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ENHANCING SURGICAL EFFICIENCY THROUGH ARTIFICIAL INTELLIGENCE IN THE SURGICAL MANAGEMENT OF ADHESIVE OTITIS MEDIA

Ulugbek Pulatovich Abdullayev
PhD, Senior Lecturer, Tashkent State Medical University,
Tashkent, Uzbekistan

Abstract

Adhesive otitis media is a chronic middle-ear disorder characterized by severe tympanic membrane retraction, progressive adhesion of the tympanic membrane to middle-ear structures, conductive or mixed hearing loss, and a risk of ossicular damage, recurrent atelectasis, and secondary cholesteatoma. Contemporary surgical management includes cartilage tympanoplasty, endoscopic transcanal ear surgery, selective ossicular reconstruction, and, in selected cases, adjunctive Eustachian tube balloon dilatation. Recent clinical studies suggest that endoscopic surgery provides excellent visualization of retraction limits and retrotympanic spaces, while cartilage tympanoplasty combined with Eustachian tube balloon dilatation may further improve hearing outcome and quality of life in selected patients.

Direct evidence for artificial intelligence in adhesive otitis media surgery remains limited. However, adjacent otologic AI literature has shown promising performance in tympanic membrane image classification, temporal bone CT interpretation for chronic middle-ear disease, and hearing-related prediction tasks. A 2024 review in otology noted that AI is already being used for eardrum-image diagnosis, temporal bone CT analysis, and postoperative hearing-outcome prediction after tympanoplasty, while a 2024 explainable 3D convolutional neural network achieved strong performance in CT-based evaluation of chronic otitis media. Image-based systematic reviews have also reported average diagnostic accuracies around 90.8% for combined segmentation and classification tasks in middle-ear disease.

The aim of this modeled study was to evaluate whether an AI-assisted workflow could improve preoperative planning, intraoperative efficiency, and 12-month postoperative outcomes in 135 patients with adhesive otitis media treated at the TDTU ENT Department. The modeled protocol combined standard otologic assessment, endoscopic staging, temporal bone CT, AI-assisted tympanic membrane image analysis, AI-supported CT interpretation, risk-based surgical decision support, and postoperative outcome modeling. Synthetic results suggested that AI support improved diagnostic concordance, reduced time to final operative planning, shortened operating time, reduced intraoperative plan changes, and improved hearing and graft-related outcomes at 12 months.

Keywords: Adhesive otitis media, atelectatic otitis media, artificial intelligence, cartilage tympanoplasty, endoscopic ear surgery, temporal bone CT, tympanic membrane retraction, Eustachian tube dysfunction, hearing outcome prediction.

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Introduction

Adhesive otitis media develops in the setting of long-standing Eustachian tube dysfunction and chronic middle-ear ventilation failure. Progressive negative middle-ear pressure, thinning of the tympanic membrane, and myringomalacia eventually lead to retraction, atelectasis, and adhesion of the tympanic membrane to the ossicles, promontory, or middle-ear walls. This process may produce persistent conductive hearing loss, intermittent otorrhea, fullness, and structural middle-ear damage.

Surgery is generally considered in symptomatic disease, especially in patients with clinically relevant hearing loss, advanced retraction, recurrent debris retention, or failure of conservative management. Recent prospective and retrospective studies indicate that both microscopic and endoscopic cartilage tympanoplasty can provide good anatomical and functional results, while endoscopic ear surgery offers superior visualization of the retraction margins and retrotympanic recesses. In a 2024 prospective study, endoscopic and microscopic tympanoplasty showed comparable overall outcomes, but the endoscopic approach provided better visualization and favorable hearing improvement. In a 2024 study of atelectatic otitis media treated endoscopically, graft success reached 95.5%, overall success 88.8%, and the mean air-bone gap improved from 28 dB to 11.8 dB.

Adhesive otitis media surgery remains technically demanding because the surgeon must accurately define the extent of retraction, assess hidden retrotympanic spaces, anticipate ossicular chain status, and balance disease clearance against preservation of middle-ear mucosa. These are precisely the areas in which AI may offer practical assistance. Although direct AI studies focused specifically on adhesive otitis media are still scarce, otologic AI has advanced in related domains such as tympanic membrane image classification, chronic otitis media evaluation on temporal bone CT, and postoperative hearing prediction.

Recent evidence supports the feasibility of this translational approach. AI systems have been shown to classify eardrum disease from images, estimate hearing-related variables, and improve CT-based evaluation of chronic middle-ear disease. A 2025 CNN-based pipeline for tympanic membrane image classification, a 2024 deep-learning model for tympanic membrane disease and hearing regression, and a 2024 explainable 3D AI model for temporal bone CT evaluation of chronic otitis media collectively suggest that AI may improve case selection, staging, operative planning, and follow-up standardization in adhesive otitis media surgery.

Aim

To assess, in a modeled 135-patient cohort from the TDTU ENT Department, whether an AI-assisted surgical workflow can improve preoperative accuracy, intraoperative efficiency, and postoperative outcomes in patients undergoing surgery for adhesive otitis media.

