

Anatomical Variants of Tensor Tympani Fold-Surgical Considerations

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Abstract: Introduction: The anterior epitympanic space or anterior attic is the small space located anterior to the head of the malleus. This space has attracted the attention of ear surgeons because of its relationship to important surrounding structures and to its frequent involvement of cholesteatoma. The data reported in the literature about the anatomy of the anterior epitympanum and the tensor tympani folds are contradictory. *Objectives:* The aim of this article is to review the anatomy of the anterior epitympanum and tensor fold area. *Methods:* Ninety-eight temporal bones were studied by micro-dissection of fresh specimens. Position and insertion of the tensor fold were analyzed and anatomical details were photographed using the operation microscope. *Results:* In all specimens there were two structures anterior to the malleus head: the anterior epitympanic space belonging to the epitympanum, and the supratubal recess belonging to the mesotympanum. The tensor tympani fold was the separating structure between these spaces. It was intact in 65% of bones while in 35% showed a membrane defect. The more horizontal the tensor fold was, the wider the anterior epitympanic space was. *Conclusions:* The anterior epitympanic space and supratubal recess are two separate cavities. Removal of the tensor fold creates an efficient additional aeration route from the supratubal recess to the anterior epitympanic space. This knowledge represents the basis for any otologist in order to achieve suitable results in cholesteatoma surgery.

Keywords: Anterior epitympanum, cholesteatoma, tensor tympani fold, supratubal recess.

INTRODUCTION

Cholesteatomas have been recognized for decades as a destructive lesion of the skull base that can erode and destroy important structures within the temporal bone, potential cause for central nervous system complications. The most commonly involved areas in recurrent cholesteatoma are the anterior epitympanum and the sinus tympani [1]. The anterior epitympanic space or anterior attic is the small space located anterior to the head of the malleus. This space has attracted the attention of ear surgeons because of its relationship to important surrounding structures and to its frequent involvement of cholesteatoma [2]. Their demarcation limits were described very early at the end of the 19th century by Siebenmann [3], who found out that the anterior epitympanic space was limited inferiorly by the tensor tendon and anteriorly and upwards it was closed by a vertically rising fold: the tensor tympani fold. The author showed that there is another space in front of the tensor fold a "pneumatic cell" that is part of the mesotympanum. This space was later named the supratubal recess. Further on, for several reasons this detailed anatomical knowledge became poorly known and there were published several papers presenting conflicting data about this

region. It was also not very clear if there are one or two spaces, what is the position of the tensor fold and its relation to the coronal oriented bony septum suspended from the anterior petrosal tegmen-the transverse crest. Schuknecht [4], named this region anterior epitympanic recess and Proctor [5] described the space as being an anterior extension of the attic, which he called the supratubal recess or geniculate recess. Terms like anterior epitympanic compartment [6], anterior attic recess [7], recessus protympanicum [8], and geniculate sinus [9] have been used synonymously. Later on, Palva [10] based on many anatomical and histological studies on new borne and adult temporal bones, showed very clearly that anterior to the malleus head there are two spaces: the anterior epitympanum and the supratubal recess that are separated by the tensor fold. The aim of this article is to review the anatomy of the anterior epitympanum and tensor fold area. The clinical and surgical implications of these regions are presented.

MATERIAL AND METHODS

Ninety-eight adult temporal bones, with no history of auricular disease, were studied by micro dissection. From these 98 temporal bones, 59 (60.7%) were collected from male subjects and 39 temporal bones (39.29%) from female subjects. The average age for subjects included in the study was of 41±6.5 years (95%CI [39.32-42.85]), with a minimum of 25 years and a maximum of 76 years.

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All temporal bones have been harvested at autopsy and were preserved in a deep freezer and thawed in temperate water immediately before processing. Documentation was done by color photography using the operation microscope. We used the following order of dissection to examine the tensor fold area: The anterior approach that was made, by cutting the temporal bone block frontally, allowing observation of the middle ear and supratubal recess from the protympanum. The superior approach *via* the middle fossa floor was performed by drilling the attical and adital tegmen, after a classical mastoidectomy. Cholesteatoma extending to the mastoid, mesotympanic or protympanic area were excluded.

