Chapter – 4

MATERIALS & METHODS

The present study was conducted in the Department of Anatomy, G S V M Medical College, Kanpur, Department of Anatomy, King George’s Medical University, U P, Lucknow and in the Department of Radiology, Geetanjali Medical College & Hospital, Udaipur, Rajasthan. A total of 347 dry adult human crania of unknown sex were collected from medical colleges of Kanpur & Lucknow as mentioned above and were analyzed for the study. 314 Computed Tomographic scans films (Dicom files) were taken from the Department of Radiology, Geetanjali Medical College & Hospital, Udaipur, (Rajasthan) and were evaluated for the study. These scans were of the study subjects who were the patients indicated to have CT scan for different clinical indications. These subjects were enrolled in the study, between 2013 to 2018.

Morphometric measurements of the foramina of the posterior cranial fossa namely foramen magnum, jugular foramen and hypoglossal canal were taken. All foramina were measured from outer side at the base of skull. The measurements of the foramina were taken in millimeters with the help of Digital Vernier Caliper, Accuracy up to 0.01 mm (Fig.4.1). The measurements were taken bilaterally both for jugular foramen (JF) and hypoglossal canal (HC).

![Digital Vernier Caliper](image)

**Figure No. 4.1:** Digital Vernier Caliper.
**Study Design**: Descriptive Study.

This observational descriptive study was approved by the Ethical Committee, Research Council of Geetanjali Medical College and Hospital, Udaipur, Rajasthan.

**Inclusion Criteria**:

Normal human adult skulls (without mandible & calvaria) of unknown sex Computed Tomographic scans of patients indicated to have CT scan for different clinical indications.

**Exclusion Criteria**:

1. Fractured or damaged skulls.
2. Skulls with congenital malformation or deformities.
3. Fetal, neonatal & children’s skulls.
4. Patients with previous trauma, surgery or pathology in the region of posterior cranial fossa.

The CT scans were obtained using a CT scan Machine, type Helical CT [Siemens Somatom Sensation, Germany (Fig.4.2)] with 64-slice and 1.6 mm thickness. The parameters were evaluated on CT scan films after 3-D reconstruction. The scans were assessed by an expert Radiologist of Geetanjali Medical College, Udaipur, using Radiant Software.

**SAMPLE SIZE**

**Objective -1**: To give measurement estimates of various foramina present in human skulls.

**Objective -2**: To compare the finding radiological and morphologically.
Objective -1

n (sample size) = 258

\[
\frac{(Z_1 - \alpha/2)^2 \times (SD)^2}{d^2}
\]

Objective -2

For comparison of anatomical & radiological finding:

Sample size (each group)

\[
\frac{[Z(1-\alpha/2) + Z(1-\beta)]^2 \times [(SD_1)^2 + (SD_2)^2]}{X_1 - X_2}
\]

\((X_1 - X_2)\) – mean of radiological and morphological

SD_1 & SD_2 - SD of radiological and morphological

Using conventional \(\alpha\) & \(\beta\) error of 0.05 (two tailed) and 0.20.

Data Collection: The soft copy of CT scan images was collected in DVD

Procedure

The scanning was performed with the patient in the supine position. Precautions were taken that there is no rotation or tilt of head in order to avoid any bilateral asymmetry. Slice thickness depends on the structure to be scanned. Because of the dense bone of the base of skull, beam-hardening artifacts are often seen in images of the posterior cranial fossa. Bone requires slice thickness of 5mm for reformatted images. Thin slices can help to reduce these artifacts. Helical mode was used for 3D reformations.

Scanning Protocol

<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>kVp</td>
<td>120</td>
</tr>
<tr>
<td>mAs</td>
<td>323</td>
</tr>
<tr>
<td>Slice Thickness</td>
<td>5 mm</td>
</tr>
</tbody>
</table>
1. Morphometric Measurements of Foramen Magnum

The following parameters were evaluated.

2. Non-metric

   - Shape

3. Metric

   - Antero-posterior diameter (APD)
   - Transverse diameter (TRD)
   - Area

Shape of foramen magnum: - All the dry bones and patient’s CT Scans were visually assessed to determine the shape of FM and was classified into one of the following seven shapes- oval (figure-4.3 & 4.3A), round (figure -4.4 & 4.4A), tetragonal (figure – 4.5 & 4.5A), Egg shaped (figure 4.6 &4.6A) Hexagonal (figure 4.7 & 4.7A) Pentagonal (figure 4.8 &4.8A), and irregular (figures 4.9A, 4.9B & 4.9C).
Figure Showing Shapes of Foramen Magnum.

