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PRUSSAK'S SPACE – Endoscopically Revisited

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Abstract

Background: Until now, anatomic descriptions of the epitympanic diaphragm and Prussak's space have been performed using a microscope. The aim of this study is to thoroughly describe and review the epitympanic diaphragm and the anatomy of Prussak's space from an endoscopic point of view.
Study design: Cadaveric dissection study.
Setting: Tertiary Rural referral centre.
Materials and methods: 21 temporal bones were dissected using an endoscope, and mastoidectomy was carried out in all. Thereafter trans-mastoid approach was used to visualize the attic from a postero-superior aspect and the Prussak's space was demonstrated in its entirety in all the bones.
Results: In all the specimens, the prussak's space could be visualized with the use of a 450 endoscope. Also, a very good visualization of the epitympanic diaphragm, and other middle ear structures was carried out.
Conclusion: This unique visualisation technique for Prussak's space will undoubtedly increase our understanding of the anatomy of this essential middle ear area, which in the majority of cases is the initial site for cholesteatoma formation. It will also assist aspiring otologists in orienting themselves to this three-dimensional area and its ventilation pathways.

Keywords: Prussak's Space, Endoscope, Attic, Transmastoid approach

Introduction

Prussak described Prussak's space as superior pouch of the tympanic membrane located between Shrapnell's membrane and the malleus neck that differed from von Tröltsch's anterior and posterior pouches[1].

The Prussak's space is developed by a prolongation of either a low portion or a high portion of the superior saccus, which replaces the mesenchymal tissue between the neck of malleus and Shrapnell's membrane[2].

The aeration pathway follows the same path as the original source, the von Tröltsch posterior pouch. Prussak's space is the lower unit of the attic, which is located beneath the tympanic diaphragm. Laterally, the Prussak's space extends 0.4 mm above the external auditory canal's roof and reaches its maximum cross section of 2.6 mm at the level of the external ear canal's roof[3].

The upper unit of the attic does not affect the Prussak's space ventilation route. The Prussak's space is ventilated by the von Tröltsch posterior pouch, which is rough and narrow in comparison to the tympanic isthmus, which is broader and offers a lot of ventilation to the upper unit of the attic[4].

Hence, the possibility of anatomical reduction or blockage in the passage or even a complete closure of the posterior pocket is not so uncommon, particularly in the presence of thick and viscous secretions within Prussak's space, there by leading to chronic sectorial dysventilation associated with Sharpnell's membrane retraction and adhesion to the malleus neck[5]. This event may occur without the involvement of the upper unit's other compartments, which are located above the tympanic diaphragm[6].

Also, one of the most common pathways of attical cholesteatoma is Prussak's space from where the cholesteatoma spreads to the upper unit of the attic, then to the posterior attic, aditus, and finally the antrum through a thin part of the lateral malleal fold[3].

The epitympanum, the attic, and the adjacent anatomical structures are complex and convoluted in the middle ear cavity and its compartments[2]. To perform precise procedures, otology surgeons should have a thorough understanding and orientation of the middle ear anatomy. The epitympanic diaphragm and Prussak's space have been described anatomically until now using a microscope. The epitympanum space is difficult to assess for surgeons operating in the middle ear under microscopic view because it is obscured by the lateral wall of the tympanic segment of the temporal bone. To see the anterior boundary of the epitympanic space, a mastoidectomy with malleus head and incus removal is required[7,8].

Endoscopic approach of attic cholesteatoma allows for clear visualization of the tensor fold area, but as this approach involves excision of tensor fold, hence the architecture of the epitympanic diaphragm gets altered. However, endoscopic access allows for the clearance of the cholesteatoma as well as direct ventilation of the epitympanum, preventing the formation of a retraction pocket or attic cholesteatoma recurrence thereby further providing good functional results[5].

This research with wide field magnification achieved by endoscopes, will help us to visualize the anatomy of prussak's space as it is, and thereby understand the three-dimensional orientation of Prussak's space and its relationships, better. With the aid of an otoendoscope, the superior limit of Prussak's space, as well as the medial and inferior elements of Prussak's space and the anatomical changes connected with it, can be seen more clearly during dissections.

