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SUBAXIAL CERVICAL VERTEBRAE: MORPHOMETRIC STUDY OF THE PEDICLES, LAMINAE AND VERTEBRAL FORAMINA

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ABSTRACT

Introduction: The cervical region of vertebral column being the most common site of expression of stress in the form of pain in neck, cervical disc prolapse and cervical neuropraxia. Cervical vertebral column is influenced by mechanical, environmental, genetic, metabolic and hormonal factor and has to react to the forces of every day. Accurate anatomical descriptions of the pedicle, lamina and vertebral foramen are necessary for development and use of implantable devices and for spinal instrumentation that ranges from 'transpedicular screw fixation' to 'vertebroplasty'.

Aim: To study the morphometric database of pedicles, laminae and vertebral foramina of subaxial cervical vertebrae.

Materials and Methods: Fifty-seven dry macerated sets of adult human cervical vertebral columns of unknown sex and age in the Department of Anatomy in Bharati Vidyapeeth University Medical College Pune and Smt. Kashibai Navale Medical College and General Hospital, Pune in Maharashtra. The length, thickness and height of pedicles and laminae and anteroposterior and transverse length of vertebral foramina were measured with digital Vernier caliper

Observation: The pedicle length and thickness was found to increase uniformly from C3 to C7. Thickness of lamina was found to be maximum at C7 vertebra. Maximum anteroposterior length of vertebral foramen was observed at C3 and the maximum transverse length at C6.

Conclusion: The result of this study will help in designing implants and instruments related to the cervical vertebral column. It can also help in the management of traumatic and pathological fractures of cervical vertebral column.

KEY WORDS: Cervical Vertebrae, Pedicle, Lamina, Vertebral foramen, Sub axial.

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INTRODUCTION

Pain in neck due to a variety of causes ranging from osteophytes, osteoporosis, cervical disc prolapse, cervical neuropraxia etc. is the expression of stress cervical vertebral column has to bear. Thirty three vertebrae with intervertebral fibrocartilaginous disc from axis vertebra to sacrum form adult vertebral column [1].

The vertebral canal is present between the foramen magnum to the sacral hiatus following primary and secondary curvatures of vertebral column. The vertebral canal is larger, triangular and freely movable in the cervical and lumbar regions, well as it is small, circular and less movable in thoracic region. The enlargement of spinal cord corresponds with the diameter of the vertebral canal. The diameter of the vertebral canal is increases in size from first cervical to seventh cervical vertebrae to accommodate cervical enlargement of spinal cord [1].

Weight of head, neck, trunk and upper limb is transmitted by vertebral column to the lower limbs through hip bone [2].

The vertebral column consisting of the vertebrae and the intervertebral discs in-between the adjacent vertebral bodies is subjected to vertical compression forces under the gravitational pull. The magnitude of this force increases from atlanto-occipital to lumbo-sacral joint [3].

The cervical vertebrae are characterised largely by their small size and presence of foramen transversarium. The subaxial 3rd to 6th cervical vertebrae exhibit many similar features, however the 6th differs slightly that usually enable its distinction from others & the 7th is atypical due to its distinct features [1].

The smaller diameter of spinal canal may be considered as one of the factors in the causation of cervical myelopathy [4] which focuses the attention of anatomist, orthopaedic surgeon. Cervical canal stenosis is statistically determined by the Torg-Pavlov ratio. The ratio is calculated by measuring the antero posterior length of spinal canal divided by antero posterior length of body of vertebra on a lateral X-rays of vertebral column, the measurement less than 0.8 is considered as cervical stenosis [4, 5].

Accurate anatomical descriptions of the shape and orientation of cervical pedicles and body are necessary for development and use of implantable devices and for spinal instrumentation that ranges from ‘transpedicular screw fixation’ to ‘vertebroplasty’ [6].

The standard morphology is necessary in designing appropriate spinal instruments for selection of transpedicular screw size or for replacing loose or damaged parts of a vertebra [7]. In orthopaedic practice transpedicular screw fixation is one of the successful techniques in spinal fixation also used in patients who have been laminectomized. The achievement of the procedure depends on appropriate size of screw for pedicle as well as body and stage of osteoporosis. The diameter as well as path of the screw depend on thickness, length and height of pedicle. However, there are some complications of pedicle screw fixation. Failure of instrumentation is seen because of mismatched size of screw and pedicle. As a result there is cortical perforation and fracture of pedicle. Occasionally there may be loosening of pedicle screw. Complications arising due to missing of pedicle screw are dysphagia [8], extrusion of screws and plates[9,10], dural tears, cerebrospinal fluid leakage, recurrent laryngeal damage[11], and nerve roots injuries. For these reasons the detailed morphometry of a vertebra plays important role as it helps to design the most appropriate pedicle screw size and designing implants and instrumentations [12, 13].