Materials and Methods

This manuscript was designed as a modeled prospective comparative study. A total of 135 patients with clinically and endoscopically confirmed adhesive otitis media were included. All modeled patients had persistent tympanic membrane retraction or adhesion, conductive or mixed hearing loss, and temporal bone CT suitable for operative planning. Surgical candidacy was based on symptomatic disease, hearing loss, and stage-related structural progression, which is consistent with recent adhesive and atelectatic otitis media surgical literature.

The modeled cohort was divided into two groups. Group A, the conventional pathway, included 67 patients assessed with standard otologic examination, otoendoscopy, pure-tone audiometry, tympanometry, and expert temporal bone CT review. Group B, the AI-assisted pathway, included 68 patients assessed by the same standard workflow plus four modeled AI components:

1. AI-assisted tympanic membrane image classification and retraction-stage support based on endoscopic images;
2. AI-supported temporal bone CT interpretation for middle-ear pathology extent and ossicular-risk mapping;
3. a machine-learning surgical decision-support module integrating hearing level, retraction severity, CT findings, and suspected Eustachian tube dysfunction;
4. an AI-based postoperative hearing and recurrence-risk support model. These components were selected because adjacent otologic literature has already demonstrated their feasibility in tympanic membrane diagnosis, chronic middle-ear CT interpretation, and hearing-related prediction.

In the modeled study, all patients underwent surgery by the same otologic team. Endoscopic cartilage tympanoplasty was the planned primary procedure in anatomically favorable cases, while microscopic cartilage tympanoplasty or combined microscopic-endoscopic surgery was selected for more extensive disease, narrow access, ossicular work, or anticipated retrotympanic difficulty. Eustachian tube balloon dilatation was selectively added in patients with strong evidence of persistent Eustachian tube dysfunction, reflecting the current but still evolving evidence base.

The primary endpoints were preoperative diagnostic concordance, time to final operative decision, operating time, intraoperative change of plan, and 12-month surgical success. Secondary endpoints included graft integrity, recurrence of retraction or adhesion, postoperative air-bone gap, patient-reported symptom improvement, and revision-free status. As this was a modeled manuscript, all statistical values below are synthetic and intended to represent a realistic academic template rather than a real clinical dataset.

Results

Table 1. Baseline Characteristics of the Modeled Cohort

Variable	Group A: Conventional Pathway (n=67)	Group B: AI-Assisted Pathway (n=68)
Mean age, years	36.9 ± 10.7	37.4 ± 11.1
Male, n (%)	29 (43.3)	30 (44.1)
Female, n (%)	38 (56.7)	38 (55.9)
Bilateral disease, n (%)	34 (50.7)	36 (52.9)
Mixed hearing loss, n (%)	14 (20.9)	15 (22.1)
Mean preoperative air-bone gap, dB	27.8 ± 8.4	28.1 ± 8.1
Mean Sade grade III-IV disease, n (%)	41 (61.2)	43 (63.2)
Suspected ossicular adhesion/erosion on CT, n (%)	28 (41.8)	31 (45.6)
Suspected Eustachian tube dysfunction, n (%)	39 (58.2)	40 (58.8)
Planned cartilage tympanoplasty, n (%)	67 (100)	68 (100)

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The modeled baseline distribution reflects the clinical pattern reported in surgical adhesive and atelectatic otitis media series, where adult symptomatic patients with moderate-to-advanced retraction, hearing loss, and variable ossicular involvement predominate.

Table 2. Modeled Preoperative Diagnostic and Planning Performance

Metric	Group A: Conventional Pathway	Group B: AI-Assisted Pathway
Diagnostic concordance with intraoperative findings, n (%)	55 (82.1)	64 (94.1)
Mean time to final operative decision, days	3.9 ± 1.3	2.1 ± 0.8
Additional imaging or repeat review required, n (%)	15 (22.4)	6 (8.8)
Mean image interpretation time per case, min	12.9 ± 3.4	7.3 ± 2.1
Correct prediction of retrotympanic extension, n (%)	46 (68.7)	60 (88.2)
High-confidence preoperative hearing counseling, n (%)	39 (58.2)	58 (85.3)

In the modeled analysis, the AI-assisted pathway produced higher preoperative concordance and faster planning. This is biologically and technically plausible because AI models in otology have already shown utility in eardrum-image diagnosis, chronic middle-ear CT interpretation, and hearing-related prediction tasks.

Table 3. Modeled Intraoperative Efficiency Outcomes

Variable	Group A: Conventional Pathway	Group B: AI-Assisted Pathway
Mean operating time, min	71.6 ± 15.8	59.8 ± 13.4
Intraoperative change of plan, n (%)	12 (17.9)	4 (5.9)
Unexpected retrotympanic adhesions, n (%)	11 (16.4)	4 (5.9)
Need for broader exposure than planned, n (%)	9 (13.4)	3 (4.4)
Surgeon-rated anatomical confidence /10	7.1 ± 1.2	8.5 ± 0.9
Selective ET balloon dilatation added, n (%)	8 (11.9)	13 (19.1)

The modeled reduction in operative time and unplanned intraoperative modifications likely reflects improved preoperative mapping of adhesion limits and hidden recesses. Recent endoscopic studies in adhesive and atelectatic otitis media emphasize that better visualization is one of the main reasons for better control of retraction boundaries and reduced epithelial residue.

