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Original Article

MORPHOMETRIC EVALUATION OF SUPERIOR ARTICULAR FACET AND INFERIOR ARTICULAR FACET IN HUMAN ATLAS VERTEBRAE

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ABSTRACT

Introduction: Trauma and degenerative changes are observed frequently in the cervical column. The first two cervical vertebrae constitute crucial sites for cervico-spinal instability. Accurate surgical intervention in this region requires detailed quantitative analysis of the Atlas and Axis vertebrae. Aim and objectives: To provide baseline data pertaining to morphometric details of SAF & IAF of Atlas vertebra in Indian population. To compare the right and left sided morphometric values. To explore any morphological variations of SAF & IAF of Atlas vertebra.

Materials and methods: 50 human dry Atlas vertebrae were examined in the present study. The study was conducted in the Department of Anatomy, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi.

Results: Mean length of the SAF of Atlas vertebrae on right side was found to be 21.35 mm and 20.27 mm on left side. Mean width of right SAF was 11.48 mm and 11.12 mm on the left side. A statistically significant difference of 0.047 was observed in mean length of SAF of right and left sides of the Atlas vertebrae . Mean length of the IAF of Atlas vertebrae on right side was 15.80 mm and 16.03 mm on left side. Mean width of right IAF side was 15.1 mm whereas 15.05 mm on the left side.

Conclusions: Familiarity with the morphological variations and morphometric details of the first two cervical vertebrae is of paramount significance for Radiologists, Orthopedic surgeons and Neurosurgeons. Precise information pertaining to morphometric details of the first two cervical vertebrae enhances the accuracy of screw fixation and prevents inadvertent injuries to neurovascular structures

Keywords: Atlas, Superior Articular Facet (SAF), Inferior Articular Facet (IAF)

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INTRODUCTION

The Atlas vertebrae may be involved in fractures, dislocation, arthritis, tumours and developmental anomalies. Trans-articular and transpedicular screw fixations have been widely used to correct the instability of the atlantoaxial complex or occipito-cervical junction caused by numerous traumatic and non-traumatic conditions.

Despite the benefits conferred by screw fixation in the cervical column, controversy exists regarding its potential risks. Therefore, a thorough anatomical study of this region in terms of morphometry and biomechanics is mandatory before attempting to treat pathologies of this region.

MATERIALS AND METHODS

The study was conducted in the Department of Anatomy, Vardhman Mahavir Medical College and Safdarjung Hospital, New Delhi. The present study was performed on 50 dry adult human Atlas and Axis vertebrae with a view to elucidate the morphometric details. Bones showing gross deformity or any degenerative changes were excluded from the study. The osteometric evaluation of these two vertebrae was taken by using Digital Vernier Calliper (sensitive to 0.1mm). Statistical analysis of the recorded data was done using SPSS software.

All the Atlas and Axis vertebrae were carefully studied and were discussed in the light of previous literature. The current study also attempted to explore any difference of data between the osseous components of two sides (left and right). It is hoped that the observations of the present study will contribute as an anatomical reference for researchers and clinicians. The observations were noted using the following parameters:

1. SUPERIOR ARTICULAR FACET OF ATLAS VERTEBRA -

(a) Length: Maximum antero-posterior diameter of SAF (Fig. 1).

(b) Width: Maximum transverse diameter of SAF (Fig. 1).

2. INFERIOR ARTICULAR FACET OF ATLAS VERTEBRA -

(a) Length - Maximum antero-posterior diameter of IAF (Fig. 2).

(b) Width - Maximum transverse diameter of IAF (Fig. 2).

The data obtained from the present study were entered in MS Excel and statistical analysis carried out using SPSS version 21. The morphometric values of the two sides were analysed using ‘t’ test and ‘p’ value < 0.05 were considered statistically significant. Mean value, standard deviation and range were taken into consideration while performing statistical analysis.

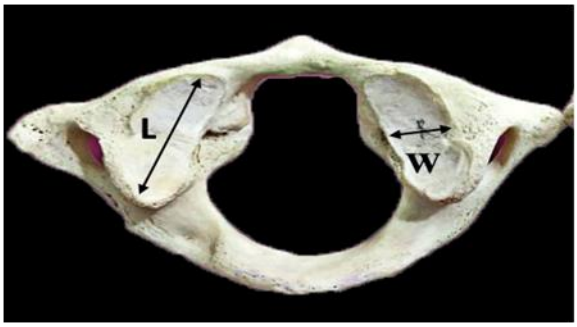

Fig. 1: Length and width of SAF of Atlas vertebra.

