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Original Research Paper

Radio-Diagnosis

# COMPUTED TOMOGRAPHY EVALUATION OF ANATOMICAL VARIATIONS IN THE SKULL-BASE FORAMINA OF THE MIDDLE CRANIAL FOSSA.


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KEYWORDS :

## INTRODUCTION:

The middle cranial fossa, situated centrally among the three cranial fossae at the base of the skull, accommodates the temporal lobes of the cerebral hemispheres and the pituitary gland.

It is deeper than the anterior cranial fossa and narrower medially, widening laterally towards the sides of the skull. It is separated from the posterior cranial fossa by the clivus and the petrous crest.

The base of the skull contains numerous foramina that serve as passages for blood vessels and nerves, facilitating communication between extra-cranial and intracranial structures.{1}

The middle cranial fossa, also known as the central skull base, is a complex region within the skull that houses many structures vulnerable to pathology. Its critical anatomical and functional importance makes it directly relevant to neurosurgeons, neurologists, otolaryngologists, ophthalmologists, radiologists, and endocrinologists {2}{3}

The middle cranial fossa is delimited anterolaterally by the lesser wings of the sphenoid and anteromedially by the limbus of the sphenoid.{4}

Posteriorly, it is bounded by the petrous ridge and the dorsum sellae.

Lateral boundaries include the greater wings of the sphenoid, squamous temporal bone, and sphenoidal angles of the parietal bones. This complex structure accommodates numerous nerves and vessels passing through its many foramina.{5}

The greater wing of the sphenoid bone consistently contains three foramina.

These are the foramen ovale (FO), foramen spinosum (FS), and foramen rotundum (FR). Apart from these foramina the base of the skull has various foramens like Foramen of Vesalius, Canaliculus innominatus,{6}

The foramen rotundum (FR) is located just below and behind the medial end of the superior orbital fissure, leading forward into the pterygopalatine fossa where it transmits the maxillary nerve.

The Foramen of Vesalius, also known as the sphenoid emissary foramen, acts as a small and variable passage enabling communication between the middle cranial fossa and the scaphoid fossa. Its primary role is to transmit an emissary vein that connects the cavernous sinus to the pterygoid venous plexus

Posterior and lateral to the foramen rotundum (FR) is the foramen ovale (FO), through which the trigeminal part of mandibular nerve passes and alsoaccessory meningeal artery and the emissary vein .Behind the foramen ovale (FO) lies the foramen spinosum (FS), which transmits the middle meningeal artery.

## AIMS AND OBJECTIVES:

- To assess the anatomical variations of the foramina in the middle cranial fossa using high-resolution CT imaging.
- This study investigated the presence or absence of these foramina, as well as variations in their size, shape, and location, along with the relationships between these structures.

## METHODS AND MATERIALS:

Non enhanced CT scans of the temporal bone from 230 consecutive patients were retrospectively reviewed to evaluate the prevalence of anatomical variants on the floor of the middle cranial fossa. The studies utilized 1.5-mm contiguous sections in an axial plane parallel to the infraorbitomeatal line. Scans were conducted on GE 16 slice CT MACHINE and reconstructed using a bone algorithm, with each side zoomed separately to a 9.6-cm field of view. While primarily aimed at detecting temporal bone disorders, this protocol also provided generally clear visualization of the more anteromedially situated skull-base foramina.

- **Place of Study: Department of radiodiagnosis ,** Konaseema Institute of Medical Sciences and Research Foundation, Amalapuram.
- **Duration of Study:**July 2024 to December 2024.
- **Type of Study:** Prospective,observational study.
- **Ethics Approval:** The present study was approved by the Ethics Committee of KIMS, Amalapuram.
- **Consent:** Consent for the computed tomography scan examinations was obtained after providing relevant information to the participants.

**Inclusion Criteria:**
- Patients aged [specific age range].
- No prior surgeries or conditions affecting cranial anatomy.

