

## MORPHOMETRY AND SEXUAL DIMORPHISM OF LUMBAR PEDICLES IN DRY BONES OF MAHARASHTRA REGION

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### ABSTRACT

**Introduction:** Pedicle is strongest part of lumbar vertebra. The fixation of lumbar spine is needed for various spinal problems. The transpedicular screw fixation of lumbar spine is developed as a very successful method of spinal fixation. Morphometric data on the parameters of the pedicles is therefore useful in preoperative planning and designing of pedicle screws and other implantable devices. Identification of sex of an individual from the remains of skeleton has great medico legal significance.

**Aims and Objectives:** To measure the height, thickness and length of lumbar pedicles in dry bones and find out sexual dimorphism in Maharashtra region.

**Materials and Method:** 70 sets of known sex (35 male and 35 female) of lumbar vertebrae from L1 to L5 were obtained from Department of Anatomy of various Medical Colleges of Maharashtra region. The height, thickness and length of lumbar pedicles were measured by using digital vernier caliper. The data was statistically evaluated and seen for sexual dimorphism.

**Observations and Results:** The height and length of pedicle increased from L1 to L3 and decreased up to L5 levels on right and left side in both sexes. The thickness of pedicle increased from L1 to L5 levels on both right and left side and in both sexes. Height (right side L1 to L4 and on left side at all vertebral levels) and thickness of lumbar pedicle (L1 to L3 on right side and L1, L2, L3 and L5 on left side) exhibited sexual dimorphic features in lumbar vertebrae. However, statistically significant difference was not observed in the length of pedicle.

**Conclusion:** The present study confirmed that there are regional as well as racial variations in the parameters of lumbar pedicles. This necessitates the study of particular geographic area and population to find out the range of normal values for that particular population and thus can be helpful for instrumentation. Height & thickness of pedicle showed sexual dimorphic features particularly in L1 to L3 levels, which can be considered for sex determination. Present study can be useful in designing pedicle screw and also be helpful for anthropometric studies and forensic investigations.

**KEY WORDS:** Lumbar pedicle, Screw fixation, Sexual dimorphism, Maharashtra region.

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### Access this Article online

Quick Response code



DOI: 10.16965/ijar.2017.428

**Web site:** International Journal of Anatomy and Research  
ISSN 2321-4287  
[www.ijmhr.org/ijar.htm](http://www.ijmhr.org/ijar.htm)

Received: 23 Aug 2017

Peer Review: 23 Aug 2017

Revised: 28 Aug 2017

Accepted: 20 Oct 2017

Published (O): 01 Dec 2017

Published (P): 01 Dec 2017

## INTRODUCTION

The lumbar vertebrae are identified by, their large size, absence of costal facets on the body and absence of foramen transversarium. The spine is short and rounded at the tip.

There are five lumbar vertebrae. First four are typical and fifth is atypical. Atypical lumbar (Fifth) vertebra is identified by the distance between inferior articular processes, which is equal or more than the distance between superior articular processes. The transverse processes are thick, short and pyramidal in shape [1].

Pedicle is the strongest part of lumbar vertebra. It acts as strut to transmit forces between body and neural arch. It is highly loaded element of neural arch along with facets and laminae. The pedicles of lumbar vertebrae are close to the horizontal position hence the weight transmission in lumbar spine is from body to neural arch towards line of gravity and they connect anterior column (body) to posterior column (neural arch) [2].

The lumbar region of vertebral column is frequently involved during accidents, degenerative conditions, congenital defects and neoplastic metastases. Thus it requires instrumentation for its anatomy and activity to be regained. Surgical intervention in this region requires a thorough knowledge of anatomy and different parameters of pedicles of lumbar vertebrae to identify suitable sites for instrumentation and spinal fixation [3, 4].

The choice of screw is determined by minimum horizontal diameter of pedicle whereas the pathway of the screw is decided by transverse and vertical parameters of the pedicle [5-7]. Morphometric data on the diameters of the pedicles are therefore useful in preoperative planning. The details of pedicle morphometry become important not only in designing of pedicle screw but also in selection of suited pedicle screw and other implantable devices.

Morphometric measurements of skeleton also provide important and useful data regarding the race to which they belong. This helps to determine the age, sex, and stature of an individual. Identification of sex of an individual from the remains of skeleton has great medico legal significance. Sexual dimorphism in vertebrae has

received little attention and has been also used as basis for sex prediction in the analysis of skeletal materials (particularly when bones like hip, skull, sacrum etc are not available). The present study was undertaken in Maharashtra region to measure the height, thickness and length of lumbar pedicles in both sexes. Thus this study was an attempt to collect the database for detailed knowledge of different parameters of pedicles of lumbar vertebrae in dry bones.

