

A STUDY OF PEDICLE MORPHOLOGY OF LOWER THORACIC AND LUMBAR VERTEBRAE

Siddhartha Avuthu¹, Parameswara Rao Gompa²

¹Senior Resident, Department of Orthopaedics, NRI Institute of Medical Sciences, Sanghivalasa, Visakhapatnam, Andhra Pradesh.

²Assistant Professor, Department of Orthopaedics, NRI Institute of Medical Sciences, Sanghivalasa, Visakhapatnam, Andhra Pradesh.

ABSTRACT

BACKGROUND

Anatomy of pedicle has gained importance because of accelerated use of pedicle fixation devices. The detail of pedicle morphometry becomes important as it helps in the selection of most suited pedicle screw.

METHODS

Computed tomography scans of lower thoracic and lumbar vertebrae (T9-L5) were reviewed. Using the bone window, the transverse section on which the left and right pedicle appeared largest is selected. Transverse pedicle width, Transverse pedicle angle, Chord length/Screw path length were measured.

RESULTS

Widest pedicle was seen at L5 with a mean of 12.74 mm. The narrowest was seen at T9 with a mean of 5.81 mm. The shortest distance is seen at T11 with a mean of 31.59 mm. The longest distance is seen at L5 with a mean of 40.12 mm. The largest angle is seen at L5 with a mean angle of 20.4°. The shallowest was at T12 with a mean of -0.16°.

CONCLUSION

Differences exist between the pedicles within same population. Preoperative CT-based pedicle dimensions should be recorded if possible for preoperative planning of pedicle implant placement and sizes to avoid inadvertent complications.

KEYWORDS

Pedicle, Morphology, Lumbar.

HOW TO CITE THIS ARTICLE: Avuthu S, Gompa PR. A study of pedicle morphology of lower thoracic and lumbar vertebrae. J. Evid. Based Med. Healthc. 2016; 3(73), 3991-3995. DOI: 10.18410/jebmh/2016/853

INTRODUCTION: Pedicular fixation of the lumbar spine with screws is becoming increasingly popular. This is because of facts that it is the only fixation strategy that engages all three columns.¹ Pedicles are the strongest parts even of osteoporotic vertebrae.¹ Anatomy of pedicle has become important because of this accelerated use of pedicle fixation devices. Accurate anatomical descriptions of the shape and orientation of pedicles are necessary for the development and use of implantable devices and spinal instruments. The detail of pedicle morphology becomes important as it helps in the selection of most suited pedicle screw. If the dimensions of pedicles change at each vertebral level and vary according to the sex and age of patients, information on these variations might help to prevent failure of fixation and injury to vital structures. Several studies have investigated the morphology of pedicles. Most of the studies are based on white populations. They used various techniques such as direct measurement

and measurement on plain radiographs or computerised tomographic scans. Computed Tomography scan is the best means of evaluating the pedicle morphology.² Various authors have shown that no significant statistical difference exists between data obtained from computed tomographic scans and direct cadaveric measurements.^{3,4}

MATERIALS AND METHODS: Computed tomographic scans of the 100 adult patients were examined. Vertebrae from 9th thoracic level to 5th lumbar vertebrae are included. All the pathologic vertebrae were excluded from the study. All the measurements are made directly from the scanner software using bone window setting. All measurements are made by same investigator to avoid interobserver discrepancy.

Using the bone window, the cut section of CT where the left and right pedicles appear largest is selected. The following measurements are made. (Fig. 1).

- 1. Pedicle width (PDW):** This is measured as distance between outer cortex to outer cortex at the narrowest part of the pedicle.
- 2. Pedicle Inclination (PDI) in transverse plane:** This is the angle formed by the longitudinal axis of the pedicle to the midline of the vertebral body. Angulation anteromedially is referred to as positive and that towards anterolaterally is referred to as negative.

