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The deep oval window

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Abstract
This article presents the results of an analysis of the variable and surgically important relationship between the oval window, the fossular walls and the related posterior tympanic recesses in 50 temporal bones. The visual impressions of superficial and deep oval windows seem to correspond fairly closely to the depth of the inferior wall of the fossula fenestra vestibuli (FFV). The depth of the superior and anterior walls of the FFV by themselves, did not appear to have such a dominating relationship in determining the deep oval window. There does not appear to be a well defined posterior wall in the vast majority of the specimens (86 per cent). In the event of scar tissue forming between the superior, inferior and anterior walls, the gap between the postero-superior part of the promontory and the posterior tympanic wall (posterior communication) could allow aeration of the region of the deep oval window in such an instance. Closure of this gap by a solid shelf of ponticulus or scar tissue could cause a localized malaeration of the fossula in most cases of deep oval windows. This is an entirely new concept of the likely problems of malaeration of a deep oval window which could arise due to anatomical variations and of the possible safety valve mechanism which could prevent such malaeration and its consequences.

Introduction

The oval window lying postero-superior to the promontory on the medial wall of the middle ear presents a visual impression of varying relationship to the promontory. Sometimes, it appears to be relatively superficial, easily and fully seen with flaring fossular walls and at other times it seems deep. An overhanging facial nerve may further impede the visibility of the oval window. Over the past several years while re-operating on some of the failed cases of total ossicular chain reconstruction using cortical bone grafts, it became apparent that one of the causes of failure was a 'deep oval window'. In an effort to define it and to find out the approximate incidence of this anatomical variation, the present investigation was undertaken.

Material and methods

Fifty temporal bones were used in the investigation. The following details of obtaining the specimens is a modification of the method described by Michaels (1987). Blocks of petrous temporal bones between the internal auditory meatus and 1.5 cm medial to the squamous part of the temporal bone were removed from cadavers and the specimens were kept in formalin for two weeks or longer. Further preparation was done by removing the tegmen tympani, the malleus, the incus and the greater part of the external auditory meatus and the specimens were reduced to approximately 2.5 × 2.5 × 2.5 cm. The final specimens contained the tympanum and its related walls. At this stage the specimens were examined under the operating mircoscope and an assessment was made whether the oval window was superficial or deep. Measurements were also made of the size of the oval window. The line of section was marked on the specimens with a view to obtaining coronal sections, either through the oval window or immediately in front of it. Details of the slicing technique have been described by Michaels (1987). The coronal sections were made using a Microslice 2 Precision Annular saw with a stainless steel, diamond-tipped blade (Malvern Instruments, Spring Lane South, Malvern, Worcs). It is an instrument *par excellence* for temporal bone sections without the need for decalcification. In some of the specimens, 1.0 mm thick slices of undecalcified temporal bones were cut through the oval window to see if these would give any further or improved information (Fig. 1). This has not found to be the case. These prepared specimens gave an excellent view of the relationship of the oval window to the adjoining structures and were ideal for measurements. Measurements were made using the measuring graticule calibrated against an electron microscope 3.05 mm copper grid. The following measurements were made.

1. The length and the width of the oval window.
2. The distance between the centre of the upper margin of the oval window and the most laterally projecting point of the facial nerve above it. This is the depth of the superior wall of the fossula (Fig. 2).
3. From the centre of the inferior margin of the oval window to the point on the superior surface of the promontory which is still at right angles to the oval window before it starts to flare away. This is the depth of the inferior wall of the fossula (Fig. 2).
4. The anterior depth (anterior wall). This is the dis-