**AIM:** To study morphometry and sexual dimorphism of lumbar pedicles in dry bones of Maharashtra region.

**OBJECTIVES:** To measure the height, thickness and length of pedicles of lumbar vertebrae in Maharashtra region. To evaluate the data for sexual difference in height, thickness and length of pedicles of lumbar vertebrae.

## MATERIALS AND METHODS

**Study Design:** Cross sectional study

**Sample Size:** 70 sets of known sex (35 male and 35 female) of lumbar vertebrae obtained from Department of Anatomy of various Medical Collages of Maharashtra.

**Inclusion Criteria:** Normal and fully ossified lumbar vertebrae

**Exclusion Criteria:** Deformed And broken vertebrae

**Method:** After obtaining ethical approval, 70 sets (35 male and 35 female) of lumbar vertebrae from L1 to L5 were obtained from Department of Anatomy of various Medical Collages of Maharashtra region. Following measurements were recorded on both sides using a digital vernier caliper (Precision 0.01 mm). Three readings were taken for each measurements and mean of these was obtained to exclude the personal error. All measurements were recorded in mm.

**Height:** This was measured as maximum vertical distance at the posterior end of pedicle between superior and inferior border of pedicle. After obtaining the measurements, readings were tabulated and analyzed. The range of measurements of parameters (minimum and maximum values) and standard deviation were calculated. The parameters in males and

females were compared with each other to know sexual dimorphism by applying 'Z' test. For each of the parameter, 'p' values were calculated. It was interpreted as -  $p < 0.01$  was considered as highly significant,  $p < 0.05$  significant and  $p > 0.05$  not significant. Statistical calculations were done with help of Statistical Software (SPSS Software version 22).



**Fig. 1:** Height of the Pedicle.

**Thickness:** This was measured as a distance between medial and lateral surface at the posterior end of pedicle.



**Fig. 2:** Thickness of the Pedicle.

**Length:** This was measured distance between two points, one at the junction of pedicle and vertebral body and second at junction of pedicle and superior articular process.



**Fig. 3:** Length of the Pedicle.

Photograph 3 Length of Pedicle

### OBSERVATIONS AND RESULTS

The height of right sided pedicle increased from L1 to L3 level and decreased at L4 and L5 levels in both sexes. The mean height of right sided pedicle was maximum at L3 level and minimum at L5 level in both the sexes. The difference

between the mean values of male and female vertebrae was statically significant at all vertebral levels except at L5.

**Table 1:** Height (mm) of right side pedicle in male and female vertebrae.

Vertebra	Sex	Mean	S.D.	Range	p Value	Significance
L1	M	13.98	1.24	11-17	0.001	HS
	F	13.07	0.91	11-15		
L2	M	14.4	1.16	12-18	0.01	S
	F	13.72	0.97	12-16		
L3	M	15.23	1.14	13-18	0.001	HS
	F	14.26	1.22	12-17		
L4	M	13.11	1.16	10-15	0.002	HS
	F	12.16	1.24	10-15		
L5	M	11	1.73	6-14	0.269	NS
	F	10.59	1.31	8-17		

**Table 2:** Height (mm) of left side pedicle in male and female vertebrae.

Vertebra	Sex	Mean	S.D.	Range	p Value	Significance
L1	M	13.8	1.04	12-16	0.001	HS
	F	12.91	1.06	11-15		
L2	M	14.15	0.99	12-16	0.002	HS
	F	13.39	1.06	11-15		
L3	M	14.85	1.23	13-19	0.012	S
	F	14.11	1.17	11-16		
L4	M	12.78	1.13	10-16	0.002	HS
	F	12.02	0.87	10-14		
L5	M	10.89	1.3	7-14	0.03	S
	F	10.19	1.34	8-13		

The height of left side pedicle increased from L1 to L3 level with maximum height at L3. The height then decreased at L4 and L5 in both sexes. The difference between mean values of male and female vertebrae was statistically highly significant at L1, L2 and L4 level and significant at L3 and L5 levels.

**Table 3:** Thickness (mm) of right side pedicle in male and female vertebrae.

Vertebra	Sex	Mean	S.D.	Range	p Value	Significance
L1	M	7.47	1.1	5-11	0	HS
	F	6.4	1.03	5-9		
L2	M	8.33	1.23	5-11	0	HS
	F	7.19	1.14	6-10		
L3	M	9.51	1.59	6-12	0.005	HS
	F	8.51	1.29	6-11		
L4	M	10.44	1.66	6-13	0.312	NS
	F	10.02	1.71	6-13		
L5	M	13.65	2.35	9-18	0.059	NS
	F	12.58	2.28	9-18		

The thickness of right side pedicle increased from L1 to L5 level in both sexes. The thickness of the pedicle was maximum at L5 level and minimum at L1 level in both the sexes. The difference between the mean values of male

and female vertebrae was statistically highly significant at L1, L2 and L3 levels whereas the difference was not significant at L4 and L5 vertebrae.

