

# A study of height and width of typical lumbar pedicles in relation to mechanical load

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## Abstract

**Background:** Spinal instrumentation has been increasingly used to treat degenerative spinal disorders. Adequate anatomical knowledge of vertebral pedicles is necessary for proper instrumentation.

**Objectives:** This study aimed at typical lumbar vertebrae to understand various measurements of pedicle.

**Materials and Methods:** This study was conducted on 45 dry typical lumbar vertebrae obtained from Department of Anatomy Shyam Shah Medical College, Rewa, Madhya Pradesh. Pedicle vertical height ( $h$ ) and width ( $w$ ) were taken with the help of a sliding vernier caliper.

**Results:** It was found that the height of the typical lumbar pedicle varied between 10 and 16.1 mm whereas the width varied between 4 and 19.6 mm.

**Conclusion:** Steffee pedicle screw of 4 mm size is safe in typical lumbar vertebrae for spinal instrumentation.

**KEY WORDS:** Typical lumbar vertebrae, pedicle dimensions, spinal instrumentation

## Introduction

The fixation of lumbar spine is needed for various problems such as fracture in lumbar spine, resection of tumors in vertebral bodies, gross spondylolisthesis, and lumbar instabilities. The strongest part of a lumbar vertebra is pedicle that is made up of cortical as well as cancellous bone.<sup>[1]</sup> Strong and large lumbar pedicles are most suitable for screw instrumentation. This study, which was conducted in the population of Rewa region of central India, aimed at typical lumbar vertebrae to understand various measurements of pedicle in relation to their mechanical load.

vertical height ( $h$ ) and width ( $w$ ) were measured using sliding vernier caliper. All measurements were carried out at three sittings, and the mean of the values corrected to the nearest millimeter was recorded. We used the following method for recording different measurements:

**Pedicle Vertical Height ( $h$ ):** Two closest points on the upper and lower margins of the pedicles in the vertical plane on its lateral aspect, as shown in Figure 1.

**Pedicle Width ( $w$ ):** Two closest points on the medial and lateral surfaces of the pedicle, at right angle to the long axis of pedicle, as shown in Figure 2.

## Materials and Methods

The study was conducted on 45 typical dry lumbar vertebrae obtained from the Department of Anatomy Shyam Shah Medical college, Rewa, Madhya Pradesh, India. Pedicle

## Results

Pedicle vertical height ( $h$ ) and width ( $w$ ) of typical dry lumbar vertebrae were measured (see Graphs). Mean, standard deviation, range,  $P$ -value, and correlation coefficient for height and width are depicted in Tables 1 and 2.

## Discussion

In various ethnic regions different anatomical and morphometric studies have been carried out for lumbar vertebrae. The dimensions used in these studies were based on radiological parameters as well as direct measurements.<sup>[2-6]</sup> Table 3 presents the comparison of various parameters obtained from previous studies with those obtained in the present study.

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**Figure 1:** Pedicle vertical height ( $h$ )

The pedicle of the vertebra has been widely used as a fixation site for vertebral implants. There is increased diameter at the cranial–caudal direction of lumbar pedicle. The increased dimensions are shown by pedicles at more caudal vertebrae. Because of increase in vertical as well as horizontal dimension, the shape of the lumbar pedicle becomes oval. This increase in dimensions with oval shape is well correlated to the stronger support for physiological mechanical loads at this level. After transfacet screw placement by King,<sup>[6]</sup> there has been continuous development in the screw placement

**Table 1:** Pedicle height of typical lumbar vertebrae

		Right	Left
Typical lumbar vertebrae	Mean (mm)	13.442	13.068
	SD	1.539	1.531
	Range (mm)	10.7–16.1	10–15.8
	<i>P</i> -value	0.251	
	Correlation coefficient	0.803	



