International Journal of Medical and Pharmaceutical Research
Website: https://ijmpr.in/ | Print ISSN: 2958-3675 | Online ISSN: 2958-3683
NLM ID: 9918523075206676
Volume: 4 Issue:5 (Sep-Oct 2023); Page No: 167-172

Original Article

IJMPR

Craniovertebral Junction Anomalies Evaluation by CT Head in Asymptomatic Individuals with MRI Correlation

Dr. Shivani Raghuvanshi[1]*, Dr. Lovely Kaushal[1], Dr. Swati Goyal[1], Dr. Harsha Dubey[1], Dr. Balram Malviya[1], Dr. Anita Uikey[1]

[1] Department of Radiodiagnosis, Gandhi Medical College and Hamidia Hospital Bhopal, India, 462001

ABSTRACT

Objective: To measure cranio-vertebral parameters in asymptomatic individual in CT head and to study the deviation from the normal range in Indian population with their MRI correlation.

Materials & Methods: The present study was carried out as a prospective cross-sectional comparative study at Department of Radiodiagnosis, Gandhi Medical College & associated Hamidia Hospital Bhopal during the study period of one year. Data collection was done & information was recorded on a proforma. The patients then underwent NCCT head. Parameters such as Welcher basalangle, Clivus canal angle, Boogards angle, Foramen magnum (Anteroposteriorand transverse diameter), Length of clivus, Distance between tip of dens & Mcrae'sline, clivus canal line tangential/transecting the dens and cord abnormality were assessed. Any deviation from the normal values were noted normal being the mean value under one standard deviation of the population assessed. The subjects with abnormal parameters underwent MRI which were then correlated with the CT findings.

Results: This study was conducted on a total of 3822 participants of them, 42 had CVJ anomaly on CT scan. Among the patients with incidentally detected CVJ anomalies, majority (69%) of patients reported BI followed by AOA (42.9%), PTB (21.4%), OSD (4.8%) and OT (2.4%). Combination of anomalies are also found. Among the patients with abnormal CVJ parameters, 11.9% of subjects reported presence of cord signal in MRI, 69% of subjects found clivus canal line transecting dens and remaining 31% found tangential to dens in both MRI and CT scan.

Conclusions: Basilar invagination (BI) was the most common CVJ anomaly found in our study. The most common combination were (BI)+ (AOA). Comparison of CT and MRI findings with respect to Dens in relation to McRae's line and association of CT and MRI findings with respect to Wackenheims clivus canal line (TTT) was found significant. Spinal cord signals could be pickedup by MRI.

Key Words: *Craniovertebral parameters, cranio-vertebral*

***Corresponding Author**
Dr. Shivani Raghuvanshi*
Department of Radiodiagnosis, Gandhi Medical College and Hamidia Hospital Bhopal, India, 462001

INTRODUCTION

The cervical spinal cord, different cranial nerves, blood arteries, and lymphatics are all located at the craniovertebral junction (CVJ), an anatomical passageway between the skull and the cervical spine. The caudal portion of the occipital bone, the atlas, axis, atlantooccipital, and atlantoaxial articulations, as well as ligaments, make up the CVJ. In addition, it provides the necessary support for head movement and protection [1]. CVJ, which is the most mobile segment of the spine, is a complex region that contains vital neurovascular structures [2]. Craniovertebral Junction, being the transit zone between cranium and spine, is the most complex and dynamic region of the cervical spine. Any deformity of this segment subjected to correction is complicated, and detailed knowledge of this area is mandatory prior to any intervention. Congenital, developmental, or related to an acquired disease condition, CVJ abnormalities may occur. These anomalies can lead to neural and vascular compromise, obstructive hydrocephalus, and cerebrospinal fluid dynamics [3].

