Failure Rate of Posterior Atticotomy to Establish Middle Ear and Mastoid Cavity Communication

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Abstract

Background: Obstruction of middle ear (ME) ventilation pathways may impair mastoid aeration despite canal wall-up mastoidectomy. This study designed to examine the failure rate of posterior atticotomy (PA) in establishing ME mastoid communication and the need for alternative surgical procedures.

Methods: This observational study was executed on 50 participants, identified as chronic suppurative otitis media (CSOM) (tubotympanic type) and tympanic membrane perforation with recurrent ear discharge unresponsive to medical treatment, and computed tomography (CT) temporal bone may have showed otomastoditis. All patients were subjected to, physical examinations, audiological assessment, laboratory investigation and radiological examination

Results: All participants had tubotympanic (safe) CSOM. Large tympanic membrane perforations (36%), edematous ME mucosa (46%), complete TIO (64%), high dural plate (76%), and inadequate epitympanic exposure (70%) were frequent findings. Saline testing showed absent ME –mastoid communication in 70% of participants. Despite PA being performed in 62% of cases, satisfactory communication was achieved in only 18%, while 56% continued to exhibit absent communication. Adjunctive procedures were required in 70% of participants, most frequently gel foam soaked with antibiotic and dexamethasone (44%).

Conclusions: PA alone was often insufficient to restore ME –mastoid communication in tubotympanic CSOM, supporting the need for selective adjunctive procedures.

Keywords: Adequate Mastoid Aeration, Posterior Atticotomy, Middle Ear, Mastoid Cavity

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Introduction:

The primary role of the mastoid air cell system is to buffer fluctuations in middle ear (ME) pressure during periods of Eustachian tube obstruction. A well-aerated mastoid system increases the volume of the ME cleft, thereby facilitating compensation for pressure variations within the ME cavity [1].

In a well-aerated mastoid, substantial fluctuations in ME pressure may exert minimal effects on the ME structures and tympanic membrane. During mastoidectomy, establishing adequate communication between the mastoid cavity and the ME cleft promotes mastoid re-aeration and may reduce the consequences of recurrent negative pressure, including atelectasis and cholesteatoma formation. However, restoration of mastoid aeration following canal wall-up mastoidectomy may not be achieved in a considerable proportion of patients [2].

Ventilation of the ME cleft relies primarily on adequate Eustachian tube function, patency of the tympanic isthmus and aditus ad antrum, appropriate mastoid pneumatization, and the integrity of the ME mucosa. The mesotympanum and protympanum receive direct aeration from the Eustachian tube, whereas the epitympanum is anatomically separated from the mesotympanum by the epitympanic diaphragm and is ventilated mainly through the tympanic isthmus, with additional ventilation sometimes occurring through an incomplete tensor fold [3].

The mastoid air cell system communicates with the epitympanum through the aditus ad antrum, and effective aeration requires a patent aditus and tympanic isthmus, with the incomplete tensor fold potentially providing an additional ventilation pathway in the presence of normal Eustachian tube function and an intact tympanic membrane. The epitympanic diaphragm forms the inferior boundary of the epitympanum and separates it from the mesotympanum. It is composed of the malleus and incus, together with their related ligaments and membranous folds. Aeration of the epitympanic compartment originates from the Eustachian tube through the protympanum and subsequently passes across the epitympanic diaphragm via the tympanic isthmus. One study reported obstruction of the tympanic isthmus in the majority of patients with attic disease, whereas isthmus obstruction was uncommon among control subjects [4].

Thickened edematous mucosa, adhesions, granulation tissue, polyps, and cholesteatoma can obstruct the tympanic isthmus, thereby compromising ventilation of the atticoantral compartment. Posterior tympanotomy involves accessing the ME cavity through the facial recess during canal wall-up mastoidectomy. Initially, this technique was primarily employed for selected indications, particularly limited cholesteatoma confined to the facial recess and during cochlear implantation procedures [5].

