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Original Research Article

MORPHOMETRIC STUDY OF PEDICLES OF DRIED ADULT HUMAN LUMBAR VERTEBRAE IN UDAIPUR ZONE

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ABSTRACT

Introduction: It has been suggested that reduced inter-pedicular distance is one of the cause of primary narrowing of the spinal canal may lead to low back pain.Transpedicular approaches are being widely used in many surgeries such as bone biopsy, bone grafting, Pedicle screw fixation, vertebroplasty and kyphoplasty. The morphometric data of lumbar vertebra from Udaipur district i.e. in southern Rajasthan is to the best of our knowledge, virtually unexplored so we under took this study.

Aims and objectives: The present study aims at determining the morphometric norms of Pedicle of the lumbar vertebra in Udaipur zone measured in dried bone. In this study the following measurements on Pedicle of lumbar vertebra are taken i.e. pedicle height, pedicle width and Interpedicular distance.

Materials and methods: The present study was done on the 110 dry adult human lumbar vertebrae from various medical colleges of Udaipur. The morphometrical data of the Pedicle of human lumbar vertebrae were measured and analysed. Digital vernier calliper was used to measure the morphometric data.

Result and discussion: The pedicle height of Pedicle decreased from L1 to L5 except in L2 and width of Pedicle increased from L1 to L5. Interpedicular distanced gradually increased from L1 to L5.

KEY WORDS: Lumbar Vertebra, Pedicle Length, Pedicle Width, Interpedicular Distance, Pedicle Screw Fixation.

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INTRODUCTION

Posterior instrumentation through the Pedicle is a common surgery. Understanding the morphometry of the Pedicle and the anatomy of adjacent neural structures helps decrease the risk of postoperative complications. Various causes have been attributed to low backache, but lumbar spinal canal Stenosis as a causative factor is of great interest in "lumber Stenosis" especially in cases where the cauda equina may be compressed within the lumbar spinal canal by constriction or narrowing of the bony ring of the canal, in contrast to impingement by soft tissues. Stenosis due to decreased sagittal diameter has been reported in the cervical spine as well as in the lumbar spine. It has been suggested that reduced interpedicular distance is one of the cause of primary narrowing of the spinal canal [1].

Pedicles of the lumbar vertebrae are short and strong. In the lumbar region the Pedicles play an important role in the transfer of weight from

the neural arch to the anterior part of the vertebral column [2].

The lumbar vertebrae are the five vertebrae between the rib cage and the pelvis. They are the largest segments of the vertebral column and are characterized by the absence of the foramen transversarium within the transverse process (as it is only found in the cervical r egion), and by the absence of facets on the sides of the body (as only found in the thoracic region). They are designated L1 to L5, starting at the top. The lumbar vertebrae help support the weight of the body, and permit movement. Lumbar vertebral Pedicles are short, thick and flat to rounded dorsal projections from the superior part of the body at the junction of its lateral and dorsal surface.Pedicles form the concavity by the curved superior and inferior border. Superior border of Pedicle is shallower than the inferior one. When vertebrae articulate by the intervertebral disc and facet joints, these adjacent vertebral notches contribute to an intervertebral foramen. The foramen contains a segmental mixed spinal nerve and its sheaths, two to four recurrent meningeal nerves, variable numbers of spinal arteries, and plexiform venous connections between the internal and external vertebral venous plexus. These structures, particularly the nerves, may be affected by trauma or other disorders affecting the adjacent tissue. The complete perimeter of an intervertebral foramen consists of the notches, the dorsolateral aspects of parts of adjacent vertebral bodies and the intervening disc, and the capsule of the synovial facet joints [3].

Low back pain is a major public health problem all over the world. An estimated 75% of all the people will experience back pain at some time in their lives out of which most of them recover without surgery, while 3-5% of the patients present with herniated disc and 1-2% have compression of a nerve root. Treatment can be conservative by physical therapy (or) by surgical decompression also called laminectomy in persons experiencing severe pain, claudication, neurological deficit (or) myelopathy [4].

