Original Research Article

Morphometric study of pedicles of dried human lumbar vertebrae

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Abstract

Background: The growing interest in transpedicular screw fixation in the present time has warranted improved knowledge in morphometric details of the pedicles. Performing pedicular screw fixation is technically challenging. The key to successful surgery is an explicit knowledge of intracanal anatomy and the location of the pedicle. Detailed knowledge of pedicle size and dimensions is crucial while using the pedicle to gain hold and strength of the vertebra. The sizes of the screws used in surgery must take pedicle dimensions into consideration. M**ethods**: The study was performed on 75 dry human lumbar vertebrae of 15 sets of vertebral columns and measured the height, width, and interpedicular distance of pedicles of lumbar vertebrae using a digital verniercaliper. **Results**: Out of 75 vertebrae, 50 male and 25 female lumbar vertebrae, and 60 were typical, and 15 atypical. The mean pedicle height of the typical vertebrae is 13.35±1.26 mm,and it was higher in comparison to atypical vertebrae. The mean pedicle width of the atypical vertebrae is 16.47±2.48 mm, and it was higher in comparison to the typical vertebrae. The mean interpedicular distance of atypical vertebrae is 24.31±2.29 mm, and it was higher in comparison to the typical vertebrae. The mean pedicle height, width, and interpedicular distance in male are 13.28±1.78 mm, 9.93±3.96 mm, and 21.11±2.67mm, respectively, and it was observed higher in male compared to female lumbar vertebrae. **Conclusion**: There is always an increase in the width of lumbar pedicles proceeding from L1 to L5 levels and the width maximum at L5 level to enable in weight transmission. Further, in this study, there was a significant correlation between the height of typical and atypical vertebrae ($p<0.05$)and also between the height and interpedicular distance of male and female vertebrae ($p<0.05$).

Keywords: lumbar vertebra, pedicle height, pedicle width, interpedicular distance

Introduction

The growing interest in transpedicular screw fixation in the present time has warranted improved knowledge in morphometric details of the pedicles[1].With the advancement of imaging technique and operative procedures, transpedicular screw fixation is indicated to stabilize the unstable spine conditions that occurred due to trauma, compression fractures, tumours, and infections like tuberculosis. Detail anatomical knowledge of the pedicle is the key to successful transpedicular screw fixation[2]. The size of the screw used in fixation is taken into consideration in respect of the dimension of the pedicle[3].The screw of the unmatched dimension and its misplaced position and direction may lead to damage to the bony cortex of the pedicle resulting in compromising the stability and strength of the vertebral column[4]. Designing the screw considering its biomechanics requires detail anatomical knowledge of the pedicle and the vertebral body[5]. Due to the increasing problem of the unstable lumbar region universally; we have focused our study on this region. The data obtained will be relevant and helpful to the clinicians dealing with the unstable lumbar region and biomechanical engineer designing the screw as the morphometric data varies within sex, race and ethnic groups spread over the different demographic areas.

Aims: To measure and compare the height, width, and interpedicular distance of pedicles in typical and atypical lumbar vertebrae of the male and female

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Material and methods

The current study was observational and conducted in the department of Anatomy with prior permission from the institutional ethical committee of Government Medical College, Shivpuri M.P. The study was performed on 75 dry human lumbar vertebrae of 15 sets of the vertebral column. Undamaged vertebrae of unknown age & known sex were included in the study.The height, width, and interpedicular distance of pedicles in typical and atypical lumbar vertebrae of male and female were studied individually by using Digital verniercaliper.

Pedicle height (P.H.): It is the vertical distance between the superior and inferior border of the pedicle at its midpoint (fig 1a).

Pedicle width (P.W.):It is the horizontal distance between medial and lateral surfaces of the pedicle at its midpoint, measured at right angles to the long axis of the pedicle(fig 1b).

Interpedicular distance (IPD): It is the maximum distance between the medial surfaces of the right and left pedicles of the same vertebra (fig 1c).