Financial or Other, Competing Interest: None.
Submission 21-07-2016, Peer Review 15-08-2016,
Acceptance 21-08-2016, Published 10-09-2016.

Corresponding Author:

Dr. Siddhartha Avuthu,
#55-43-65/1, Doctors Colony,
Seethammadhara,

Visakhapatnam-530013, Andhra Pradesh.

E-mail: drasiddhu@gmail.com

DOI: 10.18410/jebmh/2016/853



3. Chord length (CL): It is the depth to anterior cortex along the axis of the pedicle. It is measured along the axis of the pedicle from the flattest portion of the posterior cortex of lamina to anterior cortex.

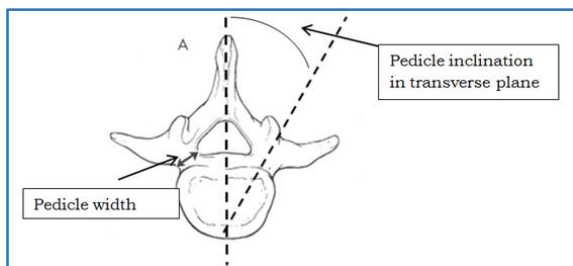


Figure 1

OBSERVATION AND RESULTS: The average age in the present study is 45.23. The youngest was of age of 29 years. Oldest was 68 years. In the present study, there are 67 males and 33 females.

Transverse Pedicle Width: Widest pedicle was seen at L5 with a mean of 12.74 mm (range 6.9-16.0 mm). The narrowest was seen at T9 with a mean of 5.81 mm (range 4.1-8.3 mm) (Table 1).

The mean transverse pedicle width was increasing gradually from T9-L5. (Fig. 2).

A diameter of less than 6.0 mm was most common at T9 (74.12%) followed by T10 (23.66%). The range is more in lower lumbar vertebrae.

In females, pedicle width is smaller than that of males at all levels except T12 (male-6.62, female-6.96).

Pedicle Width			
	Mean	Female	Male
T9	5.81	5.59	5.73
T10	6.39	6.18	6.51
T11	6.72	6.43	6.86
T12	6.73	6.96	6.62
L1	6.78	6.27	7.05
L2	7.25	6.65	7.54
L3	8.33	7.36	8.8
L4	10.27	10.16	10.31
L5	12.74	12.26	13.03

Table 1

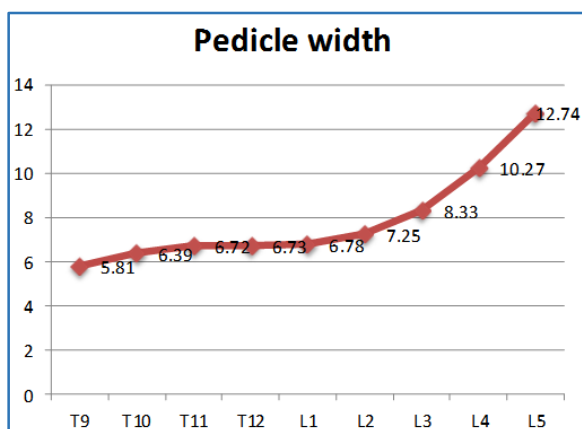


Figure 2

Pedicle Inclination in Transverse Plane: The largest angle is seen at L5 with a mean angle of 20.4° (range: 10-31). The shallowest was at T12 with a mean of -0.16° (range: -7-7). In the lumbar spine, the shallowest angle was 5.38 at L1 (range: 0-14). (Fig.3).