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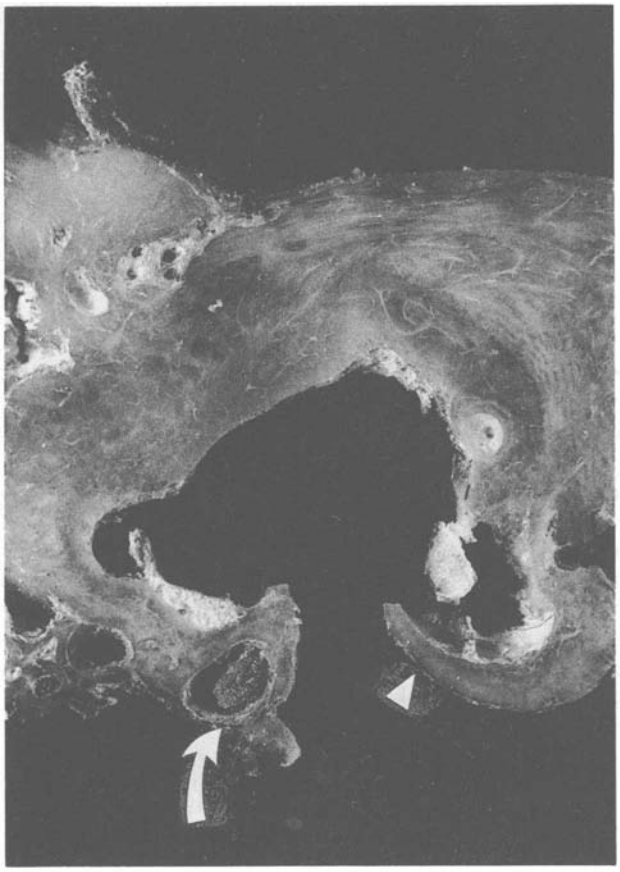

FIG. 1

1 mm section through oval window. Arrow head shows the promontory (superficial oval window). Arrow shows the facial canal.

tance between the centre of the anterior margin of the oval window and the adjoining medial wall at its most lateral projection. The difficulty of measuring this accurately lies in the fact that there is no fixed anterior point. Furthermore in most specimens, the medial tympanic wall gradually projected laterally although in some specimens there was a steep and almost a vertical ledge at right angles to the oval window. In most specimens a branch of the inferior tympanic nerve and its accompanying vessel would mark the anterior point.

5. The distance between the posterior superior margin of the promontory and the pyramid.

Apart from the measurements mentioned above, particular attention was paid to the presence of the ponticulus (present in 58 per cent) and its attachments; the presence or absence of the posterior tympanic sinus, the formation of the posterior wall of the fossula and its communication with the sinus tympani (Fig. 3).

Results

On the basis of visual impressions, the oval windows were classified as superficial or deep. Subsequent measurements were made of the depth of the walls of the fossula and details of these measurements are given below.

(1) Oval window measurements:
Average 2.8 × 1.3 mm; range length 2 to 3.2 mm; width 1–1.7 mm.

(2) Depth of the inferior wall:
a. Superficial oval window group: average 1.2 mm; range 0.5 to 1.8 mm.
b. Deep oval window group: average 2.3 mm; range 1.8 to 2.7 mm.

(3) Depth of the superior wall:
a. Superficial oval window group: average 1.6 mm; range 0.8–3 mm.
b. Deep oval window group: average 1.7 mm; range 1.4–3 mm.

(4) Depth of anterior wall:
a. Superficial oval window group: average 0.9 mm; range 0.5–1.5 mm.
b. Deep oval window group: average 1.1 mm; range 0.5–1.8 mm.

(5) Distance between the postero-superior part of the promontory and the pyramid:
a. Superficial oval window group: average 1.4 mm; range 0.9–1.9 mm.
b. Deep oval window group: average 1.2 mm; range 0.7–1.9 mm.

Of the 50 specimens assessed, 31 were in the superficial group, and 19 in the deep group. What one was looking for, was (a) whether any particular parameter would confirm that the visual impressions were correct and (b) whether the fossula in the event of obstruction at its lateral end had any communication with the rest of the tympanum.

The findings were as follows:

(i) The length and width of the oval window had little effect on the visual impression of the oval window being superficial or deep.

