Subject Area: Otolaryngology

**Posterior tympanotomy versus posterior atticotomy in creating well-ventilated middle ear cleft pros and cons**

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Abstract

Background
Cortical mastoidectomy is considered a cornerstone step in the surgical management of noncholesteatomatous chronic suppurative otitis media. It comprises the canal wall-up technique, preserving the posterior and superior bony canal walls. The goal of cortical mastoidectomy is mainly to ventilate the middle ear cleft besides eradication of diseased mastoid air cells. The ventilation of the middle ear cleft has no way except through the aditus ad antrum and patent epitympanic diaphragm besides well-functioning Eustachian tube. This way of ventilation is usually affected in chronic infected ears by edematous and polypoid mucosa, leading to its obstruction. Traditional practice used to perform posterior atticotomy to overcome this problem, exposing the incudomalleolar complex and to excise edematous and polypoid mucosa. This technique may be ineffective in many cases owing to multiple factors, so posterior tympanotomy may acts as an alternative pathway to bypass obstructed aditus ad antrum and epitympanic diaphragm.

Aim
The aim was to compare the effectiveness of both posterior tympanotomy and posterior atticotomy in achieving well-ventilated middle ear cleft in noncholesteatomatous chronic suppurative otitis media and to identify advantages and disadvantages of both techniques.

Patients and methods
A prospective, comparative, randomized study was conducted from March 2019 to December 2020. A total of 40 patients experiencing safe non chronic suppurative otitis media CSOM with central perforation were included. Patients have been randomized into two groups of 20 patients each (groups A and B). The patients in group A underwent cortical mastoidectomy and posterior atticotomy, whereas the patients in group B underwent cortical mastoidectomy and posterior tympanotomy. Regular follow-up visits were done every 2 months for at least 6 months for both groups.

Results
In group A, 12 patients were doing well throughout the follow-up period with intact graft and ventilated middle ear, 4 patients had retracted grafts, 2 patients had retraction pockets, and 2 patients had recurrent tympanic perforation and discharge. In group B, 17 patients were doing well with intact grafts and ventilated middle ear, and 3 patients had mild tympanic retraction.

Conclusion
The authors found that posterior tympanotomy is an effective and viable alternative ventilation pathway to middle ear cleft bypassing obstructed aditus ad antrum with better address to the epitympanic diaphragm and less complications in patients with CSOM.

Keywords: Middle ear ventilation, posterior atticotomy, posterior tympanotomy

INTRODUCTION
The main function of mastoid air cell system is to buffer the changes in middle ear pressure during the intervals of Eustachian obstruction. So, a well-aerated mastoid system will increase the volume of the middle ear cleft and can compensate pressure changes in the middle ear cavity [1,2].
In a well-aerated mastoid, marked changes in the middle ear pressure may have little effect on the middle ear and tympanic membrane [3]. During mastoidectomy, if we connect the mastoid cavity to the middle ear cleft properly, this will result in mastoid aeration, so the sequelae of repeated negative pressure, including atelectasis and cholesteatoma, can be minimized. However, the aeration of the mastoid system after a canal wall up mastoidectomy may not be achieved in many patients [3,4]. Vrabec et al.[4] found that only 46% of 35 patients with canal wall-up mastoidectomies showed good mastoid aeration. They concluded from the review of several previous reports that the prevalence of mastoid aeration following a canal wall-up mastoidectomy was no greater than 50% [4]. Ventilation of the middle ear cleft is mainly dependent on the Eustachian tube function, patent isthmus tympanicum, patent aditus ad antrum, pneumatization of the mastoid cavity, and status of the middle ear cleft mucosa. The mesotympanum and prototympanum are aerated directly from the Eustachian tube, whereas the epitympanic space is separated from the mesotympanum by the epitympanic diaphragm and ventilated through the isthmus tympanicum and sometimes through the incomplete tensor fold [5,6]. The mastoid system is separated from the epitympanic space by the aditus ad antrum and needs for aeration patent aditus, patent tympanic isthmus plus or minus incomplete tensor fold in case of good Eustachian function and intact tympanic membrane [6].

The epitympanic diaphragm forms the floor of the epitympanum and separates it from the mesotympanum. This diaphragm consists of the malleus, incus, and their attached ligaments and membranous folds [7]. Aeration of the epitympanic space comes from the Eustachian tube to the prototympanum and then through the isthmus tympanicum crossing the diaphragm [8]. In a study, the isthmus tympanicum was blocked in most patients with attic disease, whereas the prevalence of blocked isthmus was low in the control group [9].