**Exclusion Criteria:**
1. Technically suboptimal scans.
2. Severe traumatic or destructive neoplastic or inflammatory lesions that made the anatomy difficult to interpret.
3. Patients younger than 1 year of age, due to challenges in discerning certain structures in very small skulls.

**Sample Size:** 230

**Study Design:** Prospective, observational study

**Study Technique:** Convenience sampling .

**METHOD OF COLLECTION OF DATA:**
- **Sample Population:**

230 CT studies of the temporal bone from patients with no known diseases affecting foramina anatomy.
- **Data Collection:**

A checklist of known variants and suspected structures was employed.
Systematic examination for the presence/absence of foramina and their variations in size, shape, and location.

- **Statistical AnalysisW**

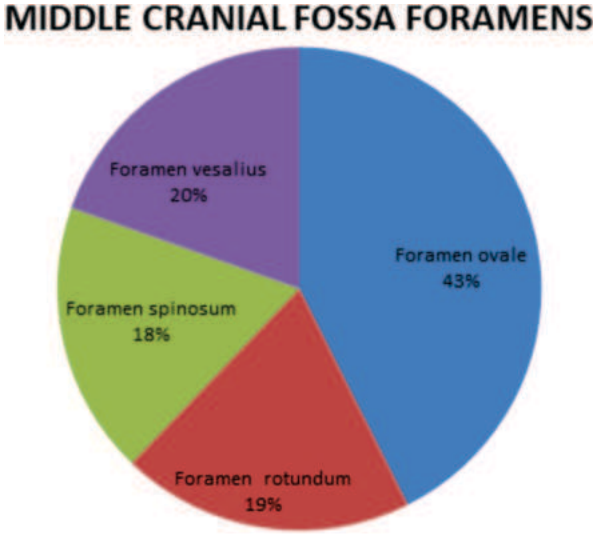
**Descriptive Statistics**: Frequencies and percentages of identified variants.

**Inferential Statistics**: Chi-square tests for categorical data and ANOVA for continuous variables.

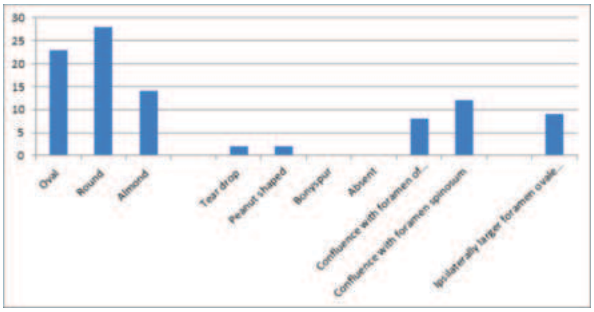
**Correlation Analysis**: Assess relationships between foramina size and patient demographics.

