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Original Research Article

# A Morphometric Study of the Body, Pedicles, and Laminae of Typical Thoracic Vertebrae in Humans: A Cross-Sectional Study

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**Conflict of interest: Nil**

**Abstract**

**Background:** The thoracic vertebrae play a crucial role in maintaining spinal stability, protecting the spinal cord, and facilitating movement. Detailed knowledge of their morphometric characteristics is essential for clinical applications, particularly in spinal instrumentation and surgical procedures.

**Aim:** To perform a detailed morphometric analysis of the vertebral body, pedicle, and lamina of typical thoracic vertebrae and to evaluate bilateral symmetry of pedicle and laminar dimensions.

**Materials and Methods:** This descriptive cross-sectional study was conducted on 110 dry human thoracic vertebrae. Measurements of the vertebral body, pedicle, and lamina were obtained using a digital Vernier caliper. Parameters assessed included anteroposterior diameter (APD), transverse diameter (TD), anterior height (AH), posterior height (PH), pedicle height and width, and lamina height and width. Data were analyzed using SPSS version 27.0. Descriptive statistics were expressed as mean ± standard deviation (SD), and comparisons between left and right sides were performed using the independent samples t-test, with $p < 0.05$ considered statistically significant.

**Results:** The mean APD, TD, AH, and PH of the vertebral body were 18.1 ± 2.1 mm, 25.7 ± 9.1 mm, 16.4 ± 7.2 mm, and 17.3 ± 4.5 mm, respectively. The transverse diameter and anterior height showed greater variability compared to APD. Pedicle height and width demonstrated no statistically significant differences between the left and right sides ($p = 0.72$ and $p = 0.81$, respectively). Similarly, lamina height and width showed no significant bilateral differences ($p = 0.96$ and $p = 0.74$, respectively), indicating symmetrical morphology.

**Conclusion:** The study highlights that while vertebral body dimensions exhibit variability, the pedicle and lamina demonstrate significant bilateral symmetry. These findings provide valuable anatomical data that can aid in surgical planning, spinal instrumentation, and the design of implants, thereby enhancing the safety and efficacy of thoracic spine procedures.

**Keywords:** Thoracic Vertebrae, Vertebral Body, Pedicle, Lamina, Spinal Instrumentation.

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## Introduction

The vertebral column, sometimes referred to as the spine, is a part of the skeletal system. The fundamental function of the trunk is to maintain an upright posture by protecting the spinal cord and nerves and offering attachment places for the muscles. It also allows motion and provides stability. Seven cervical, twelve thoracic, five lumbar, five sacral, and four coccygeal vertebrae comprise the 33 irregular vertebrae that comprise the adult spinal column. There are two types of thoracic vertebrae: typical and atypical. T2 to T8 thoracic vertebrae are usual, but T1 and T9 to T12 thoracic vertebrae are abnormal [1]. The thoracic vertebrae have a body size that falls between the cervical and lumbar vertebrae, progressively increasing from above downward, and are identified by the presence of facet joints for articulation with the head of the ribs on the side of the vertebral bodies [2]. A normal thoracic vertebra seems to have a heart-shaped body with two demi-facets at the junction of the body and pedicle when viewed from above. The vertebral arch is made up of two pedicles, laminae, transverse processes, superior and inferior articular processes, and

spinous processes. While the Anteroposterior Diameter (APD) of the vertebral bodies gradually grows from T1 to T12, transverse width decreases from T1 to T3 and then gradually increases down to T12 [3]. These morphometric evaluations help create a variety of implants and surgical methods. Age-related changes in vertebral morphology are necessary for the diagnosis of degenerative shape alterations and vertebral fractures [4]. The discovery and broad adoption of this approach has made the morphometric study of the thoracic pedicle a clinical requirement for all surgeons conducting pedicle screw fixation of the thoracic spine. The pedicle may fracture or perforate if the wrong size screw is utilized, which would harm the nerve roots [5].

**Aim & Objectives**

**Aim:** To perform a detailed morphometric analysis of the vertebral body, pedicle, and lamina of typical thoracic vertebrae and to evaluate bilateral symmetry of pedicle and laminar dimensions.

**Objectives**

1. To measure the dimensions of the vertebral body, including anteroposterior diameter (APD), transverse diameter (TD), anterior height (AH), and posterior height (PH).
2. To assess the morphometry of the pedicles by measuring pedicle height (PH) and pedicle width (PW) on both left and right sides.
3. To evaluate the lamina dimensions by measuring lamina height (LH) and lamina width (LW) bilaterally.
4. To compare the morphometric parameters between the left and right sides using appropriate statistical methods.
5. To determine the variability and symmetry of thoracic vertebral components for their clinical and surgical relevance.

