

Morphometric Analysis of Dry Typical Thoracic Vertebrae: A Cross sectional Study from Telangana, India

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ABSTRACT

Introduction: Morphometric measurements of dry typical thoracic vertebrae play an important role clinically in managing scoliosis, performing laminectomies, guiding pedicle screw fixation, and in designing spinal implants or prostheses for traumatic injuries. A precise understanding of typical thoracic vertebral dimensions is essential when planning thoracic spine surgery. Most of the screw and implant sizes are derived from Caucasian data, and hence may not be appropriate for all populations. Therefore, developing region specific morphometric data for typical thoracic vertebrae is crucial.

Aim: To establish the normative morphometry of typical thoracic vertebrae in the population of Telangana region to guide spinal instrumentation.

Materials and Methods: The present cross sectional study involved 80 adult dry typical thoracic vertebrae collected from the Department of Anatomy, Mahavir Institute of Medical Sciences, Vikarabad, Telangana, India. The study was conducted from October 2024 to February 2025. Various parameters including dimensions of the vertebral body, diameter of the vertebral foramen, pedicle dimensions and angles, laminae dimensions and length of spinous process were measured using vernier callipers. The statistical analysis was performed using Statistical Package for Social Sciences (SPSS) version 21. Range, Mean and standard deviations were calculated for all the parameters

and Student's t-test was performed to compare the right and the left-sides.

Results: The mean transverse and anteroposterior diameters of the bodies were 31.49 ± 3.35 mm and 22.05 ± 3.53 mm, respectively. The vertebral foramen transverse and anteroposterior diameters were 15.61 ± 1.34 mm and 13.75 ± 1.26 mm, respectively. The transverse angle of the pedicle was $14.55 \pm 3.72^\circ$ on the right side and $14.95 \pm 3.95^\circ$ on the left-side. The sagittal angle of the pedicle was on the right-side $10.54 \pm 2.74^\circ$ and $10.36 \pm 2.90^\circ$ on the left-side. The mean lamina height and the thickness on the right-side were 21.03 ± 2.42 mm and 06.18 ± 1.06 mm, respectively and on the left-side were 20.96 ± 2.09 mm and 06.35 ± 1.03 mm, respectively. There was no statistically significant difference observed between the right and left-sides of the pedicle and lamina dimensions and also chord length as the p-value was more than 0.05. Hence, bilateral symmetry was observed.

Conclusion: There were few variations observed in Telangana regional data collected in the current study namely transverse diameter of vertebral bodies, pedicle chord lengths, and sagittal and transverse angles were greater than in previous studies. These parameters are crucial for spinal surgeries and also the current study provides baseline data for the Telangana population that could help in improving instruments accuracy, reducing the risk of misplaced pedicle screws and neural injury.

Keywords: Implants, Lamina, Laminectomy, Pedicle, Screw, Spinal

INTRODUCTION

The vertebral column in human beings is made up of 33 vertebrae namely seven cervical, 12 thoracic, five lumbar, five sacral fused to form one single bone, the sacrum and four coccygeal fused to form one single bone, the coccyx. Among the 12 thoracic vertebrae 2nd to 8th vertebrae possess same features and are categorised as typical thoracic vertebrae whereas the 1st thoracic vertebra and 9th to 12th thoracic vertebrae possess variations in their features and categorised as atypical thoracic vertebra [1,2]. The thoracic vertebral body is bigger than the cervical vertebrae and smaller than the lumbar vertebrae and have spinous processes that are pointed and inclined downward. Articulation with the ribs is one of their key distinguishing characteristics [3].

Understanding the morphometry of vertebrae is crucial for various applications in the surgical field, including surgical planning, implant design, and the diagnosis of spinal disorders and selecting proper size of the instrumentation to minimise the risk of complications [4]. Thoracic spine surgeries provide unique challenges to surgeons due to the narrow vertebral canal diameter, the close relation to important vascular structures including the aorta especially from T3 to T7 and narrow pedicles [5].