In 1964, Proctor[10] described the isthmus tympanicum as a tiny opening between the mesotympanum and the attic and located between the stapes posteriorly and the tensor tympani tendon anteriorly, with its primary function being ventilation of the atticomastoid compartment as mentioned before [10]. Even in the presence of a well-functioning Eustachian tube, a blocked isthmus tympanicum may hinder ventilation and pneumatization of the atticomastoid compartment of the middle ear cleft, resulting in hypopneumatized mastoid and possible formation of attic retraction and cholesteatoma [11]. Thick edematous mucosa, adhesions, granulation tissue, polyps, and cholesteatoma may block the isthmus tympanicum and interfere with the ventilation of the atticocentral compartment [12].

Posterior tympanotomy is a technique in which we address the middle ear cavity through the facial recess in a canal wall-up mastoidectomy. Originally this technique was described mainly as a management of limited situations, mainly limited facial recess cholesteatoma and cochlear implantation surgery [13]. This route has the advantage of proper wide connection between the middle ear cleft and the mastoid cavity with bony boundaries not lined by mucosa and permanent patency with subsequent minimal narrowing [13]. Moreover, it can be widened safely anterosuperiorly toward the incus buttress with minimal risk to the facial nerve, chorda tympani, or the annulus [13]. However, in nonexperienced hands, there may be risks of complications involving the facial nerve, the chorda tympani nerve, the annulus, and the posterior bony wall. Moreover, the incus and incudostapedial joint may be at risk, especially in chronically inflamed mastoid with altered anatomy [14].

Regarding the posterior atticotomy (Fig. 1), 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 [15]. The aim of posterior atticotomy is good exposure of the incudomalleolar complex to excise thick edematous mucosa [16]. Low dural plate may interfere with good exposure with a risk of ossicular chain injury (Fig. 2), 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 [16]. It was found also that a good connection between the mastoid and the mesotympanum was not universally achieved after long meticulous procedure owing to difficult control of the tympanic isthmus and the tensor fold [4,17]. In our study, we have conducted a comparison between posterior atticotomy and posterior tympanotomy regarding the surgical steps, difficulties, complications, and the outcomes (Tables 1–3).

**Patients and methods**

A prospective, comparative, randomized study was conducted from March 2019 to December 2020. In all, 40 patients experiencing safe noncholesteatomatous CSOM with central perforation were included. Patients have been randomized into two groups of 20 patients each (groups A and B). The patients in group A underwent cortical mastoidectomy and posterior atticotomy, whereas the patients in group B underwent cortical

![Figure 1: Comparison between routes of ventilation in both groups, group A on the right and group B on the left.](image)
mastoidectomy and posterior tympanotomy. Regular follow-up visits were done every 2 months for at least 6 months for both groups.

**Ethics**

The Ethics Committee of our institution approved this work according to the Declaration of Helsinki. A detailed informed consent was obtained from each patient.

**Methods**

All patients were assessed based on a thorough history, otologic examination, and full audiological evaluation. High-resolution computed tomography scan of the temporal bone was performed for each patient to assess the middle ear cavity and mastoid pneumatization.

**Operative technique**

Under general anesthesia, we performed cortical mastoidectomy via a postauricular approach, raising a periosteal flap, exposing the spine of Henle to start drilling in the Mc Ewen’s triangle proceeding in the three main directions, the dural plate, the sinus plate, and the line parallel to the posterior canal wall. After exenteration of the diseased mastoid air cells and good identification of the antrum and lateral semicircular canal, the patients were divided into two equal groups of 20 patients each (group A and group B) according to the following steps.

**Table 1: Comparison between groups according to operative time, blood loss, complications, hospitalization, and return to normal life activities**

<table>
<thead>
<tr>
<th>Patient groups</th>
<th>Operative time (h)</th>
<th>Blood loss</th>
<th>Intraoperative complications</th>
<th>Hospitalization</th>
<th>Return to normal life</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Range</td>
<td>1.5 to 2.4 h</td>
<td>105-130 ml</td>
<td>No complications in both groups</td>
<td>1 day</td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>1.8 h</td>
<td>123 ml</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>Range</td>
<td>1.2 to 1.9 h</td>
<td>107-125 ml</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Mean</td>
<td>1.5 h</td>
<td>117 ml</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 2: Comparison between groups regarding intraoperative difficulties and postoperative complications**

<table>
<thead>
<tr>
<th>Patient groups</th>
<th>Exposure of the epitympanum</th>
<th>Communication between the mastoid and the mesotympanum</th>
<th>Postoperative complications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group A</td>
<td>Inadequate in 6 patients (15%)</td>
<td>Proper</td>
<td>High-frequency sensor neural hearing loss in 2 patients (10%)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inadequate</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Absent</td>
<td></td>
</tr>
<tr>
<td>Group B</td>
<td>-</td>
<td>Proper</td>
<td></td>
</tr>
</tbody>
</table>