Fractures of the lumbar Pedicles are common in older age group due to osteoporosis and requires open surgical or percutaneous Pedicle screw fixation to stabilize the vertebrae. Hence the morphometric knowledge of the lumbar Pedicle is important [5]. Many studies have been under taken in various parts of the world to measure morphometric data of lumbar vertebra but such a study has not been done in Udaipur zone. Hence the study was taken up.

Pedicle screw fixation is a popular method of spinal internal fixation [6]. Therefore, it is a probability to operate on patients who have lumbosacral transitional Vertebrae (LSTV) requiring insertion of Pedicle screws through the Pedicles of the segment and adjacent levels. Despite the high occurrence in population and knowledge about the measurements of the Pedicles is compulsory for the safe application of Pedicle screws. Studies concerning the morphometric values of these spinal segments are rare in the literature[7,8].

Transpedicular approaches are being widely used in many surgeries such as bone biopsy, bone grafting, Pedicle screw fixation, vertebroplasty and ky-phoplasty.

Aims and objectives: The present study aims at determining the norms of interpedicular distance, Pedicle width and vertical height of Pedicle of the lumbar spinal canal in Udaipur zone population measured in dried bone.

To measure the morphometric data of lumbar vertebra

Pedicle height,

Pedicle width and

Interpedicular distance

MATERIALS AND METHODS

The present study was done on the 110 dry adult human lumbar vertebrae from Department of Anatomy of various medical colleges in Udaipur, which formed the material for the current study. After approval of institutional ethics committee the morphometrical data of the Pedicle of human lumbar vertebrae were measured.

The following measurements on vertebra were taken using instrument a Digital Vernier Caliper.

Inclusion criteria: A normal adult human lumbar vertebra without any apparent damage or major, common and known congenital anomaly was included in the study.

Exclusion criteria: Abnormal human lumbar

vertebra as seen in congenital, pathological anomalies and damaged vertebra was excluded from the study. Age and sex criteria were not considered.

Sample size: 110 vertebrae

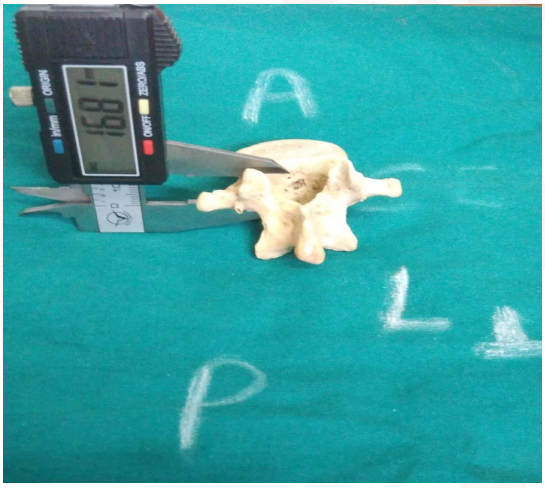
Study design: Descriptive study

Fig. 1: Digital Vernier Caliper.

Measurement criteria:

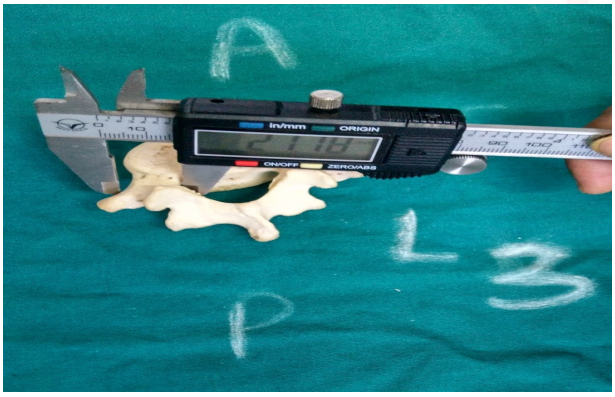
Pedicle height: Measured at the points just opposite each other on the upper and lower margins of the Pedicles in the vertical plane on its lateral aspect.

Fig. 2: Method of measurement of pedicle height.



