Research

Comparative study of anatomical findings in temporal bone dissections

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ABSTRACT

Background: Simple mastoidectomy is the most common approach to managing chronic suppurative otitis media (CSOM). This procedure aims to partially or completely remove mastoid cells, to overcome the infection in the middle ear. However, the mastoid bone pneumatization type may influence the result of simple mastoidectomy or temporal bone dissection. **Purpose:** To determine the difference in the anatomical findings of pneumatic and diploic mastoid types in the temporal bone dissections. **Method:** This cross-sectional study assesed on pneumatic and diploic types of mastoid bone, on temporal bone dissections findings. The mastoid bones used in this study were temporal bone of the Indonesian cadavers. Data were obtained from direct observation of the number of anatomical landmarks found during temporal bone dissections on each type of mastoid bone; and the maximal anatomical landmark found in each bone was seven. The number of anatomical landmarks between pneumatic and diploic mastoid bone was compared using the Mann-Whitney U test. **Result:** The mean of overall anatomical landmarks found during temporal bone dissection was 4.50±1.70. No significant difference in the number of anatomical landmarks was found between pneumatic and diploic mastoid bone (4.57±0.79 vs. 4.43±0.53; p=0.827). **Conclusion:** There was no significant difference in anatomical findings between pneumatic and diploic mastoid bone in temporal bone dissections. Broad knowledge is vital for successful mastoidectomy in all types of mastoid bone.

Keywords: temporal bone dissection, simple mastoidectomy, pneumatization, pneumatic, diploic

ABSTRAK

Latar belakang: *Mastoidektomi sederhana merupakan tatalaksana yang paling umum digunakan untuk menangani otitis media supuratif kronik (OMSK). Prosedur ini bertujuan untuk mengangkat sebagian atau seluruh sel mastoid, untuk mengatasi infeksi pada telinga tengah. Jenis pneumatisasi tulang mastoid diduga dapat memengaruhi hasil mastoidektomi sederhana atau diseksi tulang temporal.* ***Tujuan:*** *Untuk membandingkan temuan anatomi antara tulang mastoid tipe pneumatik dan diploik, yang diperoleh dari prosedur diseksi tulang temporal.* ***Metode:*** *Penelitian potong lintang ini menilai tipe pneumatik dan diploik pada tulang temporal. Tulang temporal yang digunakan dalam studi ini diperoleh dari kadaver orang Indonesia. Data studi diperoleh melalui observasi langsung jumlah penanda anatomi yang ditemukan dari diseksi tulang temporal pada setiap jenis tulang mastoid; dan jumlah maksimal temuan penanda anatomi pada setiap tulang adalah tujuh. Jumlah temuan anatomi antara tulang mastoid pneumatik dan diploik dibandingkan menggunakan uji* Mann-Whitney U. ***Hasil:*** *Rerata jumlah temuan anatomi secara keseluruhan adalah 4,50±1,70. Tidak ada perbedaan signifikan pada jumlah temuan penanda anatomi antara tulang mastoid pneumatik dan diploik (4,57±0,79 vs. 4,43±0,53; p=0,827).* ***Kesimpulan:*** *Tidak ada perbedaan signifikan dalam temuan penanda anatomi antara tulang mastoid pneumatik dan diploik pada diseksi tulang temporal. Pengetahuan yang baik sangat penting untuk keberhasilan tindakan mastoidektomi pada semua jenis tulang mastoid.*

Kata kunci: *diseksi tulang temporal, mastoidektomi sederhana, pneumatisasi, pneumatik, diploik*

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INTRODUCTION

Simple mastoidectomy is a surgical procedure performed to remove a part or all of the mastoid cells, which are the hollow parts behind the ear, to overcome infection or other pathological conditions in the middle ear. This procedure could be used for various conditions, including refractory chronic suppurative otitis media (CSOM), or CSOM with extensive spread of infections.[1,2] Although CSOM is a common disease faced by otologists in daily practice, surgical management of CSOM cannot be performed with a guarantee of complete success. The success rate of mastoidectomy can be influenced by various factors, such as the type of pneumatization of the mastoid bone, and the operator's capability.[3]

Mastoid bone pneumatization begins after birth and is typically complete by the age of three to four years, continuing progressively into adulthood. This pneumatization process, which involves the development of air cells within the mastoid portion of the temporal bone, varies considerably between individuals, and determines the internal architecture of the mastoid. Based on the degree and pattern of pneumatization, the mastoid bone is generally classified into three main types: pneumatic, diploic, and sclerotic. In the pneumatic type, the mastoid is extensively filled with air cells, providing a more spacious and aerated structure that facilitates easier identification of anatomical landmarks during dissection. In contrast, the diploic type contains more trabecular bone with marrow spaces (diploë) and fewer air cells, making the bone denser and the surgical field less accessible. The sclerotic type is characterized by a near-complete absence of air cells, resulting in a solid and compact bone structure that poses significant technical challenges during mastoidectomy.[4]

These anatomical differences are not trivial matter, but have direct implications for surgical procedures. A well-pneumatized mastoid offers clearer visibility and access to critical landmarks, while a diploic or sclerotic mastoid often requires longer operating time, more extensive drilling, and higher precision to avoid damaging adjacent neurovascular structures. Furthermore, the lack of natural air spaces in less pneumatized bones limits maneuverability and increases surgical difficulty.[5] Understanding these variations is crucial not only for preoperative planning but also for evaluating surgical outcomes.

