

MORPHOMETRY OF PEDICLES OF LUMBAR VERTEBRAE IN ADULT INDIAN POPULATION: STUDY IN DRY HUMAN BONES

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INTRODUCTION

The lumbar vertebrae are the five vertebrae located in the lower back, numbered L1 through L5. They are the largest vertebrae in the spine and are crucial for supporting the weight of the upper body, providing stability, and allowing for movement.

They are characterized by their large, kidney-shaped vertebral bodies, which are designed to bear significant weight. The largest part of the vertebra, designed to withstand compressive forces. The lumbar vertebrae have strong bony elements, including the vertebral arch, which protects the spinal cord and nerve roots. The Vertebral Arch protects the spinal cord and nerves. The Facet Joints allow for movement between vertebrae. They also feature various processes (bony projections) that serve as attachment points for muscles and ligaments. The Spinous Processes are projections that can be felt as the "knobs" of the spine. The Transverse Processes are projections that serve as attachment points for muscles and ligaments. The Intervertebral Discs are located between the vertebrae, acting as shock absorbers and allowing for movement. Since the entire weight of the torso is supported by the vertebral column, and the whole body weight is transmitted through the lumbar spine. Because of this, the lower segment vertebrae are most susceptible to degenerative changes. This causes deformities of this region as the age advances in many individuals. Proper correction of deformity is challenging. There have been advances in spinal fusion procedures and interspinous implantation of devices including pedicle screws.

Pedicle screw fixation along with the spinal fusion surgery is commonly used for the treatment of infections, fractures, tumours, vascular and congenital anomalies of lumbar spine.

Screw fixation is also being used for treating the fractures of lumbar pedicles in old age as they become weak because of the underlying osteoporosis.(1) For achieving successful fixation, there should be no mismatch between the size of the screw and the dimensions of the pedicle (2-3). Thus, it becomes very important for the spinal surgeons to have in depth knowledge of the morphometric details of lumbar pedicles. Use of unsuitable dimensions of screw may cause problem of destruction of pedicle. Correct meticulous data of pedicle is necessary for the choice of appropriate screw size.

Aims and Objectives

- 1) To measure the various dimensions in Indian adult human lumbar vertebral pedicles.
- 2) To prepare data of lumbar pedicles useful in various surgical procedures.

Methods: This study was conducted in the Department of Anatomy at Government Medical College, Jammu under Jammu University. The morphometric measurements of the 40 dry lumbar vertebrae were taken using vernier calipers. The parameters included in this study are pedicle cortical length, pedicle corticle height, pedicle corticle thickness and interpeduncular distance. SPSS software for Windows version 22.0 (IBM Corp., Armonk, NY) is used for statistical analysis. The data were analyzed and recorded.

Introduction: The pedicles of lumbar spine are stronger and larger and are commonly used for screw fixation during lumbar spinal stabilization for back pain and other associated signs of lumbar spinal diseases in modern world and it is estimated that around 70-90% of general population has chronic low backache and 4% of them require operation at certain time [4]. 'Spinal fixation' is often indicated in certain ailments of lumbar columns like fractures, degenerative changes, malignancy or lumbar instabilities [5]. In the cases of vertebroplasty, bone grafting, kyphoplasty, bone biopsy, and pedicle screw fixation, knowledge of the morphometry parameters of the lumbar vertebrae becomes important [6]. Pedicle screw fixation is an important surgical procedure in which the selection



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of the appropriate length and diameter of the screw is important so that the screw is carefully inserted through the pedicle for stabilization of the spine. Various orthopaedic procedures like biopsies, vertebroplasties and kyphoplasties are performed through the vertebral pedicles. The quantitative assessment of pedicle diameters help in deciding the appropriate size of the screw to be placed. The transverse and vertical diameters of the pedicle decide the trajectory of the screw. The horizontal diameter of the pedicle is relevant for predicting the screw diameter (3). For choosing the suitable implant, the morphometric measurements of the pedicle are important so as to avoid injury to blood vessels caused by exceeding the intervertebral space(7). The present study was conducted to evaluate the pedicle cortical width, cortical height, cortical length and interpeduncular distance of the lumbar vertebrae. These parameters help in selecting the size of the screw needed for transpeduncular screw fixation.

