# Retraction Pockets and Adhesive Otitis Media

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María José Herrera J and Javiera Pardo

## Definition

A retraction of the tympanic membrane occurs when a portion or the entirety of the membrane collapses within the middle ear cavity, as a result of negative pressure from impaired airflow in this space.

The importance of retraction pockets lies in the loss of the original histological and anatomical structure, which is associated with the development of ossicular chain erosion, cholesteatoma formation, and potentially life-threatening complications from cholesteatoma. The development of retraction pocket presumes a change in the histological structure of the tympanic membrane, typically the loosening of the elastic fibers in the middle layer and reductions in thickness and tensile strength and in the layer's abilities to maintain the shape and position of the tympanic membrane and to return to its original thickness and strength. Retraction pockets are considered sequels of abnormal pressure regulation in the middle ear; however, inflammation or earlier perforations may also contribute to the development of retraction pockets [1].

## Prevalence

Retractions are much more common in children than in adults. The incidence of atrophy increases from 4% at age 4 years to 11% at age 16 years [2]. In a study of 294 healthy children between 5 and 16 years old, the prevalence of atelectasis of the eardrum was estimated at 14%–26% in the pars flaccida and only 0.3%–3.7% in the pars tensa [3]. Re-examinations of children who had secretory otitis media noticed that 34% of the ears had developed different degrees of attic retractions after 3–8 years [4].

In 2011, Maw et al. used video-otoscopy to perform an important longitudinal cohort study with 6908 healthy children, whose ages ranged from birth to 10 years. They found pars flaccida retractions in 9.6% of cases and pars tensa retractions in 7.9%. Most of these retractions were mild, and a few cases were severe [5]. The prevalence of retractions in adults has been reported in a population sample as 9.6% for pars flaccida and 7% for pars tensa [5].

Bilateral retraction pockets are often present. The association between pars tensa and pars flaccida abnormalities in the same ear shows that pars flaccida retractions are frequently associated with pars tensa abnormalities, but when abnormalities have been found in the pars tensa, the pars flaccida has been completely normal [5].

Many studies have reached a similar conclusion: When otitis media is present, the frequency of tympanic membrane pathology is significantly higher. Abnormalities in the tympanic membrane in ears without histories of otitis have been present in 11% of cases. In children with a history of otitis, the rates of abnormalities have been 46% and 92% (as found with the use of a ventilation tube, or VT) for 8-year-olds. In the same study, a high number of mild retractions that were present during the initial examination at this age had substantially diminished at 10-year follow-ups [6].

## Pathogenesis

Tympanic retraction is a sequel secondary to an inflammatory process of the tympanic membrane, such as otitis media with effusion or recurrent acute otitis media, and it is associated with the poor ventilation of the middle ear. Anatomically, the tympanic membrane is formed by three layers of skin, connective tissue, and mucosa. At the level of the pars tensa, the lamina propria, corresponding to the middle layer, has two layers: the stratum radiatum and the stratum circulare. On one hand, in the posterosuperior part of the pars tensa, the

M. J. Herrera J (✉)
Otolaryngologist Department of Otolaryngology,
Clínica Universidad de Los Andes,, Santiago, Chile

J. Pardo
Otolaryngologist Department of Otolaryngology,
Clínica Universidad de Los Andes, Santiago, Chile
e-mail: jpardo@clinicauandes.cl

stratum circulare is poorly developed and more vascularized, which makes it a weaker zone. On the other hand, at the level of the pars flaccida, this zone has no annulus (Rivinus segment), and its lamina propria has few elastic and collagen fibers, which are also disorganized. This exacerbates the weakness of this zone and increases the risk of retraction [7].

From a ventilation point of view, the middle ear is divided into two compartments by the tympanic diaphragm: a posterosuperior compartment, which includes the superior epitympanum and mastoid, and an anteroinferior compartment, which includes the mesotympanum, protympanum, hypotympanum, inferior retrotympanum, and inferior epitympanum (Prusak's space). The ventilation of the posterosuperior compartment depends on the tympanic diaphragm and its isthmus, whereas the anteroinferior compartment is ventilated directly by the Eustachian tube. In addition, the inferior epitympanum, which lies below the diaphragm and is independent of the superior epitympanum, is ventilated through the posterior pocket of the Von Tröltsch fascia into the mesotympanum.

