Intraoperative endoscopy of the anterior epitympanum recess through the posterior tympanotomy

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Abstract

Introduction: The anterior epitympanum recess (AER) is a common place of the development of the cholesteatoma, which is why removal of the matrix from this area plays a key role in the surgical treatment of chronic otitis media.
Aim: To evaluate the intraoperative visibility of AER in endoscopic optics in comparison to microscopic optics and to determine the prevalence of cholesteatoma in various types of construction of the AER. Study design: retrospective analysis of intraoperative search.
Material and methods: The study included 55 patients treated in the Department of Otolaryngology, Medical University of Warsaw within the years 2009–2011, who underwent endoscopy-assisted canal wall up tympanoplasty with posterior tympanotomy. The type of construction of the AER – cellular or dome-shaped – was determined.
Results: Cellular type of recess was found intraoperatively in 32% of ears and dome-shaped in 68% of the study group. The population with chronic otitis media does not differ significantly compared to the general population in terms of the construction of the anterior epitympanum recess ($p = 0.668108$; $\chi^2 = 0.1838235$, $df = 1$). Among the ears with cholesteatoma a cellular AER was found in 48.3% of cases and a dome-shaped AER was found in 51.7%.
Conclusions: The cellular type of AER was significantly more frequent in ears with cholesteatoma ($p < 0.01$, $\chi^2 = 29.86492$, $df = 1$). Level of evidence: 1b.

Key words: middle ear, endoscopy, cholesteatoma, chronic otitis media.

Introduction

The epitympanum has been the subject of anatomical studies for more than a hundred years, since the times when Prussak described its structure in 1867 [1]. Prussak's space is in fact the lower floor of the epitympanum, separated from the proper epitympanum by bands of connective tissue: mainly by the lateral malleolar ligament, which is the upper wall of Prussak's space. This space is located medial to the tympanic membrane (in this section known as Shrapnell's membrane) above the short hammer process and medially from its neck, and the front is closed by the anterior malleus ligament. Prussak's space extends to the rear as the pouch of von Tröltsch located between the tympanic membrane and the posterior malleus ligament, which extends from the posterior surface of the malleus neck and the upper one-third of the malleus handle.

The pouch of von Tröltsch extends posteriorly-inferiorly towards the mesotympanum and constitutes the primary route of aeration of Prussak's space. The epitympanum is separated from the mesotympanum by the epitympanic diaphragm. It consists of four fibrous structures: malleus ligaments (the lateral, anterior and posterior, and posterior incus ligament) and two membranous bands: the tensor fold which extends anteriorly from the tensor tendon, and the

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lateral incudomalleal fold, extending posteriorly from the malleus and the incus. Epitympanum aeration is done by the tympanic isthmus, between the posterior incudal ligaments and the tensor tendon.

The anterior epitympanic recess (AER) is separated from the posterior epitympanum by a cog, descending from the tegmen tympani and the vertically extending mucosal fold. The superior and anterior epitympanic compartment, or the air space in the front of the head of the malleus, is called variously by different authors: *sinus epitympani* [2], *anterior epitympanic recess/compartment* [3–5], *anterior attic recess* [6] or *geniculate sinus* [7]. Medial to the AER lies the inferior part of the geniculate and the anterior part of the tympanic section of the facial nerve. In the anterior-lateral direction, this space is adjacent to the petro-tympanic fissure, in which lies the chorda tympani. The bone structure of the AER is differentiated. This structure may be a single air chamber of a hemispherical dome shape (Photo 1) which was found in about 50% of the population bilaterally. In another version AER consists of a system of many small air cells (Photo 2). Such a cellular construction bilaterally was found in approximately 28% of the population. Other people have a different structure of the AER on each side [8].