**Table 4:** Thickness (mm) of left side pedicle in male and female vertebrae.

Vertebra	Sex	Mean	S.D.	Range	p Value	Significance
L1	M	7.51	1.52	5-10	0.005	HS
	F	6.63	0.92	5-9		
L2	M	8.2	0.96	5-11	0.001	HS
	F	7.39	0.97	5-9		
L3	M	9.41	1.18	6-12	0.002	HS
	F	8.46	1.21	6-11		
L4	M	10.74	1.52	6-13	0.146	NS
	F	10.21	1.5	7-13		
L5	M	13.98	2.29	9-18	0.03	S
	F	12.83	2.07	10-18		

The thickness of left side pedicle increased from L1 to L5 level in both sexes. The thickness of the pedicle was maximum at L5 level and minimum at L1 level in both the sexes. The difference between the mean values of male and female vertebrae was statistically highly significant at L1 to L3 level and significant at L5 level but not significant at L4 level.

**Table 5:** Length (mm) of right side pedicle in male and female vertebrae.

Vertebra	Sex	Mean	S.D.	Range	p Value	Significance
L1	M	6.74	0.84	5-9	0.643	NS
	F	6.84	0.97	5-9		
L2	M	7.17	1.04	5-10	0.394	NS
	F	7.39	1.04	5-10		
L3	M	7.91	1.4	6-11	0.606	NS
	F	8.07	1.12	6-13		
L4	M	6.24	0.82	4-8	0.857	NS
	F	6.28	0.85	4-8		
L5	M	5.49	0.84	4-7	0.327	NS
	F	5.68	0.74	4-7		

The length of right side pedicle increased from L1 to L3 and then decreased up to L5 level in both sexes. The difference between mean values in male and female was not significant at any level.

The length of left side pedicle increased from L1 to L3 and then decreased up to L5 level in both sexes. The difference between male and female vertebrae was not significant at any level. Present study showed statistically significant difference in the height of lumbar pedicle of male and female lumbar vertebrae (right side L1 to L4 and on left side at all vertebral levels). Thickness of lumbar pedicle (L1 to L3 on right

side and L1, L2, L3 and L5 on left side). However, statistically significant difference was not observed in the length of pedicle. Thus height and thickness of pedicle showed sexual dimorphic features particularly at L1 to L3 levels, which can be considered for determination of sex in skeletal remains.

**Table 6:** Length (mm) of left side pedicle in male and female vertebrae.

Vertebra	Sex	Mean	S.D.	Range	p Value	Significance
L1	M	6.54	0.73	5-8	0.724	NS
	F	6.61	0.93	5-8		
L2	M	7.08	0.89	5-10	0.663	NS
	F	6.97	1.1	6-9		
L3	M	7.85	1.36	5-11	0.816	NS
	F	7.93	1.34	6-12		
L4	M	6.13	0.81	4-8	0.783	NS
	F	6.19	0.81	5-8		
L5	M	5.44	1	4-7	0.271	NS
	F	5.67	0.75	4-8		

## DISCUSSION

The transpedicular screw fixation of lumbar spine is developed as a very successful method of spinal fixation which is needed for various spinal problems like fracture in lumbar spine, resection of tumours in vertebral bodies, gross spondylolisthesis and lumbar instabilities [6]. Vertebral pedicles are used very often for procedures performed inside the vertebral body like biopsies, vertebroplasties or kyphoplasties [8, 9].

In pedicle screw insertion, the screw is passed through posterior aspect of pedicle into the body of vertebra anteriorly. By using the screws, several devices such as rods, plates or wires can be applied to the spine for immobilization or fixation. The success of technique depends upon ability of the screw to obtain and maintain purchase within the vertebral body. This is based on accuracy of choice of screw, size of pedicle and the quality of bone of the pedicle. Larger diameter screws are stronger and gave better results; hence majority of surgeons prefers as large size of screw as possible for any given pedicle. Inappropriate size of (oversized) screw may result in cortex perforation of pedicle or fracture of pedicle and can result in dural tears, leakage of cerebrospinal fluid and injuries to nerve roots [5]. Hence the knowledge of height, thickness and length of pedicle helps for deciding



the size of pedicle screw.

