Original Article

Morphometric Analysis of Laminae of C3–C6 Vertebrae of Cervical Spine in the Population of North West India

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Abstract

Introduction: The knowledge of morphometric parameters of laminae of cervical vertebrae is indispensable in surgical procedures and developing instrumentation for surgical processes. Literature reports ethnic and geographical variations reported in these dimensions. **Materials and Methods:** This cross-sectional study included analysis of laminae of 212 cervical vertebrae (C3–C6). The length of superior border of lamina and inferior border of lamina was measured on the right and left sides using vernier caliper. Descriptive and inferential statistical analysis was done with the help of Microsoft Excel version 2021. **Results:** The length of the superior border of lamina on both sides increases from C3 to C5. The length of the inferior border of the lamina on both sides decreases from C3 to C4, then on the right side, it increases from C4 to C5 and then decreases from C5 to C6, and on the left side, it increases from C4 to C6. At C4, the length of superior border of lamina on the right side differed statistically from the length of superior border of lamina on the left side ($P = 0.042$). A significant difference between lengths of the inferior border of laminae on the right and left sides was also found at the C5 vertebra ($P = 0.001$) and C6 vertebra ($P = 0.012$). No significant difference in thickness and height of lamina was observed between right and left sides. **Conclusion:** The present study indicates morphometric parameters of laminae of typical cervical vertebrae in the North West Indian population differ from the same parameters in Brazilian as well as South Indian populations. The length of superior border as well as inferior border of lamina has significant differences between right and left sides. However, there is no significant difference in height and thickness of laminae between right and left sides.

Keywords: Cervical, Indian, lamina, morphometric

Introduction

Functionally, the cervical spine is the most important part of the vertebral column, not only due to its high range of movements but also because the integrity of this part is vital for the preservation of life of individuals. Transverse processes of cervical vertebrae have foramina as an unmistakable peculiarity.[1] Each vertebra consists of the vertebral body anteriorly and neural arch posteriorly. The vertebral body consists of cancellous bone in the center and compact bone in the periphery.[2] Laminae constitute the most important part of the neural arch which protects the spinal cord within.

Besides protecting the spinal cord, stability of this region of the spine is also an indispensable function of laminae. Morphometry of cervical vertebrae may provide crucial information for the neurosurgeons, radiologist, or clinicians and may help surgeons to achieve greater success in operations involving the cervical region of the spine.

The present study quantifies morphometric dimensions of laminae of C3–C6 vertebrae. These vertebrae have been chosen as these have common features and are termed typical cervical vertebrae. The knowledge of these morphometric dimensions is indispensable in choosing the correct size and design of screws and plates during operative procedures. On the basis of a computed tomography (CT)-based small pilot study done in Bombay, the authors concluded that there was a need for redesign of cervical disc prostheses to match Indian patients.[3] In a CT scan study based on 50 typical vertebrae, significant authors reported the length of laminae on two sides to be symmetrical.[4] The study population is not mentioned in

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the article, hence it is difficult to comment on why their data differs from the current study. However, this contradiction indicates the necessity of conducting more studies on bones in addition to CT scan studies.

Materials and Methods

Study design and study setting

This cross-sectional study was carried out in the Department ofAnatomy, PGIMS, Rohtak, Haryana. C–3 to C–6 vertebrae were retrieved from the skeleton collection of a postgraduate medical institute. The study was conducted from 2020 to 2022.

Study Sample

Total of 212 vertebrae were measured. Fifty-three of each of C–3 to C–6 were used in the study. Vertebrae were retrieved by maceration method. Separate tank was used for retrieving each skeleton. Skeletons were numbered and preserved in separate skeletal bags. Hence, these vertebrae belonged to 53 persons or cadavers. The consent of body donors was taken for research on cadavers. The Biomedical Research Ethics Committee (IRB) of the institute approved the study vide letter No. BREC/19/147 dated December 26, 2019.

Inclusion and exclusion criteria

The procedures in the study followed the guidelines laid down in the Declaration of Helsinki. Bones with deformity, distortion, and breaks were excluded from the study. Vertebral sets having any missing cervical vertebrae were also excluded from the study. All other typical cervical vertebrae of skeletal collection were included in the study.

Measurements and Tools

Parameters were defined as per the study published by Rao *et al*. as described in Table 1 and Figures 1 and 2.[5] Instruments used in the study include vernier calipers with the least count of 0.01 mm. All the measurements were taken three times and the mean value was calculated for each parameter. Data management and statistical analysis were done using Microsoft Excel version 2021. Student's t-test was applied to compare the mentioned morphometric parameters of two sides.