Regarding the posterior atticotomy, it is the traditional technique done as an extension of cortical mastoidectomy in the anterosuperior direction to address the attic between the tegmen tympani and the superior bony wall. This procedure is meticulous, demanding a highly skilled surgeon. The aim of posterior atticotomy (PA)is good exposure of the incudomalleolar complex to exercise thick edematous mucosa. Low dural plate may interfere with good exposure with a risk of ossicular chain injury, and the length of the procedure and its proximity to the incudomalleolar heads has the probability of noise-induced sensorineural high-frequency hearing loss even with experienced hands [6].

This study designed to estimate the failure rate of PA to establish ME and mastoid cavity communication and the requirement of alternative procedures as endoscopic approach or posterior tympanotomy.

Patients and Methods:

This observational study was executed on 50 participants, >18 years, both sexes, identified as CSOM (tubotympanic type) and tympanic membrane perforation with recurrent ear discharge unresponsive to medical treatment, and computed tomography (CT) temporal bone had showed otomastoditis. The study was executed after authorization from the Ethical Committee of October 6th University Hospital, Giza, Egypt. A documented form was gathered from the participants.

Exclusion criteria were individuals with cleft palate, congenital malformations of the ear, cholesteatoma, and suspected **ME** tumor.

All participants underwent a comprehensive history taking, physical examinations, audiological assessment [by Pure Tone Audiometry (PTA)], laboratory investigation [complete blood count (CBC), erythrocyte sedimentation rate, C-reactive protein, liver and kidney functions, renal function tests (RFT), coagulation profile (prothrombin time (PT), partial thromboplastin time (PTT), international normalized ratio (INR)), and viral markers] and radiological examination [CT temporal bone, and operative technique].

Local Ear Examination:

Local ear examination was considered an essential component in the assessment of participants identified with chronic suppurative otitis media (CSOM, safe type). It provided comprehensive evaluation of the auricle, external auditory canal, tympanic membrane, and ME cavity. local ear examination was crucial for confirming the diagnosis, assessing the extent of ME disease, identifying any anatomical variations, and excluding hidden pathology that might influence the success or failure of **PA** in establishing adequate ME mastoid cavity communication. Careful local assessment also helped in detecting signs of persistent inflammation, granulation tissue, mucosal edema, or structural abnormalities that could predispose to postoperative obstruction or failure of aeration between the ME and mastoid cavity.

The auricle and postauricular region were inspected for deformity, scars of previous surgery, swelling, sinus, or fistula. Palpation was performed to detect tragal tenderness, mastoid tenderness, postauricular edema, or fluctuation. The external auditory canal was examined for narrowing, edema, discharge, debris, granulation tissue, or polyp formation. When necessary, the canal was gently cleaned under direct vision. The tympanic membrane was assessed regarding the site, size, and margins of perforation. The condition of the remnant tympanic membrane was evaluated for tympanosclerosis, retraction, or thickening. ME mucosa was examined for congestion, edema, polypoidal changes, or persistent discharge. All findings were carefully documented.

Otoscopic Examination:

Otoscopic examination was performed as a primary diagnostic tool for confirming CSOM (safe type). It allowed direct visualization of the tympanic membrane and assessment of the external auditory canal. otoscopy was particularly important to confirm central perforation, evaluate the level of ME inflammation, and exclude attic retraction or marginal perforation suggestive of unsafe disease.

Proper preoperative otoscopic assessment contributed to predicting surgical endpoints and identifying factors that might affect postoperative ME mastoid communication.

The external auditory canal was inspected and cleaned if discharge or debris was present. The auricle was gently pulled upward and backward to straighten the canal. A properly sized sterile ear speculum was inserted carefully. The tympanic membrane was examined for perforation site, size, and margin condition. The condition of the ME mucosa and the nature of discharge were documented.

