

Morphometric study of atypical lumbar vertebrae and its physiological correlation

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Abstract

Background: The fixation of lumbar spine is needed for various spinal problems such as fracture in lumbar spine, resection of tumors in vertebral bodies, gross spondylolisthesis, and lumbar instabilities. Majority of pedicle morphometric studies are based on white population in different parts of the world, whereas only a few studies are available on Indian population.

Objective: To report the results of a morphometric study of adult atypical lumbar vertebrae's pedicles and correlate them physiologically to provide morphometric inputs for the use of this vertebral component in implants fixation in the population of Rewa, Madhya Pradesh, India.

Materials and Methods: This study was conducted on 20 dry human atypical lumbar vertebrae obtained from Department of Anatomy, Shyam Shah Medical College, Rewa (Madhya Pradesh, India). Pedicle vertical height (h) and pedicle width (w) were measured with the help of a sliding vernier caliper.

Results: Positive correlations have been found between height and width of dry human lumbar vertebrae.

Conclusion: Results indicated that in Rewa region of central India, 15-mm Steffee pedicle screw can be used safely for atypical lumbar vertebrae.

KEY WORDS: Lumbar vertebrae, pedicle dimensions, spinal instrumentation, screw size

Introduction

A pedicle is the strongest part of a lumbar vertebra, which is entirely made up of cortical bone with a small core of cancellous bone.^[1] Strong and large pedicles of lumbar vertebra as compared with the thoracic and cervical ones make them ideal for screw instrumentation. Transpedicular screw fixation of spine has developed as a very successful method of spinal fixation. The fixation of lumbar spine is needed for various spinal problems such as fracture in lumbar spine, resection of tumors in vertebral bodies, gross spondylolisthesis, and lumbar instabilities. Majority of pedicle morphometric studies are based on white population in different parts of the world.^[2-5] Indian population forms the one-fifth of

the total population of the world and the nonresident Indians are also distributed widely in many countries, whereas only a few studies are available on this population. Also, there is a significant difference in size and shape of body parts in different places.

The aim of this study was to report the results of a morphometric study of pedicles of adult atypical lumbar vertebrae and correlate them physiologically to provide morphometric inputs for the use of this vertebral component in implants fixation in the population of Rewa, Madhya Pradesh, India.

Materials and Methods

We randomly selected 20 dry human atypical lumbar vertebrae obtained from Department of Anatomy, Shyam Shah Medical College, Rewa (Madhya Pradesh, India), for pedicle morphometry. All the vertebrae were fully ossified. We have excluded deformed and broken vertebrae from the study. Pedicle vertical height (h) and pedicle width (w) were measured using sliding vernier caliper. All measurements were done at three sittings, and the mean of the values corrected to the nearest millimeter was recorded.

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We used the following methods for recording measurements:

- Pedicle vertical height (*h*): Two closest points on the upper and lower margins of the pedicles in the vertical plane on its lateral aspect, as shown in Figure 1.
- Pedicle width (*w*): Two closest points on the medial and lateral surfaces of the pedicle, at right angle to the long axis of pedicle, as shown in Figure 2.

Results

Pedicle vertical height (*h*) and pedicle width (*w*) of atypical dry human lumbar vertebrae were measured. Mean, standard deviation, range, *p*-value, and correlation coefficient for height and width are given in Tables 1 and 2. For both height and



Figure 1: Pedicle vertical height (*h*) measurement (lateral view)



Figure 2: Pedicle width (*w*) measurement (lateral view)

Table 1: Pedicle height of lumbar vertebrae

	Right	Left
Atypical lumbar vertebrae		
Mean (mm)	14.565	14.565
SD	1.862	1.576
Range (mm)	11.5–18.4	11.7–17.5
<i>p</i> -Value	1	
Correlation coefficient	0.863	

Table 2: Pedicle width of lumbar vertebrae

	Right	Left
Atypical lumbar vertebrae		
Mean (mm)	17.385	17.705
SD	1.645	1.717
Range (mm)	15–20.8	15–21.3
<i>p</i> -Value	0.550	
Correlation coefficient	0.698	

width, the difference in the measurements between the right and the left sides was statistically insignificant ($p > 0.05$). Oval shape of the pedicles shows their associated physiological loads.

Correlations between height and width of dry human lumbar vertebrae are shown in Figure 3 (Graphs 1 and 2), indicating a positive correlation between the two.

Discussion

Pedicle screw fixation is rapidly becoming a widely used method of spinal instrumentation. Since King^[6] first placed short screws almost transversely across the lateral articulations

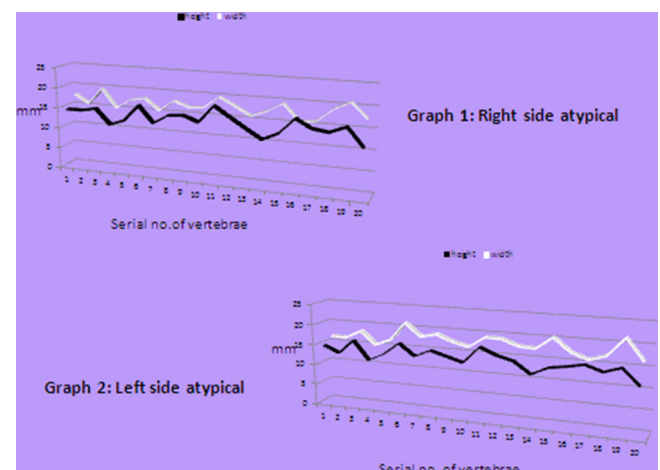


Figure 3: Correlations between height and width of dry human lumbar vertebrae

Table 3: Comparison of this study with earlier works

Vertebra level	Amonoo-Kuofi ^[2]		Singel et al. ^[15]		Arora et al. ^[14]		This study	
	Male	Female	Male	Female	Male	Female	Male	Female
L5 Height	20.7	17.5	13.4	13.25	19.48	18.3	14.56	17.54
Width	14.2	12.5	18.2	19.25	15.34	13.31		

Height and width are in millimeters.

of the posterior column of lumbar vertebrae (transfacet screw placement), there has been an almost continuous development based on the work of surgeons such as Boucher,^[7] Pennal et al.,^[8] Louis,^[9] Dick,^[10] Steffee et al.,^[11] and others.

Pedicle screws of several sizes and shapes are available. These include cortical as well as cancellous screws of varying pitch and screw patterns. Some are available in cannulated and uncannulated designs. Screws vary from 4.5 to 7.0 mm in outer and inner diameters. The length of pedicle screws varies, mostly increasing from 30 mm in 5-mm increments. The screws are designed to connect with certain fixation devices, most commonly either a plate or a rod.

Porter et al.^[12] suggested that increasing levels of physical activity were associated with increased strength of vertebral column in individuals aged more than 18 years. The variation in diameter of pedicles in different age groups may be due to the weight-bearing function.

Kothe et al.^[13] also reported difference of thickness on vertebral pedicle's corticals. According to these authors, the pedicle's lateral cortical thickness ranged from 0.4 to 0.6 mm, and the medial cortical from 0.9 to 1.7 mm. Pedicle's upper and lower corticals also showed different thickness at more cranial levels as per their physiological load.

In pedicle screw insertion, the screw is passed through the posterior aspect of the pedicle into the body of the vertebra anteriorly. Because the success of this technique depends on the ability of the screw to obtain strength within the vertebral body, the choice of the screw to be used is determined by the minimum diameter of the pedicle. Therefore, morphometric data concerning pedicles are useful in preoperative planning and also in designing pedicle screws and other implantable devices.

In our study, in atypical lumbar vertebrae mean pedicle vertical height was same on both right and left sides (14.565 mm). As compared to this study, slightly higher values for vertical height were reported by Arora et al.^[14] (16.42 mm in males and 15.6 mm in females) and lower values by Singel et al.^[15] (10.4 mm in males and 10.6 in females).

Because screw diameter is decided by the minimum diameter of the pedicle, vertical height is of little significance.

In our study in atypical lumbar vertebrae mean width of the pedicle was 17.385 mm on right side and 17.705 mm on left side, with minimum value of 15 mm on both sides.

If we compare our study with earlier works by other authors, some interesting facts come out (Table 3). In previous

reports by Amonoo-Koufi^[2] and Singel et al.,^[15] values for right and left pedicles of the lumbar vertebrae were nearly same. In our study also values for both sides were nearly same, as the *p*-value was more than 0.05, so the difference is insignificant. Chawla et al.^[16] and authors of earlier studies say that vertical height is always greater than its width, contrast to our study results, which indicates that in atypical lumbar vertebrae width is greater than height.

Increment in vertical and horizontal diameter leads to an oval shape of the pedicle and increased physiological loads at caudal direction may be correlated to the increased dimensions of the pedicles at more caudal vertebrae.

Conclusion

In Rewa for atypical lumbar vertebrae, 15-mm Steffee pedicle screw can be safely used, with exceptions of congenitally malformed vertebrae and the vertebrae having anatomical variations. Because the diameter of the pedicle screw is governed by the minimum diameter of the pedicle, according to this study above-mentioned size is safe in this region, which is also well correlated with physiological load at this level. It would be prudent to conduct further such type of studies in different parts of world, given its wide usage and subsequent beneficial implications.

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