Results

Morphometry of 212 cervical vertebrae was done. In these 212 vertebrae, 53 cervical vertebrae for each level (C3, C4, C5, and C6) retrieved from 53 cadavers. Parameter-wise results are as follows:

Length of the superior border of lamina on the right side

This parameter increases from C3 (14.93 mm) to C5 (16.60 mm) and then decreases from C5 (16.60 mm) to C6 (16.20 mm) [Table 2].

Length of the superior border of lamina on the left side

This parameter increases from C3 (15.18 mm) to C5 (16.51 mm) and then decreases from C5 (16.51 mm) to C6 (15.84 mm) [Table 2].

Table 1: Morphometric parameters of lamina of typical cervical vertebrae

Parameter	Definition
LSL Rt	Distance from junction of lamina with superior articular process to the anterior-most point on the superior border of spine on the right side
LSL Lt	Distance from junction of lamina with superior articular process to the anterior-most point on the superior border of spine on the left side
LIL Rt	Distance from junction of lamina with inferior articular process to the junction of lamina with spine on the inferior border of lamina on right side
LIL Lt	Distance from junction of lamina with inferior articular process to the junction of lamina with spine on the inferior border of lamina on the left side
TL Rt	Thickness of lamina at midpoint of lamina on the right side
TL Lt	Thickness of lamina at midpoint of lamina on the left side
HL Rt	Distance between superior and inferior border of lamina at midpoint of lamina on the right side
HL Lt	Distance between superior and inferior border of lamina at midpoint of lamina on the left side

LSL Rt: Length of the superior border of lamina on the right side, LSL Lt: Length of the superior border of lamina on the left side, LIL Rt: Length of inferior border of lamina on the right side, LIL Lt: Length of inferior border of lamina on the left side, TL Rt: Thickness of lamina on the right side, TL Lt: Thickness of lamina on the left side, HL Rt: Height of the lamina on the right side, HL Lt: Height of lamina on the left side

Table 2: Length of the superior border of lamina on the right side and the left side

Vertebra	Mean (mm)±SD		*P*
	LSL Rt	LSL Lt	
C3	14.93±1.49	15.18±1.73	0.148
C4	16.16±1.64	15.78±1.63	0.042
C5	16.60±1.69	16.51±1.75	0.618
C6	16.20±2.06	15.84±2.32	0.173

SD: Standard deviation, LSL Rt: Length of the superior border of lamina on the right side, LSL Lt: Length of the superior border of lamina on the left side

Table 3: Length of inferior border of lamina on right side and left side

Vertebrae	Mean (mm)±SD		*P*
	LIL Rt	LIL Lt	
C3	13.57±1.66	13.75±1.95	0.34
C4	13.09±1.59	12.96±1.52	0.50
C5	14.05±1.91	13.23±1.93	0.001
C6	14.02±2.39	13.53±2.19	0.012

SD: Standard deviation, LSL Lt: Length of the superior border of lamina on the left side, LIL Rt: Length of inferior border of lamina on the right side

A significant difference between the lengths of superior borders of laminae on the right and left sides was found at C4 vertebra ($P = 0.042$) but not statistically significant at other levels of cervical vertebra [Table 3].

Length of the inferior border of lamina on the right side

This parameter decreases from C3 (13.57 mm) to C4 (13.09 mm), increases from C4 (13.09 mm) to C5 (14.05 mm) and then decreases from C5 (14.05 mm) to C6 (14.02 mm) [Table 3].

Length of the inferior border of lamina on the left side

This dimension decreases from C3 (13.75 mm) to C4 (12.96 mm) and then increases from C4 (12.96 mm) to C6 (13.53 mm) [Table 3].

The difference between the lengths of inferior borders of laminae on the right and left sides was found to be statistically significant at C5 vertebra and C6 vertebra and insignificant at other levels of the cervical vertebra [Table 3 and Figure 3].

Thickness of lamina of typical cervical vertebrae was measured and results are tabulated.

The thickness of the lamina on the right and left side was found symmetrical with no significant difference at any vertebral level. These parameters were found least at the level of C3 vertebrae and maximum at the level of C6 vertebrae [Table 4].

The mean height of laminae of typical cervical vertebrae was also found similar on both sides without any significant difference between two sides. This parameter was found maximum at the C3 level and minimum at the C4 level [Table 5].

