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Original Research Article

Morphometric Assessment of Pedicles of Indian Adult Lumbar Vertebrae: A Cross Sectional Study

Balu Gangaram Londhe [1], Rajendra Somnath Garud [2]. Ganesh Bhausaheb Khemnar[*3].

[1] Associate Professor, Department of Anatomy, Bharati Vidyapeeth (Deemed to be University) Medical College, Pune, Maharashtra, India.

[2] (Retd.) Professor and Head of Department of Anatomy, Bharati Vidyapeeth (Deemed to be University) Medical College, Pune, Maharashtra, India.

[3] Professor, Department of Anatomy, Bharati Vidyapeeth (Deemed to be University) Medical College, Pune, Maharashtra, India.

ABSTRACT

Introduction: Lumbar vertebral column is exposed to various kinds of stress during locomotion. In erect posture weight transmitted through posterior part including pedicles. This causes deformities of this region as the age advances in many individuals. Proper correction of deformity is challenging. There have been advances in spinal fusion procedures and interspinous implantation of devices including pedicle screws. Use of unsuitable dimensions of screw may cause problem of destruction of pedicle. Correct metricular data of pedicle is necessary for choice of appropriate screw size.

Aims and Objectives: 1) To measure the various dimensions in Indian adult human lumbar vertebral pedicles. 2) To prepare data of lumbar pedicles useful in various surgical procedures.

Material and Methods:

A Cross-sectional study was done on 45 dry, fully ossified human lumbar vertebral sets. The bones were grouped into typical (L1 to L4) and atypical (L5) lumbar vertebrae. The dimensions measured included pedicle length, height, thickness, axial length, transverse and sagittal angles. 'Digital Vernier Caliper' and Protractor were used. The data was analyzed statistically.

Results: The mean length, height and thickness of typical vertebral pedicles increases gradually. In atypical (L5), pedicle thickness suddenly increases. The transverse angle of pedicle elevated gradually from L1 to L4 but at L5, it abruptly increased.

Conclusions: The study reported significant differences in several dimensions of pedicles of typical as well as atypical lumbar vertebrae. These differences should be considered by neurosurgeons.

KEY WORDS: Anatomy; Dimensions; Lumbar Vertebral Pedicle; Pedicle Screw Fixation.

Corresponding Author: Dr. Ganesh Bhausaheb Khemnar, Professor, Department of Anatomy, Bharati Vidyapeeth (Deemed to be University) Medical College, Pune, Maharashtra, India. Mobile number, +91 9960348338. **E-Mail:** ganesh.khemnar@bharatividyapeeth.edu.in

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INTRODUCTION

The pedicles of lumbar spine are stronger and larger and are commonly used for screw fixation during lumbar spinal stabilization surgeries [1]. 'Spinal fixation' is often indicated in certain ailments of lumbar columns like fractures, degenerative changes, malignancy or lumbar instabilities [2]. The prevalence of low

back pain and other associated signs of lumbar spinal diseases is being increased in modern world and it is estimated that around 70-90% of general population has chronic low backache and 4% of them require operation at certain time [3].

'Lumbar fusion' is one of the minimally invasive interventions for lumbar disorders. It is frequently preferred operation due to less invasiveness and speedy postoperative recovery [3]. 'Transpedicular spine fixation' is also one of techniques to ensure adequate lumbar stabilization during management of various vertebral diseases in lumbar region like trauma, fractures, tumors, degeneration and lumbar instability [4]. In order to perform these procedures in risk free environment, an accurate morphometric data of lumbar pedicles is crucial [5].

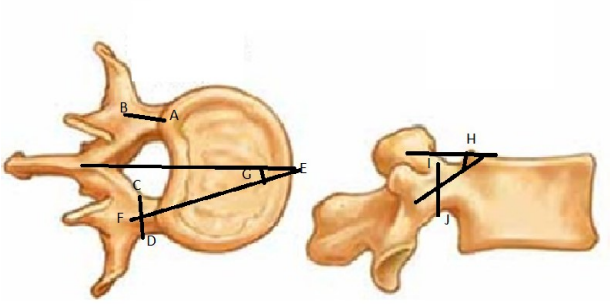
There have been rapid developments in spinal fusion procedures and interspinous implantation of devices including pedicle screws. Use of inappropriate dimensions of screw may cause lethal complication in the form of fracture of pedicle [1]. Therefore, selection of screws should be based on its correct measurements [1]. Lumbar pedicle thickness in diverse populations like Asians, Black, White and other groups is documented in literature.

The present study was undertaken to determine the multiple dimensions of lumbar vertebral pedicles from L1 to L5. The generated results would be useful to estimate size of pedicular screw during lumbar spinal stabilization operations.