**RESULTS:**

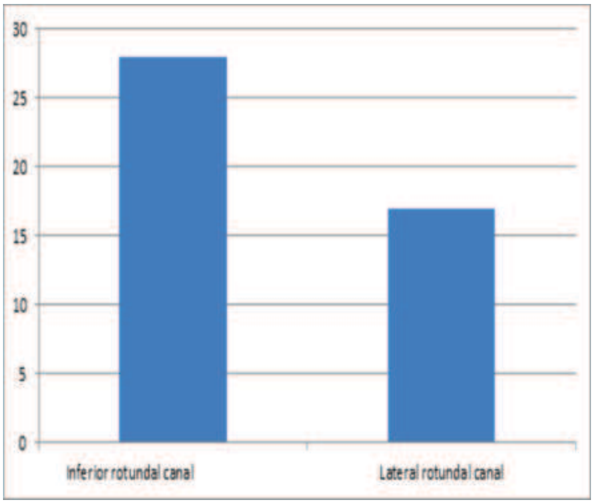
| Total study population ;230 | | | | |
|---|---|---|---|---|
| **Name of foramen** | **No. of patients** | **Variations of foramens** | | **percentages** |
| Foramen ovale | 98 | Oval | 23 | 23.4% |
| | | Round | 28 | 28.5% |
| | | Almond | 14 | 14.2% |
| | | Tear drop | 02 | 2.1% |
| | | Peanut shaped | 02 | 2.1% |
| | | Bony spur | 00 | 0.0% |
| | | Absent | 00 | 0.0% |
| | | Confluence with foramen of Vesalius | 08 | 8.1% |
| | | Confluence with foramen spinosum | 12 | 12.2% |
| | | Ipsilaterally larger foramen ovale with unilaterally smaller or absent foramen spinosum | 09 | 9.2% |
| Foramen rotundum | 45 | Inferior rotundal canal | 28 | 62.2% |
| | | Lateral rotundal canal | 17 | 37.8% |
| Foramen spinosum | 42 | Duplication | 01 | 2.3% |
| | | Absent | 06 | 14.2% |
| | | Medial defect (confluence with sphenopetrosal synchondrosis) | 24 | 57.1% |
| | | Confluence with foramen ovale | 11 | 26.1% |
| Foramen vesalius | 45 | Presence unilaterally | 10 | 22.2% |
| | | Presence bilaterally | 8 | 17.7% |
| | | Bilateral, equal | 13 | 28.8% |
| | | Bilateral, unequal | 02 | 4.4% |
| | | Duplication | 06 | 13.3% |
| | | Absence | 06 | 13.3% |



