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Original Research Article

A STUDY OF MORPHOMETRY OF SUPERIOR ARTICULAR FACET OF ATLAS AND ITS CLINICAL IMPLICATION IN CENTRAL INDIA

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ABSTRACT

Introduction: The dimensions of superior articular facet of atlas are important in understanding kinematics of craniovertebral joint and also for any kind of surgery in this region. The aims of the present study are to report the metric parameters of superior articular facet and also to study the morphological variations in shape, constrictions and separation of facets.

Material and Methods: 50 adult human dry atlas vertebra from central India were studied.

Results: The anteroposterior diameter of superior articular facet was found to be 21.33mm 0n right side and 21.37mm on left side, the Transverse diameter was found to be 11.53mm on right side and 11.72mm on left side. Surface area of Superior articular facet was found to be 164.34mm on right side and 165.28mm on left side. Tendency of complete separation of the facets was seen in 2(4%) cases. Oval shape was found to be the dominant shape in 31(31%) cases followed by dumb-bell shape in 24(24%) cases, kidney shape in18(18%) cases and figure of 8 shape in 13(13%) cases.

Conclusion: The detail study of dimensions, shape , surface area of superior articular facet of atlas are useful in internal fixation techniques for craniovertebral junction abnormalities . The knowledge of the dimensions can help in safe planning of these surgeries. This study will be useful for the anatomists, forensic experts, physical anthropologists, radiologists, neurosurgeons, orthopedic surgeons.

KEY WORDS: Superior articular facet, Atlas vertebra, Transarticular screw.

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INTRODUCTION

The atlas (C1) is the first cervical vertebra which supports the globe of the head [1]. The first cervical vertebra is named after the Greek God

who carried the world on his shoulders. The atlas does not look like a typical vertebra with its ring like structure and absence of body. It consists of two symmetrical lateral masses that are united by anterior and posterior arches. These laterals masses consist of superior and inferior articular surfaces [2].

Superior Articular Facet (SAF) is present on atlas vertebra on upper surface of lateral mass lying obliquely. Facets are usually concave, with concavity in both longitudinal and transverse directions but more marked in the former. In the long and deeply concave facets the anterior part may face backwards and the posterior forwards in addition to the general direction,i.e. upwards and medial .The facets form an atlanto occipital joint with occipital condyles and this joint is responsible for nodding movements [3].

The description of the superior articular facet of the atlas vertebra, as has been found in the most of the text books of anatomy, makes no mention of its variations [3]. Literature has revealed marked variations in the shape, symmetry, partial or complete separations of the facets and constrictions of superior articular facets of the atlas [1,3,5].

The complex structure of the cranio-vertebral junction plays a significant role in global kinematics of the cervical spine to maintain head in upright posture [4]. As a result of prolonged inappropriate posture the atlantooccipital joint may undergo strain which may induce a tension like headache. Craniovertebral junction abnormalities may lead to hyper mobility of atlantooccipital joint and consequent neurological and vascular symptoms. Alterations in the morphometry of superior articular facet will alter the kinematics of the joint, leading to restricted movements [6].

The instability of the cervical spine can be caused by various traumatic and non-traumatic conditions which requires internal fixation. Recently transarticular and transpedicular screw fixation methods have been widely used [7].

For the locations of points of screw insertion on the SAF the knowledge of its dimensions is necessary [8]. So this study was undertaken to study the morphometric parameters of superior articular facet.

Objectives of the Study: measuring the anteroposterior and transverse diameters of superior articular facet of atlas vertebra, note the number, shape and size of superior articular facets of atlas vertebra and also to measure the surface area of superior articular facet of atlas vertebra.

MATERIALS AND METHODS

Fifty atlas vertebrae, from the Department of Anatomy, Government Medical College, Nagpur, were studied. The specimens selected were dry, complete, human cadaveric vertebrae of Indian origin. Vertebrae with gross vertebral pathology were excluded. Anteroposterior and transverse diameter diameters of superior articular facet of atlas vertebra were taken with the help of electronic Vernier Caliper (Fig. 1). All the measurements were recorded bilaterally, in millimeters. The measured data was statistically analyzed.

