

# The anatomy of the tympanic sinus

S. Nitek<sup>1</sup>, J. Wysocki<sup>1, 2</sup>, K. Niemczyk<sup>3</sup>, E. Ungier<sup>1</sup>

<sup>1</sup>Department of Normal Anatomy, Centre of Biostructure, Medical University, Warsaw, Poland

<sup>2</sup>Department of Vertebrate Morphology, Academy of Podlasie, Siedlce, Poland

<sup>3</sup>Clinic of Otolaryngology, Medical University, Warsaw, Poland

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*The tympanic sinus is one of the most important structures of the human temporal bone. Located in its vicinity are the round window, posterior semicircular canal and facial nerve. The study was performed on 30 temporal bones taken from adult cadavers of both sexes. After the tympanic sinus had been identified, its morphological features were evaluated. The sinus was then measured using a graticule with an accuracy of 0.05 mm. Also measured were the shortest distances from the tympanic sinus to the neighbouring structures (the lateral and posterior semicircular canal, the facial nerve canal and the jugular fossa). The measurements were performed under a surgical microscope with eye-piece graduation of 0.05 mm accuracy.*

*Four main morphological types of fossa of the tympanic sinus and two main developmental forms, a deep sinus and a shallow sinus, were distinguished. The existence of a deep sinus was associated with absence of the bridge and the sinus was shallower when the bridge was prominent. The very deep sinuses were located close to the facial canal, in some cases penetrating deep in its vicinity (in some cases even going beyond two thirds of the canal's circumference), which poses a real risk of facial nerve damage during surgical removal of a lesion located in close proximity to the nerve. In most cases the tympanic sinus is elliptical in shape and its long diameter lies in the vertical plane (mean value: 2.73 × 2.23 mm). The mean distances from the tympanic sinus to the facial nerve canal, lateral semicircular canal, posterior semicircular canal and jugular fossa were 1.5 mm, 2.1 mm, 1.59 mm and 5.5 mm respectively. No correlation was observed between the measurement results and either sex or side.*

**Key words:** tympanic sinus, temporal bone, anatomy, cadavers

## INTRODUCTION

A number of structures are lodged within the medial wall of the tympanic cavity, also known as the labyrinthine wall, and knowledge of these is essential for the otosurgeon. The promontory lies centrally on the wall. It is a rounded eminence whose diameter measures 5–8 mm [14, 16]. The fossa of the round window, also known as the round window niche, is a kind of a vestibule that leads to the round window. The entrance to this

vestibule may be oval, round or triangular. It has for its boundaries the lateral and medial lip and one of the bony trabeculae of the hypotympanum from beneath. The medial lip is also known as the subiculum of the promontory [14, 15]. The lateral lip is created by the posterior margin of the promontory. The round window, which lies medially to the lateral lip is deeply located and is not accessible to inspection via the external acoustic meatus [4, 14].

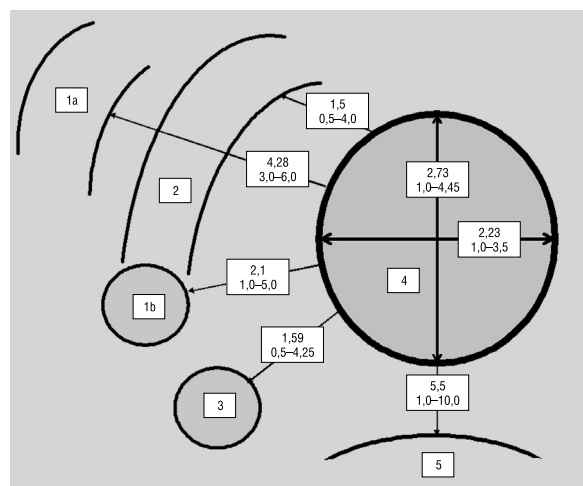
The tympanic sinus has been the focus of clinical interest because of its tendency to be invaded by cholesteatoma, its visual obscurity and the lack of a straightforward surgical approach by which it can be addressed [1, 12]. It may be attained through the retrofacial approach. Viewed from the mastoid, the anatomical structures that define the boundaries of the retrofacial approach include the facial nerve and the stapedius muscle laterally, the lateral semicircular canal superiorly, the posterior semicircular canal posteromedially, the vestibule anteromedially and the jugular bulb inferiorly [8, 9]. The tympanic sinus extends posteriorly to the fossa of the round window. Superiorly to the tympanic sinus runs the promontory bridge, which is a bone trabecula connecting the promontory to the pyramidal eminence lying within the posterior wall of the tympanic cavity [4, 5, 10, 11, 14, 16]. The promontory bridge happens to be multiple and sometimes does not exist at all [6, 17]. Up to the promontory bridge lies the fossa of the oval window, into which the base of the stapedius fits. Anteriorly to the oval window lies a bony prominence termed the cochleariform process, which is known to contain the tendo of the tensor of the tympanic muscle [4, 14, 16].

