Computed tomography based morphometric analysis of Foramen Magnum in South Indian population

S Aloysius Anton Hercules¹, R Archana*², Aro Shime Hercules³

¹MBBS Student, Saveetha Medical College, Saveetha Institute of Medical and Technical Sciences, Chennai-602105, India

²Professor, Department of Physiology, Saveetha Medical College, Saveetha Institute of Medical and Technical Sciences, Chennai-602105, India

³Consultant Obstetrician Gynecologist, New Hope Medical Centre, Chennai – 600010

*Corresponding author: professorarchana2017@gmail.com (Dr Archana)

ABSTRACT

The Cranio Vertebral Junction (CVJ) is a complex anatomical region. Basilar Invagination is a common pathology involving CVJ. Craniometric lines are used to measure the position of tip of Odontoid process. In this retrospective study, the craniometric skull base lines in normal South Indian population was measured and compared with the standard base line value measurements. The mean distance between tip of Odontoid process and Chamberlain line was 1.68 mm ± 1.31 mm and McRae line was 5.33 mm ± 1.73 mm. There was a significant difference in Chamberlain and McRae line values between male and female population in this study. The tip of Odontoid did not cross the McRae line in any of the population. There was no significant difference between the parameters of the skull baselines in South Indian population when compared with standard baseline values. These values will serve a useful purpose in preoperative planning.

Keywords: Cranio Vertebral Junction, Odontoid process, Chamberlain line, McRae line


INTRODUCTION

The cranio vertebral junction (CVJ) is a complex anatomical region at cervico cranium. The cervico cranium includes basi occipital, c1 and c2 up to second cervical interspace\(^1\). A number of congenital and acquired anomalies occur in this region. Basilar invagination is a common pathology involving the CVJ. Basilar invagination is the upward migration of odontoid process through the foremen magnum into the posterior fossa\(^2\). It is a cranio cervical junction abnormality where the tip of the dens projects up into the foramen magnum. Normally the x-ray of the upper cervical spine will be used to evaluate the basilar invagination. However the computerized tomography (CT) scan gives better visualization of CV junction and gives better resolution of this complex anatomical region.

Craniometric lines are used to measure the position of the tip of odontoid process. Normally used craniometric lines are Chamberlain line and McRae’s line. CT scan is better than other imaging modalities like X-ray and MRI because CT scan gives accurate identification of the bony landmarks which helps to assess these craniometric lines. Though these lines are taken as standard cut-off to diagnose basilar invagination, there are ethnical and regional variations in the position of odontoid process in relation to foramen magnum\(^3\). Studies also show that there is variation in cervical pedicle size in different population groups\(^4,5\).

In our present study, we measured the craniometric skull based lines in normal South Indian population and compared these measurements with the standard base lines values and assessed the difference in the male and female values. This will give an idea about our population’s normal base line values.

**MATERIALS AND METHODS:**

**Study Design:**

The retrospective study was conducted in a tertiary care hospital in collaboration with a tertiary center in South India after obtaining Institutional ethical clearance (SMC/IEC/2020/03/009).

**Study Participants and Sample Size:**

Patients whose CT scan of brain and cervical spine with no history of neurological deficit were taken for the study in the CT scan department. A total of 123 male and female patients in the age group of 20 – 70 years, trauma patients, patients with headache who took CT brain and cervical spine were included for the study. Patients who were admitted for CV junction anomaly or cervical spine disease were excluded from the study. The study was conducted after explaining the study protocol to all the participants. Information sheet about the study was given and a written informed consent was obtained from all the willing participants.
Procedure:

The CT scan was done by GE Revolution ACT 16 slice by qualified and well trained CT technicians. Measurements were taken by qualified radiologist. The demographic details of the patients like age, sex were included in the study. Each subject’s CT scan was retrieved and the mid-sagittal line was taken for measurements. In this study, if the tip of the odontoid process was below Chamberlain line the distance was designed as (+) mm and if the tip of odontoid was below the line it was designed as (-) mm.

The following measurements were taken:

1. **Chamberlain line**: posterior hard palate to posterior margin of foramen magnum (opisthion). Less than 3mm or half of dens should be above this line, with 6mm being definitely pathological.

2. **McRae’s line**: drawn across foramen magnum (tip of bastion to opisthion). The mean position of the odontoid tip below the line is 5mm on CT. No part of odontoid should be above this line.

These measurements were assessed by a qualified neurosurgeon. All these measurements were compared with previously accepted values.

**DATA ANALYSIS:**

Data was analysed by SPSS 20.0. The pre and post test values of the Menopause Rating Scale Score was compared using paired Student’s t test. P < 0.05 was considered to be statistically significant.

**RESULTS:**

In this study 75.2% had tip of odontoid process below chamberlain line and 24.8% had Tip of odontoid process above chamberlain line. The mean chamberlain line was 1.68 mm with the standard deviation of ± 1.31 mm.

The mean McRae line was 5.33 mm with standard deviation of ± 1.73 mm (Table 1).