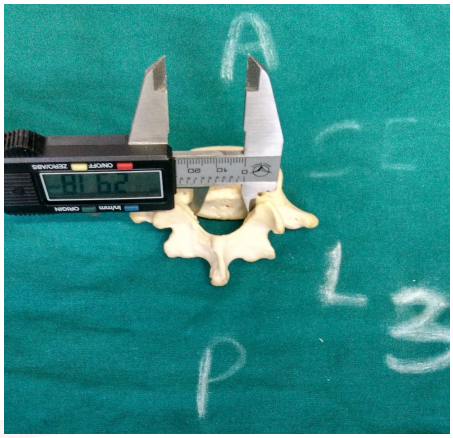
Pedicle width: Measured at the points on the medial and lateral surfaces of each Pedicle at right angle to the long axis of Pedicle.

Fig. 3: Method of Measurement of Pedicle width.



Interpedicular distance: This is the maximum distance between the medial surfaces of the right and left Pedicles of the same vertebra. This was recorded as the transverse diameter of the vertebral canal

Fig. 4: Measurement of Interpedicular distance.



RESULTS AND DISCUSSION

Results obtained in our study regarding the Pedicle of lumbar vertebrae are as follows:

The values of Pedicle height, pedicle width and interpedicular distance of L1 to L5 lumbar vertebrae are shown in tables.

The values of pedicle height is shown in table no. 1 and Graph no.1

The values of width of Pedicle is shown in table no. 2 and Graph no.2

The values of interpedicular distance is shown in table no. 3 and Graph no.3

The comparative statistical values of right and left side of all 110 lumbar vertebrae are shown in table no. 04.

The comparison of result of present study with previous studies is shown in table no. 05

The result of present study is that the height of Pedicle decreased from L1 to L5 mean range with standard deviation for right side 15.14±2.30mm to 13.55±2.10mm; left side 15.08±2.30 mm to 13.43±2.15mm except in L2.

Width of Pedicle increased from L1 to L5 mean range with standard deviation for right side 8.30±0.90mm to 12.14±2.90mm and on left side 8.21±0.82 mm to 12.06±2.45mm.

Interpedicular distance is gradually increased from L1 to L5 Mean range with standard deviation range from 20.32±1.48mm to 24.76 ± 2.07 mm.

Table 1: Height of Pedicle.

Lumbar vertebra	Right side Mean ±Standard deviation (mm)	Left side Mean ±Standard deviation ((mm)	Minimum(mm)		Maximum(mm)	
			Right	Left	Right	Left
L1	15.14±2.30	15.08±2.30	11.21	11.37	19.43	19.51
L2	15.47±2.43	15.38±2.55	12.27	12.18	20.97	20.96
L3	14.70±2.11	14.87±2.08	12.11	12.01	18.61	19.2
L4	13.62±1.89	13.85±1.86	9.09	10.17	17.14	17.44
L5	13.55±2.10	13.43±2.15	9.97	9.31	18.75	18.67

Table 2: Width of Pedicle.

Lumbar vertebra	Right side Mean ±Standard deviation (mm)	Left side Mean ±Standard deviation ((mm)	Minimum(mm)		Maximum(mm)	
			Right	Left	Right	Left
L1	8.30±0.90	8.21±0.82	6.51	6.38	9.96	9.45
L2	8.93±1.33	8.97±1.41	6.35	6.55	11.71	12.73
L3	9.51±1.34	9.55±1.31	7.87	7.85	13.7	13.65
L4	10.73±1.91	10.85±1.91	7.95	8.05	15.8	16.56
L5	12.14±2.90	12.06±2.45	8.38	9.27	22.98	21.05

Table 3: Interpedicular Distance.

Lumbar vertebra	Mean ±Standard deviation (mm)	Minimum (mm)	Maximum (mm)
L1	20.32±1.48	17.43	23.01
L2	21.44±1.70	18.04	25.07
L3	22.02±2.19	18.31	26.46
L4	23.07±2.56	18.55	28.98
L5	24.76±2.07	21.01	28.22

Table 4: Comparison between right and left side statistical parameters of 110 lumbar vertebra.

parameter	side	Mean	Std. Deviation	Std. Error Mean	P value
Pedicle height	right	14.4943	2.29048	0.21839	0.828
	left	14.4266	2.32578	0.22175	
Pedicle width	right	9.9344	2.22455	0.2121	0.968
	left	9.9226	2.15309	0.20529	

No significant statistical difference was found between right and left side. P value for Pedicle height (right and left) is 0.826 and for Pedicle width (right and left) is 0.968.

