

# Morphometric Analysis of the Body, Pedicle and Lamina of Typical Thoracic Vertebrae: An Observational Study

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## ABSTRACT

**Introduction:** Thoracic vertebrae are a part of the vertebral column. The thoracic vertebrae have a body size between the cervical and lumbar vertebrae, which increase gradually from above downward and are characterised by the presence of facet joints for articulation with the head of the ribs on the side of the vertebral bodies.

**Aim:** To measure the various morphometric parameters of different components of dry thoracic vertebrae and compare various components on the right and left-sides.

**Materials and Methods:** The present observational study was carried on 100 dry human thoracic vertebrae for direct measurements of the vertebral body, pedicle and lamina. Using a digital Vernier calliper, all the parameters were measured. The data was entered in Microsoft excel sheet. The mean and standard deviation (M±SD) of all parameters were analysed using Statistical Package for the Social Sciences (SPSS) version 21.0. Student's t-test was used for the comparison of morphometric dimensions of the right and left-sides.

**Results:** In a typical thoracic vertebra, the mean Transverse Diameter (TD) was 25.58±2.34 mm, and the mean Anteroposterior Diameter (APD) of the vertebral body was 18.53±2.59 mm. The mean Anterior Height (AH) and Posterior Height (PH) of the body were 16.24±1.54 mm and 17.81±1.67 mm, respectively. The mean Pedicle Width (PW) was 3.75±0.98 mm on the right-side and 3.74±0.97 mm on the left-side. The mean Pedicle Height (PH) was 9.64±1.04 mm on the right-side and 9.68±1.14 mm on the left-side. The mean Lamina Height (LH) on the right-side was 17.07±2.15 mm and on the left-side was 17.20±1.98 mm. The right-side and left-side mean Lamina Widths (LW) were 5.26±0.94 mm and 5.13±0.85 mm, respectively. PW and PH and lamina thickness and LH measurements showed no statistically difference between right and left-sides.

**Conclusion:** Designing implants and instruments using data from such researches can benefit the surgeon during preoperative planning.

**Keywords:** Anteroposterior distance, Height, Transverse diameter, Thickness, Width

## INTRODUCTION

A component of the skeletal system is the vertebral column, sometimes known as the spine. By providing attachment points for the muscles and shielding the spinal cord and nerves, the trunk's primary job is to maintain an upright posture. In addition, it offers stability and permits motion. The 33 irregular vertebrae that make up the adult spinal column are divided into seven cervical, 12 thoracic, five lumbar, five sacral, and four coccygeal vertebrae. Thoracic vertebrae can be categorised as either typical or atypical. T1 and T9 to T12 thoracic vertebrae are atypical but T2 to T8 thoracic vertebrae are typical.

The thoracic vertebrae are distinguished by the presence of facet joints for articulation with the head of the ribs on the side of the vertebral bodies and have a body size that lies between the cervical and lumbar vertebrae, which increases gradually from above downward. When viewed from above, a typical thoracic vertebra has a heart-shaped body with two demi-facets at the point where the body and pedicle meet. A pair of pedicles, laminae, transverse processes, superior and inferior articular processes, and spinous processes comprise the vertebral arch [1]. Transverse width reduces from T1 to T3 and then gradually increases down to T12, but the Anteroposterior Diameter (APD) of the vertebral bodies gradually increases from T1 to T12. The design of a wide range of implants and surgical techniques is aided by these morphometric analyses. The detection of vertebral fractures and degenerative shape changes depends on age-related changes in vertebral morphology [2].

The morphometric analysis of the thoracic pedicle has become a clinical prerequisite for all surgeons performing pedicle screw fixation of the thoracic spine due to the development and widespread acceptance of this technique. If the improper size screw is used, the

pedicle may fracture or perforate, injuring the nerve roots as a result [3]. The aim of the study was to assess the various morphometric characteristics of the thoracic vertebral body, pedicle, and lamina in a northern Indian population.

## MATERIALS AND METHODS

The observational study was carried out on 100 dry human typical thoracic vertebrae from the bone bank at the SGT Medical College, Hospital and Research Institute in Gurugram, Haryana, India and Department of Anatomy, KM Medical College and Hospital, Mathura, Uttar Pradesh, India. The study was conducted from March 2022 to December 2022. The study was approved by the ethical committee of SGT Medical College, Hospital and Research Institute (vide letter no. IEC/FMHS/PhD/S/2022) and KM Medical College and Hospital (vide letter no. KMMCH/2021/628).

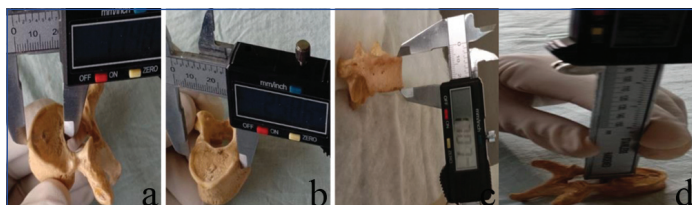
**Inclusion criteria:** Vertebrae that were normal, adult-sized, dry, and intact were included in the study.