RESULTS

Anterior epitympanum is a space usually stealthy by the malleus head. It is limited anteriorly by the root of zygomatic arch (a thick bony plate which separates it from pericarotic cells), superiorly by the tegmen tympani (that separates it from the dura mater), laterally by the tympanic bone and chorda tympani, and medially by a bony wall that separates it from the geniculate fossa, which contains the homonymous ganglion. The tensor fold that separates it from the underlying supratubal recess, when completed, represents its inferior limit (Figure 1). The transverse crest that starts from the anterior tympanic spine and crosses the tegmen transversely while its medial leg may continues until the cochleariform process (Figure 2). This low portion, which may be discontinuous with the segmental portion, is always present, resembles a cog, and is a surgical landmark [11]. The transverse crest was present at all temporal bones. The tensor fold was present in all pieces and completely formed in

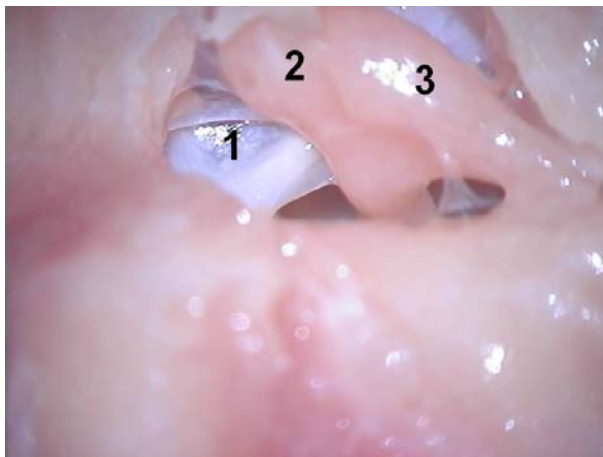


Figure 1: Right ear, superomedial view of epitympanum after removal of the bony island flap 1. Complete tensor fold 2. Malleus head 3. Body of the incus.

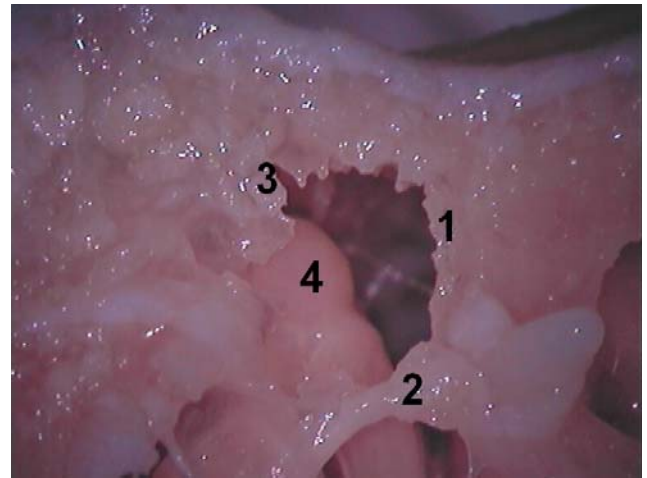


Figure 2: Right ear, medial view of the tympanic cavity 1. Medial portion of the transverse crest 2. Cochleariform process 3. Lateral portion of the transverse crest 4. Malleus head.

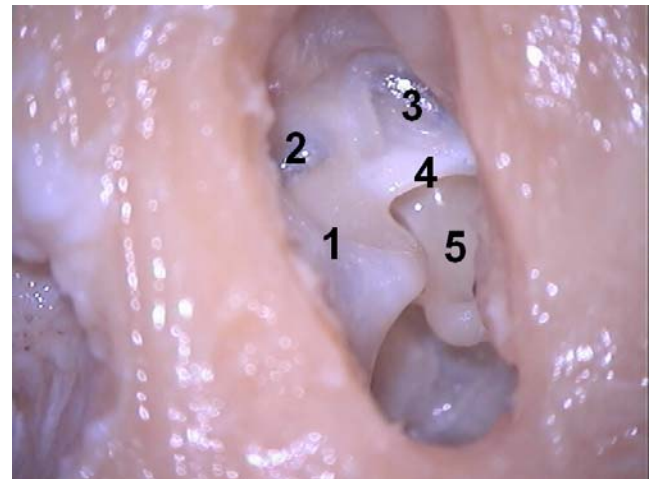


Figure 3: Left ear, view of the tympanic cavity from the eustachian tube. 1. Tympanic membrane 2. Malleal ligament anterior fold 3. The tensor tympani fold 4. The tensor tympani tendon 5. The long process of the incus

64 bones, 65% of pieces (Figure 3) and in 34 bones, 35% of them showed a central defect (Figure 4). Bony tags appeared in the medial wall of the anterior epitympanum. In all bones the tensor fold extended from the tensor tympani tendon to a similar composite connective tissue, fat and bone containing insertion ring. The portions of the fold near the tendon were somewhat thicker than the thin central portion. The insertion of the fold was anterior to the transverse crest in 84 bones, 85% of pieces (Figure 5) and in 14 bones, 15% of pieces at the transverse crest level (Figure 6). The anterior epitympanum was found to be of variable size, which was related to the inclination of the tensor fold. In most of the cases tensor fold was found to have horizontal direction (Figure 7). The more horizontal the

