Natural Resources for Human Health
eISSN: 2583-1194

Original Research

Received 27 May 2026
Revised 28 June 2026
Accepted 12 July 2026

Natural Resources for Human Health 2026, Vol. 6 (12s): 273–281

KEYWORDS:
computed tomography; morphometry; pedicle screw; thoracic pedicle; thoracic spine

Computed Tomography-Based Morphometric Analysis of Thoracic Pedicles: A Single-Centre Study from Moradabad, India

Jitendra Kumar Tiwari[1], Raushan Kumar[2*], Dr. Bhawna Solanki[3], Vashist Baburao Mhalsekar[4], Mohd Wakash[5], MD Akbar[6], Chandrashekhar Chauhan[7], Reeshabh Kumar[8], Prof. (Dr.) Rajul Rastogi[9]

[1]Assistant Professor and Head, Department of Paramedical Sciences, Faculty of Medical Sciences, P.K. University, Shivpuri, Madhya Pradesh, India. Email: jitendratiwari201293@gmail.com

[2]Assistant Professor, College of Allied and Healthcare Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India. Email: singhraushan01@gmail.com, ORCID: 0009-0009-4149-2295.

[3]Assistant Professor, Department of Radio-diagnosis (Medical Imaging Technology) Goa Medical College & Hospital, Goa University, Goa, India. Email: bhawna.solanki4739@gmail.com, ORCID: 0000-0003-0152-6103.

[4]Lecturer, Department of Radio-diagnosis (Medical Imaging Technology) Goa Medical College & Hospital, Goa University, Goa, India. Email: vashistmhalsekar@gmail.com, ORCID: 0000-0001-7366-0112.

[5]College of Allied and Healthcare Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India. Email: wakashk81@gmail.com, ORCID: 0009-0006-1788-2443.

[6]College of Allied and Healthcare Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India. Email: akbar.maintha2001@gmail.com, ORCID: 0009-0005-1894-0732.

[7]College of Allied and Healthcare Sciences, Teerthanker Mahaveer University, Moradabad, Uttar Pradesh, India. Email: chandrashekharckc2@gmail.com, ORCID: 0009-0006-9457-7370.

[8]Nursing Officer, Department of Anesthesiology, AIIMS Guwahati, Changsari, Guwahati, India. Email: rksing.25@gmail.com

[9]Professor, Radiodiagnosis, Teerthanker Mahaveer Medical College & Research Center, Teerthanker Mahaveer University, Moradabad, Uttar-Pradesh, India. Email rajulrst@yahoo.co.in, ORCID: 0000-0001-6407-9756.

ABSTRACT:

Background: Thoracic pedicle morphology varies across vertebral levels and individuals, influencing the selection of screw dimensions and insertion trajectories during spinal instrumentation. Region-specific CT-based morphometric data remain limited.

Methods: This prospective cross-sectional study included 71 adults aged 20–60 years who underwent thoracic CT at a tertiary-care centre in Moradabad, India. Pedicle length (PL), transverse pedicle angle (TPA), transverse pedicle diameter (TPD) and sagittal pedicle diameter (SPD) were assessed from T1 to T12. Measurements were compared according to sex using the independent-samples t-test and across age groups using one-way analysis of variance.

Results: The participants had a mean age of 43.25 ± 12.16 years; 44 (62.0%) were male and 27 (38.0%) were female. The mean PL, TPA and TPD were 32.02 ± 2.12 mm, 27.15 ± 3.31° and 7.52 ± 0.96 mm, respectively. Mean SPD increased descriptively from 7.38 ± 0.68 mm at T1 to 15.43 ± 1.23 mm at T12. Males had greater PL (32.67 ± 1.75 vs. 30.96 ± 2.25 mm; $p = 0.001$) and TPD (7.83 ± 0.84 vs. 7.03 ± 0.95 mm; $p < 0.001$) than females, whereas TPA was comparable between the sexes ($p = 0.591$). SPD was greater in males at most thoracic levels, with significant differences from T2 through T10 and at T12. No age-group differences were observed in PL, TPA or TPD. Age-related differences in SPD were limited to T10 and T11.

Conclusion: Thoracic pedicle dimensions demonstrated vertebral level- and sex-related variation, whereas age-related differences were limited and inconsistent. These findings provide preliminary local morphometric data and support individualized CT assessment before thoracic pedicle instrumentation

1. INTRODUCTION

Thoracic pedicle screw fixation provides three-column stability and is widely used in the management of spinal trauma, deformity, tumours, infection and degenerative disorders[1]. However, screw placement in the thoracic spine is technically demanding because the pedicles are relatively narrow and lie close to the spinal cord, nerve roots, pleura and major vascular structures. Inaccurate selection of screw diameter, length or trajectory may therefore result in cortical breach and neurovascular or visceral injury [2].