Endoscopic Ear Examination: Endoscopic ear examination provided enhanced visualization of hidden areas of the ME, particularly the attic, epitympanum, and posterior mesotympanum. Endoscopic evaluation was essential to assess the anatomical integrity of this area and exclude concealed pathology that could interfere with successful establishment of ME mastoid communication. It also allowed better assessment of ventilation pathways and mucosal status.

A rigid 0-degree endoscope was used under adequate illumination. The external auditory canal was cleaned before insertion of the endoscope. The instrument was introduced gently while maintaining continuous visualization on a monitor. The tympanic membrane, attic region, anterior epitympanum, posterior mesotympanum, and Eustachian tube orifice were systematically examined. All findings were recorded.

Audiological Assessment by Pure Tone Audiometry:

PTA was executed to examine the type and level of hearing loss in participants identified with CSOM (safe type). PTA was essential to establish a baseline hearing status before surgery and to correlate preoperative hearing with the extent of ME and mastoid disease. Since CSOM typically causes conductive hearing loss, PTA helped quantify the functional impact of the disease and assess the potential benefit of **PA** in improving sound conduction and ME mastoid communication.

Patients were seated in a soundproof audiometry booth. Standard PTA was performed using air conduction thresholds at frequencies of 250 Hz, 500 Hz, 1 kHz, 2 kHz, 4 kHz, and 8 kHz, and bone conduction thresholds at 250 Hz, 1 kHz, 2 kHz, and 4 kHz. Both ears were tested separately using calibrated headphones and a bone vibrator according to standard audiometric procedures. Air bone gap was calculated to determine the type and degree of hearing loss. All results were recorded and documented for further analysis.

CT Temporal Bone:

High-resolution CT of the temporal bone was executed to examine the extent of disease in patients with CSOM (safe type). CT provided detailed visualization of the ME cavity, mastoid air cells, and ossicular chain. It was particularly essential to verify the existence of oto-mastoiditis, to assess mastoid pneumatization, and to rule out any bony erosion or cholesteatoma, which could affect the endpoint of **PA** and the establishment of ME mastoid communication.

Patients underwent high resolution CT scanning of the temporal bone using a multi-slice CT scanner. Axial and coronal sections with thin slices (≤1 mm) were obtained. The **ME** cavity, mastoid air cells, ossicles, and tegmen tympani were systematically evaluated. Findings such as opacification of mastoid air cells, **ME** effusion, or sclerosis indicative of otomastoiditis were documented. The images were reviewed and all relevant findings were recorded in the patients' files.

Operative technique (Cortical mastoidectomy with Posterior atticotomy):

Under general anesthesia, cortical mastoidectomy was performed via a postauricular approach. A periosteal flap was raised, and the spine of Henle was exposed to initiate drilling at McEwan's triangle.

Drilling was then carried out in three main directions:

The dural plate, the sinus plate, a line parallel to the posterior canal wall, cortical mastoidectomy was extended in the anterosuperior direction, and **PA** was performed, in cases with a high dural plate and optimal anatomical conditions, dissection was continued anteriorly to open the anterior epitympanic recess beyond the cog, careful drilling was ensured to avoid injury to the ossicular chain, to confirm the establishment of a connection among the mastoid cavity and the mesotympanum (**ME**), a saline test was performed by irrigating normal saline using a 20 cc syringe and observing the free passage of saline from the mastoid cavity into the mesotympanum.

Intraoperative Assessment:

The rate of intraoperative failure in establishing communication between the **ME** and mastoid cavity was recorded. The requirement for alternative techniques, such as endoscopic approach or posterior tympanotomy, was documented when standard **PA** did not achieve adequate communication.

Postoperative Care:

Parenteral antibiotics and analgesics were administered for the first five days, followed by oral antibiotics for an additional five days.

Follow-Up: Visits were conducted weekly during the first month, then monthly for six months. During each follow-up, data regarding wound healing, recurrence of discharge, and overall status of ME – mastoid communication were recorded.