**Table 3: Final Outcome**

<table>
<thead>
<tr>
<th>Patient groups</th>
<th>Conducive gap closure [n (%)]</th>
<th>Intact graft [n (%)]</th>
<th>Retracted graft [n (%)]</th>
<th>Retraction pocket [n (%)]</th>
<th>Residual perforation [n (%)]</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Gap closure</td>
<td>Minimal gap closure</td>
<td>Persistent conductive gap</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Group A</td>
<td>8 (40)</td>
<td>2 (10)</td>
<td>10 (50)</td>
<td>12 (60)</td>
<td>4 (20)</td>
</tr>
<tr>
<td>Group B</td>
<td>12 (60)</td>
<td>3 (15)</td>
<td>5 (25)</td>
<td>17 (85)</td>
<td>3 (15)</td>
</tr>
</tbody>
</table>

**Figure 2:** Two different situation regarding the dural level showing low level in the right side and high level in the left.

In group A (Fig. 3), we have completed the cortical mastoidectomy in the anterosuperior direction performing posterior atticotomy or the superior canal wall-up atticotomy. We started by exposing the incus body and short process followed by careful drilling between the dural plate superiorly and the superior canal wall inferiorly to expose the rest of incus body, the incudomalleolar joint, and head of malleus correspondingly. In case of high dural...
plate with optimal circumstances, we proceeded anteriorly to open the anterior epitympanic recess beyond the cog. Careful drilling not to touch the ossicular chain is crucial. In this group of patients, we have excised edematous polypoid mucosa in the attic and around ossicles by using different instruments to reach hidden areas in the epitympanic diaphragm (the tympanic isthmus and the tensor fold) to establish good connection between the epitympanum and the mesotympanum. This connection is marked by the free passage of saline between these two compartments.

In group B (Fig. 4), we performed posterior tympanotomy or the facial recess approach. At first, we exposed the incus short process, which points to the fossa incudis in the incus buttress, as it represents the base of the inverted pyramid of the facial recess. By a coarse diamond burr, we drilled carefully parallel to the facial nerve and the chorda tympani nerve along an axis from the incus buttress to the chordofacial angle besides thinning of the posterior canal wall. After establishing proper connection between the mastoid and the mesotympanum, we widened it in the anterosuperior direction safely. Additionally, through this approach, we assessed the tensor fold and the tympanic isthmus clearly and excised edematous polypoid mucosa to ventilate the attic region.

In both groups, the procedures were continued in the same steps, such as grafting the tympanic membrane perforation by temporalis fascia, periosteal closure, and skin closure by interrupted silk or vicryl sutures.

Postoperative management was the same in both groups. Parenteral antibiotics and analgesia were given for the first 5 days followed by oral antibiotics for 5 days.

Follow-up visits were done every week for the first month and then monthly for 6 months recording data about healing, recurrence, and complications.

**Statistical analysis**

Data management and analysis were performed by using the statistical analysis systems. Numerical data were summarized using means and SDs or mean and ranges and Fisher’s exact test, with statistical significance at \( P \) less than or equal to 0.05. Categorical data were summarized as percentages. The \( \chi^2 \)-test was used to compare between the groups concerning categorical data. All \( P \) values are two sided. \( P \) values less than 0.05 were considered significant.

**Results**

The average age of the patients in group A was 32.0 ± 5.5 years, whereas that in group B was 29.5 ± 7.75 years. The difference was statistically not significant (\( P = 0.5 \)). The study population comprised 22 male patients (55%) and 18 female patients (45%). Both groups were comparable (\( P = 0.6 \)).

**Operative results**

In group A, the operative time ranged from 1.5 to 2.4 h, with a mean of 1.8 h. Blood loss ranged from 105 to 130 ml, with a mean of 123 ml. Hospitalization was 1 day in all patients of this group, with discharge on the second postoperative day. Regarding complications, there were no complications in the form of injury to adjacent critical structures, including ossicles, dura, sinus, and facial nerve. Exposure of the epitympanum was inadequate in six patients due to low dural plate and narrow outer attic mass with relatively long procedure. Communication between the mastoid and the mesotympanum was proper in 11 patients (55%), inadequate or slow saline passage in four patients (20%), and absent in five patients (25%). Return to regular normal life activity or work was possible in all patients after 7 days.

Regarding the final outcome, all patients were subjected to periodic regular monthly assessment after the first month. In group A, 12 patients were doing well throughout the follow-up period with intact graft and ventilated middle ear, four patients had retracted grafts, two patients had posterosuperior retraction pockets, and two patients had recurrent tympanic membrane perforation and discharge.
Pure tune audiometry revealed conductive gap closure in eight patients (40%), minimal gap closure in two patients (10%), and persistent conductive gap in 10 patients (50%). High-frequency sensorineural hearing loss affecting 6 and 8 KHz was found in two patients (10%) in whom the procedure was lengthy.

