Original Article

Anatomy

Morphological Study of Superior Articular Facets of Atlas Vertebrae

1. Owais Hameed 2. Zubia Athar 3. Athar Maqbool

1. Asstt. Prof. of Anatomy, Sheikh Zayed Medical College, R.Y. Khan 2. Prof. of Anatomy, WMC, Wah Cantt, Rawalpindi 3. Prof. of Anatomy, Sheikh Zayed Medical College, R.Y. Khan

ABSTRACT

Objective: To assess morphological variations of superior articular facets of atlas vertebrae.
Study Design: Descriptive observational study.
Place and duration of study: This study was conducted at the Anatomy Department, Sheikh Zayed Medical College, Rahim Yar Khan and Wah Medical College, Wah Cantt., district Rawalpindi. Duration of this study was two years.
Materials and Methods: The study included 60 dried human atlas vertebrae of unknown age and sex. The instruments were hand lens, lead pencil and markers. Morphological parameters of presence of a notch/ constriction, presence of a groove, tendency of separation, pressure facets and shape of 120 superior articular facets (SAFs) were examined and noted.
Results: In superior articular facets notch/constriction on medial border was 13.33%, lateral border 15% and on both borders 40%. The SAFs without notch/constriction were 31.67%. Grooves on right, left and bilateral facets were 11.67%, 23.33% and 46.67% respectively. No groove was present in 18.33% SAF. The tendency of separation on right and left facets (right 50%, left 48.33%) showed no significant difference. Incomplete separation (right 6.66%, left 8.33%) and complete separation (right 3.33%, left 5%) was slightly more frequent on left side as compared to the right SAF. The pressure facets were present on 5% on right side, 6.66% on left side and 51.66% SAF on both sides. Regarding the shapes of SAF, dumb-bell was the most frequent (34.17%) followed by oval (31.67%) figure of eight (20.83%) and kidney shape (13.33%).
Conclusion: The knowledge of quantitative anatomy of superior articular facets of atlas vertebrae will prove useful for the surgeons who perform operative procedure in this region and will help in avoiding complications.
Key Words: Cervical spine, superior articular facets, atlas, morphological parameters.

INTRODUCTION

The upper cervical complex, including occiput, atlas and axis, is often regarded as a separate and distinct entity. Although the three bones are attached to each other by articulations and/ or ligaments, the bones are very different in shape and have biomechanical properties which are equally different from the rest of the spine. The occiput articulates with the atlas via a hinge joint consisting of two occipital condyles which are received by two superior articular facets of atlas vertebra.[1,2] The anterior arch of the atlas articulates with the odontoid process of the axis, and the inferior facets of the atlas articulate with the superior facets of the axis vertebra. There is no bony articulation between the axis and the occiput, but alar and apical ligaments from the odontoid process of axis do attach to the inside of the foramen magnum.[3] The atlas or first cervical vertebra has a unique structure and is very important due to its inherent range of movement, which is greater than any other vertebra in the spine.[4] Superior articular facets which are present on atlas vertebra face superomedially and are admirably accepted for nodding movements and also for the weight bearing of the head.[5] The superior articular facets are larger and more concave as compared with the smaller flatter inferior articular facets.[6] About one-half of all cervical flexion and extension occurs at the atlanto-occipital joints.[7]

The malformations and abnormalities of upper cervical complex which lead to hypermobility of atlanto-occipital joints give rise to neurological and vascular symptoms.[8-10] Traumatic dislocation of the atlantooccipital joint is often fatal and even in survivors severe persistent neurological defect is common.[11,12] The traumatic atlantooccipital dislocation has been noted to be three times commoner in children than in adults which may be attributed to anatomical difference.[13] The craniovertebral junction in children is inherently less stable than in adults because of the relatively small occipital condyles and the horizontal orientation of the articulation between the cranium and the atlas.[14,15]

Surgical management of these abnormalities and malformations of upper cervical complex requires a precise identification of pathophysiological conditions.[16] Unfortunately well illustrated and clinical oriented classification of malformation of upper cervical complex has not yet been carried out. Keeping this information in mind we planned to find out variations of the morphology in the superior articular facets of atlas vertebrae in our population.