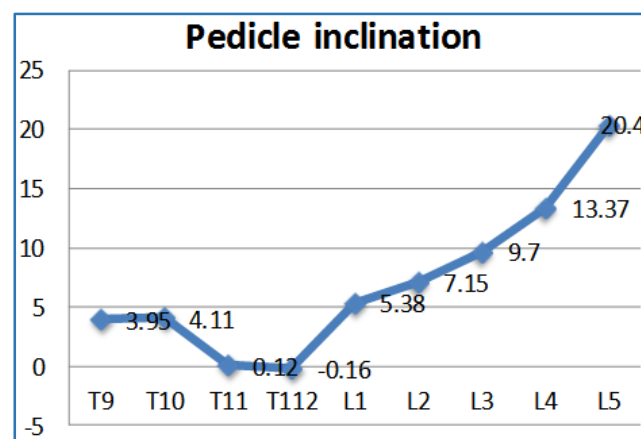


Figure 3

Pedicle Inclination			
	Mean	Female	Male
T9	3.95	3.16	4.4
T10	4.11	4.24	4.03
T11	0.12	-0.39	0.39
T12	-0.16	-0.48	0
L1	5.38	4.79	5.67
L2	7.15	5.67	7.89
L3	9.7	8.27	10.4
L4	13.37	12.53	13.75
L5	20.4	19.2	20.97

Table 2

Chord Length (Depth along Pedicle Axis): The shortest distance is seen at T11 with a mean of 31.59 mm (Fig. 4) (range: 23.4-45.7 mm). The longest distance is seen at L5 with a mean of 40.12 mm (range: 32.4-51.5 mm). (Table 3).

Chord Length			
	Mean	Male	Female
T9	33.44	34.7	31.23
T10	34.12	35.18	32.19
T11	31.59	32.04	30.72
T12	32.24	32.27	32.16
L1	38.03	38.7	36.79
L2	38.27	39.07	36.63
L3	38.85	40.11	36.29
L4	38.98	39.03	38.86
L5	40.12	40.17	40.01

Table 3

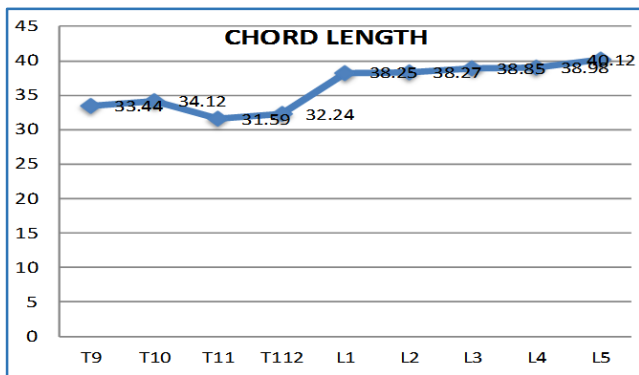


Figure 4

Comparison with Previous Studies: The observations from our study are compared with the previous studies made by Zindrick et al, Berry et al, Krag et al, Hou et al and other Indian studies done by Manish Chada et al, Datir and Mitra, Balaji et al (Fig. 5,6,7).

