BILATERAL CT SCAN MEASUREMENTS OF PEDICLE WIDTH, SCREW PATH LENGTH AND SCREW PATH ANGLE IN THORACOLUMBAR SPINES OF A SOUTH INDIAN POPULATION

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Ethical Approval

Ethical approval (IEC:721/2020) has been 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)**.**

Abstract:

Background: The thoracolumbar spine is a critical region of the spine that is prone to various degenerative and traumatic conditions. Understanding the anatomy and biomechanics of the thoracolumbar spine is essential for the diagnosis and treatment of spinal disorders. **Aim:** The aim of this study is to investigate the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population. **Materials & methods:** Full spine CT scans of 125 patients were collected and analyzed. Out of these 100 patients' (84 males and 16 females) scan between the age of 25-86 years were selected, with normal vertebral anatomy. The pedicles of the thoracolumbar spines of the 100 patients were observed in an axial section using a DICOM image viewer (RadiAnt DICOM viewer 64 bit). **Results:** A gender difference was observed in the width of the right and left pedicles at various vertebral levels (T1-T12 and L1-L5) and in the screw path angles of the pedicles at T1-T12 levels and L1 and L5 levels ($P < 0.05$). However, no significant variation in the screw path length was found between the genders regarding thoracic and lumbar vertebrae of both the sides ($P > 0.05$). **Conclusion:** Our research shows that measuring pedicle width, screw path length, and screw path angle in the thoracolumbar spine of South Indian individuals using bilateral CT scans offers valuable insights.

Establishing normative data for these parameters assists in surgical planning and decision-making, improving the outcomes of spinal fixation procedures.

Key words: Computed Tomography, Thoracolumbar spine, Spinal fixation procedures, Pedicle width, Screw path length, Screw path angles, South Indian Population.

Introduction:

The thoracolumbar spine is a critical area of the spine that is susceptible to various degenerative and traumatic conditions. It is crucial to have a comprehensive understanding of the anatomy and biomechanics of the thoracolumbar spine to accurately diagnose and treat spinal disorders [1-3]. Previous studies have investigated the anatomy and biomechanics of the thoracolumbar spine using unilateral and bilateral measurements [4-8]. Studies have consistently shown that the pedicles of the Asian population are significantly smaller than those of other ethnicities [4-6]. Before performing transpedicular screw fusion for the cervical spine in their study population, recommended utilizing a preoperative computed tomography scan [7,8].

There is a lack of studies that have investigated the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population. The research question is what are the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population? The aim of this study is to investigate the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population. We hypothesize that the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population will differ from those reported in previous studies conducted in other populations.

Materials & methods:

With the authorization of the Institutional Review Board of our Institution, we conducted an investigation into the hypothesis that hat the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population will differ from those reported in previous studies conducted in other populations. In light of the study's retrospective design and minimal risk profile, it was concluded that informed consent were taken from each individual participated in the present study. Full spine CT scans of 125 patients were collected and analyzed. Out of these 100 patients' (84 males and 16 females) scan between the age of 25-86 years were selected, with normal vertebral anatomy. The pedicles of the thoracolumbar spines of the 100 patients were observed in an axial section using a DICOM image viewer (RadiAnt DICOM viewer 64 bit). Three measurements were taken for the thoracolumbar spines at all levels: pedicle width, screw path length and screw path angle (transverse pedicle angle). A total of 1700 vertebrae were studied (1200 thoracic; 1008 males and 192 females and

500 lumbar; 420 males and 80 females). Pedicle measurements of a total of 3400 pedicles (2400 right and left thoracic and 1000 right and left lumbar) were taken. A comparison between the two sides and the difference in measurements at different levels were analyzed with respect to pedicle screw placement procedure.

Statistical analysis:

Genders of the study population were counted. Descriptive statistics including mean, standard deviation, standard error mean, with lower bound and upper bound with 95% confidence were calculated. The mean and standard deviations between the different parameters were calculated by the two tailed P value. The P value was considered significant when it is < 0.05.

Results:

A sample of 100 patients, comprising 84 males and 16 females, aged between 25 and 86 years, with normal vertebral anatomy, was selected for analysis. A total of 1700 vertebrae were studied, including 1200 thoracic vertebrae and 500 lumbar vertebrae. Pedicle measurements were taken for a total of 3400 pedicles, consisting of 2400 right and left thoracic pedicles and 1000 right and left lumbar pedicles.