In group B, the operative time ranged from 1.2 to 1.9 h, with a mean of 1.5 h. Blood loss ranged from 107 to 125 ml, with a mean of 117 ml. Hospitalization was 1 day in all patients of this group, with discharge on the second postoperative day. Regarding complications, there were no complications in the form of injury to adjacent critical structure, mainly the facial nerve, the lateral canal, and the posterior canal wall. Exposure of the facial recess area was adequate in all patients, except in two patients owing to anteriorly placed sinus plate with relatively long procedure. Communication between the mastoid and the mesotympanum was proper in all patients (100%). Return to regular normal life activity or work was possible in all patients after 7 days.

Regarding the final outcome, all patients were subjected to periodic regular monthly assessment after the first month. In group B, 17 patients were doing well throughout the follow-up period with intact graft and ventilated middle ear, and three patients had mild tympanic retraction.

Pure tune audiometry revealed conductive gap closure in 12 patients (60%), minimal gap closure in three patients (15%), and persistent conductive gap in five patients (25%). No high-frequency sensorineural hearing loss affection was noted.

Return to regular life activity or work was possible in all patients after 7 days.

**DISCUSSION**

With intact tympanic membrane, the middle ear cleft has a dual ventilation system, composed of direct and indirect routes. The direct route occurs through the Eustachian tube, which ventilates the mesotympanum during its momentary opening equalizing its pressure with the atmospheric pressure [18].

The second route is the pneumatized cellular mastoid system, which acts as a standby buffer system to compensate the intervals of Eustachian blockage. However, the second route needs patent aditus ad antrum to ventilate the epitympanum and needs in addition a patent epitympanic diaphragm to further ventilate the mesotympanum [19]. Proper Eustachian tube function besides its direct effect on the mesotympanum also has an indirect effect on the mastoid system in the form of good pneumatization [20]. Moreover, this indirect effect requires a patent epitympanic diaphragm and a patent aditus ad antrum. So, hypopneumatized mastoid may be a result of chronic Eustachian dysfunction, obstructed aditus ad antrum, or blocked epitympanic diaphragm as a single factor or in combinations [20,21]. A vicious circle aggravates the middle ear condition, which may start by long-standing poor Eustachian tube function, leading to poorly pneumatized mastoid system, which in turn may adversely affect the middle ear buffer system. This circle may continue by chronic inflammatory mucosal edema leading again to more Eustachian obstruction [22]. Breaking this circle may be achieved by proper connection of the mesotympanum with the mastoid system. This connection has its physiological route through two steps, the aditus ad antrum and epitympanic diaphragm, which may be occluded by inflammatory mucosal edema or granulation. In this case, we practice posterior atticotomy to excise the obstructing element in its steps (aditus ad antrum and epitympanic diaphragm) [23]. 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 [24]. In these situations, posterior tympanotomy can establish proper wide connection between the mesotympanum and the mastoid cavity, bypassing the natural route, which is full of ossicles, membranous folds, and ligaments [24].

In our study, we compared both procedures (posterior atticotomy and posterior tympanotomy) regarding operative details and postoperative outcome. We found significant intraoperative difference between both groups regarding the length of the procedure, which was more in group A of posterior atticotomy owing to some anatomical issues in some patients, like as low dural plate and marked polypoid thick mucosal changes mandating careful meticulous drilling. Moreover, achieving proper connection between the mastoid cavity and the middle ear was significantly less in group A, with proper connection in 11 patients only (55%), inadequate or slow saline passage in four patients (20%), and absent in five patients (25%). However, it was proper in all patients of group B of posterior tympanotomy. Unfortunately, high-frequency sensorineural hearing loss was a complication in two patients of group A, which was explained as a noise trauma by the prolonged drilling near to the ossicular heads. Although the facial nerve was at a higher risk of injury in group B, it was not affected in all patients. Postoperatively, we found a significant deference in the outcome of patients, who showed higher graft taking of this group, with discharge on the second postoperative day. Regarding complications, there were no complications in patients, except in two patients owing to anteriorly placed sinus plate with relatively long procedure, which was more in group A of posterior atticotomy.

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**CONCLUSION**

We found that posterior tympanotomy is an effective and viable alternative ventilation pathway to middle ear cleft bypassing obstructed aditus ad antrum with better address to the epitympanic diaphragm with less complications in patients with chronic supportive otitis media.

**Conflicts of interest**

There are no conflicts of interest.

**REFERENCES**