The most advanced approach to arthrodesis is transpedicular screw fixation, in which the pedicles of adjacent vertebrae are fixed

with screws. The most common method of transpedicular screw fixation of the dorsal spine is due to its stable construction and its biomechanical benefits. However, there is a chance that improper screw placement could cause damage to the nearby neurovascular tissue [6]. The widespread adoption of pedicle screw fixation in the thoracic spine has made the morphometric analysis of thoracic pedicles essential for surgeons performing this procedure. Use of improper size screws can lead to complications such as pedicle cortex perforation, pedicle fracture, or nerve root injury [7,8].

Spinal diseases such as thoracic spondylotic myelopathies lead to spastic paresis in the lower limbs, and abnormalities of the bladder and bowel which are brought about by spinal cord compression. The main etiological factors contributing in the thoracic cord compression are ossification of the posterior longitudinal ligament, ossification of the ligamentum flavum, degenerative thoracic spondylotic myelopathy, and vertebral disk herniation [9]. The degenerative changes are mainly due to mechanical stress on the adjacent vertebral bone bridges [10]. Thoracic spine stenosis is treated either by anterior decompression or posterior decompression methods to relieve symptoms and lead a better life [11]. A detailed morphometry of thoracic vertebrae is very much essential to carry out these procedures.

Though there are numerous studies on vertebral morphometry across different global populations, region-specific morphometric

data for the typical thoracic vertebrae remains insufficient in the Telangana region of India [12-15]. Most available literature either aggregates data from all over Indian populations or focuses on cervical and lumbar regions, overlooking the thoracic spine's unique anatomical and biomechanical significance. Most of the studies in India focused on pedicle morphometry only while other parameters were neglected [1,16]. There is a lack of comprehensive studies evaluating multiple morphometric parameters. Thus, the present study was focused on multiple morphometric parameters such as dimensions of the vertebral body, canal, pedicle, lamina, chord length, spinous process and the pedicular angles in the Telangana region of India.

MATERIALS AND METHODS

The present cross-sectional study was conducted from October 2024 to February 2025 in the Department of Anatomy, Mahavir Institute of Medical Sciences, Vikarabad, Telangana, India. The study was carried out on dry bones. So, ethical permission was not required. A total of 80 dried typical thoracic vertebrae of unknown sex were collected from the departmental bone bank.

Inclusion criteria: The adult intact typical thoracic vertebrae (2nd to 8th) were included in the study.

Exclusion criteria: Vertebrae with any bony spurs, pathologies or anomalies and damaged vertebrae were excluded from the study.

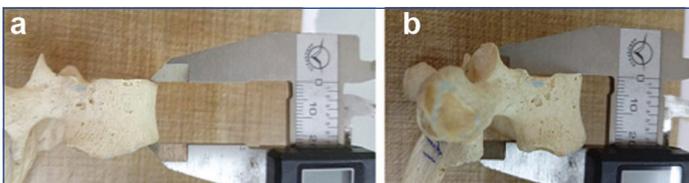
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Study Procedure

Various morphometric parameters were measured using vernier callipers and the angles were measured using goniometer. The vertebral body dimensions, pedicle dimensions, laminae dimensions, and vertebral foramen diameters, were measured. Each measurement was taken thrice by two observers to overcome intra-observer and inter-observer bias and the average was recorded.

A) Vertebral body dimensions: The anterior and posterior thickness or height, transverse diameter and the anteroposterior diameters were measured using vernier callipers [12].

- (i) Anterior thickness/height: Distance measured between the superior and inferior surfaces of the body in the midsagittal plane anteriorly [Table/Fig-1a].
- (ii) Posterior thickness/height: Distance measured between the superior and inferior surfaces of the vertebral body in the midsagittal plane posteriorly [Table/Fig-1b].