The endpoint measures were to assay proper connection between mastoid cavity & ME cleft intra operative, saline test were done which was free passage of 20 cc normal saline from mastoid cavity into mesotympanum of ME.

Sample size:

It was determined via the IBM[a] SPSS[a] Sample Power[a] version 3.0.1 (IBM[a] Corp., Armonk, NY, USA). A previous study executed by Abdelfatttah and Alzami. [7], reported that the incidence of gap closure in the posterior tympanotomy was 0.6%. Thus, it was determined that a least sample size of 50 cases was needed to reach a power of 80% to identify the anticipated difference in the incidence of failure of communication of 20%, at a significance level of 0.05.

Statistical Analysis:

It was executed via SPSS v27 (IBM Inc., Chicago, IL, USA). Shapiro-Wilks test and histograms were utilized to examine the normality of the distribution of data. Quantitative parametric data were shown as mean and standard deviation (SD). Quantitative non-parametric data were shown as median and interquartile range (IQR). Qualitative variables were presented as frequency (%).

Results:

The age from 18 to 63 years with a mean value (± SD) of 39.2 (±10.92) years. There were 29 (58%) males and 21 (42%) females. Ear side was right side in 27 (54%) participants and left side in 23 (46%) participants. **Table 1**

Table 1: Demographic data of the investigated participants

		N=50
Age (years)		39.2±10.92
Sex	Male	29(58%)
	Female	21(42%)
Ear side	Right	27(54%)
	Left	23(46%)

Data are presented as mean ±SD or frequency (%)

All participants had the tubotympanic (safe) type of CSOM. The median duration of ear discharge was 17.5 (11.25–28) months. Large tympanic membrane perforations were the most common finding (36%), followed by medium perforations (32%). Edematous ME mucosa predominated (46%), while complete tympanic isthmus obstruction (TIO) was documented in 64% of participants. High dural plate was present in 76%, tensor fold obstruction (TFO) in 34%, and inadequate epitympanic exposure in 70% of cases. **Table 2**

Table 2: Clinical characteristics, otoscopic findings, TIO, TFO, dural plate and epitympanic exposure of the investigated participants

		N=50
CSOM type	Tubotympanic (safe)	50(100%)
Discharge duration(months)		17.5(11.25–28)
Perforation size	Small	8(16%)
	Subtotal	8(16%)
	Medium	16(32%)
	Large	18(36%)
ME mucosa	Edematous	23(46%)
	Mild edema	17(34%)
	Granulation	2(4%)
	Polypoid	8(16%)
TIO **and** TFO		
TIO	Complete	32(64%)
	Partial	12(24%)
TFO		17(34%)
Dural plate	High	38(76%)
	Partial	10(20%)
	Low	2(4%)
Epitympanic exposure	Adequate	15(30%)
	Inadequate	35(70%)

Data are shown as median (IQR) or frequency (%)

The saline test showed absent communication in 70% of participants, with poor and good communication observed in 18% and 12%, as listed. Alternative surgical procedures were required in 70% of cases, most commonly **PA** (62%) and gel foam soaked with antibiotic and dexamethasone (44%). Despite intervention, **PA** restored only limited communication (6%), while 56% of participants continued to have no communication. At final assessment, proper communication was achieved in 18%, sluggish communication in 26%, and absent communication persisted in 56% of participants. **Table 3**

Table 3: Saline test findings, communication status, posterior atticotomy, posterior tympanotomy, postoperative communication status alternative procedures, final communication status and final management category of the investigated participants