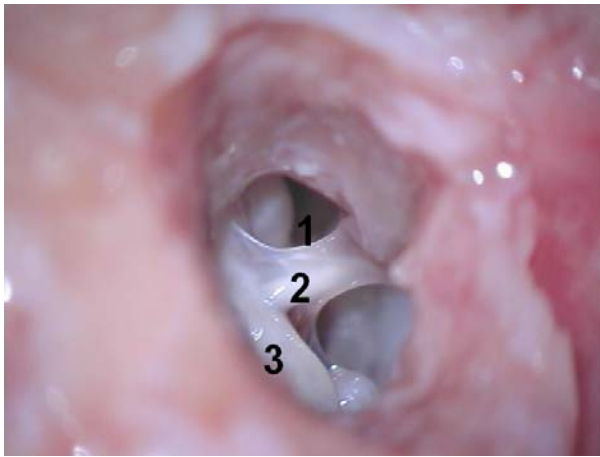


Figure 4: Left ear, view of the tympanic cavity from the eustachian tube 1. Incomplete tensor fold 2. Tensor tympani tendon 3. Malleus handle.

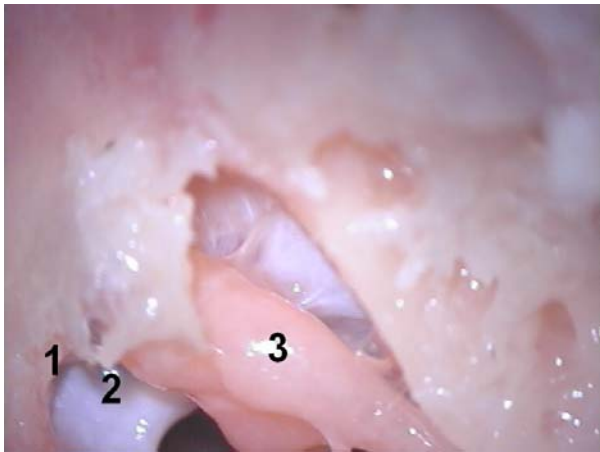


Figure 5: Right ear, superior view of the tympanic cavity: 1. The transverse crest 2. The tensor tympani fold. The body of the incus.

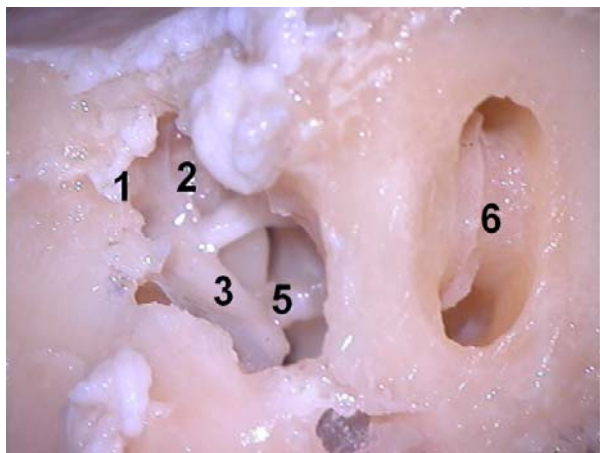


Figure 6: Left ear, view of the tympanic cavity from the eustachian tube: 1. The transverse crest 2. The tensor tympani fold 3. The malleus handle 5. The incudo-stapedial joint 6. The cochlea.

tensor fold was, the wider was the anterior epitympanic space. The bony crest is a valuable landmark for the

facial nerve, as long as the cochleariform process is, and at this level the facial nerve is situated right above the cochleariform process and medially to the crest. The bony crest follows a superior external trajectory, the facial nerve having an anterior internal trajectory towards the geniculate ganglion (Figure 8). The supratubal recess is a mediosuperior extension of the protympanum and anterior meztympanum, a space in front of the tensor fold (Figure 9). In our study, the supratubal recess represented an independent area and was well developed in all ears with the more upright tensor fold while in the specimen with the nearly horizontal fold; the space was small and directly adjacent to the main air flow to the mesotympanum.