Discussion

The length of lamina obtained in the present study is compared with other authors in Table 4. Differences are evident at all levels[Figure 4]. Further in the present study, the length of lamina increases from C3 vertebrae to C5 vertebrae and then decreases from C5 vertebrae to C6 vertebrae on both sides. The same trend was observed in a study in Northeastern Mexico.[6] However, studies in the South Indian and Rajasthan population mentioned that the length of lamina increased from C3 to C6 [Table 4].[2,7]

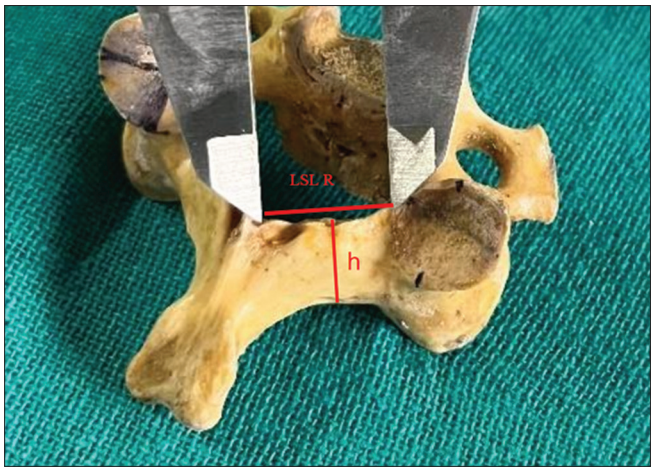

Figure 1: Measurement of morphometric dimension of lamina by digital vernier caliper

The mean length of superior border of lamina obtained in our study (right side = 15.98 mm and left side = 15.83 mm) is higher than the values reported by Saluja *et al.*[1] (right side = 14.51 mm and left side = 14.54 mm), Parashar *et al.*[7] (right side = 14.99 mm and left side = 15.28 mm), Polat *et al.*[8] (right side = 13.44 mm and left side = 13.49 mm), and Balamurugan *et al.*[4] (14.53 mm).

The integrity of laminae of typical cervical vertebrae is very important in keeping this region stable. We have seen that there are population differences in these dimensions. Basic orthopedic hardware such as plates, nails, and wires needed to be designed taking into consideration these population variations in the dimensions of laminae of typical cervical vertebrae. Instrumentation of the cervical spine is vital in decompression of neural contents of the vertebral canal.[5] Vertebral arteries and nerve roots are other important structures needed to be protected in cervical instrumentation procedures.[4]

Table 4: Thickness of lamina on the right side and left side

Vertebra	Mean (mm)±SD		*P*
	TL Rt	TL Lt	
C3	1.49±2.52	1.38±2.43	0.46
C4	2.45±0.88	2.49±0.79	0.43
C5	2.26±0.73	2.28±0.64	0.50
C6	2.86±1.01	2.98±0.92	0.28

SD: Standard deviation, TL Rt: Thickness of lamina on the right side, TL Lt: Thickness of lamina on the left side

Table 5: Height of lamina on the right side and left side

Vertebra	Mean (mm)±SD		*P*
	HL Rt	HL Lt	
C3	10.79±1.49	10.73±1.39	0.45
C4	10.54±1.52	10.56±1.57	0.5
C5	10.71.6±0.1.46	10.40±1.38	0.21
C6	11.78±1.42	11.68±1.59	0.43

SD: Standard deviation, HL Rt: Height of the lamina on the right side, HL Lt: Height of lamina on the left side

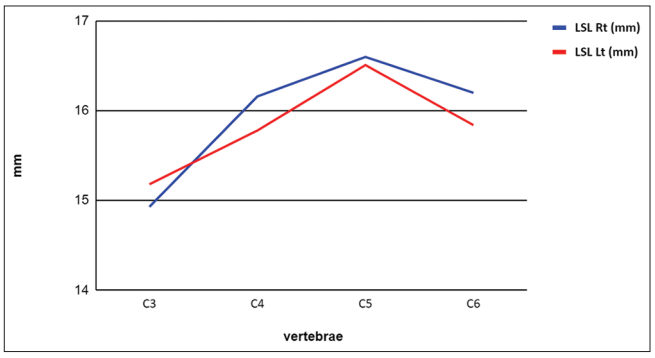

Figure 2: Length of the superior border of the lamina on the right side (LSL Rt) and left side (LSL Lt). LSL Rt: Length of the superior border of the lamina on the right side

Table 6: Comparison of length of superior border of lamina (mm)

Vertebrae	Prabavathy *et al*.[2]	Bezaldua *et al*.[6]	Parashar *et al*.[7]		Present study	
			Right side	Left side	Right side	Left side
C3	21.58±1.64	13.92±1.82	21.35±0.94	21.67±0.94	14.93±1.49	15.18±1.73
C4	22.72±0.86	15.27±1.77	22.66±0.94	22.69±0.66	16.16±1.64	15.78±1.63
C5	23.20±0.74	15.59±2.01	22.90±0.48	22.92±0.56	16.60±1.69	16.51±1.75
C6	23.74±1.03	14.81±2.03	23.60±1.12	23.48±1.09	16.20±2.06	15.84±2.32
Population	South Indian	Northeastern Mexico	Rajasthan		North West Indian	

