Anatomical Position and Classification of the Sigmoid Sinus on High-Resolution Computed Tomography Temporal Bone: A Retrospective Cross-Sectional Study

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ABSTRACT

Background

The sigmoid sinus demonstrates considerable anatomical variability, which is of critical importance during otologic and lateral skull-base surgeries. Variations in its position may increase the risk of intraoperative complications, including hemorrhage and limited surgical access.

Objective

To evaluate the anatomical position and classification of the sigmoid sinus on high-resolution computed tomography of the temporal bone and determine associated demographic and radiological variations.

Method

A retrospective cross-sectional study was conducted at the Department of ENT-HNS, Dhulikhel Hospital. High-resolution computed tomography temporal bone scans performed between January 2024 and December 2025 were retrospectively reviewed. Patients with adequate imaging quality and complete demographic data were included, while those with prior temporal bone surgery, congenital malformations, fractures, or distorted anatomy were excluded. Sigmoid sinus anatomy was classified according to the system proposed by Sun et al. using standardized anatomical landmarks on axial and coronal high-resolution computed tomography images. Data were analyzed using SPSS version 22.

Result

A total of 212 patients' temporal bone scans were analyzed from patients aged 3 to 82 years (mean age: 31.5 ± 17.1 years). Type 3 Sigmoid Sinus was most common on the right side (31.1%), whereas Type 4 predominated on the left side (33–34%). Age demonstrated a significant association with left-sided Sigmoid Sinus ($p = 0.010$), but not with the right side. No significant association was observed with sex or ethnicity. Sigmoid sinus dehiscence was identified in approximately 15% of cases without significant side predominance.

Conclusion

Significant anatomical variability exists in sigmoid sinus position and morphology. Preoperative high-resolution computed tomography evaluation and standardized classification are essential for improving surgical planning, radiological reporting, and operative safety in otologic practice.

KEY WORDS

Classification of sigmoid sinus, High-resolution computed tomography, Temporal bone, Sigmoid sinus

INTRODUCTION

Temporal bone anatomy is characterized by intricate three-dimensional relationships of vital structures including major nerves, and vessels, all contained within a confined area. The sigmoid sinus (SS) is a paired venous channel that originates as a continuation of the transverse sinus posteriorly and descends in an S-shaped course within a groove on the inner surface of the temporal bone.[1] Anteriorly, its horizontal segment expands to form the jugular bulb, which represents the transition between the SS and the internal jugular vein. The position and dimensions of the SS show considerable variability.[2-4] Such anatomical variability, along with its proximity to other temporal bone structures, adds to the challenges encountered in neurotological surgery.

Otological and lateral skull-base procedures require detailed knowledge of the anatomical relationships of SS and surrounding structures for preoperative planning, surgical interventions, and patient-specific implants parameter optimization. A thorough understanding of sigmoid sinus anatomy is essential for many surgical procedures, yet there is a lack of regional data regarding its anatomical variations in this part of the world. The variations in anatomy of SS have to be studied in order to generate a baseline data in this geographical region and classification is essential for uniformity in surgical planning. A standardized classification is essential also to ensure ease of description and effective communication among surgeons. Understanding population-specific anatomical variations is essential for improving surgical outcomes and minimizing iatrogenic complications. Most available literature on sigmoid sinus position is derived from limited sample sizes or non-uniform classification systems. An anomalously positioned or dehiscent sigmoid sinus increases the risk of intraoperative hemorrhage, limits surgical access, and may lead to serious complications if not identified preoperatively.[5] The sigmoid sinus can also act as a landmark for mastoid surgery when other conventional landmarks are destroyed by pathology.[6]

This retrospective cross-sectional study aims to determine the anatomical positions and frequency of sigmoid sinus variants on HRCT of the temporal bone and classify these to improve radiological reporting and surgical planning. It is based on the study done by Sun et al. in 2009 in Korea.[7] It evaluates the anatomical position and classifies the sigmoid sinus using HRCT of the temporal bone, thereby providing clinically relevant data that can aid radiologists and otologic surgeons to improve preoperative risk assessment, enhance radiological reporting standards, and support safer surgical planning in otologic practice.[4]

METHODS

The study is an observational, retrospective and cross-sectional type conducted in the ENT-HNS Department of Dhulikhel Hospital. The study population consisted of patients who underwent high-resolution computed tomography (HRCT) of the temporal bone at Dhulikhel Hospital for various otological indications between 1st January 2024 and 31st December 2025. HRCT studies performed during this two-year study period were retrieved from the Archives of the ENT-HNS department and reviewed retrospectively. Data collection was carried out after obtaining approval from the Kathmandu University School of Medical Sciences Institutional Review Committee (KUSMS-IRC 287/25).