**Materials & Methods**

**Study Design:** This study was a descriptive cross-sectional morphometric study conducted to evaluate the dimensions of the vertebral body, pedicle, and lamina of typical thoracic vertebrae.

**Study Population:** The study included 110 dry human thoracic vertebrae of unknown age and sex, obtained from the osteology collection.

**Study Place:** The study was carried out in the Department of Anatomy at Himalaya Medical College & Hospital, Chiksi, Paliganj, Patna, Bihar, India, a tertiary care teaching institution.

**Study Period:** The study was conducted over a period of 10 months from April 2025 to January 2026.

**Ethical Considerations:** Ethical clearance was obtained from the Institutional Ethics Committee prior to commencement of the study. As the study was conducted on dry human bones, no direct human or animal participation was involved; therefore, issues of informed consent were not applicable.

**Inclusion Criteria**

- Intact and well-preserved typical thoracic vertebrae
- Vertebrae without any visible deformities or damage
- Vertebrae with clearly identifiable anatomical landmarks

**Exclusion Criteria**

- Broken, deformed, or eroded vertebrae
- Vertebrae showing pathological changes
- Atypical thoracic vertebrae or vertebrae with unclear anatomical features

**Methodology:** All measurements were performed using a digital Vernier caliper with high precision. Each parameter was measured carefully, and the mean value was recorded to minimize observational error.

The following parameters were assessed:

**Vertebral Body Measurements**

- Anteroposterior Diameter (APD): Distance in the midline between the anterior and posterior borders of the superior surface of the vertebral body.
- Transverse Diameter (TD): Maximum width of the superior surface of the vertebral body.
- Anterior Height (AH): Vertical distance between the superior and inferior surfaces at the anterior midline.
- Posterior Height (PH): Vertical distance between the superior and inferior surfaces at the posterior midline.

**Pedicle Measurements**

- Pedicle Height (PH): Maximum vertical distance between the superior and inferior borders at the midpoint of the pedicle.
- Pedicle Width (PW): Maximum transverse distance between the medial and lateral surfaces of the pedicle at its midpoint, measured perpendicular to its long axis.

**Lamina Measurements**

- Lamina Height (LH): Maximum vertical distance between the superior and inferior borders of the lamina.
- Lamina Width/Thickness (LW): Maximum distance between the anterior and posterior surfaces of the lamina.
- All data were obtained through direct morphometric measurements.

**Outcome Measures**

- Primary outcome measures included mean values and standard deviations of all morphometric parameters.
- Secondary outcome measures included comparison between right and left sides for pedicle and lamina dimensions.

**Statistical Analysis:** Data were entered into Microsoft Excel 365 and analyzed using Statistical Package for the Social Sciences (SPSS) software (version 27.0). Descriptive statistics were expressed as mean ± standard deviation (SD). Comparative analysis between left and right sides was performed using the independent samples t-test. A p-value < 0.05 was considered statistically significant. Results were presented in the form of tables and appropriate statistical interpretations.

**Results**

**Table 1: Measurement of vertebral body of thoracic vertebrae**

| Parameters | Mean | SD |
|---|---|---|
| Anteroposterior diameter (APD) | 18.1 | 2.1 |
| Transverse diameter (TD) | 25.7 | 9.1 |
| Anterior height (AH) | 16.4 | 7.2 |
| Posterior height (PH) | 17.3 | 4.5 |

Table 1 presents the morphometric measurements of the vertebral body of thoracic vertebrae. The mean anteroposterior diameter (APD) was 18.1 mm with a standard deviation (SD) of 2.1 mm, indicating relatively low variability among the specimens. The transverse diameter (TD) showed a higher mean value of 25.7 mm with a larger SD of 9.1 mm, suggesting considerable variation in the width of the vertebral bodies.

The anterior height (AH) had a mean of 16.4 mm with an SD of 7.2 mm, while the posterior height (PH) was slightly higher, with a mean of 17.3 mm and an SD of 4.5 mm. Overall, the data indicate that while the anteroposterior diameter is relatively consistent, other parameters, particularly transverse diameter and anterior height, exhibit greater variability among thoracic vertebrae.

