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Original Article

# Endoscopic Assessment of the Isthmus Tympanicum and Tensor Tympani Fold and their Relationship with Mastoid Pneumatization in Chronic Otitis Media

**Yasser Shewel, Mokhtar Bassiouny, Mohammad Ebrahim**

Department of Otorhinolaryngology-Head and Neck Surgery, Alexandria University, Alexandria, Egypt

ORCID iDs of the authors: Y.S. 0000-0003-1593-0748; M.B. 0000-0002-8161-3444.

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**OBJECTIVES:** To endoscopically evaluate the patency of the isthmus tympanicum and integrity of the tensor tympani fold as routes of ventilation of the attic and mastoid in chronic otitis media (COM) and to assess their effects on mastoid pneumatization.

**MATERIALS and METHODS:** Sixty patients with COM were categorized into two groups: (1) Group A: 36 patients with tympanic membrane perforation (2) Group B: 24 patients with limited attic disease of whom 14 patients had attic retraction pockets and 10 with limited attic cholesteatoma. A multislice computed tomography scan of the temporal bone was performed for each patient to assess the degree of mastoid pneumatization. Notably, either myringoplasty or tympanomastoid surgery was performed in all patients. An endoscope was inserted into the middle ear for evaluation of the isthmus tympanicum and tensor fold area.

**RESULTS:** The isthmus tympanicum was patent in most ears (83.3%) of group A, whereas it was blocked in most ears (83.3%) of group B. The tensor fold was complete in 77.8% of ears in group A and 83.3% of ears in group B. It was observed that 94.1% of ears with patent isthmus in both groups had normal mastoid pneumatization and 5.9% of ears had poorly pneumatized mastoid. By contrast, 7.7% of ears with blocked isthmus tympanicum had normal mastoid pneumatization and 92.3% had poor mastoid pneumatization. Normal mastoid pneumatization was observed in 50% of ears in both groups with complete tensor fold, and 83.3% of ears with an incomplete tensor fold.

**CONCLUSION:** A significant correlation was observed between COM with limited attic disease and obstruction of the isthmus tympanicum. Obstruction of isthmus tympanicum was associated with poor mastoid pneumatization. Furthermore, an incomplete tensor fold was associated with well pneumatized mastoid.

**KEYWORDS:** Chronic otitis media, cholesteatoma, isthmus tympanicum, tensor fold, endoscopic

## INTRODUCTION

Ventilation of the middle ear cleft is generally dependent on the Eustachian tube function, patency of isthmus tympanicum, pneumatization of the mastoid cavity, and status of the middle ear cleft mucosa and tensor tympani fold if it is not intact. All previous factors should be evaluated when analyzing middle ear pathophysiology or when taking decisions regarding the appropriate management of chronic otitis media (COM) [1-4].

The mesotympanum and protympanum are aerated directly from the Eustachian tube, whereas the epitympanum is separated from the mesotympanum by the epitympanic diaphragm and ventilated through the isthmus tympanicum and sometimes through the incomplete tensor fold [1, 5, 6].

In 1964, Proctor [7] described the isthmus tympanicum as a tiny opening between the mesotympanum and the attic and located between the stapes posteriorly and the tensor tympani teindon anteriorly, with its primary function being ventilation of the atticomastoid compartment.

**Corresponding Address:** Yasser Shewel E-mail: yshwel@yahoo.com

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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 sclerosed mastoid and possible formation of attic retraction and cholesteatoma [6, 8].

Thick edematous mucosa, adhesions, granulation tissue, polyps, and cholesteatoma may block the isthmus tympanicum and interfere with the ventilation of the atticoantral compartment [8, 9].

It is well evident that an intraoperative assessment of the middle ear aeration routes is very valuable in COM surgeries [10-14].