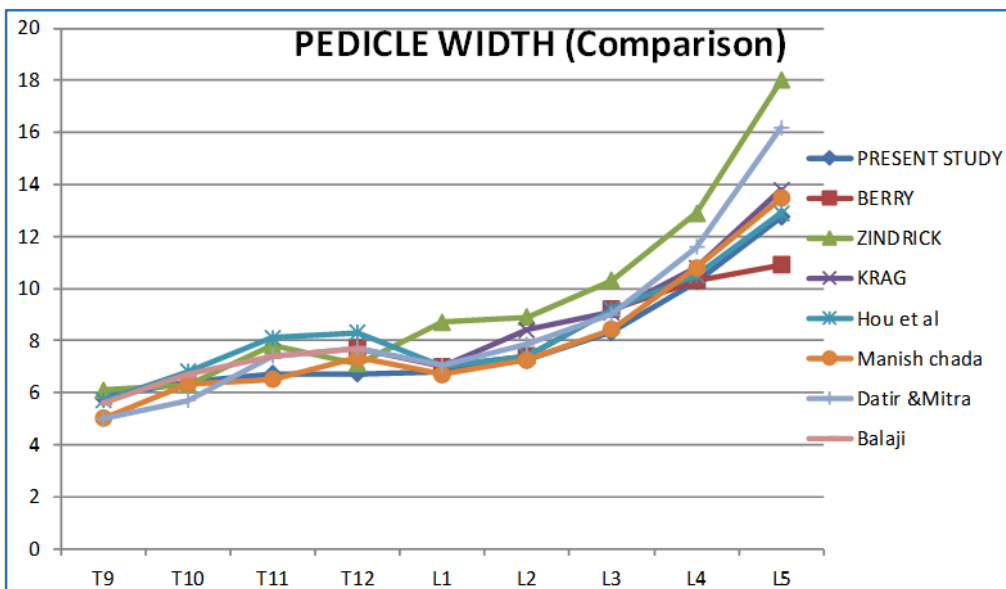


Figure 5

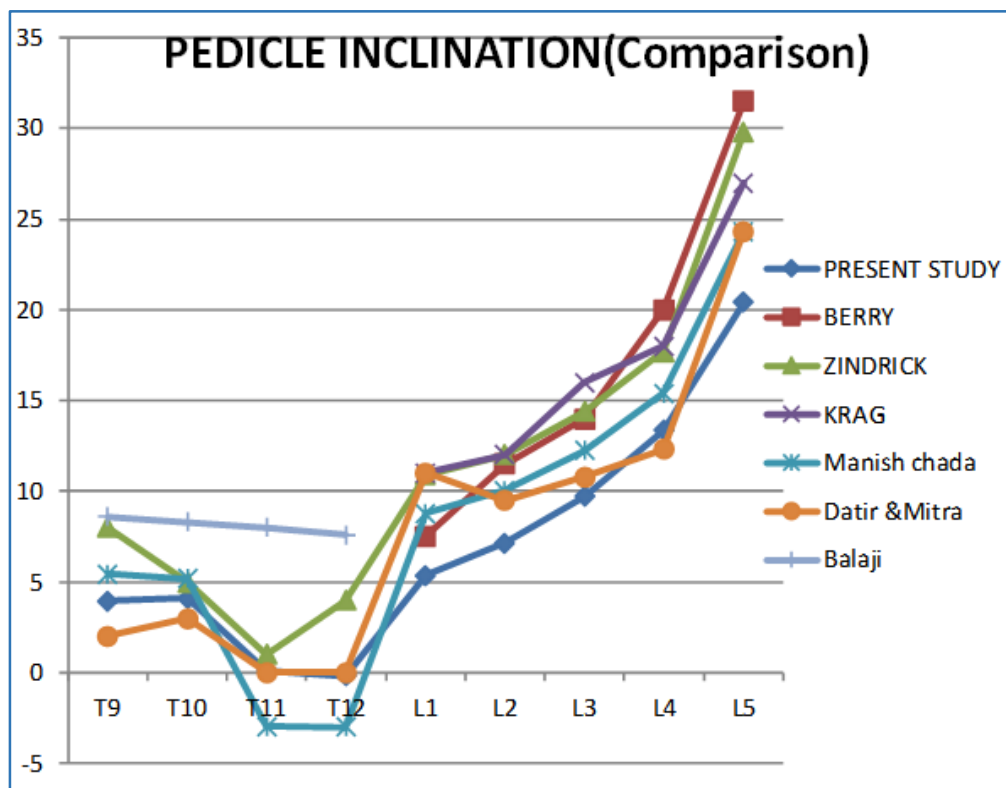


Figure 6

Chord length of present study is compared with Zindrick et al, Datir and Mitra.

