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Research Article

MORPHOMETRIC STUDY OF PEDICLES OF LUMBAR VERTEBRAE– A CROSS-SECTIONAL STUDY

Shivanand ND[1*], Sumangala Kadi [2], Yusuf saleem khan K [3], Suresh SB [4],Shirish Patil [5], Channabasanagouda [6]

1.Assistant professor, Department of Anatomy, College of medicine, Al jouf University, skaka, Saudi Arabia.

2.Assistant professor, Department of Biochemistry, College of medicine, Al jouf University, skaka, Saudi Arabia.

3.Assistant professor, Department of Anatomy, College of medicine, Al jouf University, skaka, Saudi Arabia.

4. Assistant professor, Department of Anatomy, AJ Medical college,Mangalore,575004, Karnataka state, India

5. Assistant professor, Department of Anatomy, Basaweshwara Medical college, Chitradurga,577502, Karnataka state, India

6.Assistant professor, Department of Anatomy, VIMS, Bellary, 583104, Karnataka state, India

Corresponding Author: Dr Shivanand ND

ABSTRACT

To provide morphometrical data support for successful pedicle screw fixation and also to analyse the quantification of spinal stenosis directly relevant to South Indian population. Twenty five sets of normal, adult, dry lumbar vertebrae were studied for their dimensions (height, width and length of the pedicles, mid-sagittal diameter and interpedicular distance) with the help of Vernier caliper. Total of 125 lumbar vertebrae were obtained from 25 cadavers. The following readings (Mean ± Standard Deviation) were obtained for different dimensions of lumbar vertebrae L_1, L_2, L_3, L_4 and L_5 respectively. Height of the pedicle: 19.5 ± 2.89, 18.4 ± 3.74, 18.1 ± 3.21, 17.7 ± 2.51 and 18.7 ± 3.08. Width of the pedicle: 10.7 ± 2.03, 12.8 ± 2.73, 13.4 ± 2.66, 14.9 ± 2.51 and 20.9 ± 3.36. Length of the pedicle: 15.5 ± 2.69, 15.8 ± 2.75, 16.1 ± 2.91, 14.2 ± 2.84 and 13.6 ± 2.05. Mid-sagittal diameter: 18.3 ± 2.86, 16.2 ± 3.26, 16.0 ± 3.32, 17.8 ± 3.12 and 18.1 ± 2.99. Interpedicular distance: 22.5 ± 3.46, 22.9 ± 3.14, 24.8 ± 3.22, 24.9 ± 3.47and 27.1 ± 4.01. The present study concludes that, the different dimensions of the lumbar pedicle morphometry studied would be of help for successful pedicle screw fixation with minimum post-operative complications and also for quantification of spinal stenosis, specifically relevant to South Indian population. The data would also come handy to the clinicians dealing with the problem of low backache.

Key words: Lumbar vertebrae, Pedicles, Spinal stenosis, Transpedicular screw fixation.

INTRODUCTION

The pedicle is the sole bridge between the posterior column and the middle and anterior columns. Hence pedicle screws traverse all three columns and as such can rigidly stabilize both the ventral and dorsal aspects of the spine. The growing interest in transpedicular screw fixation for spinal stabilizing implants is the basis for the improved morphometric details

about the pedicles[1]. Some data exist on this subject[2], but these are limited in certain ways. No standard deviations or ranges are reported. With advances in the pre and intraoperative imaging techniques, transpedicular screw fixation is mostly indicated in unstable spine conditions like traumatic listhesis, wedge compression fractures, primary and secondary tumours, infections like brucellosis and tuberculosis. However, a number of complications associated with pedicle screw fixation have been reported[3][4]. A break in the cortex of the pedicle can result from the misplaced screw[5]. Intraoperative complications for the pedicle screw fixation include screw cut out or maldirection, and pedicle fracture[6]. One of the most serious complications is neurological injury, secondary to misplaced screws injuring a nerve root or the cauda equina.To minimize the complications a number of techniques have been employed. These include varying points of insertion, pre-measuring and assessing the pedicle size on the preoperative CT and / or MRI scan, use of intra operative fluoroscopy or image guidance, use of electrophysiologic monitoring while entering and tapping the pedicle, probing the pedicle with small metal tools after entering the pedicle, etc.In developing countries, many of the above listed techniques are not routinely available in the operating room. Hence in this part of the world, screw design, details, biomechanics and implantation safety depend upon the anatomic constraints, especially the morphometry of pedicles. One of the most important and pertinent cause of chronic low backache especially in elder age group could be lumbar canal stenosis[7]. Due to common occurrence of low backache and thoracic and lumbar spines being the prime targets resulting into this symptom, workers over the world have tried to concentrate on this region for their exhaustive study.It is well established that the same varies within different sex, race, ethnic and regional groups. Even though the problem of low backache is equally prevalent all over the world, we see little studies being done in Indian context. Hence there is a need for our own metrical data specifically relevant to South Indian population.