MATERIALS AND METHODS

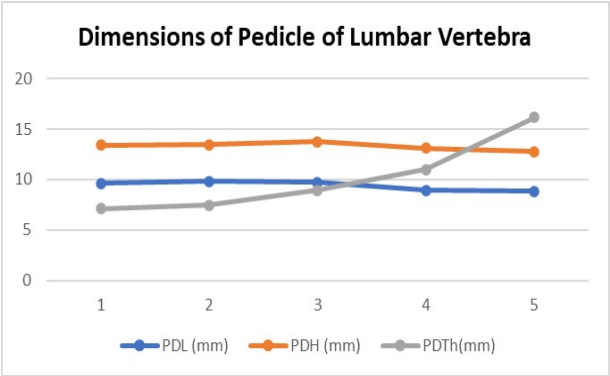
The study was implemented on 45 dry, fully ossified normal lumbar vertebral sets from the Department of Anatomy, Bharati Vidyapeeth Deemed to be University Medical College, Pune. For study purpose, all vertebrae were categorized into typical (L1 to L4) and atypical (L5). Exclusion of deformed vertebrae was done. The dimensions including length, height, thickness, axial length, transverse and sagittal angles were measured by 'Digital Vernier Caliper' with 0.01 mm precision and 'Geometrical Protractor' with marking up to 180 degrees. All observations were entered and analyzed in 'SPSS Version 25' software. Mean and Standard Deviations (SD) of each side were calculated. The statistical differences were computed by 'ANOVA' test. Pedicle parameters were recorded in millimetres and angle in degrees as follows (Fig.1);

Fig. 1: Pedicle dimensions



Key: AB – Pedicle length, CD – Pedicle thickness, EF – Pedicle axial length, G – Pedicle transverse angle, H – Pedicle sagittal angle, IJ – Pedicle height.

Fig.2: Pedicle length, height and thickness.



PDL – Pedicle length, PDH - Pedicle height, PDTh – Pedicle thickness

Pedicle Length - (PDL) - measurement between two points, one at the junction of pedicle and vertebral body and the second at the junction of pedicle and superior articular process.

Pedicle Height - (PDH) - maximum vertical measurement at the posterior end of pedicle.

Pedicle Thickness - (PDTh) - maximum transverse measurements of pedicle at its posterior end.

Pedicle Axis length- (PDAL) - measurement between posterior end of pedicle at the junction with superior articular process to anterior aspect of cortex of the vertebral body along the long axis of the pedicle.

Pedicle Transverse Angle: (PDTAn) - angle formed by the long axis of the pedicle with mid-sagittal line.

Pedicle Sagittal angle :(PDSAn) – angle formed by the long axis of the pedicle with the superior surface of the body.

All the dimensions were measured twice, first on right and then on left side to minimize error.

RESULTS

In present study, the mean length and height of pedicles in typical vertebrae (L1 to L4) ranged from 8.85 mm to 10 mm and 13.08 mm to 13.81mm respectively. The pedicle thickness of typical vertebrae was noted between 7.11 mm 11.22 mm. For L5, the mean values of PDL, PDH and PDTh were 8.80 mm, 12.79 mm and 16.10 mm respectively (Table 1). It was observed that PDL increased till L3 but after that it declined at L5. (Fig.1). There was a gradual gain in PDH from L1 to L4. However, it was reduced at L5. (Table 1, Fig.2). PDTh was enhanced from L1 to L5 but in the fifth lumbar vertebra, the thickness of pedicle suddenly increased as compared to that of fourth (Table 1).

Table 2 shows the measurements of pedicle angles and axial length of typical and atypical lumbar vertebral pedicles. The transverse angle of pedicle elevated steadily from L1 to L4 but at L5, it abruptly increased than in L4. The mean transverse angle of right and left side (22.63 degree and 21.61 degree) of pedicle at L5 was greater than L4 (16.98 degree and 15.81 degree), Pedicle axial length rose from L1 to L3 and subsequently it dropped from L4 to L5 (Table 2). However, mean sagittal angle and mean axis length of pedicle of L5 was found to be less than L4 (Table 2). However, there was no any significant change in sagittal angle of typical as well as atypical vertebra.

Table 3 depicts statistically significant differences in various dimensions of pedicles of all five lumbar vertebrae. Except height, for all dimensions, highly significant ($P < 0.01$) difference was observed. There was also significant correlation between length, height, thickness as well as angles of lumbar pedicle of right and left side of typical and atypical lumbar vertebrae ($p < 0.05$).

Table 1: Dimensions of Pedicle of Lumbar Vertebra (L1 to L5) n=45.

