

MORPHOMETRIC STUDY OF THE LUMBAR VERTEBRAL PEDICLE IN MAHARAHTARIAN POPULATIONKarkhyle Md. Layeeque¹, Siraz M. Ausavi²**HOW TO CITE THIS ARTICLE:**

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ABSTRACT: The pedicle a thick and strongest part of vertebrae is being used for the implantation or fixation of screw (Transpedicular screw fixation) in various spinal problems like fracture of lumbar spine, resection of tumours in vertebral bodies or deformity of vertebral column. However, the success of technique depends on the factors like choice of size of screw for a particular pedicle size and shape. Pedicle screw has its own disadvantage because mismatched size of screw and pedicle instrumentation may fail. For this reason, study of morphometry of pedicles is of special significance as dimensions of pedicle become pivotal information for selection of screw in fixation. In the present study comprehensive morphometric measurements have been taken and an attempt is made to look into all the dimensions of pedicle. Internal and external pedicle diameter measurements give us the exact idea about available thickness of outer cortical and inner cancellous bony part of pedicle.

METHODS: The present study Twenty five vertebral columns were procured from the cadavers from Department of Anatomy of Dr. D. Y. Patil Medical College Pimpri Pune The cadavers were embalmed and fixed by 10% formalin solution. Normal vertebral columns were included in the study. Gross abnormalities such as scoliosis, kyphosis and pathological vertebrae were excluded. Cadavers were numbered from 1-25 at random. Gender differentiation was not done. Comprehensive dimensions which included pedicle width, pedicle height, internal pedicle height (IPDH) and internal pedicle width (IPDD) diameters were measured using vernier calipers. Statistical mean, standard deviation and range were obtained. Results were tabulated and analyzed. **RESULT:** In the present study Pedicle height was maximum at L1 (mean 15.2±1.7, range: 12.5 to 18.8) vertebra. Pedicle width increase from L1 (mean 8.2 ±2.4, range 4.8to16.5) to L5 (mean: 18.4 ±2.2, range 13 to 22). Internal height gradually increase from L2 to L5 on both sides, and then it increased onL1, on left side. Internal width showed a gradual increase from L1 (mean: 5.4±1.5) to L5 (mean: 8.9±1.9).

KEYWORDS: Pedicle height, pedicle width, internal pedicle height, internal pedicle width.

INTRODUCTION: Pedicle is highly loaded with elements of neural arch along with facets and laminae. The authors have reported that the pedicles in lumbar vertebrae are close to horizontal position, and hence the weight transmission in lumbar spine is from body to neural arch towards the line of gravity. They have also suggested that the pedicle connects the anterior column (body) and posterior column (Neural arch). The load in thoracic and lumbar region is transmitted through two vertical running columns, anterior of which is formed by vertebral bodies and intervertebral discs while posterior column is formed by successive articulation of neural arch element (facet joints, laminae, and ligament complex).¹ Pedicle act as a strut to transmit forces between the body and neural arch.²

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spine, resection of tumours in vertebral bodies or deformity of vertebral column. However, the success of technique depends on the factors like choice of size of screw for a particular pedicle size and shape. Pedicle screw has its own disadvantage because mismatched size of screw and pedicle instrumentation may fail.

For this reason, study of morphometry of pedicles is of special significance as dimensions of pedicle become pivotal information for selection of screw in fixation.

Previous workers have reported the data on morphometry of the pedicle based on a common pool of vertebrae (male and female vertebrae were pooled together), statistically significant sex differences in pedicle morphometry, "A study of width and height of lumbar pedicles" by different workers.³

Most of previous studies of the morphometry of pedicle are based on western population Morphometry of Vertebral Pedicles: a Comprehensive Anatomical Study in the Lumbar Region" by different workers.⁴ Racial variations in skeleton are well known, thus morphometry of the pedicle may vary from population to population.⁵

Indian Population forms one fifth of the total population of the world and the non-resident Indians are also distributed widely in many countries. Studies of pedicle morphometric measurements in the Indian population are very few. The study was undertaken to look into the detailed measurements of pedicles of lumbar spines so as to document relevant data in Maharashtra population.

MATERIALS AND METHODS: Twenty five vertebral columns procured from:

1. Department of Anatomy of Dr. D. Y. Patil Medical College Pimpri Pune,
2. Rangonwala Dental College, Pune and
3. Dr. D. Y. Patil Ayurvedic College, Pimpri Pune.