Table 1: Comparison of mean pedicle width of all right thoracic vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	T	df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
T1	5.15	98	.000	.14	.03	.09	.20
T2	4.76	98	.000	.13	.03	.08	.19
T3	4.31	98	.000	.11	.03	.06	.16
T4	4.05	98	.000	.08	.02	.04	.12
T5	.40	98	.690	.01	.01	-.02	.03
T6	.65	98	.517	.01	.01	-.02	.03
T7	.13	98	.898	.00	.01	-.03	.03
T8	-1.12	98	.266	-.02	.02	-.05	.02
T9	-1.18	98	.240	-.03	.02	-.07	.02

T10	-.92	98	.357	-.02	.02	-.06	.02
T11	-1.01	98	.317	-.02	.02	-.06	.02
T12	-1.35	98	.179	-.03	.02	-.07	.01

significance inferred at p≤0.05 based on independent samples t test

Table 2: Comparison of mean pedicle width of all right lumbar vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	T	Df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
L1	-1.08	98	.284	-.02	.02	-.07	.02
L2	-1.01	98	.316	-.03	.03	-.08	.03
L3	-2.74	98	.007	-.07	.03	-.12	-.02
L4	-1.56	98	.122	-.04	.03	-.10	.01
L5	-.77	98	.443	-.02	.03	-.07	.03

significance inferred at p≤0.05 based on independent samples t test

Table 3: Comparison of mean pedicle width of all left thoracic vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	Df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
T1	5.12	98	.000	.14	.03	.09	.20
T2	4.86	98	.000	.13	.03	.08	.19

T3	4.26	98	.000	.11	.03	.06	.16
T4	4.01	98	.000	.08	.02	.04	.12
T5	.33	98	.745	.00	.01	-.02	.03
T6	.44	98	.661	.01	.01	-.02	.03
T7	.65	98	.515	.01	.01	-.02	.04
T8	-1.10	98	.274	-.02	.02	-.05	.02
T9	-1.22	98	.224	-.03	.02	-.07	.02
T10	-.90	98	.371	-.02	.02	-.06	.02
T11	-.87	98	.387	-.02	.02	-.06	.02
T12	-1.29	98	.199	-.03	.02	-.07	.01

significance inferred at p≤0.05 based on independent samples t test

Table-4: Comparison of mean pedicle width of all left lumbar vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	T	Df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
L1	-.84	98	.404	-.02	.02	-.06	.03
L2	-.93	98	.353	-.03	.03	-.08	.03
L3	-2.82	98	.006	-.08	.03	-.13	-.02
L4	-1.60	98	.112	-.05	.03	-.10	.01
L5	-1.20	98	.233	-.03	.03	-.09	.02

significance inferred at p≤0.05 based on independent samples t test

A notable variation in the width of the right pedicle was identified across the T1, T2, T3, and T4 levels (P <.001; table 1). Furthermore, a statistically significant difference was observed in the pedicle width of the right lumbar vertebra at L3 between the two genders (P < 0.05; table 2). Additionally, a statistically significant difference in the width of the left pedicle was observed across the T1, T2, T3, and T4 levels (P <.001; table 3). Lastly, a statistically significant difference was observed in the pedicle width of the left lumbar vertebra at L3 between the two genders (P < 0.05; table 4).

Table 5: Comparison of mean screw path length of all right thoracic vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	Df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
T1	.04	98	.971	.00	.03	-.07	.07
T2	.01	98	.993	.00	.03	-.06	.06
T3	.32	98	.750	.01	.04	-.07	.10
T4	-.72	98	.476	-.02	.03	-.08	.04
T5	.21	98	.838	.01	.05	-.08	.10
T6	-.33	98	.741	-.01	.04	-.09	.06
T7	-.73	98	.464	-.02	.03	-.09	.04
T8	-1.09	98	.279	-.03	.03	-.09	.03
T9	-1.27	98	.208	-.04	.03	-.10	.02
T10	-.16	98	.870	-.01	.03	-.07	.06
T11	.23	98	.817	.01	.04	-.07	.09
T12	.19	98	.847	.01	.05	-.09	.11

There is no significant variation in the screw path length of the right pedicle was identified across the T1 – T12 levels (P >0.05; table 5). Furthermore, no statistically significant difference was observed in the screw path length of the right lumbar vertebra between L1 to L5 of the two genders (P > 0.05; table 6). Additionally, no statistically significant difference in the screw path length of the left thoracic vertebrae was observed across the T1 to T12 levels (P > 0.05; table 7). Lastly, no statistically significant difference was observed in the screw path length of the left lumbar vertebrae from L1 to L5 between the two genders (P > 0.05; table 8).

