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Original Article

Grading of the Position of the Mastoid Tegmen in Human Temporal Bones – A Surgeon's Perspective

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OBJECTIVES: To establish a new surgically relevant classification system of the anatomic variations of the temporal bone tegmen plate as well as to perform a comparative analysis, with respect to the pneumatization patterns in the cadaveric temporal bones.

MATERIALS and METHODS: Microdissection of the human cadaveric temporal bones was performed after obtaining ethical approval from the Institutional Ethical Committee (F.8-522/A-522/2017/RS). The pneumatization pattern of the temporal bones was noted as "under-pneumatized" or "well-pneumatized." The tegmen mastoid (TM) was classified into two grades as per the position of the tegmen plate and the visibility of the superior semicircular canal (SSCC) and the aditus. The latter two structures were well visualized in Grade A and poorly visualized in Grade B. The data were analyzed using Stata 14.0 (Stata Corp, 4905, Lakway drive, College Station, Texas, USA).

RESULTS: Ninety-three temporal bones were dissected under microscope. Fifty-eight bones were well-pneumatized and 35 were under-pneumatized. The tegmen plates were classified as Grade-A in 49 bones (well-pneumatized -37 and under-pneumatized -12), and as Grade-B in 44 bones (well-pneumatized-21, poorly-pneumatized-23). Grade-A classification was significantly more common in well-pneumatized temporal bones, while Grade-B was more common in under-pneumatized bones (p=0.0057).

CONCLUSION: We propose a surgically relevant classification for TM positioning. A well-pneumatized temporal bone is associated with a significantly higher position of the tegmen plate (Grade-A TM).

KEYWORDS: Temporal bone, otologic surgical procedures, anatomic variation, middle cranial fossa, cerebrospinal fluid leak

INTRODUCTION

The tegmen plate is a thin bone that separates the mastoid cavity from the middle cranial fossa (MCF). It is the superior limit during mastoid surgeries [1-3]. The linea temporalis or the supra mastoid crest provides the external surface marking for the tegmen plate as well as the MCF [4]. The anatomic variations of the temporal bone need to be remembered while performing mastoid surgeries and using transmastoid approaches. Tegmen defects can result from infectious processes, such as chronic suppurative otitis media with or without cholesteatoma), neoplasms, and fractures in the temporal bones leading to cerebrospinal fluid leak or brain herniation, or can be iatrogenic (post-surgery) [1, 3, 5-7]. The latter make it imperative for the surgeon to be aware of the patterns of variability in the numerous structures encountered during temporal bone surgeries and to exercise caution to avoid disastrous consequences arising from their damage [3]. The positional variability of the surrounding structures can make it difficult for the surgeons to locate the mastoid antrum [4]. Otologic surgeons need to be trained to anticipate and assess these variations to minimize complications.

Limited information is available about tegmen plate variations and its classification in the literature. We hypothesize that the low-lying tegmen can misguide the surgeon regarding the position of the antrum.The current study aimed to establish a new classification or grading system of the anatomic variations of the tegmen plateand tocompare the same with respect to the pneumatization patterns in cadaveric temporal bones.

MATERIALS AND METHODS

After approval from the Institute ethical committee (F.8-522/A-522/2017/RS), microdissection of cadaveric temporal bones was performed in our departmental temporal bone surgical skill laboratory with the assistance of Leica M320 F12 microscope with

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LED that has an inbuilt 3 mega pixel camera plus HD video system (Wetzlar, Germany) under 6.4 magnification. Forte 200 electric microdrill (Saeshin Precision, Daegu, Korea) at 25,000 rpm was used for dissection.

After the removal of the soft tissue, the temporal bones were fixed in the temporal bone holder. McEwen's triangle was identified, and complete cortical mastoidectomy was performed. Each dissection procedure was recorded, and important pictures were taken in a direction perpendicular to the mastoid cortex under microscopy (magnification x10) for further analyses. The pneumatization pattern of each temporal bone was noted as "well-pneumatized" (WP) or "under-pneumatized" (UP). A mastoid with a large antrum and well-defined cellularity in the periantral/perisinus/perifacial area was labeled as WP, while the one with a small/contracted mastoid and periantral sclerosis was labeled as UP. The images were analyzed, and the tegmen mastoid (TM) was classified with respect to the surrounding anatomic references (Figure 1). The aditus and superior semi-circular canal (SSCC) were considered as reference points to classify the TM into Grade-A and B.