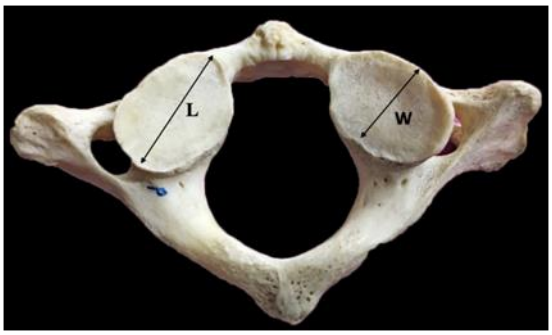

Fig. 2: Length and width of IAF of Atlas vertebra.

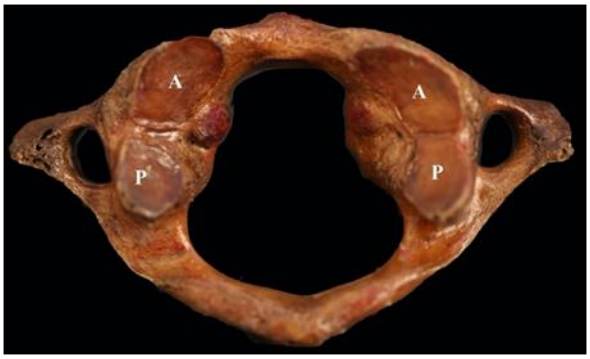

Fig. 3: Division of SAF of Atlas vertebra into anterior (A) and posterior (P) sections.

Fig. 4: Osseous projection emanating from the posterior end of SAF of Atlas vertebra (Marked by arrow).

Fig. 5: Osseous projection emanating from the posterior end of SAF, overriding the groove for vertebral artery on the posterior arch (Marked by arrow).

Fig. 6: Oval shaped facet on left side and kidney shaped facet on right side of the atlas vertebra.

RESULTS

The study was centred at evaluating the morphometric details and exploring the morphological variations of SAF & IAF of Atlas vertebra.

Superior articular facet- It was present bilaterally in all the dry Atlas vertebrae. Most of the vertebrae showed oval shaped facet, few of the facets had constriction only on one side which was considered as a kidney-shaped facet (Fig. 6). Only two vertebrae showed bilateral constrictions, completely divided into anterior and posterior sections by a groove in the centre of the facet (Fig. 3). In one specimen, a small conical projection was detected bilateral emanating from the posterior end of SAF (Fig. 4). No Atlas showed flat superior articular facets.

Morphometric Evaluation - Mean length of the SAF of Atlas vertebrae on right side was found to be 21.35 mm and 20.27 mm on left side. Range of the maximum length of SAF was 16-36mm on right and 14-24.8 mm on left side respectively with p value of 0.0473. Upon comparison of the mean length of SAF of right and left sides of the Atlas vertebrae a statistically significant difference of 0.047 was observed. Mean width of right SAF was 11.48 mm and 11.12 mm on the left side. Range of the maximum width of SAF was 7.3-38 mm on right side and 6.7-24.5 mm on the left side respectively with p value of 0.61. No significant difference was found in mean width of two sides. The morphometric observations on SAF are depicted in Table 1.

Inferior articular facet -The shape of all observed IAF varied from flat, slightly concave, circular and slightly drop shaped facing medially and slightly backwards. Morphometric Evaluation - Mean length of the IAF of Atlas vertebrae on right side was 15.80 mm and 16.03 mm on left side. Range of the maximum length of IAF was 8.7-19.4mm on right and 10.9-21.4 mm on left side respectively with p value of 0.55. Mean width of right IAF side was 15.1 mm whereas 15.05 mm on the left side. Range of the maximum width of IAF was 9-19.2 mm on right side and 9-18.65 mm on the left side respectively with p value of 0.69. No significant statistical difference was found between the two sides with respect to the mean length and width of IAF. The morphometric observations on IAF are depicted in Table 2.

