MORPHOMETRIC STUDY OF OCCIPITAL CONDYLES IN ADULT DRY HUMAN SKULLS OF RAJASTHAN POPULATION

Anatomy

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ABSTRACT

BACKGROUND: Skull is the most complex osseous structure in the body. Foramen magnum (FM) is an important landmark of the base of the skull. Anteriorly on each side of FM oval occipital condyles are present. The occipital condyles project downwards to articulate with the superior articular facets on lateral masses of the atlas vertebra to form synovial atlanto-occipital joint. Understanding the anatomy of the occipital condyles is important for different approaches.

OBJECTIVE: The present study aims to morphometric analysis of occipital condyles and foramen magnum and its importance in transcondylar approach.

MATERIAL AND METHODS: The present study was carried out on **75 dry human skulls of unknown** age and sex from Rajasthan population from the department of **Mahatma Gandhi Medical College Jaipur, Rajasthan.**

All the measurements were taken with the help of digital vernier calipers.

RESULTS : The mean value of anterior intercondylar distance was 21.50mm and posterior intercondylar was 38.99mm. The mean antero-posterior diameter was 35.11 ± 3.12 mm and transverse diameter was 29.35 ± 3.48 mm.

CONCLUSION : The occipital condyles form the lateral limits of the cranio-vertebral junction. The configuration and orientation of the occipital condyles, as well as the location of the intracranial and extracranial orifices of hypoglossal canal may affect the lateral approaches to the cranio-vertebral junction.

KEYWORDS

Foramen Magnum, Occipital Condyles, Cranio-vertebral Junction.

INTRODUCTION

The Foramen Magnum(FM) is a large opening (Latin: great hole) in the base of the skull. Foramen Magnum is an important landmark of the base of skull and is of particular interest for Anthropologists, Anatomists, Forensic Medicine, Neurosurgeons and Radiologists. The FM is surrounded by different parts of the occipital bone that is two condylar parts, squamous part and occipital part. The squamous part lies behind and above, basilar part in front and a condylar part on either side.¹

BORDER OF FM:

The anterior border of FM is formed by basilar process of the occipital bone, the lateral border by left and right ex-occipitalis and posterior border is formed by the supraoccipital part of the occipital bone.² Anteriorly on each side of FM oval occipital condyles are present. Hence the FM is narrow anteriorly. The occipital condyles project downwards to articulate with the superior articular facets on lateral masses of the first cervical vertebra (atlas) to form synovial atlanto-occipital joint. OCs obliquely placed so that anterior end is nearer to median plane than the posterior end. Above the anterior part of the occipital condyle hypoglossal canal lies which transmit hypoglossal nerve, meningeal branch of ascending pharyngeal artery.³ The anterior edge of the FM is slightly thickened and lies between the anterior ends of both the condyles. The posterior half of FM lying beyond the posterior ends of occipital condyles is thin and semicircular. The upper ends of anterior and posterior atlanto-occipital membranes are attached to the foramen magnum at its anterior and posterior margins respectively. and their lower ends are attached to the superior surface of anterior and posterior arch of the atlas respectively.⁴ The foramen magnum is a wide communication between the posterior cranial fossa and the vertebral canal. Alar ligament of dens divides the foramen into anterior "**Osseo-ligamentous compartment**" and posterior "**Neurovascular compartment**". Upper fasciculus of the cruciate ligament and membrana tectoria; both are attached to the upper surface of basioccipital bone in front of the FM.

Its wide posterior part contains the medulla oblongata and its meninges. In subarachnoid space, spinal rami of the accessory nerve and vertebral arteries with their sympathetic plexus ascend into the cranium.

The posterior spinal arteries descend posterolateral to the brain stem, whereas the anterior spinal artery descends anteromedian to the brain stem. The cerebellar tonsils may project into the foramen magnum.⁵

The dimensions of the foramen magnum are clinically important because the above mentioned vital structures passing through it may endure compression such as in cases of foramen magnum herniation, FM meningiomas and FM achondroplasia. Transverse diameter of FM will be increased in Arnold chiari syndrome.^{6,7,8}

MATERIAL AND METHODS

The study was conducted on 75 adult dry human skulls of unknown age and sex from Rajasthan population from the Departments of Anatomy of Mahatma Gandhi Medical College, Jaipur and Sawai Man Singh Medical College, Jaipur.