MATERIALS AND METHODS

Twenty five sets of normal, adult, dry lumbar vertebrae were studied. The material for the study that is the total of 125 lumbar vertebrae were obtained from 25 cadavers from the Department of Anatomy, Jawaharlal Nehru Medical College, Belgaum. Ethical clearance was obtained from the Institutional Ethical Committee, Jawaharlal Nehru Medical College, Belgaum. The vertebrae were obtained from the dissection room cadavers by taking cross sections of the body at T_{12} and S_1 levels and were buried in soil for 90 days for maceration. Then they were immersed in water for 15 days.The tissues which were still undissolved were removed. Care was taken not to damage the vertebrae. The following measurements were taken with the help of Vernier caliper.

1. Superoinferior diameter (Height) of the pedicle was taken as the narrowest diameter between the superior and inferior surface of pedicle .

2. Transverse diameter (Width) of the pedicle was taken as the narrowest diameter between the medial and lateral surface of pedicle.

3. Length of a pedicle was taken from the body to the line joining superior articular facets, transverse process and the lamina .

4. Mid-sagittal diameter of vertebral canal was measured in the midline sagittal plane between the wall of vertebral body and laminal arch.

5. Interpedicular distance(IPD) that is transverse diameter of the canal was taken as the greatest distance between the pedicles of a vertebra.

Statistical analysis

The mean and standard deviation were calculated from the readings obtained. The range of different dimensions was also noted.

RESULTS

The results of the present study are summarized in the tables 1, 2, 3, 4 and 5 . The minimum (12.0 mm) and maximum (26.7 mm) readings for height of the pedicles were noted at L_5 (Set No. 16) and L_3 (Set No. 13) respectively(Table No.1). The minimum (7.0 mm) and maximum (28.7 mm) readings for width of the pedicles were noted at L_1 (Set No. 21) and L_5 (Set No. 3) respectively (Table No.2). The minimum (7.2mm) and maximum (21.9mm) readings for length of the pedicles were noted at L_4 (Set No. 10) and L_1 (Set No. 17) respectively (Table No.3). The minimum (10.3mm) and maximum (24.9mm) readings for the mid-sagittal diameter were noted at L_2 (set No. 4) and L_5 (Set No. 14), respectively (Table No.4). The minimum (14.2mm) and maximum (34.8 mm) readings for IPD were noted at L_2 (Set No. 5) and L_5 (Set No. 19) respectively (Table No.5).

Table No. 1: Height of the pedicle

Vertebral level	Height (in mm)		Range in mm
	Mean	SD	
L_1	19.5	2.89	13.1 – 21.8
L_2	18.4	3.74	13 – 24.9
L_3	18.1	3.21	13 – 26.7
L_4	17.7	2.51	14 – 23.9
L_5	18.7	3.08	12 – 23.9