**Table 2: Measurement of Pedicle of thoracic vertebrae**

| Parameters | Left | Right | P value |
|---|---|---|---|
| Pedicle height (PH) | 9.1±2.4 | 9.4±2.5 | 0.72 |
| Pedicle width (PW) | 3.6±1.0 | 3.2±1.1 | 0.81 |

Table 2 and figure I, presents the morphometric measurements of the pedicles of thoracic vertebrae on both the left and right sides, along with their statistical comparison. The mean pedicle height (PH) was 9.1 ± 2.4 mm on the left side and 9.4 ± 2.5 mm on the right side. Similarly, the pedicle width (PW) measured 3.6 ± 1.0 mm on the left and 3.2 ± 1.1 mm on the right. The p-values for pedicle height (0.72) and pedicle width (0.81) indicate that there is no statistically significant difference between the left and right sides for either parameter.

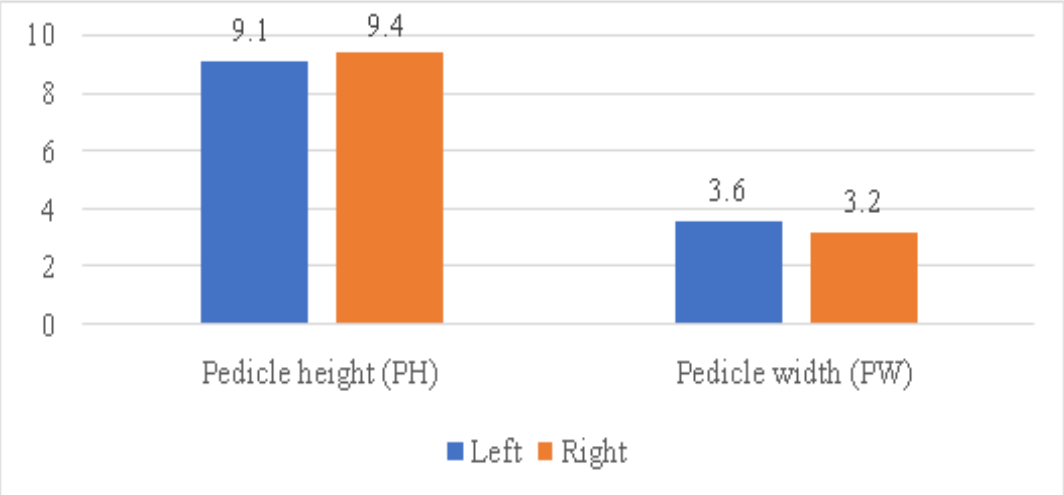


**Figure 1: Measurement of pedicle of thoracic vertebra**

**Table 3: Measurement of lamina of thoracic vertebrae**

| Parameters | Left | Right | P value |
|---|---|---|---|
| Lamina height (LH) | 17.3±2.1 | 17.8±2.2 | 0.96 |
| Lamina width (LW) | 5.4±1.6 | 5.5±1.9 | 0.74 |

Table 3 shows the morphometric measurements of the lamina of thoracic vertebrae on both the left and right sides, along with their statistical comparison. The mean lamina height (LH) was 17.3 ± 2.1 mm on the left side and 17.8 ± 2.2 mm on the right side. Similarly, the lamina width (LW) measured 5.4 ± 1.6 mm on the left and 5.5 ± 1.9 mm on the right. The p-values for lamina height (0.96) and lamina width (0.74) indicate that there is no statistically significant difference between the left and right sides. Overall, these findings suggest that the lamina dimensions are nearly symmetrical on both sides in thoracic vertebrae.

**Discussion**

Numerous studies of a quantitative anatomical nature have examined the differences in vertebral body, pedicle, and lamina diameters across populations and nations [6,7]. Numerous authors have studied the thoracic vertebrae using a range of techniques, such as simple radiography, direct measurements from dry bones, cadaveric bones, and CT and MRI scan approaches [8,9]. The present study was conducted to measure the various morphometric parameters of different components of dry thoracic vertebrae.

