"ANATOMY AND VARIATIONS OF SIGMOID SINUS IN WET TEMPORAL BONE AND ITS RADIOLOGICAL CORRELATION"

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LIST OF ABBREVIATIONS

GLOSSARY	ABBREVIATIONS
CPA	Cerebellopontine angle
CSF	Cerebrospinal fluid
EAM	External acoustic meatus
HRCT	High-resloution computed tomography
JB	Jugular bulb
MA	Mastoid antrum
MRI	Magnetic resonance Imaging
PBP	Presigmoid bony plate
PSSC	Posterior semi circular canal
SS	Sigmoid sinus
TB	Temporal bone
TT	Trautmann's triangle

ABSTRACT

Title: Anatomy and Variations of Sigmoid Sinus In Wet Temporal Bone And Its Radiological Correlation

Objectives:

- To assess the anatomy and variations of sigmoid sinus in relation to the posterior semicircular canal and to the exposure of the presigmoid dural plate.
- To assess the position of the sigmoid sinus plate in relation to external auditory canal radiologically

Materials and Methods: A cross-sectional observational study was conducted on 30 cadaveric wet temporal bones was dissected in Temporal bone dissection skill laboratory of ENT department, KLE's Hospital and MRC. X-ray mastoid (Schüller's view) were utilized to assess the sigmoid sinus position. Anatomical dissection was performed using a Zeiss microscope and microdrill, and variations in the sigmoid sinus were classified into three grades based on its relation to the presigmoid bony plate and posterior semicircular canal. Statistical analysis was conducted to evaluate associations between sinus positioning and mastoid pneumatization with the help of Epi Info.7.2 software.

Results: The mean distance between the sinus plate and the posterior wall of the external auditory canal was 2.91 ± 0.85 mm on X-ray and 2.2 ± 0.82 mm on wet temporal bone dissection ($p<0.05$). Mastoid tip prominence was observed in 80% of specimens. Pneumatization types were distributed as 30% sclerotic, 30% diploic, and 30% pneumatic. Sigmoid sinus was classified as Grade 1 (30%), Grade 2 (40%), and

Grade 3 (30%). A significant association was found between mastoid pneumatization and sigmoid sinus positioning, with less pneumatization correlating with more anteriorly placed sigmoid sinus ($p<0.05$).

Conclusion: This study highlights the anatomical variability of the sigmoid sinus and its correlation with mastoid pneumatization. Anterior displacement of the sinus is more common in poorly pneumatised mastoids, whereas well-pneumatised mastoids tend to have a more posteriorly positioned sinus. Preoperative imaging is crucial for assessing these variations, aiding in surgical planning, and minimizing complications in otologic and skull base procedures.

Keywords: Sigmoid sinus, Temporal bone, Posterior semicircular canal, Presigmoid plate.

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INTRODUCTION

The sigmoid sinus (SS), a key venous structure within the temporal bone, is vital for neurosurgical and otologic procedures, particularly those involving the mastoid cavity. Its anatomical variability poses challenges in surgical planning and execution, as its location influences critical landmarks such as Trautmann's triangle and the (PSCC). "The sigmoid sinus forms the posterior boundary of Trautmann's triangle, which provides a pathway for accessing the cerebellopontine angle and posterior fossa during transpetrosal and retrolabyrinthine approaches"[1]. "These variations not only impact surgical access but also increase the risk of complications, particularly in approaches targeting the petroclival region"[2].

The complex anatomy of the temporal bone presents significant challenges during otologic and neurosurgical interventions. The sigmoid sinus, an S-shaped dural venous sinus, is a prominent structure that traverses the posterior cranial fossa and plays a pivotal role in venous drainage. Its anatomical variations are of paramount importance in surgeries involving the mastoid, posterior semicircular canal, and the presigmoid region. "Alterations in the position or morphology of the sigmoid sinus can impact access to the middle ear, internal auditory canal, and the petroclival region"[1].

"Trautmann's triangle, delineated by the posterior semicircular canal anteriorly, the sigmoid sinus posteriorly, and the superior petrosal sinus superiorly, provides an important surgical window for accessing the cerebellopontine angle. However, variations in the sinus position significantly alter the size and accessibility of this triangle"[4]. Consequently, a detailed radiological assessment of the sigmoid

sinus and its relationship to surrounding structures is critical for avoiding complications and improving surgical outcomes.

High-resolution computed tomography (HRCT) and other imaging modalities have advanced the ability to delineate temporal bone anatomy in both normal and pathological states. “These techniques facilitate the identification of anatomical variations, such as an anteriorly displaced sigmoid sinus, a high dehiscent jugular bulb, or a deep sinus tympani, each of which has implications for surgical planning and execution”[3].

Recent developments in high-resolution computed tomography (HRCT) have made it possible to examine temporal bone architecture in greater detail. “To maximize surgical techniques and reduce risks, it is essential to comprehend the sigmoid sinus's location in relation to the external auditory canal and how it interacts with surrounding structures like the presigmoid dural plate and PSCC”[3]. Many neurosurgical and otologic procedures, especially those involving the mastoid cavity, posterior semicircular canal (PSCC), and presigmoid dural plate, are complicated by the anatomical diversity of the sigmoid sinus (SS). Its exact placement must be known in order to maximize surgical techniques, reduce problems, and protect vital tissues like the endolymphatic sac, internal auditory canal, and facial nerve.

Advancements in high-resolution computed tomography (HRCT) have allowed for better visualization of temporal bone anatomy. However, conventional imaging methods like mastoid X-ray (Schüller’s view) still play a role in assessing the position of the sigmoid sinus in relation to the external auditory canal and mastoid air cells. A combination of HRCT and Schüller’s view can aid in preoperative evaluation and surgical planning, ensuring safer and more effective interventions.

This study seeks to bridge this gap by providing a structured radiological framework for evaluating the anatomy and variations of the sigmoid sinus, thereby enhancing preoperative planning and surgical precision.

AIMS AND OBJECTIVES

OBJECTIVES

- To assess the anatomy and variations of sigmoid sinus in relation to the posterior semicircular canal and to the exposure of the presigmoid dural plate.
- To assess the position of the sigmoid sinus plate in relation to external auditory canal radiologically

REVIEW OF LITERATURE

The brain's dural venous sinuses are endothelial-lined venous passages that run between the dura mater layers. These structures drain venous blood from the brain and surrounding regions into the internal jugular veins. They lack valves and serve as low-pressure conduits for venous blood flow returning to the systemic circulation. The major sinuses are the superior sagittal sinus, lower sagittal sinus, transverse sinuses, sigmoid sinuses, cavernous sinuses, and the straight sinus, among others.

Blood from the cerebral hemispheres and cerebrospinal fluid (CSF) from arachnoid villi are collected via the superior sagittal sinus, which runs along the convex upper border of the falx cerebri. As it develops, it gets bigger and empties into the tortuous Herophili, a confluence of sinuses, which is close to the occipital protuberance. The smaller inferior sagittal sinus empties into the straight sinus after draining blood from deeper areas of the brain. It is situated at the inferior edge of the falx cerebri. Venous blood is transported to the sinus confluence by the straight sinus, which is created by the union of the major cerebral vein (vein of Galen) and the inferior sagittal sinus[7].

Bilaterally extending down the tentorium cerebelli from the confluence, the transverse sinuses curve downward into the sigmoid sinuses, which finish at the jugular foramen and continue as the internal jugular veins. Situated on either side of the sella turcica, the cavernous sinuses are intricate venous plexuses that connect to the facial veins through the ophtlamic veins and pterygoid venous plexus. These connections create a potential pathway for infections to spread from the face to the brain.

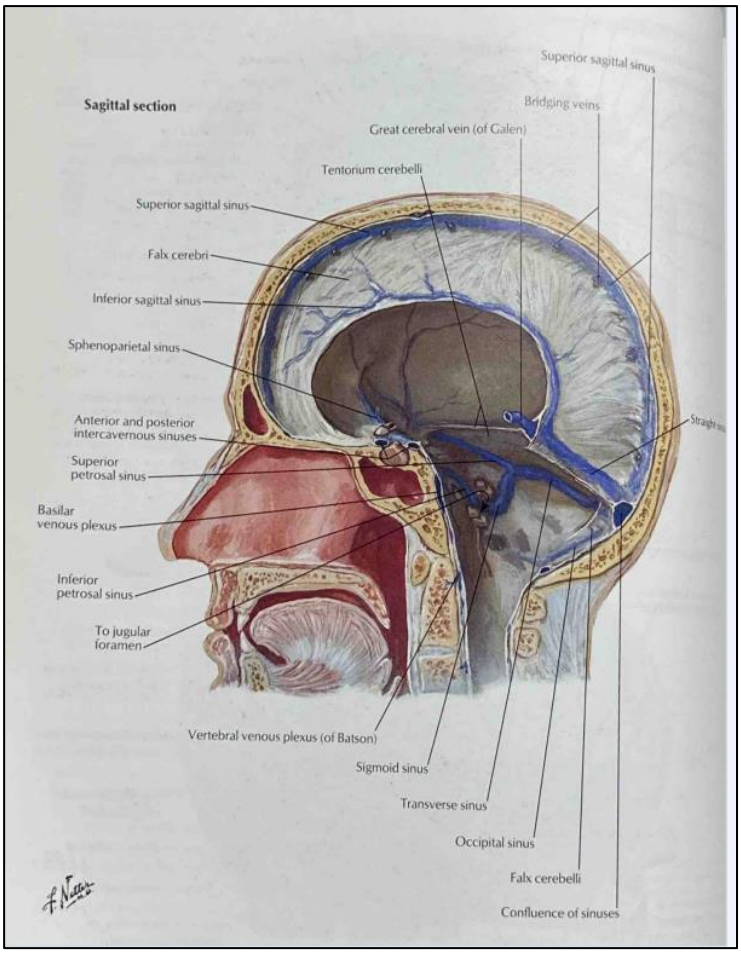


Fig 1: Diagramatic representation of anatomy of dural venous sinuses[9]

The internal cerebral veins and the basal veins (of Rosenthal) supply blood to the vein of Galen, which is a component of the deep venous system. It empties into the straight sinus and is important for the draining of deep brain regions. Venous drainage of the posterior fossa tissues is facilitated by the occipital sinus, which runs along the posterior border of the falx cerebelli.

PHYSIOLOGY:

The brain's circulation relies on the dural venous sinuses to help empty the cranial cavity's deoxygenated blood and cerebrospinal fluid (CSF). Located between the dura mater's periosteal and meningeal layers, these sinuses are valveless and permit bidirectional blood flow that is impacted by pressure gradients.

Arachnoid granulations are the main route by which cerebral vein venous blood and subarachnoid space cerebrospinal fluid (CSF) enter the dural sinuses. As one-way valves, these granulations make sure that when CSF pressure rises above venous pressure, CSF enters the venous system, preserving intracranial pressure balance.

After passing through a system of sinuses, including the superior and inferior sagittal sinuses, the straight sinuses, the transverse sinuses, and the sigmoid sinuses, the collected venous blood and CSF eventually flow into the internal jugular veins. Maintaining the equilibrium of the brain and eliminating metabolic waste depend on this mechanism. Thrombosis and other disorders that impair the dural venous sinuses' ability to drain blood to the brain can raise intracranial pressure and possibly cause neurological problems. The diagnosis and treatment of disorders affecting cerebral circulation depend on an understanding of the physiology of these sinuses.

HISTOLOGY:

The periosteal (outer) and meningeal (inner) layers of the dura mater are separated by specialized channels called the dural venous sinuses. Like other blood arteries, these sinuses are lined by endothelial cells; however, they do not have the usual muscle layer present in veins, and instead depend on the structural support of the dura mater to remain open.

The dura mater itself is a dense connective tissue composed predominantly of collagen fibers interspersed with elastic fibers, providing both strength and limited flexibility. Fibroblasts are the primary cellular component, responsible for producing and maintaining the extracellular matrix. Recent studies have identified the presence of telocytes—specialized cells involved in intercellular communication—within the dural tissue, suggesting a more complex cellular environment than previously understood.

Within the dural sinuses, arachnoid granulations (also known as arachnoid villi) protrude into the sinus lumen. These structures are extensions of the arachnoid mater that facilitate the transfer of cerebrospinal fluid (CSF) from the subarachnoid space into the venous system, playing a crucial role in maintaining CSF homeostasis.