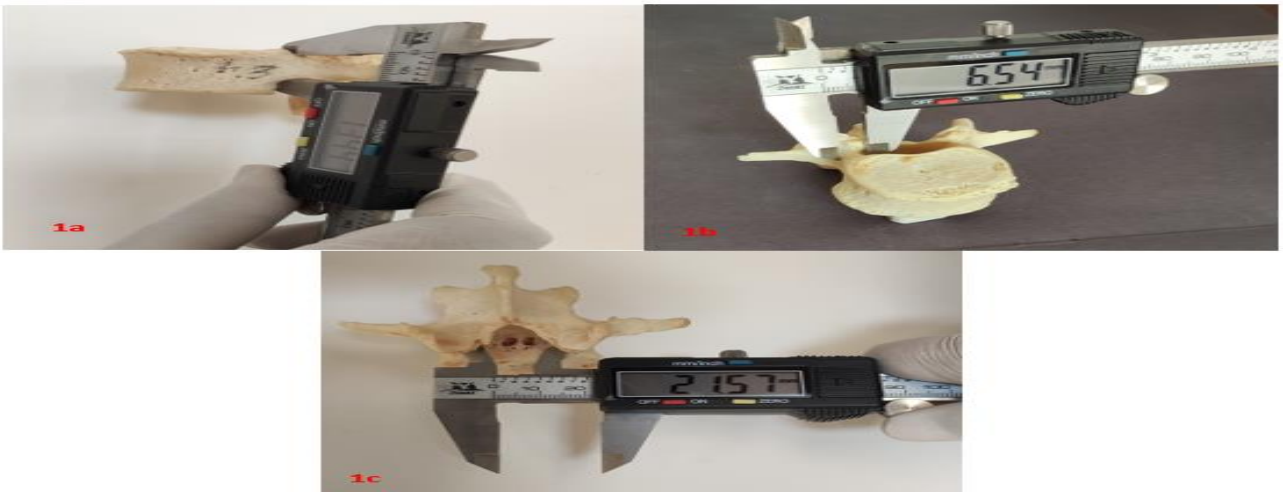

Fig 1: **Measuring the height (1a), width (1b), and interpediculardistance (1c) of pedicles.**

Results

The study was performed on 50 male and 25 female lumbar vertebrae, out of which 60 were Typical and 15Atypical.

Table 1:Lumbar vertebrae and its dimensions

Lumbar vertebrae		Height (mm)	Width(mm)	Interpedicular Distance (mm)
L1	Mean±SD	13.25±1.14	6.15±1.14	19.30±1.92
	Min.-Max	11.47-15.06	4.00-8.33	16.95-22.55
L2	Mean±SD	13.50±1.45	6.79±1.20	19.72±1.17
	Min.-Max	11.00-15.87	4.77-8.94	16.86-22.87
L3	Mean±SD	13.38±1.17	8.49±1.32	20.15±1.48
	Min.-Max	11.27-15.59	6.03-10.67	17.93-22.34
L4	Mean±SD	13.25±1.37	10.63±1.65	21.04±1.96
	Min.-Max	10.92-16.37	7.87-13.26	18.20-25.08
L5	Mean±SD	12.97±3.27	16.47±2.48	24.31±2.29
Atypical Vertebrae	Min.-Max	9.37-21.75	11.23-21.20	19.85-29.59
L1-L4	Mean±SD	13.35±1.26	8.02±2.18	20.05±1.84
Typical vertebrae	Min.-Max	10.92-16.37	4-13.26	16.86-25.08
P- Value between typical and atypical lumbar vertebrae		**P<0.05**	**P>0.05**	**P>0.05**
Male	Mean±SD	13.36+0.98	8.21+2.030	20.25+1.87
L1-L4				
Typical vertebrae	Min.-Max	11-16	5-13	17-25
Male	Mean±SD	12.96+3.59	16.83+1.22	24.56+2.65

L5 Atypical Vertebrae	Min.-Max	9.37-21.75	15-19	20-30
Female	Mean±SD	13.32+1.72	7.64+2.48	19.68+1.75
L1-L4 Typical vertebrae	Min.-Max	11-16	4-13	17-23
Female	Mean±SD	13.01+2.91	15.77+4.15	23.81+1.45
L5 Atypical Vertebrae	Min.-Max	10-17	11-21	22-26