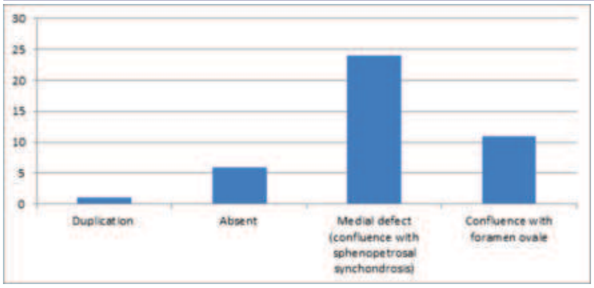

**FORAMEN OVALE ANATOMICAL VARIATIONS**



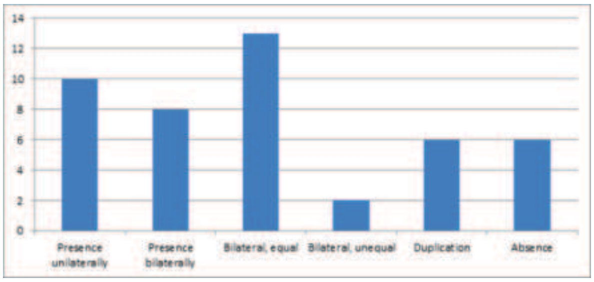

**FORAMEN ROTUNDUM ANATOMICAL VARIATIONS**




**FORAMEN SPINOSUM ANATOMICAL VARIATIONS**

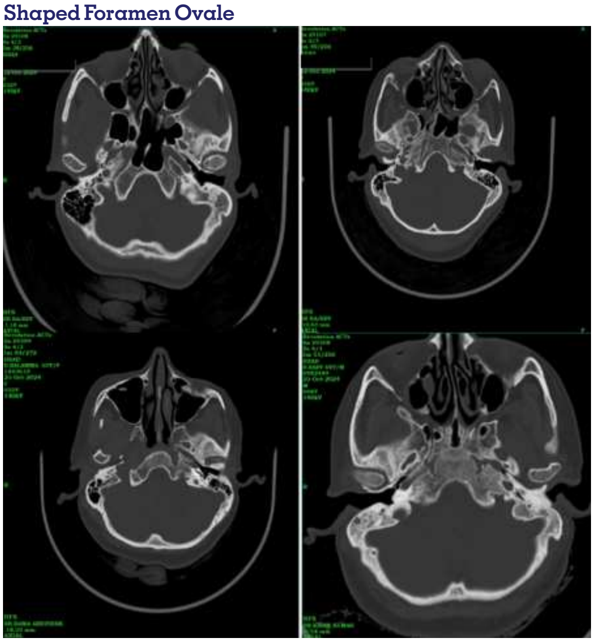



**FORAMEN VESALIUS ANATOMICAL VARIATIONS**

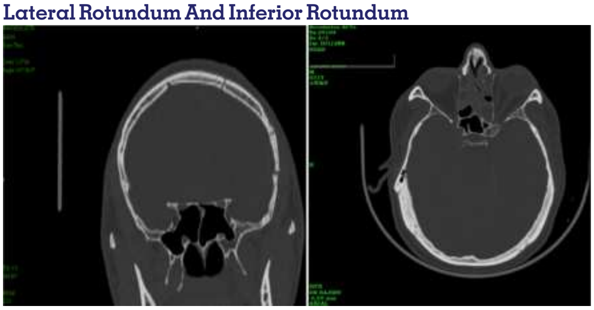



**IMAGES :**

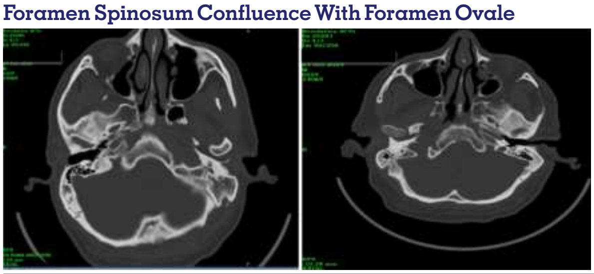
**Round Foramen Ovale, Almond Shaped And Tear Drop Shaped Foramen Ovale**



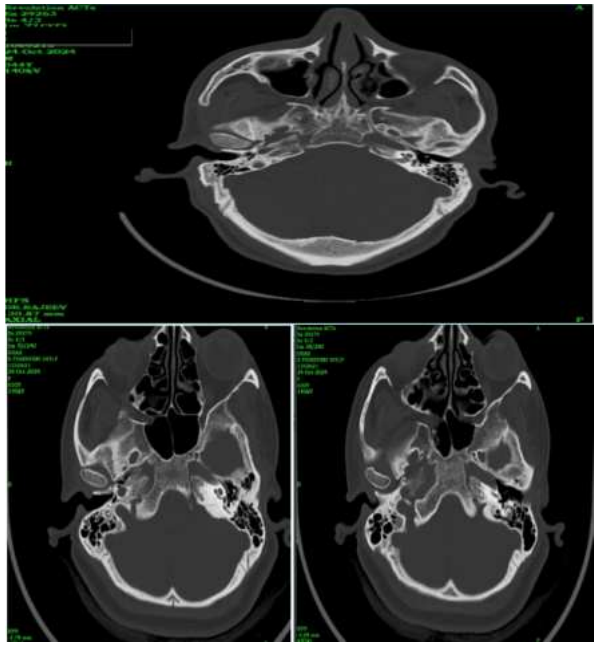
**Lateral Rotundum And Inferior Rotundum**



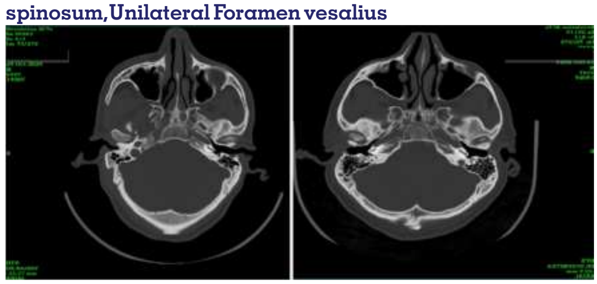
**Foramen Spinosum Confluence With Foramen Ovale**



**Bilateral Foramen Vesalius**



**Peanut Foramen ovale and medial defect of foramen spinosum, Unilateral Foramen vesalius**



**DISCUSSION :**

**1. Anatomical Structure:**

o The sphenoid is a butterfly-shaped bone located at the base of the skull.

o It consists of a body, greater wings, lesser wings, and pterygoid processes.