MATERIALS AND METHODS

In this study sixty dry human atlas vertebrae obtained from the Anatomy department of Sheikh Zayed Medical College, Rahim Yar Khan and Wah Medical College, Wah Cantt were used. The vertebrae were of unknown age and sex. The instruments used during this study were hand lens, lead pencil and markers. Observations of 120 superior articular facets (SAFs) were noted. The SAFs were outlined by black marker to enhance the visibility in photographs. Each SAF was meticulously examined for the following important morphological features:

1. Presence of a notch/ constriction: The presence of notch/ constriction in the medial and lateral borders of each SAF was noted.[17]

2. Presence of a groove: A separating groove of variable depth and breadth was observed which was present in the facets throughout the whole or part of breadth of the facets i.e. in the central region or on the medial or lateral boundaries. Sometimes this groove is well defined and divides the facet into two.[17]

3. A tendency of separation: The presence of constriction or groove or both is suggestive of division of facet into two or a tendency towards it. The amount of tendency of separation was represented as absent, present, marked and well marked or as a separation into two (complete and incomplete separation).[17]

4. Pressure facets: The presence of pressure facets at anterior and posterior ends of main articular facets were observed and noted.[17]

5. Shape of superior articular facet: According to presence of a constriction or a groove and a tendency of separation, different shapes of SAF were defined as follows: Oval shaped - without any constriction, Kidney shaped - constriction present on one side of the facet, Dumb-bell shaped - constriction on both sides of the facet and a groove connecting these constrictions and the Figure of eight shaped - the extension of these constrictions towards the center of the facet.[17].

RESULTS

1. Notches/ constrictions: The incidence of notches/ constrictions at the medial, lateral or both borders of the SAFs are presented in Table-I. Constrictions were present on medial border in 16 (13.33%) facets, on lateral border in 18 (15%) and on both the borders in 48 (40%) out of total 120 SAFs (Fig. 1). Thirty eight SAF (31.67%) showed no notch/ constriction.

2. Grooves: The incidence of grooves in the right, left or both SAFs is given in Table-II. Grooves were present in 7 right (11.67%), 14 left (23.33%) and 28 bilateral facets (46.67%). Eleven SAF (18.33%) showed no groove.

3. Tendency of separation: The tendency of separation in the present study showed no significant difference between the right and left facets (right 50%, left 48.33). Incomplete separation (right 6.66%, left 8.33%) and complete separation (Fig. 2) (right 3.33%, left 5%) was slightly more frequent on left side as compared to the right SAF (Table-3).

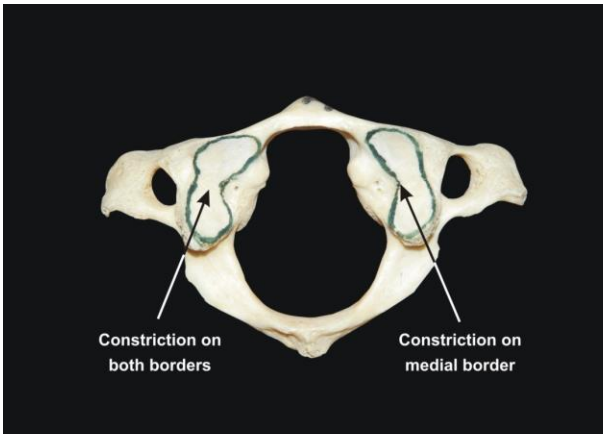

Figure No. 1: SAF showing notch/ constriction.