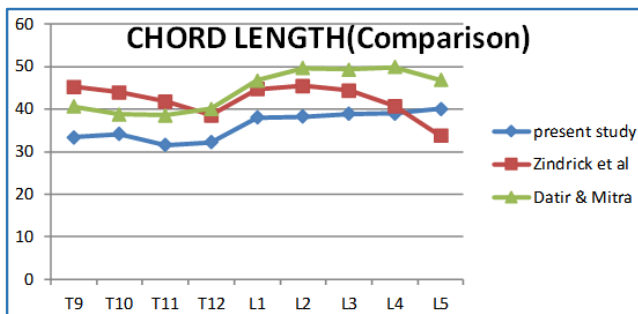


Figure 7

DISCUSSION: Spinal pedicle fixation with screws has become an important method of internal fixation of spine.⁵ Pedicle width and chord length are limiting factors for the transpedicular screw diameter and length.^{6,7} However, anatomic variations can make screw placement challenging and retrospective studies have demonstrated that even in experienced hands pedicle wall violations can occur in up to 29% of cases.^{8,9} Although, neurological deficits related to screw misplacement are less common. Asymptomatic violations of the cortical bone can result in a weakened biomechanical construct.¹⁰ The key to a successful transpedicular procedure is that the small pedicle, especially the deep isthmus section be safely penetrated; otherwise, severe complications such as nerve, vascular and visceral injuries may occur. A penetration should ideally be placed along the axis of the pedicle incorporating the largest available transverse and sagittal pedicle diameters.¹¹

Pedicle Width: The observations from our study are compared with the previous studies.¹²⁻¹⁹ All studies showed a similar trend in pedicle width with gradual increase from L1 to L5 similar with that of Berry et al,¹² Zindrick et al,¹³ Krag et al¹⁴ and Indian studies.¹⁶⁻¹⁹ Zindrick et al¹³ reported a higher pedicle width values lumbar region compared to present study. Krag et al¹⁴ reported slightly higher values than present study. Berry et al¹² and Indian studies had observations similar to present study. Lowest value recorded for pedicle width in the present series is 3.5 mm at L1 and highest at L5 with 16 mm. Pedicle width at L4 and L5 are never below 6 mm. Pedicle widths in lumbar region are well above 5 mm except at L1. According to present study, pedicle widths of females are less compared to that of males except at T12 where they are marginally higher. At T9, 74% of values are less than 6.0 mm.

Pedicle Inclination: The pedicle inclination is reversed at T12 that they are laterally faced. The range is more in the lumbar vertebrae than in the thoracic vertebrae. Males have a lower values compared to females in the lumbar vertebrae. Observations of present study are smaller compared to values reported by Zindrick et al,¹³ Berry et al,¹² Krag et al.¹⁴ Zindrick¹³ reported smallest angle at T11 in contrast to present study where T12 has the smallest (reversal of angle). The results are consistent with that of Datir and

Mitra^{17,18} except that they reported a higher value at L1. Manish Chada et al¹⁶ reported smaller values at T11 and T12 and higher values in lumbar vertebrae.

Pedicles are angulated anteromedially at all levels except T11 and T12 where they may face either anteromedially or anterolaterally, so care has to be taken not to penetrate medial cortex inadvertently while placing a screw at these levels. This anterolateral angulation is more common in females. 46% of pedicles at T11 and 53% of pedicles at T12 are facing anterolaterally.

One should be careful about the angle of screw insertion while preparing the pedicle in L5 vertebra as the range is from 10-31°. The variation is much less in lower thoracic region (T9:0-8°).

Chord Length: Chord lengths of lumbar vertebrae are almost similar and those of thoracic vertebrae are slightly smaller. The smallest chord length is seen at T12 with a value of 22.5 mm and the highest is at L5 with a value of 51.5 mm. Males have a higher values compared to females except at T12, L4 and L5.

Datir and Mitra^{17,18} reported higher values at mid lumbar vertebrae and all values are higher when compared to present study. Zindrick et al¹³ reported a lower value at L5.

CONCLUSION: Pedicle screw of less than 6 mm should be used in thoracic region. 46% of pedicles at T11 and 53% of pedicles at T12 are facing anterolaterally, so care has to be taken while using a pedicular screw at this level. Screw length of 30 mm at lumbar region and 25 mm at lower thoracic levels seem to be safe.