DISCUSSION

The first cervical vertebra, Atlas has different anatomical features as compared to other cervical vertebrae. Atlas vertebra is an important part of bony anatomy of cranio-vertebral junction. The C-1 vertebra has an anterior and a posterior arch, two lateral masses and two wide transverse processes. It consists of a pair of superior articular facets superiorly for occipital condyles and a pair of inferior articulating facets for the second cervical vertebra. Anatomically, the Atlas is embedded in the neck muscles and is

therefore protected from injury. The unique structure and anatomical location of the atlas forms a safety mechanism [1].

Motagi et al [2] noticed that the frequency of irregular shape was 39%, oval shape was 33%, figure of eight was 18% and kidney shape was 10%. According to Motagi et al there were no symmetrical facets in the study and this is in accordance with the present study. Motagi et al also observed that the constrictions in SAF are present in 64% and absent in 36%. According to Motagi et al the frequency of complete separation was 35%, incomplete separation was 23% and separation was absent in 42%. According to Lalit M et al [3] the frequency of oval shape was 28.33%, kidney shape was 20%, dumb bell shape was 35% and the figure of 8 was 16.67%. According to Lalit M et al the separation was absent in 40% and complete separation was present only on the left side with a frequency of 3.3%.

In the present study complete separation was observed only in two vertebrae bilaterally, while majority displayed absence of separation of SAF appearing oval shaped. Some of the specimens exhibited unilateral constriction on medial side of the SAF appearing to be kidney shaped. The current analysis found coincidence with two previous researchers Lalit M et al, Motagi et al and Yogesh et al [4] where they also reported an incidence of complete separation of SAF.

In one specimen, a small conical projection was detected bilateral emanating from the posterior end of SAF (Fig. 4). This osseous projection was seen overriding the groove for vertebral artery on the posterior arch. This finding is in accordance with results by Gupta C et al [5] and Karau, Ogeng'o, Hassanali et al [6] who reported, that atlas bridges, also called ponticles, are bony outgrowths occurring on the atlas vertebra over the third segment of the vertebral artery, converting its groove into a sulcus, incomplete or complete foramen.

The posterior bridge is found dorsal to the lateral mass on the posterior arch of the atlas and when complete, forms the retro-articular canal also called a Kimmerle's variant or arcuate foramen. Cirpan et al [7], Bilodi et al [8], Khanfour et al [9], Schilling et al [10] and Mehta et al [11] also observed similar kind of findings. Lateral bridges, are less common than the posterior and may also exist as complete foramina, called the supratransverse foramina [2]. Supratransverse foramina was also seen by Taitz et al [12].

The mean value of the antero-posterior diameter of the inferior articular facet of right and left side of the present investigation were within the mean range of the previous studies of Gosavi et al [13], Gupta C et al [5], Kaur et al [14] and Rekha BS et al [15]. The mean value of the transverse diameter of the right

Parameters	Mean ± SD (mm) Range = Min - Max (mm)		p value
	Right	Left	
Length	21.35 ± 3.047 16 - 36	20.271 ± 2.289 14 - 24.8	**0.047***
Width	11.48 ± 4.21 7.3 - 38	11.12 ± 2.66 6.7 - 24.5	0.61

Table 1: Morphometric observations on superior articular facet in Dry Atlases

Parameters	Mean ± SD (mm) Range = Min-Max (mm)		p value
	Right	Left	
Length	15.80 ± 1.99 8.7 - 19.4	16.03 ± 1.92 10.9 - 21.4	0.55
Width	15.1 ± 1.75 9 - 19.2	15.05 ± 1.67 9 - 18.65	0.69

Table 2: Morphometric observations on inferior articular facet of Dry Atlases

Author	Right APD Mean (mm)	Left APD Mean (mm)	Right TD Mean (mm)	Left TD Mean (mm)
Sengul et al [6]	19.9±3.4	18.6±3.2	9.6±1.9	9.8±1.5
Gosavi et al [26]	21.24±2.39	21.02±2.52	10.36±1.72	10.47±1.61
Gupta C et al [10]	21.5	21.8	11.8	11.5
Kaur et al [30]	21.52±2.36	21.51±2.07	11.21±1.47	11.32±1.3
Khanfour et al [32]	13.6±1.8	12.7±2	12±0.6	12.1±0.6
Rekha BS et al [9]	22.33±2.14	22.26±2.19	8.74±2.04	9.57±2.33
Present study	21.35±3.047	20.27±2.28	11.48 ± 4.21	11.12±2.66