1. The pedicle height at the midpoint of the pedicle observed on typical lumbar vertebrae ranged from 10.92 to 16.37mm with a mean of 13.35±1.26 mm, but in atypical lumbar vertebrae, pedicle height was observed which was ranged from 9.37 to 21.75mm with a mean of 12.97±3.27mm (Table 1). The pedicle height of typical and atypical lumbar vertebrae were compared, and its p-value ($p<0.05$) shows a significant difference between the pedicle height of typical and atypical lumbar vertebrae.
2. The pedicle width at the midpoint of pedicle measured on typical lumbar vertebrae ranged from 4 to 13.26 mm with mean of 8.02±2.18 mm, but in atypical lumbar vertebrae, pedicle width was ranged from 11.23 to 21.20 mm with mean of 16.47±2.48mm (Table 1). The pedicle width of typical and atypical lumbar vertebrae were compared, and we found p-value ($p>0.05$), shows no significant difference between the width of typical and atypical vertebrae.
3. The interpedicular distance was measured on typical vertebrae ranged from 16.86 to 25.08mm with mean of 20.05±1.84 mm, but in atypical lumbar vertebrae, interpedicular distance was ranged from 19.85 to 29.59mm with mean of 24.31±2.29 mm (Table 1). The interpedicular distance of typical and atypical lumbar vertebrae were compared and found p-value ($p>0.05$), which shows no significant difference between interpedicular distance of typical and atypical lumbar vertebrae.

Table 2: Dimensions of male and female lumbar vertebrae

	Height		**Width**		**IPD**	
	Male lumbar vertebrae in mm	**Female lumbar vertebrae in mm**	**Male lumbar vertebrae in mm**	**Female lumbar vertebraein mm**	**Male lumbar vertebrae in mm**	**Female lumbar vertebrae in mm**
Mean±SD	13.28±1.78	13.25±1.94	9.93±3.96	9.26±4.33	21.11±2.67	20.50±2.37
Range	9.37-21.75	10.14-17.10	4.86-18.73	4.00-21.20	16.86-29.59	17.46-25.82

Table 3: Comparison of height, width and interpedicular distance of pedicles in male and female lumbar vertebrae.

Pedicles		**Mean**	**SD**	**p-value**
Height (mm)	**Male**	13.37	1.00	$p<0.05$
	Female	13.57	1.93	
Width (mm)	**Male**	7.32	1.21	$p>0.05$
	Female	9.61	4.52	
Interpedicular distance (mm)	**Male**	20.18	1.46	$p<0.05$
	Female	20.50	2.37	

1. The pedicle height in males was ranged from 9.37 to 21.75mm with a mean of 13.28±1.7 mm,but in the female, it was ranged from 10.14 to 17.10mm with mean of 13.25±1.94 mm (table 3). The height of pedicles of male and females were compared, and its p-value($p<0.05$) shows a significant difference between them.
2. The pedicle width in males was ranged from 4.86 to 18.73mm with a mean of 9.93±3.96 mm, but in the female, it was ranged from 4.00 to 21.20mm with mean of 9.26±4.33 mm(table 3).The width of pedicles of male and female were compared, and its p-value ($p>0.05$)shows no significant difference between them.
3. The pedicle interpedicular distance in male was ranged from 16.86 to 29.59 mm with mean of

21.11±2.67 mm, but in a female, it was ranged from 17.46 to 25.82mm with mean of 20.50± 2.37mm (table 3). The interpedicular distance of male and female were compared, and its p-value ($p<0.05$)shows a significant difference between them.