All the measurements were taken with the help of digital vernier calipers.

1. **Antero-Posterior Diameter (APD)** - It is the distance between Basion (midpoint of the anterior margin of the FM) and Opisthion (midpoint of the posterior margin of the FM) **Figure 1**

Figure-1: Antero-Posterior Diameter

Figure-2: Transverse Diameter

2. **Transverse Diameters (TD)** - It is the distance between the lateral margins of the FM at the point of greatest lateral curvature

Figure 2.

3. **Intercondylar Distance (ICD)** –It is the distance between two points, taken on each medial margin of the occipital condyles (Ocs).
- a) At the level of the anterior most point of OCs (E-F) **Figure-3,4.**
- b) At the level of the posterior most point of OCs (G-H) **Figure-3,5.**

Figure-3: AICD(E-F) and PICD (G-H) **Figure-7: Anterior intercondylar distance** **Figure-8: Posterior intercondylar****RESULT**

- The mean antero-posterior diameter was 35.11 ± 3.12 mm. The maximum antero-posterior diameter was 43.14 mm and minimum antero-posterior diameter was 27.01 mm observed (table-1).
- The mean transverse diameter was observed to be 29.35 ± 3.46 mm. The maximum transverse diameter was 38.11 mm and minimum transverse diameter was 25.49 mm (table-1).

Table-1 : Antero-Posterior and Transverse Diameter

Parameter	APD (mm)	TD (mm)
Minimum	27.01	25.49
Maximum	43.14	38.11
Mean	35.11	29.35
Standard Deviation	3.12	3.48

TABLE-3: Antero-posterior and Transverse diameter of Foramen Magnum of Ethnic groups.

Authors	Year	Population	N	Sex	APD $\pm$ S.D. (mm)	TD $\pm$ S.D. (mm)
Olivier et al (1)	1975	French	125	-	35.7 $\pm$ 2.72	30.34 $\pm$ 2.15
Mursed et al (9)	2003	Turkish	110	-	35.9 $\pm$ 3.29	30.4 $\pm$ 2.59
Suazo GIC et al (10)	2009	Brazil	211	Male	36.5 $\pm$ 2.6	30.6 $\pm$ 2.5

- The mean value of anterior intercondylar distance (AICD) was observed 21.50 ± 2.62 mm. The maximum value of AICD was 26.74 mm and minimum AICD was 12.13 mm (table-2).
- The mean value of posterior intercondylar distance (PICD) was observed 38.99 ± 3.03 mm. The maximum PICD was 44.94 mm and Minimum PICD was 32.44 mm (Table-2).

Table-2: Anterior Intercondylar Distance and Posterior Intercondylar Distance

Parameter	AICD (mm)	PICD (mm)
Minimum	12.13	32.44
Maximum	26.74	44.94
Mean	21.50	38.99
Standard Deviation	2.62	3.03

DISCUSSION:

Mean antero-posterior diameter observed in the present study was **35.11 mm** which is comparable to the study of Ethnic researchers Olivier et al (1975), Sentemir et al (1994), Mursed et al (2013), SuazoGIC et al (2009), Monoel et al (2009), Lyrtizis et al (2016). They observed the mean value of antero-posterior diameter is 35.7 mm, 35.6 mm, 35.9 mm, 35.6 mm (in female), 35.7 mm (in male) & 35.1 mm (in female) and 35.05 mm respectively (table-3).

Mean transverse diameter was reported **29.35 mm** in the present study which is similar to findings of Ethnic researchers Sendemir et al (1994), SuazoGIC et al (2009), Monoel et al (2009), EmelAVCI et al (2010), Kumar A et al (2015), Lyrtizis et al (2016), Pires LAS et al (2017), Pelimllhan et al (2018) that is 29.5 mm, 29.5 mm (in female), 29.4 mm, 29 mm, 29.49 mm (In female), 30.19 mm, 28.62 mm, 29.73 mm respectively (table-3).

Mean antero-posterior diameter and transverse diameter were highest reported **47.1 mm** and **43.6 mm** respectively by Farid SA et al (2018) in Egyptian population.