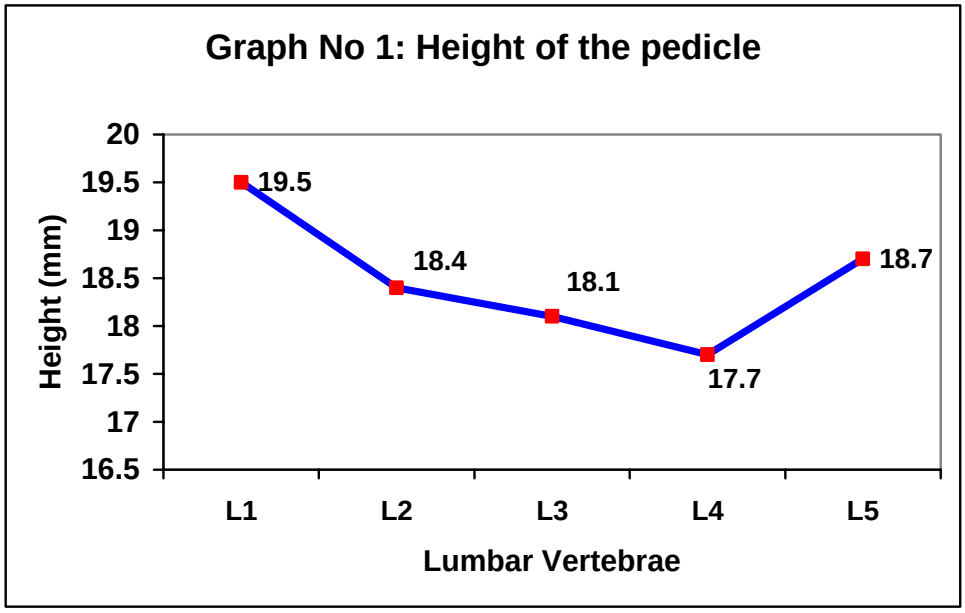


Table No. 2: Width of the pedicle

Vertebral level	Width (in mm)		Range in mm
	Mean	SD	
L_1	10.7	2.03	7 – 14.6
L_2	12.8	2.73	8.2 – 19.9
L_3	13.4	2.66	8 – 17.8
L_4	14.9	2.51	10.3 – 22.6
L_5	20.9	3.36	14.1 – 28.7