Table 6: Comparison of mean screw path length of all right lumbar vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	df	Sig. (2-tailed)* P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
L1	.34	98	.738	.01	.04	-.07	.09
L2	.60	98	.548	.02	.04	-.05	.10
L3	.55	98	.587	.02	.04	-.06	.10
L4	1.01	98	.317	.03	.03	-.03	.10
L5	.95	98	.345	.03	.03	-.03	.10

Table 7: Comparison of mean screw path length of all left thoracic vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	Df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
T1	.15	98	.878	.01	.03	-.06	.07
T2	-.05	98	.962	.00	.03	-.06	.06
T3	.27	98	.79	.01	.04	-.07	.09
T4	-.70	98	.487	-.02	.03	-.08	.04
T5	.17	98	.865	.01	.04	-.08	.10
T6	-.41	98	.685	-.01	.04	-.08	.06
T7	-.76	98	.452	-.02	.03	-.09	.04
T8	-1.10	98	.276	-.03	.03	-.09	.03

T9	-1.13	98	.262	-.04	.03	-.10	.03
T10	-.27	98	.790	-.01	.03	-.07	.05
T11	.37	98	.715	.01	.04	-.07	.10
T12	.16	98	.877	.01	.05	-.08	.10

Table 8: Comparison of mean screw path length of all left lumbar vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
L1	.37	98	.713	.015	.041	-.066	.096
L2	.64	98	.525	.030	.048	-.064	.125
L3	.42	98	.676	.015	.035	-.055	.084
L4	1.03	98	.305	.034	.033	-.032	.100
L5	.89	98	.377	.030	.034	-.038	.098

Table 9: Comparison of mean screw path angles of all right thoracic vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	Df	Sig. (2-tailed) *P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
T1	11.46	98	.000	2.26	.20	1.87	2.65
T2	3.61	98	.000	1.60	.44	.72	2.48
T3	2.45	98	.016	1.48	.60	.28	2.68
T4	2.67	98	.009	1.72	.64	.44	3.00
T5	2.60	98	.011	1.75	.67	.41	3.09
T6	3.65	98	.000	2.20	.60	1.00	3.39
T7	4.57	98	.000	2.44	.53	1.38	3.50

T8	6.55	98	.000	2.45	.37	1.71	3.19
T9	8.80	98	.000	2.83	.32	2.19	3.46
T10	5.98	98	.000	2.06	.34	1.38	2.75
T11	5.14	98	.000	1.63	.32	1.00	2.26
T12	3.16	98	.002	1.19	.38	.44	1.94

A notable variation in the screw path angles of the right pedicle was identified from T1 to T12 levels among both genders (P <.001; table 9). Furthermore, a statistically significant difference was observed in the screw path angles of the right lumbar vertebra at L1 and L5 between the two genders (P < 0.05; table 10). Additionally, a statistically significant difference in the screw path angles of the left pedicle was observed across T1 – T12 vertebrae (P <.001; table 11). Lastly, a statistically significant difference was observed in the screw path angles of the left lumbar vertebra at L1 and L5 between the two genders (P < 0.05; table 12).

Table 10: Comparison of mean screw path angles of all right lumbar vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	df	Sig. (2-tailed)* P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper
L1	2.25	98	.027	.75	.34	.09	1.42
L2	1.31	98	.193	.54	.41	-.28	1.36
L3	.67	98	.502	.29	.43	-.56	1.13
L4	.94	98	.351	.34	.36	-.38	1.07
L5	5.89	98	.000	1.36	.23	.90	1.81

Table 11: Comparison of mean screw path angles of all left thoracic vertebrae of males and females

Vertebrae number	t-test for Equality of Means						
	t	Df	Sig. (2-tailed)* P value	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference	
						Lower	Upper

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T1	11.71	98	.000	2.24	.19	1.86	2.62
T2	3.56	98	.001	1.60	.45	.71	2.49
T3	2.61	98	.011	1.53	.59	.37	2.70
T4	2.75	98	.007	1.75	.64	.49	3.01
T5	2.67	98	.009	1.79	.67	.46	3.12
T6	3.72	98	.000	2.22	.60	1.03	3.40
T7	4.93	98	.000	2.46	.50	1.47	3.45
T8	6.81	98	.000	2.46	.36	1.75	3.18
T9	9.51	98	.000	2.87	.30	2.27	3.47
T10	6.06	98	.000	2.07	.34	1.39	2.75
T11	5.13	98	.000	1.63	.32	1.00	2.26
T12	3.11	98	.002	1.19	.38	.43	1.95

Table 12: Comparison of mean screw path angles of all left lumbar vertebrae of males and females