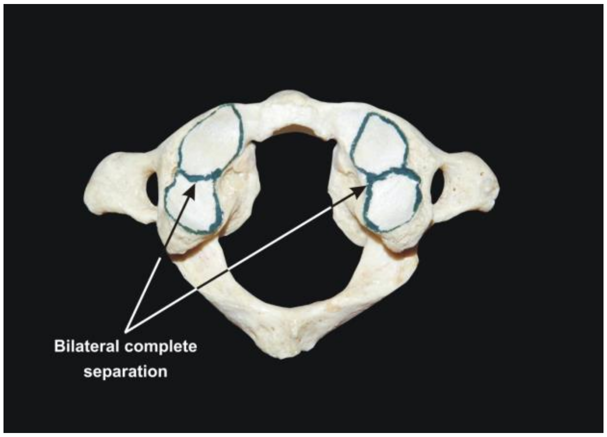

Figure No. 2: SAF showing bilateral complete separation.

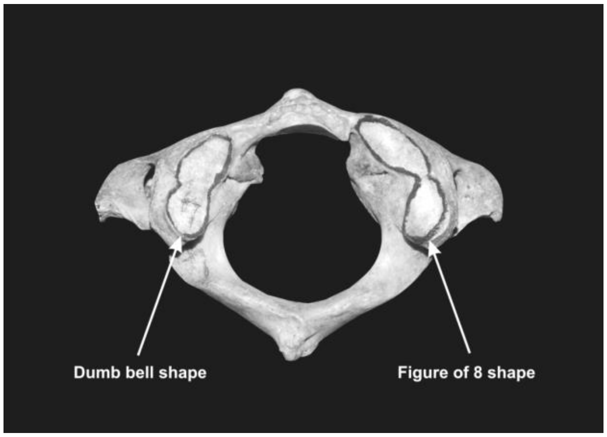

Figure No. 3: SAF showing dumb bell shape and Figure of 8 shape.

4. Pressure facts: These were quite evident in those vertebrae that showed no signs of division of their SAF by notches and grooves. These were lying within the outline of SAF and were present in the anterior and posterior parts of SAF in most of the cases studied. These pressure facets were found to be present in 3 (5%) SAF on right side, 4 (6.66%) SAF on left side and 31 (51.66%) SAF on both sides (Table-4).

5. The shapes of SAF: There was a great diversity regarding the shapes of SAFs. We found dumb-bell shape of SAF (Fig.3) as most frequent (34.17%) followed by oval (31.67%) (Fig.4) figure of eight (20.83%) (Fig.3) and kidney shape (13.33%) (Table-5, Fig.4). The difference between the percentage of the types of shapes on the right and left sides of the superior articular facets was found to be statistically insignificant.

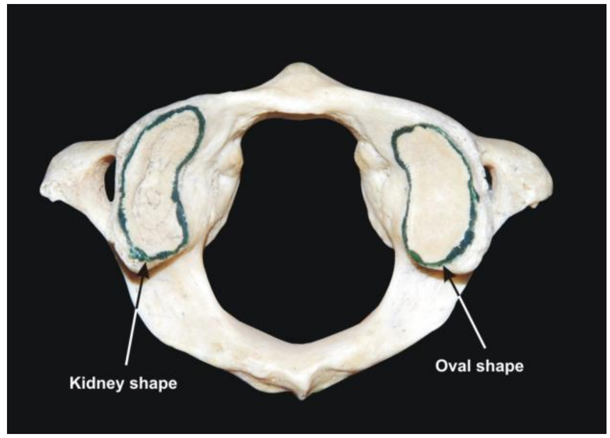

Figure No. 4: SAF showing oval & kidney shape.

Table No.1: Comparison of presence of notches/ constriction on medial and lateral borders on both sides (right & left) of superior articular facet (SAF) in atlas vertebrae.

Researchers	Number of atlas vertebrae	Notches/ Constrictions, *n* (%)				
		SAF	Absent	Medial Side	Lateral Side	Both Sides
Present Study 2013	60	Right	22 (36.67%)	12 (20%)	2 (3.33%)	24 (40%)
		Left	16 (26.67%)	4 (6.66%)	16 (26.67%)	24 (40%)
Lalit M, et al. 2009	30	Right	10 (33.3%)	4 (13.3%)	2 (16.66%)	14 (46.6%)
		Left	7 (23.3%)	3 (10%)	3 (10%)	17 (56.6%)
Singh S. 1965	200	Right	53 (26.5%)	8 (4%)	5 (2.5%)	134 (67%)
		Left	42 (21.0%)	6 (3%)	14 (7%)	138 (69%)

Table No.2: Comparison of presence of grooves on both sides (right & left) of SAF in atlas vertebrae.