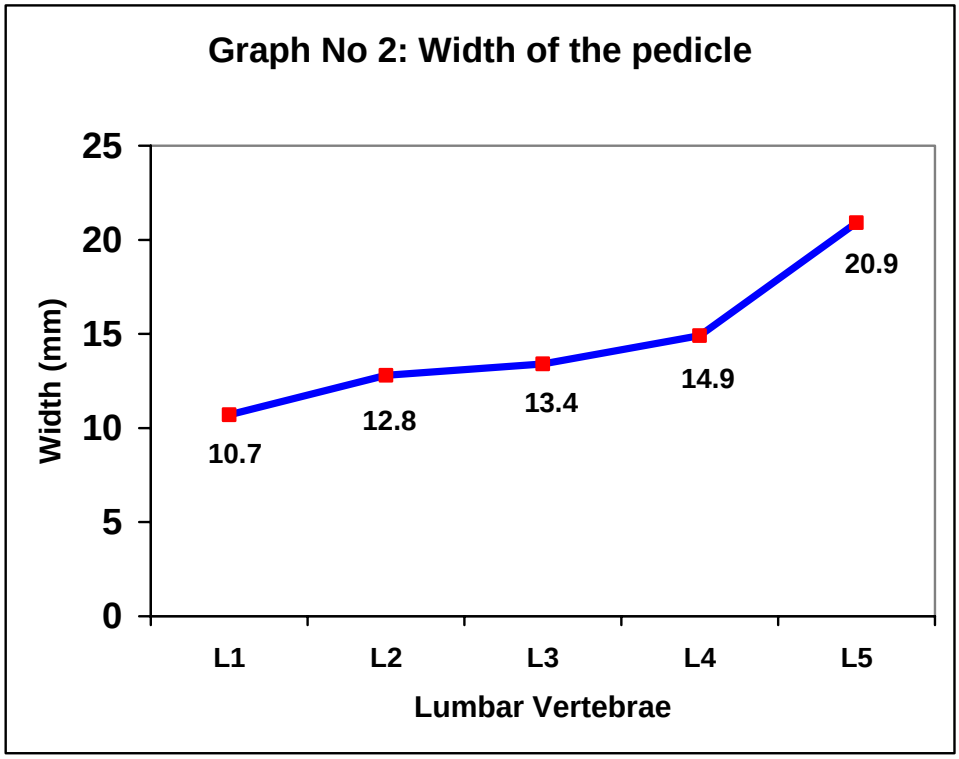


Table No. 3: Length of the pedicle

Vertebral level	Length (in mm)		Range in mm
	Mean	SD	
L_1	15.5	2.69	10.1 – 21.9
L_2	15.8	2.75	10.1 – 19.8
L_3	16.1	2.91	11.2 – 20.8
L_4	14.2	2.84	7.2 – 19.7
L_5	13.6	2.05	8.4 – 17.8

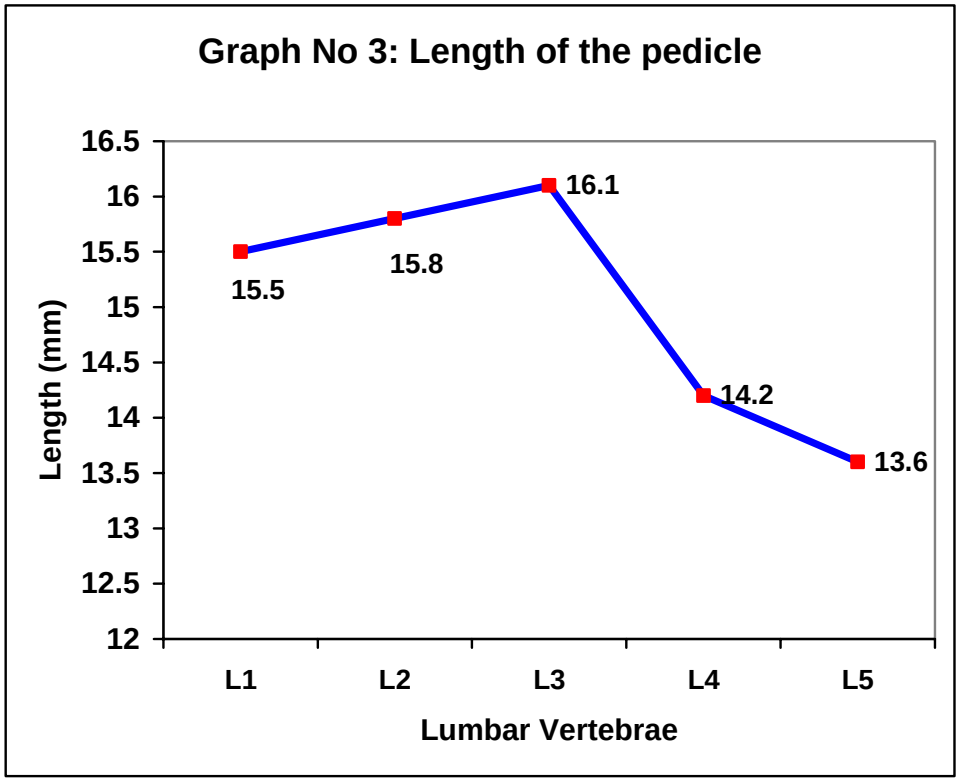


Table No. 4: Mid-sagittal diameter of the vertebral canal

Vertebral level	Mid-sagittal diameter (in mm)		Range in mm
	Mean	SD	
L_1	18.3	2.86	13.9 – 23.7
L_2	16.2	3.26	10.3 – 23.7
L_3	16.0	3.32	11.1 – 23
L_4	17.8	3.12	12 – 23.9
L_5	18.1	2.99	14.1 – 24.9

