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Original Research Article

A CT-Guided Analysis of the Morphology of the Thoracolumbar Pedicles in A South Indian Population

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ABSTRACT

Background: Pedicle screw fixation is a method of choice to treat spinal instabilities. Pre- operative CT scan measurements are important in determining the screw sizes in accordance to the pedicle measurements. A mis-sized screw can violate the pedicle leading to breaches.

Context and purpose of study: Present literature shows pedicle measurement studies in caucasian population. The study in Indian population are sparce. This study aims to assess the morphology of thoracolumbar pedicle parameters bilaterally using CT scans of patients and to compare the measurements between genders in a south Indian population.

Results: Gender-based variations were observed in the pedicle width for upper thoracic vertebrae (T1-T5). Screw path length was consistent in thoracic and lumbar vertebrae except T11, L1, and L2 which showed significant differences in mean between genders and screw path angle showed a significant variation in vertebrae T1, T8-T12 and L5. Bilateral symmetry was present in screw path length of thoracic vertebrae and asymmetry was noted in L2-L3 among males. Correlation was observed to be strong bilaterally with high reliability in pedicle measurements.

Conclusions: This study helps to understand gender-based variations in morphology of thoracolumbar pedicle which is important for enhancing pedicle screw fixation outcomes in spinal surgeries and reducing complications.

KEYWORDS: pedicle, morphology, computed tomography, thoracolumbar, transpedicular screw fixation.

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INTRODUCTION

The thoracolumbar spine is the junction between the firm thoracic spine and a highly mobile lumbar spine and is prone to injuries [1]. The organization of the thoracolumbar area with the pedicle screws is the most common and supreme choice in handling these abnormalities [2]. Pedicle and vertebral canal morphology of this junction are the important factors assisting in better perspective and management of thoracolumbar ailments [3].

The prevalent location in spinal fixation is the

pedicle and its dimension determines the size of screw used in fixation [4]. The pedicle is an anatomical structure having a small rounded extension from the body of vertebrae bridging the body of vertebra and posterior elements. The narrowest region of the pedicle is "pedicle isthmus", and its measurements has a significant role in determining the extend, a screw should have for accurate pedicle fixation. Therefore, pedicle screw fixation surpasses other methods of spinal fixation in terms of biomechanics [2,5]. Lumbar vertebrae have a differentiating big size and a lack of transversarium foramen and are five in count with first four being typical and last one atypical [6].

The morphology of vertebrae has genetic and ethnic disparities in dimensions and orientation of vertebra and pedicles [7]. Information regarding variation in dimension of pedicle at each vertebral level as per the age and sex, will aid in choosing a suited pedicle screw and also prevent fixation failures and ensure safe spinal procedures (Avuthu et al., 2014; Avuthu & Gompa, 2016; Mughir et al., 2010; Pai et al., 2010). In recent years, various techniques to correct thoracolumbar abnormalities have been advanced and for the best suited complex fixing devices, configurations need to be assessed [12]. A deep insight of the morphology of the pedicle and the anatomy of adjoining neural structures aid in reducing postoperative adverse events, proper screw selection, precise screw placement and to prevent cortical perforations [7,13]. For the treatment of spinal injuries, pedicle screw fixation technique of instrumentation is gaining surge in popularity by delivering reliable fixation, enhanced stability and addressing spinal abnormalities [14,15].

To explore the morphology of vertebrae various techniques are used like plain radiography, computed tomography (CT) scan, direct cadaveric dissections, and dry vertebra which help in detecting the exact point of nsertion of pedicle screws thus averting post-surgical complications [5,15]. As using posterior instrumentation via pedicle is a routine surgical procedure, surgeons need to thoroughly evaluate the morphology of vertebra and pedicle prior to the surgery to prevent complications [7,15–17]. For the development and usage of implant devices, accurate information on the dimensions of pedicle is necessary in choosing best pedicle screw [2].

Computed tomography has been shown to be optimal in assessing pedicle morphology and improving accuracy of screw placement (Avuthu et al., 2014; Fu et al., 2008). With the help of computed tomography (CT-scan), pedicle screw insertion has enhanced and it has been mentioned in various studies that precision of insertion can be markedly enhanced with image assisted systems in contrast with traditional methods [19].

Imaging technique such as CT, MRI, and DSA aid in providing good imaging approach for both pre- and post-surgery [20]. CT scans are used in spinal surgeries successfully intraoperatively. There is an increase in its use in neurosurgeries too [21].