Mean antero-posterior diameter and transverse diameter were least reported **31 mm** and **27 mm** respectively by Tubbs RS et al (2011) in Spanish population.

Mean antero-posterior diameter observed in the present study was **35.11 mm** which is comparable to Indian researchers Kanchan T et al (2013), Radhika PM et al (2014), Sahoo S et al (2015), Rohinidevi M et al (2016), Arora S et al (2017), Sampada PK et al (2017), Veeramani et al (2018), FeridozJ et al (2018). They observed the mean value of antero-posterior diameter is 34.51 mm, 35.30 mm, 35.30 mm, 34.80 mm, 35.42 mm, 34.84 mm, 35.23 mm (in female), 35 mm respectively.

Mean transverse diameter was reported **29.35 mm** in the present study which is similar to findings of Indian researchers Radharkrishna et al (2012), Jain SK et al (2013), ShepurMP et al (2014), Radhika PM et al (2014), Vedanayagam et al (2015), Saini K et al (2015), Sahoo S et al (2015), Riyaz et al (2015), RohinideviM et al (2016), SampadaPK et al (2017), Mishra AK et al (2018), FeridozJ et al (2018) that is 28.63 mm, 29.5 mm (in female), 28.50 mm (in male), 29.49 mm, 28.5 mm, 29.39 mm, 28.22 mm, 29.4 mm respectively.

Mean antero-posterior diameter and transverse diameter were highest reported **38.22 mm** and **35.15 mm** by Fathima et al (2016) respectively. Mean antero-posterior diameter was least reported **18.4 mm** and **17.6 mm** in male and female respectively by Vedanayagam et al (2015).

Mean transvers diameter was least reported **22.5 mm** and **20.4 mm** in male and female respectively by Rasthava A et al (2015).

In the present study anterior intercondylar distance (AICD) was seen **21.50 mm** which is comparable with the study of Naderi et al (2004), Tale AK et al (2016) and Lyrtizis et al (2016) but least reported by Bayat et al (2014).

In the present study posterior intercondylar distance (PICD) was seen **38.99 mm** which is comparable with the study of Divya P et al (2017).

				Female	35.6±2.5	29.5±1.9
Monoel et al (11)	2009	Brazil	215	Male	35.7±0.29	30.3±0.20
				Female	35.1±0.33	29.4±0.23
Gruber et al (12)	2009	Europe	348	-	36.6±2.8	31.1±2.7
Tubbs RS et al (13)	2011	Spanish	13	-	31	27
Kumar A et al (14)	2015	USA	36	Male	36.78±0.0.35	30.05±0.54
				Female	33.22±0.49	29.49±0.4
Lytzizis et al (15)	2016	Greek	141		35.05±2.57	30.19±2.69
Pires LAS et al (16)	2017	Brazil	77		34.23±2.54	28.62±2.83
Chovalopoulou ME et al (17)	2017	Greece	154	Male	36.69±2.47	32.48±2.70
				Female	34.87±2.41	30.62±2.18
Farid SA et al (18)	2018	Egyptian	75		47.1±0.3.4	43.6±2.5
PelinIlhan et al (19)	2018	Turkish	100		35.18±2.94	29.73±2.54
Present study	2019	Rajasthan	75	-	35.11±3.12	29.35±3.46

N= no. of skulls studied

Table-4: Antero-posterior and Transverse diameter of Foramen Magnum of Indian population.