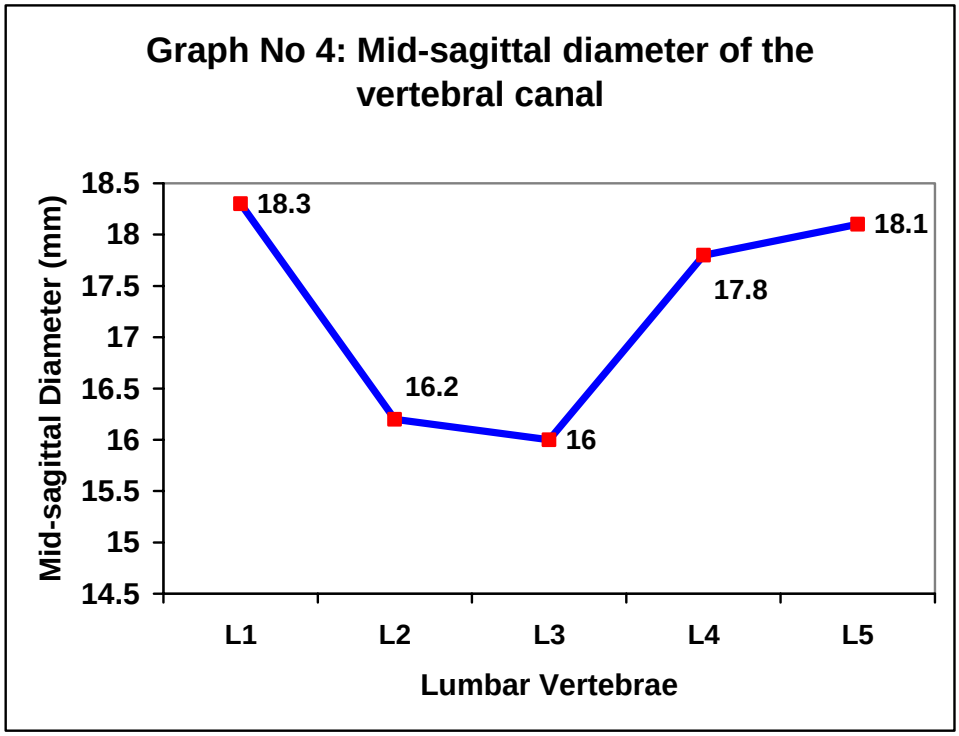
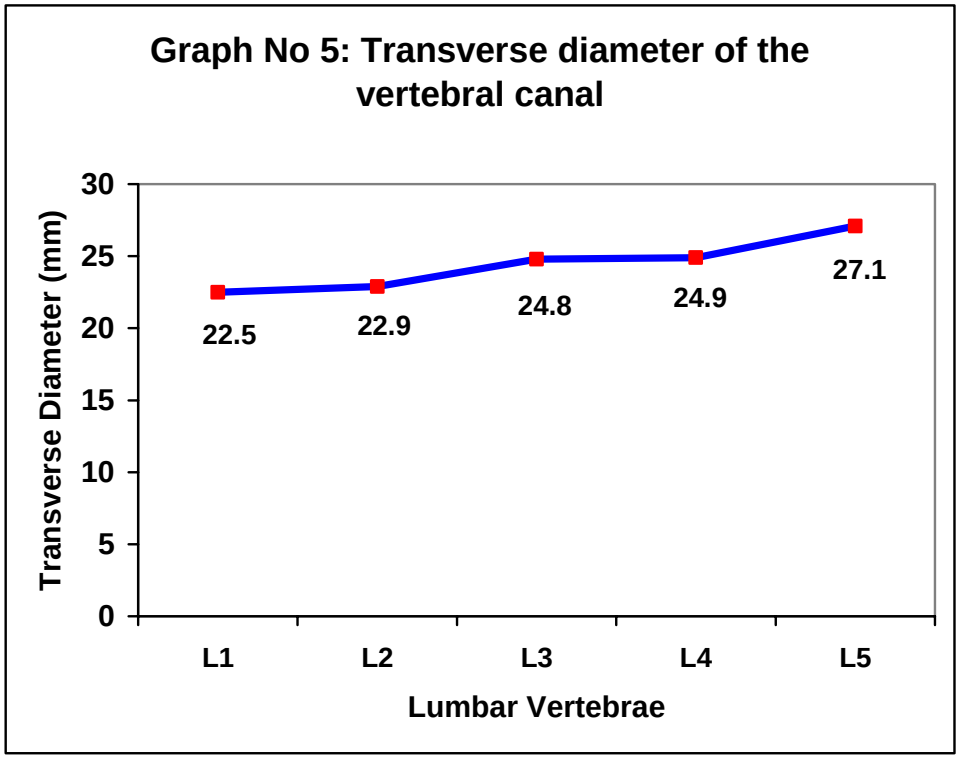


