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Morphometric evaluation of pedicle vertical height and pedicle width of lumbar vertebrae in Indian population for surgical application of transpedicular screw fixation: A computerised tomography scan based study

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Abstract

Introduction: Measurement of bone or any part of human body provides accurate knowledge about morphology of the structure which helps the clinicians in diagnosing and treating various diseases. Due to present lifestyle and with its speed, it has resulted in increase in the incidence of assaults on the vertebral column in the form of different spinal pathologies such as prolapsed intervertebral discs, spondylolisthesis, spondylosis, fractures^[1]. The horizontal diameter of pedicle decides the screw diameter. The transverse (width) and vertical (height) parameters of pedicle help in determining the screw path. So, the pedicle morphometry becomes important in the selection of most suited pedicle screw. The morphometry of the pedicle may vary from population to population.

Aims and objectives: To investigate the variability of the morphology and provide morphometric data of crucial parameters useful for accurate designing and placement of lumbar pedicle screw. The result of this study can be used to carry out larger studies.

Method and Materials: This prospective study is based on Salim A. Lad *et al.*^[2]. Data was collected by CT scan measurement of the pedicles along with its parameters (vertical height and width), and was compared with other associated studies with a collection of a mixed group of 80 patients age group of 18–60 years admitted to R.N.T Medical College and M. B. Hospital, Udaipur.

Result: The mean L1 pedicle width from left is 7.20mm and from right side is 7.23, L2 pedicle width from left is 7.88 and from right side is 7.90, L3 pedicle width from left is 9.20 and from right side is 9.23, L4 pedicle width from left is 10.5 and from right side is 10.51 and L5 pedicle width from left is 12.7 and from right side is 12.7mm.

Conclusion: In the present study we have made an attempt to understand the morphometry of the lumbar pedicles to decrease the risk of postoperative complications. The present study concludes that the different dimensions of the pedicle which have been studied would be of great help for successful pedicle screw fixation and also for quantification of spinal stenosis. There are, of course, a few limitations in our study.

Keywords: Lumbar vertebrae, pedicle Morphometry, lumbar pedicle screw diameter, transpedicular screw fixation

Introduction

It is well established that lumbar pedicle morphometric data varies within different sex, race, ethnic and regional groups. The growing need of various orthopaedics procedures as a part of treatment of lumbar spine pathologies demands accurate knowledge of measurements of the vertebra^[1].

The pedicles of lumbar vertebrae are short, thick, dorsal projections, from the superior part of body at the junction of its lateral and dorsal surfaces^[3]. The pedicle is strongest part of a lumbar vertebra. They are made of entirely cortical bone with a small core of cancellous bone. The success of surgical technique depends upon the size of screw for a particular pedicle size, and the presence or absence of osteoporosis in pedicle. A 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 this procedure must take pedicle dimensions into consideration [4]. The pedicle is the sole bridge between the posterior column and the middle and anterior columns. Hence pedicle screws traverse all three columns and as such can rigidly stabilize both the ventral and dorsal aspects of the spine. A break in the cortex of the pedicle can result from the misplaced screw. We see little studies being done in Indian context. Hence there is a need for our own metrical data specifically relevant to this region, which may, if found appropriate, fill up a big void.

Material and Method

This prospective study is based on Salim A. Lad *et al.* [2]. Data was collected by CT scan measurement of the pedicles along with its parameters (transpedicular height and width), and was compared with other associated studies with a collection of a mixed group of 80 patients of age range 18–60 years, admitted to R.N.T Medical College and M.B. Hospital, Udaipur during the period of 1st October 2017 to 30th October 2018. Patients were informed about the study, written consent was taken, and then they were evaluated.

Inclusion Criteria

1. Indian person of either male or female gender.
2. Person of age 18 – 60 years.
3. Patients presenting at the Imaging Diagnosis Department for lumbar spine for CAT scan for various soft tissue and visceral pathologies.
4. Patients willing for treatment and giving informed and written consent.

Exclusion Criteria

1. Persons with a history of lumbar spine pathology regardless of the etiology.
2. Persons with contraindications for a CAT scan.
3. Persons below 18 years of age or above 60 years of age.
4. Person with congenital or developmental musculoskeletal disorder.

Method

This prospective study included the patients who underwent computed tomography scans of lumbar spine irrespective of the nature of the spinal problem. The dysmorphic, diseased or fractured pedicle was not included in the study. The morphology of each pedicle was studied in terms of pedicle vertical height and pedicle width. The transverse section of CT scan on which both left and right pedicle appeared largest was considered as the mid pedicle cut and the same was used at each vertebral level to measure the morphological characters for both the right and left pedicles. The average of the two values was taken as the mean value.