To measure the surface area, the impression of the articular facet was taken on the silver foil paper by placing and pressing the silver foil paper on each superior articular facet of atlas vertebrae. The margins of the facets were demarcated and impression of the facet was cut along the demarcated margin of the articular facet. The cut impression was placed on the graph paper in millimeter scale and the impression of the articular facet was drawn on the graph paper. Then the total surface area of each impression of the articular facet was calculated by method as suggested by Yogesh et al [9].

RESULTS

In the 50 atlas vertebra, superior articular facets were studied for Anteroposterior diameter, Transverse diameter. The mean for Anteroposterior diameter, Transverse diameter were calculated. Presence of constriction, grooves, tendency of complete separation of facets, also the different shapes of superior articular facets were also studied. The percentage was calculated for each parameter and the results were compared with the findings of other workers. (Table 1,2 and 3).

In the present study out of the 50 atlas vertebra

studied 17(34%) facets on the right side and14 (28 %) facets on the left side showed no constriction and these were defined as oval shaped. 18 facets (18%) showed a constriction only on the medial side and were considered as kidney shaped. 24 facets (24%) were found to have a constriction on both the sides, which were defined as dumb-bell shaped and 13 facets (13%) showed a constriction on both the sides along with a groove in the centre of the facet, which were considered as the 'figure of 8' shape (Table 7). Complete separation was seen in 2 facets (4%) on both sides and in 3(6%) facets on the left side, 2(4%) facets on left side (Table 3).

Fig. 1: Atlas vertebra- Superior view. a – b = Maximum anteroposterior diameter of superior articular facet. d – c = Maximum transverse diameter of the superior articular facets.

Fig. 2: Atlas vertebra showing both sides oval facets.

Fig. 3: Atlas vertebra- showing both sides complete separation of the facets.

Fig. 4: Atlas vertebra- showing dumbbell facet on right side and leaf shaped facet on left side.

Fig. 5: Atlas vertebra- showing Kidney shaped facets on both sides.

Fig. 6: Atlas vertebra- showing figure 8 facet on right side and kidney shaped facet on left side.

Table 1: Dimensions of Superior articular facet of atlas.

Dimensions	Range (mm)		Mean(mm)		P value
	Right	Left	Right	Left	
Anteroposterior diameter of Superior articular facet	16.75-25.26	16.31-25.35	21.33	21.37	N.S (P>0.05)
Transverse diameter of Superior articular facet	6.24-12.60	6.54- 12.74	11.53	11.72	N.S (P>0.05)
Surface area of Superior articular facet	120.56-220.38	115.32-230.14	164.34	165.28	N.S (P>0.05)

Table 2: Presence of constrictions on the superior articular facet.

Side of facets	No constriction	Constriction on medial side only	Constriction on lateral side only	Constriction on both sides	Total
Left facet	14 (28 %)	10(20%)	8(16 %)	18(36 %)	50
Right facet	17(34%)	8(16 %)	6(12 %)	19(38 %)	50

Table 3: Tendency of complete separation in Superior articular facet of atlas.

Tendency to complete separation	Left facet only	Right facet only	Both facets
Presence	2(4 %)	3 (6 %)	2 (4 %)
Absence	48(96 %)	47(94 %)	48 (96 %)

DISCUSSION

In the present study the anteroposterior diameter of superior articular facet of atlas was found to be 21.33mm on the right side and 21.37mm on the left side. There was no statistically significant difference in the the anteroposterior diameter of superior articular facet of left side and right side. The dimensions have been compared with that of other workers (Table 4). While Sengul et al [12] has reported lower dimensions, findings of Konig et al [11] and Gomez Olivencia et al [13] show higher values. Our findings are comparable to that of Kaur et al [8] and Gosavi et al [14]. Wood-jones F [15] observed that dimensions of Europeans are larger in comparison to other races. In the present study most of the parameters observed on Indian subjects are shorter than that of the European studies. These differences in the findings can be attributed to racial variations.