In case of spine surgeries, placement of implants, pedicle screws freehand causes "suboptimal" positions in contrast to guidance with image reducing breach in pedicle from 15% to 6% showing pedicle screw insertion being more accurate while using image guidance [20,22].

The precision of CT scan in measuring the diameter, axis of pedicle, screw path length has well known to be the means of assessing radiographic morphology of pedicle [16].

Understanding of thoracolumbar pedicle morphology is crucial to define pedicle screw shape and dimensions. Yet, variation in pedicle dimensions as per ethnicity and gender are not well researched and documented [23].

Studies on thoracolumbar vertebral morphology using CT scan are insufficient around world and fewer in India [2].

This study aims to -

i. Measure bilaterally, the width of pedicles, screw path angle and screw path length in the CT scans of patients with normal spine anatomy.

ii. Compare bilateral measurements in CT scan of male and female.

METHODOLOGY

Participants: This study is a retrospective observational experimental study examining 284 CT scans spanning the period from 2010-2020, with a focus on anatomy of spine. From this dataset 200 scans were selected using simple random sampling for the analysis. The CT imaging was done with Phillips Brilliance Big Bore operating at 120kv, and a thickness of 1.04mm. The study covered a period of one-year duration. CT scans of patients with normal spine anatomy were selected for the study. Patients were aged between 25-86 years with a gender distribution of 113 (56.5%) being males and 87 (43.5%) females at the Kasturba Hospital, Manipal.

Inclusion and exclusion criteria: CT scans of patients with normal spine anatomy admitted under "Spine services unit of orthopedics department" of Kasturba hospital, Manipal were included in the study. Patients with abnormal anatomy like fractures, scoliosis, kyphosis etc. of the spines in the CT scans were excluded from the study.

Procedure: Quantitative variables for the study were pedicle width, pedicle length and screw path angle of both the sides of thoracolumbar vertebrae. Measurements were acquired in CT images in axial section at the junction between the lower 2/3rd and upper 1/3rd for right and left side pedicles for pedicle width, Screw path angle, and screw path length. Comparison is done for the bilateral measurements among male and female patients. Measurement of various morphometric parameters are acquired using the RadiAnt DICOM viewer (64 bit). The measured data are recorded in an excel spreadsheet and statistical analysis was done.

Statistical analysis: Data was analyzed using the SPSS statistical package version 24. The pedicle width, screw length and screw path angle in thoracolumbar pedicle of both left and right side based on gender was represented using mean and standard deviation. An independent sample t-test was done to compare the means of both sides of the vertebrae with respect to gender distribution. Paired sample t-test was performed to compare the means of both left and right-side thoracolumbar pedicle measurements and correlation of width of pedicle, screw length and screw path angle of all right and left thoracic and lumbar vertebrae of both males and females were estimated. The results of all the tests with $p < 0.05$ were considered to be statistically significant.

Observer agreements: To compare the inter observer and intra observer variations 5 male and 5 female patients CT scans were chosen. Kappa analysis was performed for intra observer and inter observer reliability. For inference, Landis and Koch's interpretation of reliability coefficients was taken: kappa 0–0.2 indicated slight agreement, 0.21–0.4 fair agreement, 0.41–0.6 moderate agreement, 0.61–0.8 substantial agreement, and 0.81–1.0 excellent agreement (24).

Intra observer: The measurements on the scans are performed by the observer on two occasions, 3-5 weeks apart

Inter observer: The measurements on the scans are performed by two observers (novice and intermediate level expert)

Ethical considerations: Ethical approval (IEC:721/2020) was obtained for the study from the Kasturba Medical College and Hospital Institutional Ethics Committee (Registration No. ECR/146/Ins/KA/2013/RR-19 and DHR Registration No. EC/NEW/INST/2019/374)

RESULTS

Pedicle Width

Right and left thoracic vertebrae: The pedicle width of right and left thoracic vertebrae (T1-T12) for both male and female patients were measured based on CT image. Table 1 presents the comparison of pedicle width of right and left thoracic vertebrae among males and females. Mean (standard deviation; S.D.) pedicle width of thoracic vertebra in the right side was maximum at T12 (0.873 ± 0.081 cm in males and 0.892 ± 0.059 cm in females) and minimum at T5 (0.459 cm ± 0.056 cm in males; 0.477 cm ± 0.52 cm in females). Mean (S.D.) pedicle width of left thoracic vertebra was maximum at T12 (0.872 ± 0.08 cm in males and 0.892 ± 0.06 cm in females) and minimum at

T5 (0.458 cm ± 0.056 in males and 0.477 cm ± 0.52 in females). Independent t-test revealed a significant difference in the mean pedicle width of right and left thoracic vertebrae in T1 and T4 only between males and females ($p \leq 0.05$), however, no statistical difference in the rest ($p > 0.05$) was observed between the rest of the thoracic vertebrae. Hence, it can be inferred that there is a gender-based difference in the width of pedicles in the right and left upper thoracic vertebrae T1 and T4.

Right and left lumbar vertebrae: The mean (S.D.) pedicle width of right and left lumbar vertebra (L1-L5) in cm were measured based on CT image. Table 2 presents the comparison of pedicle width of right and left thoracic vertebrae among males and females. It was observed to be maximum at L5 (1.281 ± 0.098 cm in males and 1.233 ± 0.085 cm in females) and minimum at L1 (0.927 ± 0.087 cm in males and 0.941 ± 0.067 cm in females) on the right side. The mean (S.D.) on the left side was maximum at L5 (1.286 ± 0.99 cm in males and 1.237 ± 0.087 cm in females) and minimum at L1 (0.928 ± 0.088 cm in males and 0.941 ± 0.067 cm in females). No significant differences in the mean pedicle width of right and left lumbar vertebrae among males and females ($p > 0.05$) was observed using independent t- test.

Right and left thoracic vertebrae: The screw path length of right and left thoracic vertebrae (T1-T12) for both male and female patients were measured. Table 3 presents the comparison of screw path length of right and left lumbar vertebrae among males and females. Mean (S.D.) screw path length of thoracic vertebra in the right side was maximum at T1 (31.910 ± 0.870 cm in males and 31.300 ± 1.260 cm in females) and minimum at T9 (19.630 ± 1.250 cm in males and 18.810 ± 1.800 in females). Mean (S.D.) screw path length of left thoracic vertebra was maximum at T1 (31.892 ± 0.853 cm in males and 31.298 ± 1.260 cm in females) and minimum at T9 (19.667 ± 1.189 cm in males and 18.810 ± 1.801 cm in females). Independent t -test revealed that there are statistically significant differences in the mean difference in screw path length of right and left thoracic vertebrae T1, T9, T10, and T11 among males and females ($p \leq 0.05$). There is no statistically significant difference in the mean difference of screw path length in the rest of them. This suggests there is gender-based difference in the screw path length in the right and left thoracic vertebrae, T1, T9, T10, and T11 (Table 3).

Right and left lumbar vertebrae:

Table 4 presents the comparison of screw path length of right and left lumbar vertebrae among males and females Mean (S.D.) screw path length of right and left lumbar vertebra (L1-L5) was observed maximum at L5 (31.148 ± 0.959 cm in males and 30.725 ± 0.947 cm in females) and minimum at L1 (25.156 ± 1.228 cm in males and 24.840 ± 1.263 cm in females) on the right side. The mean (S.D.) on the left side was maximum at L5 (25.156 ± 1.228 cm in males and 25.156 ± 1.228 cm in females) and minimum at L1 (31.155 ± 0.938 cm in males and 31.155 ± 0.938 cm in females). According to the independent t-test, there are no statistically significant differences in mean screw path length for any of them. Hence, there is no gender-based differences in the screw path length of the lumbar vertebra (Table 4).

Screw path angle

Right and left thoracic vertebrae:

Table 5 describes the screw path angle of right and left thoracic vertebrae (T1-T12) for both male and female patients. Mean (S.D.) screw path angle of thoracic vertebra in the right side was maximum at T12 (4.492 ± 0.198 cm in males and 4.453 ± 0.121 cm in females) and minimum at T1 (3.244 ± 0.126 cm in males and 3.236 ± 0.109 cm in females). Mean (S.D.) screw path angle of left thoracic vertebra was maximum at T12 (4.489 ± 0.177 cm in males and 4.52 ± 1.120 cm in females) and minimum at T1 (3.247 ± 0.125 cm in males and 3.237 ± 107 cm in females). No statistically significant differences in the mean screw path angle bilaterally ($p > 0.05$) were observed in the independent t-tests. From the results, it is evident that the mean screw path angle shows no significant difference based on gender for vertebrae T1 to T12 bilaterally.

Table 1: Comparison of pedicle width of right and left thoracic vertebrae among males and females.