Unlike typical veins, dural venous sinuses lack valves, allowing for bidirectional blood flow based on pressure gradients. This unique feature, combined with their rigid walls, ensures efficient venous drainage from the brain, maintaining intracranial pressure and overall cerebral homeostasis[8].

SIGMOID SINUS:

Sigmoid sinuses are intracranial vessels that are paired. It originates at the point where the transverse sinus exits the tentorium cerebelli. From here, it passes through a groove on the mastoid process and curves downward in an s-shape to reach the jugular foramen. After draining into the jugular bulb, it joins the internal jugular foramen.

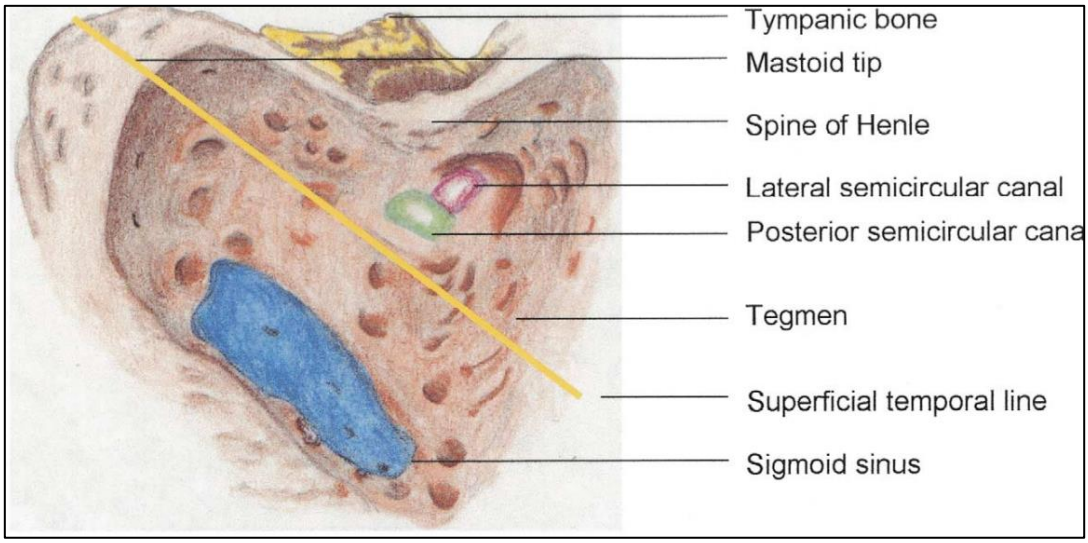


Fig 2: Diagramatic representation of sigmoid sinus[1]

VARIATIONS:

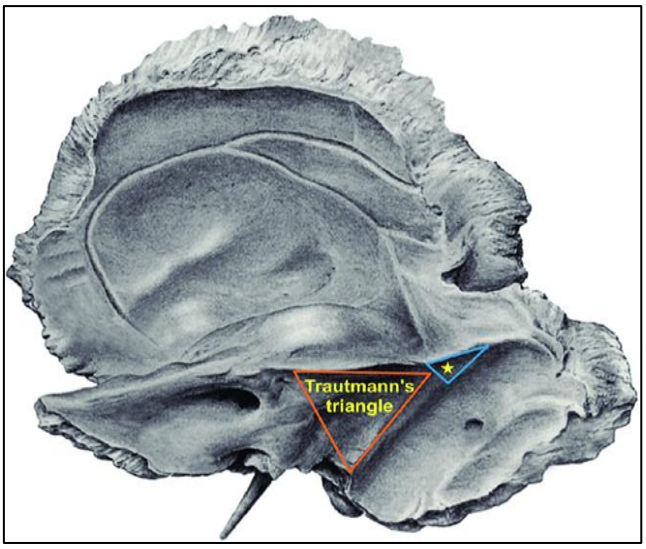
Anatomical Variations:

- Position and Course: The sigmoid sinus normally travels in the posterior cranial fossa in an S-shape. Some people have a more anteriorly positioned sinus, however the precise path can differ. In some instances, the external auditory canal and sinus are only separated by a thin bony plate, which may affect surgical techniques for the mastoid antrum.
- Dominance and Size: The sigmoid sinuses on the right and left sides are frequently asymmetrical, with one side being larger and more dominating. According to a study that used high-resolution imaging, 74% of patients had right dominance. This dominance affects the spatial interactions between the sinus and other structures, including the external auditory canal and facial nerve.
- Association with Mastoid Pneumatization: The degree of mastoid pneumatization is correlated with the site of the sigmoid sinus. The safety and viability of transmastoid surgical techniques may be impacted by a more laterally positioned sinus, which is linked to bigger mastoid volumes and well-pneumatized mastoids.
- Jugular Bulb Variations: The sigmoid sinus transforms into the internal jugular vein at the jugular bulb. A diverticulum or a high-riding jugular are two variations that impact surgical access to the inner ear and increase the risk of intraoperative complications.

Surgical Importance of the Sigmoid Sinus

- Posterior Limit of Mastoid Cavity: During mastoidectomy and posterior fossa approaches, the sigmoid sinus, which defines the posterior limit of the mastoid cavity affects surgical access. "A crucial surgical landmark for obtaining the cerebellopontine angle (CPA) and carrying out posterior transpetrosal approaches is the sinus, which defines the posterior limit of Trautmann's triangle"[4].

Trautmann'striangle:



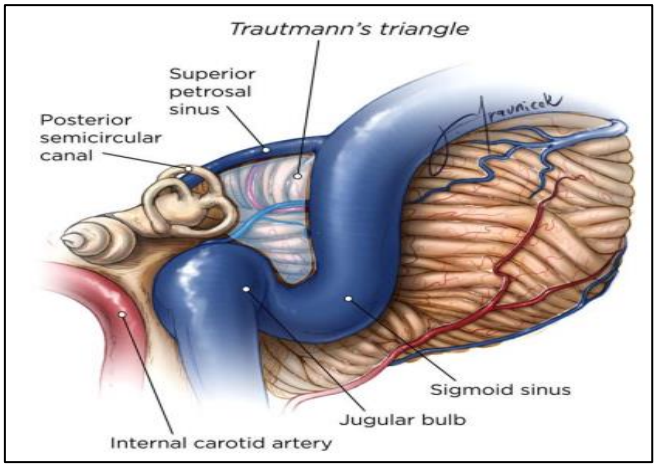


Fig 3: Diagramatic representation of Trautmann's and Citell's triangle(*)[4]

The semicircular canals antero-inferiorly, the sigmoid sinus posteriorly, and the superior petrosal sinus superiorly define the borders of Trautmann's triangle.

Citelli's angle:

"Citelli's angle, sometimes referred to as the sinodural angle, is formed by the dural plates of the sigmoid sinus posteriorly, the middle fossa superiorly, and the posterior fossa anteriorly."[6]

- **Variability in Location**:
    - "Anatomical variations, such as anterior or medial displacement, can significantly impact the size of Trautmann's triangle and limit surgical access to areas like the internal auditory canal and endolymphatic sac''[4]
- **Landmark for Safety**:
    - The sinus is a constant structure used as a landmark in cases where other landmarks (e.g., semicircular canals) are eroded or altered by pathology. Awareness of its position is crucial to avoid accidental injury
- **Risk of Complications**:
    - Accurate diagnosis and preservation are crucial because serious bleeding and air embolism can occur from damage to the sigmoid sinus during surgery.

Relation to Key Structures

1. Middle Ear and Mastoid: "The sigmoid sinus is closely related to the posterior wall of the external auditory canal, mastoid air cells, and jugular bulb. Surgical approaches, such as mastoidectomy, must carefully navigate these relationships"[4]
2. Semicircular Canals: " Sigmoid sinus lies near the posterior semicircular canal, making it relevant in retrolabyrinthine and translabyrinthine surgical approach"[2]
3. Cranial Nerves and Dura: "The sinus is near the superior petrosal sinus and cranial nerves IX–XI at the jugular foramen, influencing approaches to posterior cranial fossa lesions"

TEMPORAL BONE:

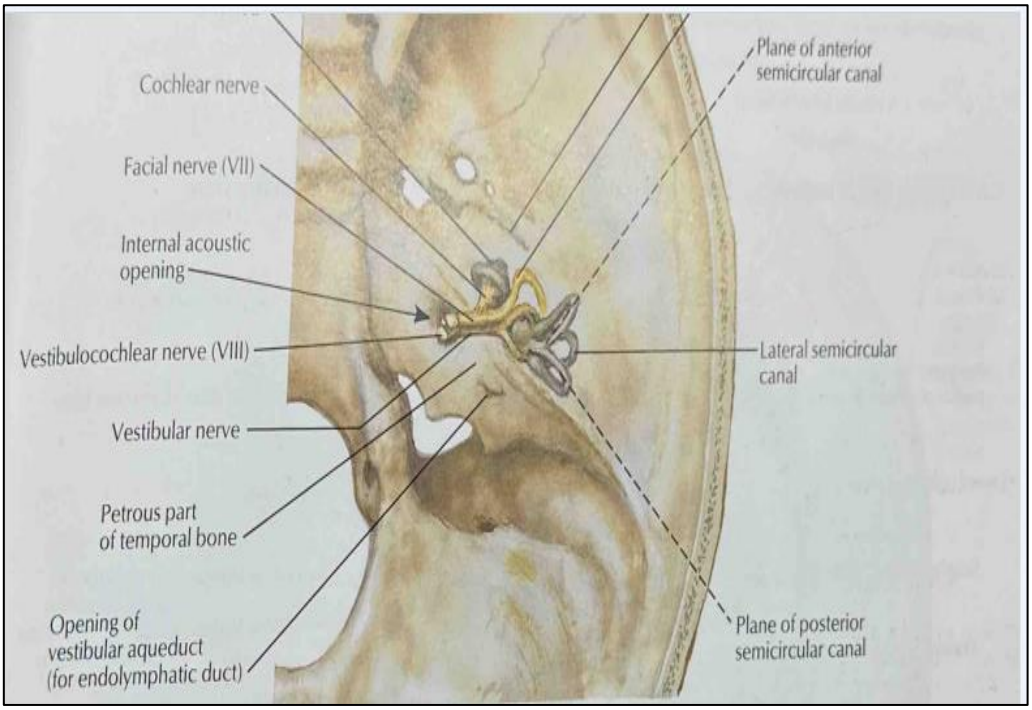


Fig 4: Diagramatic representation of Petrous part of Temporal bone showing inner ear structures[9]

"The temporal bone is a complex structure forming part of the skull base and housing critical anatomical landmarks for the external, middle, and inner ear. It consists of four embryologically distinct components: **squamous, mastoid, petrous, and tympanic**. It articulates with the sphenoid, parietal, and zygomatic bones and features several notable landmarks, including:

- The **temporal line**, which is approximately 5 mm inferior to the lowest level of the middle fossa floor.
- The **mastoid process**, a prominent bony projection for muscle attachments, housing air-filled spaces called mastoid air cells.
- The **styloid process**, a slender, pointed projection serving as a muscle and ligament attachment site.

Key features also include:

- The **squamotympanic suture**, a critical landmark in surgical dissections.
- The **jugular foramen**, positioned at the junction of the petrous and occipital bones, allowing the passage of key neurovascular structures"[10].