With the advancement in endoscopic ear surgery, Marchioni et al. [8, 15] and Tarabichi [13] suggested an exclusive endoscopic strategy for the management of cholesteatoma. This endoscopic approach allows for wider exposure of hidden spaces like the anterior epitympanic recess and facilitates the exenteration of cholesteatoma of the anterior epitympanic space without disconnecting the ossicular chain—an extremely challenging maneuver using the microscopic approach. Moreover, the exclusive endoscopic strategy offers the otologist excellent visualization of the isthmus tympanicum and tensor tympani fold (complete or incomplete) and enables him/her to open or remove it simultaneously, restoring appropriate ventilation to the attic and protympanum.

This study aimed to endoscopically evaluate the patency of the isthmus tympanicum and the status (complete or incomplete) of the tensor tympani fold as the ventilation routes to the attic and mastoid in COM and to assess their influence on mastoid pneumatization.

## MATERIALS AND METHODS

This study was planned as a prospective investigation involving 60 patients with COM who underwent surgery from June 2017 to June 2018. The contralateral ears were normal. The ethics committee of our institution approved this work according to the Declaration of Helsinki. A detailed informed consent was obtained from each patient.

The 60 patients were categorized into two groups:

1- Group A: Thirty-six patients with tympanic membrane perforation, eight of whom had a persistent discharge.
2- Group B: Twenty-four patients with limited attic disease—14 with attic retraction pockets and 10 with limited attic cholesteatoma. Notably, patients with previous ear surgery and those with aggressive cholesteatoma filling the protympanum, mesotympanum, or mastoid antrum were excluded.

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. The degree of mastoid pneumatization was classified as follows: well pneumatized (normal) and poorly pneumatized. The latter included diploic (hypopneumatized) and sclerotic mastoids.

1- Well pneumatized (normal): pneumatization extends into the antral, zygomatic, apex of mastoid, and sinodural areas.
2- Diploic (hypopneumatized): pneumatization limited to the antrum and periantral areas.
3- Sclerotic mastoid: the antrum may or may not be pneumatized [16].

In all patients, either myringoplasty or tympanomastoid surgeries were performed. The surgeries were either endoscopic or microscopic-aided endoscopic surgery. Sinuscopes of 3 mm diameter and 14 cm length and variable degrees, such as 0°, 30°, and 45°, were used. The microscope was prepared for intraoperative use in case the surgeon decided to move to microscopic surgery.

The isthmus tympanicum and the tensor fold region were assessed endoscopically during surgery. The isthmus tympanicum was investigated between the tensor fold and the posterior incudal ligament.

The tensor fold was examined by inserting a 45° sinuscope into the protympanum. The supratubal recess and Eustachian tube were identified, and the lower surface of the tensor fold was clearly assessed.

In case of obstructed isthmus or complete tensor fold, the cause of obstruction was endoscopically removed, and the isthmus and tensor fold were opened to restore atticomastoid ventilation.

We investigated the correlation of patency of isthmus and condition of the tensor fold with types of COM and degree of mastoid pneumatization.

### Statistical Analysis

Data were analyzed using GraphPad Prism version 5 for Windows (GraphPad Software, San Diego, California, USA). Data analysis was performed using the Fisher exact test, and $p<0.05$ was considered statistically significant.

## RESULTS

The average age of patients in group A was 26.0±6.75 years, whereas that in group B was 25.2±8.13 years. The study population comprised 22 male patients (36.67%) and 38 female patients (63.33%).

### Radiological Evaluation

The degree of mastoid pneumatization was assessed using CT. We compared the findings between the two groups and between the operated and contralateral ears within the same group (Table 1).

A statistically significant intergroup difference was observed regarding the degree of pneumatization in the operated ears ($p<0.0001$) because 32 out of 36 ears (88.9%) in group A had normal mastoid pneumatization, whereas only 2 out of 24 ears (8.3%) had it in group B. No significant intergroup difference was observed concerning the contralateral ears ($p=0.4219$).

### Isthmus Tympanicum

Regarding the intraoperative assessment of the isthmus tympanicum patency, the isthmus was either patent or blocked. We determined different causes for isthmus blockage, such as edematous inflamed mucosal folds, inflammatory exudates, medialized malleus, granulation tissue, and cholesteatoma sac. These factors were either present individually or in conjunction with each other.