Thoracic pedicle morphology varies considerably across vertebral levels. Previous computed tomography (CT)-based studies have shown that pedicle width generally decreases toward the mid-thoracic region and subsequently increases toward T12, while pedicle length and angulation demonstrate distinct level-specific patterns [3]. Differences have also been reported according to population, sex, age and body size, indicating that morphometric values derived from one population may not be directly applicable to another [4]. These variations support the use of CT for patient-specific assessment of pedicle dimensions and orientation before thoracic spinal instrumentation[5].

Indian studies have provided important morphometric data; however, several were based on cadaveric specimens, small CT samples or measurements restricted to selected thoracic and lumbar levels [6]. Furthermore, evidence integrating bilateral measurements across the complete thoracic spine with age, sex and body mass index remains limited, particularly for patients from Moradabad and its surrounding region[3]. Therefore, the present single-centre study aimed to evaluate the CT-based morphometric characteristics of thoracic pedicles from T1 to T12 and to examine their level-wise, and side-wise. The findings are intended to provide locally relevant anatomical data that may support individualized preoperative planning and appropriate selection of thoracic pedicle screw dimensions.

2. MATERIAL AND METHODS

Study design and setting: This prospective cross-sectional imaging study was conducted at Teerthanker Mahaveer Hospital and Research Centre, Moradabad, Uttar Pradesh, India, between September 2023 and February 2024. Adult patients undergoing routine computed tomography (CT) of the thorax during the study period were screened for eligibility.

Ethical considerations: The study protocol was approved by the Institutional Ethics Committee of Teerthanker Mahaveer University, Moradabad (TMU/IEC/2022-24/042; approval date: 18/10/2023). Written informed consent was obtained from all participants before enrolment. Participant information and CT images were anonymized before analysis.

Study participants: A total of 71 participants of either sex, aged 20–60 years, were included. CT examinations were eligible when the complete thoracic spine from T1 to T12 was visualized with adequate image quality for morphometric assessment. Patients with vertebral tumours, thoracic kyphosis or traumatic injury involving the thoracic spine were excluded.

Anthropometric assessment: Age and sex were recorded for each participant. Height was measured in centimetres and weight in kilograms. Body mass index (BMI) was calculated as weight in kilograms divided by the square of height in metres (kg/m^2). Participants were classified into four age groups: 20–30, 31–40, 41–50 and 51–60 years.

CT acquisition protocol: CT examinations were performed using a 128-slice multidetector CT scanner (Ingenuity Core 128, Philips Healthcare). Participants were positioned head-first and supine with their arms elevated. An anteroposterior topogram was acquired from approximately 2.5 cm below the chin to the level of the umbilicus. Scanning was performed in the craniocaudal direction using helical acquisition during a single breath-hold. The field of view was adjusted to include the entire thoracic cavity and chest-wall soft tissues. Images were acquired at 120 kVp and 250 mA, with a slice thickness and reconstruction increment of 5 mm. Dose measurements were referenced to a 32-cm CT dose index phantom. Axial images and sagittal multiplanar reformations were reviewed using a bone-window setting.

Morphometric assessment: Thoracic vertebral levels were identified sequentially from T1 to T12. Measurements were obtained on axial and sagittal images using the scanner workstation. The following parameters were evaluated Pedicle length (PL), Transverse pedicle diameter (TPD), Transverse pedicle angle (TPA), and Sagittal pedicle diameter (SPD). Linear measurements were recorded in millimetres and angular measurements in degrees.

Statistical analysis: Data were analysed using IBM SPSS Statistics. Continuous variables were summarized as mean, standard deviation and range, while categorical variables were presented as frequencies and percentages. Morphometric parameters were compared between males and females using the independent-samples *t*-test. Differences across the four age groups were assessed using one-way analysis of variance. All tests were two-sided, and a p value < 0.05 was considered statistically significant.

3. RESULTS

3.1 Participant characteristics

The study included 71 participants aged 20–60 years, with a mean age of 43.25 ± 12.16 years. Of these, 44 (62.0%) were male and 27 (38.0%) were female. The largest proportion belonged to the 41–50-year age group (33.8%), followed by the 51–60-year group (29.6%). Males had a higher mean height than females (158.61 ± 6.24 vs. 155.67 ± 5.47 cm; p = 0.047). Weight and body mass index did not differ significantly between the sexes (Table 1).

Table 1. Demographic and anthropometric characteristics of the study participants

Characteristic	Overall (n = 71)	Male (n = 44)	Female (n = 27)	*p* value
Age, years	43.25 ± 12.16 (20–60)	—	—	—
Age group, n (%)				
20–30 years	14 (19.7)	9 (20.5)	5 (18.5)	—
31–40 years	12 (16.9)	8 (18.2)	4 (14.8)	—
41–50 years	24 (33.8)	16 (36.4)	8 (29.6)	—
51–60 years	21 (29.6)	11 (25.0)	10 (37.0)	—
Height, cm	157.49 ± 6.09 (150–168)	158.61 ± 6.24	155.67 ± 5.47	0.047
Weight, kg	56.11 ± 7.32 (46–70)	56.75 ± 7.64	55.07 ± 6.79	0.353
BMI, kg/m²	23.95 ± 1.97 (19.9–28.3)	24.21 ± 1.79	23.53 ± 2.20	0.161

Data are presented as mean ± standard deviation (range) or frequency (percentage). Percentages within the male and female age groups were calculated using the respective sex-specific totals. The independent-samples t-test was used for comparisons of continuous variables. BMI, body mass index.

3.2 Sex-based differences in axial pedicle parameters

Males had a greater mean pedicle length than females (32.67 ± 1.75 vs. 30.96 ± 2.25 mm; p = 0.001). The mean transverse pedicle diameter was also greater in males (7.83 ± 0.84 vs. 7.03 ± 0.95 mm; p < 0.001). However, the transverse pedicle angle did not differ significantly between males and females (p = 0.591) (Table 2).

Table 2. Sex-based comparison of axial thoracic pedicle parameters

Parameter	Male (n = 44), mean ± SD	Female (n = 27), mean ± SD	*t* value	*p* value
Pedicle length, mm	32.67 ± 1.75	30.96 ± 2.25	3.59	0.001
Transverse pedicle angle, degrees	26.99 ± 3.48	27.43 ± 3.05	−0.54	0.591
Transverse pedicle diameter, mm	7.83 ± 0.84	7.03 ± 0.95	3.70	<0.001

Values are presented as mean ± standard deviation. Between-sex comparisons were performed using the independent-samples t-test. All p values are two-sided.

3.3 Sex-based differences in sagittal pedicle diameter

The mean sagittal pedicle diameter was numerically greater in males than in females at all thoracic levels. Significant between-sex differences were observed from T2 through T10 and at T12. The differences at T1 and T11 were not statistically significant (Table 3).

Table 3. Sex-based comparison of sagittal pedicle diameter across thoracic vertebral levels

Vertebral level	Male (n = 44), mean ± SD, mm	Female (n = 27), mean ± SD, mm	*t* value	*p* value
T1	7.46 ± 0.70	7.24 ± 0.64	1.31	0.195
T2	8.43 ± 0.92	7.93 ± 0.66	2.45	0.017
T3	9.63 ± 1.34	8.70 ± 0.70	3.34	0.001
T4	10.28 ± 0.93	8.97 ± 0.74	6.19	<0.001
T5	10.69 ± 1.12	9.20 ± 0.92	5.81	<0.001
T6	10.79 ± 1.83	9.34 ± 0.96	3.79	<0.001
T7	11.14 ± 1.13	9.84 ± 0.87	5.09	<0.001
T8	11.44 ± 2.00	10.28 ± 0.92	2.83	0.006
T9	12.44 ± 1.27	10.81 ± 0.97	5.74	<0.001
T10	13.52 ± 1.32	12.11 ± 1.31	4.40	<0.001
T11	14.44 ± 1.50	13.78 ± 1.21	1.93	0.057
T12	15.68 ± 1.20	15.04 ± 1.18	2.17	0.033

Values are presented as mean ± standard deviation. Between-sex comparisons were performed using the independent-samples t-test. Reported p values are unadjusted and two-sided.

3.4 Age-group differences in axial pedicle parameters

Mean pedicle length, transverse pedicle angle and transverse pedicle diameter did not differ significantly among the four age groups (all $p > 0.05$) (Table 4).

Natural Resources for Human Health
eISSN: 2583-1194

Table 4. Comparison of axial thoracic pedicle parameters across age groups

Parameter	20–30 years (n = 14), mean ± SD	31–40 years (n = 12), mean ± SD	41–50 years (n = 24), mean ± SD	51–60 years (n = 21), mean ± SD	*F* value	*p* value
Pedicle length, mm	31.43 ± 1.70	32.33 ± 1.70	31.45 ± 2.67	32.88 ± 1.59	2.30	0.085
Transverse pedicle angle, degrees	27.76 ± 2.75	26.36 ± 3.50	26.76 ± 3.83	27.65 ± 2.96	0.65	0.587
Transverse pedicle diameter, mm	7.24 ± 0.72	7.21 ± 1.23	7.68 ± 0.95	7.72 ± 0.93	1.33	0.273

Values are presented as mean ± standard deviation. Comparisons were performed using one-way analysis of variance. All p values are two-sided.

3.5 Age-group differences in sagittal pedicle diameter

Sagittal pedicle diameter did not differ significantly among the age groups from T1 through T9 or at T12. Significant overall between-group differences were observed at T10 ($F = 3.32$, $p = 0.025$) and T11 ($F = 4.51$, $p = 0.006$) (Table 5). As pairwise post-hoc results were unavailable, no specific age-group comparison was interpreted as statistically significant.

Table 5. Comparison of sagittal pedicle diameter across age groups

Vertebral level	20–30 years (n = 14), mean ± SD, mm	31–40 years (n = 12), mean ± SD, mm	41–50 years (n = 24), mean ± SD, mm	51–60 years (n = 21), mean ± SD, mm	*F* value	*p* value
T1	7.60 ± 0.59	7.68 ± 0.75	7.31 ± 0.66	7.13 ± 0.66	2.51	0.066
T2	8.54 ± 0.86	8.48 ± 0.89	7.97 ± 0.76	8.20 ± 0.90	1.77	0.161
T3	9.49 ± 0.90	9.65 ± 2.19	8.85 ± 0.88	9.41 ± 0.89	1.65	0.186
T4	9.92 ± 1.31	9.69 ± 1.18	9.81 ± 1.06	9.72 ± 0.89	0.13	0.940
T5	10.37 ± 1.04	10.16 ± 1.51	9.97 ± 1.47	10.12 ± 1.07	0.29	0.831
T6	10.54 ± 1.00	10.37 ± 1.46	9.97 ± 2.37	10.29 ± 1.31	0.36	0.781
T7	10.83 ± 0.87	10.69 ± 1.34	10.62 ± 1.42	10.52 ± 1.14	0.19	0.900
T8	11.45 ± 1.00	11.60 ± 1.63	10.74 ± 2.45	10.65 ± 1.10	1.24	0.304
T9	12.11 ± 1.40	12.17 ± 1.71	11.71 ± 1.34	11.55 ± 1.34	0.73	0.539
T10	13.73 ± 1.26	13.57 ± 1.51	12.75 ± 1.45	12.42 ± 1.40	3.32	0.025
T11	15.15 ± 0.77	14.55 ± 1.12	13.58 ± 1.45	14.05 ± 1.56	4.51	0.006
T12	16.04 ± 0.97	15.46 ± 1.14	15.43 ± 1.39	15.02 ± 1.13	2.04	0.117

Values are presented as mean ± standard deviation. Comparisons were performed using one-way analysis of variance. Reported p values are unadjusted and two-sided.

3.6 Age-group differences in sagittal pedicle diameter

Sagittal pedicle diameter did not differ significantly among the age groups from T1 through T9 or at T12. Significant overall between-group differences were observed at T10 ($F = 3.32$, $p = 0.025$) and T11 ($F = 4.51$, $p = 0.006$) (Table 6). As pairwise post-hoc results were unavailable, no specific age-group comparison was interpreted as statistically significant.

