

Computed Tomography Analysis of Sinus Tympani in Nepalese Population

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ABSTRACT

Background

Sinus tympani is a hidden recess in the retrotympaum with variable anatomy in terms of shape and size. This area is frequently involved in middle ear diseases and surgical removal of disease is particularly difficult, often leading to residual disease. However, its morphology has not yet been studied in the Nepalese population.

Objective

To evaluate the morphology of sinus tympani using axial view of high-resolution computed tomography (HRCT) scans.

Method

A retrospective cross-sectional study was conducted at Dhulikhel Hospital, Kathmandu University Hospital. High-resolution computed tomography temporal bone scans of patients 18 years and above acquired between January 2021 and December 2021 with adequate imaging quality were included, whereas cases with congenital ear malformations, previous history of tympanomastoid surgery, temporal bone trauma and malignancy were excluded. Axial images were assessed independently by three observers and the sinus tympani was classified into Types A, B and C according to its relationship with the mastoid segment of the facial nerve.

Result

A total of 92 patients were included in the study with a total of 180 ears being studied. Patients ranging in age from 18 years to 77 years (Mean age 35.7 years) were included. 123 ears (68.3%) had chronic otitis media. Radiomorphological configuration of sinus tympani was found to be Type A (limited sinus tympani) in 65%, Type B (deep sinus tympani) in 32%, and Type C (deep sinus tympani with posterior extension) in 3%.

Conclusion

Radiomorphological classification of sinus tympani is an essential tool for preoperative planning.

KEY WORDS

High-resolution computed tomography, Radiomorphological, Sinus tympani

INTRODUCTION

Sinus tympani (ST) is a space medial to the pyramidal eminence, stapedius muscle and facial nerve, and lateral to the posterior semicircular canal and vestibule.¹ It is delineated superiorly by ponticulus and inferiorly by subiculum. Apart from being relatively inaccessible, ST also presents great anatomical variations in terms of its size and shape. These factors result in ST being the commonest site of residual cholesteatoma fragments in cases with intraoperative use of endoscope after traditional microscopic surgery.²

Several anatomical studies have focussed on the dimensions of sinus tympani.³⁻⁶ Endoscopic visualisation of ST has further enabled the classification based on its shape into four different types: Classical, Confluent, Partitioned, and Restricted.⁷ The extension of sinus tympani has special significance in terms of difficulty in complete removal of disease from this area. So, it is helpful for the surgeon to study the extension of sinus tympani preoperatively.

Role of High Resolution Computed Tomography (HRCT) for assessment of hidden recesses pre-operatively has been well established. Marchioni et al. proposed a radio-morphological classification of sinus tympani with an aim to aid the surgeon in preoperative planning of the best surgical approach to this particularly hidden area in the middle ear.¹ This study aims to evaluate the ST morphology in Nepalese population based on HRCT scans and classify the prevalence of various types of ST.

METHODS

This is an observational, retrospective and cross-sectional study conducted in the Department of Otorhinolaryngology, Dhulikhel Hospital, Kathmandu University School of Medical Sciences. It included patients 18 years and above in age with aural complaints who underwent HRCT Temporal bone between 1st January, 2021 and 31st December, 2021. HRCT studies with adequate imaging quality were retrieved from the Archives of the department and were retrospectively reviewed. Ethical approval was obtained from Institutional Review Committee with protocol number 156/22 and study was conducted as per the ethical principles of the Declaration of Helsinki.

Inclusion criteria included HRCT data sets from patients 18 years and above in age with adequate imaging quality, and documented demographic profiles. Exclusion criteria included patients with congenital ear malformations, prior tympanomastoid surgery, temporal bone trauma and malignancy.

Axial projections with sequential 1 mm slices were obtained from the arcuate eminence to the jugular fossa. The posterior and medial extent of medial boundary of ST was analyzed with respect to the third portion of the facial nerve to assess the depth of the ST. The first line was drawn

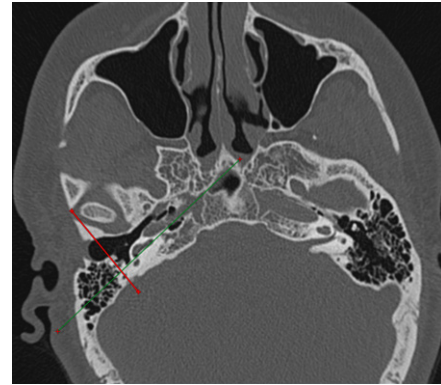


Figure 1. Depth of sinus tympani portrayed with two lines, one line parallel to the major axis of petrous bone and passing through the medial aspect of medial boundary of sinus tympani, and the other line perpendicular to the first line and passing through the posterior aspect of third portion of facial nerve.

parallel to the major axis of petrous bone and passing through the medial aspect of medial boundary of ST. The second line was drawn perpendicular to the first one and passing through the posterior aspect of the third portion of the facial nerve (Fig. 1). These two planes were used to delineate the radiological classification of ST into following types:

Type A : Limited ST (medial limit of third portion of facial nerve corresponded to the depth of ST)

Type B : Deep ST (medial boundary of ST lies medially with respect to third portion of facial nerve)

Type C : Deep ST with posterior extension (medial boundary of ST lies medially and posteriorly with respect to third portion of facial nerve)

After independent rating by all three authors, consensus meeting was held to review all cases subject to disagreement so as to finalize single rating per subsite.