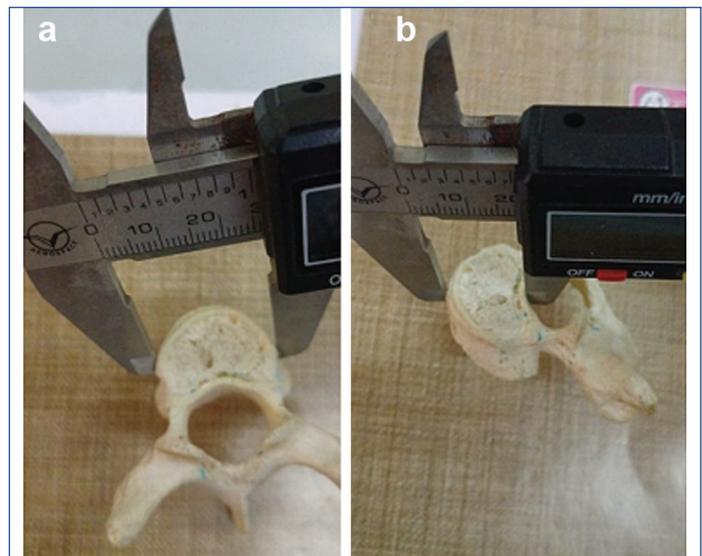


[Table/Fig-1]: Showing: a) Anterior thickness/height; and b) Posterior thickness/height of the vertebral body of a typical thoracic vertebra.

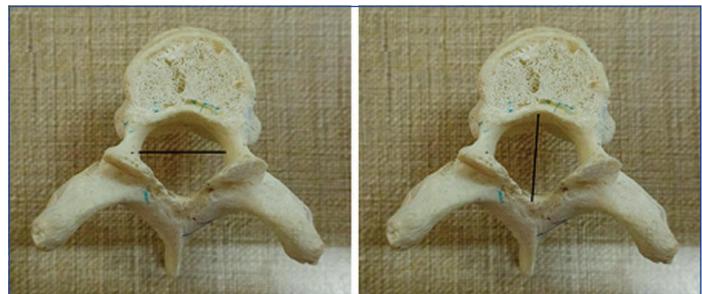
- (iii) Transverse diameter: The maximum transverse diameter of the vertebral body on its superior surface [Table/Fig-2a].
- (iv) Anteroposterior diameter: Distance measured between the anterior and posterior borders of the superior surface of the vertebral body in mid sagittal plane [Table/Fig-2b].

B) Vertebral foramen: The transverse and the anteroposterior diameters were measured using vernier callipers [13].

- (i) Transverse diameter: The maximum transverse diameter of the vertebral foramen [Table/Fig-3a].
- (ii) Anteroposterior diameter: The anteroposterior diameter of the vertebral foramen in mid sagittal plane [Table/Fig-3b].



[Table/Fig-2]: Showing: a) Transverse diameter; and b) Anteroposterior diameter of the typical thoracic vertebra.



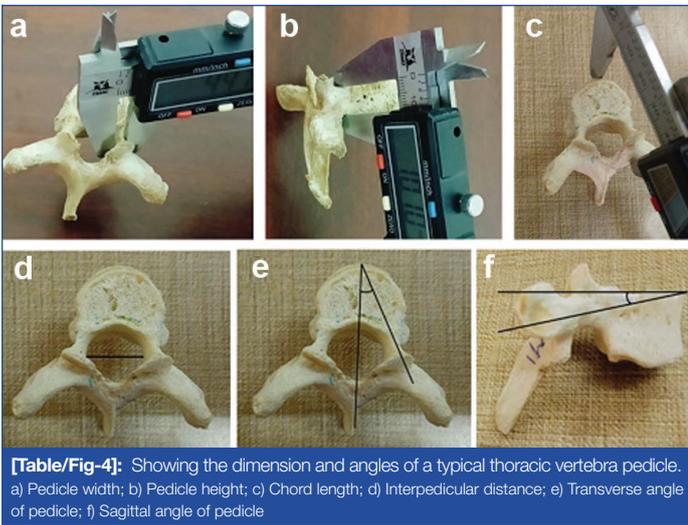
[Table/Fig-3]: Showing: a) Transverse diameter; and b) Anteroposterior diameter of vertebral foramen of typical thoracic vertebra.