**Table 1.** Comparison between the studied groups according to mastoid pneumatization

| | Group A (n=36) | | Group B (n=24) | | |
|---|---|---|---|---|---|
| | n | % | n | % | $^{FE}$p |
| Type of mastoid in the operated side | | | | | |
| Normal pneumatization | 32 | 88.8 | 2 | 8.3 | <0.0001* |
| Poor pneumatization | 4 | 11.2 | 22 | 91.7 | |
| Contralateral side mastoid | | | | | |
| Normal pneumatization | 33 | 91.67 | 20 | 83.33 | 0.4219 |
| Poor pneumatization | 3 | 8.33 | 4 | 16.67 | |

FE: Fisher exact test *: Statistically significant at p≤0.05

**Table 2.** Relation between isthmus patency and type of mastoid pneumatization in each group and overall study population

| | Isthmus patency | | | | |
|---|---|---|---|---|---|
| | Patent | | Blocked | | |
| **Type of mastoid** | **No.** | **%** | **No.** | **%** | $^{FE}$p |
| **Group A** | **(n=30)** | | **(n=6)** | | |
| Normal pneumatization | 30 | 100.0 | 2 | 33.3 | <0.001* |
| Poor pneumatization | 0 | 0.0 | 4 | 66.6 | |
| **Group B** | **(n=4)** | | **(n=20)** | | |
| Normal pneumatization | 2 | 50.0 | 0 | 0.0 | 0.022* |
| Poor pneumatization | 2 | 50.0 | 20 | 100.0 | |
| **Overall study population** | **(n=34)** | | **(n=26)** | | |
| Normal pneumatization | 32 | 94.1 | 2 | 7.7 | <0.001* |
| Poor pneumatization | 2 | 5.9 | 24 | 92.3 | |

FE: Fisher exact test *: Statistically significant at p≤0.05

**In group A:** Out of 36 operated ears with perforation, 30 ears (83.3%) had patent isthmus, whereas, in the remaining 6 ears (16.7%), the isthmus was blocked owing to edematous mucosal folds, granulation tissues, or medialized malleus (Figure 1).

**In group B:** Out of 24 ears with limited attic diseases, 4 ears (16.7%) had patent isthmus, whereas it was blocked in 20 ears (83.3%). The isthmus was blocked because of edematous mucosa, granulation, inflammatory exudate, and medialized malleus in 10 ears and because of cholesteatoma sac in the remaining 10 ears (Figure 2).

Therefore, a statistically significant intergroup difference was present (p<0.001) because the isthmus was patent in most ears of group A, whereas it was blocked in most ears of group B.

On analyzing the patency of isthmus in group B, it was observed that the isthmus was patent in 4 of 14 (28.57%) ears with retraction pockets, whereas it was patent in 0 of 10 (0%) ears with attic cholesteatoma. However, this difference was statistically insignificant (p=0.114).

**Table 3.** Relation between the tensor fold and mastoid pneumatization in each group and overall study population

| | Tensor fold | | | | |
|---|---|---|---|---|---|
| | Incomplete | | Complete | | |
| **Type of mastoid** | **No.** | **%** | **No.** | **%** | $^{FE}$p |
| **Group A** | **(n=8)** | | **(n=28)** | | |
| Normal pneumatization | 8 | 100.0 | 24 | 85.7 | 0.555 |
| Poor pneumatization | 0 | 0.0 | 4 | 14.3 | |
| **Group B** | **(n=4)** | | **(n=20)** | | |
| Normal pneumatization | 2 | 50.0 | 0 | 0.0 | 0.022* |
| Poor pneumatization | 2 | 50.0 | 20 | 100.0 | |
| **Overall study population** | **(n=12)** | | **(n=48)** | | |
| Normal pneumatization | 10 | 83.3 | 24 | 50.0 | 0.036* |
| Poor pneumatization | 2 | 16.7 | 24 | 50.0 | |

FE: Fisher exact test *: Statistically significant at p≤0.05

### Tensor Fold

Intraoperative assessment of the tensor fold area revealed no significant intergroup differences (p=0.746). Overall, 12 of 60 ears (20%) in both groups had incomplete tensor fold, and 48 ears (80%) had complete tensor fold.