Vertebrae Number	Right			Left		
	Male	Female	t	Male	Female	t
T1	0.603±0.112	0.557±0.11	2.881*	0.603±0.113	0.558±0.110	2.871*
T2	0.631±0.109	0.593±0.107	2.499	0.631±0.109	0.592±0.108	2.52
T3	0.599±0.103	0.566±0.102	2.214	0.599±0.104	0.566±0.102	2.238
T4	0.489±0.075	0.462±0.062	2.781*	0.490±0.076	0.462±0.062	2.783*
T5	0.459±0.056	0.477±0.052	-2.233	0.458±0.056	0.477±0.052	-2.341
T6	0.534±0.049	0.533±0.042	0.08	0.534±0.049	0.534±0.042	0.037
T7	0.598±0.057	0.597±0.048	0.129	0.598±0.056	0.596±0.049	0.354
T8	0.669±0.068	0.676±0.057	-0.722	0.670±0.068	0.676±0.057	-0.675
T9	0.747±0.086	0.761±0.07	-1.25	0.746±0.085	0.761±0.068	-1.362
T10	0.798±0.085	0.812±0.064	-1.295	0.797±0.086	0.812±0.064	-1.33
T11	0.854±0.081	0.867±0.051	-1.289	0.852±0.084	0.866±0.052	-1.369
T12	0.873±0.081	0.892±0.059	-1.773	0.872±0.082	0.892±0.059	-1.882

*Significance inferred at $p \leq 0.05$ based on independent samples t test

Table 2: Comparison of pedicle width of right and left lumbar vertebrae among male and females.

Vertebrae Number	Male			Female		
	T1R	T1L	t	T1R	T1L	t
L1	0.927±0.087	0.928±0.088	-1.061	0.942±0.067	0.941±0.067	-1.061
L2	0.988±0.101	0.989±0.102	-0.764	0.999±0.078	0.999±0.078	-0.764
L3	1.050±0.099	1.050±0.102	0	1.057±0.084	1.058±0.085	0
L4	1.144±0.109	1.147±0.111	-2.304	1.146±0.076	1.147±0.076	-2.304
L5	1.281±0.098	1.286±0.099	-1.073	1.233±0.085	1.237±0.087	-1.073

*Significance inferred at $p \leq 0.05$ based on paired samples t test

Table 3: Comparison of screw path length of right and left thoracic vertebrae among males and females.

Vertebrae Number	Right			Left		
	Male	Female	t	Male	Female	t
T1	31.910±0.870	31.300±1.260	4.067**	31.892±0.853	31.298±1.260	3.970**
T2	30.930±1.710	30.480±1.700	1.833	30.926±1.730	30.482±1.704	1.812
T3	28.880±2.390	28.670±2.110	0.632	28.917±2.341	28.671±2.111	0.767
T4	27.470±2.530	27.240±2.290	0.649	27.487±2.508	27.244±2.292	0.707
T5	25.710±2.700	25.610±2.310	0.252	25.710±2.690	25.608±2.320	0.282
T6	24.300±2.450	24.110±2.180	0.583	24.319±2.430	24.110±2.182	0.628
T7	22.820±2.080	22.380±2.200	1.465	22.859±1.988	22.382±2.192	1.611
T8	21.200±1.460	20.700±1.800	2.191	21.223±1.430	20.700±1.793	2.294
T9	19.630±1.250	18.810±1.800	3.813**	19.667±1.189	18.810±1.801	4.042**
T10	20.650±1.300	20.030±1.600	3.025*	20.660±1.294	20.032±1.595	3.072*
T11	22.120±1.200	21.590±1.360	2.909*	22.103±1.203	21.585±1.369	2.843*
T12	23.610±1.470	23.180±1.360	2.141	23.613±1.489	23.178±1.362	2.123

*Significance inferred at $p \leq 0.05$ and ** Significance inferred at $p \leq 0.01$ based on independent samples t tests

Table 4: Comparison of screw path length of right and left lumbar vertebrae among males and females.

Vertebrae Number	Male			Female		
	T1R	T1L	t	T1R	T1L	t
L1	25.139±1.231	25.156±1.228	-1.259	24.840±1.263	25.156±1.228	1
L2	26.540±1.528	26.558±1.515	-2.014	26.345±1.506	26.558±1.515	1
L3	28.279±1.595	28.251±1.655	2.115	28.278±1.503	28.251±1.655	
L4	29.568±1.318	29.584±1.297	-1.309	29.473±1.359	29.584±1.297	1.423
L5	31.148±0.959	31.155±0.938	-0.493	30.725±0.947	31.155±0.938	

*Significance inferred at $p \leq 0.05$ based on paired samples t test

Table 5: Comparison of screw path angle of right and left thoracic vertebrae and screw path angle of right and left lumbar vertebrae based on gender.