MacEwen Triangle:

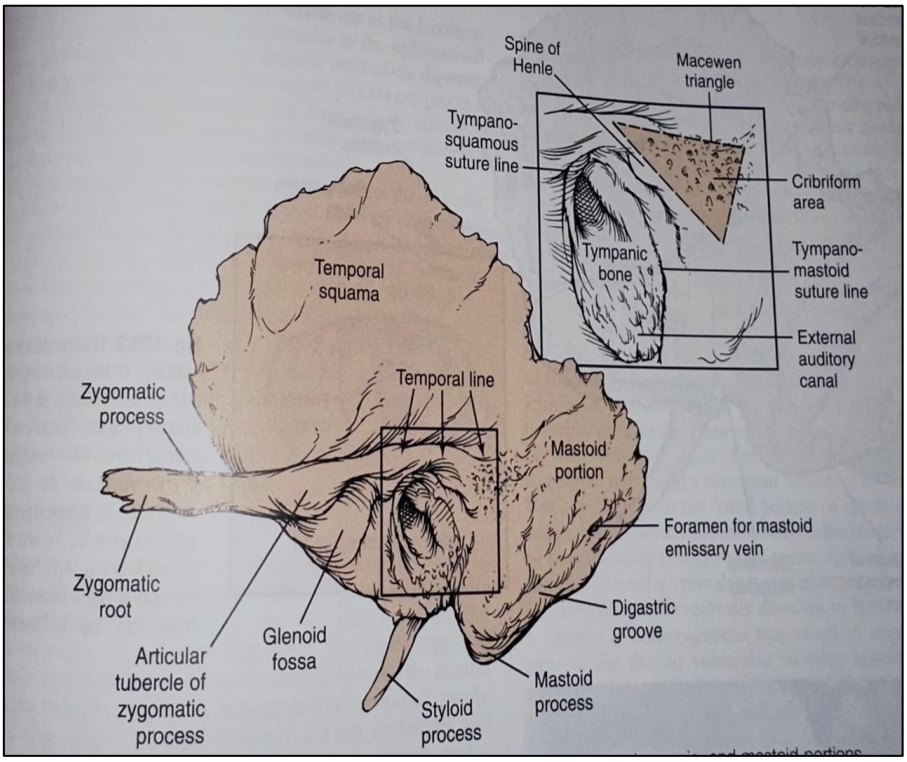


Fig 5: Diagramatic representation of Macewen triangle[10]

The MacEwen Triangle, also known as supra-meatal triangle, it is a significant surgical landmark for the mastoid antrum (MA).

It is formed by the following anatomical boundaries:

- Superiorly: Temporal line
- Antero-inferiorly: Posterosuperior wall of the external acoustic meatus (EAM)
- Posteriorly: The opening of the mastoid emissary vein or sinodural angle
- Key anatomical considerations:
- The cribriform area within this triangle is perforated with small holes, facilitating vascular passage to the mucosa of the antrum.
- Drilling within the triangle provides a safer approach during mastoidectomy, as vital neurovascular structures are absent.

PRESIGMOID PLATE:

Anatomically, the presigmoid plate is situated in the posterior cerebral fossa, behind the temporal bone's petrous ridge and before the sigmoid sinus. It serves as an important anatomical and surgical landmark, particularly in the context of otologic and neurotologic surgeries, such as presigmoid approaches to the cerebellopontine angle.

Key features include:

- **Location**: It lies between the sigmoid sinus posteriorly and the middle ear structures anteriorly.
- **Clinical Importance**: In procedures that involve access to the internal auditory canal, tumors of the cerebellopontine angle (such as acoustic neuromas), or vascular diseases in the posterior cerebral fossa, the presigmoid plate is passed through.
- **Relation to Temporal Bone**: It forms part of the petrous temporal bone and requires careful identification to avoid injury to adjacent critical structures, including the sigmoid sinus, jugular bulb, and facial nerve.

  The presigmoid approach often involves drilling the plate to gain access while preserving the vital neurovascular structures in the region.

SEMICIRCULAR CANALS

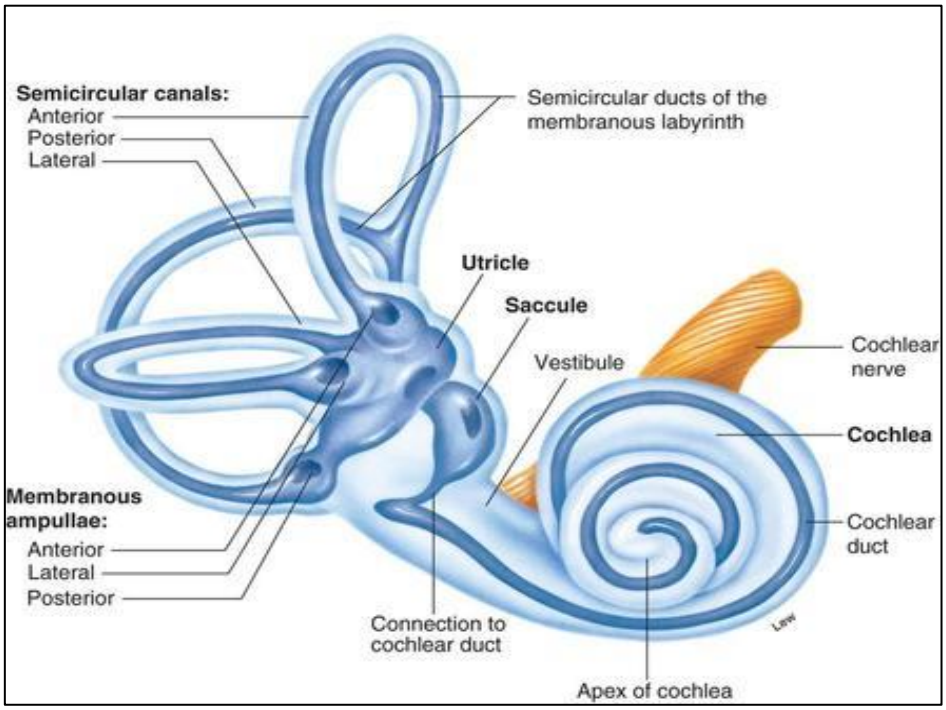


Fig 6: Diagramatic representation of semicircular canal[10]

The **semicircular canals** are part of the bony labyrinth located in the temporal bone and are essential for maintaining balance and spatial orientation. They are three in number: **superior**, **posterior**, and **lateral**, positioned perpendicular to each other to detect angular movements of the head. Each canal forms approximately two-thirds of a circle and has a lumen diameter of about 0.8 mm.

Key features include:

- **Ampullae**: Enlarged ends of the canals containing sensory epithelium, which houses the vestibular receptors (crista ampullaris) and opens into the vestibule.
- **Non-ampullated ends**: These join to form the vestibule, which is connected to the crus commune

- **Orientation**: The superior canal lies nearly vertical, the posterior canal is inclined at an angle of 30° to the sagittal plane, and the lateral canal is almost horizontal. Together, they help detect head rotations in different planes.

The semicircular canals interact with the utricle and saccule in the vestibule to provide signals about balance and orientation to the brain through the vestibular nerve.

Surgical Approaches Involving the Sigmoid Sinus

The sigmoid sinus plays a pivotal role in various skull base and otologic surgical approaches. Here are the primary surgical approaches and their relation to the sigmoid sinus.

1. Presigmoid Approach

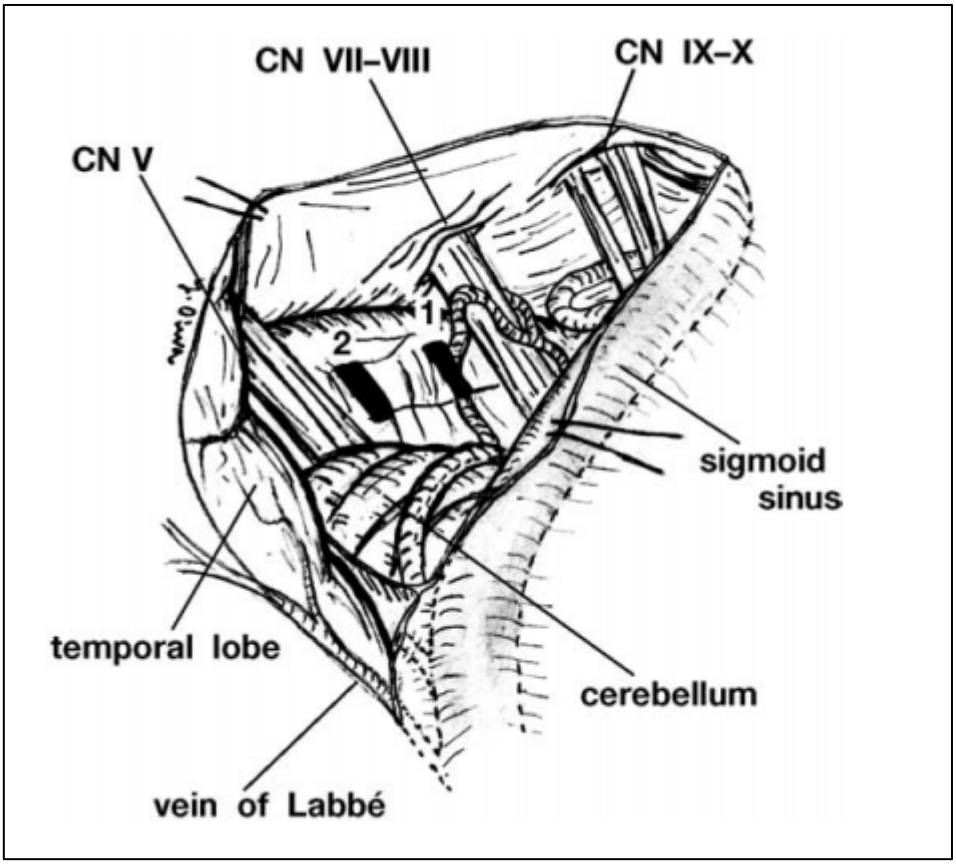


Fig 7: Diagramatic representation of presigmoid approach[19]

- Description:This method entails using the region in front of the sigmoid sinus to enter the posterior cerebral fossa. Applicable to conditions affecting the petroclival and cerebellopontine angles (CPA).

- Steps:

➢ Perform a mastoidectomy to reveal the dura and sigmoid sinus.

➢ Recognize and maintain Trautmann's triangle, which is delimited anteriorly by the posterior semicircular canal, superior petrosal sinus, and sigmoid sinus posteriorly.

Widen access by retracting or decompressing the sigmoid sinus.

- Applications:

➢ Tumor resections (e.g., vestibular schwannomas, meningiomas).

➢ Access to vascular lesions like aneurysms or arteriovenous malformations.

- Challenges:

➢ Variability in sinus position (e.g., medial or anterior displacement) may reduce working space[5]

2. Retrolabyrinthine Approach

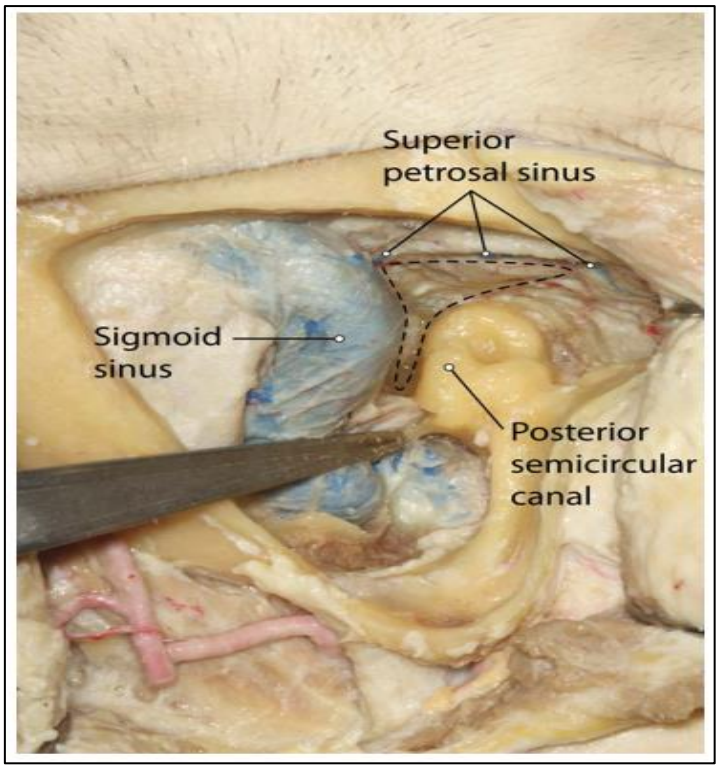


Fig 8: Diagramatic representation of retrolabyrinthine approach[4]

- Description:

  The retrolabyrinthine approach can indeed be advantageous in the presence of a prominent or somewhat anteriorly displaced sigmoid sinus, because it provides direct access to the posterior fossa behind the labyrinth (rather than drilling extensively around the sinus). Below are some key points:

1. **Exposure Behind the Labyrinth**

   - In the retrolabyrinthine approach, the surgeon drills away mastoid air cells and opens Trautmann's triangle behind the labyrinth. The sigmoid sinus forms the posterior boundary of that triangle. If the sinus is placed more anteriorly, the surgeon often has more direct—and safer—access behind the labyrinth without as much manipulation around or decompression of the sinus.