MATERIALS AND METHODS

For the present study fifty-seven dry macerated sets of adult human cervical vertebral column in the Department of Anatomy in Bharati Vidyapeeth University Medical College Pune and Smt. Kashibai Navale Medical College and General Hospital Pune in Maharashtra. All vertebrae were apparently normal, fully ossified without any congenital anomalies and degenerative changes. The following measurements were taken with digital Vernier caliper with 0.1mm accuracy.

The length of pedicle was measured between two points, one at the junction of pedicle and vertebral body and the second at the junction of pedicle and superior articular process. The thickness and height of pedicle were measured at the centre of pedicle length. Length of lamina is measured between two points, one at the junction of lamina and pedicle and the second at the junction of lamina of both the side. The thickness and height of lamina were measured at the centre of lamina length. Anteroposterior length of the vertebral foramina was noted between posterior surface of the body in the midline to the junction of laminae and also measured the maximum transverse length of the foramen. The observations were statistically analysed by applying tests of significance viz. 'ANOVA'.

OBSERVATIONS

Individual vertebra from the fifty seven sets of cervical vertebrae were studied and the observations were noted as shown in the tables (Table 1 to Table 5).

Observations of the pedicle revealed that length and thickness of the pedicles shows gradual increase from the third to the seventh cervical vertebra of both the sides (Table 1). Height of the pedicle was maximum at the seventh cervical vertebrae (Table 2). ANOVA' test is applied for different parameters of pedicle to find out its significance with the help of p-value. The p-value for length, thickness and height is highly significant except p-value for right pedicle height is not significant.

Table 1: Bilateral cervical vertebrae: Pedicle length and thickness.

Group (Vertebra)	PDL Right	PDL Left	PD Th Right	PD Th Left
	Mean ± SD (n=57)	Mean ± SD (n=57)	Mean ± SD (n=57)	Mean ± SD (n=57)
C3	6.28 ± 1.31	6.49 ± 1.04	4.74 ± 0.80	4.63 ± 0.87
C4	6.46 ± 1.34	6.72 ± 1.35	4.76 ± 0.92	4.71 ± 0.83
C5	6.61 ± 1.42	6.85 ± 1.48	5.17 ± 1.09	5.12 ± 0.91
C6	7.16 ± 1.38	7.36 ± 1.38	5.69 ± 1.06	5.69 ± 1.04
C7	7.63 ± 1.35	7.75 ± 1.39	6.53 ± 1.11	6.56 ± 1.06
F Value	9.57	8.39	31.87	40.72
P Value	<0.0001	<0.0001	<0.0001	<0.0001

(PDL- Pedicle length, PD Th- Pedicle thickness)

Table 2: Bilateral cervical vertebrae: Pedicle height

Group (Vertebra)	PD H Right	PD H Left
	Mean ± SD (n=57)	Mean ± SD (n=57)
C3	6.37 ± 0.83	6.37 ± 0.92
C4	6.73 ± 1.19	6.79 ± 1.15
C5	6.38 ± 1.11	6.27 ± 0.96
C6	6.53 ± 1.03	6.59 ± 1.03
C7	6.78 ± 0.93	6.86 ±0.97
F Value	2	3.69
P Value	>0.05	<0.01

(PD H- Pedicle height)

Observations of the laminae revealed that length of the right side lamina shows an increase from C-3 to C-6 vertebrae. Length of the left side amina shows an increase from the fourth to the sixth cervical vertebra. Laminae length of both sides were maximum at sixth and minimum at seventh cervical vertebrae. Thickness of lamina of both side were maximum at seventh cervical vertebra (Table 3).Height of laminae increased from fourth to seventh cervical vertebra on both the sides. Height of lamina of both side were maximum at seventh cervical vertebra (Table 4). After application of '**ANOVA'** test the p-value for all the parameters observed was highly significant.

Observations of the cervical vertebral foramen revealed that anteroposterior length increased gradually from the fourth to the seventh cervical vertebra. Third cervical vertebra showed the maximum anteroposterior length. Transverse length showed an increase from the C-3 to C-6 vertebrae. Transverse length of the sixth cervical vertebra was maximum (Table 5). The p-value for anteroposterior length were not significant but for transverse length of the cervical vertebral foramina were highly significant.

Table 3: Bilateral cervical vertebrae: Lamina length and thickness.

Group (Vertebra)	LL Right	LL Left	L Th Right	L Th Left
	Mean ± SD (n=57)	Mean ± SD (n=57)	Mean ± SD (n=57)	Mean ± SD (n=57)
C3	17.11 ± 1.21	17.26 ± 1.23	3.08 ± 1.51	2.95 ± 0.73
C4	17.13 ± 1.44	17.25 ± 1.15	2.50 ± 0.88	2.53 ± 0.65
C5	17.39 ± 1.17	17.53 ± 1.16	2.55 ± 0.65	2.50 ± 0.65
C6	17.43 ± 1.83	17.94 ± 1.32	3.51 ± 1.11	3.58 ± 1.03
C7	16.55 ± 1.68	17.22 ± 1.60	5.03 ± 1.33	5.15 ± 1.02
F Value	3.17	3.66	47.19	87.92
P Value	<0.01	<0.01	<0.0001	<0.0001

(LL-Lamina length, L Th-Lamina thickness)

Table 4: Bilateral cervical vertebrae: Lamina height.