Microsoft Office Excel (Microsoft Corp.; Redmond, WA, USA) was used for data recording and analysis. During data processing, strict confidentiality was maintained.

RESULTS

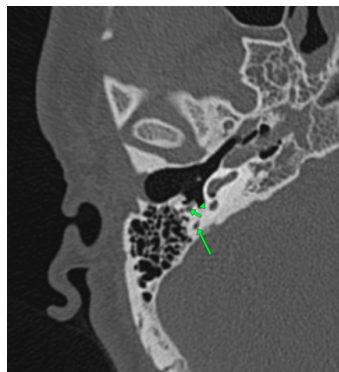
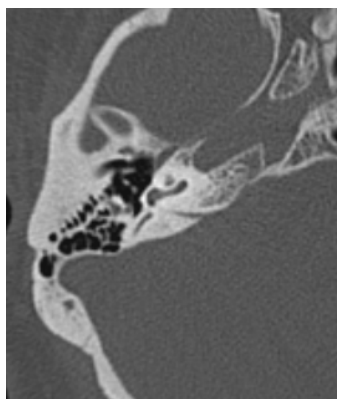
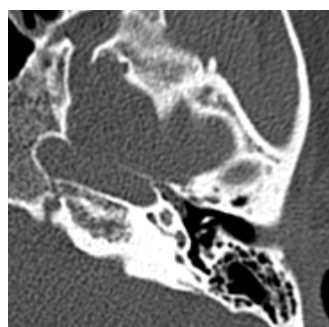
A total of 92 patients were included in the study. The study population included 47 (51.1%) males and 45 (48.9%) females. Mean age of the patients was 35.7 years, the youngest being 18 years and the oldest being 77 years. Four ears were excluded due to post mastoid exploration (n=2) and temporal bone fracture (n=2). A total of 180 ears were thus analyzed.

Radiomorphological configuration of sinus tympani [A5.1] revealed Type A (65%) to be the commonest morphology (Fig. 2), followed by Type B (32%) (Fig. 3) and Type C (3%) (Fig. 4) respectively.

The distribution of various configuration of sinus tympani was comparable between male and female, and also between right and left sides (Table 1).

Table 1. Types of sinus tympani configuration on right and left according to gender

Gender	Type of (Right Sinus Side) Tympani			Type of (Left Sinus Side) Tympani		
	Type A	Type B	Type C	Type A	Type B	Type C
Male (n=90 ears)	30	15	1	27	16	1
Female (n=90 ears)	30	14	1	30	13	2

**Figure 2.** Type A (shallow) sinus tympani with arrowhead showing Sinus tympani, short arrow showing mastoid segment of facial nerve, long arrow showing posterior semicircular canal.**Figure 3.** Type B (deep) sinus tympani.**Figure 4.** Type C (deep with posterior extension) sinus tympani.**Table 2.** Types of sinus tympani configuration according to the ear disease

Ear Disease	Type A	Type B	Type C
Chronic otitis media (n=123 ears)	91	32	0
Normal (n=50 ears)	20	25	5
Others (n=7 ears)	6	1	0

Among these 180 ears, 50 ears were normal. One hundred twenty-three ears had chronic otitis media, four had otosclerosis, two had external auditory canal cholesteatoma, and one had tumor in the cerebellopontine angle. In ears with Chronic otitis media, Type A was the commonest morphology (73.9%), whereas in normal ears, Type B was the commonest morphology (50%) as shown in table 2. All five cases of Type C morphology was observed in normal ears.

DISCUSSIONS

Sinus tympani was first described by Meckel in 1820.⁸ However, he only described the portion anterior to the pyramidal eminence. Steinbrugge described the posterior extension of the sinus medial to the pyramidal eminence and facial nerve.⁹ He also pointed out the consequences of disease in sinus tympani owing to its inaccessibility. Study of the middle ear anatomy with the operating microscope by Dworacek pointed out the variability in the depth of the sinus tympani, and he also proposed the name recessus retrotympanicus.¹⁰ Donaldson et al. studied the anatomy of fetal, infant and adult temporal bone sections to establish the developmental anatomy of sinus tympani.³ They also established the marked variation in the size and shape of sinus tympani in adults. Saito et al. studied the horizontal serial sections of adult and infant temporal bones and established the wide variability in terms of volume (0.43 to 84.72 cu mm), depth (0.61 to 5.87 mm), width (0.96 to 3.22 mm) and extension of the sinus tympani.⁴ This study established the difference in depth and width of the sinus among various racial groups. Cadaveric study by Baki et al. using operating microscope and endoscopes with different angles also established the marked variation in depth (0.9 to 6.1 mm) and width (1.2 to 3.3 mm) of the sinus tympani.⁵ Deep sinus tympani extending posterior to the facial nerve was found in 6/30 specimens, where removal of a lateral rim of bone anterior to the facial nerve allowed proper exposure with an endoscope.