2. **Hearing Preservation**

- This approach is typically used when hearing preservation is a goal (for instance, for small cerebellopontine angle lesions such as certain vestibular schwannomas). By working posterior to the labyrinth and behind an anteriorly positioned sigmoid sinus, the labyrinth can be left intact.
- Steps:

➢ Perform a mastoidectomy and identify the posterior semicircular canal.Drill away bone between the canal and sigmoid sinus to expose the dura of the CPA.

- Applications:
  - ➢ Small CPA tumors.
  - ➢ Vestibular nerve sectioning for intractable vertigo.
- Considerations:
  - ➢ Requires careful preservation of the sigmoid sinus to prevent venous injury and air embolism[11]

3. Translabyrinthine Approach

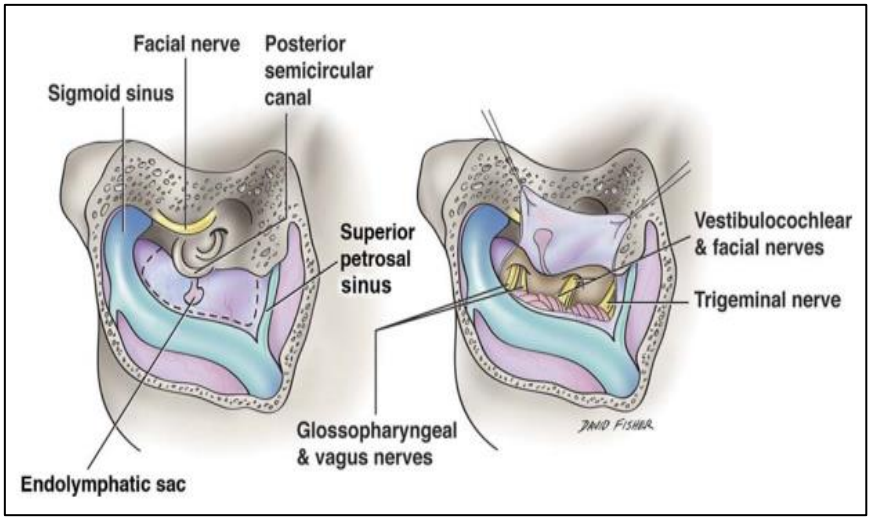


Fig 9: Diagramatic representation of translabyrinthine approach[4]

- Description:
    - Sacrifices hearing to access the CPA via removal of the labyrinth and widening exposure to the sigmoid sinus.
- Steps:The superior, posterior, and lateral semicircular canals are excised following mastoidectomy.
    - Expose sigmoid sinus posteriorly to create a broad surgical corridor.
    - Extend drilling to the internal auditory canal.
- Applications:
    - Large Cerebropontine angle tumors, particularly acoustic neuromas.
- Risks:
    - High risk of sigmoid sinus injury due to proximity during extensive bone removal[1,2]

4. Combined Presigmoid-Petrosal Approach

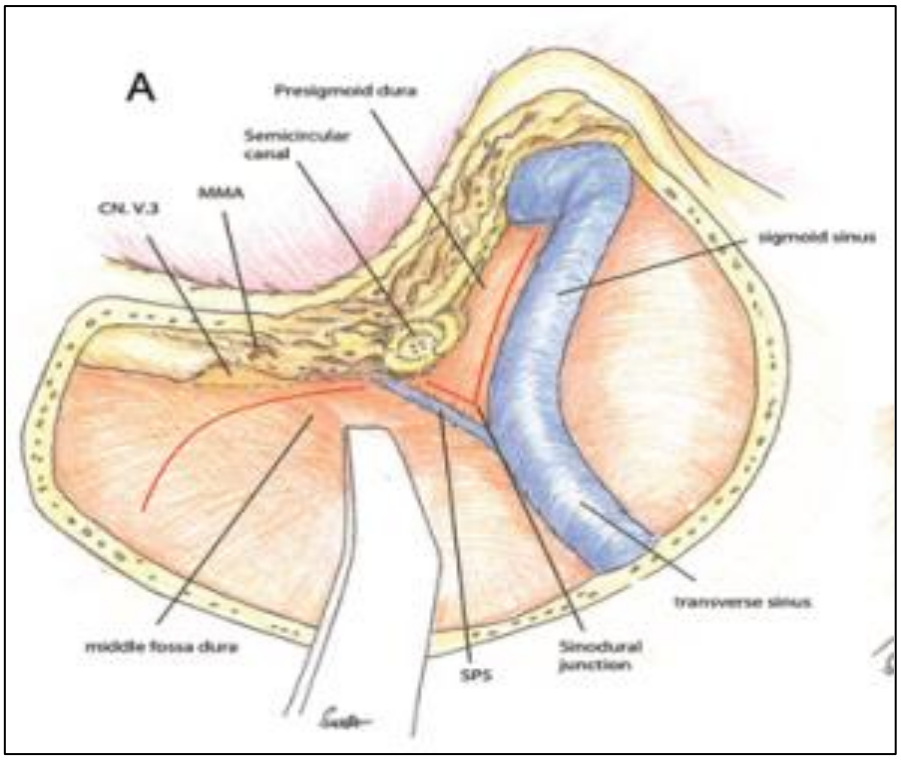


Fig 10: Diagramatic representation of presigmoid -petrosal approach[15]

- Description:
  - Combines anterior petrosectomy with a presigmoid approach to access deeper regions of the posterior and middle cranial fossae.
- Steps:
  - Expose the sigmoid sinus and its relationship to the superior petrosal sinus.
  - Combine exposure by working around the petrous apex anteriorly and sigmoid sinus posteriorly.
- Applications:
  - Petroclival tumors and vascular lesions.
  - Cases requiring expanded exposure compared to the presigmoid approach alone.

- Key Features:

  Anterior or medially located sigmoid sinus reduces surgical freedom

5. Transjugular and Jugular Bulb Approaches

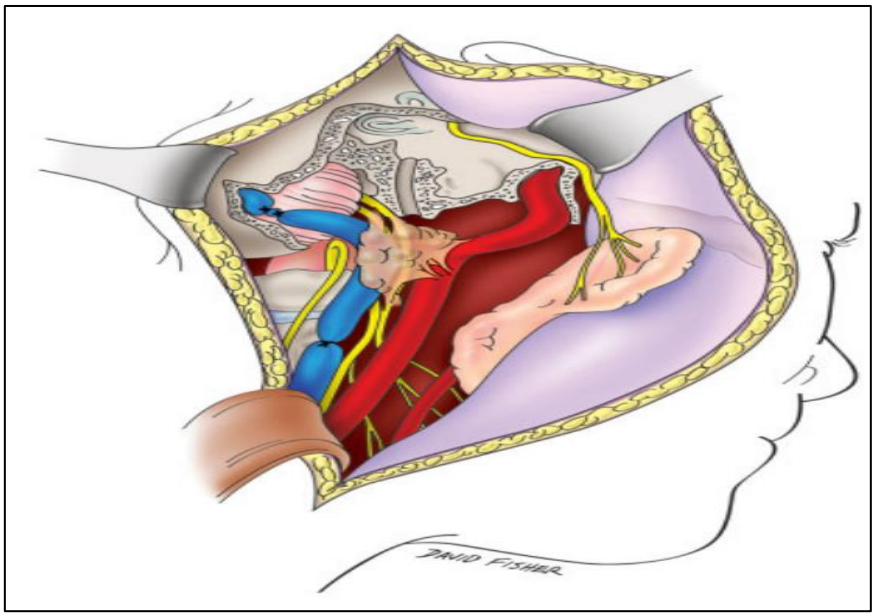


Fig 11: Diagramatic representation of transjugular approach[11]

- Description:

  - Targeted at lesions involving the jugular foramen and lower cranial nerves.

- Steps:

- Identify the jugular bulb, which is the termination of the sigmoid sinus.
- Drill bone around the jugular foramen, avoiding sigmoid sinus injury.

- Applications:

  - Glomus jugulare tumors, jugular bulb abnormalities.

- Risks:
    - Venous bleeding from the sinus and bulb[7] .

Key Considerations in Sigmoid Sinus-Related Surgeries:

- Preoperative Imaging:
    - CT and MR imaging help identify anatomical variations (e.g., anterior displacement or dehiscence of the sigmoid sinus)[1].
- Bleeding Control:
    - Sigmoid sinus injury requires prompt management with hemostatic agents and, if necessary, surgical repair[2].
- Sinus Preservation:
    - Whenever possible, preserving the sinus avoids complications like venous hypertension or air embolism[6,7].

These approaches highlight the surgical significance of the sigmoid sinus and its careful management during temporal bone and skull base surgeries.

RADIOLOGICAL STUDY:

X-RAY of mastoid (schuller sview):

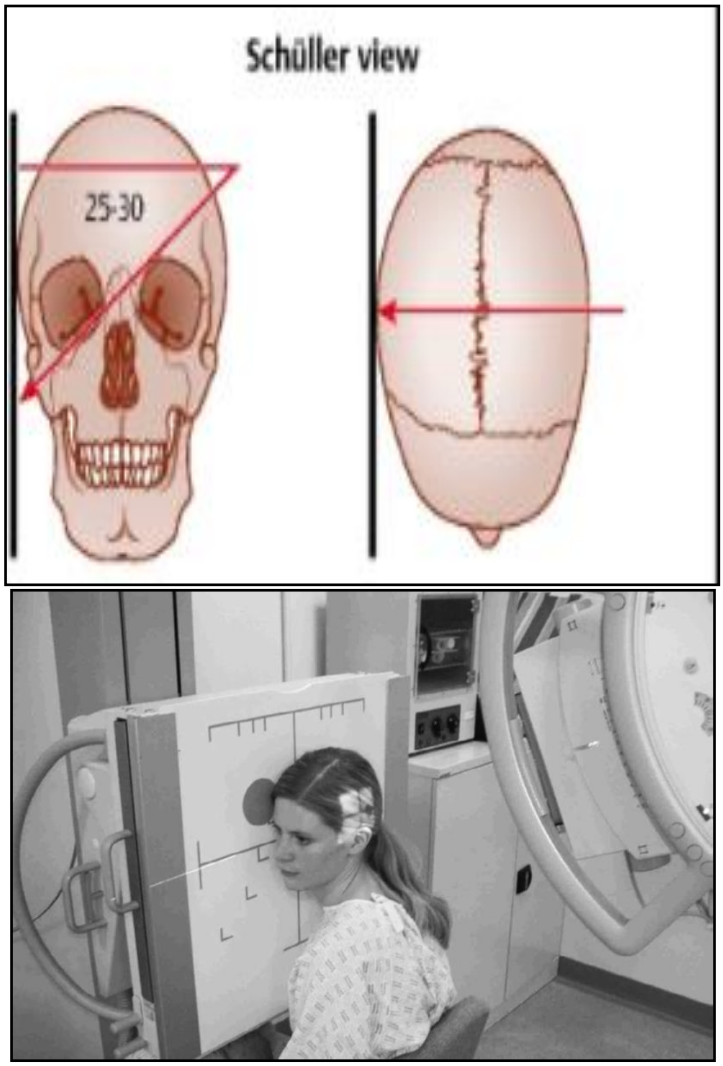


Fig 12: Diagrammatic presentation of Schuller's view

The central beam of X- rays will be passed from one side of the head end and at an angle of 30 degree caudal to radiographic plate, at a vertical distance of about 100cm. Structures that will be seen and assessed are:

- Mastoid air cells.
- External auditory canal.

- Temporomandibular joint.
- Dural plate
- Sinus plate.
- Distance between the posterior wall of external auditory canal and sinus plate will be measured.