The tympanic sinus is a small depression which is always present and is located on the border of the posterior and medial walls of the tympanic cavity [2–4, 13–16] and is assumed to be the analogue to the *bulla tympanica* of other mammals [2]. There is no accord in the literature either on the topographical localisation of the structure or its name and so the tympanic sinus is also referred to as the tympanofacial recess [2] or the hypopyramidal d'Huguier sinus or fossula [16]. In terms of topography, most studies define the structure as a depression lying between the round and the oval windows. The sinus is bounded laterally by the facial canal and the pyramidal eminence [2]. For its upper boundary it has the promontory bridge or its analogues [2, 16]. The sinus is bounded inferioanteriorly by the round window and the two structures are divided by the subiculum of the promontory. The sinus has for its posterior boundary the pyramidal eminence and for its medial boundary the ampulla of the posterior semicircular canal and is separated from the canal by a thin plate of bone [2, 14–16]. The sinus is of variable size and may reach 10 mm in depth [2].

## MATERIAL AND METHODS

The material consisted of 30 temporal bones taken from adult cadavers of both sexes obtained from the Department of Forensic Medicine of the Medical

University of Warsaw. After the tympanic sinus had been identified, its morphological features as well as the morphological features of the neighbouring structures were evaluated. The study investigated the shape of the fossa of the tympanic sinus, the presence or absence of the promontory bridge and the developmental forms of the sinus: the shallow sinus and the deep one, which penetrated under the facial canal and/or up near the prominence of the lateral semicircular canal. Next the vertical and horizontal measurements of the sinus were taken and the shortest distances from the tympanic sinus to the neighbouring structures (the lateral and posterior semicircular canal, the facial nerve canal and the jugular fossa) were measured as follows: a surgical saw was used to cut a temporal bone in the frontal section at the level of the ampulla of the posterior semicircular canal and the minimal distances from the floor of the tympanic sinus to the posterior and lateral semicircular canal were measured (Fig. 1). The measurements were performed under a surgical microscope with eye-piece graduation of 0.05 mm accuracy. To assess the statistical significance of the measurements the results obtained concerning side and sex underwent statistical analysis for sex and age (Student's t-test). Pearson's t-test was applied for investigation of correlations between the parameters measured.

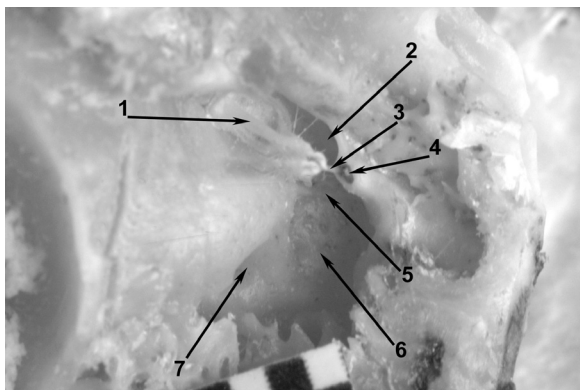


**Figure 1.** Scheme showing the tympanic sinus measurements and the minimal distances between the sinus and the neighbouring structures (all measurements in millimetres). 1 — lateral semicircular canal; 1a — distance measured on the prominence of the canal located on the medial wall of tympanic cavity; 1b — distance measured on the temporal bone frontal section; 2 — facial canal; 3 — posterior semicircular canal (seen on the frontal section of the temporal bone); 4 — tympanic sinus; 5 — jugular fossa.