Different cadaveric, radiographic and osteological studies were done on the lumbar pedicle considering its importance in weight transmission and related trauma. Various studies are done for getting the morphometerical data on the lumbar pedicles.

Dr. Wankhede harish A.et al (2014) observed that Vertical height of the pedicle goes on increasing from L1 to L3 vertebrae and again reduces in L4 and L5, in L5 it is least. Width of the pedicle goes on increasing from L1 to L5 vertebrae; width is nearly similar in L2 and L3 vertebrae. Interpedicular distance is less in L1 and almost similar in L2, L3, L4 and larger in L5 vertebrae.

Similar to their study the Vertical height of pedicle is decrease from L1 to L5 except at L2 where it increased (maximum at L2) and width of pedicle is increasing from L1 to L5. Interpedicular distance is gradually increased from L1 to L5 [5].

Amonoo-Kuofi (1994) studied plain radiographs of the lumbar spines of male and female, aged from 10 to 65 years from Saudi Arabia. There was a significant difference between the pedicle diameters of males and females. Vertical diameters ranged from 14.2 to 20.7 mm. Horizontal diameters ranged from 7.4 to 14.2 mm. There was increase of horizontal and vertical diameters from L1 to L5 in both sexes.

Opposite to their study in our study the Vertical height of pedicle decreased from L1 to L5. Range from 9.09mm to 20.97mm; and width of pedicle increased from L1 to L5 range from 6.35 mm to 22.98mm [9].

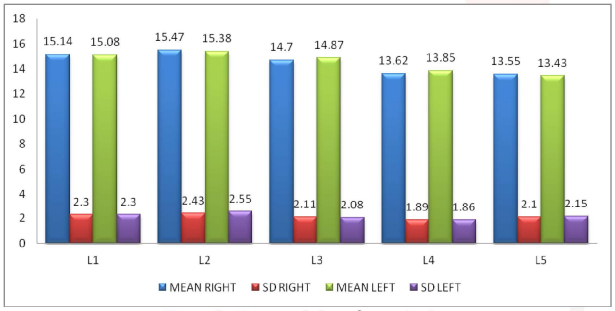
Arora et al (2006) studied 55 dry lumbar vertebrae from Ghaziabad, North India. Horizontal and vertical diameter of the pedicle showed an increase in measurement from L1 to L5 vertebrae. These findings differ from the present study regarding height of the pedicles [10].

Ayhan Attar et al (2001) twenty cadavers were used for observation. The vertical height, pedicle width and IPD gradually increased from L1 to L5. In contrast to their study in our study pedicle

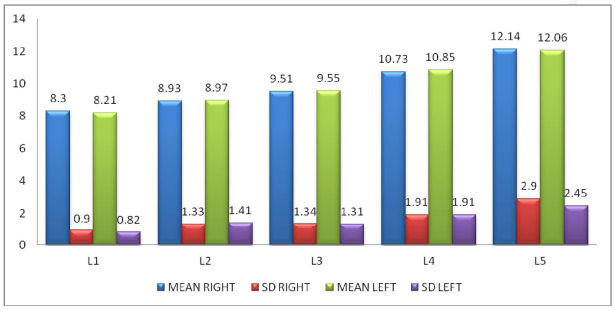
Table 5: Comparison with previous work.