Mastoid cells exhibit pneumatization, which occurs progressively from birth, from which age it eventually reaches only the antrum and is completed in adolescence. The mucosa of the mastoid is cuboidal, and its main function is gas exchange. In contrast, the mucosa of the middle ear is secretory, and its main function is mucociliary clearance.

When the middle ear mucosa becomes inflamed, it tends to reabsorb more gas, thus generating more negative pressure [8]. In addition, the inflamed mucosa tends to obstruct the airways, both at the level of the isthmus and at the level of the Eustachian tube. Obstruction at the level of the Eustachian tube generates poor diffuse ventilation, which predisposes the membrane to the generation of otitis media with effusion and to the global retraction of the tympanic membrane. On the other hand, altering segmental ventilation at the level of the isthmus predisposes the membrane to focal retractions and the formation of attic cholesteatomas.

At the cellular level, the infiltration of the eardrum by inflammatory cells in cases of otitis media with effusion destroys the lamina propria of the tympanic membrane, through the secretion of collagenase and elastase, which also generates atrophy [9, 10]. Atrophy is what predisposes the membrane to the formation of retraction pockets.

## Formation of Retraction Pockets in the Pars Tensa

During otitis media with effusion, the chronic inflammatory process around the ossicular chain is more severe than in other areas of the middle ear. Draining this area around the ossicular chain is difficult, so the effusion tends to remain there, and granulation tissue could form [11]. This tissue can

obstruct the superior retrotympanic airway, resulting in the poor ventilation of the posterior retrotympanum. The anatomical passage through which this area drains into the inferior mesotympanum is easily blocked by mucosal folds and by the infrastructure of the tympanic isthmus.

The inflame area around the ossicular chain irritates the eardrum and triggers the infiltration of inflammatory cells in the squamous layer of the pars flaccida and the posterosuperior quadrant of the pars tensa of the tympanic membrane. The inflammatory process's invasion into the tympanic membrane plays an important role in the development of retraction pockets and subsequent cholesteatoma formation, through the destruction of the lamina propria and the stimulation of keratinocyte growth and proliferation [12–14].

## Formation of Retraction Pockets in the Pars Flaccida

Ventilation routes to the attic compartments are secured by the tympanic isthmus and by the anterior route through the incomplete tensor tympani fold in an anterior epitympanic recess of normal size.

Selective epitympanic dysventilation syndrome occurs when the tympanic isthmus of a complete tensor tympani fold has been blocked, resulting in the complete isolation of the epitympanum from the mesotympanum. This event induces a gas deficit and could be the basis for the selective decrease of gas pressure in the attic, which leads to the development of an attic retraction pocket and its possibly evolving into a cholesteatoma, even in subjects with normal Eustachian tube function [14].

An incomplete tensor tympani fold prevents the development of extensive pathology around the malleus and the attic, even in the presence of chronic otitis media [14]. In one study, the blockage of the isthmus and a complete tensor tympani fold were present in more than 96% of patients with attical disease, whereas only present in 19% in the control group [15].

The anterior epitympanic recess is important in the recurrence of otitis media with effusion. Complete control of the retraction pocket was not achieved even with a tympanoplasty with cartilage or the reconstruction of the lateral wall of the attic if there the surgery on the aeration of the anterior epitympanic recess was insufficient [14, 16].

## Clinic

Clinical evaluations of a retraction pocket allow for differentiation between a stable retraction pocket and an unsafe retraction pocket, which progresses and is at risk of evolving into a cholesteatoma. Retraction pockets can remain silent

for a long time. Their clinical symptoms depend on their extent and severity. Mild retractions are usually asymptomatic, and they may be associated middle ear effusion.

Retractions of the tympanum are incidentally diagnosed during examinations. Their symptoms, such as otorrhea and conductive hearing loss, as a result of a middle ear effusion, splinting of the tympanic membrane, or ossicular chain erosion, are recurrent. Otalgia may be present because of changes in middle ear pressure or infection [17]. Dizziness is a very rare symptom [14].

Otorrhea is mostly intermittent and can be spontaneous or can follow exposure to water. Hearing loss is mostly of the mild conductive type but can reach up to 45–55 dB in some cases. No correlation has been established between hearing threshold and retraction stages [14, 18]. But improvement in audiometry exams has been found over time in mild retraction pockets [19].