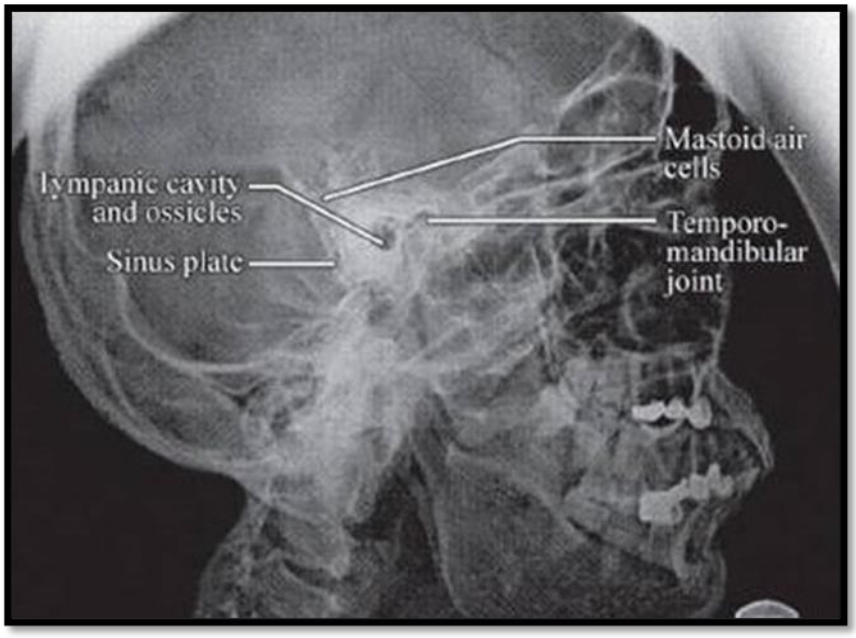


Fig 13: Figure showing left side mastoid x-ray in Schuller's view[12]

CT Imaging:

- The sigmoid sinus is best identified in axial or coronal CT sections using high-resolution bone algorithms.
- It appears as a prominent vascular channel carved into the medial aspect of the mastoid bone, continuing inferiorly into the jugular bulb[12]

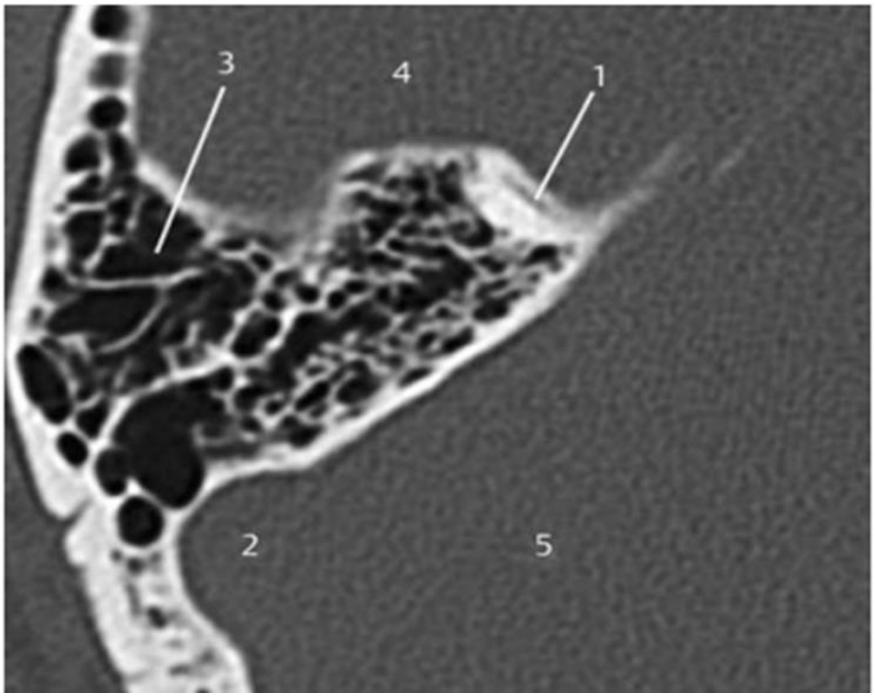


Fig 14: CT axial cut of right side temporal bone. 1-anterior semicircular canal,2-sigmoid sinus,3-highly pneumatized mastoid bone,4-middle cranial fossa, 5-posterior cranial fossa[12].

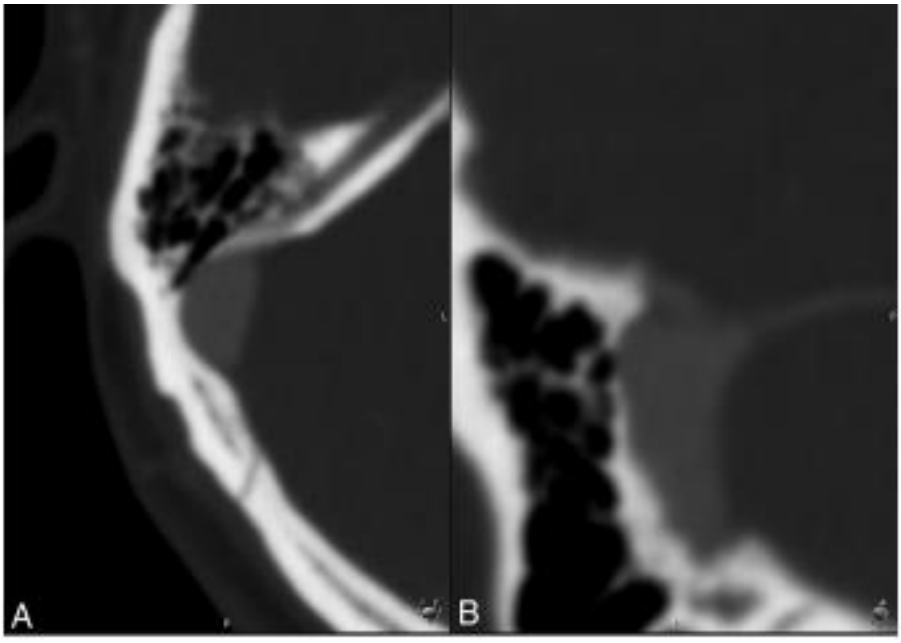


Fig 15: CT axial cut of right side temporal bone. Dehiscence of the sigmoid sinus wall: "air-on-sinus" sign in the axial (A) and sagittal planes (B)[18]

- Thrombosis or other abnormalities can present as non-enhancing areas within the sinus. Coalescent mastoiditis may erode the sigmoid plate, providing clues on CT[12]

MRI:

- On T1-weighted imaging, the sigmoid sinus typically shows a low signal due to rapid blood flow, creating a "flow void."

- T2-weighted imaging and venography sequences (e.g., time-of-flight or phase-contrast MRV) help visualize flow characteristics an d diagnose thrombosis, showing hypointensity or absent flow signal in pathological cases[12].

- Gadolinium-enhanced imaging highlights enhancement abnormalities in thrombotic or inflammatory conditions, aiding in differentiation from normal flow-related artifacts[12].

MATERIALS AND METHODS

Materials and Methods:

Source of Data: Wet temporal bone dissections was performed in the

Temporal bone dissection skill laboratory of ENT (WARD) department after approval from Ethical Committee of our Institute (KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH). The temporal bones was harvested from unclaimed cadavers and preserved in 10% formaldehyde for sterilization before dissection.

- **Study Design:** An observational study
- **Study Period:** 1 year
- **Sample Size:** 30 wet temporal bones were dissected in Temporal bone dissection skill laboratory of ENT department, KLE's Hospital and MRC.
- **Sampling technique:** At 95% confidential intervals

$$n = 15 + Z_{1-\alpha/2} \times 7.5$$

$$n = 15 + 1.96 \times 7.5$$

$$n = 29.7$$

$$n \cong 30$$

Required sample: 30 cadaveric temporal bone.

Where,

$Z_{1-\alpha/2}$ =1.96

- **Inclusion Criteria:**

All wet temporal bones were harvested from the cadaver which was available during the study period at the department of Anatomy, JNMC.

- **Exclusion Criteria:**

Diseased temporal bone.

Surgery to the temporal bone.

Dry temporal bone.

- **Data collection procedure:**

After approval of study by the Ethical Committee of our Institute (KLE ACADEMY OF HIGHER EDUCATION AND RESEARCH) wet temporal bone specimens was obtained from Dept of Anatomy. X- ray mastoid(Schuller's view)of specimens was taken of 30 pathology free wet temporal bone .The central beam of X- rays was passed from one side of the head end and at an angle of 30 degree caudal to radiographic plate, at a vertical distance of about 100cm. Structures that was seen and assessed were:

- Mastoid air cells
- External auditory canal
- Temporomandibular joint
- Dural plate
- Sinus plate.
- Distance between the posterior wall of external auditory canal and sinus plate was measured

Wet temporal bone dissections were carried out with a Zeiss microscope 5100 and an electric microdrill(marathon), a Forte 200, running at 25,000 rpm. The conventional approach was followed for dissection once the soft tissues from the temporal bone was removed and then temporal bone was secured in the House-Urban Temporal bone holder .It was then followed by the Macewen triangle's discovery, a cortical mastoidectomy was carried out which was exposing the entire sigmoid sinus and pre sigmoid plate and significant images were acquired independently after examination under a microscope. Distance between SS and PSSC , SS and posterior wall of external auditory canal was measured with the help of digital caliper

The Sigmoid sinus was classified according to the visibility of the structures parallel to the thinned out posterior wall of the external auditory canal. Sigmoid sinus was classified into three grades based on its anatomical position, presigmoid bony plate(defined as the bone between the anterior margin of sigmoid sinus and the posterior semicircular canal.) and to the dome of the PSCC.

A. **Grade 1:** Sigmoid sinus placed more posteriorly, presigmoid plate, and posterior semicircular canal are visible.

B.**Grade 2:** Sigmoid sinus is anteriorly placed, obscuring the presigmoid bony plate, but the posterior semicircular canal remains visible (intermediate risk).

C. **Grade 3 :** Sigmoid sinus is significantly anteriorly placed, obscuring the presigmoid bony plate and the posterior semicircular canal, with a compromised mastoid cavity (anteriorly placed).

Radiological evaluation, dissection-based assessment, and photographic data collection was conducted to analyze variations in the sigmoid sinus.

Statistical analysis:

Data was gathered utilizing a proforma format. Data was entered and examined on an MS Excel sheet. Proportions were used to represent qualitative data. The mean and standard deviation were used to express quantitative data. The Chi square/Student t test revealed an association between two qualitative variables outcomes. Data analysis was done with the help of Epi .Info.7.2 software. Data was cleaned, Validated and Analysed by Epi. Info 7 software.

RESULTS

Table 1: Distance between sinus plate &sigmoid sinus from posterior wall of the external auditory canal [N=30]

Distance	Mean ± SD	P value*
Sinus plate & posterior wall of the external auditory canal on mastoid x-ray (Schuller's view)	2.91 mm ± 0.85	0.56
Sigmoid sinus & posterior wall of the external auditory canal on wet temporal bone	2.2 mm ± 0.82	

* - Student 't' Test $p<0.05$

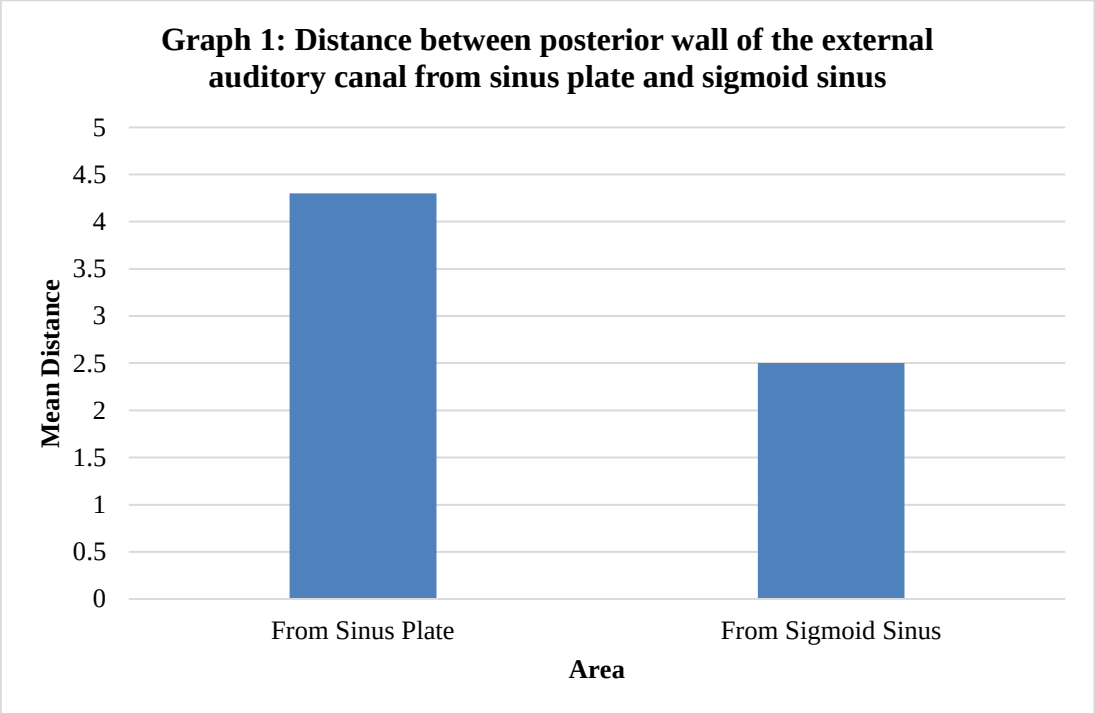


Table 2: Prominence of mastoid tip [N=30]