Inclusion criteria

• Patients of all ages who underwent HRCT temporal bone imaging during the study period.

• HRCT studies with adequate image quality for assessment of sigmoid sinus anatomy.

• Scans with complete demographic information (age, sex) available in the medical record.

Exclusion criteria

• Prior temporal bone surgery (e.g., mastoidectomy, cochlear implantation) on the side being analyzed.

• Evidence of temporal bone fracture, major congenital temporal bone malformation, large posterior fossa mass, or other pathology that distorts normal sigmoid sinus anatomy.

• Significant motion or technical artifacts that preclude reliable assessment of sigmoid sinus position.

• Incomplete imaging series (missing axial or coronal reformats required for classification).

Demographic data including age and sex were collected from electronic medical records using a standardized data collection sheet and proforma. No personally identifiable information was recorded. HRCT images were reviewed using standard DICOM viewing software. Axial and coronal images with thin sections (0.6 mm slice thickness) were evaluated. The sigmoid sinus were assessed on each side based on the study done by Sun et al7 which included three lines taken as follows:

1) The posteriorly-extended line that joins the common crus of the PSCC to the PSCC (Fig. 1)

2) The posteriorly-extended line of the tympanic segment of the Facial Nerve (Fig. 2)

3) The posteriorly-extended line of the malleal-incudal axis (Fig. 3)

Depending on the location of the sigmoid sinus, it was categorized as Type 1, 2, 3 or 4 (Fig. 4). To ensure reliability and minimize observer bias, image evaluation was performed by the primary investigator and supervised by the senior Consultant Otologist with years of experience in temporal bone imaging. A pilot assessment of 10–20

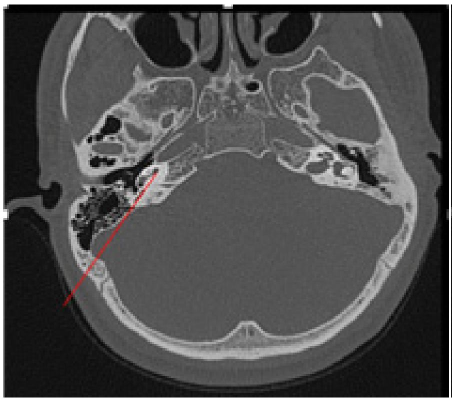

Figure 1. **The posteriorly-extended line that joins the common crus of the PSCC to the PSCC**

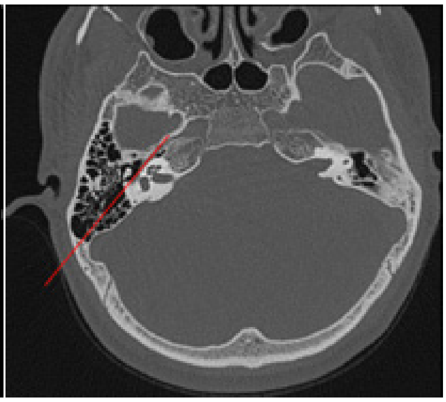

Figure 2. **The posteriorly-extended line of the tympanic segment of the Facial Nerve**