## Diagnosis

Diagnosis is clinical and requires a visual examination of the tympanic membrane using an otoscope or microscope. A retraction is defined as an intact tympanic membrane that has been transformed into a very thin epidermal membrane retracted toward the medial wall of the tympanic cavity [14]. It is important to describe the severity of a retraction. The description should include its position, its depth, whether it is fixed or mobile, the presence of discharge, the accumulation of keratin, and the presence of bony erosion. This could be carried out by using one of the published staging methods or by describing it with text, drawings, or photographs [20].

## Descriptions of Retractions

Retractions are localized to the pars flaccida and pars tensa; they are marginal, nonmarginal, or bilateral [14]. The location can be made more specific by describing the involved quadrant [1]. For adherence, the mobility of a retraction can be tested via the Valsalva maneuver; via delicate suctioning, which requires exercising caution so as not to disrupt the pocket membrane [14]; or by using a pneumatic otoscope [20].

In the pars tensa, descriptions should include the adhesion to the ossicular structures, the facial recess, the sinus tympani, the promontory, and the area deep into the retrotympanum. In the pars flaccida, descriptions should include the adhesion to the malleus.

For the external auditory canal's status, descriptions should include the presence of keratin accumulation at the retraction pocket and granulations; any bone erosion in the scutum and the posterosuperior quadrant; and the presence of otorrhea.

Ossicular status includes the focal lysis of the incus, any interruption of the incudostapedial joint, myringostapediopexy, and the lysis of the stapes.

Descriptions of the bottom of the retraction pocket should include whether it is visible, any crusting, and the presence of debris accumulation. If all the frontiers of the retraction pocket can be seen, it is called a controllable retraction pocket. This could be assessed by using an endoscope.

Descriptions of the neck of the retraction pocket should include whether it stays large and wide enough and whether it is capable of self-cleaning. A constricted neck results in debris accumulation inside the pocket and runs the risk of cholesteatoma formation [14].

In addition to their clinical uses, classification systems for retractions are useful for research, where the behavior of retractions can be studied. Also, any system must be validated and reproducible. All the currently used systems suffer from a high degree of interobserver variability by an individual and between individuals [17, 21]. Grading a retraction is considered a good protocol for the evaluation of its risk factors, especially those for developing a cholesteatoma, and helpful for making comparative assessments over time, once the retraction has progressed. However, studies have lacked a universally accepted or adopted staging system for retraction pockets. In addition, the functional deficit has not been included in any staging system [14], and none of these systems has a specific treatment method [1].

## Retraction of the Pars Tensa

When the retraction compromises the pars tensa, it could be seen as retraction pocket, atelectasis, or adhesive otitis media. A retraction pocket is defined by a retraction of a fragile portion of the tympanic membrane, such as the pars tensa or the pars flaccida. Also, retraction pockets in both portions can occur in the same ear. The collapse of the whole membrane is called atelectasis. When the atelectatic membrane adheres to the middle ear floor, it is called adhesive otitis media [14]. An instance of general retraction or atelectasis is not called a retraction pocket until specific sections have been more retracted [1].

### Retraction Pockets
A retraction pocket is a dynamic pathology with variable outcomes, and it's important to describe the stage of the retraction. For pars tensa retractions, the Sadé classification is the most popular [10], although others have been reported, such as Charachon [22]. Dornhoffer's staging is like the Sadé classification except that stage 4 is assigned to retraction pockets with invisible depths [1].

The Sadé classification is divided as follows:

Sadé I—retracted tympanic membrane
Sadé II—retraction with contact on the incus
Sadé III—middle ear atelectasis (tympanic membrane on the promontory, but mobile)
Sadé IV—adhesive otitis media (tympanic membrane on the promontory, but fixed) [17]

The Charachon classification is divided as follows:

Stage 1—mobile retraction pocket
Stage 2—fixed and controllable retraction pocket
Stage 3—fixed and uncontrollable retraction pocket [17]

## Atelectasis or Adhesive Otitis Media

Mansour et al. described atelectic ears as follows: when the middle ear space has been partially or completely obliterated but the tympanic membrane has not adhered to the medial wall of the middle ear and the mucosal lining of the middle ear is intact. They also described adhesive otitis media: when the tympanic membrane has been partially or totally bound to the medial wall of the middle ear by fibrous adhesions with no possibility of reversing the retraction. In cases of partial adhesions, there may be effusion in the middle ear. In mild cases, only a few adhesions may be present, while in more severely affected ears, the space area of the middle ear cavity has vanished and the ossicular system is no longer functional. Fibroadhesive otitis media is characterized by the presence of fibrosis in the middle ear cavity [14]. Finally, a cholesteatoma is defined as a non-self-cleaning retraction pocket with keratin accumulation inside the pocket even if the ear is free of discharge [20].