**In group A:** Out of 36 ears, 8 (22.2%) had incomplete tensor fold, and the remaining 28 ears (77.8%) had complete tensor fold.

**In group B:** The tensor fold was incomplete in 4 of 14 ears (28.57%) with retraction pockets and 0 of 10 ears (0%) with attic cholesteatoma (p=0.114). Therefore, the tensor fold was incomplete in 4 of 24 ears (16.67%) in group B.

We removed any obstructing tissues that blocked the isthmus tympanicum, as well as opened or excised the complete tensor fold to maintain postoperative attic and mastoid aeration.

### The Relation between Isthmus Patency and Type of Mastoid Pneumatization

Out of 34 ears with patent isthmus in both groups, 32 ears (94.1%) had normal mastoid pneumatization, and only 2 ears had poorly pneumatized mastoid.

On the other hand, 24 out of 26 ears (92.2%) with blocked isthmus in both groups had poorly pneumatized mastoid, and normal mastoid pneumatization was observed in only 2 ears (7.8%).

Accordingly, a significant correlation between the isthmus tympanicum patency and normal mastoid pneumatization was observed in the studied population (p<0.001) (Table 2).

### The Relation between Tensor Fold and Type of Mastoid Pneumatization

Table 3 reveals a significant association between a complete tensor fold and poorly pneumatized mastoid in patients with limited attic diseases (p=0.022).