The cadavers were embalmed and fixed by 10% formalin solution. Normal vertebral columns were included in the study. Gross abnormalities such as scoliosis, kyphosis and pathological vertebrae were excluded. Cadavers were numbered from 1-25 at random. Gender differentiation was not done. Vertebral columns were dissected out from the cadavers. The vertebral column was scraped to remove muscles, fascia, vessels, and thus column was freed from the attached soft tissues (Photo NO. 1). All the vertebrae obtained by boiling and chemical procedures, were scrubbed by scalpel and kept in sun light for three days for drying. Dried vertebrae were finally labeled and numbered for proper identification. Respective vertebrae of single column were tied with wire to prevent mixing and repetition while taking measurements. Vertebrae thus cleaned were measured with Vernier caliper. Measurements include the following dimensions. (According to the HRDLICKA'S Practical anthropometry).⁶

1. Pedicle height (PDH) in mm: The closest points just opposite to each other on the upper and lower margin of pedicles in the vertical plane on its lateral aspect were considered. Where the main jaws of vernier caliper touched were considered and the distance was measured in mm. (Photo no. 2).
2. Pedicle diameter (PDW) in mm: Touching by the main jaws of vernier caliper the outer and inner surfaces of the pedicle were chosen. The thickness was measured at these points.
3. Internal measurements of the pedicles: Vertical section was carried out in the middle of pedicle with a fine handcraft saw. Two diameters were measured (Photo no. 3):

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- a. Internal pedicle width (IPDW) in mm: - was measured by using the small jaws of vernier caliper touching two maximum transverse points of inner side of the pedicles.
- b. Internal pedicle height (IPDH) in mm: - was measured by measuring the distance between smaller jaws of vernier calipers touching two upper and lower of inner side of pedicle. (Photo no. 4).

OBSERVATIONS & RESULTS: Observations were recorded separately for right and left pedicles. Observations are shown in table No. 2 & 3.

From the table No. 1 & 2 it is observed that the height of pedicle decrease from L1 to L5, height was maximum at L1 (mean 15.2 ± 1.7 , range: 12.5 to 18.8) and at L5 (mean: 13.1 ± 5.4 mm, range: 11 to 19) vertebra. From L2 on wards gradual decrease was seen on left but individual variations occurred on right side. The widest reading of the pedicle was seen at L5 (mean: 18.4 ± 2.2 mm, range: 13 to 22) whereas the narrowest one at the L1 (mean: 8.2 ± 2.4 range: 4.8 to 16.4). Overall measurements were more on left side than on right side.

The maximum internal width was seen at the L5 (mean 8.9 ± 1.9 , range 5 to 12) whereas the minimum was at L1 (mean 5.2 ± 1.7 , range: 2.8-9.). Width of lumbar vertebrae showed increase from L1 to L5 on both sides. Internal height showed a gradual increase from L1 (mean: 10.5 ± 1.7 , range: 7.5-14.8) to L5 (mean: 12.8 ± 2.7 , range: 9-15).

DISCUSSION: Pedicle dimensions play a vital role in the fixation of vertebrae with plating in cases of fractures or degeneration of vertebral column. Proper selection of screw and plating plays a key role in the long time success of reparative procedure.

In the present study comprehensive morphometric measurements have been taken and an attempt is made to look into all the dimensions of pedicle. Internal and external pedicle diameter measurements give us the exact idea about available thickness of outer cortical and inner cancellous bony part of pedicle. This thickness is the one which gives the screws perfect anchor and thus the stability of the plate in fixation.

Review recalled that many workers have worked on the pedicle measurements, the method being direct anatomical or imaging modality.

Comparison with previous studies is shown in table no. 3.

	Name of Author	Findings	Present Study
1	Kim N H et al in 1994 (T1 to L5) ⁷	PDH widest at T12, narrowest at T1	PDH was decreased from L1 mean (15.2 ± 1.7 , range: 12.5 - 18.8) to L5 (mean: 18.4 ± 2.2 mm, range: 13 to 22)
		PDW maximum at L5 and minimum at T4	PDW increase from L1 (mean: 8.2 ± 2.4 range: 4.8 to 16.4) to L5 (mean: 18.4 ± 2.2 mm, range: 13 to 22)
2	H S Amonoo-Kuofi (1995) ⁸	PDH in female maximum at L5 (18.2 mm), in male at L5 (20.7 mm) and minimum in female at L2 (14.2mm) in	PDH was decrease from L1 mean (15.2 ± 1.7) to L5 (mean: 18.4 ± 2.2 mm)