<p>| Table 1: Finding of measurements for Chamberlain line and McRae line (all in millimetres) |
|---------------------------------|----------------|-------------------------------------------------|----------------|</p>
<table>
<thead>
<tr>
<th>Distance of Odontoid tip from Chamberlain Line</th>
<th>Mean</th>
<th>SD</th>
<th>Maximum</th>
<th>Minimum</th>
</tr>
</thead>
<tbody>
<tr>
<td>---------------------------------</td>
<td>------</td>
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<td>---------</td>
<td>---------</td>
</tr>
<tr>
<td>Distance of Odontoid tip from McRae Line</td>
<td>5.33</td>
<td>1.73</td>
<td>10.40</td>
<td>.90</td>
</tr>
</tbody>
</table>

There was a significant difference in Chamberlain and McRae line values between males and females in this study (P<0.05). The mean chamberlain line in males was 2.02±1.11 and in females 1.24±1.13 given in Figure 1. Mean McRae line in males and females are 5.02±1.22 and 4.83±1.31 respectively (Figure 2).
DISCUSSION:

Craniovertebral junction refers anatomically to occiput, the first (atlas) and second cervical (axis) vertebral segments, articulations and connective tissues. It represents the complex transition between the skull, upper cervical spine and the brain and the spinal cord respectively. It supports the head and enables its flexion and rotation in three dimensions. There are many lesions involving the craniovertebral junction like congenital
anomalies, fractures of special type, degenerative disorders, infectious/inflammatory diseases, tumor and its mimics. Also common vascular lesions occur in this particular anatomic region.

Radiology plays a major role in diagnosing and treating these abnormalities. To aid in radiological diagnosis, there are certain lines and angles proposed to measure the alignments of craniovertebral junction like Chamberlain line, McGregor line, McRae line, Wackenheim line, Welcher basal angle. Since 1940s these skull base lines have been used to assess basilar invagination on plain radiographs. These measurements are helpful in preoperative planning of the surgery. The commonly used lines are Chamberlain’s line and McRae’s line, which we have compared in our study in the South Indian population.

The Chamberlain line is drawn from the posterior surface of the hard palate to the tip of the opisthion (posterior aspect of the foramen magnum). It is used to measure the distance of how much the odontoid tip extends above this line. If the tip of the dens extends > 3 mm above this line then it helps to recognize the presence of basilar invagination.

The McRae line is a line drawn on a lateral radiograph of the skull or on a sagittal cut from a CT or MRI scan that connects the posterior (opisthion) and anterior (basion) aspects of the foramen magnum. The tip of the dens (or odontoid process) should be ~5 mm below this line. If it is above this line it is concerning for a possible basilar invagination. The Chamberlain and McRae line values in this study are similar to the study conducted in Nairobi, Kenya where they evaluated the relationship of odontoid peg of c2 to standard skull baselines of Chamberlain, McGregor and McRae in computed tomography.

Cronin et al. in Ireland evaluated the relationship of the odontoid tip to the skull baselines in 150 asymptomatic Caucasian adults. In this study Cronin demonstrated that the mean distance from the odontoid tip to Chamberlain’s line was 1.4 millimetres with a standard deviation of ±2.4 millimetres, 0.8 millimetres with a standard deviation of ±2.4 millimetres to McGregor’s line and then finally to McRae’s line the distance was five with a standard deviation of ±1.8 millimetres. These values almost concur with our study.

Amrit et al. conducted a study on Indian population. Their aim was to provide an overview of morphometric measurements of skull baselines in normal Indian population and compare this with those of other races and ethnicities. Also to compare values as measured from X-ray and CT scan. In this study the mean distance from
the dens tip to Chamberlain’s line on CT was 0.498 mm and on X-ray was 0.528. The mean value for distance between dens tip and McGregor on CT was 0.213 mm and on X-ray was 0.228 mm. Mean distance between tip of odontoid process and McRae line was $4.67 \pm 1.69$ on CT scan and $4.7 \pm 1.76$ mm on X-ray. There was no significant difference between male and female values in this study. Seven cases out of 116 had the tip of odontoid exceeding more than 3 mm above chamberlain line. But in our study 9 out of 113 cases had the dens tip exceeding more than 3 mm above chamberlain line. But these patients had no neurological symptoms and fall under asymptomatic category. In our study, there was a significant difference between the Chamberlain and McRae line values among males and females.

The odontoid tip was never above the McRae’s line. This finding has also been documented on plain radiograph studies in which there were asymptomatic elderly patients whose tip of the odontoid process was less than five millimetres above the Chamberlain’s line and less than four point five millimetres above Mc Gregor’s line.

CONCLUSION:

According to our study there is no significant difference between the parameters of the skull baselines in south Indian population when compared with the standard baseline values in other race and ethnicities. There is a significant difference between the mean distances in males and females. These dimensions will serve a useful purpose in pre operative planning.

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REFERENCES: