

PEDICLE DIMENSIONS OF THORACIC VERTEBRAE IN MAHARASHTRIAN POPULATIONKarkhyle Md. Layeeque¹, Rohini R. Karambelkar², Avinash D. Shewale³**HOW TO CITE THIS ARTICLE:**

Karkhyle Md. Layeeque, Rohini R. Karambelkar, Avinash D. Shewale. "Pedicule Dimensions of Thoracic Vertebrae in Maharashtrian Population". Journal of Evolution of Medical and Dental Sciences 2014; Vol. 3, Issue 65, November 27; Page: 14146-14153, DOI: 10.14260/jemds/2014/3893

ABSTRACT: Pedicles are thick and strong part of vertebrae. They are used for the implantation or fixation of screw in various spinal problems like fracture, resection tumour, deformity of vertebral column etc. 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 T12 (mean 16.3 ± 2 , range: 12.1 to 18.4) vertebra. Pedicle width decreased from T1 (mean 8.4 ± 2.4 , range 5 to 15) to T5 (mean: 5.2 ± 1.3 , range 2.8 to 9.8) on both sides. From T6, width increased up to T12 on both sides (right mean: 8.4 ± 1.7 and left mean: 8.5 ± 1.8). Internal width gradually decreased from T1 to T5 on both sides, and then it increased from T6 up to T12, on right side. Internal height showed a gradual increase from T1 (mean: 6.4 ± 1.6) to T12 (mean: 11.9 ± 2.2).

KEYWORDS: Pedicle height (PDH), pedicle width (PDW), internal pedicle height (IPDH), internal pedicle width (IPDW).

INTRODUCTION: The pedicles are two short rounded processes generally oval in shape that extends posteriorly from the lateral margin of the dorsal surface of the vertebral body. The pedicles are stronger in thoracic vertebrae and increase in length and width above downwards from thoracic T1 to the T12 vertebrae. Pedicle act as a strut to transmit forces between the body and neural arch.¹

The other most important point is that 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.

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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.²

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.³ Racial variations in skeleton are well known, thus morphometry of the pedicle may vary from population to population.⁴

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 thoracic and lumbar spines so as to document relevant data in Maharastrian 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).⁵

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.
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.2).
 - 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.

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- 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.3)
- c)** The data thus obtained was compiled, tabulated and analyzed statically with the help of Microsoft Excel 2010.

OBSERVATIONS & RESULTS: Observation was recorded separately for right and left pedicles. Observations are shown in table No. 1 & 2.

Level	Pedicle height						Pedicle width					
	Right			Left			Right			Left		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
T1	8	3.4	6-12	8.0	3.5	6.4-12	8.4	2.4	5-15	8.1	2.1	4.4-15
T2	9.9	3.3	8.3-13.8	9.9	3.3	8-11.4	6.9	1.4	5.1-11	6.9	1.7	4.5-13
T3	11.3	1.6	8-14	11.2	1.3	8.7-14	5.9	1.1	4.4-9	5.9	1.4	4-10
T4	10.9	1.4	8.6-14.2	11	1.4	9-13.8	5.4	1.6	3.4-10	5.6	1.7	4-10.5
T5	11	1.6	9-16	10.9	1.6	9-15	5.2	1.3	2.8-9.8	5.5	2.0	3.8-12.9
T6	11.5	1.9	9-16	11.4	1.8	8.4-15.8	5.9	1.5	3.8-9.8	5.8	1.6	3.8-10
T7	11.7	2.1	8.4-17.2	11.7	1.9	9-17	5.8	1.6	3.4-10.3	5.7	1.6	3-10.2
T8	12	2.4	9.2-19	11.8	1.9	8.8-18.3	5.9	1.4	4-10	6.2	1.9	3.2-11.8
T9	13	1.9	9.8-17.8	13.3	2.0	10-18.2	6.6	1.6	4-11.3	6.5	1.4	4.6-9.6
T10	14.1	3.7	11-19.6	13.4	3.8	9.7-18.4	7.5	1.7	4-10.4	7.9	2.0	5.4-15
T11	14.6	3.7	10.3-19.5	15	3.7	1.28-19	8.4	1.6	5.8-12.5	8.3	1.6	6-12.5
T12	14.9	3.6	12.2-18.2	16.3	2.0	12.1-18.4	8.4	1.7	6-12.6	8.5	1.8	5.5-13