Traditionally, the imaging technique used to evaluate basilar impression was an X-ray of the skull with the cervical spine. Modern imaging technologies, like as computed tomography (CT), which provides a three-dimensional image of this area with very complicated anatomy, have greatly improved our ability to see the CVJ. Good spatial resolution, speed, and the capacity for high-quality multiplanar imaging may all be found in a CT scan. Superior to a simple X-ray, it reveals details of the bone anatomy. For an accurate evaluation of the foramen magnum and spinal canal's transverse and anteroposterior (AP) dimensions, CT is a dependable diagnostic tool [4, 5]. It is more difficult to identify the reference points in the CVJ in direct radiographs, due to overlapping structures [6]. An MRI is ideal for evaluating soft tissues, nerves and ligaments, and a Multi-Slice CT describes the bone anatomy and pathology of the CVJ well [7]. Although three dimensional images of bony structures can be obtained by spiral and multiplanar-CT, cone beam computed tomography (CBCT) may be accepted as a more ideal imaging modality due to lower radiation exposure and lower costs involved [8].

Since the anatomical bony landmarks required for the angle measurements are easily accessible due to use of CT/MRI, it can be used as a standard diagnostic tool in CVJ malformations. In the literatures, few studies have mentioned the normal range of angles based on comparative studies. Additionally, few factors like race, sex, age, and height of an individual can alters the CVJ craniometry [9, 10].

To the best of our knowledge, no study has been conducted to evaluate the normal craniovertebral angles among the Indian population. We thus aimed to measure cranio-vertebral parameters in asymptomatic individual in CT head and to study the deviation from the normal range in Indian population and their MRI correlation.

MATERIAL & METHODS

The present study was carried out as a prospective cross-sectional comparative study at Department of Radiodiagnosis, Gandhi Medical College, & associated Hamidia Hospital Bhopal during the study period of one year (August 2021-September 2022). Allpatientsreferred for CT head from various departments of hamidia hospital were included whereas previously diagnosed cases of CVJ anomalies or patients operated for the same, with cardiac pacemaker, with ocular or cochlear implants and ocular foreign bodies were excluded from the study.

Permission to conduct the study was obtained from the ethical committee of Gandhi Medical College, Bhopal, Madhya Pradesh. After obtaining informed consent & explaining the purpose of study to the participants, data collection was done & information was recorded on a predesigned, pretested & semi-structured proforma. The proforma included socio-demographic variables such as age, gender etc. The patients then underwent NCCT head. Parameters such as Welcher basal angle, Clivus canal angle, Boogards angle, Foramen magnum (Anteroposteriorand transverse diameter), Length of clivus, Distance between tip of dens & Mcrae'sline, clivus canal line tangential/transecting the dens and cord signals were assessed. Any deviation from the normal values were noted normal being the mean value under one standard deviation of the population assessed. The subjects with abnormal parameters underwent MRI which were then correlated with the CT findings.

Statistical analysis:

Data was entered into MS excel 2007, analysis was done with the help of Epi info Version 7.2.2.2. Frequency & percentages were calculated. Quantitative variables were expressed as the mean & standard deviation. Categorical data was expressed as percentage. Microsoft office was used to prepare the graphs. Chi- square/Fischer's exact test was applied for comparison. Independent t-test was applied for continuous variables, $P<0.05$ was considered to be statistically significant.

RESULTS

The present study was conducted on a total of 3822 participants with mean age of 46.31±16.284 years, who presented for CT head at our study area during the study period, out of which only 42 had incidentally detected CVJ anomalies on CT scan. Thus, the incidence of CVJ anomalies in asymptomatic participants was found to be10.98per1000 people, detected on CT.