		N=50
Saline test result	Good communication	6(12%)
	Poor communication / sluggish flow	9(18%)
	No communication / no passage	35(70%)
Communication failure		35(70%)
Alternative procedure	Gel foam with antibiotic/dexamethasone	22(44%)
	No posterior atticotomy	4(8%)
	Posterior tympanotomy	3(6%)
	Endoscopic mucosal folds management	3(6%)
Alternative procedure needed		35(70%)
PA done		31(62%)
Posterior Tympanotomy done		3(6%)
Endoscopic mucosal folds management		4(8%)
Combined endoscopic and tympanotomy		1(2%)
Communication after atticotomy	Slightly improved; sluggish flow	3(6%)
	Failed posterior atticotomy	28(56%)
	Not applicable	15(30%)
Final communication status	Proper communication	9(18%)
	Sluggish communication	13(26%)
	No communication	28(56%)
Final management category	Gel foam soaked with antibiotic and dexamethasone	22(44%)
	Endoscopic mucosal folds management;	1(2%)

	slight improvement	
	PA not done	4(8 %)
	Cortical mastoidectomy only	15(30%)
	Posterior tympanotomy after failed posterior atticotomy	3(6 %)
	Sluggish saline flow	9(18 %)
	PA improvement	3(6 %)
	No meaningful improvement	2(4 %)

Data is presented as frequency (%)

Discussion:

CSOM was a frequent chronic inflammatory disease of the ME that was frequently related with persistent tympanic membrane perforation, recurrent ear discharge, and conductive hearing loss. Successful surgical management depends not only on eradication of disease but also on restoration of normal ME ventilation [8].

In our study, all participants were identified with the tubotympanic (safe) type of CSOM 50 (100%) participants. The median (IQR) of duration of ear discharge was 17.5 (11.25–28) months. Regarding tympanic membrane perforation, large perforations were the most frequent finding documented in 18 (36%) participants followed by medium-sized perforations in 16 (32%) and (small and subtotal perforations) were observed in 8 (16%) cases. Examination of the ME mucosa revealed that edematous mucosa was the predominant finding, observed in 23 (46%) participants, while mild edema was observed in 17 (34%) participants, polypoid mucosal changes were identified in 8 (16%) participants and granulation tissue was the least common finding was present in 2 (4%) participants. Overall, these findings suggest that chronic mucosal inflammation and the extent of tympanic membrane perforation may adversely affect ME ventilation and contribute to the difficulty of establishing adequate ME –mastoid communication during surgery.

Our findings are comparable to those of Borah et al. [9], who documented a mean interval of ear discharge of 24.0 ± 14.7 months among participants with CSOM, indicating the chronicity of the disease before surgical intervention.

Similarly, Maniu et al. [10] reported that edema, inflammation, and granulation tissue can obstruct the communicating pathways between the ME, attic, and mastoid, thereby impairing drainage and ventilation of the atticoantral compartment. They further suggested that persistent obstruction and infection lead to irreversible inflammatory alterations within the ME cleft, contributing to the persistence of CSOM.

In this study, tympanic isthmus patency demonstrated that complete TIO was observed in 32 (64%) participants, while partial obstruction was observed in 12 (24%) participants. TFO was observed in 17 (34%) participants. These findings emphasize the importance of evaluating the patency of the tympanic isthmus and tensor fold during surgery, as obstruction of these ventilation pathways may compromise ME aeration and influence surgical endpoints.

Similarly, Ali et al. [11] reported that endoscopic evaluation and reestablishment of tympanic isthmus patency throughout myringoplasty improved ME ventilation and audiometric endpoints, highlighting the critical role of the tympanic isthmus in maintaining normal ME ventilation.

Likewise, Shewel et al. [12] reported that obstruction of the tympanic isthmus was significantly related with poor mastoid pneumatization, whereas a patent isthmus was strongly related with normal mastoid aeration. They also reported that intraoperative endoscopic assessment of the tympanic isthmus and tensor fold facilitates restoration of attic ventilation by identifying and removing obstructing tissues.