Table No. 5: Interpedicular distance (Transverse diameter of the vertebral canal)

Vertebral level	Interpedicular distance (in mm)		Range in mm
	Mean	SD	
L_1	22.5	3.46	15.1 – 29.7
L_2	22.9	3.14	14.2 – 30.7
L_3	24.8	3.22	16.6 – 30.8
L_4	24.9	3.47	14.3 – 30.8
L_5	27.1	4.01	17.3 – 34.8



DISCUSSION

Performing pedicular screw fixation is technically challenging[8]. The key to intracanal anatomy is the location of the pedicle[9]. To decrease failures in arthrodesis a number of different devices have been developed to provide internal stability while the fusion is exhaling. Because the pedicle offers the strongest point of attachment to the spine, most spinal instrumentation systems use screws for fixation placed in to the pedicle and then the vertebral body.The sizes of the screws used in this procedure must take pedicle dimensions into consideration.[10] The mean height of the pedicle(Graph No.1) showed a decreasing pattern form L_1 to L_4, followed by an increase at L_5, the maximum height being at L_1 and minimum height being at L_4. The mean width of the pedicle(Graph No.2) showed an increase in pattern form L_1 to L_5, the maximum width being at L_5 and minimum width being at L_1. There was only one lumbar vertebtra (L_1) with pedicle width equal to 7 mm. There were no pedicles with the width less than 7 mm among any of the 125 lumbar vertebrae in our study. This suggests that it is dangerous to use a 7 mm screw during transpedicular screw fixation surgery at L_4 level. The mean length of the pedicle(Graph No.3) showed an increasing pattern from L_1 to L_3, followed by a decreasing pattern from L_3 to L_5, the maximum length being at L_3 and minimum length being at L_5. The mean mid-sagittal diameter(Graph No.4) of the vertebral canal showed a decreasing pattern from L_1 to L_3 followed by an increasing pattern from L_3 to L_5, suggesting that the narrowest mid-sagittal diameter of the canal is at L_3. The mid-sagittal diameter, however, was narrower dimension than IPD. Among the 125 lumbar vertebrae studied, there were 8 lumbar vertebrae (6.4%) with mid-sagittal diameter of the canal less than 13 mm, indicating that they are stenotic. The mean IPD(Graph No.5) showed an increasing pattern from L_1 to L_5, the maximum IPD being at L_5 and minimum IPD being at L_1. There were 5 lumbar vertebrae with the IPD less than 18 mm, indicating that they are

stenotic.The IPD was the largest dimension of the vertebral canal in all of the vertebrae examined, a finding that supports previous studies indicating that the mid-sagittal diameter is the most significant dimension of the spinal canal. The lumbar part of the neural canal houses the cauda equina, and narrowing of the bony ring of the canal, which may be developmental or acquired, may lead to compression of these nerve roots and cause low back pain. Measurement of the transverse diameter of the lumbar spinal canal is therefore a useful aid in the diagnosis of the lumbar spinal stenosis syndrome. The results of our study were also compared with the findings of other researchers[10][11][12][13][14][15][16]. Though many of the dimensions correlate with other studies, it is probable that some differences observed as compared to other studies were due to regional (environmental) differences. With this data on the morphometrical findings of the pedicles of lumbar vertebrae, we hope that it could be of some use possibly in cases of suspected spinal stenosis and also in transpedicular screw fixation to prevent post-operative complications. These figures could also be of forensic importance because of the observed racial, ethnic and regional variations.

CONCLUSION

A key to a successful transpedicular screw insertion is that the small pedicle is correctly entered by the screw and the walls are not penetrated. Penetration of the cortex or fracture of the pedicle may result from the use of relatively oversized screws. In the present study we have made an attempt to understand the morphometry of the lumbar pedicles. The present study concludes that, the different dimensions of the pedicle which have been studied would be of great help for successful pedicle screw fixation and also for quantification of spinal stenosis.

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