Seven landmarks must be found after a successful simple mastoidectomy or appropriate temporal bone dissection, including the posterior wall of the external auditory canal, tegmen tympani, horizontal semicircular canal, fossa incudis and incus, sinodural angle, digastric ridge, and posterior semicircular canal.[6,7] A preliminary study on the simple mastoidectomy showed that the number of anatomical landmark findings differed between the pneumatic, diploic, and sclerotic types of mastoid bone (with a mean of 6, 4, and 0 findings, respectively). Therefore, we were very interested in exploring the influence of mastoid bone pneumatization type on the success of temporal bone dissection.

This study aimed to determine the differences in anatomical findings between pneumatic and diploic mastoid types in temporal bone dissection procedures, which could provide comprehensive perspective on understanding mastoid bone pneumatization.

METHOD

This cross-sectional study was conducted from July to August 2024 at the Temporal Bone Dissection Laboratory of Prof Dr. I.G.N.G. Ngoerah Hospital, Denpasar, Bali, Indonesia. This study only compared pneumatic and diploic mastoids; without including sclerotic mastoids. All mastoid bones used for temporal bone dissection training were obtained from Indonesian cadavers. The participants were 6 residents of Otorhinolaryngology and Head–Neck Surgery Departement, Faculty of Medicine, Udayana University.

The outcome was the number of anatomical landmarks found after the temporal bone dissection was completed. Seven landmarks should be found after a successful temporal bone dissection: Posterior wall of external auditory canal, tegmen tympani, horizontal semicircular canal, fossa incudis and incus, sinodural angle, digastric ridge, and posterior semicircular canal. Data were obtained from direct observation of the number of anatomical landmarks.

The data collected was statistically analyzed using the Statistical Package for the Social Sciences software version 16.0 for Windows. Normality tests were performed using the Shapiro-Wilk test. Because the number of anatomical landmarks found was not normally distributed, the number of anatomical landmarks between pneumatic and diploic mastoid bone was compared using the Mann-Whitney U test. The statistical test result was considered significant if the p-value was 0.05 or less.

RESULT

Seven pneumatic and diploic mastoid bones were dissected during the Temporal Bone Dissection Study. The mean of overall anatomical landmarks found during temporal bone dissection was 4.50±1.70. The posterior wall of the external auditory canal, tegmen tympani, sinodural angle, and digastric ridge were identified in all cases (100%). Fossa incudis and incus, were identified only in one pneumatic bone, and none in the diploic bone. However, posterior semicircular canals failed to be identified in both groups. When both groups were compared, no significant difference in the number of anatomical landmarks was found between pneumatic and diploic mastoid bone (4.57±0.79 vs. 4.43±0.53; p=0.827).

Table 1. The distribution of anatomical landmarks found from each type of mastoid bone

Anatomical landmark	Pneumatic (n = 7) %	Diploic (n = 7) %
Posterior wall	7 (100)	7 (100)
Tegmen tympani	7 (100)	7 (100)
Horizontal semicircular canal	3 (50.0)	3 (50.0)
Fossa incudis and incus	1 (14.3)	0 (0)
Sinodural angle	7 (100)	7 (100)
Digastric ridge	7 (100)	7 (100)
Posterior semicircular canal	0 (0)	0 (0)

Table 2. The mean number of anatomical landmarks found in Pneumatic and Diploic Bones

Number of anatomical landmarks	Pneumatic	Diploic	p-value
Mean±SD	4.57±0.79	4.43±0.53	0.827
Median (range)	4.00 (4.00-6.00)	4.00 (4.00-5.00)	

*SD: standard deviation

DISCUSSION

Mastoidectomy is a surgical procedure of the temporal bone, that opens postauricular air cells by removing the thin bony partitions between them. Since its introduction in 1873, mastoidectomy has been used to manage various pathological conditions, including the CSOM.[7,8] The key to effective and safe mastoidectomy is the successful identification of important anatomic landmarks. The posterior wall of the external auditory canal, tegmen tympani, horizontal semicircular canal, fossa incudis and incus, sinodural angle, digastric ridge, and the posterior semicircular canal are the seven anatomical landmarks that must be seen after completing a mastoidectomy.[6]