Objective:

TO UNDERSTAND THE 3D ORIENTATION OF PRUSSAK'S SPACE WITH THE AID OF OTOENDOSCOPY

Methodology:

The research was carried out at R.L.Jalappa Hospital's Department of ENT from JANUARY 2021 to DECEMBER 2021. During the above-mentioned time period 21 cadaveric temporal bones were dissected at our centre. Dissection of all temporal bones was done with an endoscope at two different angles (0 and 45 degrees) and a digital video camera. The bones were held in place by a House-Urban temporal bone holder. High-speed (reverse and forward cutting) drills up to 35,000 rpm were used, as well as cutting burrs of 6, 3 mm, diamond burrs of 2 and 7 mm, curette, micro scissors, and drippers.

Transmastoid approaches were used to visualize the attic and prussak's space by inserting the endoscope through the aditus and demonstrating the attic, primarily prussak's space, and its boundaries, landmarks, and variations associated, and subsequent endoscopic observations will be performed for detailed specification.

Results:

In this study, 21 adult temporal bone dissections were conducted, 12 on the right side and 9 on the left side (transmastoid approach). We could see the epitympanum (attic) which is split by the diaphragm into upper and lower units (Prussak's space) with endoscope via transmastoid approaches. The malleus and incus, as well as the three malleal ligamental folds (anterior, lateral, and posterior), the posterior incudal ligamental fold, and two purely membranous folds (the tensor fold and the lateral incudomalleal fold), could be seen forming a complete diaphragm (Fig 2,3). In all of the cadavers we dissected, the middle ear space, especially Prussak's space in the epitympanum, could be demonstrated endoscopically.

The lateral malleal ligament, which inserts laterally into the medial wall of the scutum, was the superior limit of Prussak's space. The neck and the lateral process of the malleus, respectively, formed the medial and inferior portions of Prussak's space. The pars flaccida forms a lateral boundary (Fig 4). During the dissections, no anatomical changes of the neck or the lateral process of the malleus were observed.