Table 3: Comparison of various studies on Morphometry of SAF of Atlas vertebrae

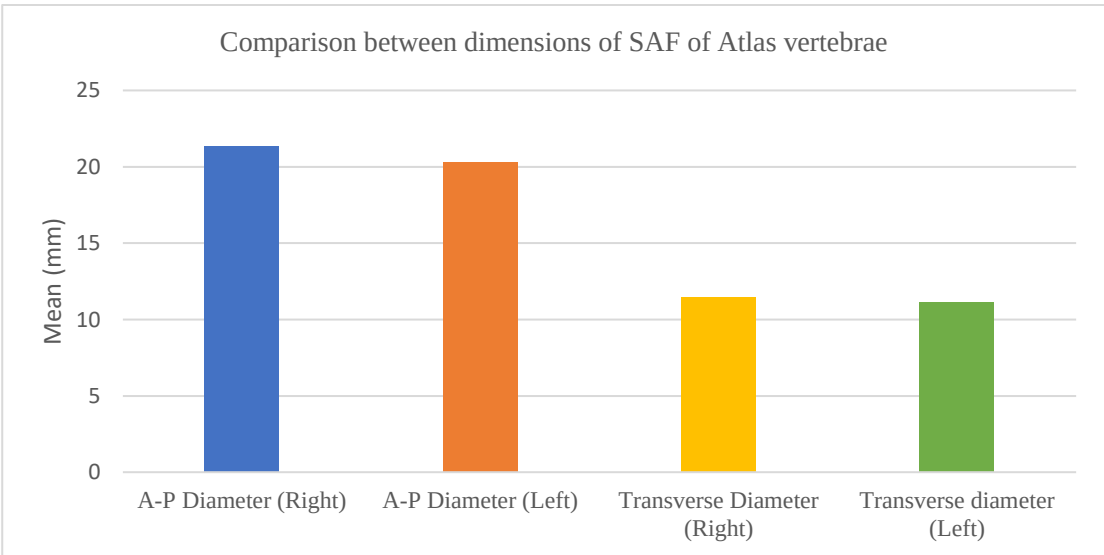

Fig. 7: Dimensions of IAF.

Author	Right APD Mean (mm)	Left APD Mean (mm)	Right TD Mean (mm)	Left TD Mean (mm)
Sengul et al [6]	17.1±2.6	17.5±2.4	---	---
Gosavi et al [26]	16.57±1.91	16.50±1.67	14.01±1.93	14.42±1.67
Gupta C et al [10]	18	17.9	14.6	15.2
Kaur et al [30]	17.54±1.50	17.70±1.60	14.99±1.65	14.94±1.51
Rekha BS et al [9]	17.9±1.61	17.82±2.35	14.84±1.31	14.48±1.80
Present study	15.80 ± 1.99	16.03 ± 1.92	15.1 ± 1.75	15.05 ± 1.67

Table 4: Comparison of various studies on Morphometry of IAF of Atlas vertebra

and left side of the inferior articular facet was within the mean range of the previous studies conducted by, Gosavi et al [13], Gupta C et al [5], Kaur et al [14] and Rekha BS et al [15] (Table 4). Figure 7 shows dimensions of IAF in the present study.

CONCLUSION

Familiarity with the morphological variations and morphometric details of the first two cervical vertebrae is of paramount significance for Radiologists, Orthopaedic surgeons and Neurosurgeons. Precise information pertaining to morphometric details of the first two cervical vertebrae enhances the accuracy of screw fixation and prevents inadvertent injuries to neurovascular structures. The observations of the present study displayed a wide range of dimensions with references to various osseous components of the first two cervical vertebrae and some of the osteometric parameters also exhibited statistically significant difference between right and left sides. Further, discrepancies were also noted on comparison of the present values with those of previous researchers. These discrepancies could possibly be attributed to racial and regional differences.

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