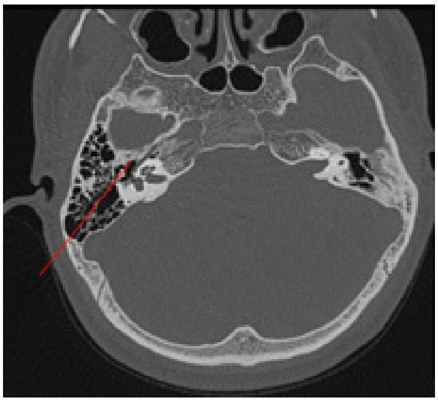

Figure 3. **The posteriorly-extended line of the malleal-incudal axis**

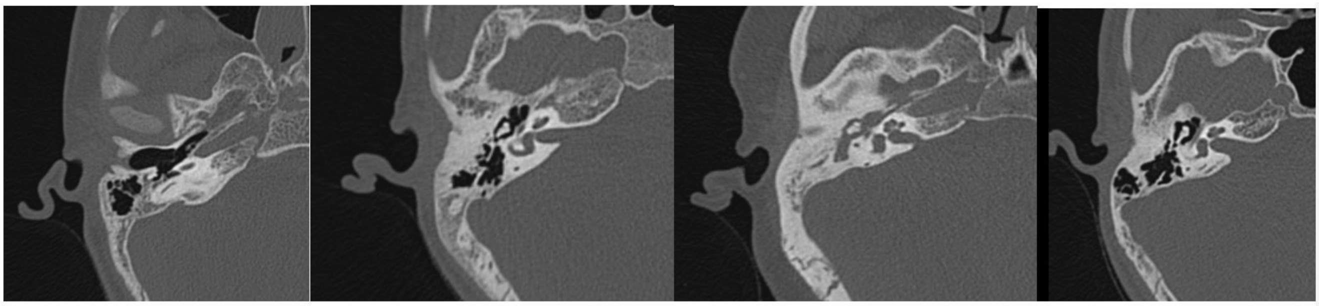

Figure 4. **Sigmoid Sinus Type 1, 2, 3 and 4 respectively**

scans was conducted before formal data collection to standardize interpretation. All collected data were entered into a password-protected database and rechecked for completeness and accuracy. Chi-square test was used to assess associations between sigmoid sinus type and demographic variables and McNemar's test was used to compare paired right- and left-sided findings. Statistical significance was set at $p < 0.05$. Data analysis were done using SPSS version 22.

RESULTS

A total of 212 patients' temporal bone scans were analyzed in this study. The study population included 93 females (43.9%) and 119 males (56.1%). The age group ranged from 3 years to 82 years with mean age of 31.5 years and standard deviation of 17.1 years. However, 6 temporal bones on the right side and 4 on the left side could not be assessed for the type of sigmoid sinus due to the absence of ossicles (Malleus and Incus) which is the landmark for classifying the sigmoid sinus into type 3 and 4. Across all participants, Type 3 sigmoid sinus was the most common on the right side (64 cases, 31.1%), followed by Type 4 (55 cases, 26.7%), Type 2 (47 cases, 22.8%), and Type 1 (40 cases, 19.4%). When analyzed by age group, there was no significant association between age and right sigmoid sinus type ($p = 0.457$). Similarly, no statistically significant association was found between sex and right sigmoid sinus type ($p = 0.695$). Ethnicity also showed no significant association with right sigmoid sinus type ($p = 0.582$) as shown in table 1.

Table 1. **Type of Sigmoid sinus in relation to Age, Sex and Ethnicity on the right side**

Age Group	Type of sigmoid sinus(Right Side)								Total	p
	1	%	2	%	3	%	4	%		
< 20	8	13.6	12	20.3	22	37.3	17	28.8	59	0.457
20-39	15	17.9	22	26.2	25	29.8	22	26.2	84	
40-59	14	29.8	7	14.9	13	27.7	13	27.7	47	
>=60	3	18.8	6	37.5	4	25.0	3	18.8	16	
Sex										
F	16	17.6	20	22.0	27	29.7	28	30.8	91	0.695
M	24	20.9	27	23.5	37	32.2	27	23.5	115	
Ethnicity										
Aryan	9	12.7	22	31.0	21	29.6	19	26.8	71	0.582
Madhes	2	20.0	2	20.0	3	30.0	3	30.0	10	
Mixed	10	18.2	11	20.0	22	40.0	12	21.8	55	
Mongolian	12	29.3	7	17.1	10	24.4	12	29.3	41	
Others	7	24.1	5	17.2	8	27.6	9	31.0	29	

On the left side, Type 4 sigmoid sinus was the most common (70 cases, approximately 33–34%), followed by Type 3 (61 cases), Type 1 (39 cases), and Type 2 (38 cases). A statistically significant association was observed between age group and left sigmoid sinus type ($p = 0.010$), indicating variation in distribution across age categories. However, no statistically significant association was found between sex and left sigmoid sinus type ($p = 0.297$). Ethnicity also did not demonstrate a statistically significant relationship with left sigmoid sinus type as indicated in table 2.