Table 4: Comparison of Antero-Posterior Diameter of Superior Articular Facet of atlas.

Author	Origin	Dimensions(mm)	
		Right	Left
Gupta et al [10]	Indian	21.5	21.8
Konig et al [11]	German	22.7 ± 3.0	22.8 ± 4.2
Sengul et al [12]	Turkish	19.9 ± 3.4	18.6 ± 3.2
Gomez olivencia et al [13]	Spanish	23.7 ± 1.8	23.5 ± 1.7
Kaur et al [8]	Indian	21.52 ±	21.51 ±
Gosavi et al [14]	Indian	21.24	21.02
Present study	Central India	21.33	21.37

In our study the transverse diameter of superior articular facet of atlas was found to be 11.53mm on the right side and 11.72mm on the left side. There was no statistically significant difference in the dimensions of two sidesThe findings are similar to most of the previous studies (Table 5). The observations made by Sengul et al [12] and Gomez-Olivencia et al. [13] are lower than our study. Transarticular screw fixation has become one of the primary treatment options for cervical spine instability. The knowledge of the Anteroposterior and transverse dimensions of Superior articular facet can help in the safe planning of these screw placements.

Table 5: Comparison of Transverse Diameter of Superior Articular Facet of Atlas.

Author	Origin	Dimensions(mm)	
		Right	Left
Gupta et al [10]	Indian	11.8	11.5
Konig et al [11]	German	11.6 ± 2.0	11.2 ± 1.5
Sengul et al [12]	Turkish	9.6 ± 1.9	9.8 ± 1.5
Gomez Olivencia et al [13]	Spanish	10.4 ± 1.2	10.5 ± 1.0
Gosavi et al [14]	Indian	10.36	10.47
Kaur et al [8]	Indian	11.21 ±1.47	11.32 ± 1.53
Present study	Central India	11.53	11.72

In the present study the surface area of superior articular facet was found to be 164.34mm on the right side and 165.28mm on the left side. The surface area on the left side was more as compared to the right side. Our values are higher as compared to the findings of Manjunath et al. [6] but lower as compared to the findings of Yogesh et al [9]. Knowledge of the surface area of superior articular facet could help head and neck and vascular surgeons during different degrees of operative procedures. Mysorekar and Nandedkar [16] noted that the human beings tend to incline their head to one side more than the other and that may influence the amount of articular surface area on each side of atlas and occipital condyles.

It is seen from Table 8, that the presence of a constriction on the right side facets and left side facets showed a higher value in the present study, as compared to the results recorded by Singh et al. [3] and Lalit et al. [1] whereas constrictions seen on both sides of the facets,

Table 6: Comparison of presence of grooves.

workers	Population	No.	Grooves			
			Absent	Left facet	Right facet	Bilateral facet
Shamer Singh [3]	Varanasi	200	52 (26%)	23 (11.5%)	16 (8%)	109 (54.5%)
Lalit et al [1]	North Indian	30	13 (43.3%)	3 (10%)	3 (10%)	11 (36.6%)
Present study	Central India	50	20 (40%)	6 (12 %)	5 (10%)	19 (38%)

Table 7: Comparative incidence and types of shape of superior articular facet of atlas.

Workers	Population	Constriction					Total
		SAF	Absent	Medial side of facet	lateral side of facet	Both sides of facet	
Shamsher Singh [3]	Varanasi	Right	53 (26 %)	8 (4%)	5 (2.5%)	134(67%)	200
		Left	42(21.0%)	6(3%)	14 (7.0%)	138(69%)	200
Lalit et al [1]	North Indian	Right	10 (33.3 %)	4 (13.2%)	2(6.66%)	14(46.6%)	30
		Left	7(23.3%)	3(10%)	3(10%)	17(56.6%)	30
Present study	Central India	Right	17(34%)	8(16 %)	6(12 %)	19(38 %)	50
		Left	14(28%)	10(20%)	8(16%)	18(36%)	50

Table 8: Comparison of presence of constrictions.