Our findings showed that high dural plate was observed in 38 (76%) participants, partial dural plate position was observed in 10 (20%) participants, while a low dural plate was observed in only 2 (4%) participants. Regarding epitympanic exposure, inadequate exposure was more common than adequate exposure was present in 35 (70%) and 15 (30%) participants respectively. These findings indicate that limited epitympanic exposure and variations in dural plate position may represent important anatomical factors contributing to the technical difficulty and potential failure of posterior atticotomy

Along with our findings, Abdelfattah and Alzami et al. [13] stated that there are many factors that may interfere with successful posterior atticotomy, including low dural plate, marked mucosal edema, and the time factor with long procedure of drilling near by the ossicular heads adding the risk of sensorineural hearing loss.

Also, Marchioni et al. [6] mentioned that low dural plate may interfere with good exposure with a risk of ossicular chain injury, and also the length of the procedure and its proximity to the incudomalleolar heads has the risk of noise induced sensorineural high-frequency hearing loss even with experienced hands.

In our study, the intraoperative saline test demonstrated no communication among the ME and mastoid cavity in 35 (70%) participants, poor or sluggish communication in 9 (18%), and good communication in only 6 (12%), indicating a communication failure rate of 70%. This high failure rate was probably attributable to persistent obstruction of the tympanic isthmus, tensor fold, and epitympanic ventilation pathways by chronic inflammatory changes, mucosal edema, adhesions, or granulation tissue, which may prevent the establishment of an adequate communication despite surgical intervention.

Furthermore, PA was performed in 31 (62%) participants, while posterior tympanotomy was required in 3 (6%), endoscopic mucosal fold management in 4 (8%), and a combined endoscopic approach with posterior tympanotomy in 1 (2%) participant. Gel foam soaked with antibiotic and dexamethasone was used in 22 (44%) participants, and PA was not performed in 4 (8%) participants. This probably reflects the need to individualize the surgical approach according to the intraoperative anatomical findings, as conventional PA alone was insufficient to overcome ventilation pathway obstruction in a subset of participants.

Following posterior atticotomy, only 3 (6%) patients showed slight improvement with persistent sluggish saline flow, whereas satisfactory communication could not be restored in 28 (56%) participants; assessment was not applicable in 15 (30%) participants. These findings can be explained by the limited surgical access provided by PA to the hidden epitympanic spaces, particularly when the tympanic isthmus or tensor fold remains obstructed or when anatomical factors, such as inadequate epitympanic exposure, restrict complete clearance of the ventilation pathways.

At the end of the procedure, proper ME –mastoid communication was achieved in only 9 (18%) participants, while 13 (26%) had sluggish communication and 28 (56%) continued to demonstrate no communication.

In line with our data, Abdelfattah and Alzami et al. [13] documented that PA may have limited effectiveness in certain cases due to several contributing factors. In such situations, posterior tympanotomy may serve as an alternative route for ventilation by circumventing obstruction of the aditus ad antrum and epitympanic diaphragm.

In this regard, Pradhan et al. [14] reported that endoscopic-assisted atticotomy was an efficient technique for the management of limited mastoid disease, providing satisfactory anatomical and hearing endpoints. They attributed these favorable results to the enhanced visualization afforded by the endoscope, which facilitates identification and management of hidden epitympanic pathology.

Limitations of the study were dimensioned sample size that may produce insignificant results, his was an observational study without a control or comparison group, preventing direct comparison of PA with other surgical techniques, the follow-up period of six months may not have been sufficient to evaluate long-term maintenance of ME –mastoid communication, hearing endpoints, or disease recurrence, assessment of communication relied primarily on the intraoperative saline test, which may not fully reflect long-term postoperative ventilation or functional aeration, and functional endpoints such as postoperative hearing improvement, quality of life, and patient satisfaction were not evaluated.

Conclusions:

PA alone was frequently insufficient to restore ME –mastoid communication in patients with tubotympanic CSOM. TIO, TFO, and inadequate epitympanic exposure were common contributors to failure, while adjunctive procedures improved communication in selected cases. Careful intraoperative assessment of ME ventilation pathways was essential to optimize surgical endpoints.

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