Table 2. Type of Sigmoid Sinus in relation to Age, Sex and Ethnicity on the left side

Age Group	Type of sigmoid sinus(Left Side)								Total	p
	1	%	2	%	3	%	4	%		
< 20	11	18.6	10	16.9	17	28.8	21	35.6	59	0.010
20-39	16	18.8	16	18.8	24	28.2	29	34.1	85	
40-59	9	18.8	9	18.8	15	31.3	15	31.3	48	
≥ 60	3	18.8	3	18.8	5	31.3	5	31.3	16	
Sex										
F	13	14.3	15	16.5	27	29.7	36	39.6	91	0.297
M	26	22.2	23	19.7	34	29.1	34	29.1	117	
Ethnicity										
Aryan	12	16.7	12	16.7	24	33.3	24	33.3	72	*
Madhes	2	20.0	0		4	40.0	4	40.0	10	
Mixed	10	17.9	10	17.9	18	32.1	18	32.1	56	
Mongolian	10	24.4	10	24.4	9	22.0	12	29.3	41	
Others	5	17.2	6	20.7	6	20.7	12	41.4	29	

*p-value couldn't be calculated as one of the variables has 0 value.

Around 15% patients had sigmoid sinus dehiscence on either side. The association between right and left sigmoid sinus types was evaluated using the McNemar test. It was found that only 50% of participants with type 1 on right side have type 1 on the left side also. Similarly, 40% had type 2, 41.3% had type 3 and 53% had type 4 on both sides. The analysis demonstrated no statistically significant difference between the right and left sigmoid sinus types (p = 0.075), indicating not so comparable distribution patterns between the two sides. In addition to that, 7.5% had sigmoid dehiscence on the right side and 6.6% had it on the left side. McNemar test showed no statistically significant difference in dehiscence between the right and left sides (p = 0.839). Although 81.3% of subjects with right-sided dehiscence did not have left-sided dehiscence, the discordant pairs were nearly equal (13 Vs 11), indicating no significant asymmetry between sides.

DISCUSSIONS

In this study, different anatomical positions and classifications of the SS were identified on HRCT temporal bone imaging. In the study, the SS was classified into four types based on its anatomical position on HRCT temporal bone imaging. Among these, Type 3 was the most common variant on the right side, whereas Type 4 predominated on the left side. These findings differ from the study conducted by Sun et al., in which Type 1 was reported as the most common variant.[7] Such differences may reflect population-based anatomical variability, ethnic diversity, differences in cranial morphology, or variations in sample characteristics and classification interpretation.[8]

The anatomical position of the sigmoid sinus is of considerable surgical importance because an anteriorly displaced sinus can significantly narrow the operative corridor during mastoidectomy, posterior tympanotomy, cochlear implantation, and lateral skull-base procedures. However, the sigmoid sinus is the only constant structure in the mastoid that is not very prone to modification by pathological processes so its crucial to know its variations also.[6,9,10] Preoperative identification of these anatomical variants is therefore essential to minimize the risk of sinus injury, excessive bleeding, and incomplete disease clearance.