Discussion

The lumbar region lost its anatomical positions and functional activity due to increasing incidences of road traffic accidents involving the lumbar region as a common site apart from degenerative disorders, congenital disabilities, and neoplastic metastases which also affect this part. Therefore, it may need artificial fixation to achieve its lost anatomy and functional activity to be regained. Every structural deformity of the pedicle might affect the weight conduction mechanism and might compress the neural structures[6]. Many studies have been done in the past on lumbar pedicles in various ethnic regions, both radiologically as well as by direct measurements. Pedicle screw fixation is a popular and preferred method of spine stabilization. It gives rigid, segmental stabilization and allows preservation of movement and locomotion. With the advancement in medical technology, newly developed navigation techniques may help the surgeons to place pedicle screws more safely in an appropriate direction and place. For successful screw fixation in the pedicle and to provide strength and stability, the position occupied by the screw within the pedicle and vertebral body areessential as the screw passes towards the posterior aspect of the vertebral body from the posterior aspect of the pedicle. In the present study on typical lumbar vertebrae, the mean height was 13.35mm. In the study conducted by Arora et al[13], the vertical height was observed (16.42mm), which is slightly higher than the value observed in our research, but in a study by Singel et al[14] the value is 10.4mm, which is somewhat lower than our value. The mean height of atypical vertebra (12.97mm) is less than the mean height of the typical vertebrae. In Aruna and Rajeshwari[15]the range for the width was 4.5–22 mm, and the range for the height was 10–20mm. In the present study, its mean width range for typical vertebrae was 4.0-13.26 mm, and for atypical was 11.23-21.20 mm.After transfacet screw placement by King[7] there has been continuous development in the screw placement techniques by various surgeons such as Boucher[8] Pennel et al[9] Louis[10] Dick[11]and Steffee et al[12]Pedicle width is an important factor which determines the diameter of screws that can be safely accommodated in a pedicle without breaching the lateral and medial cortex. The pedicle of the vertebra has also been used as a fixation site for vertebral implants. There is an increase in the width from L1 to L5 direction of the lumbar pedicle. The same has been observed in our study.It has been observed in the study performed by Singel et al[14] Lien et al[16] Tan et al[17]Wolf et al[18]and Mitra et al[19] that the width of the pedicle in the lumbar region from L1 to L4 increase gradually and there is sudden swift in the width of a pedicle from L4 to L5.

In our study also all the values of the pedicle width of atypical vertebrae were more as compared to typical vertebrae. This showed that the width of the pedicles went on increasing towards the caudal vertebrae, which was seen in all the reported studies.

The Interpedicular distance between the medial surfaces of the pedicles of the same vertebra constitutes the lateral walls of the vertebral canal. The reduction in interpedicular distance and antero-posterior shortening of the pedicle are the most typical causes of stenosis of the vertebral canal.

In the present study, the interpedicular distance of the typical vertebrae ranges from 16.86 to 25.08mm with a mean of 20.05±1.84 mm, but in atypical vertebrae, IPD was ranged between 19.85 to 29.59mm with a mean of 24.31±2.29 mm. In the present study, the maximum IPD value in male was 29.59mm, and in female, 25.82 mm was observed, but minimum IPD in male and female were 16.86mm, and 17.46 mm observed respectively. The IPD in males was slightly higher than females in our study.

Patel JP et al[20] studied in the Gujarat region and reported that the maximum IPD in male 27.0mm and in female 26.4mm at L5 (atypical) of lumbar vertebrae and minimum IPD at L1 (typical) in male 22.6mm and 21.3mm in the female. The IPD was increased from L1 to L5 in the present study, which is similarly reported by Patel JP et al[20].

Conclusion

The present study concluded that from L1 to L5, there is always an increase in the width of lumbar pedicles, and at the level of L5, the width is maximum, which justifies the weight transmission at that level. We also found a significant correlation between width and IPD of male and female lumbar vertebrae. Further, in this study, there is a significant correlation between the height of typical and atypical vertebrae. In the atypical vertebrae, the width of the pedicle was more as compared to height, while contrary to that, the height of the pedicle is more than the width in the case of typical vertebrae.With the advancement of imaging

technique and orthopaedic procedures, the data obtained from our study will be helpful to the clinician dealing with the unstable lumbar spine, and at the same time, it will be handy for the biomechanical engineer to design the screw. More study is required related to the vertebral morphometry as the morphometric data varies within sex, race, and ethnic groups spread over different demographic regions.

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