Prussak's space and the anterior epitympanic recess are the common place of growth of cholestea-toma. It is estimated that 60% of such pathologies affect the epitympanum, especially deriving from the retraction pockets. Extremely extensive cholesteatoma in this area may result in the paralysis of the facial nerve due to erosion of the nerve canal around the geniculate ganglion [9]. In addition, residual cholesteatoma is possible in the anterior epitympanic recess, because this area can be difficult to purify from the matrix. Thorough visual inspection of this recess plays a key role in the total removal of cholesteatoma. On the other hand, the removal of overabundant connective tissue and inflammatory tissue from the tympanic cavity is crucial for aeration of the ear and prevents a possible recurrence of the disease due to disorders of ventilation of the epitympanum.

Prussak's space can be well visualized by the external auditory canal. It is possible to purify this space after detachment of Shrapnell's membrane. Visualization of the anterior epitympanic recess is inadequate in microscopic view, both from the posterior tympanotomy, and by the external auditory canal. This area is in fact difficult to visualize in microscope optics because of bony structures standing in the visual axis of the microscope, especially the lateral wall of the attic and the external auditory canal. However, the use of the endoscope by posterior tympanotomy provides full visual access to the anterior epitympanic recess.

Photo 1. Dome-shaped anterior epitympanum space (right ear – view from the posterior epitympanotomy)

Photo 2. Anterior epitympanic recess of cellular structure – view from the endoscope 30° by the posterior tympanotomy (right ear – view from the posterior epitympanotomy)

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Aim

The aim of the study was to compare the visibility of the anterior epitympanum compartment in microscopic and endoscopic optics and determine the frequency of cholesteatoma in various types of construction of the epitympanum.

Material and methods

The study included 55 patients (30 women, 25 men) who underwent surgery in the Department of Otolaryngology, Medical University of Warsaw between 2009 and 2011 due to chronic otitis media. The mean age of the patients was 44.7 ±17.5 years. There were 27 right ears and 28 left ears. In all cases, canal wall up tympanoplasty with attico-antromastoidectomy and posterior tympanotomy was performed as a standard. Forty-five percent of ears had previously been operated on at least once. The operating microscope was used during surgery. In addition, after cleaning the inflammatory tissue, an endoscope (Karl Storz) with 2.7 mm diameter and 30° optics was used in order to assess each recess of the tympanic cavity in terms of completeness of removal from the matrix and the cholesteatoma mass. The endoscope was used with a camera (medical endoscope camera 3CCD Full HD 1080p, i.e. 1920 × 1080 pixels resolution, 16:9, camera driver with 2 DVI outputs for video signal transmission with a resolution of 1920 × 1080 progressive scan), which allowed registration of HD movies. The whole course of treatment was recorded both in microscope and endoscope optics. Then, the recorded images were assayed in terms of the visibility of the anterior epitympanic recess in movies from both the microscope and the endoscopic camera. To evaluate the results a three-point scale with the following values was used: grade 1 – lack of visibility of the AER or poor visibility; grade 2 – partially visible AER, over 30% of space of the recess was visible; grade 3 – full visibility of AER.

Statistical analysis

Due to the ordinal data scale, for statistical analysis, the non-parametric Wilcoxon test was used.

The type of epitympanum construction, cellular or dome, was also determined. The frequency of cholesteatoma in dome-shaped and cellular-shaped AER was determined. The statistical χ^2 analysis was performed for differences in the particular type of construction of the epitympanum being affected by cholesteatoma.

Results

Among 55 ears we found 29 cholesteatomas during surgery. Generally, in the study group, complete visualization (grade 3) of the AER in endoscopic optics was obtained in 68% of the ears, while the microscope could not fully visualize this area in any case (0%). Partial visualization (grade 2) in microscope optics was achieved in 68% of patients, while in the remaining 32% it was weak or negligible (grade 3). The endoscopic optics gave poor visualization of the AER (grade 1) only in 11% of patients, and in 21% of patients partial visibility of AER (grade 2) was achieved. Statistical analysis by the Wilcoxon matched pairs test demonstrated statistical significance of these differences ($N = 45$, $T = 21.0$, $Z = 5.6$, $p < 0.0001$).