Volume 5, Issue 2; March-April 2022; Page No 720-725

Fig 1: Attic and its sub-compartments

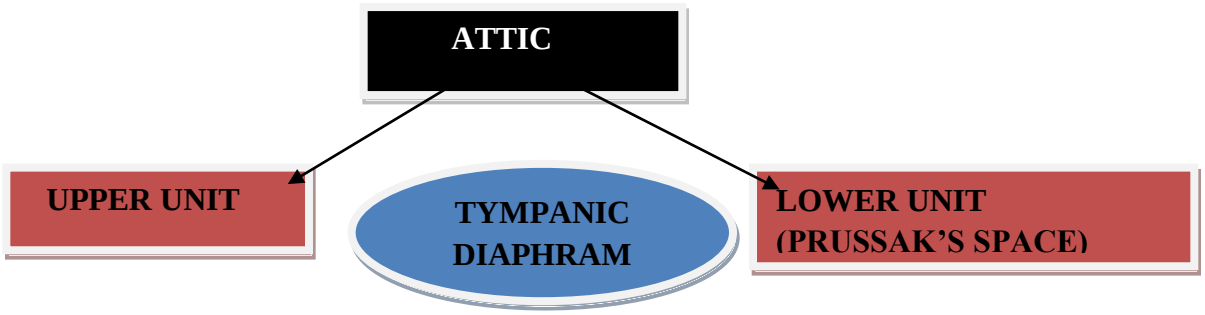
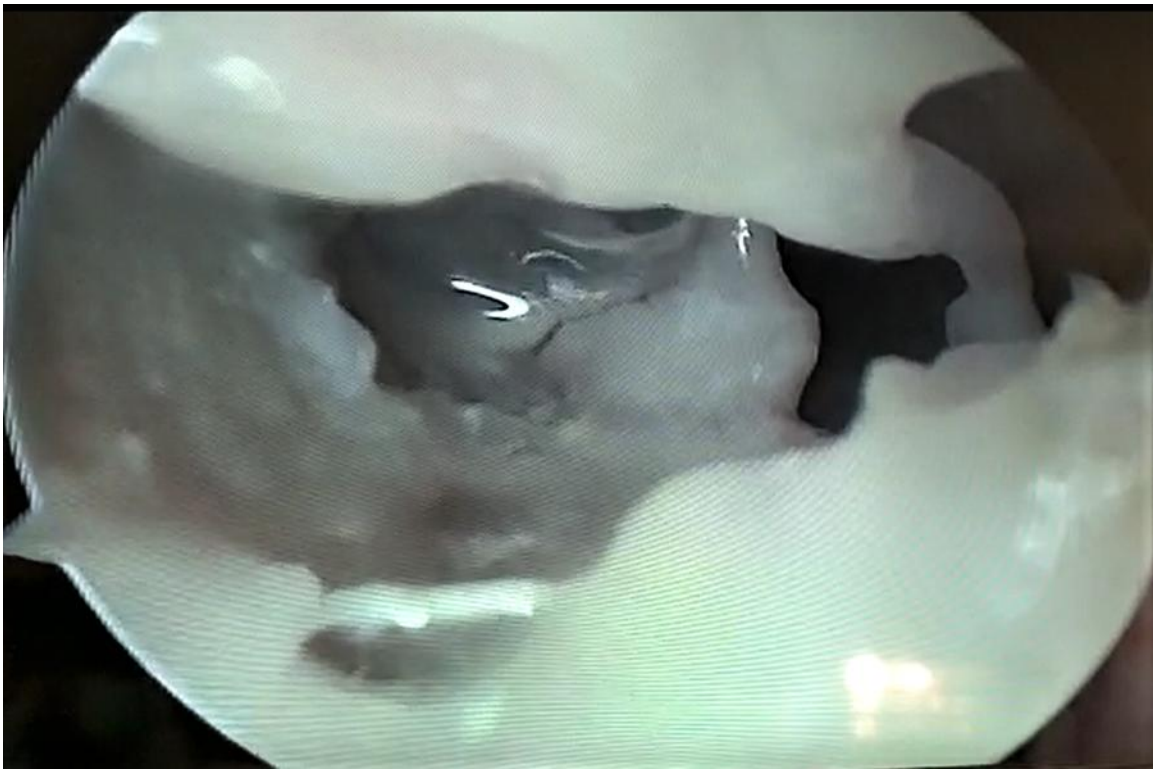


Fig 2: Superior view of Epitympanum a) Epitympanum/attic, b) Tympanic diaphragm, c) Anterior tympanic isthmus (ATI), d) Posterior tympanic isthmus, e) Incudo-Stapedial joint.



Volume 5, Issue 2; March-April 2022; Page No 720-725

Fig 3: Endoscopic view from attic of the Intact Tympanic diaphragm showing various mucosal folds, and the ossicles