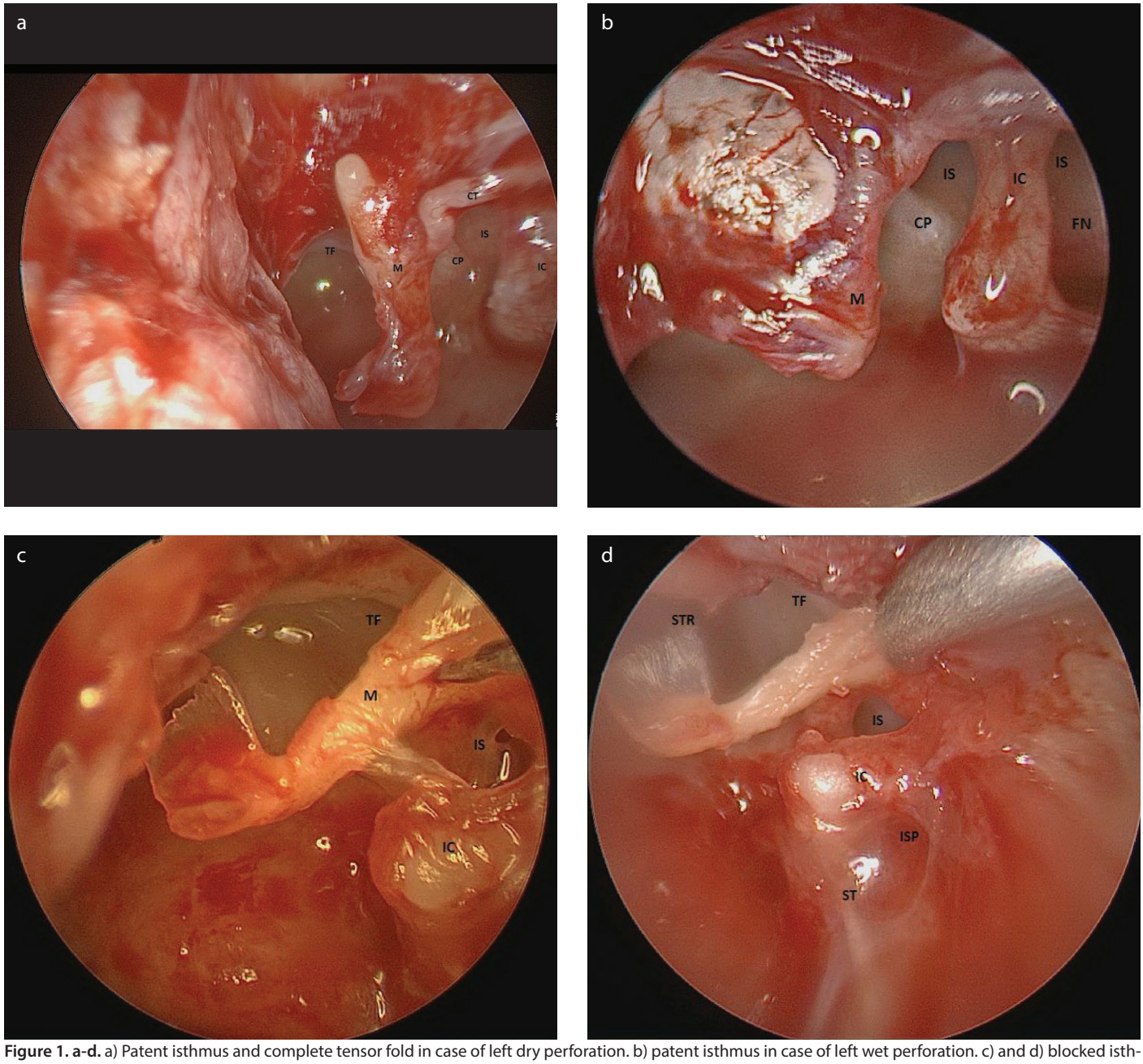


**Figure 1. a-d.** a) Patent isthmus and complete tensor fold in case of left dry perforation. b) patent isthmus in case of left wet perforation. c) and d) blocked isthmus and complete tensor fold in case of left dry perforation.
M: malleus, IC: incus, CT: chorda tympani nerve, CP: cochleariform process, IS: isthmus tympanicum, TF: tensor fold area, FN: facial nerve, ISP: blocked posterior isthmus, STR: supratubal recess, ST: stapedial tendon

Normal mastoid pneumatization was observed in 24 of 48 ears (50%) with complete tensor fold and 10 of 12 ears (83.3%) with an incomplete tensor fold.

Hence, a significant relation was observed between an incomplete tensor fold and well pneumatized mastoid (p=0.036) (Table 3).

## DISCUSSION

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. Aeration of the epitympanic space comes from the Eustachian tube to the protympanum and then through the isthmus tympanicum crossing the diaphragm [1].

Palva and coworkers explored the anatomy of the tensor fold during dissection of the temporal bones. They reported that the tensor fold was complete in most ears, separating the attic from the protympanum. In these patients, the attic is only aerated via the isthmus tympanicum, located between the posterior incudal ligament and the tensor tendon. Occasionally, the tensor fold was incomplete, providing a direct route of ventilation from protympanum to the anterior epitympanic space [17].

This study revealed a statistically significant intergroup difference regarding isthmus tympanicum patency (p=0.001). The isthmus was patent in 83.3% of ears in group A (tympanic membrane perforation) and blocked in 83.3% of ears in group B (limited attic diseases). Moreover,