Mastoid tip	Number	%
Prominent	24	80
Not prominent	6	20

Graph 2: Prominence of Mastoid Tip

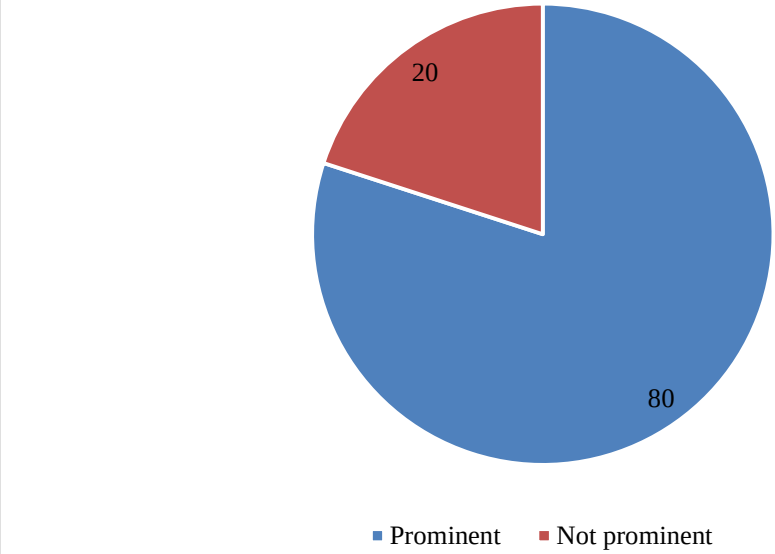


Table 3: Type of Pneumatization of temporal bone [N=30]

Pneumatization	Number	%
Mixed	3	10
Sclerotic	9	30
Diploic	9	30
Pneumatic	9	30

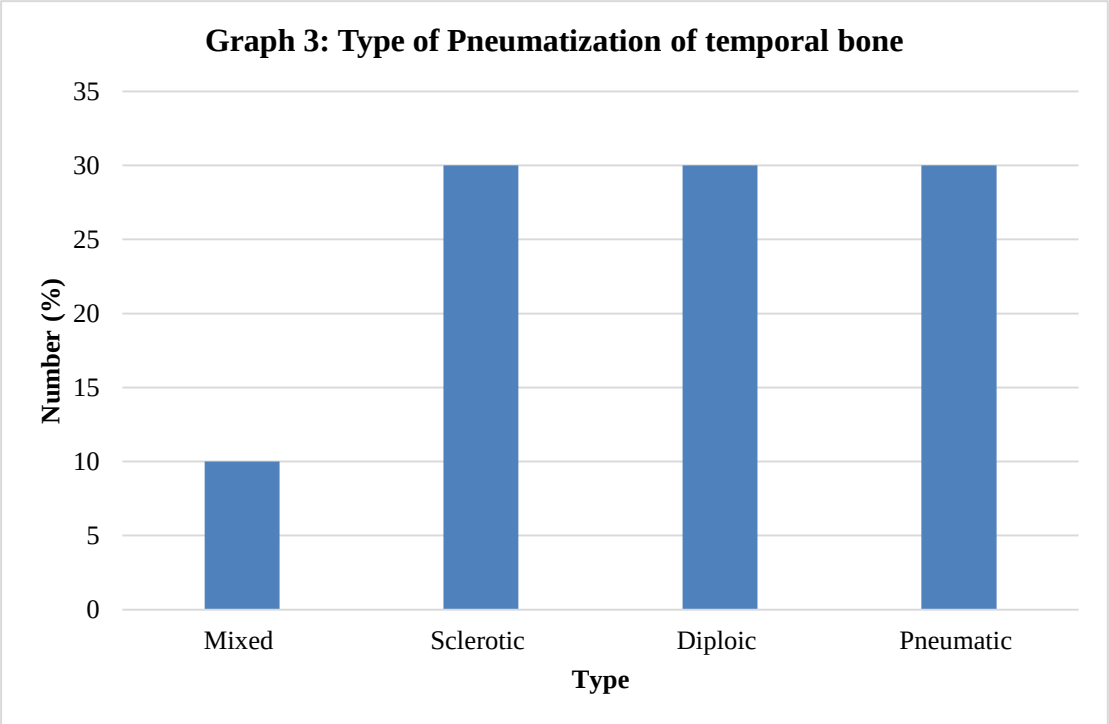


Table 4: Grading of Sigmoid Sinus in relation to posterior semicircular canal [N=30]

Sigmoidal sinus grade	Number	%
1	9	30
2	12	40
3	9	30

Graph 4: Grading of sigmoid sinus in relation to posterior semicircular canal

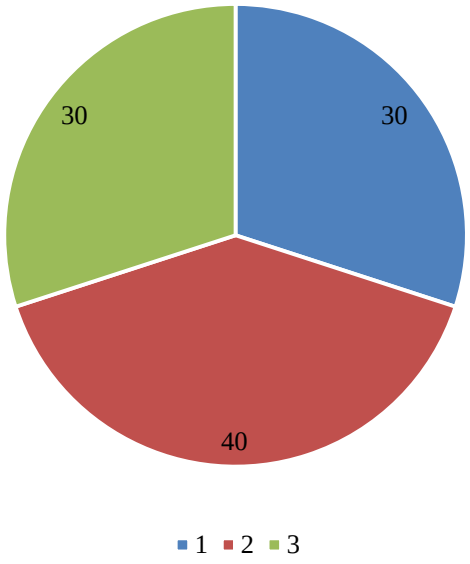
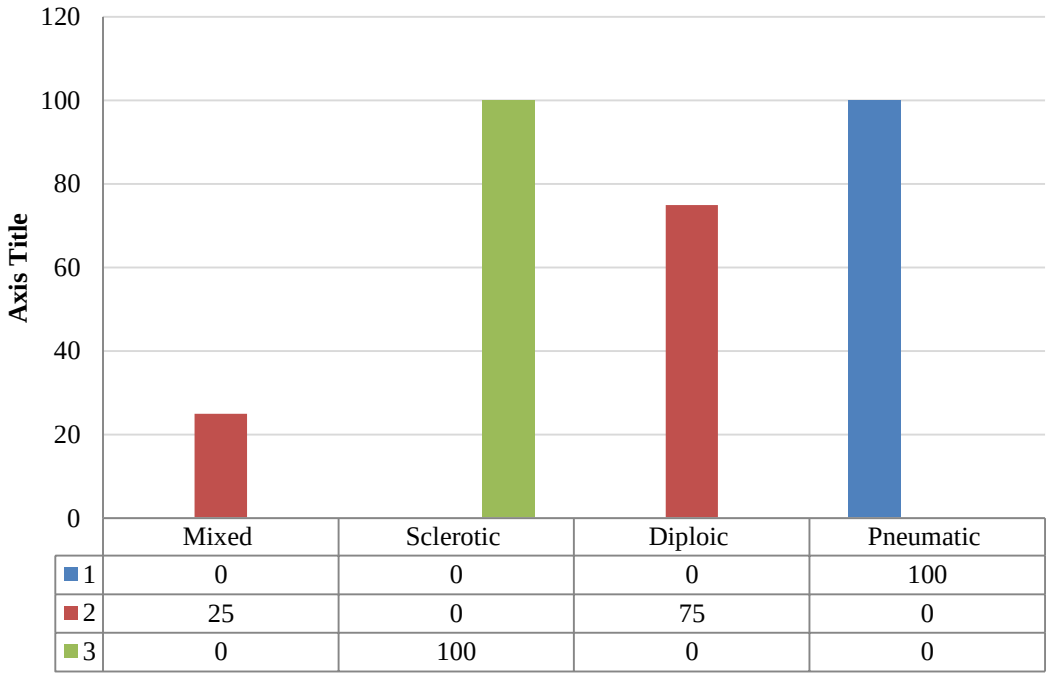


Table 5: Association between type of Pneumatization and grading of sigmoidal sinus [N=30]

Type of Pneumatization	Grading of Sigmoidal Sinus			P value*
	1	2	3	
Mixed	0 (0.0)	3 (25.0)	0 (0.0)	**0.001**
Sclerotic	0 (0.0)	0 (0.0)	9 (100.0)	
Diploic	0 (0.0)	9 (75.0)	0 (0.0)	
Pneumatic	9 (100.0)	0 (0.0)	0 (0.0)	

* - Chi-square Test $p<0.05$

Graph 5: Association between type of Pneumatization and grading of sigmoid sinus



DISCUSSION

Present cross-sectional observational study was conducted at ENT department on 30 wet temporal bones harvested from the cadaver which was available during the study period at the department of Anatomy, JNMC, Belagavi, Karnataka, India . Objectives of the study was to assess the anatomy and variations of sigmoid sinus in relation to the posterior semicircular canal and presigmoid plate in cadaver and sinus plate in relation to external auditory canal radiologically . Inclusion criteria was all wet temporal bones harvested from the cadaver which was available during the study period at the department of Anatomy. Exclusion criteria was diseased temporal bone, surgery to the temporal bone and dry temporal bone.

The location of the sigmoid sinus within the temporal bone is highly variable. Therefore, advances in otologic surgery necessitate a complete reassessment of the sigmoid sinus and this is important for the planning and execution of surgery within the mastoid cavity. The variations in its shape and position can cause problems during the surgical approach to the tympanic cavity, mastoid antrum and membranous labyrinth[22].

Temporal bone anatomy involves complicated three-dimensional (3D) relationships between critical structures. The temporal bone contains the middle and inner ear, along with several nerves and vessels, all within a relatively small space. Traditional temporal bone studies involved cadaveric dissection and histopathology[23] , but there has been a renewed interest in anatomic analysis with the advent of new imaging techniques [24]. High-resolution computed tomography (HRCT) of the temporal bone has commonly been used in the evaluation of the chronic suppurative otitis media because of its high sensitivity in the presence of soft tissue disease, bone

erosion and anatomical variations. A thorough knowledge of the surgical anatomy of the temporal bone is the key for satisfactory mastoid and middle ear surgery. High-resolution computed tomography (HRCT) is the main modality for the investigation of the ear diseases.

Table 1 and figure 1 shows that mean distance of between sinus plate on x-ray mastoid & sigmoid sinus on temporal bone from posterior wall of the external auditory canal was 2.91 mm with 0.85 SD and 2.2 mm with 0.82 SD respectively. The difference between mean distance of sinus plate on x- ray mastoid & sigmoid sinus on temporal bone from posterior wall of the external auditory canal was statistically not significant ($p>0.05$).

Karaca CT et al [25]said that the sigmoid sinus forms a shallow indentation on the posterior aspect of the mastoid. Occasionally the sinus courses more anteriorly and produces a deep groove in the mastoid, best seen in the axial sections. In some cases only a thin bony plate separates the sinus from the external auditory canal.

Present study observed that the mean distance of sinus plate studied on x- ray mastoid from posterior wall of the external auditory canal was statistically insignificant when compared to the distance of sigmoid sinus on temporal bone from posterior wall of the external auditory canal (2.91 mm Vs 2.2mm).