Cellular construction of the AER (Photo 2) was found intraoperatively in 18 ears of 55 (32.7%) patients and the dome-shaped attic (Table I) was found in the remaining 37 (67.3%) cases.

Cholesteatoma was found in 14 patients with a dome-shaped AER (37.8%) and in 15 patients with cellular attics (83.3%) (Table II).

The population with chronic otitis media does not differ significantly compared to the general population in terms of the construction of the AER ($p = 0.668108$; $\chi^2 = 0.1838235$, d$f = 1$). However, the cellular type of construction of the AER was signifi-

Table I. Prevalence of various types of construction of AER

Population	Dome-shaped	Cellular
Chronic otitis media ($n = 55$)	37 (67.3%)	18 (32.7%)
Cholesteatoma ($n = 29$)	14 (48.3%)	15 (51.7%)*
General population	66%	32%

*$p < 0.001$.

Table II. Prevalence of cholesteatoma in particular types of construction of AER

Construction AES ($n = 55$)	Cholesteatoma ($n = 29$; 52.7%)
Dome-shaped ($n = 37$)	14 (37.8%)
Cellular ($n = 18$)	15 (83.3%)*

*$p < 0.001$.

cantly correlated with the frequency of occurrence of cholesteatoma ($p < 0.01$; $\chi^2 = 29.86492$; d$f = 1$), whereas cholesteatoma was statistically significantly more frequently observed in the cellular type of AER.

Discussion

Cholesteatoma develops usually in the AER due to a retraction pocket; therefore the possibility of total insight is crucial during surgery. Access by posterior tympanotomy allows one to gain an excellent view into this area, albeit limited by the bone of the lateral wall of the attic and the medial part of the posterior wall of the external auditory canal. The endoscope 30° optics allowed for viewing medially and anteriorly from the head of the malleus and removing the remaining matrix or cholesteatoma which was not visible by the surgical microscope (Photos 3, 4).

The analysis of the data and previous experience revealed that the additional use of the endoscope significantly improved visual inspection of the epitympanum during surgery compared to the visibility of this space in the microscope optics. Intraoperatively, endoscopy serves as a diagnostic method allowing completely insight into the epitympanum in the majority of patients (89%). However, in 5 (9%) cases the visibility of this recess was poorer than in surgical microscopy, resulting from inadequate

hemostasis. The endoscopic optics can be used for removal of inflammatory tissue from the epitympanum by posterior tympanotomy (Photo 5). The additional use of the endoscope enabled the detection of residual cholesteatoma in the epitympanum in 3 cases; otherwise the disease would have been overlooked (5.5%).

Endoscopy is also used during the reconstruction of the lateral wall of the attic in order to visualize the position of the cartilage and its adhesion to adjacent structures (Photo 6).

Additional application of endoscopy during tympanoplasty by posterior tympanotomy significantly affects the quality of surgical treatment of chronic otitis media by improving the visual inspection of recesses of the tympanic cavity that are hard to reach in microscopy optics. Today in otology there are three main applications of endoscopic surgery in the middle ear:
– exclusively endoscopic surgery of the middle ear,
– endoscopic-microscopic surgery of the middle ear,
– endoscopically assisted surgery of the middle ear.

Exclusively endoscopic middle ear surgery means completely transcanal access and opening the mastoid by partial or total drilling of the posterior wall of the external auditory canal, which in fact converts the procedure to canal wall down tympanoplasty [10–12] and substantially interferes with the ana-