(ii) Only the inferior and superior walls were clearly defined. The anterior wall was less well defined but nevertheless it was present though difficult to measure accurately because of the difficulty in having a fixed anterior point. The inferior wall becomes continuous with the anterior and superior walls. However, there is a gap posteriorly between the superior and inferior fossular walls (*vide infra.*).

(iii) The depth fo the inferior fossular wall was the only measurement which consistently corresponded with the visual impressions of a deep oval window (Fig. 4). There was very little overlap in the

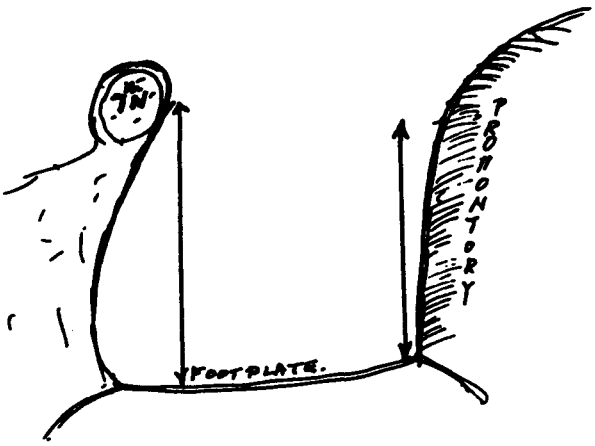

FIG. 2

Coronal section through the centre of the oval window showing the points of measurement of the superior (1) and inferior walls (2).

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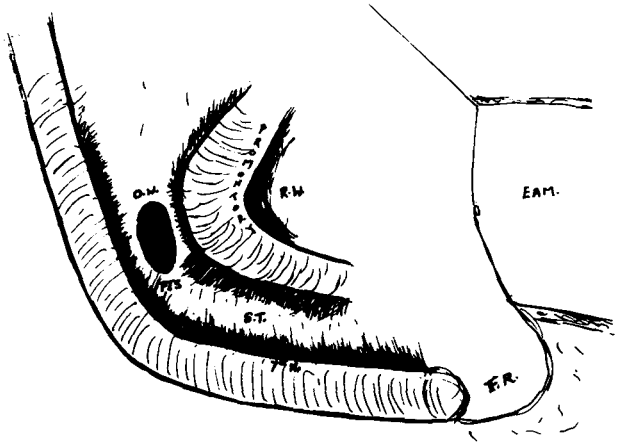

FIG. 3

R posterior mesotympanum. Viewed from above. *PTS* Posterior Tympanic Sinus. *ST* Sinus Tympani. *FR* Facial Recess.

measurements between the superficial and deep oval windows (3 out of 50 specimens). The average for superficial oval window was 1.2 mm and the average for deep oval window was 2.3 mm. These differences are statistically highly significant ($P< 0.001$). There have been no statistical differences in the depth of the superior and anterior walls of the fossula in the superficial and deep oval window groups.

(iv) The posterior relations of the fossula are variable due to variations in the development of the middle ear and these become important in cases of deep oval windows. Although the sinus tympani can be broadly described as a recess between the labyrinth and the posterior tympanic wall, Proctor (1969) in his excellent article describes the recess behind the oval window as the posterior tympanic sinus and the sinus tympani as a recess between the round window and the posterior tympanic wall and medial to the vertical part of the facial nerve (Fig. 3). Because of the influence of the posterior tympanic sinus in determining the posterior aspect of the fossula it was felt that this nomenclature was desirable to prevent any confusion.

The posterior tympanic sinus was a well developed recess in 30 of the specimens and, therefore, there was no posterior fossular wall. In a further 13 specimens there was an incomplete gently laterally sloping posterior wall going away from the fossula and in only seven specimens was there a complete posterior fossula wall. In the presence of such a variation in the posterior aspect of the fossula, it is difficult to describe the Fossula Fenestra Vestibuli as having a posterior wall.