MATERIALS AND METHOD

This study was conducted in the department of Anatomy at Government Medical College, Jammu. The morphometric measurements of the 40 dry

lumbar vertebrae in the age group of 25–68 years were taken using vernier calipers.. Exclusion of deformed vertebrae was done. The dimensions including pedicle corticle length, pedicle corticle height, pedicle corticle thickness and interpeduncular distance were measured by ‘Digital Vernier Caliper’ with 0.01 mm precision. All observations were entered and analyzed in ‘SPSS Version 25’ software. Mean and Standard Deviations (SD) of each side were calculated. Pedicle parameters were recorded in millimetres as follows.

Pedicle Length - (PDL) - measurement between two points, one at the junction of pedicle and vertebral body and the second at the junction of pedicle and superior articular process.

Pedicle Height - (PDH) - maximum vertical measurement at the posterior end of pedicle.

Pedicle Thickness - (PDTh) - maximum transverse measurements of pedicle at its posterior end.

Interpeduncular distance (IPD): the distance between the medial borders of right and left pedicles at the junction of pedicle with superior articular facet.



Fig 1. Measurement of Pedicle Corticle Width



Fig 2. Measurement of Pedicle Corticle Height



Fig 3. Measurement of Pedicle Cortical Length



Fig 4. Measurement of Pedicle Interpeduncular Width

Observations

Table 1 Morphometric Analysis of Pedicle Cortical Width, Pedicle Cortical Height, Pedicle Cortical Length and Interpedicular Distance of the Lumbar Pedicle

s.no.	Pedicle length		Pedicle height		Pedicle width		Interpedicular distance
	Right	left	Right	Left	Right	Left	
1.	8.40	8.67	14.72	13.08	8.94	9.12	16.79
2.	3.91	4.17	13.73	13.60	9.05	9.37	18.62
3.	5.67	4.22	14.77	13.39	7.14	6.76	20.23
4.	5.83	4.81	15.49	15.18	6.74	6.43	21.15
5.	4.44	4.18	13.99	13.45	6.83	7.07	20.64
6.	4.11	3.34	15.50	15.44	10.36	11.03	21.58
7.	4.13	3.77	10.38	9.78	16.44	17.01	20.02
8.	5.48	4.93	12.98	12.72	9.24	11.09	23.95
9.	4.76	4.10	16.29	15.59	8.32	8.50	20.34
10.	6.65	5.18	14.49	12.76	9.36	9.50	18.60
11.	5.57	5.03	17.86	17.07	6.48	5.89	21.33
12.	7.18	6.45	14.37	14.17	7.27	7.03	18.54
13.	3.63	3.97	12.65	12.43	9.01	9.26	17.94
14.	7.21	6.63	14.25	14.09	7.01	6.79	18.47
15.	4.62	4.20	13.85	13.32	6.39	6.89	21.02
16.	5.28	4.85	13.86	13.04	7.34	6.98	20.01

17.	4.19	3.82	10.76	10.03	16.69	17.76	21.02
18.	6.32	4.99	13.96	12.01	8.97	9.17	18.01
19.	4.91	4.12	13.02	12.93	7.06	6.72	19.91
20.	3.62	3.64	12.23	12.01	8.62	8.73	16.85
21.	4.17	4.58	13.12	13.25	4.62	5.54	18.78
22.	6.00	5.34	13.50	14.43	7.67	8.28	22.63
23.	5.79	6.5	14.44	15.26	12.62	12.87	21.17
24.	4.89	5.32	11.34	10.63	8.38	10.35	22.07
25.	4.86	5.12	14.08	13.76	7.70	8.64	21.25
26.	6.55	4.27	13.38	13.19	6.34	6.86	18.79
27.	5.42	4.42	12.20	13.86	11.78	12.13	23.69
28.	5.85	5.28	15.12	14.70	9.69	9.80	20.64
29.	7.46	6.55	13.99	14.64	7.27	7.59	20.15
30.	4.79	5.62	18.33	18.05	10.89	10.04	27.03
31.	8.70	10.29	17.12	18.10	15.03	15.87	29.03
32.	5.12	5.63	12.34	12.98	11.06	11.87	20.72
33.	4.10	4.86	13.08	12.86	6.45	6.91	19.64
34.	8.64	8.43	17.23	18.56	14.05	14.86	27.92
35.	7.32	6.42	13.64	14.19	7.04	7.26	20.02
36.	3.06	3.45	12.02	11.56	8.45	8.65	16.05
37.	5.76	4.32	13.93	12.92	8.34	8.93	18.01
38.	4.02	4.35	12.64	12.87	5.03	5.08	17.54
39.	3.64	3.70	12.21	11.78	8.52	8.79	19.03
40.	8.03	8.42	14.54	13.01	8.59	9.13	16.50

