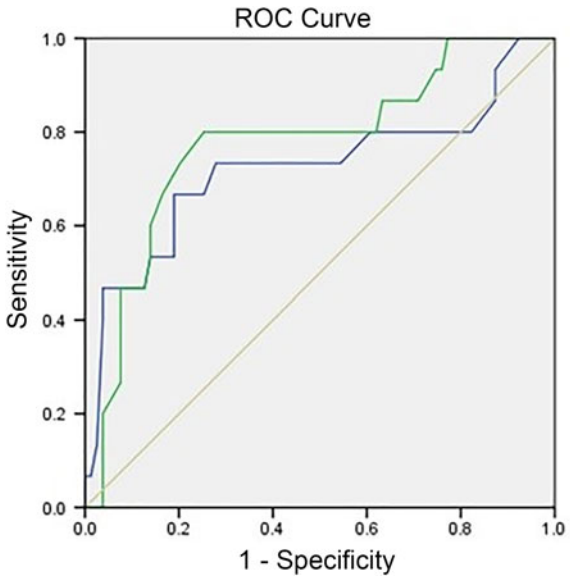

PTA	Area under curve	S.E	*p*-value	95% confidence interval
Average AC	0.776	0.070	0.001	0.64-0.91
Average ABG	0.723	0.088	0.006	0.55-0.89

Figure 2. Receiver-operating characteristic (ROC) curve for different pure tone audiometry averages in predicting ossicular discontinuity. Diagonal segments are produced by ties. ABG = air–bone gap; AC = air-conduction threshold; PTA = pure tone audiometry; S.E. = standard error.

The ABG threshold of greater than 45 dB was the least sensitive (47 per cent) but most specific in detecting ossicular discontinuity, with an accuracy as high as 84 per cent. The mean ABG among the ossicular discontinuity-positive group was 41.75 dB (± 11.09), while among the non-ossicular discontinuity group, it was 33.69 (± 8.62). The non-parametric Mann–Whitney test revealed a highly significant difference in mean ABG between the two groups.

The receiver-operating characteristic curve was used to obtain the various pure tone audiometry thresholds to confirm ossicular discontinuity (Figure 1). The average ABG has an area under curve of 0.723 (p-value < 0.05). The coordinates of the curves indicate that an average ABG value greater than 38.12 has the optimal diagnostic test values with a sensitivity of 0.73, specificity of 0.72, and negative likelihood ratio of 0.38. The diagnostic accuracy of pure tone audiometry at ABG greater than 38.12 was 72.3 per cent.

Discussion

Ossicular discontinuity is typically identified and confirmed intra-operatively in chronic otitis media cases, often as a surprise to the surgeon. Pre-operative information for determining the integrity of the ossicular chain is deemed helpful in terms of better surgical preparation and patient counselling.[9,10]

The long process of the incus is the most commonly eroded part of the ossicular chain.[2,3,11] High osteoclastic activity and weak osteoblastic activity are considered possible reasons for this condition.[12] Although ossicular erosion is more frequent in cholesteatoma, it is also observed in mucosal chronic otitis media.[13,14] In cases without cholesteatoma, the reported incidence of ossicular erosion is 10 per cent (Albera *et al.*),[5] 10.8 per cent (Tos),[11] 11.1 per cent (Jeng *et al.*),[15] 15 per cent (Zahnert *et al.*)[16] and 16 per cent (Ebenezer and Rupa).[1] In this study, ossicular erosion was observed in 15 cases, which accounts for 15.95 per cent; the long process of incus was the most commonly observed part of the ossicle to be eroded in 9 out of 15 cases (60 per cent).

Pure tone audiometry helps predict ossicular erosion; ABG and air-conduction threshold are indicators of the same with variable reliability. The ABG was reported as a non-reliable predictor of ossicular erosion in a study by Jeng *et al.*, which noted that granulations may act as a bridge and decrease the ABG.[15] No defined cut-off thresholds of ABG and air-conduction threshold to predict ossicular erosion have been reported. The lack of a definitive threshold to predict ossicular erosion mandates the examination of ossicular integrity in the intra-operative period.

This study found that a 2.7-mm endoscope is readily accessible via medium to large perforations and facilitates examination of the middle ear without any difficulty to the patient on an outpatient basis. It was also found that the ossicular chain (except the head of the malleus and body of the incus) can be examined through such perforations involving posterior quadrants. Isolated erosion of the head of the malleus and body of the incus is rarely observed in mucosal chronic otitis media;[2,3,11,15] hence, ossicular chain continuity can be reliably assessed using an endoscope in such cases.

In this study, the endoscopic assessment of ossicular continuity status was conducted a day before surgery for better patient compliance by avoiding an additional hospital visit. However, surgeons can perform it any time before surgery to better arrange their operation theatre list. The authors recommend performing it in a non-discharging ear and as close to the surgery date as possible, depending on the individual institutional setup.

- Confirmation of ossicular erosion is done only during surgery in patients with chronic otitis media
- Pure tone audiogram is a non-reliable predictor of ossicular erosion
- There are no defined cut-off thresholds of the air-bone gap to predict ossicular erosion
- Angled otoendoscopy is a more reliable predictor of ossicular erosion in mucosal chronic otitis media than pure tone audiometry
- In patients with conclusive findings of oto-endoscopy, diagnostic test values to rule out ossicular discontinuity are very high, with sensitivity of 100 per cent and specificity of 95.5 per cent
- Angled otoendoscopy to assess ossicular status can be performed in the pre-operative period as an outpatient procedure without any discomfort to the patient, leading to better operative preparation

The endoscopic assessment in this study was found to be highly specific (97.47 per cent overall and 96 per cent in the conclusive group) in predicting ossicular discontinuity;

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sensitivity for the same was found to be optimum (100 per cent) in the conclusive group but low (73.3 per cent) overall. The endoscopic evaluation had higher sensitivity, specificity, positive predictive value, and negative predictive value than average ABG at the thresholds of 37.5 dB, 40 dB, and 45 dB as predictors of ossicular discontinuity (Table 4).

Assessment was non-conclusive in 25 patients because the endoscope was non-negotiable through the perforation. This was attributed to small perforations in 20 cases of posterior and 5 cases of the anterior parts of pars tensa. Out of 25 cases, only one had ossicular erosion. This suggests that ossicular erosion is uncommon in small perforations and signifies the high specificity and positive predictive value of endoscopic assessment. Although the endoscope was negotiable, the middle-ear zone behind the malleus handle could not be visualised as the perforation was limited to the anterior quadrants in 13 patients of the non-conclusive group.

Conclusion

In this study, the optimal diagnostic test values of average ABG and air-conduction threshold to predict ossicular discontinuity were 38.12 dB and 51.9 dB, respectively (Figure 2). Pure tone audiometry had lower sensitivity and specificity than otoendoscopy in ossicular discontinuity prediction. Ossicular fixation was observed in only one out of 94 cases subjected to intra-operative assessment; stapes footplate fixation was observed in one case; no cases of malleus fixation were detected. Fixation of ossicles cannot be examined through pre-operative endoscopy, which is a limitation of the proposed procedure.

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Competing interests. None declared

Ethical standards. The authors assert that all procedures contributing to this work comply with the ethical standards of our national and institutional guidelines on human experimentation and with the Helsinki Declaration of 1975, as revised in 2008. The authors assert that all procedures contributing to this work comply with our institutional and national ethical standards. The Institutional Ethical Committee has approved the study.

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