Sr. No.	author	Length (mm) (Mean & S.D.)	Width (mm) (Mean & S.D.)	IPD (mm) (Mean & S.D.)
1	A. Attar et al (2001)	10.4 to 18.2 L1 – 14.9±2.0 L2– 14.5±1.3 L3– 14.1±1.4 L4– 13.7±1.8 L5– 13.6±2.0	5.9 to 23.8 L1 – 8.1±1.7 L2– 8.7±1.7 L3–10.5 ±2.5 L4– 12.7±2.9 L5– 17.2±3.4	Mean IPD range from 19.1 to 28.5. L1 to L5 (Increased) L1 – 22.2±1.0 L2– 22.8±1.6 L3– 23.8±1.8 L4– 25.4±1.7 L5– 27.5±2.7
2	Rudra prasad (2014)	Mean Range 12.59 to 15.28 L1 – 15±2.0 L2– 15.28±1.3 L3– 15.21±1.4 L4– 13.44±1.8 L5– 12.59±2.0	Mean range 7.17 to 11.30 L1 – 7.17±2.0 L2– 7.62±1.3 L3– 9.50±1.4 L4– 10.57±1.8 L5– 11.3±2.0	Mean range 25.54 to 31.29 L1 – 25.54±2.0 L2– 27.03±1.3 L3– 27.7±1.4 L4– 28.62±1.8 L5– 31.29±2.0
3	Jaskaran singh -2014	L1 – 14.8±1.41 L2– 14.31±1.43 L3– 14.45±1.43 L4– 13.92±1.62 L5– 14.37±1.92	L1 – 07.6±1.64 L2– 07.88±1.76 L3– 09.7±2.00 L4– 12.04±2.30 L5– 16.93±2.91	L1 – 21.13±1.63 L2– 22.00±2.27 L3– 21.98±1.42 L4– 22.16±2.87 L5– 26.13±2.62
4	Wankhede -2014	RANGE – RT – 10.3 -18.5 LT – 9.6-18.4	RANGE – RT – 4.5 TO 19.9 LT – 4.5 TO 20.3	RANGE – – 13.5 TO 28.9
5	Seema , verma (2016)	L1 To L3 (Increased) L3 To L5 (Decreased)	L1 TO L4 (Increased) L4 To L5 (Decreased)	L1 to L5 (Increased)
6	Amrish tiwari(2014)	R –10.7 and 16.1 L – 10.0 TO 15.8	R-4.0 TO 17.9 L- 5.0 TO 19.6	Not available
7	Dhaval K. Patil , (2014)	Mean (R) – 13.96 ± 1.34 Range 10.42 – 17.42 Mean (L) 13.9 ± 1.39 Range 10.22 – 17.54	Mean (R)– 08.41 ± 1.62 Range 05.02 – 13.02 Mean (L) 08.57 ± 1.69 Range 04.32 – 13.44	Not Available
8	Chawla et al. 11(2011)	R - 14.0 ± 1.1 L - 14.1 ± 1.0	R – 8.7± 1.4 L- 8.7 ±1.7	Not Available
9	Present study (2018)	Decreased from L1 to L5 except in L2 (R) 15.14±2.30 to 13.55±2.10; (L)15.08±2.30 to 13.43±2.15	Increased from L1 to L5 (R)8.30±0.90 to 12.14±2.90 (L)8.21±0.82 to 12.06±2.45	Increased from L1 to L5 20.32±1.48 to 24.76±2.07

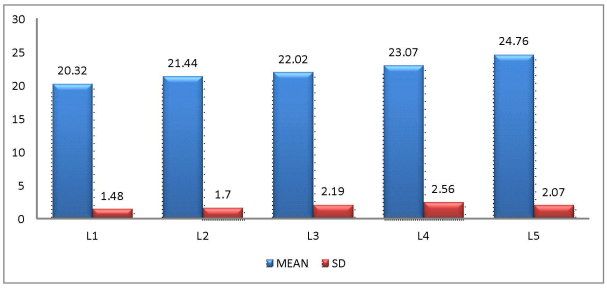
Graph 1: for Height of Pedicle:



Graph 2: Width of pedicle.



Graph 3: Interpedicular distance.



height decreased. The result of pedicle width and IPD were similar to present study. There was wide range in height as well as diameter of pedicles in their study [11].

Chawla et al.(2011) conducted study on 30 dry lumbar vertebrae and 10 adult male cadavers from Chandigarh, North-West India. In the dry bone specimens the mean height of the L3 pedicle was 14.0 ± 1.1 mm on right side and on left side the mean was 14.1 ± 1.0 mm. The mean pedicle width L3 on right and left side was 8.7 mm with S.D. 1.4 and 1.7 mm.

In present study result are almost similar [12].

Dhaval K. Patil , Pritha S. Bhuiyan (2014) Two hundred dry human typical lumbar vertebrae of undetermined gender and age were selected for the study .The results are similar to the present study [13].