Researchers	**Number of atlas vertebrae**	**Grooves, *n* (%)**			
		Absent	**Right SAF**	**Left SAF**	**Bilateral SAF**
Present Study 2013	60	11 (18.33%)	7 (11.67%)	14 (23.33%)	28 (46.67%)
Lalit M, et al.2009	30	13 (43.3%)	3 (10%)	3 (10%)	11 (36.6%)
Singh S. 1965	200	52 (26%)	16 (8%)	23 (11.5%)	109 (54.5%)

Table No.3: Comparison of tendency of separation on both sides (right & left) of SAF in atlas vertebrae. (*n*=number)

Amount of Separation	Present Study 2013 (*n* = 60)						Lalit M, et al. 2009 (*n* = 30)						Singh S. 1965 (*n* = 200)					
	Right Facet only *n*	(%)	Left Facet only *n*	(%)	Both Facets *n*	(%)	Right Facet only *n*	(%)	Left Facet only *n*	(%)	Both Facets *n*	(%)	Right Facet only *n*	(%)	Left Facet only *n*	(%)	Both Facets *n*	(%)
None	4	6.66	3	5	4	6.66	3	10	1	3.3	12	40	17	8.5	11	5.5%	29	14.5
Present	8	50	9	48.33	3	20	3	30.0	4	33.3	3	13.3	18	40.5	17	52	12	24.5
Marked	16		16		5		4		3		1		36		40		22	
Well marked	6		4		4		2		3		-		27		17		15	
Incomplete	4	6.66	5	8.33	3	5	2	6.6	2	6.6	-	-	10	5.0	19	9.5	5	2.5
Complete	2	3.33	3	5	1	1.66	-	-	1	3.3	-	-	6	3	10	5	3	1.5
Total	40		40		20		14		14		16		114		114		86	

Table No.4: Comparison of pressure facets on right and left side of SAF of atlas vertebrae.

Researcher	Right SAF	Left SAF	Both SAF
Present Study 2013	3 (5%)	4 (6.66%)	31 (51.66%)
Vyas K. 2013	4 (4%)	6 (6%)	68 (68%)

DISCUSSION

The superior articular facets (SAFs) of the atlas vertebrae provide the sole bony support between the head and the spine. Precise data concerning the morphology of SAF of human atlas vertebrae are scarce; the data of the main series of the literature alongwith our own are given in Table-I to Table-V.

In the present study, a large number of variations of shape and morphological parameters were seen in superior articular facets of 60 atlas vertebrae and data was compared with only the findings of the researchers who studied skeletal material. The differences between the values of the present study and those observed by other workers may be due to racial factors, different living conditions or the environment.

Table No.5: Comparative incidence and types of shape of SAF on both sides (right & left) of atlas vertebrae.

Researcher	Population	n	Shape of SAF	Right SAF	Left SAF	Total
Present study, 2013	Pakistani	60	Oval	22 (36.67%)	16 (26.67%)	38 (31.67%)
			Kidney shape	12 (20%)	4 (6.67%)	16 (13.33%)
			Dumb-bell	18 (30%)	23 (38.33%)	41 (34.17%)
			Figure of eight	8 (13.33%)	17 (28.33%)	25 (20.83%)
Lalit M, et al. 2009	North Indian	30	Oval	10 (33.3%)	7 (23.3%)	17 (28.33)
			Kidney shape	6 (20%)	6 (20%)	12 (20%)
			Dumb-bell	11 (36.6%)	10 (33.3%)	21 (35%)
			Figure of eight	3 (10%)	7 (23.3%)	10 (16.67%)
Gupta & Goel, 2000	Maharashtrian	50	Oval	-	-	74 (74%)
			Kidney shape	-	-	24 (24%)
Singh S. 1965	Varanasi	200	Oval	53 (26.5%)	42 (21%)	95 (23.75%)
			Kidney shape	13 (6.5%)	20 (10%)	33 (8.25%)
			Dumb-bell	134 (67%)	138 (69%)	272 (68%)