An interesting observation in this study was the variability in bilateral correspondence of sigmoid sinus types. Only 50% of patients with Type 1 on the right side demonstrated the same type on the left side. Similarly, bilateral concordance was observed in 40% of Type 2, 41.3% of Type 3, and 53% of Type 4 cases. These findings further emphasize the highly variable nature of sigmoid sinus anatomy and support the need for individualized radiological evaluation prior to surgery similar to the study done by Tubbs et al.[11]

The study also demonstrated that age group was significantly associated with left-sided sigmoid sinus type (p = 0.010), whereas no significant relationship was observed on the right side. The reason for this asymmetrical association remains uncertain but may relate to developmental or anatomical remodeling changes occurring with age.[5,12] Further studies with larger sample sizes would be beneficial to clarify this observation. Although the diversity of human cranial morphology across global populations is well documented, no statistically significant association was found between sigmoid sinus type and sex or ethnicity, suggesting that these demographic variables may have limited influence on sigmoid sinus configuration within the studied population.[8]

Several previous studies have demonstrated right-sided dominance of the sigmoid sinus. In the study by Van Osch et al., right dominance was observed in approximately 74% of paired sigmoid sinuses, and multiple studies have similarly reported that the right sigmoid sinus tends to be larger and positioned more anteriorly compared to the left side.[3,4] However, in the present study, no statistically significant difference was identified between right and left sigmoid sinus types (p = 0.075) which is a similar finding in a study done by Kayahoglu et al.[13] Although asymmetry was present, the distribution pattern between sides appeared relatively comparable. This suggests that while side dominance and anatomical variability are common, they may not always follow a predictable pattern within all populations. Consequently, both temporal bones should be evaluated independently during preoperative imaging assessment rather than assuming symmetry or predictable dominance.

Sigmoid sinus dehiscence was identified in approximately 15% of patients overall, with 7.5% occurring on the right side and 6.6% on the left side. This prevalence is notably higher than that reported by Schoeff et al., who found radiological sigmoid sinus dehiscence in only 1.25% of asymptomatic patients.[14] The higher prevalence observed in the present study may be attributed to differences in imaging criteria, population characteristics, or inclusion of patients undergoing HRCT for otologic pathology. Recognition of sigmoid sinus dehiscence is clinically important because exposed sinus walls increase the risk of inadvertent injury during mastoid drilling and may contribute to symptoms such as pulsatile tinnitus.

HRCT temporal bone imaging proved to be an effective modality for evaluating sigmoid sinus anatomy because of its excellent spatial resolution and detailed visualization of bony landmarks.[15] The classification system used in this study also provides a standardized framework for describing sigmoid sinus position, thereby facilitating clearer communication between radiologists and otologic surgeons. Standardized reporting is especially important in complex otologic and skull-base procedures where minor anatomical variations may substantially influence surgical approach and operative safety.[6]

Despite its strengths, this study has several limitations. The classification described by Sun et al. was adopted due to its simplicity and ease of application on HRCT temporal bone imaging. Nevertheless, some anatomical variations could not be distinctly categorized, especially in the patients who have diseases eroding the landmarks taken into consideration, potentially reducing the ability to fully represent the diverse positional relationships of the sigmoid sinus. As a retrospective cross-sectional study, it relied on previously acquired imaging data, limiting control over imaging parameters and patient selection. The study was conducted at a single tertiary care center, which may limit the generalizability of the findings to other populations. In addition, interobserver variability was not formally assessed, although image interpretation was supervised by experienced faculty to improve consistency. Future multicenter prospective studies with larger sample sizes and interobserver reliability analysis are recommended to validate these findings and further explore anatomical correlations. Since scans were obtained from patients undergoing imaging for otologic conditions, the study population may not fully represent normal population anatomy.

Overall, this study demonstrates significant variability in the anatomical position and morphology of the sigmoid sinus. The findings highlight the importance of meticulous preoperative HRCT evaluation and support the use of standardized classification systems to improve radiological reporting, surgical planning, and patient safety during otologic and lateral skull-base procedures.

CONCLUSION

The present study demonstrates considerable anatomical variability in the position and classification of the sigmoid sinus on high-resolution computed tomography (HRCT) of the temporal bone. The findings highlight the importance of preoperative HRCT evaluation of the temporal bone to identify anatomical variations of the sigmoid sinus, particularly in otologic and lateral skull base surgeries where inadvertent sinus injury may result in serious complications. Furthermore, the use of a standardized classification system facilitates consistent communication among surgeons and radiologists, thereby improving surgical planning and patient safety.As there is limited regional data regarding sigmoid sinus anatomy, this study contributes valuable baseline information for this population and may serve as a reference for future anatomical and radiological research.

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