Authors	Year	Population	N	Sex	APD±S.D. (mm)	TD±S.D. (mm)
Muthukumar et al (20)	2005	Madurai	110	-	33.3	27.9
Mahajan D et al (21)	2011	Chandigarh	126	-	32.83±2.62	27.47±2.25
Radhkrishna et al (22)	2012	Mangalore	100	-	34.04±2.36	28.63±1.89
Chethan P et al (23)	2012	Mangalore	53	-	31±2.4	25.2±2.4
Jain SK et al (24)	2013	Moradabad (North Indian)	68	Male	36.9±0.2	31.5±0.27
				Female	32.9±0.3	29.5±0.28
Kanchan T et al (25)	2013	Mangalore	118	Male	34.51±2.77	33.60±2.63
				Female	27.36±2.09	26.74±2.36
Patel R et al (26)	2014	Surat	100	-	42.2	28.29
Shepur MP et al (27)	2014	Karnataka	150	Male	33.40±2.60	28.50±2.20
				Female	33.10±2.70	27.30±2.00
Radhika PM et al (28)	2014	Bangalore	150	-	35.30±2.7	29.49±2.6
Ganapathy et al (29)	2014	Pondicherry	100		33.9	28.7
Vedanayagam et al (30)	2015	Chennai	420	Male	18.4±0.7	28.2±0.6
				Female	17.6±1.0	21.8±0.7
Rathva A et al (31)	2015	Gujarat	210	Male	33.5±0.45	22.5±0.20
				Female	31.0±0.30	20.4±0.15
Sahoo S et al (32)	2015	Orissa	150		35.30±2.709	29.49±2.572
Riyaz et al (33)	2015	Maharashtra	61		33.4±2.5	28.5±2.2
Khanday et al (34)	2016	Chennai	60		36.8	30.9
Jasuja VR et al (35)	2016	Mumbai	100		34.13±2.73	27.82±3.32
Fathima et al (36)	2016	Chennai	53		38.22	35.15
Rohinidevi M et al (37)	2016	Tamilnadu	35		34.80	28.5
Naqshi et al (38)	2017	Shrinagar	25		31.6±0.21	26.5±0.21
Singh KC et al (39)	2017	Varanasi	50		33.76±2.18	28.09±1.92
Rajkumar et al (40)	2017	Rajasthan	298		33.98±2.75	28.16±2.15
Remya et al (41)	2017	Mangalore	50		33.64±0.228	27.04±0.214
Arora S et al (42)	2017	Bareilly	40		35.42±3.22	27.90±2.58
Sampada PK et al (43)	2017	Karnataka	100		34.84±2.32	29.391.73
Veeramani et al (44)	2018	Puducherry	100	Male	37.0.3±0.3	33±0.23
				Female	35.23±0.23	32±0.43
Ashwini C et al (45)	2018	Karnataka	162		33±1.4	27±1.6
Mishra AK et al (46)	2018	Lucknow	71		34.09±2.33	28.22±2.19
Raikar et al (47)	2018	Bengaluru	150		34.19±3.57	31.77±3.59
Feridoz J et al (48)	2018	Chennai	50		35±2.8	29.4±2.9
Present study	2019	Rajasthan	75	-	35.11±3.12	29.35±3.46

N= no. of skulls studied

Table:8 Anterior and Posterior Intercondylar Distance

Authors	Year	Population	N	Sex	AICD	PICD
Naderi et al (49)	2004	Turkish	202	-	21.0±2.8	41.6±2.9
Bayat et al (50)	2014	Iranian	46	-	15.39±7.99	35.60±8.4
Sahoo S et al (32)	2015	Orissa	150	-	20.31±3.43	41.17±3.75
Tale AK et al (51)	2016	Indian	100	-	21.28±3.03	40.61±3.34
Lytzizis et al (15)	2016	Greece	141	Male	21.17±2.71	43.36±3.35
				Female	20.05±2.45	41.23±3.30
Jasuja et al (35)	2016	Mumbai	100	-	18.59±2.96	-
Divya P et al (52)	2017	Mangaluru	55	-	19.2±0.17	39.3±0.28
Dubey A et al (53)	2017	Sagar	80	Male	18.11±2.19	-
				Female	18.77±1.97	-
Arora S et al (42)	2017	Bareilly	40	-	17.25±1.91	30.66±1.97
Ashwini et al (45)	2018	Karnataka	162	-	15.78±1.26	31.63±2.93

Farid et al (18)	2018	Egyptian	75	-	18.97±2.03	38.39±4.4
Present study	2019	Rajasthan	75	-	21.50±2.62	38.99±3.03

N= no. of skulls studied

CONCLUSION

The occipital condyles form the lateral limits of the cranio-vertebral junction. The configuration and orientation of the occipital condyles may affect the posterior and lateral approaches to the cranio-vertebral junction. So the parameters will be helpful in interpreting the neurological investigative procedures and also in planning surgical interventions involving the base of skull.

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