About superior articular facets of atlas vertebra, five morphological parameters were studied. Presence of notches/ constriction on medial border, lateral border and both sides of SAF were calculated (Table-I) and data shows that constrictions on medial and lateral sides of SAF are more than that of Singh and constriction on both sides are less than that of Singh. In the present study, the grooves (Tables-II) on the right and left facets were 7 (11.67%) and 14 (23.33%) respectively and were more than the work of Lalit[18] [right - 3 (10%), left - 3 (10%)] and Singh[17] [right - 16 (8%), left - 23 (11.5%)]. The groove on both the facets was seen in 28 cases (46.67%) thus carrying a higher value in Pakistani population as compared to North Indian population (36.6%) and a lesser value than the Varanasi population (54.5%). No groove was found in 11 cases (18.33%) thus carrying lesser value than the work of Lalit (43.3%) and Singh (26%). These grooves may give rise to pressure facets which are smooth circular impressions and indicate a greater pressure at these sites during movement at the atlanto-occipital joints.

Division of one facet into two or tendency of separation on both sides (right and left) of SAF of atlas vertebrae was also studied (Table-III). The tendency of separation showed no significant difference between right and left facets (right - 50%, left - 48.33%). The value of incomplete and complete separation was slightly higher on left side as compared to right side. This matches with the studies of Lalit and Singh. The result of the present study account for a higher value in amount of separation in Pakistani population as compared to the North Indian population. The tendency of the SAF of the atlas to split into two is an indication of the further restriction of the movement at the atlanto-occipital joint. The incidence of the division of the SAF of the atlas is of anthropological interest.

The pressure facets were quite evident in those vertebrae that showed no signs of division of their SAF by notches and grooves. These were lying within the outline of SAF and were present in the anterior and posterior parts of SAF in most of the cases studied. The pressure facets (Table-IV) were found to be present in 3 (5%) SAF on right side, 4 (6.66%) SAF on left side and 31 (51.66%) SAF on both sides. The value of pressure facets on right and left side were comparable with that of Vyas[19] (right - 4%, left - 6%) but their value on the both SAF (51.66%) was less than that of Vyas (68%).

The present study reported the shape of the SAF in a majority of the cases as dumb-bell shape (38.33%) followed by oval shape, figure of eight and kidney shape (Table-V). The difference between the percentages of the types of shapes on the right and left sides of the SAF was found to be statistically insignificant. Gupta and Goel[20] defined only two shapes and found the oval as the commonest (74%). Singh described three shapes, dumb-bell being the commonest (69%) followed by oval and kidney shape. In a study conducted on North Indian population by Lalit, dumb-bell shape of the SAF was the commonest (36.6%) followed by oval shape, figure of eight shape and kidney shape. Paraskevas et al[21] categorized the shape of superior articular facets as oval, kidney, S like, eight like, triangle, circular and two portioned facets. The superior articular facets of the atlas with a different shape are an indication of the further restriction of the movements at the atlanto-occipital joint and requires more studies in different populations.

Considerable innovations in the internal fixation techniques have created a need for a more detailed quantitative description of the anatomy of this bone.[22] The knowledge of the quantitative anatomy of atlas vertebrae will prove useful to the surgeons who perform operation procedures in this region and will help in avoiding complications.[23]

CONCLUSION

The knowledge of quantitative anatomy of superior articular facets of atlas vertebrae will prove useful for the surgeons who perform operative procedure in this region and will help in avoiding complications.

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Address for Corresponding Author:
Dr. Owais Hameed,
Assistant Professor of Anatomy,
Sheikh Zayed Medical College,
Rahim Yar Khan