Table 6. Comparison of sagittal pedicle diameter across age groups

Vertebral level	**20–30 years (n = 14), mean ± SD, mm**	**31–40 years (n = 12), mean ± SD, mm**	**41–50 years (n = 24), mean ± SD, mm**	**51–60 years (n = 21), mean ± SD, mm**	***F* value**	***p* value**
T1	7.60 ± 0.59	7.68 ± 0.75	7.31 ± 0.66	7.13 ± 0.66	2.51	0.066
T2	8.54 ± 0.86	8.48 ± 0.89	7.97 ± 0.76	8.20 ± 0.90	1.77	0.161
T3	9.49 ± 0.90	9.65 ± 2.19	8.85 ± 0.88	9.41 ± 0.89	1.65	0.186
T4	9.92 ± 1.31	9.69 ± 1.18	9.81 ± 1.06	9.72 ± 0.89	0.13	0.940
T5	10.37 ± 1.04	10.16 ± 1.51	9.97 ± 1.47	10.12 ± 1.07	0.29	0.831
T6	10.54 ± 1.00	10.37 ± 1.46	9.97 ± 2.37	10.29 ± 1.31	0.36	0.781
T7	10.83 ± 0.87	10.69 ± 1.34	10.62 ± 1.42	10.52 ± 1.14	0.19	0.900
T8	11.45 ± 1.00	11.60 ± 1.63	10.74 ± 2.45	10.65 ± 1.10	1.24	0.304
T9	12.11 ± 1.40	12.17 ± 1.71	11.71 ± 1.34	11.55 ± 1.34	0.73	0.539
T10	13.73 ± 1.26	13.57 ± 1.51	12.75 ± 1.45	12.42 ± 1.40	3.32	0.025
T11	15.15 ± 0.77	14.55 ± 1.12	13.58 ± 1.45	14.05 ± 1.56	4.51	0.006
T12	16.04 ± 0.97	15.46 ± 1.14	15.43 ± 1.39	15.02 ± 1.13	2.04	0.117

Values are presented as mean ± standard deviation. Comparisons were performed using one-way analysis of variance. Reported p values are unadjusted and two-sided.

3.7 Age-related variations in thoracic pedicle morphometry stratified by sex

Among males, pedicle length, transverse pedicle angle and transverse pedicle diameter did not differ significantly across age groups (all $p > 0.05$) (Figure 1). Sagittal pedicle diameter was also comparable across age groups from T1 to T11; however, an overall difference was observed at T12 ($F = 3.57$, $p = 0.022$) (Figure 2). Among females, transverse pedicle angle and transverse pedicle diameter did not differ across age groups. Pedicle length showed a borderline overall difference ($F = 3.02$, $p = 0.050$) (Figure 1). For sagittal pedicle diameter, overall age-group differences were observed at T1 ($F = 3.33$, $p = 0.037$) and T5 ($F = 4.39$, $p = 0.014$), whereas no differences were identified at the remaining vertebral levels (Figure 2). As post-hoc comparisons were unavailable, no specific pairwise differences between age groups were inferred.

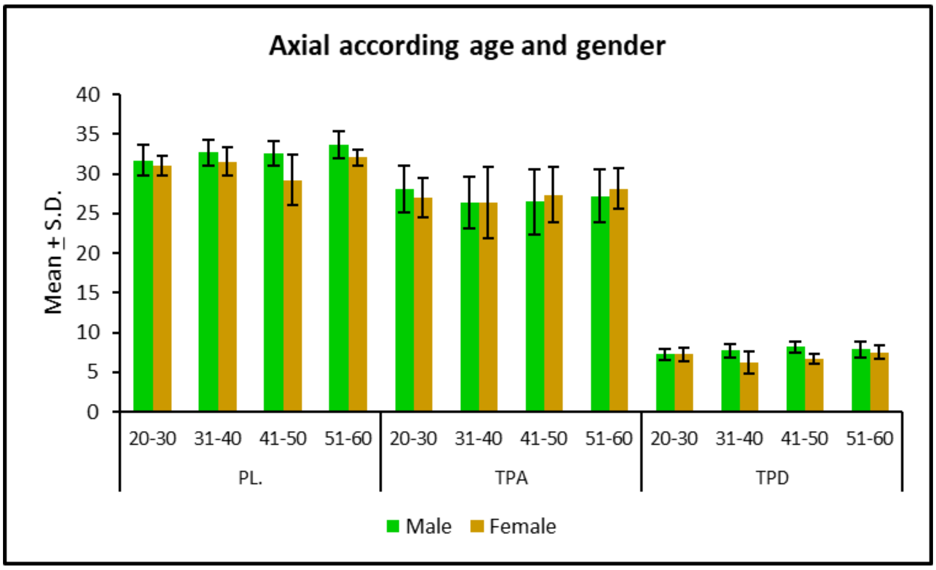

Figure 1. Age-group variation in axial thoracic pedicle parameters stratified by sex. Mean values for (A) pedicle length, (B) transverse pedicle angle and (C) transverse pedicle diameter are presented across the four age groups separately for males and females. Error bars represent standard deviations. Male group sizes were 9, 8, 16 and 11, while female group sizes were 5, 4, 8 and 10 for the 20–30, 31–40, 41–50 and 51–60-year age groups, respectively.