In the present study, the mean anteroposterior diameter (APD) of the thoracic vertebral body was 18.1 ± 2.1 mm, indicating relatively low variability among specimens. Comparable findings were reported by Sharma et al. (2021), who observed a mean APD of 17.8 ± 2.3 mm, suggesting consistency in sagittal dimensions across populations [10]. However, slightly higher values were documented by Li et al. (2023), who reported a mean APD of 19.2 mm in a Chinese population, indicating possible ethnic variations [11]. The transverse diameter (TD) in this study was 25.7 ± 9.1 mm, demonstrating greater variability. This finding aligns with the study by Patel et al. (2022), who reported a wide range in TD due to anatomical diversity and vertebral level differences [12]. The relatively high standard deviation observed in the present study suggests heterogeneity among specimens, which may be attributed to variations in age, sex, and regional anatomical differences. The anterior height (AH) and posterior height (PH) were found to be 16.4 ± 7.2 mm and 17.3 ± 4.5 mm, respectively. The slightly higher posterior height is consistent with findings by Singh et al. (2020), who noted a similar trend reflecting the natural curvature of the thoracic spine [13]. The variability in anterior height, as indicated by a higher SD, may be due to degenerative changes or specimen-related factors. The pedicle dimensions are critical for spinal instrumentation, particularly for pedicle screw fixation. In the present study, the mean pedicle height (PH) was 9.1 ± 2.4 mm on the left and 9.4 ± 2.5 mm on the right side, with no statistically significant difference (p = 0.72). This symmetry is consistent with findings by Kumar et al. (2022), who reported no significant side-to-side variation in pedicle height among thoracic vertebrae [14].

Similarly, the pedicle width (PW) was 3.6 ± 1.0 mm on the left and 3.2 ± 1.1 mm on the right, with no significant difference (p = 0.81). These findings are comparable to those of Zhang et al. (2024), who reported mean pedicle widths ranging from 3.0 to 4.0 mm in thoracic vertebrae [15]. The relatively narrow pedicle width observed in this study highlights the importance of careful preoperative planning to avoid complications during pedicle screw insertion.

The absence of significant bilateral differences in pedicle dimensions supports the anatomical symmetry of thoracic vertebrae and suggests that standardized surgical approaches may be safely applied on both sides. These findings are clinically relevant for spinal surgeons in determining appropriate implant size and trajectory.

The lamina plays a crucial role in posterior spinal stability and serves as an important landmark in various surgical procedures. In this study, the mean lamina height (LH) was 17.3 ± 2.1 mm on the left and 17.8 ± 2.2 mm on the right side, with no statistically significant difference (p = 0.96). These findings are in agreement with those of Verma et al. (2021), who also reported symmetrical laminar heights in thoracic vertebrae [16].

The lamina width (LW) was found to be 5.4 ± 1.6 mm on the left and 5.5 ± 1.9 mm on the right, again showing no significant difference (p = 0.74). Similar values were reported by Chen et al. (2023), who emphasized the consistency of laminar thickness across both sides [17]. The relatively uniform lamina dimensions observed in this study further support the concept of bilateral symmetry in thoracic vertebrae. The lack of significant differences between the left and right lamina parameters suggests that these structures maintain consistent morphology, which is beneficial in procedures such as laminectomy and laminoplasty. Additionally, the moderate variability observed may be attributed to individual anatomical differences.

**Limitations of the Study**

- The study was conducted on dry human vertebrae, and therefore, soft tissue influence and in vivo anatomical variations could not be assessed.
- The age and sex of the specimens were unknown, which may affect morphometric dimensions and limit population-specific conclusions.
- The sample size, although adequate, may not fully represent regional or ethnic variations.
- Vertebral levels (T1–T12) were not analyzed separately, which may mask level-specific anatomical differences.
- Measurements were taken manually using a Vernier caliper, which may introduce observer-related bias, despite precautions.
- Radiological correlation (CT/MRI) was not performed, limiting comparison with clinical imaging-based studies.

**Conclusion**

The present study provides a comprehensive morphometric evaluation of typical thoracic vertebrae. The vertebral body measurements revealed that the anteroposterior diameter is relatively consistent, while transverse diameter and anterior height exhibit greater variability. The posterior height was found to be slightly higher than anterior height, reflecting normal anatomical curvature.

Pedicle morphometry demonstrated no statistically significant difference between the left and right sides for both height and width ($p > 0.05$), indicating a high degree of bilateral symmetry.

Similarly, lamina measurements showed comparable dimensions on both sides with no significant differences, further supporting symmetrical anatomical configuration.

Overall, the findings suggest that while vertebral body dimensions show variability, the pedicle and lamina maintain consistent bilateral symmetry. These morphometric data are valuable for clinical applications, particularly in spinal instrumentation, surgical planning, and implant design, contributing to safer and more effective thoracic spine procedures.

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