Worker	Population	No.	Shape (SAF)	Right (SAF)	Left (SAF)	Total
Shamer Singh [3]	Varanasi	200	Oval	53(26.5%)	42(21%)	-
			Reniform	13 (6.5%)	20(10%)	-
			Dumb-bell	134(67%)	138(69%)	-
Gupta C et al [10]		35	Oval			42.80%
			Reniform			7.10%
			Figure of eight			31.40%
Lalit et al [1]	North Indian	30	Oval	10(33.3%)	7(23.3%)	17 (56.6%)
			Reniform	6 (20%)	6(20%)	12 (40%)
			Dumb-bell	11 (36.6%)	10 (33.3%)	21 (70%)
			Figure of eight	3 (10%)	7 (23.3%)	10 (33.3%)
Manjunath et al [6]	South Indian	100 sides	Oval			33(33%)
			Reniform			10(10%)
			Figure of eight			18(18%)
			Irregular shape			39(39%)
Present study	Central India	50	Oval	17(34%)	14(28%)	31(31%)
			Reniform	8(16%)	10(20%)	18(18%)
			Dumb-bell	13(26%)	11(22%)	24(24%)
			Figure of eight	6(12%)	7(14%)	13(13%)

in the present study had a lower value as compared to that which was observed by Singh et al. [3] and Lalit et al [1].

As can be evaluated from Table 6, in the present study, no groove was found in 20 cases (40%), thus showing a higher value than that which was reported by Singh et al. [3].

The grooves on the right and left facets were found to be in 5(10%) cases and6(12%) cases respectively , which was comparable with the findings of Lalit et al [1] on the right side facet, but the groove on both the facets was seen in 19 cases (38%), thus carrying a lesser value as compared to the findings of Singh et al [3].

These grooves may give rise to pressure facets which are smooth circular impressions present on the medial sides of the articular surfaces. These pressure facets indicate a greater pressure at these sites during movement at the atlanto occipital joints [3].

Presence of a constriction or a groove or both indicates the tendency of facet to divide into two.

Tendency of complete separation of facets (Table 3) on both sides is seen 2(4%) cases in the present study which show higher values as compared to findings of Singh et al. [3]. The first cervical vertebra is formed by the caudal half of occipital somite 4 and the cranial half of cervical somite 1 [17]. Occasionally the anterior arch is formed by the extension and ultimate union of centres in the lateral masses and sometimes from two lateral centres in the arch itself.

The posterior part of superior articular facet is develop posterior arch. This different embryological development of the two parts of the superior articular facets explains their partial or complete dissociation [18]. The tendency of the Superior articular facet of the atlas to split into two is an indication of the further restriction of the movement at the atlanto-occipital joint [3].

Table 7, depicts the different shapes of the Superior articular facet as was observed by different authors. The present study thus reported the shape of the Superior articular facet in a majority of the cases as a oval shape 31(31%) followed by an dumb-bell (24%), reniform 18(18%) and a figure of eight (F8) 13(13%). Singh et al. [3] reported a combined dumbbell and F8 as the commonest shape and Manjunath et al. [6] reported irregular shape 39(39%) as the commonest shape.

The superior articular facet of the atlas with a different shape i.e an oval kidney, dumb-bell shape, is also an indication of the furthur restriction of the movements at the atlanto-occipital joint [1].

CONCLUSION

The difference between the values of present study and findings of other workers may be due to racial factors, different living conditions or the environment. The detail study of dimensions, shape and surface area of superior articular facet of atlas are useful in internal fixation techniques for craniovertebral junction abnormalities. The knowledge of the dimensions can help in safe planning of these surgeries. This study will be useful for the anatomists, forensic experts, physical anthropologists, radiologists, neurosurgeons, orthopedic surgeons.

Conflicts of Interests: **None**

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