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		male at L3 (14. 8mm). PDW maximum mean at L5 (13. 6 mm) in females and in male at L5 (14. 2mm), minimum at L1 (7. 4mm) in female and in male at L1 (7. 5mm).	PDW increase from L1 (mean: 8. 2±2.4) TOL5 (mean: 18.4 ±2.2mm) In the present study gender differentiation is not done.
3	P. Chaynes et. al (2000) ⁹	PDH increased from T1 to L5.	PDH was decreased from L1 mean (15.2±1.7, range: 12.5 - 18. 8) to L5 (mean: 18.4 ±2.2mm, range: 13 to 22)
4	Abtullah MiLCAN et. al 2001 T11 to L2) ¹⁰	PDW widest in females at T12 (5. 9+1. 2 mm) and min at T11 (5. 6±1. 4 mm) , in males max at L2 (6. 5±1. 6 mm) and min (6. 1+2 mm)	In the present study gender differentiation is not done. PDW increase from L1 (mean: 8.2±2.4 range: 4.8 to 16.4) toL5 (mean: 18.4 ±2.2mm, range: 13 to 22).
5	Singel TC 2004 (L1 to L5) ³	PDH in male max at L2 (15mm) PDW in males maximum at L5 mean (18. 2mm) and minimum at L1 mean (8. 2mm) , in female maximum at L5 mean (19. 25mm) , min at L1mean (8. 5mm).	PDH was decreased from L1 mean (15.2±1.7) to L5 (mean: 18.4 ±2.2mm) PDW increase from L1 (mean: 8. 2±2.4) TOL5 (mean: 18.4 ±2.2mm) In the present study gender differentiation is not done.
6	Christodoulou AG 2005 (T1 to L5) ¹¹	PDH maximum at T11 mean: 17.02 mm (range: 14.84-19.57 mm), and the narrowest at T1 mean of 8.90 mm (range: 7.18-11.37 mm).	PDH was decreased from L1 mean (15.2±1.7, range: 12.5 - 18.8) to L5 (mean: 18.4 ±2.2mm, range: 13 to 22)
		PDW max at L5 mean (13.61 mm) and (range: 10.29-16.20 mm) and minimum at T5 mean (5.09 mm) and (range: 4.10-6.88 mm)	PDW increase from L1 (mean: 8. 2±2.4 range: 4.8 to 16.4) to L5 (mean: 18.4 ±2.2mm, range: 13 to 22)
7	Arora L, et. al 2006 (L1 to L5) ¹²	PDW increased from L1 to L5 range (8-15 mm) in male and (7-14mm) in females	PDWINCREASE from L1 (mean: 8.2±2.4 range: 4.8 to 16.4) TOL5 (mean: 18.4 ±2.2mm, range: 13 to 22)
8	Shiu-Bii Lien et. al 2007 T1 to L5) ¹³	PDH largest at T11 (mean: 15. 3 ± 1. 3) and smallest at T1 (mean: 8. 6 ± 1. 1) PDW widest at L5 (17. 7 ± 2. 7) and narrowest at T4 (3. 4 ± 0. 6) check it	PDH was decreased from L1 mean (15. 2±1. 7) to L5 (mean: 18. 4 ±2. 2mm) PDW increase from L1 (mean: 8.2±2.4) TOL5 (mean: 18.4 ±2.2mm)

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9	T. Yazar A. K. US, I Tekdemir (L1 to L5) ¹⁴	PDW range (between 10.6mm and 5.5mm), mean 8.2mm	PDW increase from L1 (mean: 8.2±2.4) TOL5 (mean: 18.4 ±2.2mm)
10	Prakash et. al 2007 (L1 to L5) ¹⁵	PDH maximum at (mean: 17.4+0.39mm) and minimum at L1 (14.6+0.39mm) PDW max at L5 (16.2 +0.39) and min at L1 (mean 8.2+0.43) both side.	PDH was decreased from L1 mean (15.2±1.7) to L5 (mean: 18.4 ±2.2mm) PDW increase from L1 (mean: 8.2±2.4) TOL5 (mean: 18.4 ±2.2mm)
11	Bashar Abuzayed (2009) ¹⁶	PDW They observed that the transverse pedicle diameter was largest at L5 (14.95 mm)	PDW increase from L1 (mean: 8.2±2.4) TOL5 (mean: 18.4 ±2.2mm)

In the present study, widest reading of the pedicle was seen at L5 (mean: 18.4 ±2.2mm, range: 13 to 22mm) whereas the narrowest one at the L1 (mean: 8.2±2.4 range: 4.8 to 16.4).

The mean values and range of PDW and PDH are higher as compared to those earlier workers, at all levels of vertebrae. This fact may be attributed to the racial and geographical factors.

This finding was different as reported by earlier workers. Comparison of right and left measurements at various vertebrae showed inconsistency these findings differed with findings of other workers. However it was felt that the asymmetry needs to be kept in mind while designing pedicle screw.