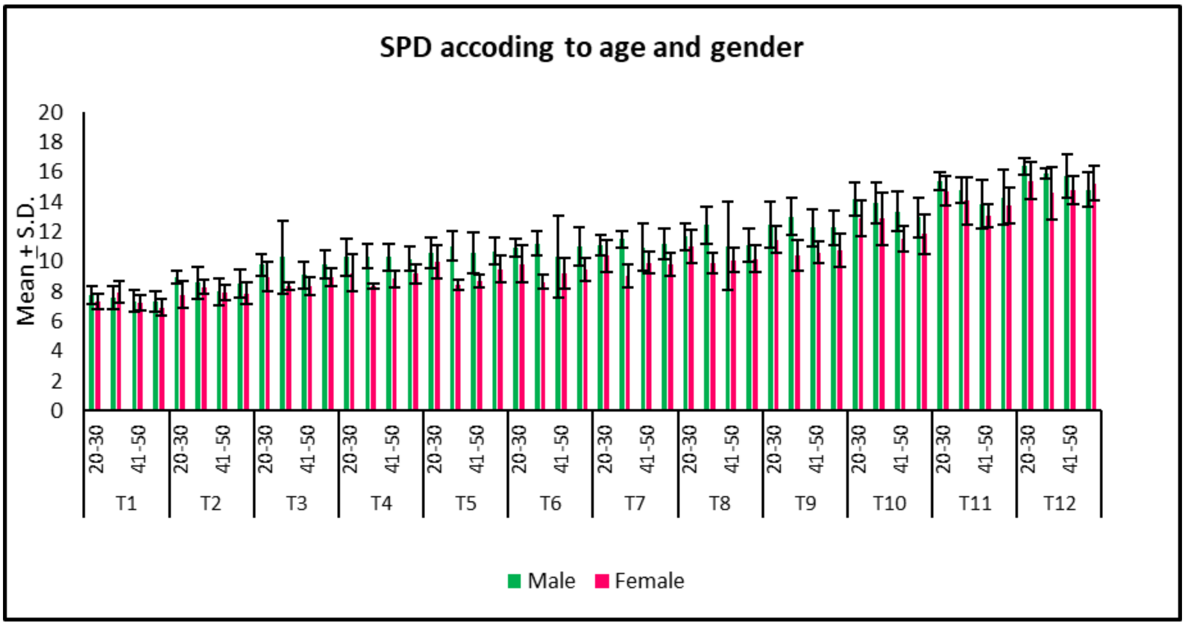

Figure 2. Age-group variation in sagittal pedicle diameter across thoracic vertebral levels stratified by sex. Mean sagittal pedicle diameters from T1 to T12 are presented across the four age groups separately for males and females. Error bars represent standard deviations. Overall age-group comparisons were performed using one-way analysis of variance.

4. DISCUSSION

This prospective cross-sectional study provides CT-based morphometric data for thoracic pedicles in 71 adults examined at a single centre in Moradabad. The mean pedicle length, transverse pedicle angle and transverse pedicle diameter were 32.02 mm, 27.15° and 7.52 mm, respectively. Sagittal pedicle diameter increased descriptively from 7.38 mm at T1 to 15.43 mm at T12. Pedicle length and transverse pedicle diameter were greater in males, whereas transverse pedicle angle was comparable between the sexes. Age-related differences were limited to selected vertebral levels rather than being consistently observed throughout the thoracic spine. The progressive increase in sagittal pedicle diameter toward the lower thoracic spine is consistent with previously reported segmental changes in thoracic pedicle anatomy. **Singh et al. (2011)** observed smaller transverse dimensions in the mid-thoracic region and larger dimensions toward both ends of the thoracic spine in an Indian population[6]. Similarly, **Kaur et al. (2016)** reported distinct level-wise changes in pedicle dimensions across T1–T12 using CT images from Indian adults [3]. These findings confirm that thoracic pedicles cannot be considered morphometrically uniform and should be assessed at the individual vertebral level. The mean pedicle length observed in the present study falls within the broad range reported in earlier Indian morphometric studies. **van der Houwen et al (2010)** reported chord lengths ranging from approximately 29.9 mm in the upper thoracic spine to 37.3 mm at T11 [7], while **Mohanty et al. (2018)** reported a minimum screw-path length of 35.8 mm in the lower thoracic region[8]. Direct numerical comparison should nevertheless be made cautiously because previous studies have used different definitions of pedicle length, vertebral levels, imaging planes and CT reconstruction thicknesses[9]. The same consideration applies to the overall transverse pedicle angle and diameter reported in the present study, as aggregation across T1–T12 may obscure the marked level-specific variation documented in earlier studies.