**Figure No. 4.3**: Posterior part of base skull showing Oval shape of FM.

**Figure No. 4.3A**: CT image showing Oval shape of FM.
Figure No. 4.4: Posterior part of base skull showing Round shape of FM.

Figure No. 4.4A: CT image showing Round shape of FM.
Figure No. 4.5 : Posterior part of base skull showing Tetragonal shape of FM.

Figure No. 4.5A : CT image showing Tetragonal shape of FM.
Figure No. 4.6: Posterior part of base skull showing Egg shape of FM.

Figure No. 4.6A CT image showing Egg shape of FM.
Figure No. 4.7: Posterior part of base skull showing Hexagonal shape of FM.

Figure No. 4.7A: CT image showing Hexagonal shape of FM.
Figure No. 4.8: Posterior part of base skull showing Pentagonal shape of FM.

Figure No. 4.8A: CT image showing Pentagonal shape of FM.
Figure No. 4.9A: Posterior part of base skull showing Irregular shape of FM.

Figure No. 4.9B: Posterior part of base skull showing Irregular shape of FM.
Figure No. 2.8A: CT image showing Irregular shape of FM.

**Anteroposterior diameter (APD) or Length:** - It is the distance between the opisthion and the basion along the midsagittal plane. Opisthion is median point on the posterior margin of the foramen magnum and the basion is median point on the anterior margin of the foramen magnum. (Figure no.3.1 & 3.1A.)

Figure Showing Diameters of base of Skulls.

Figure No. 4.10: Anteroposterior diameter of FM.
Transverse diameter (TD) or Width: It is the maximum distance along the transverse plane. (Figure no. 4.11 & 4.11A).
Area of the Foramen Magnum: The area of the foramen was calculated from the length and width of foramen magnum using the following formulae given by Radinsky.

$$\text{Area} = \frac{1}{4} \text{LFM} \times \text{WFM} \times 3.14$$

Where LFM & WFM are length & width of foramen magnum respectively.

The same parameters were also evaluated in patient’s CT scan films after 3D reconstruction.

Morphometric Measurements of Jugular Foramen

The following parameters were determined.

1. Metric
   - Medio-lateral Diameter.
   - Anteroposterior Diameter.

Mediolateral (ML) diameter: This diameter is the distance taken in a straight line from the end of the medial border through the center of the jugular foramen until the end of the lateral border in the mediolateral plane (Figure no.4.12)
Anteroposterior (APD): - It is the distance taken in a straight line from the end of the anterior border through the center of the jugular foramen until the end of the posterior border in the median sagittal plane (Figure no. 4.13).

4. Morphometric Measurements of Hypoglossal canal

The following parameters were determined

1. Non-Metric
   - Presence or absence of anterior hypoglossal and posterior hypoglossal canal, unilaterally or bilaterally.

2. Metric
   - Antero-posterior Diameter (APD)
   - Transverse Diameter (TRD)
Presence and absence

Anterior hypoglossal and posterior hypoglossal canal, whether present or not, were noted.

**Anteroposterior Diameter (APD):** - APD is the distance taken in a straight line from the end of the anterior border through the center of the hypoglossal canal (Ant. & Post.) until the end of the posterior border in the median sagittal plane (Figure no. 4.14 & 4.14A).

![Anteroposterior diameters of anterior Hypoglossal canal](image)

**Figure No. 4.14:** Anteroposterior diameters of anterior Hypoglossal canal.

![Anteroposterior diameters of posterior Hypoglossal canal](image)

**Figure No. 4.14A:** Anteroposterior diameters of posterior Hypoglossal canal.
Transverse Diameter (TD): - It is the maximum distance in a straight line from the right to left side (Figure no. 4.15 & 4.15A).

![Image](image1)

**Figure No. 4.15**: Transverse diameters of anterior hypoglossal canal.

![Image](image2)

**Figure No. 4.15A**: Transverse diameters of posterior hypoglossal canal.

The measurements obtained were later compared with the previous data available.

**Statistical Analysis**

The data obtained from the present study was analyzed as per standardized methods. The analysis was performed by applying Independent $t$-test using SPSS software version 21 IBM. Mean ± standard deviation and range was taken into consideration in the statistical analysis ($p \leq 0.05$.)