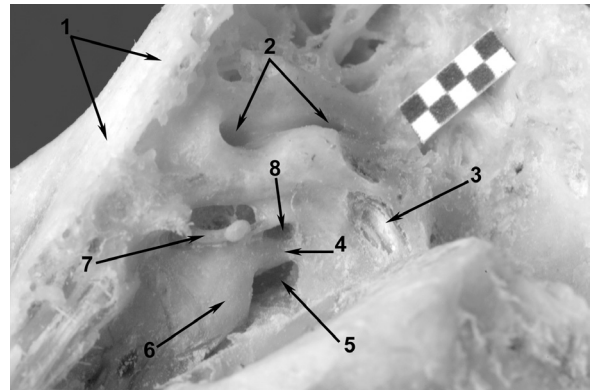
**RESULTS**

The results of this morphological study revealed that in most cases the tympanic sinus was oval, with its long diameter directed vertically (14 cases). An oval tympanic sinus with its diameter directed horizontally occurred much less frequently (one case) and a round or polygonal fossa of the tympanic sinus was of equal frequency (seven cases of both types). Significantly, in 10 cases out of 30 the study revealed the incidence of a deep tympanic sinus penetrating under the facial canal, which might complicate surgical conditions, and in one case the tympanic sinus did not exist. Moreover, 3 cases revealed additional single or multiple bony trabeculae within the tympanic sinus. It was noted that almost always when a prominent promontory bridge was present the sinus was shallow (Fig. 2), and a deep sinus correlated with a very small bridge (Fig. 3) or its absence. The correlation was statistically significant. Table 1 presents the variability of the tympanic sinus observed in the present study.

The mean maximum height and maximum width of the tympanic sinus were 2.73 mm and 2.23 mm respectively. The mean shortest distance between the tympanic sinus and the jugular fossa was 5.5 mm, while the mean shortest distance from the tympanic cavity to the jugular fossa was 3 mm (0.25–6.0 mm). The shortest distance between the tympanic sinus and the jugular fossa presented great variability with maximum and minimum values of 1.0 mm and 10.0 mm respec-



**Figure 2.** Medial wall of left temporal bone. Shallow and wide tympanic sinus without promontory bridge. One-millimetre gauge. 1 — anterior branch of the stapedius; 2 — superior part of the tympanic sinus; 3 — stapedius muscle tendon; 4 — pyramid eminence; 5 — bony trabecula on the medial wall of the remains of the extinct promontory bridge of the tympanic sinus; 6 — inferior part of the tympanic sinus; 7 — round window niche.



**Figure 3.** Medial wall of the left temporal bone. Deep tympanic sinus with prominent promontory bridge dividing the tympanic sinus into two completely separated parts, superior and inferior. One-millimetre gauge. 1 — tympanic roof; 2 — opened lateral semicircular canal; 3 — facial nerve; 4 — promontory bridge; 5 — inferior part of the tympanic sinus; 6 — promontory; 7 — anterior branch of the stapedius; 8 — superior part of the tympanic sinus.

**Table 1.** Morphology of the tympanic sinus and the promontory bridge

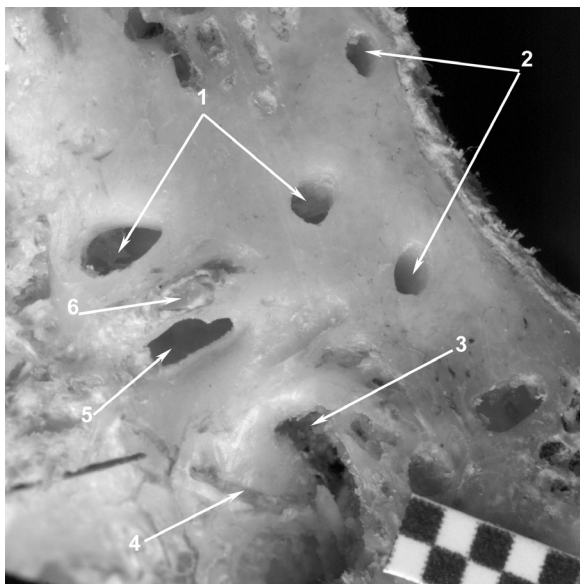
| Shape of the sinus entrance |                 |                   |        |           |
|-----------------------------|-----------------|-------------------|--------|-----------|
| Feature                     | Vertically oval | Horizontally oval | Round  | Polygonal |
| Number                      | 14              | 1                 | 7      | 7         |
| Sinus developmental form    |                 |                   |        |           |
| Feature                     | Shallow         | Deep              | Absent |           |
| Number                      | 19              | 10                | 1      |           |
| Promontory bridge           |                 |                   |        |           |
| Feature                     | Present         |                   | Absent |           |
| Number                      | 16              |                   | 14     |           |

tively. The mean shortest distance between the tympanic sinus and the facial canal was 1.5 mm (0.5–4.0 mm) and the mean shortest distance between the tympanic sinus and the lateral semicircular canal (measured on its prominence located on the medial wall of tympanic cavity) was 4.28 mm (3.0–6.0 mm). The frontal sections of the temporal bone showed that the shortest distances between the tympanic sinus and the posterior semicircular canal and between the tympanic sinus and the lateral semicircular canal were 1.59 mm (0.5–4.24 mm) and 2.1 (1.0–5.1 mm) respectively. Table 2 shows the measurement results.