Vertebrae number	**t-test for Equality of Means**						
	t	**df**	**Sig. (2-tailed) *P value**	**Mean Difference**	**Std. Error Difference**	**95% Confidence Interval of the Difference**	
						Lower	**Upper**
L1	2.34	98	.021	.78	.33	.12	1.45
L2	1.40	98	.165	.57	.41	-.24	1.38
L3	.56	98	.577	.25	.44	-.63	1.13
L4	1.12	98	.266	.40	.36	-.31	1.11
L5	6.13	98	.000	1.37	.22	.92	1.81

Discussion:

Analysis of precise pedicle width, screw length, and screw path angles prior to surgery is critical. Hence, The aim of this study is to investigate the bilateral measurements of pedicle width, screw path length, and screw path angle in the thoracolumbar spine of a South Indian population. The additional demographic information gathered from this anatomical study may enable surgeons to more precisely determine the appropriate size using the data obtained. Image guidance and robotic assistance are gaining popularity and can serve as an indispensable intraoperative supplement during pedicle screw insertion and spinal fusion if pedicle width, screw path length, and screw path angle in the spines are known. The primary benefits of this method include enhanced precision, reduced malposition, and diminished radiation exposure for both the patient and the surgeon [12,13]. Consequently, it could be contended that preoperative planning is unnecessary, as the measurement of pedicle width and length can be performed intraoperatively. Despite its increasing prevalence due to its reliability and precision, navigation-assisted surgery remains costly, lacks global adoption, and has demonstrated suboptimal accuracy in the lumbar spine [14,15]. Using navigated-assisted insertion, [16] recently examined pedicle screws from T10 to S1 to ascertain the extent of misplacement. The lumbosacral spine exhibited the highest incidence of screw misplacement, with improper depth being the most frequently cited cause for screw revision. Additionally, a study [17] reached the conclusion that the accuracy of navigation assistance in the lumbar spine was inferior to that of the freehand technique. One of the primary deductions that can be made is the significance of preoperative planning and intraoperative adjustments in instrumented spinal surgery is demonstrated by this research. Although this research provides a more comprehensive understanding of pedicle width and screw length in relation to the patient's race, significant variability remains.

The findings of this study consistently revealed that the screw length in the lumbar spine was considerably significant in the populations compared to the two genders. At present, these are the only data comparing pedicle screw length across racial groups. Furthermore, our research has shown that pedicel width varied considerably between ethnicities. These findings corroborate the conclusions of [1,3], who similarly identified substantial racial disparities in lumbar spine pedicle width. Transverse outer cortical pedicle width in the lumbar spine was investigated using CT scans with coronal incisions across different racial groups. A study [18] established that relying solely on the coronal view to measure the outer cortical pedicle width may result in an overestimation of the actual pedicle width. Transverse outer cortical pedicle width measurement on axial and coronal-cut CT scans is a dependable method for determining pedicle screw width, according to our findings.

As medical care becomes more cost-conscious, the utility of costly diagnostic imaging studies is diminishing. However, based on these findings, we concur with prior research that suggested preoperative CT scans be utilized for pedicle screw templating in order to insert pedicle screws with the highest withdrawal strength and safety. While preoperative CT scans may result in elevated expenses for suitably chosen patients and require increased radiation exposure for each individual, we contend that the significance of preoperative pedicle analysis considerably surpasses these concerns [19,20]. Despite this claim, preoperative CT scans may continue to serve a purpose in the case of more complex and dysplastic patients; however, the cost-benefit analysis for routine procedures involving the use of a few pedicle screws may not be feasible. Observed demographic information and such data can assist surgeons in making more informed decisions regarding x-ray images. While additional CT scans may still serve a purpose, our objective is to offer a more comprehensive understanding of reproducible guidelines within specific populations.

Our information concerning average pedicle width, screw length, and screw path angles may assist surgeons in performing the estimation and selection of the appropriate size of pedicle screws, which may improve patient outcomes and reduce intraoperative complications.

An examination of estimated marginal means yields narrow confidence intervals as a result of our sizable sample size; this verifies that our findings are exceptionally representative of the various racial groups. Our research is substantially enhanced by the substantial sample size we obtained from numerous institutions situated in a varied geographical region. As a result, our findings can be applied universally to patient populations across different geographic areas. Additional merits of the research encompass the utilization of data collected by a solitary observer and subsequently validated by a physician of greater seniority, thereby augmenting the dependability of the study in terms of interobserver variability.

Conclusion:

We conclude that bilateral CT scan measurements of pedicle width, screw path length, and screw path angle offer valuable insights into the anatomical characteristics of the thoracolumbar spine in South Indian individuals. By establishing normative data for these parameters, this study provides essential guidance for surgical planning and intraoperative decision-making, ultimately enhancing the outcomes of spinal fixation procedures in this population.

Conflict of interest:

There is no conflict of interest among the present study authors.

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