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A Morphometric Study Of Vertebral Arch Of Dry Adult Human Axis Vertebrae

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Abstract

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Introduction

Vertebra develops from sclerotome of somites, which are intersegmental in origin. A typical vertebra has vertebral body ventrally and vertebral(neural) arch dorsally, both encloses a vertebral canal. Vertebral arch consists of a pair of pedicles, a pair of laminae, and pair of superior & inferior articular processes, transverse processes and a spinous process.

Large ovoid articular facets are present on eighter side of dens at the junction of body and vertebral arch. They are flat or slightly convex for articulation with the masses of atlas. The facets lie in a plane anterior to the plane of the intercentral (Luschka) articulations which is a homologous joint to this.

The pedicles are stout & concealed superiorly by the superior articular facet, which also projects laterally & downwards onto the transverse process. The anterolateral surface is deeply grooved by vertebral artery, running beneath the thin lateral part of inferior surface of superior articular facet, because which can become quite thin. This relation makes the vertebral artery prone for injury during screw fixation. Inferior surface of each pedicle bears a deep, smooth inferior intervertebral notch. Which lodges the large root sheath of the third cervical nerve. Interarticular part of pedicle is short & lies between relatively small inferior posterior articular facet (which is located at pediculolaminar junction and bearing a small facet which faces anteriorly) and the superior articular surface.[1]

The transverse process is pointed, projects infero laterally & arises from the pediculolaminar junction & the lateral aspect of interarticular area of the pedicle. The rounded tip represents the posterior tubercle of a typical cervical vertebrae only. The foramen transversarium is directed laterally as the vertebral artery turns abruptly laterally under the superior articular facet. [1]

Because of the unique shape of superior articular process and different orientation of foramen transversarium and complex relationship with vertebral artery, morphometry of vertebral(neural) arch of axis is given more importance surgically.

The main aim of our present study is to measure various parameters of vertebral arch of axis vertebrae and to compare the results with the previous studies.

Better understanding of this dimensions of vertebral arch of axis vertebra is essential for efficient management of arising surgical problems. Many operative techniques like interspinous wiring, interlaminar clamping, plate and screw fixation pedicle have been employed to correct occipito-cervical, atlanto axial complex instability.

Materials And Methods:

100 dried adult human axis (2^{nd} cervical vertebrae) of unknown sex collected from the I

nstitute of anatomy, Madras Medical College. Only intact axis vertebrae free of any bony abnormalities were included in the study.

The morphometric analysis of vertebral arch of axis vertebrae were focused. All the linear parameter were measured by using a digital vernier calipers with the accuracy of 0.01 mm.

The data obtained were analyzed statically. Mean, standard deviation of different parameters were calculated.

The different parameters of vertebral arch of axis were measured as follows:

1. Pedicle length: anterior most point of the pedicle (anterior most point on the superior articular facet) to the posterior edge of the inferior articular facet on the inferior aspect of the vertebra measured.
2. Pedicle width: distance from external surface of pedicle to its internal surface at the level of foramen transversarium
3. Pedicle height: superior surface of the pedicle to its inferior surface.
4. Superior articulating facet: anteroposterior diameter
5. Superior articulating facet: transverse diameter
6. Inferior articulating facet: anteroposterior diameter
7. Inferior articulating facet: transverse diameter
8. Vertebral foramen inlet: anteroposterior diameter: at the midline
9. Vertebral foramen inlet: transverse diameter: maximum transverse diameter
10. Vertebral foramen outlet: anteroposterior diameter: at the midline
11. Vertebral foramen outlet: transverse diameter: maximum transverse diameter

Results:

The mean pedicle length on the right & left side were 29.2 ±2.09mm & 28.4 ±2.29mm, mean pedicle width on the right & left side were 7.9 ±1.84mm & 8.2 ±1.61mm, mean pedicle height on the right &left side were 9.1 ±1.54mm&9.1 ±1.34mm.

The mean anteroposterior diameter of superior articular facet on the right & left side were 16.8 ±1.44mm&16.6 ±1.52mm. The mean transverse diameter of superior articular facet on the right & left side were 15.5 ±1.48mm&15.5 ±1.68mm

The mean anteroposterior diameter of inferior articular face on the right & left side were 9.8 ± 1.54mm&9.7 ±1.25mm. The mean transverse diameter on the right & left side were 9.8 ± 1.44mm&9.4 ±1.26mm

The mean anteroposterior diameter of inlet & outlet of vertebral canal were 19.9 ± 2.09mm&17.41 ±2.32mmthe mean transverse diameter of inlet & outlet of vertebral canal were 23.7 ±1.89 mm&23.5 ±1.81mm.

Table 1: Measurements of Pedicle & Articular facets.

No.	Parameter		Range (mm)		Mean (n=100) ± SD (mm)	
			Right	Left	Right	Left
1.	Pedicle	Length	25.3 - 36.1	24.7 - 35.6	29.2 ± 2.09	28.4 ± 2.29
		Width	4 - 124	6 - 13.9	7.9 ± 1.84	8.22 ± 1.61
		Height	6.2 - 13.4	6.2 - 7.8	9.05 ± 1.544	9.15 ± 1.39
2.	SAF	A-P Diameter	13 - 20	12.5 - 19.4	16.87 ± 1.44	16.65 ± 1.51
		Transverse Diameter	12.1 - 19.4	6.5 - 13.4	15.5 ± 1.48	15.5 ± 1.68

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3.	IAF	A-P Diameter	6.3 - 12.1	6.7 - 14.4	9.8± 1.54	9.7 ± 1.25
		Transverse Diameter	7.4 - 13.6	4.5 - 14.5	9.8 ± 1.44	9.4 ± 1.26

Table 2 : Measurements of vertebral canal.