C) Pedicle dimensions: The height, width of the pedicle, the chord length and interpedicular distance were measured using vernier callipers. The sagittal angle of the pedicle and the transverse angle of the pedicle were measured using goniometer [14].

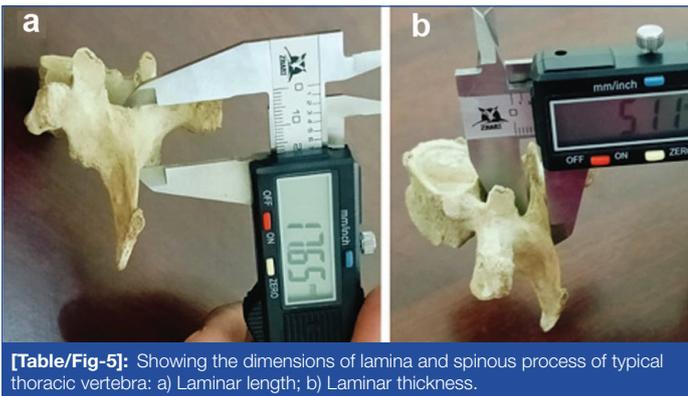
- (i) Pedicle width: Distance measured between the medial surface of pedicle to the lateral surfaces of the pedicle at its midpoint, at the right angle to the long axis of the pedicle [Table/Fig-4a].
- (ii) Pedicle height: Distance measured between superior margin of the pedicle to inferior margin of the pedicle at its midpoint [Table/Fig-4b].
- (iii) Chord length: Distance measured between the posterior cortical entrance point of the pedicle to the anterior cortex of the vertebral body along the long axis of the pedicle [Table/Fig-4c].
- (iv) Interpedicular distance: Distance between the medial surfaces of the right and the left vertebral pedicles measured at the level of the isthmus [Table/Fig-4d].
- (v) Pedicular transverse angle: The angle measured between the pedicle axis and a line parallel to the vertebral midline measured in the transverse plane [Table/Fig-4e].
- (vi) Pedicular sagittal angle: The angle measured between the superior border of the vertebral body in the midsagittal plane and the pedicle axis [Table/Fig-4f].

D) Laminae dimensions: The height and thickness were measured using vernier callipers [15].

- (i) Lamina height: Maximum distance between the superior and inferior borders of the lamina [Table/Fig-5a].
- (ii) Lamina thickness: Maximum distance between the anterior and posterior surfaces of the lamina [Table/Fig-5b].



[Table/Fig-4]: Showing the dimension and angles of a typical thoracic vertebra pedicle. a) Pedicle width; b) Pedicle height; c) Chord length; d) Interpedicular distance; e) Transverse angle of pedicle; f) Sagittal angle of pedicle

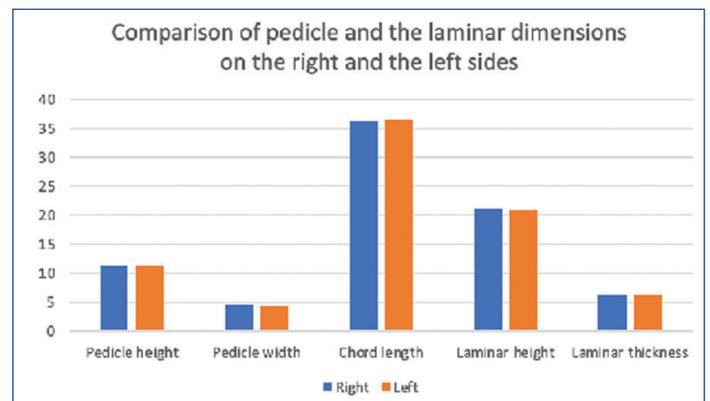


[Table/Fig-5]: Showing the dimensions of lamina and spinous process of typical thoracic vertebra: a) Laminar length; b) Laminar thickness.

difference between the right and the left-sides in relation to pedicle height, pedicle width, the chord length, lamina height and lamina thickness [Table/Fig-7,8].