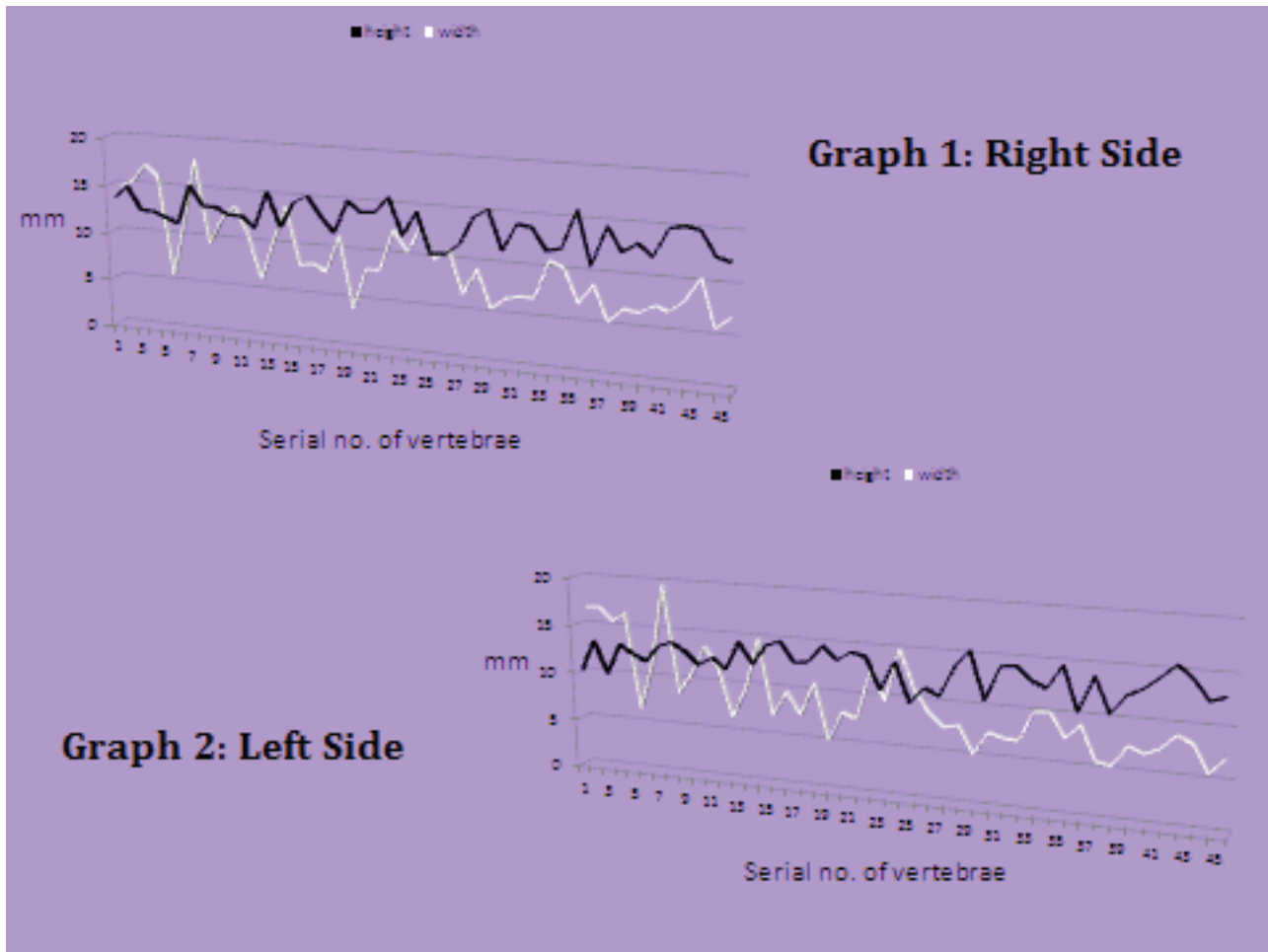
**Figure 2:** Pedicle width ( $w$ )

techniques by various surgeons such as Boucher,<sup>[7]</sup> Pennel *et al.*,<sup>[8]</sup> Louis,<sup>[9]</sup> Dick<sup>[10]</sup> and Steffee *et al.*<sup>[11]</sup>

Porter *et al.*<sup>[12]</sup> suggested that increasing levels of physical activity were associated with increased strength of vertebral column in individuals aged over 18 years. The variation in diameter of pedicles in different age groups may be due to the weight-bearing function.<sup>[12]</sup> The gradual increase in dimensions

**Table 2:** Pedicle width of typical lumbar vertebrae

		Right	Left
Typical lumbar vertebrae	Mean (mm)	9.482	9.557
	SD	3.354	3.570
	Range (mm)	4–17.9	5–19.6
	<i>P</i> -value	0.917	
	Correlation coefficient	0.958	



**Graph:** Correlations between height and width of dry typical lumbar vertebrae.

of typical lumbar vertebrae from cranial to caudal direction is related to their mechanical load. Kothe *et al.*<sup>[13]</sup> reported the cortical difference in thickness of vertebral pedicle.

Chawla *et al.*<sup>[14]</sup> and prior studies report that vertical height is always greater than its width; in our study also, pedicle height was found to be greater than pedicle width.

**Table 3:** Comparison of various parameters obtained from previous studies with present study

Vertebra level	Amonoo-kuofi		Singel <i>et al</i>		Arora <i>et al</i>		Present Study
	Male	Female	Male	Female	Male	Female	
L1 Height	19.4	16.3	14.7	15.5	14.79	14.34	L1–L4 Mean height 13.25 Mean width 9.5
L1 Width	10.3	8.7	8.2	8.5	7.51	7.49	
L2 Height	18.9	15.3	15	14.5	15.42	15.04	
L2 Width	10.7	9	8.5	8.75	7.95	7.91	
L3 Height	19.3	15.9	14.7	14.8	16.42	15.6	
L3 Width	12.1	10.5	10.4	10.6	8.75	8.71	
L4 Height	19.9	16.1	14	14	17.48	17.11	
L4 Width	13	11.1	13.5	13.8	13	12.97	

Height and width in millimeter

Design of the posterior lumbar dynamic stabilization is suggested by some studies for deciding lumbar pedicle-screw entrance point during unrestricted functional body movements with physiological weight-bearing. Physiological lumbar lordosis lies at L4–L5 level, enabling physiological changes required from the supine to the standing position. So the design of posterior dynamic lumbar pedicle fixation was mostly done with patients in supine position.<sup>[15]</sup>

The pedicle screw is passed through the posterior aspect of the pedicle into the vertebra anteriorly. The success of this technique depends on the ability of the screw to obtain strength within the vertebral body. In our study on typical lumbar vertebrae, the mean height was 13.442 mm on right side and 13.068 mm on left side. As compared to the present study, slightly higher values were reported by Arora *et al.*<sup>[16]</sup> for vertical height (16.42 mm in males and 15.6 mm in females) and lower values by Singel *et al.*<sup>[17]</sup> (10.4 mm in males and 10.6 in females).

In this study in typical lumbar vertebrae, the mean width of the pedicle was 9.482 mm on right side and 9.557 mm on left side with minimum value of 4 mm on right side and 5 mm on left side. One of the limitations of the study is that it was conducted on a typical vertebrae; more studies in various ethnic groups are required at different places for better implication.

## Conclusion

In the Rewa region of central India, the use of 4 mm Steffee pedicle screw size was found to be safe for typical lumbar vertebrae excluding deformed and degenerated vertebrae. Also, gradual increase in dimensions in craniocaudal direction in typical lumbar vertebrae is related with the mechanical load. Further studies in different parts of world are required for better outcome.

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