REFERENCES

- Halliday AL, Zileli M, Stillerman CB, et al. Dorsal thoracic and lumbar screw fixation and pedicle fixation techniques. In: Benzel EC, ed. Spine surgery: techniques, complication avoidance, and management. Philadelphia: Churchill Livingstone 2004;1053-1065.
- Bernard TN, Seibert CE. Pedicle diameter determined by computed tomography: its relevance to pedicle screw fixation in the lumbar spine Spine (Phila Pa 1976) 1992;17(6):S160-S163.
- Maalya MA, Saad A, Houlel MEE. Morphological measurements of lumbar pedicles in Egyptian population using computerized tomography and cadaver direct calibre measurements. The Egyptian Journal of Radiology and Nuclear Medicine 2010;41(4):475-481.
- Cheung KM, Ruan D, Chan FL, et al. Computed tomographic osteometry of Asian lumbar pedicles Spine (Phila Pa 1976) 1994;19(13):1495-1498.
- Gaines RW. The use of pedicle-screw internal fixation for the operative treatment of spinal disorders. J Bone Joint Surg 2000;82A(10):1458-1476.

6. Upendra B, Meena D, Kandwal P, et al. Pedicle morphometry in patients with adolescent idiopathic scoliosis. *Indian Journal of Orthopaedics* 2010;44(2):169-176.
7. Ofiram E, Polly DW, Gilbert TJ, et al. Is it safer to place pedicle screws in the lower thoracic spine than in the upper lumbar spine? *Spine* 2007;32(1):49-54.
8. Castro WH, Halm H, Jerosch J, et al. Accuracy of pedicle screw placement in lumbar vertebrae. *Spine* 1996;21(11):1320-1324.
9. Vaccaro AR, Rizzolo SJ, Balderston RA, et al. Placement of pedicle screws in the thoracic spine. Part II: an anatomical and radiographic assessment. *J Bone Joint Surg Am* 1995;77(8):1200-1206.
10. Wang MY, Kim KA, Liu CY, et al. Reliability of three-dimensional fluoroscopy for detecting pedicle screw violations in the thoracic and lumbar spine. *Neurosurgery* 2004;54(5):1138-1142.
11. Weinstein JN, Rydevik BL, Rauschnig W. Anatomic and technical considerations of pedicle screw fixation. *Clin Orthop Relat Res* 1992;284:34-46.
12. Berry JL, Moran JM, Berg WS, et al. A morphometric study of human lumbar and selected thoracic vertebrae. *Spine* 1987;12(4):362-367.
13. Zindrick MR, Wiltse LL, Doornick A, et al. Analysis of morphometric characteristics of the thoracic and lumbar pedicles. *Spine* 1987;12(2):160-166.
14. Krag MH, Weaver DL, Beynon BD, et al. Morphometry of thoracic and lumbar spine related to transpedicular screw placement for surgical spinal fixation. *Spine* 1988;13(1):27-32.
15. Hou S, Hu R, Shi Y. Pedicle morphology of the lower thoracic and lumbar spine in a Chinese population. *Spine* 1993;18(13):1850-1855.
16. Chada M, Balain B, Maini L, et al. Pedicle morphology of the lower thoracic, lumbar, and S1 vertebrae: an Indian perspective. *Spine* 2003;28(8):744-749.
17. Datir SP, Mitra SR. Morphometric study of the thoracic vertebral pedicle in an Indian population. *Spine (Phila Pa 1976)* 2004;29(11):1174-1181.
18. Datir SP, Mitra SR. Morphometric study of the lumbar vertebral pedicle in an Indian population related to pedicular screw fixation. *Spine (Phila Pa 1976)* 2002;27(5):453-459.
19. Pai BS, Gangadhara, Nirmala S, et al. Morphometric analysis of the thoracic pedicle: an anatomico-radiological study. *Neurol India* 2010;58(2):253-258.