It is not possible to predict the course of a retraction. Those that will remain stable and safe might form a cholesteatoma or might even resolve. Cholesteatoma development occurs in 1%–5% of patients [19]. For this, the timing and the nature of any intervention remain unclear [17].

## Retraction of the Pars Flaccida

The most used staging system is the Tos classification for pars flaccida retractions [2]. The Tos classification is divided as follows:

Tos I—the pars flaccida not in contact with the malleus head
Tos II—the pars flaccida in contact with the malleus head
Tos III—limited outer attic wall erosion
Tos IV—severe outer attic wall erosion

## Evaluation

As part of an assessment of a patient with a tympanic membrane retraction, an audiometric evaluation with a pure-tone audiogram and tympanometry is usually performed [17]. CT or magnetic resonance imaging (MRI) scans could also be invaluable in assessing deep retraction pockets where the bottom cannot be seen on otoscopy [20]. CT imaging of retraction pockets is an important diagnostic tool when assessing the localization, the extension and the status of the ossicular chain, and the involvement of the middle ear compartments. Finding an associated evolving inflammatory process (via condensation images) of the middle ear on the CT scan may indicate an active disease and consequently point to an unfavorable prognosis [14].

Investigations into a retraction should include assessments of the upper respiratory tract. This is particularly important for patients with nasal or sinal symptoms [20]. Formal Eustachian tube function (ETF) tests are not standard investigations for retraction pockets. They are performed mainly for research purposes or considered on an individual basis [20]. Any patient that has a retraction pocket should be evaluated for ETF, though [1].

A scoring system (ETS-7) that assigns a score for ETF after combining physical exams, the ability to perform the Valsalva maneuver, and normal tubomanometry results has been developed, but tubomanometers are used at some clinical research centers. There are other ETF testing methods, but they are also less available. Many tympanometer brands feature software to test the ETF. Another option is to decrease the ear canal pressure to −200 daPa, which increases the middle ear pressure (MEP) to +200 daPa, and then to ask the patient to swallow, in order to determine how much can be corrected after one swallow and after five swallows. Then this process is repeated with the ear canal pressure increased to +200 daPa, increasing the MEP to −200 daPa. If a patient is able to correct the positive and negative MEPs with swallows, this indicates that their ETF is normal. Another method is to measure the baseline MEP and then ask the patient to perform a Valsalva maneuver; after this, measure the MEP to determine whether it has increased. If the patient can generate significant pressure, the Eustachian tube (ET) should open. If the ET does not open after the patient has performed the Valsalva maneuver, there may be ET dysfunction (ETD). If successful, the patient is then asked to swallow and correct the MEP difference. Achieving a similar degree of correction with one swallow and/or five swallows should indicate normal ETF. Abnormal test results are not always accurate in showing ETD, but ETD is easy to interpret when normal. Also, the ETD may be intermittent and not show up on exams [1].

## Evolution

The progression should be monitored, especially in children. Regular observation is important to assess disease progression and monitor for complications, such as cholesteatoma formation. The untreated retraction pocket may stay unchanged in many cases, may show spontaneous resolution (which has been observed in about 40% of mild retraction cases), or may continuously progress to a precholesteatomatous stage or into a cholesteatoma [14]. A deep retraction pocket that cannot be completely visualized should be considered as carrying a significant risk of developing a cholesteatoma [23].

Kokko found that in 1%–4% of patients with otitis media with effusion who underwent ventilation tube insertions with or without adenoidectomy developed an attic cholesteatoma. The determinant factor in the evolution of a retraction pocket is the presence of the active and persistent inflammatory process inside the middle ear spaces and its effect on the neighboring segment of the tympanic membrane [24].