Parameters	Range (mm)		Mean±SD (mm)		T value	p-value
	Right	Left	Right	Left		
Pedicle height	08.17-14.99	09.05-14.94	11.16±1.49	11.15±1.48	0.027	0.48
Pedicle width	02.63-06.33	02.69-06.37	04.58±1.06	04.49±1.07	0.27	0.39
Chord length	29.74-42.96	30.76-42.54	36.20±3.96	36.46±3.77	0.21	0.41
Sagittal angle	11°-15°	12°-15°	10.54±2.74°	10.36±2.9°	0.61	0.27
Transverse angle	10°-16°	9°-17°	14.55±3.72°	14.95±3.95°	0.06	0.47
Lamina height	16.12-25.68	16.88-26.29	21.03±2.42	20.96±2.09	0.09	0.46
Lamina thickness	04.05-08.70	04.51-08.19	06.18±1.06	06.35±1.03	0.30	0.50

[Table/Fig-7]: Showing descriptive statistics for pedicle and laminae dimensions.



[Table/Fig-8]: Bar diagram showing the comparison of the pedicle and laminae dimensions on the right and the left-sides.

The transverse angle of the pedicle was on the right-side 14.55±3.720 and on the left-side 14.95±3.950. The sagittal angle of the pedicle was 10.54±2.740 on the right-side and 10.36±2.90 on the left-side. There was no significant difference observed between the right and the left-sides.

DISCUSSION

Morphometric analysis of typical thoracic vertebrae is essential as there are ethnic variation in the sizes of the vertebral body, vertebral foramen, pedicle and the lamina. Morphometric studies are of significance and particularly useful in clinical applications and interventions, such as spinal surgeries and artificial vertebral implant designing [10-12]. Advanced modern radiological imaging techniques such as Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) may not provide the detail and accuracy provided by the exact morphometric analysis of dry bone thoracic vertebrae [17]. Several previous studies were carried out in dry bones, cadavers, and also using radiological imaging techniques such as CT and MRI [8, 17, 18]. The vertebral shape and morphological and pathological assessment are possible with radiological techniques but its intrinsic spatial resolution limitations and propensity for image errors can mask minute anatomical differences that are essential for a thorough morphometric analysis [17]. Thus, the present study was carried out on morphometric analysis of dry typical thoracic vertebrae in Telangana population.

The morphometric analysis of thoracic vertebral bodies plays an important role in the biomechanical stability and neurological integrity of the spine that critically influences the surgical outcomes of spinal deformities such as scoliosis, kyphosis and kyphoscoliosis, as well as the management of thoracic myelopathy [19,20]. Thoracic

STATISTICAL ANALYSIS

The data was analysed using SPSS version 21. For all the parameters, quantitative data was presented with descriptive measures such as range, mean and standard deviation. To compare the dimensions on the right and the left-sides were analysed using paired student t-test. The p-value 0.05 was considered as level of significance at the 95% confidence interval.

RESULTS

The mean transverse diameter of the vertebral body was greater than the anteroposterior diameters of the bodies which were 31.49±3.35 mm and 22.05±3.53 mm respectively. The anterior height of vertebral body was lesser than the posterior height of bodies which were 17.32±1.56 mm and 18.66±1.76 mm, respectively. The vertebral foramen transverse diameter was greater than the anteroposterior diameter which was 15.61±1.34 mm and 13.75±1.26 mm, respectively. The interpedicular distance was ranging between 13.35 to 18.6 mm and the average distance was 15.91±1.19 mm. The range, mean and standard deviations of vertebral body dimensions, vertebral canal dimensions and the interpedicular distance were recorded in [Table/Fig-6].