The gap between the postero-superior part of the promontory and the posterior tympanic wall at the level of the pyramid is the communication between the posterior tympanic sinus and the sinus tympani. The posterior fossula therefore communicates with the sinus tympani via the posterior tympanic sinus. However, in 20 of the specimens the posterior tympanic sinus was tiny or absent and the fossula communicated directly with the sinus tympani (Fig. 5). In 19 of the specimens, the posterior communication was wide and open and unlikely to be blocked by scar tissue. In the remainder of the 31 specimens, the posterior communication was narrow and might be obstructed by scar tissue but in 14 of these such an obstruction would most unlikely cause malaeration of the fossula because they were in the superficial oval window group with wide clearance between the fossular walls. In the rest of the specimens, 15 were in the deep oval window group and two were in the superficial oval window group. The latter two had a complete ponticular shelf blocking the fossula from the sinus tympani and an overhanging facial nerve.

(v) The position of the processus cochleariformis was examined carefully. In all the specimens, it was placed either antero-superiorly or superiorly to the oval window. This is in contrast to its inclusion in the anterior wall by Djeric and Savic (1987). In 12 out of 50 specimens, its posterior margin was 0.3–1 mm posterior to the anterior margin of the oval window.

Discussion

Access to the footplate of the stapes becomes difficult in the presence of a deep oval window, an overhanging facial nerve and a narrow fossula may further increase these difficulties. In a stapedectomy these difficulties are not too great and it is always possible to overcome them by a suitable prosthesis. Because of the presence of the

FIG. 4

Section through the right oval window showing the anterior segment of the specimen. Arrow points to the footplate of the stapes and arrow head points to the promontory in a deep oval window.

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FIG. 5

Lateral view of coronal scan near the oval window showing the stapes, the ponticulus (arrow head) with ponticular foreman deep to it. Arrow points to sinus tympani.

long process of the incus in these cases, the prosthesis would be at right angles to the footplate and clear of the fossular walls. However, in a case of total ossicular chain reconstruction with bone graft between the footplate of the stapes and the tympanic membrane or the handle of the malleus, because of the angle of reconstruction, there is a possibility of bony fusion between the bone graft and the inferior fossular wall or even the processus cochleariformis. Furthermore, the clearance between the bone graft and the fossular walls in a deep oval window could be around 1 mm or less and scar tissue between these could lead to the deep fossula being closed laterally. In such an event, the posterior communication between the fossula and the sinus tympani can assume great importance in preventing an obstructive 'fossulitis' and granuloma formation, something similar to obstructive mastoiditis due to malaeration as a result of antral obstruction. In 15 of the 19 specimens of deep oval window, the posterior communication was considered to be narrow enough to be blocked and in the remainder of the four specimens, the posterior communication was very wide and associated with wide and open posterior tympanic sinus. In the group of the superficial oval windows, the walls of the fossular appear to flare away from the oval window, leaving a much wider gap between a bone graft and the fossula walls with little likelihood of fossula obstruction. In only two superficial oval window specimens was it considered possible that fossular obstruction could develop and these specimens were associated with a well marked overhanging facial nerve and a ponticular shelf which completely obstructed the posterior communication between the fossula and the sinus tympani.

It is difficult to compare the measurements of the depth of the fossular walls with those measured by Djeric and Savic (1987) because the points of measurements were not mentioned in their article and therefore, they could be different. They include the facial canal as forming part of the upper fossular wall and yet the only measurements taken were of the labyrinthine bony lamella. Similarly the points of measurement of the inferior wall were not mentioned. However, they mention that the fossula is deep 32 per cent of the specimens but no details were given as to how they arrived at this conclusion.

The visual impressions of the superficial and deep oval windows seem to correspond fairly accurately with the depth of the inferior fossular wall and more so than any other measurements. There was little overlap between the two groups.

Key words: Middle ear, anatomy

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