Vertebrae Number	Right			Left		
	Male	Female	t	Male	Female	t
T1	3.244±0.126	3.236±0.109	0.461	3.247±0.125	3.237±0.107	0.637
T2	3.348±0.109	3.341±0.092	0.529	3.347±0.109	3.341±0.092	0.441
T3	3.508±0.147	3.487±0.107	1.113	3.507±0.149	3.488±0.105	0.9
T4	3.628±0.107	3.635±0.109	-0.445	3.629±0.109	3.634±0.109	-0.322
T5	3.788±0.170	3.767±0.099	1.013	3.787±0.168	3.767±0.099	0.963
T6	3.934±0.146	3.917±0.103	0.91	3.932±0.137	3.916±0.102	0.926
T7	4.052±0.130	4.047±0.100	0.28	4.050±0.129	4.046±0.100	0.239
T8	4.132±0.119	4.107±0.221	1.033	4.132±0.120	4.107±0.220	1.017
T9	4.205±0.120	4.206±0.092	-0.026	4.207±0.125	4.206±0.092	0.074
T10	4.311±0.130	4.286±0.090	1.483	4.308±0.132	4.286±0.090	1.311
T11	4.408±0.158	4.370±0.110	1.916	4.412±0.164	4.370±0.109	2.092
T12	4.492±0.198	4.453±0.121	1.614	4.489±0.177	4.452±0.120	1.67

*Significance inferred at $p \leq 0.05$ based on independent samples t test

Table 6: Comparison of screw path angle of right and left lumbar vertebrae among males and females.

Vertebrae Number	Male			Female		
	T1R	T1L	t	T1R	T1L	t
L1	4.576±0.163	4.576±0.166	-0.391	4.531±0.123	4.531±0.123	1
L2	4.725±0.153	4.685±0.107	-0.82	4.685±0.107	4.685±0.107	
L3	4.835±0.157	4.801±0.093	1.47	4.801±0.093	4.801±0.093	-1.057
L4	4.939±0.136	4.919±0.094	0.635	4.919±0.094	4.919±0.094	-1
L5	5.031±0.122	5.042±0.120	0.337	5.042±0.120	5.042±0.120	-0.425

*Significance inferred at $p \leq 0.05$ based on paired samples t test

Table 7: Kappa statistics for inter and intra examiner reliability.

Variable	Group	Kappa values	
		Inter examiner	Intra examiner
Pedicle width	Female	0.753	0.826
	Male	0.753	0.83
Screw path angle	Female	0.845	0.868
	Male	0.852	0.875
Screw path length	Female	0.817	0.817
	Male	0.828	0.815

Right and left lumbar vertebrae: Table 6 presents the screw path angle of right and left lumbar vertebrae (T1-T12) for both male and female patients. Mean (S.D.) screw path angle of right and left lumbar vertebra (L1-L5) was observed maximum at L5 (5.031 ± 0.122 cm in males and 5.042 ± 0.120 cm in females) and minimum at L1 (4.576 ± 0.163 cm in males and 4.531 ± 0.123 cm in females) on the right side. The mean (S.D.) on the left side was maximum at L5 (5.042 cm ± 0.120 in both males and females) and minimum at L1 (4.531 cm ± 0.123 in males and females). Independent t- test signified that there is no statistically significant difference in mean screw path angle forvertebrae L1 to L5 bilaterally among male and female ($p > 0.05$). Hence, there is no gender-based difference in the screw path length on the lumbar vertebrae.

Kappa statistics for inter and intra examiner reliability: The results of inter and intra-examiner reliability are summed up in Table 7. The intra-examiner agreement was excellent among all the examiners with kappa values ranging from 0.815 to 0.875. Inter-examiner agreement was lower than intra examiner ranging from substantial to excellent with kappa values 0.753 to 0.852. The p-values for all variables are 0.000, indicating that the observed agreements are statistically significant.

DISCUSSION

The findings of this study gave insights in to morphological variation in the pedicle width, screw path length and angle across thoracolumbar vertebrae as well as gender-based differences in these parameters in South Indian population. Though many studies are there in literature to describe morphology of thoracolumbar region (6,7,10,23,25), there is less data analyzed from Southern India. The parameters measured and compared in the present study are discussed below.