Marchioni et al. described the endoscopic anatomy of sinus tympani by introducing the endoscope into the ear canal with 45° angle from the opposite side, and described the types: classical, confluent, partitioned and restricted.⁷ Marchioni et al. proposed a morphologic classification of sinus tympani using computed tomography of 40 patients suffering from middle ear disease and with sinus tympani involvement.¹ They found 35% Type A ST, 52.5% Type B ST and 12.5% Type C ST. Endoscopic transcanal approach was feasible for complete exploration of ST in 87.5% cases, where Type C configuration had 60% cases wherein it was not possible to explore the complete depth of the ST. It was facilitated by using a posterior retrofacial approach under microscopic visualization.

In another study by Marchiono et al. they included 148 patients with middle ear diseases, and assessed 296 ears

for radiologic conformation of ST based on axial view of HRCT.¹¹ They reported 33.1% with Type A ST, 62.5% with Type B ST, and 4.4% with Type C ST. They again reported the endoscopic inaccessibility with Type C conformation, and reported using transmastoid, retrofacial approach.

El-Anwar et al. studied 200 ears of non-pathologic temporal bones using CT images and found 28% Type A ST, 71% Type B ST, and 1% Type C ST.¹² Another study by Moneir et al. studied 250 middle ears who underwent stapedotomy and simple tympanoplasty and endoscopic evaluated the ST, with 34.4% Type A ST, 53.6% Type B ST and 12% with Type C ST.¹³

Baklaci et al. studied the relationship between mastoid pneumatization and radiomorphological configuration of ST in 202 chronic otitis media patients, and found overall predominance of Type B ST in all 3 groups, 77.4% in pneumatized mastoids, 75.6% in diploic mastoids, and 55.6% in sclerotic mastoids.¹⁴ They proposed that chronic middle ear infections restrain the mastoid pneumatization and can hence alter the ST conformation. Hool et al. studied 59 ears operated for cholesteatoma and found 64% Type A ST, 34% Type B ST and 2% Type C ST.¹⁵ Type A ST was statistically significantly more often associated with sclerotic mastoid than in pneumatized mastoid. Wojciechowski et al.¹⁶ reviewed the cone-beam computed tomography (CBCT) of 260 pneumatized temporal bones, and found the predominance of Type B ST in 70.8%, followed by Type C in 22.7% and Type A in 6.5%.

Our study observed the radiomorphological configuration of sinus tympani on HRCT temporal bone imaging as proposed by Marchionio et al.¹¹ Type A was the commonest morphology in our study which differs from the studies conducted by Marchioni et al., Marchionio et al., El-Anwar et al., Moneir et al. and Baklaci et al.^{1,11-14} The predominance of Type A morphology in our study was similar to the study by Hool et al. though the study only included ears operated for cholesteatoma.¹⁵ Predominance of Type A morphology in our study might be related to the high proportion of ears with chronic otitis media, as previous

studies have reported an association between chronic middle ear disease, reduced mastoid pneumatization and a shallower sinus tympani. Shallow ST are often accessible with endoscopic approach whereas deeper ST (Type C) often requires posterior retrofacial approach. Hence, a preoperative assessment of ST based on HRCT temporal bone is highly useful for the surgeon to plan the surgical approach.

Despite its strengths, this study has several limitations. Being a retrospective cross-sectional study, it relied on previously acquired imaging data with limited control over the imaging parameters and patient selection. The study population was diverse, including normal as well as diseased years, thus, the findings may not fully represent the general population. To limit the effects of interobserver variability, consensus was obtained in all cases with disagreement between the three observers, however, interobserver variability was not assessed. Further studies to evaluate the sinus tympani radiomorphology in diseased and non-diseased Nepalese temporal bones are warranted to clarify the relationship between ST and mastoid pneumatization.

This study demonstrates the variability in the radiomorphological anatomy of sinus tympani, and highlights the role of HRCT evaluation using standardized classification systems to anticipate surgically challenging configurations.

CONCLUSION

The present study demonstrates considerable radiomorphological variability in the configuration of sinus tympani on HRCT temporal bone. Thus, it highlights the importance of preoperative assessment of sinus tympani conformation based on HRCT to provide useful anatomical details that may aid in the surgical planning, particularly in anticipating deeper or posteriorly extending configurations. The use of a standardized classification system also facilitates consistent communication among the surgeons and radiologists.

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