Photo 3. Cholesteatoma matrix remnant in epitympanic anterior space – left ear, 30° optics introduced by the posterior tympanotomy
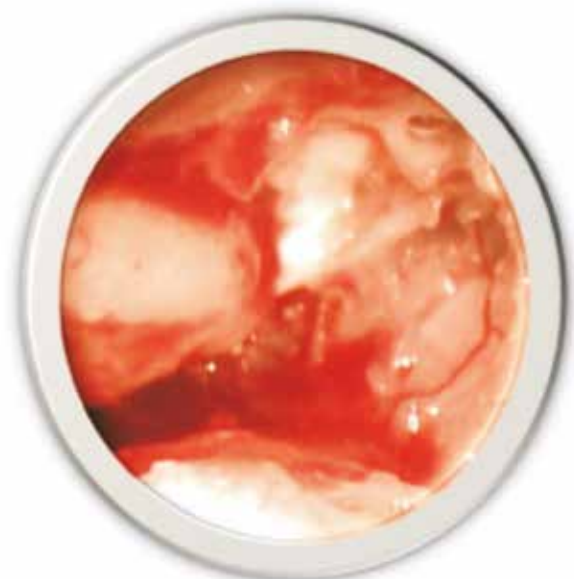
Photo 4. Cholesteatoma matrix remnant in epitympanum – left ear, 30° optics introduced by posterior tympanotomy

Photo 5. Removal of recurrent cholesteatoma of epitympanum in endoscopic optics 30° by posterior tympanotomy, right ear

Photo 6. Endoscopic control of reconstruction of lateral wall of the attic with cartilage – right ear, access by posterior tympanotomy

tomical relations. Endoscopic-microscopic surgery involves access to the tympanic cavity through the external auditory canal and the antromastoidectomy, but without posterior tympanotomy [13, 14]. In this situation, the endoscope is used primarily by the ear canal to clean the recess of the facial nerve and the sinus tympani.

In contrast, endoscopy-assisted middle ear surgery has the advantages of a standard canal wall up tympanoplasty with posterior tympanotomy, with the possibilities of visualization of the endoscope, which allows perfect cleaning of recesses of the tympanic cavity and control of the reconstruction of the ossicular chain with maintenance of the posterior wall of the external auditory canal. According to the authors, this technique allows entire cleaning of the tympanic cavity. Access to the epitympanum only from the external auditory canal may be insufficient to visualize and thoroughly clean the cholesteatoma from the epitympanum, even using an endoscope.

An interesting issue is the cellular construction of the epitympanum, which may be a single cell or a system of air cells and is associated with the prenatal development of a supratubal recess, regardless of the later emerging system of mastoid air cells [1]. During the study, it was found that in nearly two-thirds of ears, the epitympanum consisted of a single air chamber, while in 1/3 of ears small cell construction was found in this area. These results agree with observations of other authors [15], who evaluated temporal bone preparations of children and fetuses, but Petrus and Lo [8] obtained different results based on the tomographic analysis of the temporal bones of adults, showing a larger proportion of people with epitympanum cell structure (40%).

It is believed that with age there is a more cellular construction in this area. This paper presents the results on the basis of intraoperative endoscopic observation of adult patients with chronic otitis media. Although the importance of epitympanum bone construction is not known, it can be concluded that ventilation of the middle ear disorders in patients with chronic otitis media limit cell compartment reconstruction of the upper tympanic cavity. This would explain the ratio obtained in this study. On the other hand, we should mention the different test method adopted in the cited works. It should also be noted that the cellular structure of the epitympanum may affect the intraoperative control of this compartment and the removal of inflammatory tissue. Further research is required to determine the correlation between epitympanum cellular structure and a possible predisposition to chronic inflammation of the middle ear and its recurrence, as well as the assessment of cellular structure epitympanum

computed tomography in a population of patients with chronic otitis media.

Conclusions

Endoscopy plays an important diagnostic role in tympanoplasty surgery and supports previous surgical technique during the removal of inflammatory changes by approximation, magnification, and other viewing angles. It allows, in many cases, a significant improvement in the visibility of the individual elements of the middle ear, and often offers total control of tympanic cavity recesses, such as the epitympanum, which due to the shape and location can be difficult to access by the optical microscope alone. Endoscopically assisted tympanoplasty by posterior tympanotomy is the optimal access to the anterior recess of the epitympanum and provides the total control of this space for complete removal of inflammatory tissue.

Acknowledgments

Conflict of interest

The authors declare no conflict of interest.

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