**Table 7:** Comparison of height of pedicle between previous and present study.

Authors	N	Side	Sex	L1	L2	L3	L4	L5
Singel TC (2004) Saurashtra Region [6]	45	-	M	14.7	15	14.7	14	13.4
	15	-	F	15.5	14.5	14.8	14	13.25
Aruna N (2011) South Indian [10]	44	-	M	7.39	7.87	9.88	11.42	12.33
Singh J (2013) North Indian [11]	20	-	M	14.6	14.3	14.4	13.4	14.4
Wankhede H (2014) [12]	23	R	-	13.9	14	14.6	14.1	12.8
		L	-	13.8	13.8	14.7	14.1	12.5
Present study (Maharashtra region)	70	R	M	13.98	14.4	15.23	13.11	11
			F	13.07	13.72	14.26	12.16	10.59
		L	M	13.8	14.15	14.85	12.78	10.89
			F	12.91	13.39	14.11	12.02	10.19

Singel TC et al [6] has reported that height of pedicle increased from L1 to L2 and decreased from L3 to L5 level in both sexes. Aruna N et al [10] reported that height of pedicle gradually increased from L1 to L5 level. Singh J et al [11] observed that the mean height of pedicle decreased from L1 to L4 level and increased at L5 level. Wankhede H et al [12] in the study reported that the height of pedicle goes on increasing from L1 to L3 levels and decreased at L4 to L5 level. The findings of present study are similar to findings observed by Wankhede H et al [12]. Thus the patterns of increase or decrease in the height of pedicle are different in different studies and varied according to population.

The mean values of height of present study were comparable with Singel TC et al [6] at L3 level. In male vertebrae, they were comparable with study by Singh J et al [11] at L2 and L3 levels.

**Table 8:** Comparison of thickness of pedicle between previous and present study.

Authors	N	Side	Sex	L1	L2	L3	L4	L5
Singel TC 2004 (Saurashtra region) [6]	45	-	M	8.2	8.5	10.4	13.5	18.2
	15	-	F	8.5	8.75	10.6	13.8	19.25
Aruna N 2011 (South Indian) [10]	44	-	M	14.82	14.4	14.15	13.85	17.52
Jaskaran Singh 2013 (North Indian) [11]	-	-	M	14.6	14.3	14.4	13.4	14.4
Wankhede H (2014) [12]	23	R	-	6.8	8.6	8.6	10.5	14.5
	23	L	-	6.6	8.4	8.6	10.5	14.6
Present Study (Maharashtra Region)	50	R	M	7.47	8.33	9.51	10.44	13.65
			F	6.4	7.19	8.51	10.02	12.58
	L	M	7.51	8	9.41	10.74	13.98	
		F	6.63	7.39	8.46	10.21	12.83	

The thickness of pedicle in present study increased gradually from L1 to L5 levels in both sexes. This finding of the present study was

similar to study by Singel et al [6] and study by Wankhede H et al [12], whereas in study by Aruna [10], thickness decreased from L1 to L4 and abruptly increased at L5 level. The mean values of present study at L2 level in male were comparable with Singel et al and at L1, L2, L3 and L4 levels with study by Wankhede et al.

**Table 9:** Comparison of length of pedicle between previous and present study.

Authors	N	Side	Sex	L1	L2	L3	L4	L5
Sing J (North Indians) [8]	20	-	M	9.4	9.2	9.5	9	8.6
Present Study Maharashtra Region	50	R	M	6.74	7.17	7.91	6.24	5.49
	50	L		6.54	7.08	7.85	6.13	5.44
	50	R	F	6.84	7.39	8.07	6.28	5.68
	50	L		6.61	6.97	7.93	6.19	5.67

Singh J et al [8] reported the length of pedicle decreased at L2 and increased at L3 and again decreased at L4 to L5 vertebrae in males. In present study length of pedicle increased from L1 to L3 and decreased at L4 to L5 vertebrae in male and female. In present study the mean values of length of pedicle was lower than study by Jaskaran Singh et al.

## CONCLUSION

There are no mean values of the vertebral dimensions that are valid for all populations. The ethnical and racial differences are bound to present for population of different geographical areas. This necessitates the study of particular geographic area and population to find out the definitive range of normal values for that particular population

Thus the morphometric study of above mentioned parameters of lumbar pedicles can be useful in designing pedicle screw and in preoperative planning. This study will also be helpful for anthropometric studies as well as for forensic investigations.

## ACKNOWLEDGEMENTS

The authors are thankful to the Institute and all the departments of Anatomy of Maharashtra region.

## ABBREVIATIONS

**S.D.** – Standard deviations **S.** – Significant **M** – Male **N.S.** – Not Significant **F** – Female **N** – Sample size **R** – Right side **H.S.** – Highly Significant **L** – Left side

**Conflicts of Interests: None**

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### How to cite this article:

Yallawa S Kamble, Pramod R. Kulkarni, Uttama U Joshi. MORPHOMETRY AND SEXUAL DIMORPHISM OF LUMBAR PEDICLES IN DRY BONES OF MAHARASHTRA REGION. *Int J Anat Res* 2017;5(4.3):4654-4659. DOI: 10.16965/ijar.2017.428