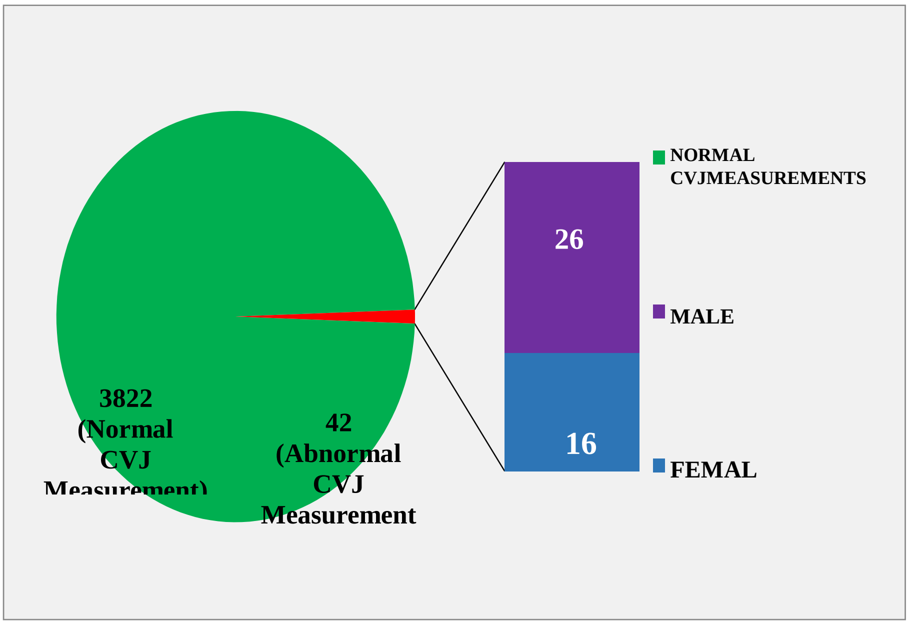

Figure 1: Overview of study participants reported for CT head

Table 1: Distribution of various CVJ anomalies

CVJ anomaly	Frequency(n=42)	Percent
Basilar invagination (BI)	29.0	69.0
Atlanto-occipital assimilation(AOA)	18.0	42.9
Platybasia (PTB)	9.0	21.4
OsOdentoidum (OSD)	2.0	4.8
Ossiculumterminal (OT)	1.0	2.4

Majority (69%) of the study subjects reported BI followed by AOA (42.9%), PTB (21.4%), OSD (4.8%) and OT (2.4%). They were also found in combinations as well.

Table 2: Combination of various CVJ anomalies

CVJ anomaly	Frequency(n=42)	Percent
BI+AOA	10	23.8
BI+PTB	3	7.1
BI+AOA+PTB	2	4.8

Table 3: Distribution of study participants on the basis of their age

Age	Frequency(n=42)	Percent
21-30	3	7.1
31-40	11	26.2
41-50	12	28.6
51-60	7	16.7
Above 60	9	21.4

Male predominance was observed among the participants. 58.9% subjects were male while 41.1% were females.

Table 4: Measurement of CVJ parameters in comparison with CT and MRI findings

Variable		Mean	N	Standard deviation	Standard error	P value
Welcher Basal Angle (WBA) (in degrees)	CT	130.031	42	9.844	1.519	0.206
	MRI	130.138	42	9.879	1.524	0.206
Clivus canal angle (CCA)	CT	134.61	42	12.687	1.958	0.372

(in degrees)		MRI	134.376	42	12.808	1.976	0.372
Boogards angle (BA) (in degrees)		CT	140.552	42	15.797	2.437	0.073
		MRI	140.402	42	15.703	2.423	0.073
Foramen magnum (in centimeters)	AP	CT	33.955	42	1.394	0.215	0.076
		MRI	33.471	42	2.231	0.344	0.076
	TD	CT	29.300	42	2.576	0.397	0.94
		MRI	29.26	42	2.549	0.393	0.94
Clivus length (CL) (in centimeters)		CT	40.56	42	5.524	0.852	0.793
		MRI	40.550	42	5.432	0.838	0.793
Distance of Dens From McRae's line (in centimeters)		CT	2.8	42	1.353	0.209	0.270
		MRI	2.9	42	1.430	0.221	0.270

In the above mentioned measurements, $p>0.05$ indicates that there is no significant difference between measurements of parameters in CT and MRI.

When looking at spinal cord abnormalities in subjects with abnormal CVJ parameters, 11.9% of subjects reported presence of cord signal in MRI, however no significant abnormality was present in CT.