No.	Parameter		Range (mm)	Mean (n=100) ± SD (mm)
1.	Inlet	AP diameter	11.6 – 23.2	19.9 ± 2.09
		Transverse diameter	20.4 – 28.3	23.7 ± 1.89
2.	Outlet	A-P Diameter	12.5 – 21.8	17.41 ± 2.32
		Transverse Diameter	19.5 – 27.6	23.5 ± 1.81

Table 3 : Comparison of dimensions of pedicle.

Study	Pedicle Length Mean ± SD (mm)		Pedicle Width Mean ±SD (mm)		Pedicle Height Mean ±SD (mm)	
	RT	LT	RT	LT	RT	LT
Sengul & kadioglu et al (2006)	-	-	9.6 ±2.4	9.6± 2.4	-	-
Gosavi et al(2012)	28.71±3.25	28.29±3.25	7.19±1.31	7.73±1.63	8.20±1.48	8.32±7.67
Kaur et al (2018)	-	-	10.52±1.99	10.61±1.67	-	-
Present study (2022)	29.2±2.09	28.4±2.29	7.9±1.84	8.2±1.61	9.1±1.54	9.1±1.34

Table 4 : Comparison of dimensions of superior articular facets

Study	AP Diametre Mean ± SD (mm)	Transverse Diametre Mean ±SD (mm)

	RT	LT	RT	LT
Sengul & Kadioglu et al (2006)	17.5	-	14	-
Gosavi et al(2012)	16.64	16.66	14.44	14.64
Mukesh et al (2018)	16.61±1.33	16.7±1.49	14.92±1.76	14.79±1.48
Present study (2022)	16.8±1.44	16.6±1.52	15.5±1.48	15.5±1.68

Table 5 : Comparison of dimensions of inferior articular facets

Study	AP Diametre Mean ± SD (mm)		Transverse Diametre Mean ±SD (mm)	
	RT	LT	RT	LT
Sengul & Kadioglu et al (2006)	11.6	-	9.5	-
Gosavi et al(2012)	9.74	9.61	9.93	9.92
Mukesh et al (2018)	11.75	12.02	11.4±1.76	11.42±1.92
Present study (2022)	9.8±1.54	9.7±1.25	9.8±1.44	9.8±1.26

Table 6 : Comparison of dimensions of vertebral canal

Parameter	A-P Inlet Mean ± SD (mm)	A-P Outlet Mean ±SD (mm)	Transverse diameter Mean ±SD (mm)
Xu et al (1995)	18	15.3	21.9

Sengul & Kadioglu et al (2006)	20.8	-	24.7
Mukesh et al (2015)	18.31± 2.05	14.84 ± 1.63	22.37 ± 1.73
Present study (2022)	19.9 ± 2.09	17.41 ±2.32	23.7± 1.89

Discussion:

The intraarticular pedicle of axis is short as it is partly concealed by the overhanging superior articular facet, so the dimensions of intraarticular pedicle is important for pedicular screw fixation. [1]

The pedicle dimensions of the present study closely correspond to the previous author's finding. The mean pedicle length on the right side is 29.2 ±2.09mm and on left side is 28.4 ±2.29mm which closely resembles the findings of gosavi et al. [3]

The mean pedicle width measured on the right side 7.9 ±1.84mm and on left side 8.2 ±1.61mm which is similar to the findings of gosavi et al and less than the findings of kaur et al (2018). [3][4]

The mean height of pedicle on the right side is 9.1 ±1.54mm and on left side 9.1 ±1.34mm which is little higher than the observations of gosavi et al[3]

The vertebral artery is intimately related to inferior surface of superior articular facet making it thin. Vertebral artery is exposed at the junction of axis and atlas as it is passing laterally from foramen transversaria of axis to atlas making this site as a one of the vulnerable site of vertebral artery.so the accurate dimensions of superior articular facet is crucial for inserting the screw at this site. [1]

The mean anteroposterior diameter of superior articular facet on the right & left side were 16.8 ±1.44mm&16.6 ±1.52mm.

The mean transverse diameter of superior articular facet on the right & left side were 15.5 ±1.48mm&15.5 ±1.68mm. These findings are equilent to the findings of mukesh et al and gosavi et al.[5][3]

Difference in the size of articular facets especially unilateral enlargement of articular facet results in limited neck movement, in the present study the dimensions of articular facets are symmetrical.

The mean anteroposterior diameter of inferior articular face on the right & left side were 9.8 ± 1.54mm&9.7 ±1.25mm.

The mean transverse diameter on the right & left side were 9.8 ±1.44mm&9.4 ±1.26mm.The findings are equilent to the findings of gosavi et al and less than the findings of mukesh et al.[3][5]

The mean anteroposterior diameter of inlet & outlet of vertebral canal were 19.9 ± 2.09mm&17.41 ±2.32mm

The mean transverse diameter of inlet & outlet of vertebral canal were 23.7 ±1.89 mm&23.5 ± 1.81mm.the findings are equilent to the findings of xu et al& mukesh et al and less than the findings of seng et al[6][5][2]

Conclusion:

Anatomical knowledge of accurate dimensions of vertebral arch of axis vertebra is required for evaluation of many surgical problems in the craniovertebral junction. Correction of instability of atlanto - axial complex or occipito cervical junction because of traumatic and pathological conditions requires surgical techniques like anterior or posterior screw fixation, interspinous wiring & interlaminar clamping. Our observations will provide wide knowledge about the dimensions of pedicle, Superior articular facet, Inferior articular facet and vertebral canal.

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