Grade-A: The mastoid-facing surface of the TM was flat and provided a clear view of the aditus with ossicles (the entire superior border of the body of incus could be visualized), SSCC and sinodural angle (Figure 2a).

Grade-B: Low-lying TM, obscuring a clear view of the aditus with ossicles, SSCC, and the sinodural angle. This configuration can mislead the surgeon while trying to locate the mastoid antrum (Figure 2b).

Further, the distance from the mastoid tip (MT) to the TM (MT-TM) was calculated in all the bones; thereafter acomparative analysis of this length was performed with respect to temporal bone pneumatization and the TM grade.

Statistical Analysis

Data were analyzed using Stata14.0 (Stata Corp, 4905, Lakway drive, College Station, Texas, USA). Categorical variables were compared by using the Chi-square test (sample size $^{3}5$) or Fisher's exact test (sample size <5). Continuous variables were compared with the independent t-test. A $p<0.05$ was considered to indicate statistical significance.

RESULTS

Total 93 cadaveric temporal bones were dissected in our surgical skills laboratory. Forty-seven bones were right-sided, while 46 were left-sided. Fifty-eight bones were classified as WP, and 35 were classified as UP. There was no statistically significant difference between the distribution of the bones on the right side and the left side in terms of pneumatization (Chi square test; p=0.47). Distribution of the bones in terms of side and pneumatization is detailed in Table 1.

The mean distance, MT-TM, in the 93 dissected bones was 26.6 mm (SD-3.4 mm; range: 19.6-35.9 mm). The difference between the length on the left side (27 mm±3.9 mm) and the right side (26.3 mm±3.4 mm) was not statistically significant (p=0.35).

The distance, MT-TM, for the UP and WP groups is presented in Table 2. The WP bones had a significantly larger MT-TM distance than the UP bones (p=0.0000). Comparison of the distance between Grade-A (27.4±3.5 mm) and Grade-B (25.8±3.6 mm) showed that the difference was statistically significant (p=0.037).

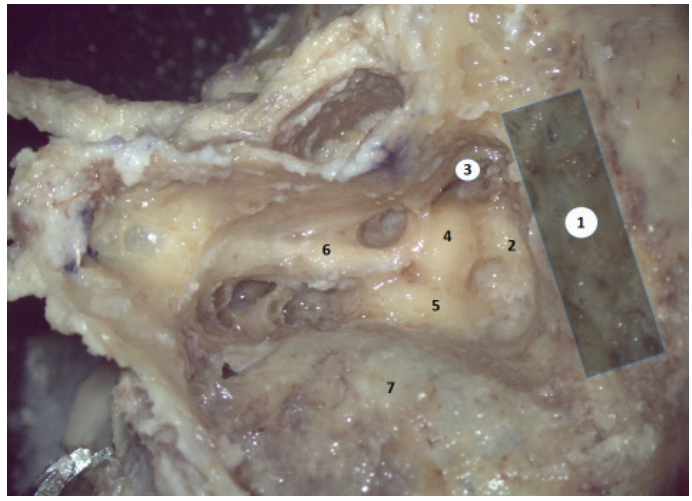

Figure 1. Dissected temporal bone with anatomic landmarks for TM grading. (1-Tegmen mastoid; 2- Superior Semicircular canal; 3- Aditus; 4- Horizontal Semicircular canal; 5-Posterior Semicircular canal; 6- Facial Nerve (Mastoid segment); 7- Sigmoid Sinus) (Original magnification x10).
TM: tegmen mastoid

Table 1. Distribution of the dissected temporal bones in terms of side and pneumatization

Side of bones	UP	WP	Total
Left	19	27	46
Right	16	31	47
Total	35	58	93

UP: Under Pneumatized; WP: Well Pneumatized

Table 2. Variation of the MT-TM length with pneumatization

Pneumatization	n	Mean (mm)	SD (mm)	Range (mm)
UP	35	24.7	2.8	19.6-33.2
WP	58	27.8	3.6	19.8-35.9
Combined	93	26.6	3.6	19.6-35.9