Figure 2: In an asymptomatic individual, Mid sagittal section of T1W MRI shows basilar invagination (Red arrow denotes basilar inavgination)

Figure 3: In an asymptomatic individual, Mid sagittal section of T1W MRI shows atlanto occipital assimilation (Red arrow denotes atlanto occipital assimilation)

DISCUSSIONS

The present study was conducted on a total of 3,822 participants, out of which only 42 had CVJ anomaly on CT scan. Thus, the incidence of CVJ anomalies in asymptomatic participants was found to be 10.98 per 1000 people, detected on CT. Other Indian study by Dash et al. also showed that CVJ anomalies are less frequent entities [11]. Various studies have also supported our finding [12-15].

We reported BI in majority (69%) of the study subjects, followed by AOA (42.9%), PTB (21.4%), OSD (4.8%) and OT (2.4%). They were also found in combinations as well. The common combination was BI+AOA in 23.8% of participants followed by BI+PTB (7.1%) and BI+AOA+PTB (4.8%). Onkar et al., also reported BI in most of their patients i.e. in 23.8% of the total subjects followed by AOA (19.04%), OT (6.34%), PTB (3.1%) and OSD (1.58%) as far as single entity was concerned. They also found anomalies in combination with BI + AOA in 26.6%. However, they haven't found any other associations of BI+AOA+PTB and BI + PTB. Other combined anomalies reported by them were BI+AOA+OCH (13.3%), BI+AOA+PP (13.3%) and BI+CAAA+PP (13.3%) [16].

Singh et al., also evidenced BI in most of the subjects (73%) followed by AOA (65%), OSD (15%), PTB(7.6%) and OT (7.6%). They also observed combined anomalies with BI + AOA in 50% and BI + PTB in 7.6% of the total subjects. Further, they noted BI+AAD in 42.3%, AAD+AOA in 42.3%, BI+BV in 38.4%, BI+AOA+AAD in34.6%,OO+AAD in 11.5%, and OH+AAD in 11.5% of the total subjects [17].

In a study in Turkey done by Mwang'ombe et al., the most common type of lesions were basilar impression (48%) followed by atlanto-axial dislocation (28%) and occipitalization of the atlas (28%) [18]. In other studies elsewhere basilar impression either in isolation or in association with other malformations was observed in 80% of the patients and occipitalization of the atlas was seen in 30% of the patients [19].

On comparison of CT and MRI findings among CVJ abnormalities in our study, it was found that the mean distance of dens from McRae's line in CT was 2.85 ± 1.35 mm and in MRI was 2.93 ± 1.4 mm. p>0.05 indicates that there is no significant difference between means of distance in CT and MRI. Marathe, et al., (2019) from Mumbai 94 evidenced comparatively higher mean distance between the tip of the dens and McRae line was 4.67 ± 1.69 mm on CT scan with a range of 1.212–9.347 mm [20].

In our study it was found that the mean Welcher Basal angle in CT was 130.03±9.84º and in MRI was 130.14±9.88º. p>0.05 indicates that there is no significant difference between means of WBA in CT and MRI. Gupta et al., (2011) noticed the mean BA in their study was 130.24 degree (SD = 4.4) on CT [21]. Using MRI and the same anatomical, Koenigsberg and colleagues assessed the normal basal angle of 200 individuals and found a mean value of 129° 6° [22]. In a cohort of 33 asymptomatic patients, Botelho and Ferreira found on MRI that the BA ranged from 107° to 132° (mean 119° 7.1°).

In our study, it was found that the mean clivus canal angle in CT was 134.61 ± 12.69º and in MRI was 134.38 ± 12.81º. p>0.05 indicates that there is no significant difference between means of CCA in CT and MRI. In a 92 craniocervical junction malformation investigation using MRI, Botelho and Ferreira evaluated the clivus canal angle in 33 asymptomatic individuals employed as controls. The study's mean CCA, which ranged from 129° to 179°, was 148° 9.8° [23]. On MRI, Raveendranath et al. JIPMER, found that the mean clival angle was larger in men than in females, at 157° and 155°, respectively. [24].