**Exclusion criteria:** Vertebrae that were diseased, pathological, or insufficiently osseous were excluded from the study.

Each typical vertebra was numbered from 1-100 at random. Age and gender differentiation was not done. Each parameter was measured twice, and the averages of those readings were computed. For linear measurements, a digital vernier caliper with a resolution of 0.1 mm was used. The following variables were measured:

### Vertebral body [Table/Fig-1]

- The Anteroposterior Distance (APD) of the vertebral body- The distance between the anterior border and posterior border of the superior surface of the vertebral body in the midline.

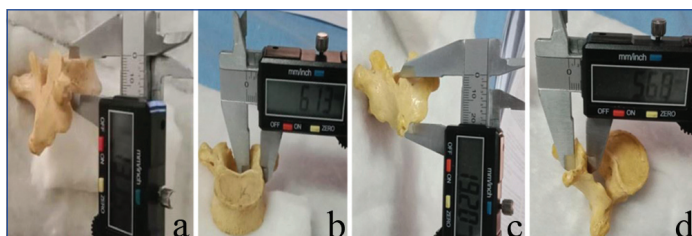


**[Table/Fig-1]:** (a) Measurement of Anteroposterior distance of body; (b) Transverse Diameter (TD); (c) Anterior Height (AH) at midline anteriorly; and (d) Posterior Height (PH) at midline posteriorly.

- ii. Transverse Diameter (TD) of the vertebral body- The maximum TD of the vertebral body at the superior surface.
- iii. Anterior Height (AH) of the body- The vertical distance between the superior and inferior surface of the body in the midline anteriorly.
- iv. Posterior Height (PH) of the body- The vertical distance between the superior and inferior surface of the body in the midline posteriorly.

**Pedicle [Table/Fig-2]**

- i. Pedicle Height (PH)- The maximum distance between the superior and inferior border of the pedicle at its midpoint.
- ii. Pedicle Width (PW)- The maximum distance between medial and lateral surfaces of the pedicle at its midpoint, measured at right angles to the long axis of the pedicle.



**[Table/Fig-2]:** (a) Measurement of Pedicle Height (PH); (b) Pedicle Width (PW); (c) Lamina Height (LH); and (d) Lamina thickness.

**Lamina [Table/Fig-2]**

Lamina Height (LH)- The maximum distance between the superior and inferior borders.

Lamina thickness- The maximum distance between the anterior and posterior surfaces.

**STATISTICAL ANALYSIS**

The level of significance ( $p < 0.05$ ) for the statistical analysis was set at 5%. The statistical analysis was done using IBM SPSS 21.0. All the morphometric parameters'  $M \pm SD$  were determined. Student's t-test was used to compare the morphometric dimensions of the right and left-sides, and a p-value was calculated. A p-value  $< 0.05$  is considered to be statistically significant.

**RESULTS**

1. **Body:** [Table/Fig-3] shows that the body's PH was higher than its AH, and the mean TD was higher than the APD.
2. **Pedicle:** The mean PH was slightly larger on the left than the right, although this difference was statistically non significant. The PW was also similar on both the sides [Table/Fig-4].
3. **Lamina:** The mean LH and LW on the right and left-sides were similar. However, the mean LW was significantly larger on the right-side [Table/Fig-5].

Parameters	Range (mm)	Mean±SD (mm)
Anteroposterior Diameter (APD)	13.25-24.84	18.53±2.59
Transverse Diameter (TD)	20.66-31.83	25.58±2.34
Anterior Height (AH)	12.31-19.75	16.24±1.54
Posterior Height (PH)	10.45-20.96	17.81±1.67

**[Table/Fig-3]:** Showing APD, TD, AH and PH of body of thoracic vertebrae.

Parameters	Range (mm)		Mean±SD (mm)		p-value
	Right	Left	Right	Left	
Pedicle Height (PH)	7.45-12.57	7.16-12.7	9.64±1.04	9.68±1.14	0.523
Pedicle Width (PW)	1.56-6.31	1.66-7.18	3.75±0.98	3.74±0.97	0.941

**[Table/Fig-4]:** Showing PH and PW of pedicle of thoracic vertebrae.

Parameters	Range (mm)		Mean±SD (mm)		p-value
	Right	Left	Right	Left	
Lamina Height (LH)	13.29-24.46	13.08-22.14	17.07±2.15	17.20±1.98	0.148
Lamina Width (LW)	3.29-8.66	3.01-7.66	5.26±0.94	5.13±0.85	0.022

**[Table/Fig-5]:** Showing LH and LW of lamina of thoracic vertebrae.

**DISCUSSION**

The variations in the sizes of the vertebral body, pedicle, and lamina in various populations and different countries have been the subject of several quantitative anatomical type of research. The thoracic vertebrae have been researched by numerous authors using a variety of methodologies, including plain radiography, direct measurements from dry bones, cadaveric bones, and Computed Tomography (CT) and Magnetic Resonance Imaging (MRI) scan approaches. The means of the various parameters acquired from other research and those of the current study are compared in the [Table/Fig-6-11] [4-11]. In the current results, PW and PH and lamina thickness and LH measurements showed no statistically difference between right and left-sides.