***Foramen Ovale:***

***Clinical Relevance:***

- The **mandibular nerve (V3)** provides sensory innervation to the lower part of the face, including the **jaw, lower teeth, chin**, and parts of the **tongue**. It also has motor components responsible for the muscles of mastication.
- **Trigeminal neuralgia** affecting the mandibular branch can result in sharp, severe pain in these areas. The foramen ovale is critical in diagnosing conditions related to the mandibular nerve, as **nerve compression** or **irritation** at or near this foramen can be the underlying cause.
- Additionally, **skull base tumors** (e.g., schwannomas, meningiomas) that compress or invade the foramen ovale can disrupt the normal function of the mandibular nerve, contributing to **pain, numbness**, or **motor dysfunction**.

***Surgical Relevance:***

· The foramen ovale's position is especially important in surgeries involving the **middle cranial fossa**, such as tumor resection, nerve decompression, or procedures for **trigeminal neuralgia**.

· Surgeons must be cautious of the foramen ovale's proximity to vital structures to avoid **nerve damage**, which could result in loss of sensation, motor dysfunction, or even cause post-surgical complications like **persistent neuralgia**.

· For procedures like **percutaneous trigeminal nerve compression** or **microvascular decompression** for trigeminal neuralgia, precise identification of the foramen ovale and the nerve's path through it is essential.

The **foramen rotundum (FR)** is a key bony structure in the skull base, situated in the **greater wing of the sphenoid bone**, on the floor of the **middle cranial fossa**. It is located near the **nasopharynx** and is often affected by conditions such as **nasopharyngeal cancer** and other **malignant brain tumors**. This study aims to provide a detailed description of the **anatomical variations** of the foramen rotundum, as well as its **relationships** with surrounding vital structures.

Understanding these variations is crucial for **preoperative planning** in **endoscopic surgery**, ensuring safe navigation and minimizing risks to adjacent structures.

The **foramen spinosum** is a small opening located in the **greater wing of the sphenoid bone**, allowing the **middle meningeal artery** to enter the **cranial cavity**.

**Clinical Significance:**

**1. Epidural Hematoma:**

If the **middle meningeal artery** is injured, typically due to trauma, blood can accumulate between the **dura mater** and the skull, forming an **epidural hematoma**. This condition can be life-threatening and requires urgent medical intervention.

**2. Tumor Detection:**

A **CT scan** is invaluable for detecting tumors that may be compressing or invading the **foramen spinosum**, potentially affecting the **middle meningeal artery** and disrupting its function. Early detection is crucial for preventing complications such as hemorrhage or ischemia.

## CONCLUSION:

The sphenoid bone and its openings are crucial in clinical practice, with variations in their size or shape potentially complicating diagnostic and therapeutic procedures. The relationship between the trigeminal nerve and surrounding structures, including mechanical compression points, has been studied. The foramen ovale (FO) is an important target in various interventions, such as percutaneous microballoon compression for treating trigeminal neuralgia, and for accessing the trigeminal cave{8}. Additionally, FO cannulation is used in electroencephalographic analysis during amygdalohippocampectomy. Understanding these anatomical details is vital for successful clinical outcomes.

This knowledge will be useful to neurosurgeons for the identification and preservation of the neurovascular structures when using approaches to the middle cranial fossa. Studying the normal and abnormal variations of the sphenoid bone enhances our understanding of cranial morphology and its implications for neurovascular anatomy. This knowledge is crucial for effective clinical practice and improving patient outcomes.

Recognition of these variants is important not only for understanding the complex regional neurovascular anatomy but also for distinguishing normal from potentially abnormal structures.

The study of the base of the skull is crucial due to its clinical implications, as these foramina serve as passages for important neurovascular structures. Trauma or the presence of space-occupying lesions in this area can cause compressive forces, leading to specific clinical symptoms. Moreover, comprehending variations in these foramina is essential for clinicians to interpret radiographs accurately and to plan surgical approaches effectively

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