In our study it was found that the mean Boogards angle (BA) in CT was 140.55 ± 15.79º and in MRI was 140.40 ± 15.70º. p>0.05 indicates that there is no significant difference between means of BA in CT and MRI. Raveendranath et al., (2022), reported the mean value of Boogaard's angle in males and females was 120°and 121°, respectively on MRI scan**.**

As per our study, mean AP diameter of foramen magnum was found to be 33.96 ± 1.39 mm in CT and 33.47 ± 2.23 mm in MRI. Similarly, the observed mean transverse diameter of foramen magnum by CT scan was found to be 29.30 ± 2.58mm and by MRI was found to be 29.26 ± 2.55 mm. No significant difference exists (p0.05 indicates that there is no significant difference between means of CL in CT and MRI). Heiss et al. reported that the mean clivus length in 18 normal patients was 43.2 ± 3.5 mm on CT [25]. Gupta et al. reported the mean CL was 44.91 mm with SD of 4.34 mm on CT, which was higher than the mean observed in our study.

On comparison of CT and MRI findings among CVJ abnormalities in our study, it was found that the mean distance of dens from McRae's line in CT was 2.85 ± 1.35 mm and in MRI was 2.93 ± 1.4 mm. p>0.05 indicates that there is no significant difference between means of distance in CT and MRI. Marathe, et al., (2019) from Mumbai 94 evidenced comparatively higher mean distance between the tip of the dens and McRae line was 4.67 ± 1.69 mm on CT scan with a range of 1.212–9.347 mm [20]. As per current study, 69% of subjects found dens above McRae's line both in CT and MRI.

Our study had certain limitations, first, this study was a facility-based study which is not representative of the population. Additionally, CVJ craniometry may be influenced by many other factors, such as patient race, sex, age, and height, among others.

CONCLUSIONS

We observed that the incidence of CVJ anomalies in asymptomatic participants was found to be 10.98 per 1000 people, detected on CT. Basilar invagination (BI) was the most common CVJ found in our study. The most common combination of developmental anomalies found basilar invagination (BI)+atlanto-occipital assimilation (AOA). CT and MRI comparison of CVJ parameters were made showing no significant differences however, cord evaluation was better by MRI. As CT was found more accurate in bony evaluation of craniovertebral junction and MRI is preferred for soft tissue evaluation including ligaments and cord, multimodality approach is recommended for complete evaluation of craniovertebral junction anomalies.