A study done by *Sun D et al, Kayalioglu G et al, Thamke S et al, Sarmiento PB et al* [22,26,27,1]concluded that the knowledge of variations in the anatomical location of the Sigmoid Sinus in the Temporal Bone is very important for performing mastoid surgeries, especially transmastoid approaches to the CPA. The anatomical variations in the location of the sigmoid sinus significantly impact the exposure of Trautmann's triangle and the volume of the mastoid cavity. When the sigmoid sinus is positioned

more anteriorly, it reduces surgical exposure to Trautmann's triangle, making access to the internal auditory canal and cerebellopontine angle more challenging. Additionally, an anteriorly placed sigmoid sinus decreases the mastoid cavity volume, which can restrict the surgical approach by limiting drilling space and reducing aeration.In contrast, when the sigmoid sinus is positioned more posteriorly, it enhances exposure to Trautmann's triangle, providing a wider surgical corridor to critical neurovascular structures. A more posteriorly placed sigmoid sinus also results in a larger mastoid cavity, allowing for improved aeration and easier surgical access during otologic and skull base procedures.

Table 2 and figure 2 shows that the mastoid tip observed was prominent in 80% temporal bone and not prominent in 20% temporal bone. A well-developed, prominent mastoid tip may push the sigmoid sinus more superiorly or anteriorly, altering its usual position.

If the sinus is displaced anteriorly, it can reduce the mastoid cavity volume, making mastoidectomy more challenging and increasing the risk of sinus injury.

Studies done by *Sarmiento PB et al, Kayalioglu G et al, Aslan A et al and Kitamura MAP etal*[1,26,28,29] said that the sigmoid sinus (SS) is a paired venous sinus beginning as the continuation of the transverse sinus posteriorly, coursing downward as an S-shaped curve in a groove on the inner surface of the temporal bone. Anteriorly, the horizontal portion of the SS terminates as an enlargement known as the jugular bulb (JB), forming the junction between the SS and internal jugular vein. The location and size of the SS is highly variable, including significant differences between the right and left SS of the same skull due to SS dominance. This variation in the position of the SS, as well as its relationships to other structures within the temporal bone,

contributes to the complexities of neurotological surgery. Lateral skull-base approaches require a thorough understanding of the relationships between the SS, JB, external auditory canal (EAC), and facial nerve (FN) in order to avoid intraoperative complications.

Table 3 and figure 3 shows that type of pneumatization of mastoid bone mixed, sclerotic, diploic, pneumatic noted in 10%, 30%, 30%, 30% cadavers respectively.

Table 4 and figure 4 shows that sigmoidal sinus grade 1, 2, 3 noted in 30%, 40%, 30% temporal bone respectively. The Sigmoid sinus was classified according to the visibility of the structures parallel to the thinned out posterior wall of the external auditory canal. Sigmoid sinus was classified into three grades based on its anatomical position, presigmoid bony plate(defined as the bone between the anterior margin of sigmoid sinus and the posterior semicircular canal.) and to the dome of the PSCC.

Grade 1: Sigmoid sinus posteriorly, presigmoid plate, and posterior semicircular canal are visible.

Grade 2: Sigmoid sinus is anteriorly placed, obscuring the presigmoid bony plate, but the posterior semicircular canal remains visible.

Grade 3 : Sigmoid sinus is significantly anteriorly placed, obscuring the presigmoid bony plate and the posterior semicircular canal, with a compromised mastoid cavity .

Table 5 and figure 5 shows that sigmoid sinus grade 1 & grade 2 were belonged to pneumatic & sclerotic type of pneumatization respectively. Out of all wet temporal bone with sigmoidal sinus grade 2, 25% temporal bone belonged to mixed pneumatization and 75% to diploic pneumatization. The association between type of Pneumatization and grading of sigmoidal sinus was statistically significant ($p<0.05$).

Present study observed that the sclerotic pneumatization (30%) & diploic pneumatization (30%) were the most common type observed among the temporal bones. Present study found that the highest number of temporal bones (40%) noted with grade 2 sigmoidal sinus. The association between type of Pneumatization and grading of sigmoidal sinus was statistically significant ($p<0.05$) i.e lesser the pneumatization more anterior was the position of the sigmoid sinus.

Although wide variability in the anatomical positions of the sigmoid sinus has been accepted clinically, the exact causes of such variability have not been established. The relationship between mastoid pneumatization and sigmoid sinus variations remain a subject of debate. In a previous study, one of the authors (*Lee DH et al*)[30]demonstrated that the location of surgically-important structures, including the sigmoid sinus, in the middle and inner ear was rarely influenced by the sclerotic change.

A study done by *Sun D et al* [22] noted the pneumatic mastoids in 62.5% temporal bones and sclerotic mastoids in 37.5%. same study observed that there were 104 cases of the type 1 sigmoid sinus, 35 cases of type 2, 21 cases of type 3 and 40 cases of type 4. A study done by *Singh A* et *al* [31]noted the sigmoidal sinus grade 1, 2, 3 in 39.4%, 41.5%, 19.1% cadavers respectively.

- Grade I (Favorable)

- The sigmoid sinus does not hinder the view of the presigmoid bony plate or the PSCC.
- Good exposure with a wide Trautmann triangle.
- Larger mastoid cavity volume and better surgical accessibility.

➢ Grade II (Intermediate)

- The sigmoid sinus is placed anteriorly, obscuring the presigmoid bony plate but not the PSCC.
- The mastoid cavity volume is reduced, and the Trautmann triangle is narrower compared to Grade I.
- Some hindrance to accessing the cerebellopontine angle (CPA) via the retrolabyrinthine (RL) approach. The translabyrinthine (TL) approach is often preferred.

➢ Grade III (Unfavorable)

- The sigmoid sinus is highly anteriorly placed, obstructing both the presigmoid bony plate and the PSCC.
- Significantly narrowed Trautmann triangle and reduced mastoid cavity volume.
- Considered unfavorable for CPA access via retrolabyrinthine (RL) or translabyrinthine (TL) approaches; the retrosigmoid (RS) approach is advisable instead.

A study done by Karaca CT et al[25]done with aim to analysis of Anatomic Variations in Temporal Bone by Radiology observed that aerated mastoids in 33%, diploic mastoids in 31% and sclerotic mastoids in 36% cadavers.

Sun D. et al. (2009)[22]suggested a radiological classification of the SS into four groups based on three lines that represent significant surgical structures on a CT scan. The authors highlighted how the classification system can represent the SS as a

surgically significant marker for transmastoid operations. However, the real-time intraoperative dissection results that validated the radiological data did not support it.

A limitation of the current study is its inability to account for the age or sex of the skulls, which is significant given the well-documented differences in temporal bone morphology between males and females. Future research should investigate how age- and sex-related variations influence intratemporal relationships. Additionally, high-resolution computed tomography (HRCT) is a superior imaging modality when compared to a radiograph that could enhance the accuracy of variations of sigmoid sinus."

CONCLUSION

Present cross-sectional observational study was conducted at ENT department on 30 wet temporal bones harvested from the cadaver which was available during the study period at the department of Anatomy, JNMC, Belagavi, Karnataka, India .Objectives of the study was to assess the anatomy and variations of sigmoid sinus in relation to the posterior semicircular canal and presigmoid plate in cadavers and to assess the position of the sigmoid sinus plate in relation to external auditory canal radiologically. The conclusion of this study are

- The difference in the distance between sigmoid sinus and posterior wall of external auditory canal on x- ray mastoid and wet temporal bone was not statistically significant (2.91 mm Vs 2.2mm).
- Prominent mastoid tip was more common when compared to non prominent tips.
- The occurrence of type of pneumatisation (i.e pneumatic,diploic and sclerotic) was almost equal.
- Position of sigmoid sinus with intermediate risk (grade 2) was most common.
- Lesser the pneumatization more anteriorly sigmoid sinus is placed.

The sigmoid sinus (SS) demonstrates significant anatomical variability.

- **A well-pneumatized mastoid is typically associated with a favorably positioned SS, providing better surgical access and enhanced visualization of critical structures.**
- **A detailed preoperative imaging assessment is crucial for evaluating the position of the SS, anticipating potential challenges, and ensuring the safety and feasibility of various transmastoid approaches.**

SUMMARY

The sigmoid sinus (SS) is a vital venous structure within the temporal bone, playing a key role in venous drainage and significantly influencing neurosurgical and otologic procedures. Anatomical variations in its position and morphology impact surgical approaches, particularly those targeting the mastoid cavity, posterior semicircular canal, and cerebellopontine angle. Understanding these variations is crucial for minimizing complications and improving surgical outcomes. This observational study was conducted on 30 wet temporal bones at the ENT department of JNMC, Belagavi, Karnataka, India, with the objective of assessing the anatomy and variations of the sigmoid sinus concerning the posterior semicircular canal and presigmoid dural plate in cadavers , as well as its position relative to the external auditory canal using radiological evaluation. Collected data was entered in the excel data sheet and data analysis was done with the help of Epi .Info.7.2 software. Data was cleaned, Validated and Analysed by Epi. Info 7 software.

Findings revealed that the distance between the sinus plate and posterior wall of external auditory canal (on X-ray) and the sigmoid sinus and posterior wall of external auditory canal (on wet temporal bone) was comparable. The majority of specimens exhibited a prominent mastoid tip, while some lacked prominence. Pneumatization patterns varied among the specimens, with pneumatic, diploic, sclerotic, and mixed types observed and among which diploic ,sclerotic pneumatic had equal incidence of occurence. The sigmoid sinus was graded based on its anatomical placement, with posteriorly positioned sinuses providing better surgical access (Grade 1), intermediate placement offering moderate accessibility (Grade 2), shows intermediate risk and highly anteriorly placed sinuses reducing the available surgical space (Grade 3). Pneumatization was found to influence sinus positioning, as

well-pneumatized mastoids were associated with a more posteriorly placed sinus, while sclerotic and diploic mastoids correlated with a more anteriorly placed sinus, posing greater surgical challenges.

These anatomical variations have significant clinical implications. A posteriorly placed sigmoid sinus enhances exposure of Trautmann's triangle, improving surgical access, whereas an anteriorly placed sinus reduces working space and increases the risk of venous injury. Detailed radiological assessments, including X-ray (Schüller's view) and high-resolution CT scans, are essential for preoperative planning to ensure safer and more effective interventions. This study underscores the importance of understanding the variability in sigmoid sinus anatomy to optimize surgical outcomes and reduce complications, emphasizing the need for thorough radiological evaluation to anticipate potential challenges.

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ANNEXURES

ANNEXURE – I - INFORMED CONSENT FORM

From,

REG NO: BE0122002

First Year Post Graduate, Department of E.N.T.

& H.N.S.,JNMC, Belagavi.

Dated: 8/02/2023

To,

DR.HARSHA HEGDE,

Chairperson, JNMC, IEC &

SCIENTIST D, ICMR, National

Institute of Traditional Medicine.

Belagavi – 590010

(Through proper channel)

Subject: Waiver off from the criteria of informed consent from subjects

Respected Madam,

I, undersigned [redacted] is doing a synopsis on topic **"ANATOMY AND ITS VARIATIONS OF SIGMOID SINUS IN WET TEMPORAL BONE AND ITS RADIOLOGICAL CORRELATION: A CADAVERIC TEMPORAL BONE STUDY."**. Since it is a cadaveric study and does notpose any risk to subjects, I am requesting you to waiver me off from the criteria of informedconsent from the subjects.

Kindly accept the same

and oblige.Thanking

you,

ANNEXURE – II- PROFORMA

"ANATOMY AND VARIATIONS OF SIGMOID SINUS IN WET TEMPORAL BONE AND ITS RADIOLOGICAL CORRELATION"

1.	DATE:	
2.	SPECIMEN NUMBER:	
3.	X-RAY MASTOID (SCHULLER 'S VIEW)	DISTANCE BETWEEN SINUS PLATE AND POSTERIOR WALL OF EXTERNAL AUDITORY CANAL
4.	CADAVERIC DISSECTION	DISTANCE BETWEEN SIGMOID SINUS AND POSTERIOR WALL OF EXTERNAL AUDITORY CANAL.