Parameters	Range (mm)	Mean±SD (mm)
Transverse diameter of vertebral body	26.23 to 34.56	31.49±3.35
Anteroposterior diameter of vertebral body	19.06 to 24.89	22.05±3.53
Anterior height of vertebral body	15.83 to 18.82	17.32±1.56
Posterior height of vertebral body	16.25 to 19.76	18.66±1.76
Transverse diameter of vertebral canal	14.23 to 16.91	15.61±1.34
Anteroposterior diameter of vertebral canal	11.98 to 14.83	13.75±1.26
Interpedicular distance	13.35 to 18.60	15.92±1.20

[Table/Fig-6]: Showing range, mean and standard deviations of vertebral body dimensions, vertebral canal dimensions and the interpedicular distance.

The range, mean and standard deviations of pedicle and lamina dimensions were recorded in [Table/Fig-7]. There was no significant

myelopathy results from compression of spinal cord due to ossification of posterior longitudinal ligament or metastasis of tumour that needs to be decompressed [21]. Most spinal metastasis occurs in the vertebral body, and the dural sac that causes only few millimeters of mobility. For all these conditions decompression is the only solution which can be performed in various approaches such as ventral or anterior decompression, dorsal or posterior decompression and circumferential decompression [22]. The vertebral anterior thickness, posterior thicknesses, anteroposterior and transverse diameter of the present study were compared with the other studies in [Table/Fig-9] [12,23,24]. These measurements were instrumental in surgical planning to achieve better postoperative outcome.

The mean dimensions of the vertebral body of the present study are similar to the study by Moulya BNH et al., who conducted study on coastal population of Andhra Pradesh [23]. The vertebral body dimensions are higher in the present study when compared to a study by Hari NY et al., in Uttar Pradesh population on the other hand the dimensions were lower than the Marathwada population of Maharashtra region [12]. The vertebral body size shows variation in different regions of the India.

The mean transverse diameter and the anteroposterior diameter of the vertebral foramen in the present study were 15.61±1.34 mm and 13.75±1.26 mm, respectively. In the present study the anteroposterior diameter was in the range between 11.98 to 14.83 mm. The thoracic vertebral canal stenosis that causes compression of spinal cord is considered to be having less than 10mm anteroposterior diameter [25].

The vertebral arch is connected to the body through pedicles which are the strongest parts and are entirely made up of compact bone with a small core of cancellous bone. The pedicles act as a

with other studies in [Table/Fig-10] [12,14,26]. The pedicle height and width were similar with other studies but the chord length was observed to be little longer when compared to the other study by Mwakikunga A et al., in Malawain population. The sagittal angle and transverse angle of the pedicles were little higher in the present study when compared to the other study by Mwakikunga A et al., in Malawain population [14].

Ossification of ligamentum flavum and ossification of posterior longitudinal ligament causes myelopathies leading to compression of spinal cord. The posterior decompression method is carried out by performing laminectomy where the lamina of the vertebrae is removed [27-29]. On the other hand, the neoplasms and the metastasis of the spine also cause vertebral stenosis [30]. Morphometric analysis of the laminae of typical thoracic vertebrae is important for surgeons while performing laminectomy in cases of vertebral canal stenosis, ossification of ligaments around it and neoplasms of thoracic spine [27-30]. The laminar dimensions of the present study were compared with other studies and the dimensions were similar with other studies [Table/Fig-11] [12,15]. Hari NY et al., found a significant difference between the right and the left laminar thicknesses but in the present study no significant difference was found between the right and the left-sides [12].