RESULT

The measurements taken are statistically analysed and following are the results:

Table 2 Mean, Standard Deviation (Sd), Median And Mode Of Morphometric Dimensions Of Lumbar Pedicle

Statistics								
		Pedicle length Right	Pedicle length Left	Pedicle height Right	Pedicle height Left	Pedicle width Right	Pedicle width Left	Interpedicular distance
N	Valid	40	40	40	40	40	40	40
	Missing	0	0	0	0	0	0	0
Mean		5.5020	5.1985	13.9350	13.6672	8.9137	8.2638	20.3920
Std. Error of Mean		.23516	.24647	.27939	.30841	.44284	.45183	.45203
Median		5.3500	4.8550	13.8950	13.2850	8.4150	8.3900	20.0850
Mode		3.06 ^a	3.34 ^a	13.99	12.01	7.27	1.03 ^a	18.01 ^a
Std. Deviation		1.48731	1.55879	1.76699	1.95054	2.80079	2.85760	2.85888
Minimum		3.06	3.34	10.38	9.78	4.62	1.03	16.05
Maximum		8.70	10.29	18.33	18.56	16.60	15.87	29.03
Percentiles	25	4.1750	4.1725	12.7325	12.7850	7.0450	6.8675	18.5550
	50	5.3500	4.8550	13.8950	13.2850	8.4150	8.3900	20.0850
	75	6.4925	5.6275	14.6750	14.5875	9.6075	9.3425	21.2300

a. Multiple modes exist. The smallest value is shown

The mean of pedicle cortical length right side is 5.5020 and left side is 5.1985. The standard error of mean for right side is 0.23516 and left side is 0.24647. The median for right side is 5.3500 and left

side is 4.8550. The mode for right side is 3.06 and left side is 3.34. The standard deviation for right side is 1.48731 and left side is 1.55879.

The mean of pedicle cortical height right side is 13.9350 and left side is 13.6672. The standard error of mean for right side is 0.27939 and left side is

0.30841. The median for right side is 13.8950 and left side is 13.2850 . The mode for right side is 13.99 and left side is 12.01. The standard deviation for right side is 1.76699 and left side is 1.95054. The mean of pedicle cortical width right side is 8.917 and left side is 8.2638. The standard error of mean for right side is and left.44284 side is 0.45183. The median for right side is 8.450 and left side is

8.3900. The mode for right side is 7.27 and left side is 1.03. The standard deviation for right side is 2.80079 and left side is 2.85760. The mean interpeduncular distance is 20.3920. The standard error of mean is .45203. The median is 20.0850. The mode is 18.01. The standard deviation is 2.85888.

Table 3. showing comparison between morphometric measurements of Right and left pedicle

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Pedicle length Right	5.5020	40	1.48731	.23516
	Pedicle length Left	5.1985	40	1.55879	.24647
Pair 2	Pedicle height Right	13.9350	40	1.76699	.27939
	Pedicle height Left	13.6673	40	1.95054	.30841
Pair 3	Pedicle width Right	8.9137	40	2.80079	.44284
	Pedicle width Left	8.2638	40	2.85760	.45183