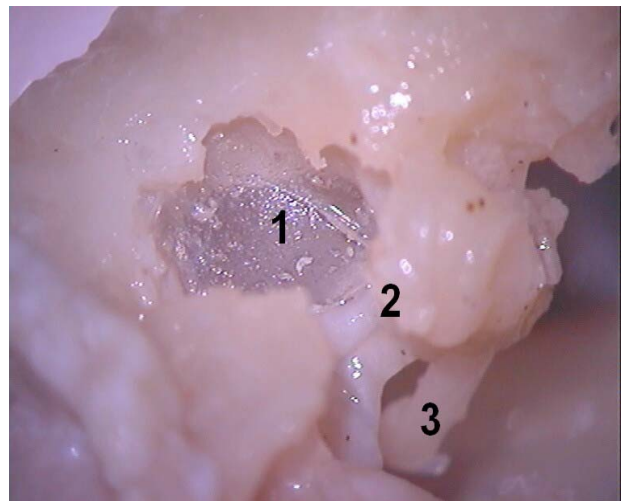


Figure 7: Left ear, superior view of the anterior attic 1. The tensor tympani fold 2. The tensor tympani tendon 3. Malleus handle.

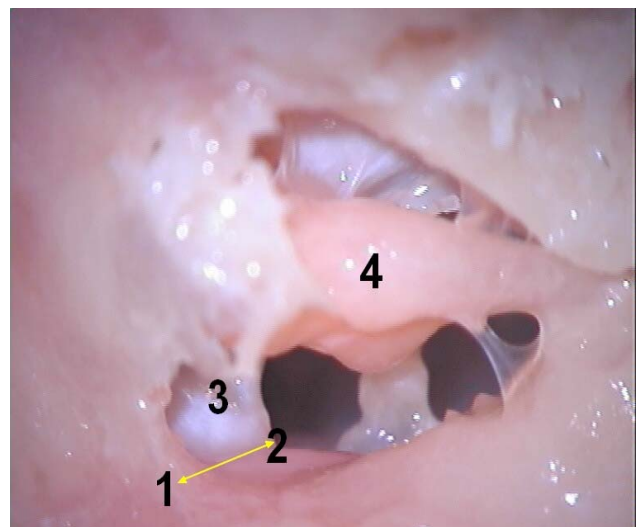


Figure 8: Right ear, superior view of the anterior attic 1. Geniculate ganglion 2. Medial leg of the transverse crest 3. Tensor tympani fold 4. The body of the incus.

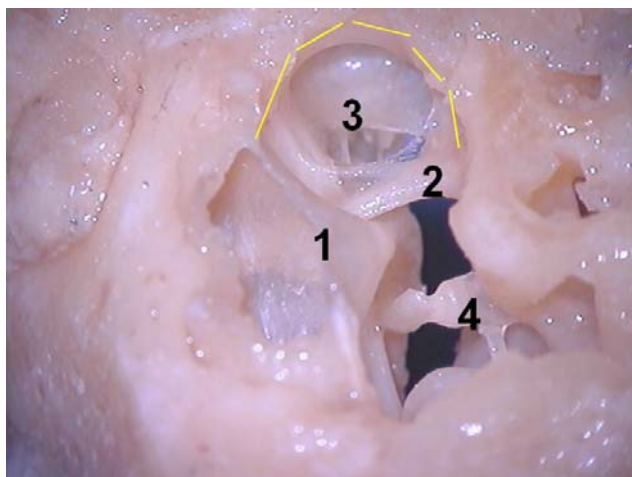


Figure 9: Right ear, inferior view of the tympanic cavity: 1. Supratubal recess 2. Cochleariform process 3. Tensor tympani fold 4. Stapes.

DISCUSSIONS

In our study, based on documented anatomic evidence, the anterior epitympanum was present in all dissected bones like a space located in front of the malleus head superior to the tensor fold. The bony wall of the anterior epitympanum generally showed good pneumatization. The transverse crest was present at all temporal bones representing a bony septum that detaches from the tegmen tympani cranially, heading vertically toward the cochleariform process, in front of the malleus head. Our results are in agreement with Palva's [12] studies; therefore the transverse crest in all our dissected temporal bones generally divides only the superior portion of the anterior epitympanum to anterior and posterior segments. Other authors refer to this transverse crest using various different terminologies [13]. House coined, and Sheehy [6] popularized, the term *cog* to refer to a bony ridge that suspends from the tegmen and ends superior to the cochleariform process and antero-superior to the head of the malleus. They believed that this bony ridge represents an embryologic remnant of the fusion plane between saccus anticus and medius which extends from the Eustachian tube, during the fetal period while the gelatinous tissue of the middle-ear cleft is gradually absorbed. They considered that this bony ridge separates the anterior from the posterior epitympanic space.