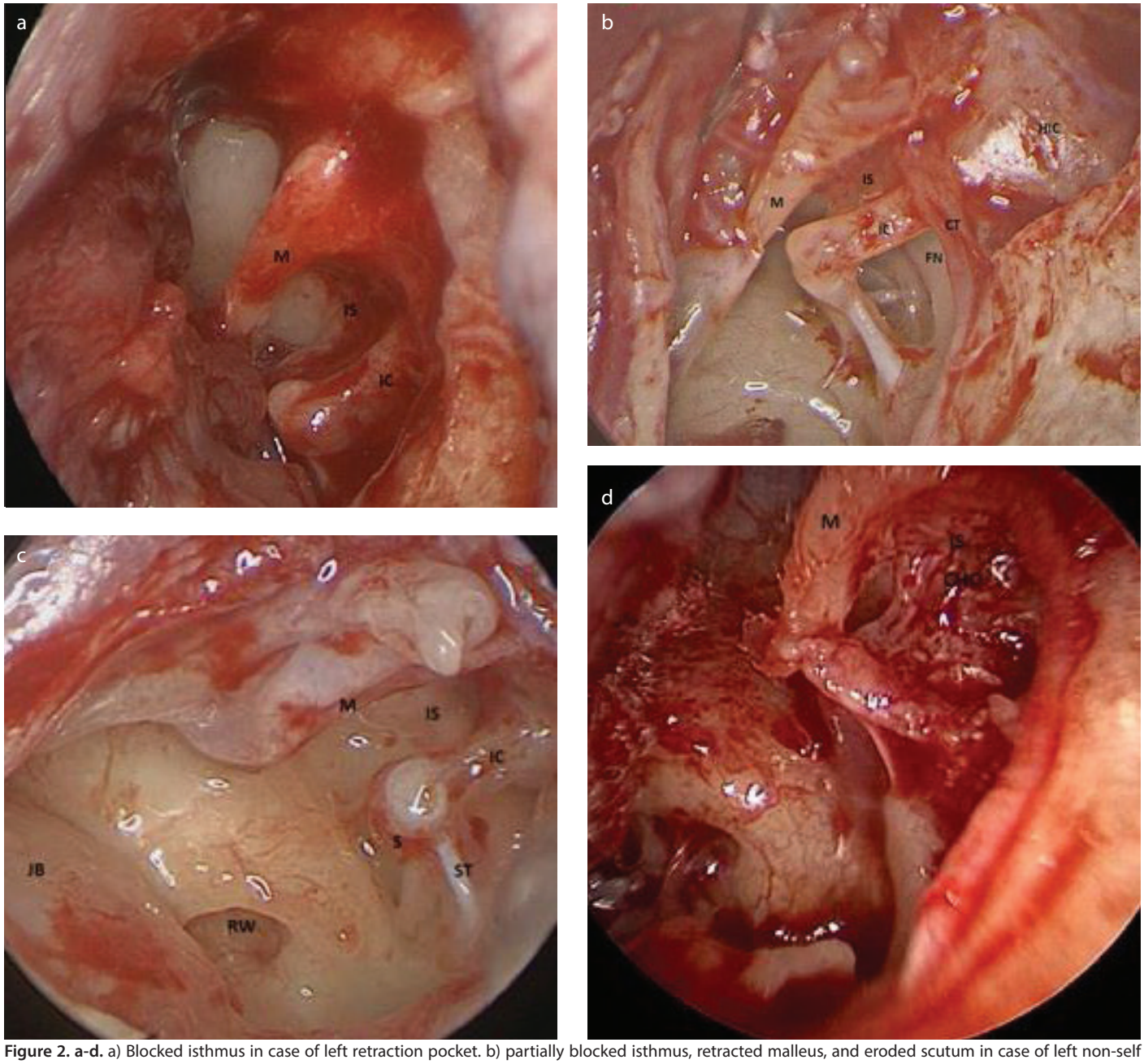


**Figure 2. a-d.** a) Blocked isthmus in case of left retraction pocket. b) partially blocked isthmus, retracted malleus, and eroded scutum in case of left non-self cleaning attic retraction pocket. c) patent isthmus, partially eroded lenticular process of incus, high jugular bulb in case of left retraction pocket. d) blocked isthmus because of cholesteatoma sac and medialized retracted malleus, complete erosion of the long process of incus in case of left attic cholesteatoma.
M: malleus, IC: incus, IS: isthmus tympanicum, ST: stapedial tendon, RW: round window, JB: jugular bulb, FN: facial nerve, CHO: cholesteatoma sac.

our results were concordant with the results of the endoscopic study of Marchioni et al. [15] regarding attic cholesteatoma. They reported that 16 out of 18 patients with attic cholesteatoma had a complete tensor fold, and obstructed isthmus was a constant finding in all patients.