Thoracic spine is unique as it contributes in the formation of ribcage through sterno-costo-vertebral articulations which provide increased stiffness and stability to the thoracic spine compared to the cervical and lumbar spines. The stability of the thoracic spine is compromised in decompression surgeries [31]. Morphometric analysis of the thoracic vertebrae in the regional population can help in selecting optimal size instrumentation and lower the postoperative complications and help to provide better stability to the thoracic spine.

Author	Ethnicity and year	Sample size	Transverse diameter (mm)	AP diameter (mm)	Anterior thickness (mm)	Posterior thickness (mm)
Moulya BNH et al., [23]	India (Andhra Pradesh) 2022	82	29.76	21.77	18.17	-
Hari NY et al., [12]	India (Uttar Pradesh) 2023	100	25.58±2.34	18.53±2.59	16.24±1.54	17.81±1.67
Deshpande SS [24]	India Maharashtra (Marathwada) 2024	75	28.25	22.37	20.15	21.12
Present study	India Telangana 2025	80	31.49±3.35	22.05±3.53	18.66±1.75	17.32±1.56

[Table/Fig-9]: Comparison of dimensions of the vertebral body with other studies [12,23,24].

Author	Ethnicity and year	Sample size	Side	Pedicle width (mm)	Pedicle height (mm)	Chord length (mm)	Sagittal angle	Transverse angle
Garg S et al., [26]	India 2020	120	Right	5.71±1.28	10.16±1.28	-	-	-
			Left	5.71±1.22	10.38±1.26	-	-	-
Mwakikunga A et al., [14]	Malawia 2021	227	Right	4.82±1.77	12.46±2.54	30.08±4.73	9.40±2.760	12.46±2.340
			Left	4.70±1.84	12.63±2.60	30.4±4.89	9.24±2.660	12.22±2.300
Hari NY et al., [12]	India 2023	100	Right	3.75±0.98	9.64±1.04	-	-	-
			Left	3.74±0.97	9.68±1.14	-	-	-
Present study	Telangana 2025	80	Right	4.58±1.06	11.16±1.49	36.20±3.96	10.54±2.740	14.55±3.720
			Left	4.49±1.07	11.15±1.48	36.46±3.77	10.36±2.90	14.95±3.950

[Table/Fig-10]: Showing comparison of pedicle dimensions, angles in various studies [12,14,26].

strut to transmit forces between the vertebral body and the arch [16]. The pedicle dimensions, chord length and sagittal angle and transverse angle play an important role in spinal surgeries such as transpedicular screw fixation and transpedicular bone grafting [26]. Size selection of screw and other instrumentations depends on the morphometric parameters of the pedicle. In most of the studies pedicle width and height were only measured whereas in the present study the chord length, sagittal angle and transverse angle were also measured as these have a very important role in pedicle screw fixation surgeries. The dimensions of pedicle were compared

Author	Ethnicity and year	Sample size	Side	Laminar height (mm)	Laminar thickness (mm)
Egwo OA et al., [15]	Nigeria 2019	208		18.13±2.38	6.86±1.20
Hari NY et al., [12]	India 2023	100	Right	17.07±2.15	5.26±0.94
			Left	17.20±1.98	5.13±0.88
Present study	Telangana 2025	80	Right	20.96±2.09	6.35±1.03
			Left	18.13±2.38	6.86±1.20

[Table/Fig-11]: Comparison of the laminar dimensions of the presents study with other studies [12,15].

Limitation(s)

The present study included only dry, typical thoracic vertebrae for morphometric analysis. Detailed morphometric evaluation of individual thoracic vertebral levels will be undertaken in future research studies.

CONCLUSION(S)

The present study provides baseline morphometric data of typical thoracic vertebrae in the Telangana population. The thoracic vertebral body transverse diameter, pedicle chord lengths, sagittal and transverse angles were greater than those reported in other studies. These findings are valuable for spinal decompression, pedicle screw fixation, and laminectomy, reducing the risk of neural injury. Additionally, this information may help improve surgical outcomes by customising spinal implants to the anatomical features of the Telangana population.

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