Males had a greater pedicle length and transverse pedicle diameter than females, with mean differences of 1.71 and 0.80 mm, respectively. Sagittal pedicle diameter was also numerically greater in males at all levels and differed significantly at most thoracic levels. These findings agree with CT-based studies reporting larger thoracic pedicle dimensions in males. **Albano et al, (2019)** reported greater pedicle length and sagittal and transverse diameters in males [10]. Large cadaveric studies of the upper and lower thoracic spine have similarly demonstrated larger pedicles in male, taller and heavier individuals. By contrast, transverse pedicle angle did not differ between the sexes in the present study, which is consistent with evidence suggesting that sex-related variation predominantly affects pedicle size rather than orientation[11]. No overall age-group differences were observed in pedicle length, transverse pedicle angle or transverse pedicle diameter. Sagittal pedicle diameter differed only at T10 and T11. In the sex-stratified analysis, an age-group difference was observed at T12 among males and at T1 and T5 among females; female pedicle length showed a borderline difference at $p = 0.050$. These localized findings do not indicate a uniform age-related change across the thoracic spine. Conversely, **Uygur et al. (2026)** observed sex-dependent age patterns, with pedicle dimensions tending to increase with age in males and decrease in females [12]. Differences in study design, age distribution, skeletal characteristics and measurement methods may partly explain these contrasting findings. Moreover, because the present age-stratified analyses involved multiple unadjusted comparisons and relatively small subgroups, the level-specific associations should be interpreted as exploratory. Males were taller than females in the present cohort, whereas weight and BMI were comparable. Consequently, the observed sex differences in pedicle dimensions cannot be attributed to BMI alone, although the influence of height and other body-size characteristics cannot be excluded. These findings have potential relevance for thoracic spinal instrumentation. Pedicle diameter constrains the permissible screw diameter, pedicle length influences screw length, and transverse angulation guides the insertion trajectory. Inappropriate selection of these parameters may increase the risk of cortical breach and injury to adjacent neural, vascular or visceral structures. However, the present data should not be interpreted as defining universal screw dimensions. A large literature review also showed that clinically relevant complications from misplaced thoracolumbar pedicle screws, although uncommon, may require revision surgery[13]. Patient-specific multiplanar CT assessment therefore remains necessary before instrumentation. The strengths of this study include its prospective design, acquisition at a single centre using a consistent CT protocol, evaluation of the complete T1–T12 region and assessment of sex- and age-related variation. Several limitations should also be considered. The sample was relatively small and derived from a single centre, limiting external generalizability. Some sex-specific age groups contained few participants, particularly among females. The 5-mm reconstruction thickness may have introduced partial-volume effects, especially when evaluating narrow pedicles; recent CT morphometric studies have used reconstructions of 1 mm or less. The cross-sectional design cannot distinguish anatomical ageing from differences between age cohorts. Furthermore, multiple level-wise comparisons were performed without adjustment. Finally, reporting pedicle length, transverse diameter and transverse angle as overall measurements limits evaluation of their segment-specific patterns.

5. CONCLUSION

Conclusion, thoracic pedicle dimensions demonstrated clear variation according to vertebral level and sex, while age-related differences were limited and inconsistent. The caudal increase in sagittal pedicle diameter and the generally larger pedicle dimensions observed in males support individualized assessment rather than reliance on a single standard measurement. These findings provide preliminary locally relevant morphometric data, but larger multicentre studies using thin-section CT, standardized level-wise measurements and multivariable analysis are required before clinical reference values can be established.

6. DECLARATION

- **Financial support and sponsorship:** None.
- **Conflicts of Interest:** None.
- **Data availability:** Available from the corresponding author upon reasonable request.
- **AI-assisted technology:** None.
- **Consent to participate:** Written informed consent was obtained from all participants.
- **Consent for publication:** Not applicable, as no identifiable participant information is reported.
- **Author contributions:** All authors contributed equally to the study conception, design, data acquisition, analysis, interpretation and manuscript preparation. All authors reviewed and approved the final manuscript.
- **Acknowledgement:** The authors acknowledge the Department of Radiodiagnosis, Teerthanker Mahaveer Hospital and Research Centre, Moradabad, for its support during CT data acquisition and morphometric assessment

REFERENCES

[1] Hartl R, Theodore N, Dickman CA, Sonntag VKH. Technique of thoracic pedicle screw fixation for trauma. Operative Techniques in Neurosurgery. 2004;Neurotrauma7(1):22–30. doi:10.1053/j.otns.2004.04.005

[2] Datir SP, Mitra SR. Morphometric study of the thoracic vertebral pedicle in an Indian population. Spine (Phila Pa 1976). 2004;29(11):1174–81. doi:10.1097/00007632-200406010-00004 PubMed PMID: 15167654.