Internal diameters (IPDW and IPDH).

In the present study, IPDW was maximum at the L5 (mean 8.9 ± 1.9, range 5 to 12) whereas the minimum was at L1 (mean 5.2±1.7, range=2.8 to 9). Width gradually increases from L1 to L5. IPDH showed a gradual increase from L2 (mean: 10.2±1.5, range: 7 to 13.8) to L5 (mean: 12.8±2.7, range: 9-15) level. In the present study, differences on right and left side were also noticed.

In a study conducted by using contact radiographs of sectioned (1mm thin) pedicles of thoracic vertebrae and digitized imaging and special computer software, ratio of cancellous and cortical bone were calculated. It was observed that, cancellous core was more than twice as large as the cortical shell.¹⁶ Present study, difference between internal diameters and width or height of pedicle, ratio of cancellous core can be obtained.

CONCLUSION: The present study concludes that:

1. Maximum pedicle width was seen at 5th lumbar vertebra. This increase in width is as a result of biomechanical factor in weight transmission.
2. Pedicular width is one of the limiting factors for screw fixation and stability.
3. Variations in the morphometric measurements have been reported. But in present study variations of dimensions on left and right side have been noticed. This factor can be used in prototyping and screw designing.
4. As per earlier observations various workers, medial wall of the pedicle was found thicker¹⁷ in the present study too. This can be calculated by finding the difference between pedicle width and internal pedicle width (PDW-IPDW). This parameter will help to assess the depth of screw fixation.

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- Quantity and the quality of cancellous bone of the pedicle plays a key role in establishing an opposing force against the pullout strength of a fixed screw. Assessment of quality, to rule out factors osteoporosis, or degeneration can be done by imaging studies of pedicle. The internal and external dimensions of pedicle (PDW, PDH, IPDW and IPDH) can be used as basis for calculation of quantity of cancellous bone.

Preoperative CT scan and width assessment is desired in such cases. Variations in the morphometric measurements have been reported. But in present study variations of dimensions on left and right side have been noticed. This factor can be used in prototyping and screw designing. The study has brought out a comprehensive data in Maharashtrian population. The mean values and range of PDW and PDH are higher as compared to those earlier workers, at all levels of vertebrae. It is believed that these dimensions will add additional input in planning screw fixation and in designing of plates and screws.



Fig. 1: Showing Sample selection



Fig. 2: Showing external measurements of pedicle



Fig. 3: Showing dry vertebrae after sectioning of pedicle from L1 to L5



Fig. 4: Showing internal measurements of pedicle

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Level		Pedicle height		Pedicle width	
		Right	Left	Right	Left
L1	Mean	15.2	15.1	8.2	8.3
	SD	1.7	1.7	2.4	2.4
	Range	12.5-18.8	11.3-18.1	4.8-16.4	4.2-16.5
L2	Mean	14.8	14.8	8.4	8.7
	SD	1.6	1.3	1.9	1.9
	Range	12-18.6	12.7-17.8	4-12.8	4.2-12.4
L3	Mean	14.7	14.5	10.4	11
	SD	1.5	1.5	2.3	2.6
	Range	12.5-18	12.2-18.3	6-16	5.8-18.2
L4	Mean	14.2	14.2	13.9	14
	SD	3.3	3.4	2.8	3.4
	Range	12.8-18.8	12.4-18	7.6-19	7.8-23
L5	Mean	13.1	13.1	17.7	18.4
	SD	5.4	5.4	3.1	2.2
	Range	11-19	11-18.8	10.3-23	13-22

Table No. 2: Measurements of Pedicle height and width

Level		Internal Pedicle height		Internal Pedicle width	
		Right	Left	Right	Left
L1	Mean	10.5	11	5.4	5.2
	SD	1.7	1.7	1.5	1.7
	Range	7.5-14.8	8-15.9	2.8-8.7	2.8-9
L2	Mean	10.2	10.2	5.8	6.2
	SD	1.5	1.4	1.5	1.7
	Range	7-13.8	7.5-13.2	3.1-9	3.1-9.8
L3	Mean	10.4	10.3	6.8	6.8
	SD	1.2	1.5	1.5	1.4
	Range	8-13	8-12.8	4-9.4	3.8-9.4
L4	Mean	10.5	10.6	7.3	7.6
	SD	1.8	2.1	1.5	1.4
	Range	6.8-13	5.8-14	4.8-11	5-10.9
L5	Mean	12.8	12	8.9	8.2
	SD	2.7	1.7	1.9	1.4
	Range	9-15	9.4-16.4	5-12	5.4-10.8

Table No. 3: Measurements of Internal Pedicle height and width

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