Pedicle width: With respect to pedicle width the results indicate that there is a significant variation in the pedicle width among male and female in the upper thoracic vertebrae (T1 to T5) bilaterally. These findings align with previous studies (3,26) where gender-based variations in the morphology in upper thoracic region was found. Likewise, among the lumbar vertebrae significant gender-based variations were observed at L5 level, whereas they were insignificant in L1 to L4 suggesting morphological variations are observed more in lower lumbar region (L5). In both males and females, the widest pedicle width was at L5 and the narrowest was at T4 or T5. Similar results were found by (27). T12 vertebra was found to have the widest pedicle width and T5 vertebra had the narrowest pedicle width bilaterally which was found similar to the study by Verma et al. (2020). In this study among male significant difference in the mean pedicle width was observed bilaterally at T11 and L4 and among females no significant difference was observed in mean pedicle width bilaterally throughout thoracolumbar vertebrae.

Screw path length: The analysis of screw path length in the lumbar vertebrae highlights variation in the morphology in both the genders. The right thoracic region shows a consistent screw path length from T1 to T12 with statistically insignificant differences between males and females suggesting there is no gender-based variations in screw path length in the thoracic region where as in the right lumbar region, L1 and L2 showed significant variations indicating gender-based differences are present in these levels of vertebrae. In earlier studies, gender-based variations in dimension was evident (29,30). In this study for both the genders across thoracolumbar vertebrae, the observed mean differences in screw path length bilaterally were found to be statistically insignificant.

Screw path angle: The finding for screw path angle shows significant gender-based differences bilaterally in thoracic vertebrae T1, T8 to T12. Similarly, in the lumbar region significant differences were seen in L5 suggesting the possible influence of gender on the screw path angles in specific vertebrae which may have effects on the screw placements in the surgical procedures. Females had significantly lower mean screw path length than males at every vertebral level similar to a study by Soh et al. (2021). T1 vertebra had the maximum pedicle angle which was found to be similar in a study by Verma et al. (2020). In this study among males the mean of screw path angle shows no statistically significant differences for thoracic vertebrae however there was statistically significant difference observed at L2 and L3 of lumbar vertebrae. In case of females, there were no statistically significant differences observed bilaterally in both thoracic and lumbar vertebrae.

The study also highlights the correlation between right and left thoracic and lumbar vertebrae among males and females and indicated a strong positive correlation between right and left pedicles implying that the pedicle width, screw path length and angle of the vertebras of right side strongly correlates with corresponding vertebra on left side in males and females indicating a symmetry in the orientation and also presents substantial to almost perfect agreement in inter-examiner and intra-examiner reliability for the pedicle measurements.

The results of this study have importance in clinical implications for surgeries related to spine particularly in pedicle screw fixation for managing spinal disorders. Hence, understanding the gender specific variations in the morphology will aid spine surgeons to optimize surgical techniques and reduce the risk of complications due to misplacement of screws. The variations in morphology in the

pedicle suggest that care should be taken in the instrumentation of thoracolumbar spine.

It is crucial to acknowledge the limitations of this study which includes reliance on CT imaging data, small sample size and the need for exploring various other sources of variability such as weight and BMI that may affect size of pedicle. Future research can explore other additional factors which influence the pedicle parameters such as demographics of patient, age, pathologies and surgical approach.

CONCLUSION

This study gives insights to the morphologic characteristics of thoracolumbar vertebrae from T1-T12 and L1 to L5 in South Indian population. It was concluded that there is gender-based variations in the morphology of the thoracolumbar pedicle with significant variations in pedicle width between genders in thoracic regions restricted to T1, T4, T9, T10, and T11 in terms of screw path angle. While no significant gender-based variations in pedicel width, screw path length and screw path angle in the lumbar region was observed. It can be suggested that knowledge of this variation in parameters across thoracolumbar vertebrae is important for spine surgeons to consider when planning and executing surgeries which involve pedicle screw fixation to reduce complications. The present study proves to be of significance, as the different dimensions of the pedicle studied would aid in successful operative procedures. This, will also help in selecting and designing implants and screws used for spinal fixation.

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Author Contributions

SM: Have made a substantial contribution to the concept of the article, the acquisition, analysis and interpretation of data for the article; and accountable for all aspects of the work in ensuring that questions related to the accuracy of any part of the work are appropriately investigated and resolved.

MH: Revised article critically for important intellectual content;and approved the version to be published.

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