Study	Year	Country	Materials for study	Mean (in mm)
Patil DK and Bhuiyan PS [4]	2014	India	Dry bones	20.78
Vasanth M et al., [5]	2017	India	Dry bones	21.96
Jha S and Sethi R [6]	2018	India	Dry bones	19.95
Present study	2023	India	Dry bones	18.53

**[Table/Fig-6]:** The mean anteroposterior distance of the vertebral body in typical thoracic vertebrae is compared with previous studies [4-6].

Study	Year	Country	Materials for study	Mean (in mm)
Singh R et al., [7]	2011	India	Dry bones	25.9
Patil DK and Bhuiyan PS [4]	2014	India	Dry bones	27.02
Vasanth M et al., [5]	2017	India	Dry bones	27.9
Jha S and Sethi R [6]	2018	India	Dry bones	26.97
Present study	2023	India	Dry bones	25.58

**[Table/Fig-7]:** Compares several studies' findings about the mean Transverse Diameter (TD) of the vertebral body in typical thoracic vertebrae [4-7].

Study	Year	Country	Materials for study	Mean (in mm)
Singh R et al., [7]	2011	India	Dry bones	17.39
Kunkel ME et al., [8]	2011	Germany	Cadaveric, Radiographic	15.84
Patil DK and Bhuiyan PS [4]	2014	India	Dry bones	17.17
Vasanth M et al., [5]	2017	India	Dry bones	17.71
Jha S and Sethi R [6]	2018	India	Dry bones	17.06
Present study	2023	India	Dry bones	16.24

**[Table/Fig-8]:** Compares the typical thoracic vertebrae's mean anterior height to results from other research [4-8].

The findings indicate that the mean APD of the typical thoracic vertebral body in the current study was lesser than the value obtained by others studies [4-6]. The mean TD of the vertebral body in the current study was higher than that of others studies [4-6], but those by Singh R et al., were identical to the present study [7]. The mean anterior height of the typical thoracic vertebral body was greater than values reported by other studies [8], but it was typically less than a few researches [4-7].

Study	Year	Country	Materials for study	Mean (in mm)
Singh R et al., [7]	2011	India	Dry bones	18.19
Kunkel ME et al., [8]	2011	Germany	Cadaveric, Radiographic	17.99
Patil DK and Bhuiyan PS [4]	2014	India	Dry bones	18.27
Jha S and Sethi R [6]	2018	India	Dry bones	18.13
Present study	2023	India	Dry bones	17.81

**[Table/Fig-9]:** The mean Posterior Height (PH) of the body in typical thoracic vertebrae is compared with findings from previous studies [4,6-8].

Study	Year	Country	Materials for study	PW (mean) mm	PH (mean) mm
Pai BS et al., [9]	2010	India	Dry bones	5.09	10.37
Singh. R et al., [7]	2011	India	Dry bones	4.88	11.12
Patil DK and Bhuiyan PS [4]	2014	India	Dry bones	Left: 4.33 Right: 4.29	Left: 10.54 Right: 10.62
Garg S et al., [10]	2020	India	Dry bones	Left: 5.71±1.22 Right: 5.18±1.28	Left: 10.38±1.26 Right: 10.16±1.28
Present study	2023	India	Dry bones	Left: 3.74±0.97 Right: 3.75±0.98	Left: 9.68±1.14 Right: 9.64±1.04

**[Table/Fig-10]:** Comparison of the pedicle dimensions from earlier investigations is shown (PH=Pedicle height, PW=Pedicle width) [4,7,9,10].

Study	Year	Country	Materials for study	LH (mean) mm	LT (mean) mm
Egwu OA et al., [11]	2019	Nigeria	Dry bones, cadaveric	18.13±2.38	6.86±1.20
Present study	2023	India	Dry bones	Left: 17.20 ±1.98 Right: 17.07±2.15	Left: 5.13±0.85 Right: 5.26±0.94

**[Table/Fig-11]:** Compares the dimensions of the lamina with earlier research (LH=Lamina height; PW=Lamina thickness) [11].

The mean PH of the typical thoracic body in the current study was consistent with the findings of other study [8], but contrarily lesser than those reported a few others [4-7]. The findings revealed that the mean PW and PH on the left and right-sides in the current study was smaller than the values reported by other researchers [4,7,9,10]. The mean LH and lamina thickness in the current investigation were lower than those reported by Egwu OA et al., [11]. In the current study, the thickness of the lamina on the right-side was slightly greater than that on the left and the height of the lamina on the right and left is almost equal. There hasn't been much research on the lamina.

## Limitation(s)

The study could not explore differences based on age and gender.

## CONCLUSION(S)

The findings of this study can be used to design implants and instruments, analyse spine diseases, and manage spinal problems in this region of the world. It is impossible to determine the appropriate pedicle screw diameter for use in surgery due to the wide range of pedicles. By using the published anatomic parameters of the laminae, this quantitative analysis may be useful for surgical placement of sublaminar instruments.

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