REFERENCES

1. Chen YF, Liu HM. (2009). Imaging of craniovertebral junction. Neuroimaging Clinics. 19(3):483-510.
2. Lopez AJ, Scheer JK, Leibl KE, Smith ZA, Dlouhy BJ, Dahdaleh NS. (2015). Anatomy and biomechanics of the craniovertebral junction. Neurosurgical focus. 38(4):E2.
3. Von Torklus D. (1972). The upper cervical spine, regional anatomy, pathology and traumatology. A Systemic Radiological Atlas and Text Book.
4. Kwong Y, Rao N, Latief K. (2011). Craniometric measurements in the assessment of craniovertebral settling: are they still relevant in the age of cross-sectional imaging? *American Journal of Roentgenology*. 196(4):W421-5.
5. Cronin CG, Lohan DG, Mhuircheartigh JN, Meehan CP, Murphy J, Roche C. (2009). CT evaluation of Chamberlain's, McGregor's, and McRae's skull-base lines. *Clinical radiology*. 64(1):64-9.
6. KAWAIDA H, SAKOU T, MORIZONO Y. (1989). Vertical Settling in Rheumatoid Arthritis: Diagnostic Value of the Ranawat and Redlund-Johnell Methods. *Clinical Orthopaedics and Related Research* (1976-2007). 239:128-35.
7. Smoker WR, Khanna G. (2008). Imaging the craniocervical junction. Child's Nervous System. 24:1123-45.
8. Bahşi I, Orhan M, Kervancıoğlu P, Yalçın ED, Aktan AM. (2019). Anatomical evaluation of nasopalatine canal on cone beam computed tomography images. Folia morphologica. 78(1):153-62.
9. Hirunpat S, Wimolsiri N, Sanghan N. (2017). Normal value of skull base angle using the modified magnetic resonance ımaging technique in Thai population. *J Oral Health Craniofac Sci*. 2:017-21.
10. Batista UC, Joaquim AF, Fernandes YB, Mathias RN, Ghizoni E, Tedeschi H. (2015). Computed tomography evaluation of the normal craniocervical junction craniometry in 100 asymptomatic patients. Neurosurgical focus. 38(4):E5.
11. Dash C, Singla R, Agarwal M, Kumar A, Kumar H, Mishra S, Sharma BS. (2018). Craniovertebral junction evaluation by computed tomography in asymptomatic individuals in the Indian population. Neurology India. 66(3):797.
12. Lofrese G, Federico De Iure F, Cappuccio M, Amendola L. (2015). Occipital condyles congenital dislocation and condylus tertius: an unstable association revealing a new abnormality of the craniocervical junction. Spine. 40(17):E992-5.
13. Garg K, Tandon V, Kumar R, Chandra PS, Kale SS, Sharma BS, Mahapatra AK. (2022). Craniovertebral Junction Anomalies: An Overlooked Cause of' Posterior Circulation Stroke'. Neurology India. 70(8):149.
14. SR C, CA S. (2014). Basilar Imagination: A Rare Cause of" Top of Basilar Artery" Syndrome. *National Journal of Integrated Research in Medicine*. 5(3).
15. Saccheri P, Travan L. (2022). The craniovertebral junction, between osseous variants and abnormalities: insight from a paleo-osteological study. *Anatomical Science International*. 1-6.
16. Onkar D, Ratnaparkhi C, Onkar P. (2019). Evaluation of congenital anomalies of craniovertebral junction by computed tomography and its embryological basis. *Indian Journal of Clinical Anatomy and Physiology*. 6(2):148-52.
17. Singh R, Yadav P, Jain R. (2021). Congenital craniovertebral junction anomalies on x- ray and its correlation with multidetector computed tomography. *Paripex Ind J of Research March*. 10(03):182-185.
18. Mwang'ombe NJ, Kirongo GK. (2000). Craniovertebral juction anomalies seen at Kenyatta National Hospital, Nairobi. *East African medical journal*. 77(3).
19. Schmidt EH, Sator K. (1978). Bone malformations of the Craniocervical region in "Handbook of clinical Neurology". E.d P.J. Vinken and G.N. Bruyn. Pub.- E. Servier/North Holland. *Biomedical press*. p180.
20. Marathe NA, Dahapute AA, Desai JR, Dhole KP, Bhaladhare S, Shah S. (2019). X-ray and computed tomography scan-based morphometric analysis of skull baseline in Indian population. Asian J Neurosurg [Internet]. 14(4):1116–21
21. Gupta PP, Dhok AM, Shaikh ST, et al. (2020). Computed Tomography Evaluation of Craniovertebral Junction in Asymptomatic Central Rural Indian Population. *Journal of Neurosciences in Rural Practice*. 11(3):442-447.
22. Koenigsberg RA, Vakil N, Hong TA, Htaik T, Faerber E, Maiorano T, Dua M, Faro S, Gonzales C. (2005). Evaluation of platybasia with MR imaging. *American journal of neuroradiology*. 26(1):89-92.
23. Botelho RV, Ferreira ED. (2013). Angular craniometry in craniocervical junction malformation. *Neurosurg Rev*. 36(4):603–610.
24. Raveendranath V, Dash PK, Kavitha T, Swathi S. (2022). Skull base angle morphometry in South Indian population with review on terminology. *Ind J Neurosurg* [Internet]. 11(02):136-9.
25. Heiss JD, Suffredini G, Bakhtian KD, Sarntinoranont M, (2012). Oldfield EH: Normalization of hindbrain morphology after decompression of Chiari malformation Type I. *J Neurosurg* 117:942–946.