Table 1: Measurements of Pedicle height and width

Level	Internal Pedicle height						Internal Pedicle width					
	Right			Left			Right			Left		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
T1	6.4	1.6	3-9	6.5	1.4	3.4-9	6.0	1.6	2.8-8.1	6.1	1.4	3-8.4
T2	7.3	1.1	5-1	7.3	0.9	5.6-9	5.2	1.3	2.8-8	5.2	1.3	2.4-7
T3	7.4	1.4	4-9.4	7.3	1.4	0.3-9-10	4.1	1.5	2-9.3	4.4	1.7	2.2-9.3
T4	7.2	1.6	3-9.8	7.1	1.9	2.6-9.8	3.4	1.3	2-8.2	3.3	1.2	1.2-7.5
T5	7.1	1.6	3.7-9.8	7.0	1.8	3.0-9.4	3.3	1.3	1.8-8.5	3.4	1.2	1.4-7.8
T6	7.5	1.7	3-9.5	7.5	1.8	3.5-10	3.8	1.8	1.8-9.2	3.9	1.7	1.8-8.6
T7	7.4	2.0	3.1-10	7.4	1.8	3.1-10.8	4.1	2.0	2-9	4.1	1.9	1.8-8.7
T8	8.2	2.2	2.8-11.1	8.1	2.0	2.6-11.8	4.0	1.6	2-8	3.8	1.5	2-7.4
T9	8.6	2.7	2-12	8.8	2.1	3.8-12	4.1	1.8	1-8	4.3	1.7	2.2-8.6
T10	10.5	1.8	6.8-13	10.6	2.1	5.8-14	5.4	1.9	3-9	5.3	2.4	2.8-13.4
T11	11.7	2.1	7.4-15	11.8	1.7	7.6-14	5.7	1.5	2.4-8.4	5.9	1.7	4-9.6
T12	11.9	2.2	7.8-17	11.8	1.7	9.8-16	6.0	1.6	3-9.8	6.1	1.6	3.4-10

Table 2: Measurements of Internal Pedicle height and width

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From the table No. 1 & 2 it is observed that the height of pedicle decrease from T1 to T12, height was maximum at T12 (mean 16.3 ± 2 , range: 12.1 to 18.4) vertebra. It gradually increased from T1 to T3 up to mean 11.3 and from T4 it increased from 10.9 to 14.8 at T12 on right side. The pedicle width decreased from T1 (mean 8.3 ± 2.4 , range 5 to 15) to T5 (mean: 5.9 ± 1.4 , range 4 to 10) on both sides. From T6, width increased up to T12 on both sides (right mean: 8.4 ± 1.7 and left mean: 8.5 ± 1.8). Abrupt increase in width at T12 (mean: 8.5 ± 1.8 , range: 4.2 to 16.5) was attributed to presence of costal facet on the pedicle. Overall measurements were more on left side than on right side. Width gradually decreased from T1 to T5 on both sides, and then it increased from T6 up to T12, on right side.

In internal pedicle height maximum measurement was seen at T12 on left side (mean: 11.9 ± 2.2 , range: 3.8 to 10) and minimum at T1 on right side (mean: 6.4 ± 1.6 , range: 2.8 to 8.1). Height showed a gradual increase from T1 (mean: 6.4 ± 1.6) to T12 level with two dips in measurements, one at T5 and T7.

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.

RIGHT AND LEFT SIDE MEASUREMENTS: Pedicular dimensions in this present study did show asymmetry as noted,⁶ as the comparison of right and left measurements has revealed a change in measurements. T1 to T6 vertebrae from 18 human cadavers found that dimensions, varied with individual and level, but not between the left and right pedicles.⁷ However it was felt that the asymmetry needs to be kept in mind while designing pedicle screws.

	Name of author	Findings	PRESENT STUDY
1	Kim N H et al in 1994 (T1 to L5) ⁸	PDH widest at T12, narrowest at T1	PDH was maximum at the level of T12 with the mean of 16.3 ± 2 (range: 12.1 to 18.4),
		PDW maximum at L5 and minimum at T4	PDW decreased from T1 (mean 8.3 ± 2.4 , range 5 to 15) to T5 (mean: 5.9 ± 1.4 , range 4 to 10) , at T12 (mean: 8.5 ± 1.8)
2	Alexander R. Vaccaro et.al in 1995 (T4 to T12) ⁹	PDW minimum at T5 (mean: 4.4 ± 1.1 mm) and maximum at T11 (mean of 8.0 ± 1.9 mm)	PDW decreased from T1 (mean 8.3 ± 2.4 , range 5 to 15) to T5 (mean: 5.9 ± 1.4 , range 4 to 10)