MT: Mastoid Tip; TM: Tegmen Mastoid; n: number of temporal bones; UP: Under pneumatization; WP: Well pneumatization; SD: Standard deviation; mm: millimeters

MAIN POINTS

- The current study classifies the position of Tegmen mastoid based on the visibility of ossicles, superior semicircular canal and sinodural angle.
- A well pneumatized mastoid is associated with a higher position of tegmen mastoid (Grade-A tegmen mastoid).
- Grade-A tegmen mastoid is associated with increased distance between tegmen and mastoid tip.

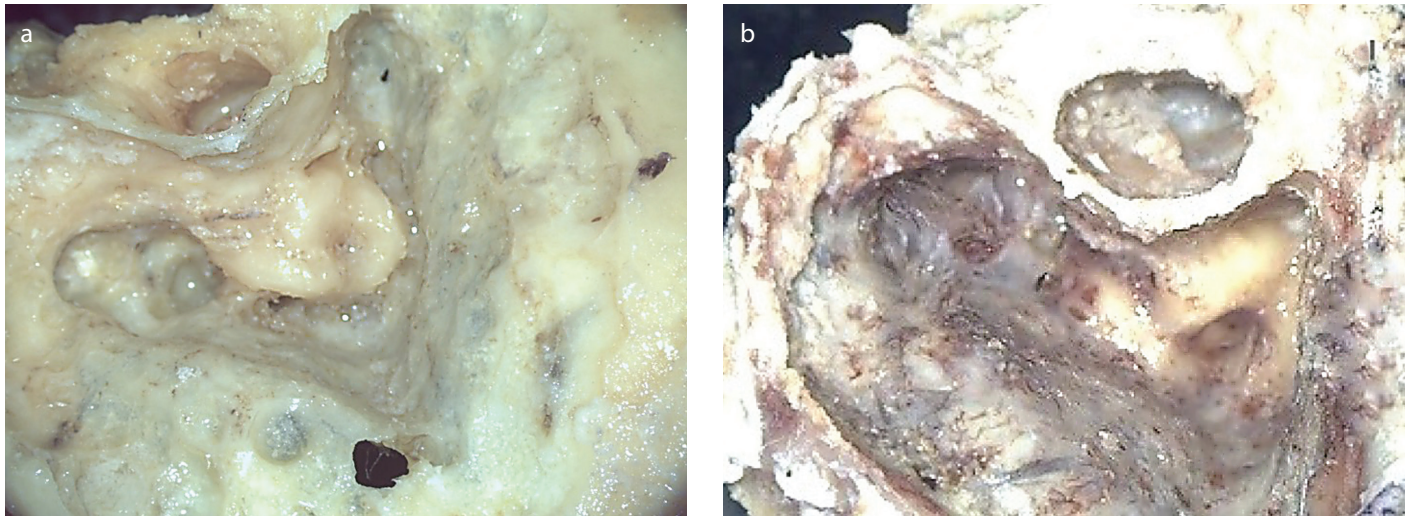

Figure 2. a, b. Dissected temporal bones depicting the proposed TM classification (Irugu DVK & Singh A). TM Grade A: fully visible SSCC and Aditus (a). TM Grade B: the TM plate obscuring the SSCC and the aditus (b). (Original magnification x10).
TM: tegmen mastoid; SSCC: superior semicircular cana

Table 3. Distribution details of the TM grading (Irugu DVK & Singh A) against pneumatization on the two sides

TM Grade		Side		Total
		Right	Left	
Grade A	WP	25	12	37 (39.8%)
	UP	10	2	12 (12.9%)
Grade B	WP	6	15	21 (22.6%)
	UP	6	17	23 (24.7%)
Total		47 (50.5%)	46 (49.5%)	93 (100%)

TM: Tegmen Mastoid; WP: Well Pneumatized; UP: Under Pneumatized

As per our grading system, 49 bones (UP-12; WP-37) were classified as Grade-A TM, while 44 bones (UP-23; WP-21) were classified as Grade-B TM (Table 3). The distribution of the grading with pneumatization was statistically significant, with the WP mastoids showing a significantly higher tendency of being associated with a Grade-A TM and UP mastoid bones having a significantly higher number of Grade-B TM (p=0.0057).