## Treatment

There is no consensus among otologists on the indications, timing, or options for the adequate management of tympanic membrane retraction pockets. The literature does not offer enough studies with high levels of evidence to support any surgical intervention over watchful waiting in the management of mild to moderate degrees of tympanic membrane retraction pockets. There is also no good evidence to favor one treatment over other [14, 17, 20].

A systematic review by Nankivell et al. found two randomized controlled trials with small numbers of patients to analyze. Another randomized controlled trial was excluded because it lacked an appropriate control group. One aspect that affects the risk of bias in the included and excluded studies is the reliability of grading retraction pockets by using a staging system. This makes the interpretation of any studies performed using these systems difficult. No good evidence for the role of any individual surgical intervention for the management of atelectasis of the tympanic membrane was found. Nankivell et al.'s review does not show any statistical benefit of surgical intervention over taking a watch-and-wait approach [17]. Bayoumy et al.'s systematic review concluded that the evidence is heterogenous and depends on the patient population, location, and severity of the retractions [19].

In general, a clean, asymptomatic retraction pocket with normal hearing does not require surgery, even if it is in contact with the intact ossicular chain. The indications for surgery for retraction pockets are generally the same for children and adults. However, in children, assessing the upper respiratory tract is an important part of the management, and any retraction pockets should be more closely monitored in children than in adults [20].

If there is evidence that the patient has ETD, this should be assessed and managed if possible. Decisions for management may be made on the assumption that the dysfunction may continue. Other risk factors include exposure to viral respiratory tract infections, allergies, recurrent acute otitis media, recurrent sinusitis, and acid reflux, which should be evaluated and treated. Nasopharyngeal or parapharyngeal tumors can also manifest with ETD, and if the masses grow slowly, retraction pockets may develop [1].

## Surgical Procedures

Indications for surgery on a retraction pocket include the following:

1. Otorrhea
2. Hearing impairment
3. Keratin accumulation within the retraction pocket
4. An inability to see the bottom of the retraction pocket or the polyp formation suggestive of cholesteatoma

However, the decision for surgery also depends on factors such as the degree of hearing loss, hearing in the opposite ear, patient compliance with follow-up monitoring, and the efficiency of the local treatment. A functional deficit of more than 30 dB could be an indication for surgery to improve hearing. The surgical indication for repairing a functional deficit is relative and must be formally studied and counseled. In children, asymptomatic but fixed retraction pockets may need to be monitored more frequently and for a longer period. In cases where compliance with the follow-up monitoring is in doubt, surgical intervention should be considered early, especially if the bottom of the retraction pocket cannot be seen. Surgical intervention is undoubtedly proposed in all cases featuring skin suffering and otorrhea with scutum erosion. A preoperative CT scan is recommended as part of an adequate workup [14, 20].

### Ventilation Tubes

Myringotomy with a ventilation tube is indicated for the early stages to promote the ventilation of the middle ear. The indication for a grommet or T-tube is based on the progression of the retraction.

Using subannular ventilation tubes aims to avoid the early extrusion of the tube and recurrences and to avoid the risk of persistent tympanic membrane perforation [14]. Such a tube is placed beneath the annulus in the posteroinferior quadrant. A small skin flap is elevated with the annulus. A small burr is

used to drill a canal in the posterior bony wall, then the tube is placed with the inner flange medial to the annulus of the middle ear [23]. This procedure confers good and lasting control over retraction pockets, but complications such as occluding the tube with debris or cerumen, chorda tympani injury and persisting otorrhea, may occur [14, 23].

## Treatment of Eustachian Tube Dysfunction

Many medical and surgical treatments for Eustachian tube dysfunction (ETD) have been investigated, but none has been proven effective in high-quality randomized controlled trials. Medical treatments primarily include decongestants, antihistamines, and nasal steroids [17]. Several devices can equilibrate the middle ear pressure to the environment, such as the Otovent nasal balloon device and the EarPopper [1]. Preventive treatment must be taken as early as possible to stop the process before it reaches the end stage: severe adhesive otitis media [14].