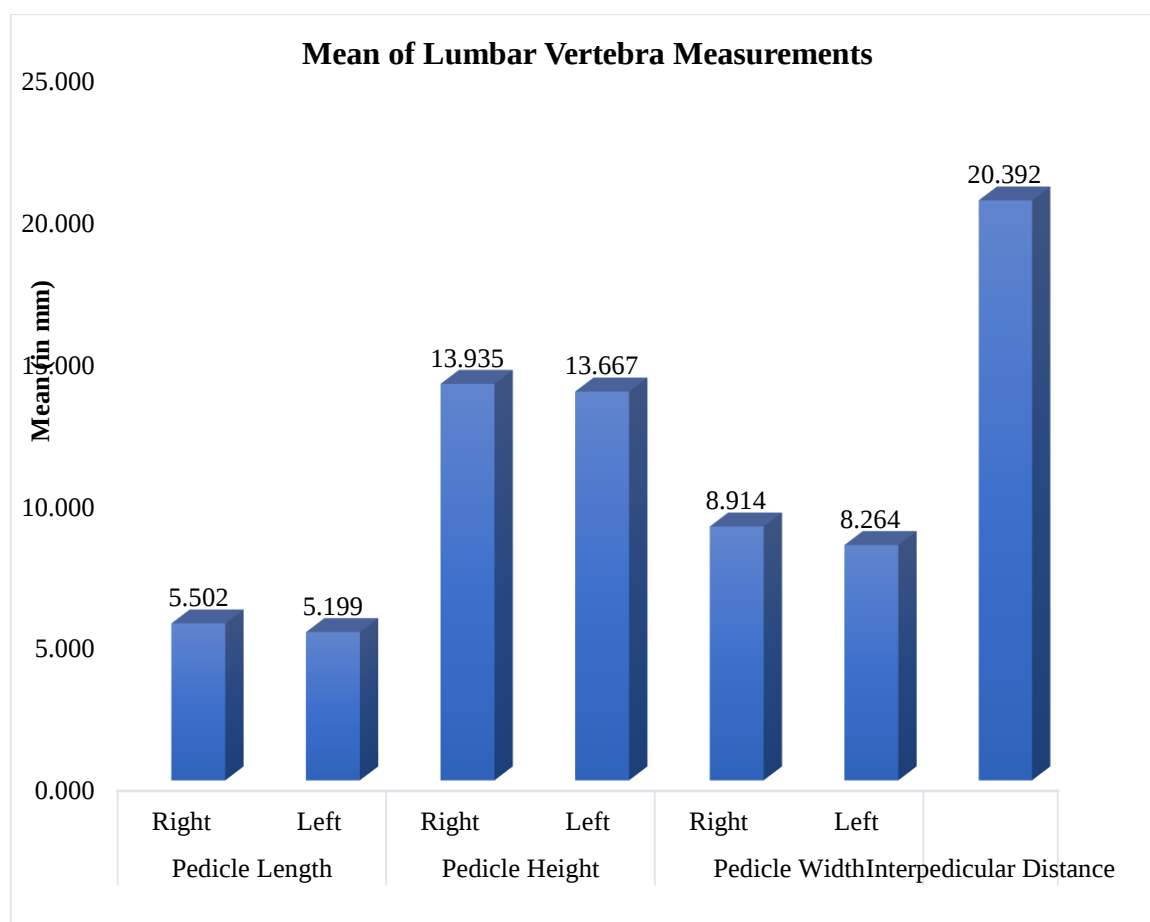


Fig 1. Bar graph showing mean of lumbar vertebra

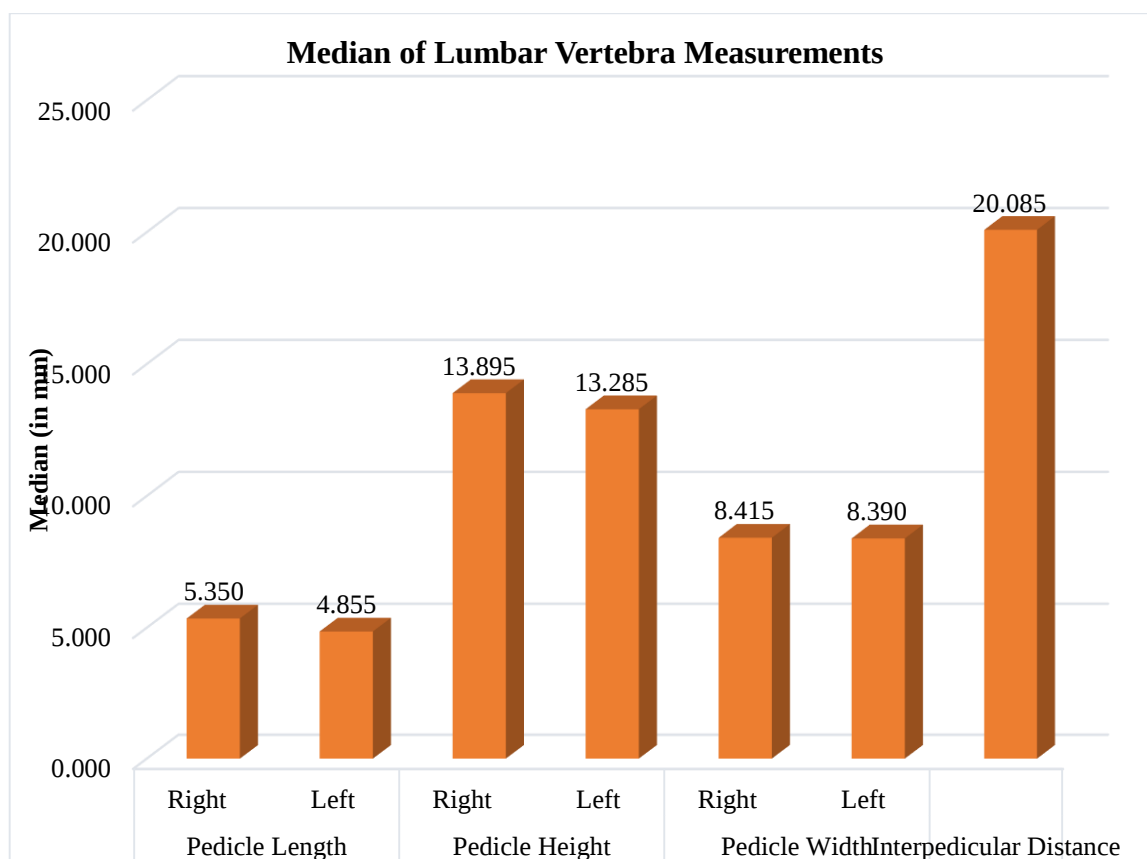


Fig 2.Bar graph showing median of lumbar vertebra

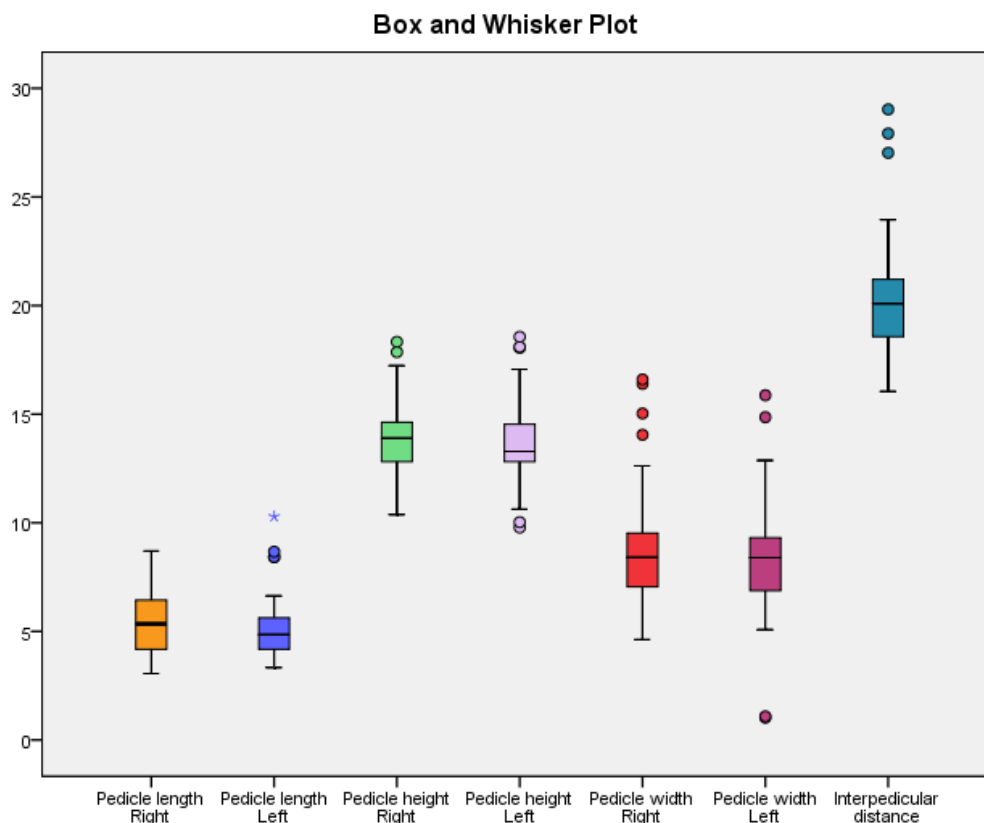


Fig. Box and Whisker plots showing the median of morphometric values of lumbar pedicles

DISCUSSION

Human lumbar vertebrae support the weight of the upper body. Loads lifted and carried by the upper extremities cause significant loading stress to the vertebral bodies.(8) The pedicle is the strongest part of the lumbar vertebrae. It is mostly made up of cortical bone with cancellous bone core in the centre.(9) As they are thick and strong, they are being used for fixation of screws for the management of various clinical conditions affecting lumbar spine.(10) the morphometric analysis of the pedicles thus help the orthopedic surgeons to determine the width, length, shape, size, direction and angulation of the screws.

The range of pedicle cortical width was measured is 4.62 to 16.60 mm on right side and 1.03 to 15.87 on left side in our study. However as per the previous studies done it ranges from 6 to 18.5 mm on both right and