DISCUSSION

The tegmen plate is a thin bone that separates the mastoid cavity from the middle cranial fossa. It extends from the anterior meatal wall anteriorly to the sinodural angle posteriorly. The surgical significance lies in the fact that a defect in this partition (due to injury during surgery or erosion by disease/infection/tumors) can lead to cerebrospinal fluid leak or brain herniation [1, 3-6]. Anatomically, the tegmen plate can be differentiated into the following three parts:

1. Tegmen tympani that roofs the epitympanum,
2. Tegmen antri that roofs the mastoid antrum, and
3. Tegmen mastoid (TM) that roofs the mastoid cavity.

During the transmastoid approaches, the first step is to locate the mastoid antrum. The superior limit of these approaches is the tegmen plate, especially the TM. Our study emphasizes on the variations in the TM plate with the understanding that a low-lying TM obscures the antrum and can mislead the surgeon while he/she is attempting to locate the antrum. Inadequate knowledge of these variations can result in complications by a young trainee. Spending time in surgical skill development and practicing dissections on temporal bones is fundamental for building confidence and skill as well as minimizing the complication risk [4, 8].

Makki et al. [3] provided the radiological classification (Amoodi-Bance classification) of the TM. It is based on the Lateral-Medial slope posteriorly and the Posterior-Anterior slope laterally, as visualized in the coronal and sagittal CT scans, respectively, and explained the low-lying dura in relation to the highest portion of the TM in each plane. Piromchai et al. [8] showed that the presence of the sclerotic mastoid was best correlated to the distance between the mastoid tip and the tegmen.

During mastoid surgeries or the use of transmastoid approaches, the drilling should proceed from the posterolateral to the anteromedial direction. A bowing dural plate, as opposed to the one in a horizontal plane (flatter configuration) will contract the antrum from above and increase the chances of dural injury when attempting to locate the antrum. We graded the TM position into two grades as detailed above. It has been observed that injury to the dural plate and other surrounding vital structures is more likely to occur in sclerotic mastoids [9]. The anterosuperior part of antrum is the most common site for injury and can be associated with injury to the labyrinthine block (especially the lateral semicircular canal) [10]. The probable causes of injury in these cases are as follows:

1. Difficult anatomy with a low-lying dural plate that partly conceals the antrum, increasing the difficulty in performing the dissection.
2. Unfavorable pneumatization (sclerotic mastoid) with a contracted and difficult-to-locate antrum. The loss of cellularity surrounding the vital structures increases the chance of the injury from the rotating burr.
3. Use of inappropriately sized drill bits.
4. Surgery being performed by a novice surgeon who is unfamiliar with the anatomical variability.

Our results show that the dural plate position varies with the pneumatization status of the temporal bone. A Well-pneumatized (WP) temporal bone tends to be associated with a higher position of the dural plate, while an Under-pneumatized (UP) temporal bone tends to have a low-positioned dural plate with poor visibility of the SSCC and the aditus region. The distance between the tegmen and mastoid tip (MT-TM) correlated well with temporal bone pneumatization, with the WP bones being lengthier than the UP bones. Similar results were obtained for the length and grading of the TM; the Grade-A TM was associated with a statistically significant longer MT-TM length compared to the Grade-B TM.

Our study presents a practical classification for the intraoperative documentation of the TM position that will enable a comparison of the results and complications in a more standardized fashion. Incorporation of this simple classification in standard mastoid surgery or transmastoid procedures will be useful for the communication and analyses of the surgical outcomes. This information would be valuable in the preoperative course, and the correlation of pre-operative CT scan with intraoperative TM positioning is currently under study in our department.

CONCLUSION

A low-lying dura or TM obscures the antrum and SSCC, predisposing to intraoperative complications. A well-pneumatized mastoid is associated with a favorable configuration of the dural plate (i.e., high position of the tegmen plate). A low-lying dural plate (Grade-B TM) is associated with a statistically significant shorter MT-TM length.

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Conflict of Interest: The authors have no conflict of interest to declare.

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