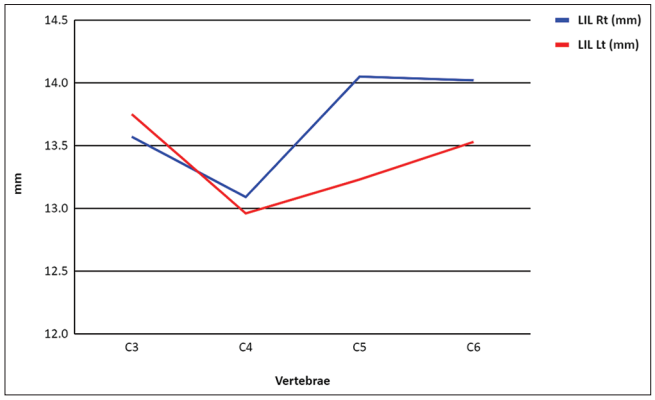

Figure 3: Length of inferior border of lamina on the right side (LIL Rt) and left side (LIL Lt). LIL Rt: Length of inferior border of lamina on the right side

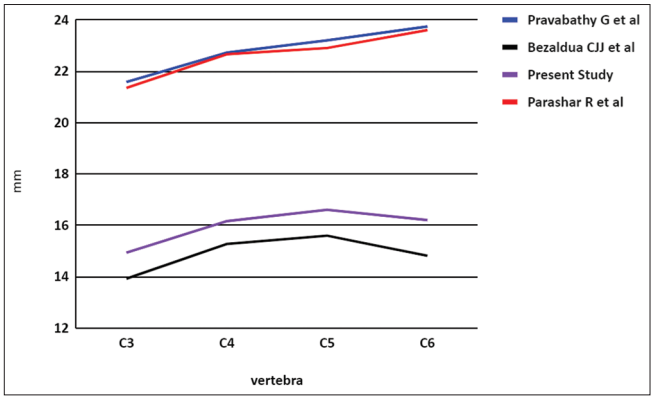

Figure 4: Comparison of length of superior border of lamina obtained in the present study with studies in various other populations

The current study complements evidence that there are significant variations in the dimensions of morphometric parameters of cervical vertebrae. These variations must be considered during surgical procedures.[9] Another study delineated the importance of assessing the correct size of instrumentation required in surgical processes performed for the cervical spine.[10]

This study found that thickness and height of lamina on the right and left sides are symmetrical and there is no significant difference between dimensions on two sides. However, the length at superior border and inferior border has significant differences as given in Tables 2 and 3. Comparison of length of superior border of lamina (mm) were shown in Table 6. Laminectomy and laminoplasty need knowledge of parameters reported in this study. These procedures are used in spondylotic myelopathy, stenosis, infection, neoplasm, and ligamentous ossification. In cervical laminectomy, the removal of lamina provides room to the spinal cord to move posteriorly away from anteriorly situated compressive lesion. This helps in improving the perfusion of the cervical spinal cord and gives relief from symptoms.[11] Laminectomy is also required during the resection of spinal medulla tumors in addition to spondylosis and posterior ligament ossification. This technique was developed to avoid the risk of complications associated with anterior decompression and fusion.[7]

This is amply clear from the above discussion that there are racial- or population-based differences in morphometric parameters of laminae of C3–C6 vertebrae. These differences in morphometric parameters have implications in selecting the right size and dimensions of surgical instruments and prostheses of cervical vertebrae. Mohi Eldin in a study on cervical vertebrae reported a high correlation between the values obtained by manual and CT measurements of pedicle dimensions.[12] It is proposed that CT scan may be useful in determining morphometric dimensions of laminae of cervical vertebrae. However, a correlational study on manual and CT measurement of morphometric parameters of laminae will be helpful in reaching a definite conclusion.

Conclusion

The present study indicates morphometric parameters of laminae of typical cervical vertebrae in the North West Indian population differ from the same parameters in Brazilian as well as South Indian populations. Furthermore, the length of superior border as well as inferior border of lamina has significant differences between right and left sides. However, there is no significant difference in height and thickness of laminae between right and left sides. The study has provided normal data of North West Indian population which can be useful in designing population-specific implants and screws needed for surgical procedures of lamina in these vertebrae. Such data allows for comparison with other study populations.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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