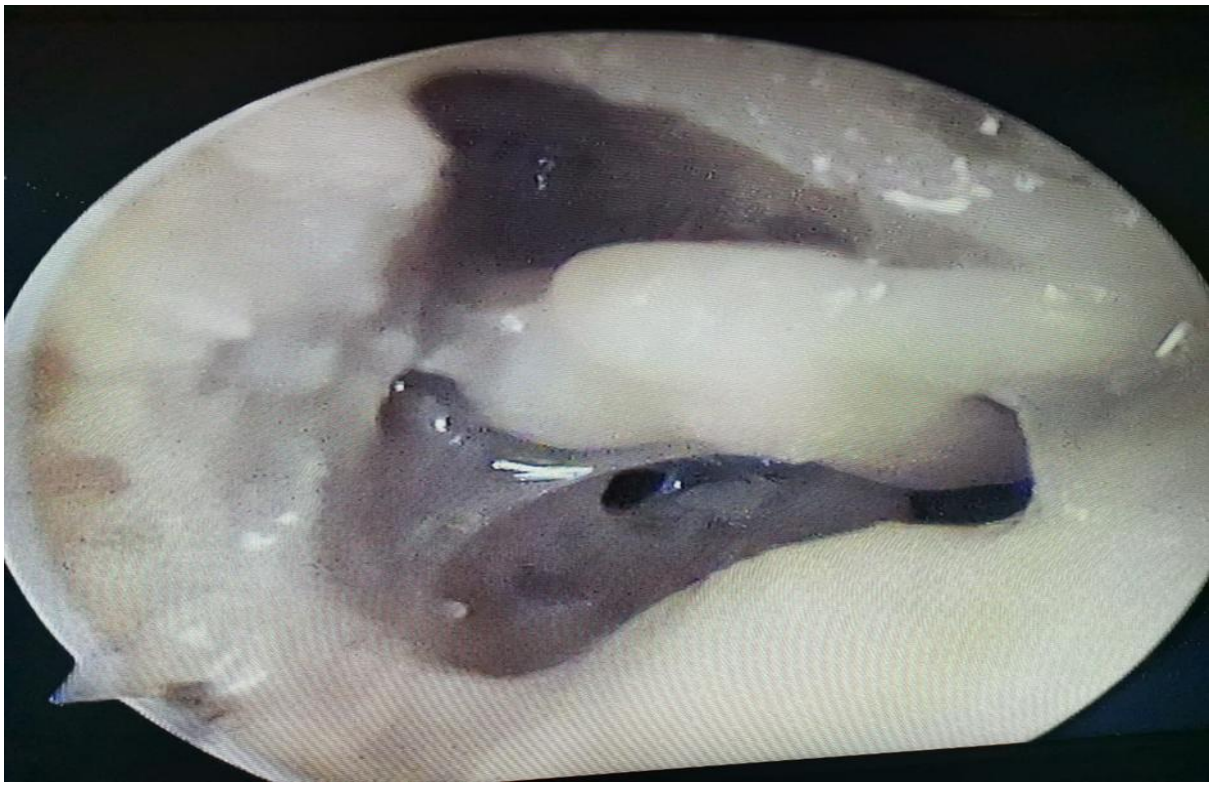


Fig 4: Demonstration of prussak's space with intact tympanic membrane (Postero- superior view). It is bordered superiorly by the Lateral Malleal Fold (LMF), inferiorly by the lateral process of the malleus, medially by the malleus neck, and laterally by the pars flaccida

Volume 5, Issue 2; March-April 2022; Page No 720-725

Discussion

The tympanic diaphragm separates the attic from the mesotympanum, dividing it into upper and lower units (Prussak's space) (fig 1). The lateral malleal fold separates Prussak's space from the upper unit of the epitympanum, hence is referred to as the lower unit of the attic. The attic and mastoid are separated from the mesotympanum by the tympanic diaphragm (fig 3). The attic is ventilated by the tympanic isthmus which is a 2.5 mm opening in the diaphragm. The isthmus is divided into two parts by the medial incudal fold[3,4]. The prussak's space, on the other hand, is ventilated via Von Troltsch's posterior pouch.

The epitympanum space is difficult to assess for surgeons, operating in the middle ear under microscopic view because it is hidden by the lateral wall of the tympanic portion of the temporal bone. To visualise the anterior limit of the epitympanic space, a mastoidectomy with malleus head and incus removal is required[4,5]. In comparison to the microscopic technique for middle ear dissection, the endoscope allows for a more thorough and a very close observation of anatomical structures with a good magnification and bright illumination.

Endoscopes also help in visualization of various landmarks of the underlying structures as well.

Endoscopes allow for wide fields of view with minimal exposure, helps in peering behind obstructions or overhangs, and into recesses with far less surgical exposure than the traditional techniques. The endoscopic approach allowed us an adequate access to the middle ear ligamental folds, mucosal folds, and spaces[5,8].