**Table 2.** Tympanic sinus measurements and the distances between the sinus and the neighbouring structures (all measurements in millimetres)

|  | Mean value | Minimal value | Maximal value |
|--|------------|---------------|---------------|
| Sinus height   | 2.73       | 1.0           | 4.45          |
| Sinus width  | 2.23       | 1.0           | 3.5           |
| Facial canal   | 1.5        | 0.5           | 4.0           |
| Lateral semicircular canal (measured on the medial wall) | 4.28       | 3.0           | 6.0           |
| Lateral semicircular canal (frontal section)             | 2.1        | 1.0           | 5.0           |
| Posterior semicircular canal (frontal section)           | 1.59       | 0.5           | 4.25          |
| Jugular fossa  | 5.5        | 1.0           | 10.0          |
| Distance between the jugular fossa and tympanic cavity   | 3.0        | 0.25          | 6.0           |

It should be noted that the lateral semicircular canal may also be located in close proximity to the floor of the tympanic sinus (Fig. 4). In about 50% of the temporal bones investigated the distances between the floor of the tympanic sinus and the lateral semicircular canal and between the floor of the



**Figure 4.** Frontal section of the temporal bone at the level of the posterior wall of the tympanic sinus. One-millimetre gauge. 1 — lateral semicircular canal; 2 — posterior semicircular canal; 3 — tympanic sinus; 4 — promontory; 5 — oval window; 6 — facial nerve.

sinus and the ampulla of the posterior semicircular canal were similar, the mean distance being 1.5 mm. It should also be noted that this localisation is a risk factor for postoperative perilymphatic fistula following surgical damage to these structures. In the remaining cases the frontal sections showed that the distance between the tympanic sinus and the lateral semicircular canal was twice as great.

## DISCUSSION

Our study showed that shape of the tympanic sinus was very variable. Marked variation in the size and shape of the sinus is the rule [1]. Absence of the tympanic sinus occurs in 2 of the 24 temporal bones [2] and in our study it occurred in only one case. Significantly, in 10 cases out of 30 the study revealed the incidence of a deep tympanic sinus, which corresponds to the finding of Abdel Baki et al. [1], who noticed that the sinus tympani is in most cases bounded laterally by a constant ledge of bone anterior to the facial nerve. Amjad et al. [2] reports that the sinus may even reach 10 mm in depth. A tympanic sinus which was over 4 mm in depth was observed surgically by Niemczyk et al. [7] in 30% of his surgical patients. It was noted that a more prominent facial canal correlated with a deeper tympanic sinus. A similar interdependence was observed between the tympanic sinus and the pyramidal eminence [2]. It is worth underlining that the results point to a statistically significant correlation between a deep tympanic sinus and an inconspicuous promontory bridge or its absence and between a shallow tympanic sinus and a prominent promontory bridge. The promontory bridge is present in 66%, partially formed in 14% and absent in 20% [6]. Wysocki [17] reported the occurrence of a double or triple promontory bridge. Three cases revealed the presence of additional single or multiple bone trabeculae within the tympanic sinus. Because of their topography and morphology it was impossible, however, to categorise the structures as a double promontory bridge or a subiculum.

The measurement results obtained in this study correspond to those attained by other authors. Amjad et al. [2] and Saito et al. [13] give the upper, middle and bottom measurements, which are 0–3 mm, 0–4 mm and 0–3.5 mm respectively. Some authors point to the location of the ampulla of the posterior semicircular canal close to the floor of the tympanic sinus [2, 4]. Other authors investigating the tympanic cavity have not noted any close proximity of the tympanic sinus to the ampulla of the posterior

semicircular canal [1, 9, 13]. Our anatomical studies revealed that in about 50% of the temporal bones investigated the distances between the floor of the tympanic sinus and the lateral semicircular canal and between the sinus and the ampulla of the posterior semicircular canal were similar and the mean distance between the structures was 1.5 mm.

Amjad et al. [2] also reports that the floor of a deep tympanic sinus may protrude upward and reach the prominence of the lateral semicircular canal. It should be noted that this localisation is a risk factor for postoperative perilymphatic fistula following surgical damage to these structures. In the remaining cases the frontal sections showed that the distance between the tympanic sinus and the lateral semicircular canal was twice as great.

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