Several surgical treatments are available when medical therapy fails. Surgical treatments aim to enlarge the narrowed Eustachian tube. The most common procedures are laser tuboplasty and balloon tuboplasty [25]. Laser tuboplasty with the ablation of some pathological findings at the posterior half of the tube in cases of tubal tonsils, a narrow orifice of the tubal ending, or an adenoid has been reported in 70% of cases, and patients who had these were offered an improvement to their ET function [14]. Balloon tuboplasty has been shown to significantly improve ETD and, compared with laser tuboplasty, has shown a greater tympanometry improvement rate [25]. A systematic review by Huisman et al. found that this procedure reduced the symptoms associated with ETD [26]. Huhnd et al. showed that 31% patients with tympanic membrane retraction experienced an improvement in middle ear ventilation and that 54% of the patients perceived an improvement in their clinical symptoms after a Eustachian tube dilatation [27].

There are no randomized clinical trials showing the efficacy of balloon dilation, but in experienced hands, this procedure is considered safe. Therefore, if this procedure were to be tried on some patients, the recommendation is in the group of patients with ongoing ETD [1].

Adenoidectomy improves tubal function. The effect of cleft palate repair on improving tubal function has been variously reported in literature. The impact of septal deviations on the middle ear has been demonstrated; it has reflected tubal dysfunction caused by turbulence from inspiratory air at the nasopharynx. The beneficial effect of septoplasty on tubal function has been demonstrated by several studies [14].

## Tympanectomy

Tympanectomy is a surgical procedure that resects the retracted portion of the ear, leaving a perforation. A ventilation tube is placed in the tympanic remnant. In a 2-year study, tympanectomy was performed on 50 ears, and the indication of this technique was retraction Sadé II or larger. After an average of 12 months of follow-up, 34 cases (68%) showed a normal eardrum. In nine cases, the eardrum retracted again, and six showed a perforation. On average, spontaneous closure occurred in 4–7 weeks [28]. Other authors have considered not excising too-large areas because large perforations may result. Such an excision should be performed only if retraction has been limited to one quadrant. Cases must be followed long enough after the extrusion of the tube to look for recurrence [14]. A systematic review showed that created perforations persist in 3%–13% and showed recurrences in 11%–25% of the patients [19].

## Tympanoplasty

This intervention involves the excision of the retraction and then reconstruction [19]. A cartilage graft is considered to provide good reinforcement for the tympanic membrane and resists middle ear pressure variations, even in the case of severe Eustachian tube dysfunction. But the cartilage is less compliant, has a negative impact during higher sudden pressure variations, may hide possible future cholesteatoma formation, and does not relieve the middle ear from its causal pathology. The reported recurrence rate of retraction with this procedure is between 5% and 45% [14]. Different techniques for cartilage tympanoplasty have been described [23]. Finally, at 10-year follow-ups examining the retraction pockets reconstructed with perichondrium or temporalis fascia, the recurrence rates were as follows: 80% of the ears were repaired with fascia and 40% with perichondrium [14].

In the Cochrane revision of 2010, the findings from one study [29] suggest that surgical intervention with the tragal cartilage reconstruction of the lateral attic wall reduces the risk of the progression of the retraction pocket, but the study design had a high potential risk of bias. The findings of another study [30] suggest no additional benefit would come from also inserting ventilation tubes into patients undergoing cartilage tympanoplasty [17].

If an ear exhibits reasonably normal ETF, a VT may not be placed, and the retraction pocket should be surgically managed with a tympanoplasty. If ETD is suspected, the recommendation is to insert a VT at the time of tympanoplasty. With evidence or suspicion of ongoing ETD, medial grafts can be used, but they carry higher risks of failure. It's important to prevent the graft from medializing. In general, using a lateral graft is better but more difficult to perform for ongoing ETD, and it carries a higher risk of blunting, lateralization, and cholesteatoma formation if not carried out by experienced hands. If the lateral graft technique is used, it is better to completely remove the retraction pocket [1].

Tympanoplasty and ossiculoplasty should be considered to treat hearing loss caused by middle ear atelectasis and ossicular chain interruption. Mastoidectomy does not add a favorable prognostic factor to the management of retraction in terms of hearing recovery or recurrence rate [31].

Patients who have undergone a successful cartilage tympanoplasty for either pars tensa retraction pockets or pars flaccida retraction pockets should be followed up with for at least 3–5 years. The patients should be informed of the symptoms of otorrhea and hearing loss and inform of the need to return for review [20].