Furthermore, our results were concordant with the results of another case-control study conducted by Marchioni and Presutti [18] on 152 patients who underwent endoscopic surgery for different ear diseases. The isthmus tympanicum was blocked in most patients with attic disease, whereas the prevalence of blocked isthmus was low in the control group.

In addition, we compared the mastoid pneumatization between the two groups and determined a statistically significant higher incidence of normal mastoid pneumatization in group A with tympanic membrane perforation (88.9%) compared with the group B with limited attic diseases (8.3%). These results are consistent with the results of Monsanto RdC et al. [19], which reported that the average volume of the human temporal bones and epitympanic volume in COM without retraction pockets are considerably larger than those with the retraction pockets.

We analyzed the relation between isthmus patency and mastoid pneumatization and determined a strong relation between isthmus tympanicum patency and normal mastoid pneumatization in the studied population ($p<0.001$). Moreover, we observed that 94.1% of ears with patent isthmus in both groups had pneuma-

tized mastoid compared with 7.7% of ears with blocked isthmus tympanicum.

Our findings were similar to those of Marchioni and his colleagues regarding the correlation between blockages of ventilation routes of the atticomastoid compartment and a higher prevalence of poorly pneumatized mastoid [8].

Nonetheless, our study results were inconsistent with that of Shirai K et al. [6] who studied the volume of the attic and patency of the isthmus tympanicum in human temporal bone with COM and without any ear pathology. They observed no significant correlation between the attic volume and COM with epitympanic pathology, or between patent isthmus tympanicum and volume of epitympanum.

In this study, intraoperative evaluation of the tensor fold revealed no significant intergroup difference because an incomplete tensor fold was present in 22.22% in group A versus 16.67% in group B (p=0.746). Data revealed that 12 of 60 ears (20%) had incomplete tensor fold, and 48 of 60 ears (80%) had a complete tensor fold. These data were similar to Palva's studies, wherein he observed incomplete tensor fold in 25% of cases [17].

Li B et al. [20] studied the endoscopic anatomy of the tensor fold in the temporal bone specimen and reported that the tensor fold was incomplete in 8 out of 28 (28.6%) specimens.

In addition, the relation between the tensor fold and mastoid pneumatization was analyzed, and a statistically significant relation was observed between the incomplete tensor fold and normal mastoid pneumatization, as well as a significant association between the complete tensor fold and poorly pneumatized mastoid in patients with limited attic pathology.

This study emphasizes the use of endoscope during ear surgery in COM because it is a minimally invasive procedure and provides excellent visualization of the tensor fold and isthmus tympanicum. Restoration of isthmus tympanicum patency and opening of the complete tensor fold can improve the ventilation of attic and mastoid, and consequently improve the surgery outcome.

## CONCLUSION

Mastoid pneumatization was normal in ears with tympanic membrane perforation, whereas it was poorly pneumatized in most ears with limited attic pathology.

A statistically significant relation was observed between obstruction of the isthmus tympanicum and COM with limited attic diseases. Ears with tympanic membrane perforation were significantly associated with a patent tympanic isthmus.

The blockage of the isthmus tympanicum was associated with poor pneumatization of the mastoid.

No significant differences were observed regarding the incidence of incomplete tensor fold in both types of COM. Incomplete tensor fold was associated with good pneumatization of the mastoid.

**Ethics Committee Approval:** Ethics committee approval was received for this study from the Ethics Committee of Alexandria University School of Medicine.

**Informed Consent:** Written informed consent was obtained from patients who participated in this study.

**Peer-review:** Externally peer-reviewed.

**Author Contributions:** Concept - Y.S., M.E.; Design - Y.S., M.E., M.B.; Supervision - Y.S., M.B.; Materials - Y.S., M.E.; Data Collection and/or Processing - Y.S., M.E.; Analysis and/or Interpretation - Y.S., M.E., M.B.; Literature Search - Yasser shewel., M.E., M.B.; Writing - Y.S., M.E., M.B.; Critical Reviews - Y.S., , M.B.

**Conflict of Interest:** The authors have no conflict of interest to declare.

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