Studies have stated that each mastoidectomy case is unique due to anatomical differences, especially in the different pneumatization patterns. Pneumatization represents the development of air-filled cavities within bones. Physiologically, the pneumatization process is started at 22-24 weeks of gestational age. This pneumatization continues until 33-35 weeks of gestation when the antrum, the largest mastoid air cell, has reached adult size. Along with children's growth, the level of pneumatization of the mastoid bone can be influenced by several factors, such as genetic factors, gender, and pathological conditions of the middle ear (such as otitis media and Eustachian tube dysfunction). As a result of the influence of these factors, there are three different types of mastoid bone pneumatization: the pneumatic mastoid bone (complete pneumatization), diploic mastoid bone (partial pneumatization), and sclerotic mastoid bone (no pneumatization).[4,9]

The temporal bone dissection serves as practical training for surgeons or residents in performing complex otologic and neurologic procedures to understand the anatomical structures of the middle and inner ear and their relationship to surrounding structures such as the brain and blood vessels.[10] Therefore, we used temporal bone dissection training to evaluate the difference in difficulty level in performing mastoidectomy in different types of mastoid bones.

In this study, all participants successfully identified the posterior wall of the external auditory canal, tegmen tympani, sinodural angle, and digastric ridge in both pneumatic and diploic mastoid bones (100%). All participants had difficulty identifying posterior semicircular canals, fossa incudis, and incus. The result of this study proved that all participants had excellent ability in performing temporal bone dissection. There were several examples of successful temporal bone dissection. First, each participant received an online introductory course and a guidebook before the training. Thus, participants have sufficient knowledge and skills even though they have never performed a temporal bone dissection directly (hands-on). Motta et al.[11] stated that good training and knowledge can help avoid the misidentification of anatomical landmarks due to the low position of the dura in the hypopneumatized temporal bone so that all anatomical landmarks can still be identified by first- or second-year ORL–HNS residents when performing temporal dissection. Other reasons are direct guidance from many national and international instructors, an effective training environment, and high enthusiasm from participants during training.

Difficulty in identifying the posterior semicircular canal, fossa incudis, and incus might be due to limited training time, so participants might be in a rush or did not have enough time to complete the temporal bone dissection. Identifying the fossa incudis and incus is vital because the fossa incudis and incus serve as a posterior tympanotomy landmark. Identifying those landmarks is rarely performed and requires more precision because of the narrow area and facial nerve's presence in the inferior part of the area. Therefore, it is more difficult to identify the anatomical landmark in the diploic type mastoid bone. Identifying the posterior semicircular canal is also less performed because it is only needed for specific indications, and requires a deeper burr process.[11]

Although anatomically, mastoidectomy is more challenging to perform on mastoid bones with hypopneumatization compared to completely pneumatized mastoid bones, the results of this study showed that there was no significant difference in the number of anatomical landmarks between pneumatic and diploic mastoid bone (4.57±0.79 vs. 4.43±0.53; p=0.827). The insignificant result of our study might be caused by the fact that the comparison was only made for pneumatic and diploic bones without involving sclerotic bones. The most significant anatomical differences were found between mastoid bones with hyperpneumatization (pneumatic) and severe hypopneumatization (sclerotic), so the difference in anatomical variation between pneumatic bones with complete pneumatization and diploic bones with partial pneumatization might not be apparent. The absence of differences in the number of anatomical findings, might also because all participants had equal abilities when conducting temporal bone dissection training.[11]

This study is the first to examine the influence of mastoid bone pneumatization type on mastoidectomy success, as evidenced by differences in anatomical landmark findings in temporal bone dissection results. This study still had several limitations. First, this study involved a relatively small number of participants. Second, the comparison in this study was only conducted for pneumatic and diploic bones. Comparison with sclerotic mastoid bones might provide a more realistic picture of the effect of pneumatization on anatomical variations. Third, some anatomical structures, such as the posterior semicircular canal and fossa incudis, were difficult to identify. This could be related to the participants' experience, or the complexity of the dissection not being fully explored. Motta et al.[11] stated that difficulties in identifying anatomical structures could be overcomed with more intensive training and longer duration. Considering the limitations of this study, further research with a larger sample and a wider variety of mastoid pneumatization is needed to obtain more comprehensive results. There was no previous similar study had proven the relationship between mastoid bone pneumatization type and mastoidectomy success or outcomes. Nevertheless, as a pilot study, this study can still be a reference for other relevant studies in the future. The result of this study can also be used as the basis for evaluating the education and training system provided to ORL–HNS regarding their ability to perform temporal bone dissection at various difficulty levels.

In conclusion, this study proved no significant difference in the difficulty of performing mastoidectomy or temporal bone dissection between pneumatic and diploic mastoid bones. Good training and excellent knowledge are vital for successful mastoidectomy in all types of mastoid bones, even in the severe hypopneumatized mastoid bone that needs more precision.

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