The modeled outcome advantage in the AI-assisted group is consistent with the existing surgical literature showing that better visualization, more accurate staging, and selective management of Eustachian tube dysfunction may improve graft and hearing outcomes in adhesive otitis media. The adjunctive role of ET balloon dilatation remains promising but still requires stronger long-term validation.

This modeled study suggests that artificial intelligence may improve adhesive otitis media surgery mainly by enhancing the preoperative and perioperative information pathway rather than by replacing surgeon judgment. Adhesive otitis media surgery is difficult because the surgeon must identify the full extent of membrane adhesion, define hidden retrotympanic involvement, anticipate ossicular status, and estimate whether limited transcanal endoscopic access will be sufficient. Current surgical

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studies show that visualization of retraction limits is one of the key determinants of successful surgery, which makes this disease particularly suitable for image-assisted planning.

The first major modeled advantage was improved diagnostic and staging support. This is credible because AI has already shown high performance in tympanic membrane image classification and strong utility in chronic middle-ear CT interpretation. A 2024 explainable 3D convolutional neural network for chronic otitis media demonstrated good accuracy and external performance on temporal bone CT, while a 2025 CNN-based tympanic membrane diagnostic pipeline further supports the feasibility of automated classification in ear disease.

The second advantage was improved operative efficiency. In adhesive otitis media, incomplete visualization may lead to residual adhesion, persistent retraction, or iatrogenic epithelial remnants. The 2024 prospective comparison of endoscopic and microscopic tympanoplasty specifically highlighted the value of wider visualization with endoscopy, and the atelectatic otitis media endoscopic series reported strong graft success and substantial air-bone gap improvement. In a real clinical pathway, AI could strengthen this advantage by helping the surgeon anticipate where extended exposure or combined microscopic-endoscopic work will be necessary.

A third likely benefit is improved selection of adjunctive procedures. The literature on cartilage tympanoplasty with ET balloon dilatation suggests that management of Eustachian tube dysfunction may improve audiological outcome and quality of life, although stronger long-term evidence is still needed. A decision-support model that combines endoscopic stage, hearing thresholds, CT findings, and Eustachian tube indicators could therefore be clinically useful, especially in borderline cases.

The hearing-related findings in this modeled manuscript also fit with the broader otologic AI literature. Reviews in otology now explicitly note that AI is being used not only for diagnosis but also for postoperative hearing prediction after tympanoplasty, and deep-learning models have already been applied to tympanic membrane disease classification with simultaneous hearing regression. These developments make it plausible that AI-assisted counseling and risk stratification could improve both case selection and postoperative expectations in adhesive otitis media.

At the same time, direct AI evidence specifically for adhesive otitis media remains limited. Most available otologic AI studies focus on general otitis media, chronic otitis media, tympanic membrane image classification, or middle-ear CT analysis rather than on adhesive disease alone. Therefore, the present article should be interpreted as a translational scientific template built from adjacent evidence rather than as proof that AI has already been validated for routine adhesive otitis media surgery.

Conclusion

In this modeled 135-patient study, an AI-assisted workflow improved the surgical management pathway for adhesive otitis media by increasing preoperative concordance, shortening time to operative planning, reducing operative time, lowering intraoperative changes in strategy, and improving 12-month graft and hearing outcomes.

The most realistic near-term role of AI in adhesive otitis media surgery is as an integrated support tool for tympanic membrane image analysis, temporal bone CT interpretation, risk-based procedure selection, and hearing-outcome prediction. A real-world prospective TDTU ENT study would be required to determine whether these modeled benefits can be reproduced in routine otologic practice.

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References

1. Özdoğan F, Özel HE, Köroğlu E, Genç S. Endoscopic and Microscopic Tympanoplasty for Adhesive Otitis Media: A Comparative Prospective Analysis. 2024.
2. Youssef AM, et al. Cartilage tympanoplasty in the treatment of adhesive otitis media with and without Eustachian tube balloon dilatation. 2022.
3. Iannella G, et al. Endoscopic ear surgery in the treatment of chronic otitis media with atelectasis. 2024.
4. Koyama H, et al. Application of Artificial Intelligence in Otology: Past, Present, and Future. 2024.
5. Chen B, et al. A 3D and Explainable Artificial Intelligence Model for Evaluation of Chronic Otitis Media Based on Temporal Bone Computed Tomography. 2024.
6. Song D, et al. Image-Based Artificial Intelligence Technology for Diagnosing Middle Ear Diseases: A Systematic Review. 2023.
7. Lee H, et al. Diagnosis of Tympanic Membrane Disease and Pediatric Hearing Using Convolutional Neural Network Models with Multi-Layer Perceptrons. 2024.
8. Seo HW, et al. Development and Validation of a CNN-Based Diagnostic Pipeline for Automated Classification of Tympanic Membrane Disease. 2025.