Vertebra		PDL (mm)		PDH (mm)		PDTh (mm)	
		R	L	R	L	R	L
L1	Mean	9.76	9.5189	13.6091	13.2317	7.1155	7.1438
	SD	1.1125	1.7482	1.7905	1.6041	1.3729	1.5072
L2	Mean	10.0055	9.6245	13.5445	13.4126	7.4836	7.4232
	SD	1.201	1.227	1.2764	1.1393	1.4781	1.3576
L3	Mean	9.8002	9.6143	13.8188	13.6902	8.7432	9.1187
	SD	1.3363	1.2309	1.3743	1.3664	1.3275	1.2851
L4	Mean	9.0004	8.8577	13.1596	13.0843	10.7489	11.2255
	SD	1.1732	1.0919	1.9338	2.6481	2.1447	2.0548
L5	Mean	8.8038	8.8523	12.7921	12.7549	16.1023	16.2074
	SD	1.4853	1.3621	1.9089	1.9692	3.4175	3.5899

PDL – Pedicle Length, PDH – Pedicle Height, P DTh – Pedicle Thickness. S.D – Standard Deviation

Table 2: Transverse, Sagittal Angles and Axial Length of Lumbar Vertebrae. n=45

Vertebra		PDTAn(degree)		PDSAn (degree		PDAL (mm)	
		R	L	R	L	R	L
L1	Mean	11.7447	11.6383	6.2979	6.2766	35.2323	35.2857
	SD	0.9434	0.8451	0.5071	0.5398	2.0877	2.1073
L2	Mean	13.2766	13.2766	7.1915	7.1915	36.344	36.2528
	SD	0.9714	0.9714	0.6801	0.6473	1.9852	2.2354
L3	Mean	14.5851	14.4362	8.234	8.234	37.5053	37.4213
	SD	1.0699	0.9244	0.8899	0.8899	2.4791	2.4031
L4	Mean	16.9894	15.8191	8.3404	8.4255	36.2732	35.9519
	SD	1.3331	2.9256	0.9841	0.8274	2.2656	2.0369
L5	Mean	22.6383	21.617	7.8936	7.7234	34.4291	34.3638
	SD	1.1214	3.5297	1.1838	1.2105	2.1911	2.3806

PDTAn – Pedicle Transverse Angle, PDSAn – Pedicle Sagittal Angle, PDAL – Pedicle Axial Length, S.D – Standard Deviation

Table 3: Significant Differences of Pedicle Dimensions (L1 to L5) n=45

	F-value	p-value	Significance
Length	8.38	< 0.001	HS
Height	2.77	0.027	S
Thickness	143.54	< 0.001	HS
Transverse Angle	707.92	< 0.001	HS
Sagittal Angle	43.87	< 0.001	HS
Axial Length	13.26	< 0.001	HS

HS: Highly Significant (p-value < 0.01),
S: Significant (p-value < 0.05),
NS: Not Significant (p-value >0. 05)

DISCUSSION

Chandni G et al. [3], Singel et al. [4] , Mitra et al. [10] and Wolf et al. [11] detected uniform patterns in pedicular height change as in all studies, PDH increased progressively from L1 to L4 and increased abruptly at L5. Their studies also mark increase in thickness at L5 which is seen in present study. Attar A, et al. [6] in their study revealed the increase in height and thickness of pedicles from L1 to L5 vertebrae. From this, it was acclaimed that as we went down the vertebrae, the pedicle height and thickness kept on elevating, which was observed in all mentioned studies. However, comparable findings were seen in the present study in which PDH was high from L1 to L4 but it showed sudden reduction at L5. The pedicular thickness shows abrupt increase at L5.

Lumbar segment is the most movable part of spine and is frequently compromised during traumatic injuries, congenital anomalies, tumors, infections or degenerative defects. Hence, it may require stabilization or reconstruction to restore its activity. Any disruption in the integrity of pedicle could affect the weight conduction mechanisms and can lead to compression of neural structures [12]. Therefore, treating lumbar instability with appropriate stabilization devices is utmost important.

The current study was carried out on dry lumbar vertebrae and it involved direct measurement of dimensions of bones rather than radiological or cadaver-based studies. Direct measurement method often provides more consistent and reproducible results than imaging sources [13]. Joseph Albano et.al. [14] demonstrated that the Asian population consistently had significantly smaller pedicles in the lumbar spine than in the Black or White populations.

Very few studies incorporated direct measurement methods to estimate lumbar pedicular dimensions in Indian subjects. The emerged results would assist surgeons as reference guide to determine the accurate screw size to be implanted in the lumbar area for spine stabilization. In present study male and female lumbar vertebrae were not identified, hence study should have been extended for gender specificity.

CONCLUSION

The present study revealed significant differences in multiple dimensions of pedicles of typical as well as atypical lumbar vertebrae. These differences bear critical implications for neurosurgeons to operate in safe environment on patients in Indian settings.

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Conflicts of Interests: None

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