4.	MAS TOID REGI ON:	MASTOID TIP: PNEUMATIZATION:	A. PROMINENT B. NOT- PROMINENT A. PNEUMATIC B. SCLEROTIC C. DIPLOIC D. MIXED
6.	SIGMOID SINUS	GRADE 1 (SIGMOID SINUS,PRESIGMOID PLATE POSTERIOR SEMICIRCULAR CANAL, LATERAL SEMICIRCULAR CANAL. SIGMOID SINUS IS PLACED POSTERIORLY.) GRADE 2 (SIGMOID SINUS IS ANTERIORLY PLACED OBSCURING THE PRESIGMOID BONY PLATE , BUT THE POSTERIOR SEMICIRCULAR CANAL, LATERAL SEMICIRCULAR CANAL) GRADE 3 (SIGMOID SINUS IS ANTERIORLY PLACED OBSCURING THE PRESIGMOID BONY PLATE AND THE POSTERIOR SEMICIRCULAR CANAL WITH SIGNIFICANTLY COMPROMISED VOLUME OF MASTOID CAVITY. SIGMOID SINUS PLACED POSTERIORLY)	
7.	REMARKS		

ANNEXURE III: PHOTOGRAPHS

Photo 1: Mixed /diploic mastoid air cells

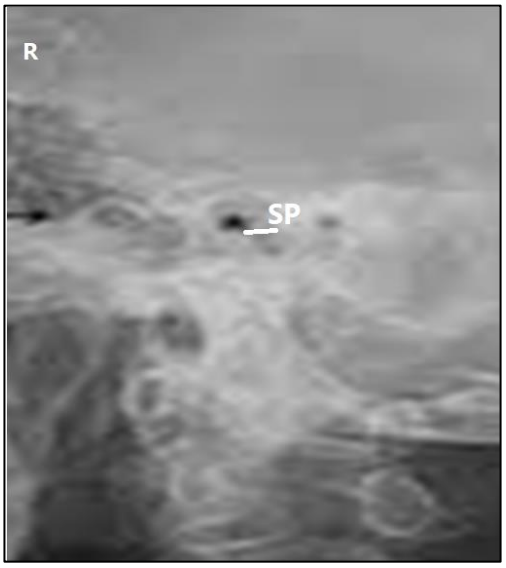

Photo 2: Sclerotic mastoid air cells

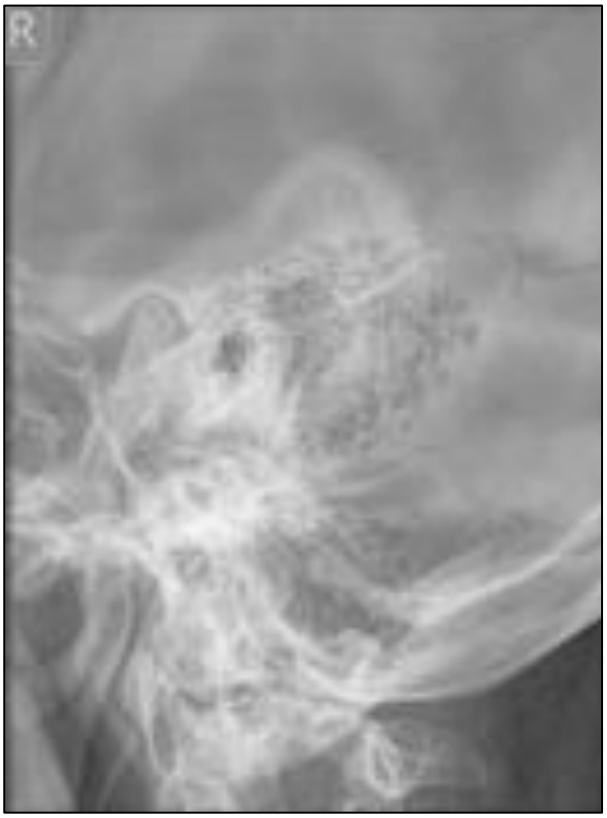

Photo 3: Pneumatic Mastoid air cells

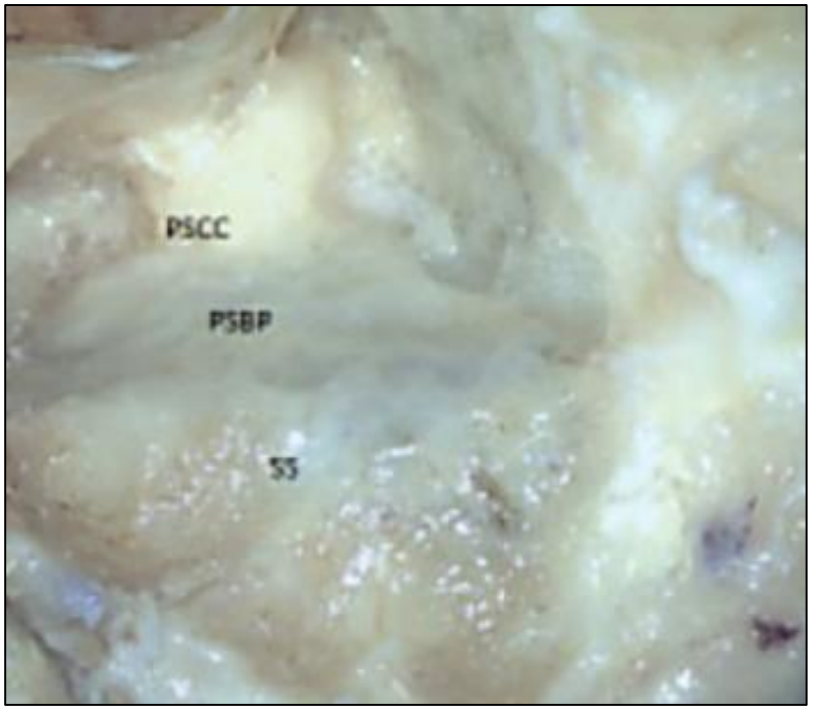

Photo 4: Grade 1: Sigmoid sinus (SS) posteriorly, presigmoid bony plate (PBP), and posterior semicircular canal are visible.

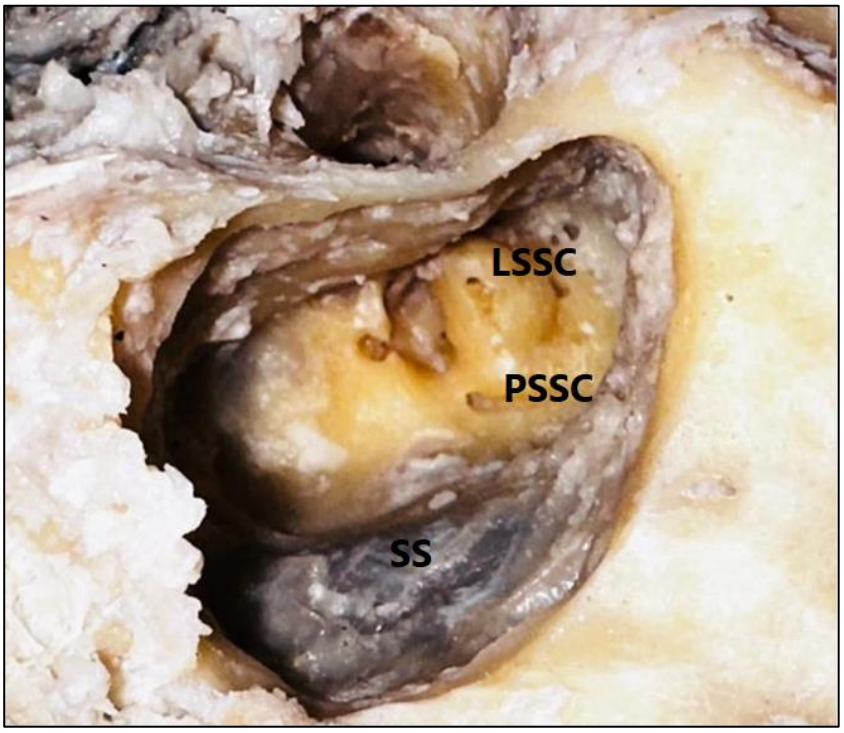

Photo 5: Grade 2: Sigmoid sinus (SS)is anteriorly placed, obscuring the presigmoid bony plate (PBP), but the posterior semicircular canal (PSSC) remains visible.

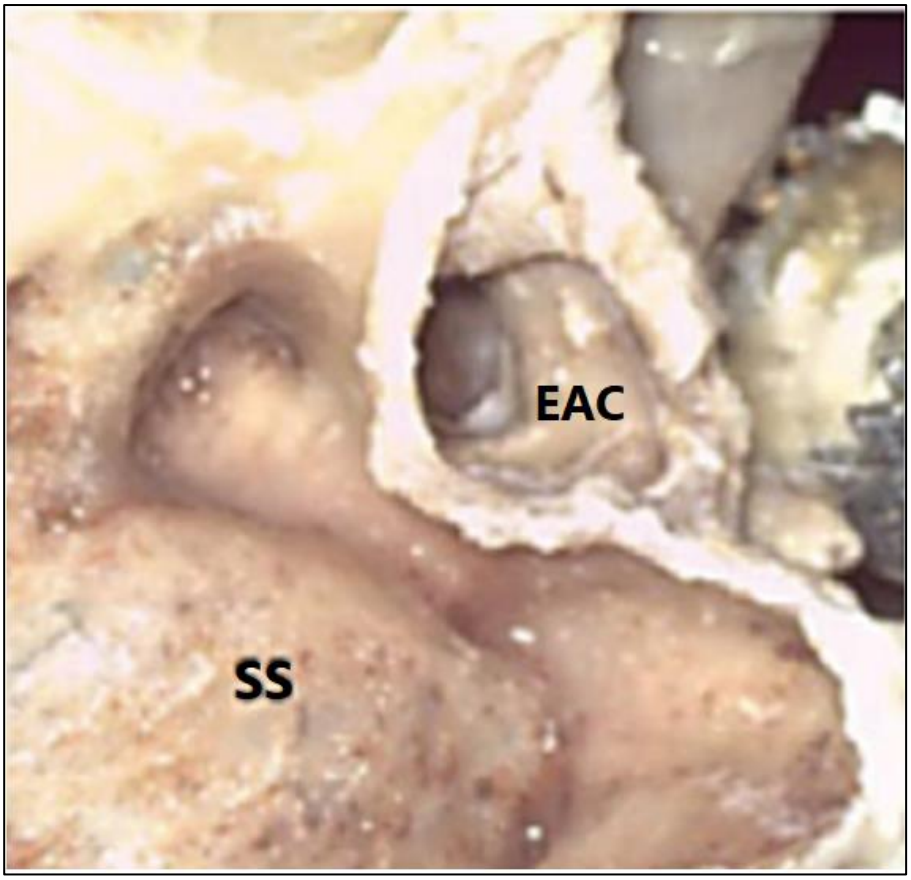

Photo 6: Grade 3: Sigmoid sinus (SS) is significantly anteriorly placed, obscuring the presigmoid bony plate and the posterior semicircular canal, with a compromised mastoid cavity.

ANNEXURE IV: MASTER CHART

Specimen number	X-Ray Mastoid (Schüller's View)(Distance between sinus plate & posterior wall of the external auditory canal) cm	Cadaveric Dissection(Distance between sigmoid sinus & posterior wall of the external auditory canal)cm	Mastoid Tip	Pneumatization	Sigmoid Sinus Grad
1	1.6	1.5	prominent	mixed	2
2	1.6	1.5	not prominent	sclerotic	3
3	3.2	2.8	prominent	diploic	2
4	3.8	3	prominent	diploic	2
5	3.7	3.5	prominent	pneumatic	1
6	3.2	3	prominent	pneumatic	1
7	1.5	1.2	prominent	diploic	2
8	3.2	3	prominent	pneumatic	1
9	1.9	1.8	not prominent	sclerotic	3
10	1.6	1.4	prominent	sclerotic	3
11	3.2	1.5	prominent	diploic	2
12	3.8	2.8	prominent	sclerotic	3
13	3.7	3	prominent	pneumatic	1
14	3.2	3.5	prominent	sclerotic	3
15	1.5	3.1	prominent	diploic	2
16	3.2	1.2	not prominent	sclerotic	3
17	2.6	3	prominent	pneumatic	1
18	3.2	1.8	not prominent	pneumatic	1
19	3.8	1.2	prominent	mixed	2
20	3.7	3	prominent	diploic	2
21	3.2	1.8	prominent	sclerotic	3
22	3.8	1.4	not prominent	diploic	2
23	3.7	1.5	prominent	mixed	2
24	3.2	2.8	prominent	pneumatic	1
25	1.5	1.2	prominent	sclerotic	3
26	3.2	3	prominent	diploic	2
27	1.7	1.8	prominent	diploic	2
28	3.2	1.2	not prominent	pneumatic	1
29	3.8	2.9	prominent	sclerotic	3
30	2.9	1.8	prominent	pneumatic	1