## Endoscopic Ear Surgery

Using an endoscope allows surgeons to explore the hidden areas of the middle ear, such the retrotympanum and its surrounding structures, the epitympanum, and the protympanum. This surgical technique preserves the healthy mucosa of the middle ear and the mastoid. The Eustachian tube plays an important role in the aeration of the middle ear, but other anatomic factors are likewise important, such are the epitympanic diaphragm and the tympanic isthmus. The tympanic isthmus is crucial in the ventilation of the attic, and the blockage of it is defined as selective epitympanic dysventilation syndrome. To treat this condition, a surgery of the isthmus must be performed to restore the ventilation pathway. Thanks to the endoscope, new concepts have been developed in the surgical treatment of middle ear pathologies [32]. Endoscopic tympanoplasty for retractions is a promising surgical technique, but further studies are needed to confirm previous results [19].

## Atticotomy

Limited pars flaccid retraction may be approached by performing an endaural atticotomy. The amount of bone removed depends on the degree of exposure required to investigate the presence of squamous epithelium and explore the tympanic isthmus. Any surgical defects can be reconstructed by using cortical bone, bone wax, or cartilage [23]. The epitympanum needs open ventilation routes, so the physiological pathways of aeration for the diseased compartments must be restored and the adequate gas exchange of the middle ear must be ensured to avoid the recurrence of the retraction [14].

## Resection of the Retraction and Mastoid Obliteration

Mastoid obliteration reduces the degree of transmucosal gas exchange in the middle ear and the need for ventilation to be compensated for by using a Eustachian tube. The indication for this procedure relies on the grade of aeration of the tympanum, as shown on CT scan images of the temporal bone. This procedure decreases the incidence of cholesteatoma development but cannot eliminate the recurrence of a retraction pocket [14].

## Treatment of Middle Ear Atelectasis

Atelectasis may be reversible with the use of ventilating tubes. Atelectatic tympanic membranes can be restored to their normal position via the administration of nitrous oxide to a patient under general anesthesia and via the insertion of a ventilating tube. Ventilating the middle ear may bring back the tympanic membrane to its normal position and restore its consistency, thus preventing its progressing to adhesive otitis media [14].

Tympanoplasty consists of carefully elevating the thin tympanic membrane from the medial wall of the middle ear, reconstructing the ossicular chain and inspecting the antrum, and then reinforcing the eardrum with cartilage to maintain an air-filled tympanic cavity [1, 23]. This procedure carries a high risk of inducing an iatrogenic cholesteatoma and hearing loss and has a high rate of failure. The surgery is not indicated in asymptomatic adhesive otitis media with normal hearing, because hearing function is not easy to improve. Recurrent otorrhea, cholesteatoma, and conductive hearing loss are indications for intervention. The risks and benefits of surgery must be discussed with the patient [14].

The European Academy of Otology and Neurotology (EAONO) wrote a consensus-based practical guide featuring several recommendations for retractions [20].

For an adult with a pars tensa retraction pocket requiring surgery, the EAONO recommends cartilage reinforcement for the retraction pocket or cartilage tympanoplasty. The added benefit of using a ventilation tube remains uncertain, except in cases with concomitant middle ear effusion.

It is prudent to monitor these pockets for at least 12 months, to check that they remain stable. Upon discharge from outpatient follow-up, patients should be informed of the symptoms of otorrhea and hearing loss and informed of the need to return for review.

For a child with a pars tensa retraction pocket requiring surgery, the EAONO recommends inserting a ventilation tube as the first line of treatment. Cartilage tympanoplasty should be reserved for retractions that persist following the failure of ventilation tube insertion. The combination of ventilation tube insertion and a simple excision of the retraction pocket is a simple technique used by some surgeons, but it may cause a residual perforation or iatrogenic cholesteatoma.

For an adult or a child with a pars flaccida retraction pocket requiring surgery, atticotomy and cartilage reconstruction for the outer attic wall is generally the surgery of choice. In less-severe cases, it may be possible to clear the debris and observe.

For patients with complete atelectasis who present with hearing loss, the EAONO recommends that they be monitored for at least 12 months with hearing rehabilitation using a hearing aid if necessary. Children may need to be monitored more frequently and for a longer period. However, the long-term results from hearing restoration surgery have been disappointing overall.

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