Hoshino [14] noted that in all of his dissected specimens, a thin bony plate, which he referred to, as the anterior attic bony plate, marked the posterior boundary of the anterior epitympanic recess. Morimitsu's [15] finding was that the "medial and

anterior air sacs do not contact each other before birth; thus a bony ledge is left between them". Tono *et al.* [16] summarized their concept of the relationship between the supratubal recess and the epitympanum by stating that the former is "clearly separated from the epitympanum by the presence of a bony partition". Onal *et al.* [17] studied 30 human temporal bones and found that the anterior epitympanic space embryologically showed two kinds of morphology. The anterior epitympanic space type I consists of two cavities separated by the tensor tympani fold which might be called the anterior malleolar space, the cavity superior to the tensor fold, whereas the cavity inferior to it could be called the supratubal recess. The anterior epitympanic space type II consists in one single cavity and it is in direct continuity with the protympanum and Eustachian tube and the tensor tympani fold is absent. Likewise other data presented in the literature, those regarding tensor tympani fold are confusing. Some authors have described the tensor tympani fold as a horizontal mucosal fold at the level of the tensor tympani muscle, while others as a vertical fold attached to the cog [6,8,14].

Palva in his study performed on 20 neonates and infants temporal bones found the tensor fold inserted superiorly to a soft tissue insertion ring of varying thickness and only once directly to a shallow transverse crest [11]. In their endoscopical study to the tensor fold area, Marchioni and co-workers described in almost all the cases the fold as being attached anteriorly to the superior limit of the Eustachian tube, and posteriorly to the tensor tendon and the cochleariform process [18]. In our anatomical study the tensor fold was regularly present in all our temporal bones stretches between tensor tympani tendon and tegmen usually completely shaped and in some cases it was incompletely formed. The separation of the epitympanum from the supratubal recess was not made by the transverse crest but by the tensor fold as described by the early papers of Palva [12].

Good knowledge of anatomy is fundamental for every surgeon. The anterior epitympanic space anatomy is really complex and ear surgeons are particularly interested in the anterior epitympanum and tensor fold area because of its frequent involvement in cholesteatoma. While the carotid canal and the cochlea also lie close together medially, the most important anatomic structures related to the anterior epitympanic space are the tympanic portion of the facial nerve canal and the geniculate fossa. This portion of the facial nerve canal lies in the medial wall of the anterior

epitympanic space superior to the semicanal of the tensor tympani. An atticocholesteatoma may extend antero-medially into the anterior epitympanic space eroding the transverse crest in the process. Chu and Jackler [19] reported five cases of facial palsy caused by attic cholesteatoma extending anteromedially to the head of the malleus and compressing the facial nerve in the region of the geniculate ganglion.

A cholesteatoma found behind an intact tympanic membrane in a patient with no history of otitis media is presumed to be congenital [20]. The common sites of origin within the middle ear include the anterior epitympanic space, the anterior mesotympanum, and the vicinity of the incudostapedial articulation [21]. Those arising in the anterior epitympanic space may erode the facial nerve canal. Besides congenital and acquired cholesteatomas, the anterior epitympanic space may also be a site of recurrent cholesteatoma formation. In 1946, Chatellier and Lemoine [22] formulated the concept of "the epitympanic diaphragm". The authors described different ligament and membranous folds, which, together with the malleus and incus, form the floor of a large epitympanic compartment. This space represents the upper unit and is aerated from the protympanic space through the tympanic isthmus. Palva *et al.* [23] suggested the removal of the tensor fold to create a large new attic aeration pathway, in patients affected by a blockage of the isthmus, to restore normal ventilation of the epitympanic space. Tensor fold has a strategic position because it prevents communication between the supratubal recess, region belonging to the mesotympanum, and the overlying anterior epitympanum. When the tensor fold is complete the only ventilation pathway to the anterior epitympanic space is through the isthmus. In our study the tensor fold was incomplete in 35% of cases, allowing an alternative ventilation route from supratubal recess directly towards the anterior epitympanum.

CONCLUSIONS

Knowledge of middle ear anatomy is the basis for any otologist. Without a good knowledge of the anatomy it is impossible to perform ear surgery and to understand ear physiology. Removal of the tensor fold creates an efficient additional aeration route from the supratubal recess to the anterior epitympanum. The goal of surgery in the chronic pathology of the middle ear should be restoration of normal ventilation of the attical-mastoid area. This is possible by removing the

tensor fold and restoring the functionality of the isthmus.

CONFLICT OF INTEREST

None.

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