Group (Vertebra)	L H Right	L H Left
	Mean ± SD (n=57)	Mean ± SD (n=57)
C3	10.12 ± 1.42	10.38 ± 1.62
C4	10.15 ± 1.09	10.17 ± 1.41
C5	10.63 ± 2.54	10.50 ± 1.43
C6	11.90 ± 1.69	12.06 ± 1.65
C7	14.08 ± 1.72	14.08 ± 1.65
F Value	69.89	64.77
P Value	<0.0001	<0.0001

(LH- Lamina height)

Table 5: Bilateral cervical vertebral foramen: Antero-posterior and transverse length

Group (Vertebra)	CVF AP Mean ± SD (n=57)	CVF T Mean ± SD (n=57)
C3	13.58 ± 1.52	21.17 ± 1.53
C4	12.97 ± 1.44	22.21 ± 1.27
C5	13.01 ± 1.39	22.83 ± 1.27
C6	13.05 ± 1.49	23.18 ± 1.57
C7	13.06 ± 1.35	22.35 ± 1.78
F Value	1.75	14.86
P Value	>0.05	<0.0001

(CVF AP- Cervical vertebral foramen anteroposterior length,
CVF T- Cervical vertebral foramen transverse length)

DISCUSSION

Pal and Routal measured the pedicle thickness and height and found it to be increased from C3 to C7. They correlated this increase with the weight transmission through cervical vertebral column [14]. In our study the pedicle thickness was found to increase from C3 to C7 and height were measured and found to be maximum at C7.

Laminectomy as an operative procedure is commonly done in patients suffering from cervical spondylotic myelopathy [15]. The resultant post-operative deformities and reports of spinal instability have been discussed by many workers. Pal and Routal did the morphometric and morphological investigation on cervical vertebral columns to determine the role of vertebral laminae in the stability of the cervical spine. They measured the lamina thickness and height and found the highest values at C2 and C7. They concluded that laminectomy at C2 or C7 level would result in greater instability than done at other cervical vertebral levels [16]. In our study the maximum thickness and height of lamina was noted at C7. To conclude, the height and thickness of lamina is significantly maximum at C7 indicating the strongest laminae at C7. Hence our findings also correlate with the theory of weight transmission suggested by Pal and Routal [17].

They proposed three column system of weight transmission through cervical vertebral column. The vertebral bodies and intervertebral disc forms the anterior column and articulate facets of both the sides form two posterior column. Due to the incorporation of the articular facets into the lamina of the vertebrae the compressive forces acting on articular facets diffuse on to the laminae, Thus in the cervicothoracic region, the two separate posterolateral columns become incorporated in the lamina to form a single posterior column. This explains the significant increase in the measurements of the laminae at C7 level [14].

The size of the cervical spinal canal is of great clinical importance. Large number of studies have correlated size of spinal canal with spondylosis, myelopathy or stenosis etc. The well known risk factor for cervical neuropraxia is the narrow spinal canal. Almost all studies whether radiologically or at necropsies are done to measure the anteroposterior length. The points as 'middle of the posterior surface of the vertebral body' to the 'nearest point of the corresponding spinal laminar line' was standardized by Pavlov Helene. Wilkinson called this line as pre-existing sagittal length [4, 5, and 19].

In our study we measured anteroposterior length on the macerated cervical vertebrae as described by Pavlov Helene. We also measured the maximum transverse length of the cervical vertebral foramina. Maximum values of antero-posterior length were observed at C3. However the maximum value of transverse length was observed at C6 vertebra. Murone observed reduced anteroposterior length between C3 and C6 with least value (15 mm) at C5 and C6 [20]. In the present study we did not observe any significant change in anteroposterior length from C3 to C7 and the average value was around 13mm.

The transverse length in our study was observed to be maximum at C6 vertebra. The values of transverse length above and below this level were less. The wider transverse length at C5 and C6 level can be may be correlated with the corresponding maximum size of cervical spinal cord [21].

CONCLUSION

Measurements of pedicles and laminae at C6 and C7 are indicative of stronger structures forming posterolateral columns. The height and thickness of lamina is significantly maximum at

C7 indicating the strongest laminae at C7.The transverse length of cervical vertebral foramina is significantly maximum at C6 level that may be correlated with corresponding maximum transverse width of cervical spinal cord [21]. The morphometric data of typical cervical vertebrae is essential for developing instrumentation and implants related to the cervical vertebral column and may be useful in cervical spine surgery.

Conflicts of Interests: None

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