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3	P. Chaynes et.al (2000) ¹⁰	PDH increased from T1 to L5, plateauing between T3 and T9, and widest at the thoracolumbar junction.	PDH was maximum at the level of T12 with the mean of 16.3±2 (range: 12.1 to 18.4),
4	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 maximum at the level of T12 with the mean of 16.3±2 (range: 12.1 to 18.4),
		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 minimum at T5 (mean: 5.9 ±1.4, range 4 to 10)
5	Shiu-Bii Lien et.al 2007) ¹² T1 to L5	PDW widest at L5(17.7 ± 2.7) and narrowest at T4 (3.4 ± 0.6)check it	PDW minimum at T5 (mean: 5.9 ±1.4, range 4 to 10)
6	Datir, Sandeep 2004 T1 to T12) ¹³	PDW more than 6 mm at (T1, T2, T11, and T12), less than 5 mm at (T3-T9)	PDW minimum at T5 (mean: 5.9 ±1.4, range 4 to 10)
7	Abtullah MiLCAN et.al 2001 T11toL2) ¹⁴	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 decreased from T1 (mean 8.3 ±2.4, range 5 to 15) to T5 (mean: 5.9 ±1.4, range 4 to 10) , at T12(mean: 8.5±1.8)

Table 3: Comparison with previous studies

Comparison with previous studies is shown in table no. 3. It must be noted that though there was a difference cephalocaudally in the present study.

PDH and PDW of T1 were found to be equal, thus making the pedicle cylindrical, a feature not reported earlier. 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.

INTERNAL DIAMETERS (IPDW AND IPDH): In the present study, IPDW was maximum at the T12 (mean 4.1 ± 2.0, range 5to12) whereas the minimum was at T5 (mean 3.3±1.3, range=1.8 to 8.5). Width gradually decreased from T1 to T5 then it's increased from T6 to T12 on both sides. IPDH showed a gradual increase from T1 (mean: 6.4±10, range: 3 to 9) to T12 (mean: 15.7±7.4, range: 1.02 -2.2) level.

In a study conducted by using contact radiographs of sectioned (1mm thin) pedicles of thoracic vertebrae and digitalized 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.¹⁵ Present study, difference between internal diameters and width or height of pedicle, ratio of cancellous core can be obtained.

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CONCLUSION: The present study conclude that:

1. Maximum height of pedicle was observed at 12th thoracic vertebra, (thoraco lumbar junction), again a factor important for providing strength to the column in weight transmission.
2. Pedicular width is one of the limiting factors for screw fixation and stability.
3. The width of pedicle is lesser at T3, T5, T6, and T7, hence care must be taken while doing screw fixation at this level.

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.

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Fig. 1: Showing Sample selection

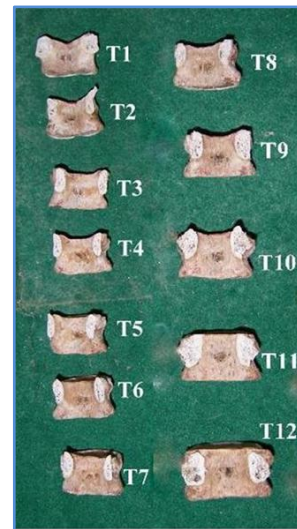


Fig. 2: Showing dry vertebrae after sectioning of pedicle from T1 to T12

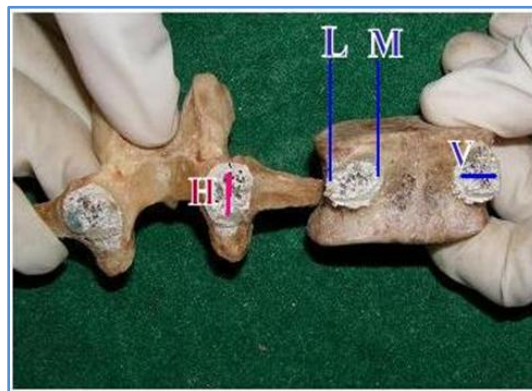


Fig. 3: Showing internal measurements of pedicle

L & M – lateral and medial internal margin of pedicle.

H – Internal height & v- internal width of pedicle.

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Date of Submission: 14/11/2014.

Date of Peer Review: 15/11/2014.

Date of Acceptance: 22/11/2014.

Date of Publishing: 25/11/2014.