[3] Kaur K, Singh R, Prasath V, Magu S, Tanwar M. Computed tomographic-based morphometric study of thoracic spine and its relevance to anaesthetic and spinal surgical procedures. J Clin Orthop Trauma. 2016;7(2):101–8. doi:10.1016/j.jcot.2015.12.002 PubMed PMID: 27182147; PubMed Central PMCID: PMC4857161.

[4] Demiroz S, Erdem S. Computed Tomography-Based Morphometric Analysis of Thoracic Pedicles: An Analysis of 1512 Pedicles and Their Correlation with Sex, Age, Weight and Height. Turk Neurosurg. 2020;30(2):206–16. doi:10.5137/1019-5149.JTN.26848-19.2 PubMed PMID: 31736035.

[5] Zellner AA, Prangenberg C, Roos J, Amar SB, Babasiz T, Wahlers C, et al. A computed tomography-based morphometric analysis of thoracic pedicles in a European population. J Orthop Surg Res. 2024;19(1):668. doi:10.1186/s13018-024-05171-3 PubMed PMID: 39420350; PubMed Central PMCID: PMC11483982.

[6] Singh R, Srivastva SK, Prasath CSV, Rohilla RK, Siwach R, Magu NK. Morphometric Measurements of Cadaveric Thoracic Spine in Indian Population and Its Clinical Applications. Asian Spine J. 2011;5(1):20–34. doi:10.4184/asj.2011.5.1.20 PubMed PMID: 21386943; PubMed Central PMCID: PMC3047895.

[7] van der Houwen EB, Baron P, Veldhuizen AG, Burgerhof JGM, van Ooijen PMA, Verkerke GJ. Geometry of the Intervertebral Volume and Vertebral Endplates of the Human Spine. Ann Biomed Eng. 2010;38(1):33–40. doi:10.1007/s10439-009-9827-6 PubMed PMID: 19876738; PubMed Central PMCID: PMC2803258.

[8] Mohanty SP, Pai Kanhangad M, Bhat SN, Chawla S. Morphometry of the lower thoracic and lumbar pedicles and its relevance in pedicle fixation. Musculoskelet Surg. 2018;102(3):299–305. doi:10.1007/s12306-018-0534-z

[9] Muthu S, Natarajan KP, Viswanathan VK, Kolarpatti Ponnusamy DV, Rajappan Chandra SK, Sharun K. Comparative CT-Based Bone Density of Traditional Pedicle Screw Trajectory, Cortical Bone Trajectory, and Modified Cortical Bone Trajectory — Radiographic Analysis of 3500 Simulated Pedicle-Screw Trajectories in 1750 Lumbar Vertebrae. Global Spine J. 2026;21925682261426267. doi:10.1177/21925682261426267 PubMed PMID: 41663296; PubMed Central PMCID: PMC12890600.

[10] Albano J, Lentz J, Stockton R, DePalma V, Markowitz M, Ganz M, et al. Demographic Analysis of Lumbar Pedicle Diameters in a Diverse Population. Asian Spine J. 2019;13(3):410–6. doi:10.31616/asj.2018.0195 PubMed PMID: 30685957; PubMed Central PMCID: PMC6547397.

[11] Umashankar DTS, Khalkho DA, Kumar DV. A Computed Tomographic Study of Thoracic Pedicle Morphometry at a Tertiary Care Centre in Eastern India. International Journal of Medical and Pharmaceutical Research. 2026;7:2794–9.

[12] Uygur S, Tekeli Barut I, Akbıyık T, Doruk E, Başar F, Ten B, et al. Radiological morphometric analysis of cervicothoracic junction vertebrae pedicles. Eur Spine J. 2026. doi:10.1007/s00586-026-09846-9

[13] Staartjes VE, Klukowska AM, Schröder ML. Pedicle Screw Revision in Robot-Guided, Navigated, and Freehand Thoracolumbar Instrumentation: A Systematic Review and Meta-Analysis. World Neurosurgery. 2018;116:433-443.e8. doi:10.1016/j.wneu.2018.05.159