Dr. Patel JP et al (2012) studied Interpedicular distances of lumbar vertebral canal at levels L1 to L5 was measured in dry vertebrae of 63 subjects (32 male, 31 female) from Gujarat of age group 35 to 80 yrs. Mean transverse diameter (Inter-pedicular distance) is minimum at L1 (22.6 mm in male and 21.3 mm in female) and maximum at L5 (27.0 mm in male and 26.4 mm in female) showing a gradual increase from level L1 to L5. The inter-pedicular distance increased steadily from L1 to L5 in all populations in both sexes. In our study also interpedicular distance is gradually increase from L1 to L5. The range in present study is more than the past study [14].

Rudra Prasad Marasini et al (2014) The Pedicle dimensions were measured by taking plain x ray in 246 Nepalese of different age groups. The findings were, Height Increased from L1 to L2 and decreased from L2 to L5.Diameter increased from L1 to L5.IPD Increased from L1 to L5. It correlates with present study. The vertical height and horizontal width in Nepalese population was

approx. 1 mm less than the present study but the interpedicular distance was approx. 5 to 6 mm more than the present study [15].

Prakash et al (2007) took measurements of 3 different diameters (v, d, and 1) of both the pedicles of LI to L5 vertebrae (200 male and 200 female) were recorded through sliding vernier calliper in Mangalore. The minimum horizontal diameter (d) of both the pedicles increased from LI to L5. Whereas, the vertical height (v) of both the pedicles increased from LI to L2, decreased from L2 to L3 and increased from L3 to L5. The findings were similar to present study except that the vertical height again increased from L3 to L5 [16].

Dr. Jaskaran Singh et al (2014) The study was done on 20 cadaver and twelve parameters of vertebrae were measured. The Mid- Pedicle width increases from L1 to L5. The Pedicle height remains relatively same from L1 to L5, maximum at L1 pedicle and the smallest at the L4 pedicle. The Interpedicular diameter (IPD) is increasing from L1 to L5.

Contrary to their study the Vertical height of pedicle is decrease from L1 to L5 except at L2 where it increased (maximum at L2) and similar to their study width of pedicle is increasing from L1 to L5. Interpedicular distance is gradually increased from L1 to L5 [17].

Singel et al (2004) studied 60 lumbar vertebrae, from Jamnagar, Gujarat. West India. There was an increase in width of lumbar pedicles from L1 to L5 levels and the width being maximum at L5, also showed that the height of lumbar pedicles decreases from L3 to L5. This finding was same as present study [18].

Seema , Verma P , Singh M . (2016) The pedicles of the lumbar vertebrae of the adult Punjabi males were measured radio graphically. Horizontal diameter of the pedicle goes on increasing from L1 to L4 vertebrae, less at L5 vertebra. Vertical height of the pedicle goes on increasing from L1 to L3 vertebrae and slightly reduces in L4 and L5. Interpedicular distance is less in L1 and almost equal in L2, L3, and L4 and larger in L5 vertebrae. No statistically significant difference is seen in height and width of the pedicle on right and left side.

In present study the vertical height is gradually decrease from L1 to L2 and then decreased from L2 to L5, width of pedicle increase from L1 to L5 and interpedicular distance is gradually increase. So we can say that the findings are almost same [19].

Amrish Tiwari1 et al (2014) study was conducted on 45 dry typical lumbar vertebrae 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. in their study the range of parameters were more in comparison to present study [20].

Vinay and Vishal (2012) conducted study on 150 plain antero-posterior radiographs of lumbar spine of 150 healthy subjects from Mangalore, South India between the age group of 20 to 50 years. The Transverse diameters of spinal canal (TDC) were measured at levels L1 to L5 using CR-35X digitizer. The results showed that the mean TDC increased gradually from L1 to L5 being minimum at L1 and maximum at L5. The results coincide with present study [21].

Yael Kapoor et al (2014) estimate the interpedicular distance. 6 sets of 30 dried cadaveric bones were taken and studied. The interpedicular distance ranged from 18.51mm to 21.50mm at L1-L5vertebral levels.

In contrast in present study Interpedicular distance is gradually increased from L1 to L5 range from 20.32mm to 24.76mm. The range of IPD is less in past study [22].

CONCLUSION

The data can be used to determine the required size of Pedicle screw for surgical needs.

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