left sides(1) and it ranged between 8.7 ± 1.4 mm on right side and 8.7 ± 1.7 mm on left side (11). Pedicle corticle width is between 6.30 – 18.40 mm in western Indian population(12). Pedicle width showed the maximum standard deviation and variance.

As the width of the lumbar pedicle is important factor to decide the minimum diameter of the transpedicular screw, it has been reported that the screws having diameter greater than 65% of pedicle diameter may result in damage to the corticle pedicle in 85% of the patients.(13) Pedicle cortical height ranged between 10.38-18.33 mm on right side and 9.78-18.56mm on left side. As per the previous studies Pedicle cortical height ranged between 12 to 16.5mm on right side and 12.5 to 15mm on left side(1). Pedicle cortical height ranged from 8.11 to 23.44mm.(14) This height will determine the trajectory or the path of the screw. If the screws deviate from the routine path, penetrating the bone, there may be injury to the nerves and vessels in the vicinity. Though the injuries to the blood vessels during surgeries of lumbar region are rare, but if occur they are

really serious. There have been reported cases of injury to abdominal aorta, common iliac artery, inferior vena cava, common iliac vein (15) and lumbar artery (15-19) during pedicle screw fixation. The interpeduncular diameter ranges from 16.05-29.03mm. As per the previous studies it is 20.24 to 24.07mm (20), 17.27 – 21.73mm (21), 17.5 – 25mm (1) and 18.23-25.40mm(14)). The measurement of interpeduncular distance is also important as the reduced transverse diameter indicates stenosis of the vertebral canal.

The pedicle cortical length ranges from 3.06 to 8.70 mm on right side and 3.34-10.29mm on left side. As per previous study Pedicle cortical length ranged between 10-15 mm on right side and 11-15 mm on left side (1).

Conclusion:

With the increase in lower backache cases and increased spinal surgeries in the modern era, the study on the morphometry of lumbar vertebrae gains importance. The morphometric variation in the pedicle anatomy in various populations should be given due importance in selecting the size of the pedicle screws based on the studies on various populations. This helps orthopedic surgeons in selecting appropriate size screws for implants.

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