As per the literature available, Prussak's space had been described in various studies after reflecting the pars flaccida part of tympanic membrane. However, in our study the objective is to demonstrate this space without reflection of the tympanic membrane and also without removing any of the other boundaries i.e., without losing the original architecture of the space.

We have demonstrated the prussak's space using angled endoscope through a transmastoid route to show the intact boundaries as well as to focus on how the lateral malleolar ligament which appear as a flimsy mucosal fold, forms the roof or the upper limit of this space. Most studies fail to demonstrate this mucosal fold as there is a high chance of its inadvertent removal injury during the process of reflecting the tympanic membrane. Also, the intact prussak's space could not be appreciated in these studies

The middle ear is a small aerated cavity with a complex anatomy that is difficult to visualize with direct human vision. Previously, in one of the studies, they attempted a non-invasive method that allows visualisation of the tympanic cavity, which is represented by otoendoscopy performed through the external auditory canal with an intact tympanic membrane. In that case, the tympanic membrane serves as a barrier between the endoscope and the middle ear structures, which can be illuminated by an intense light source that passes through the transparent membrane[9].However this method had no positive impact on surgeons.

Another study attempted a lateral endoscopic approach, which was more difficult when the subjects presented with an extremely narrow anterior epitympanic space associated with an anteriorly vertical orientation of the tensor fold, and in such cases, only the component of the fold close to the cochleariform process could be explored. Furthermore, in subjects with a narrow anterior epitympanic space with limited space between the head of the malleus and the anterior bony wall of the anterior epitympanic space, the incus and head of the malleus had to be removed for better visualisation of the superior edge of the tensor fold during the superior endoscopic approach to the tensor fold. In contrast, there is no such limitation to our approach and we were able to visualise the epitympanic diaphragm, prussak's space, and middle ear anatomy with intact ossicles and tympanic membrane[5].

Some of the authors proposed an endoscopic approach similar to ours in patients with attic cholesteatoma. They recommended two different endoscopic procedures: one using an inferior approach with a 45-degree endoscope inserted into the protympanic space to help identify the inferior edge of the tensor fold and in disease clearance. The other superior approach with a 45-degree endoscope after an anterior atticotomy can be used to expose the anterior tympanic compartment and to allow

Volume 5, Issue 2; March-April 2022; Page No 720-725

visualisation of the superior edge of the tensor fold[5,10].

However, in our study, we used a novel technique of viewing the prussak's space via transmastoid approach using angled endoscopes. The prussak's space, as well as the lateral malleal fold, were visualised in a straightforward and much simpler manner using this technique. This method also allows one to visualize all the boundaries in a three dimensional orientation without disrupting any of the anatomical landmarks. Another advantage of this technique is that the spatial relationship of the intact Prussak's space with surrounding structures is maintained, which helps in better cadaveric demonstration and understanding of the regional anatomy.

No anatomical variation in Prussak's space was observed in our research. Understanding the three-dimensional orientation of Prussak's space is critical in the genesis of cholesteatoma, and the ventilation pathways. Using, this novel technique we can explore and demonstrate other attic spaces as well like, lateral attic space, medial attic space, and so on by keeping the tympanic membrane intact and hence can be an area of research for future studies.

Conclusion

The three-dimensional structure of the epitympanum, with its distinct aeration and drainage pathways, is critical for understanding the anatomical basis of disease processes and aids in the selection of the most appropriate conservative or surgical treatment.

The innovative approach used in this study will be of great help to make the anatomy of this space easily understandable to aspiring otologists. Also, it will be beneficial for them to properly orient themselves and learn the complicated anatomy of the attic region which will prove to be of great advantage in understanding the basis of the disease process in this region.

The emphasis can then be shifted to teaching the fundamental surgical approaches while keeping in mind the effective steps to improve epitympanic aeration.

Thus, having a three-dimensional orientation of the attic and its contents aids the surgeon in performing better surgery and, as a result, providing disease-free ears.

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Volume 5, Issue 2; March-April 2022; Page No 720-725