Ortho-View Orthopaedic Digital Imaging software was used for all the measurements. Pedicle vertical height was measured as cortex- to- cortex and width of pedicle, along the line perpendicular to the pedicle longitudinal axis at the narrowest part of the pedicle.

The parameters included the following measurements

1. **Vertical Height of pedicle:** The points just opposite each other on the upper and lower margins of pedicles, in the vertical plane on its lateral aspect, where the diameter was maximum were considered. First record was taken on right pedicle and then on left.

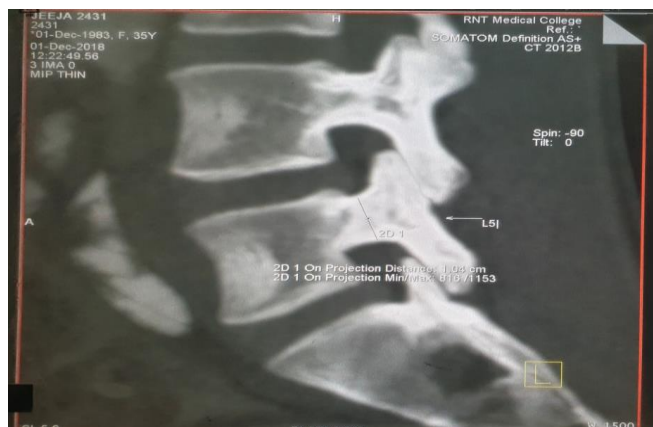


Fig 1: CT guided measurement of vertical pedicle height

2. **Pedicle Width:** The deepest points on the lateral and medial aspect of each pedicle were chosen. The thickness was measured at these points, at right angles to the long axis of pedicle. First reading was taken for right pedicle and then for the left.

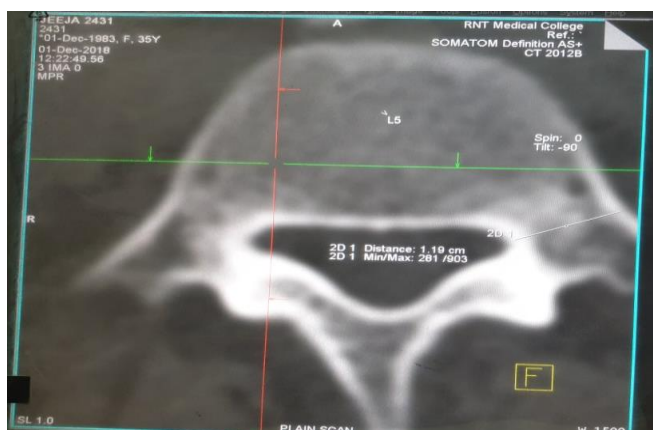


Fig 2: CT guided measurement of pedicle width of L5 vertebrae

Statistical analysis

Measurement parameters were tabulated using Microsoft Excel and analysed using SPSS version 16.0. Mean, standard deviation, and minimum and maximum values for each parameter measured was obtained and tables were constructed using these data. Categorical data were presented as number (proportion), and compared with chi-square test. Continuous variable were presented as Mean \pm SD and compared using t-test. $P < 0.05$ was considered statistically significant.

Observations

Here, 71.25% were males and 28.75% females.

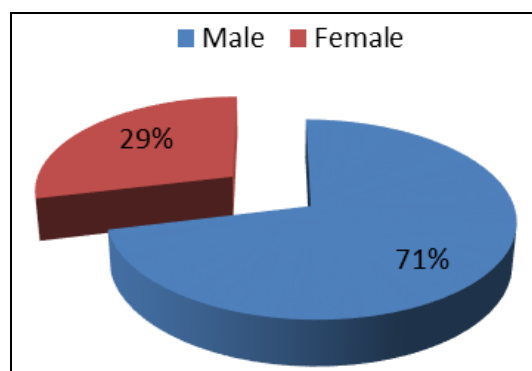


Fig 3: Gender wise distribution of patients

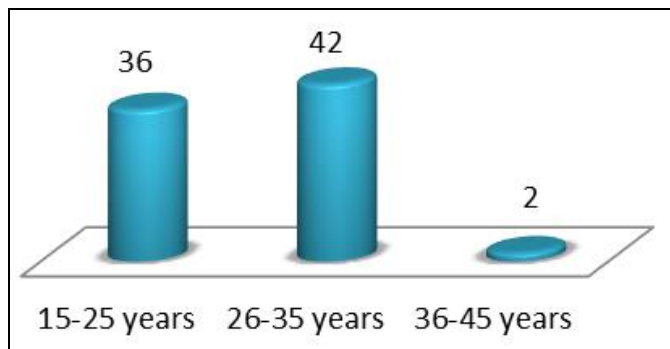


Fig 4: Age wise distribution of patients

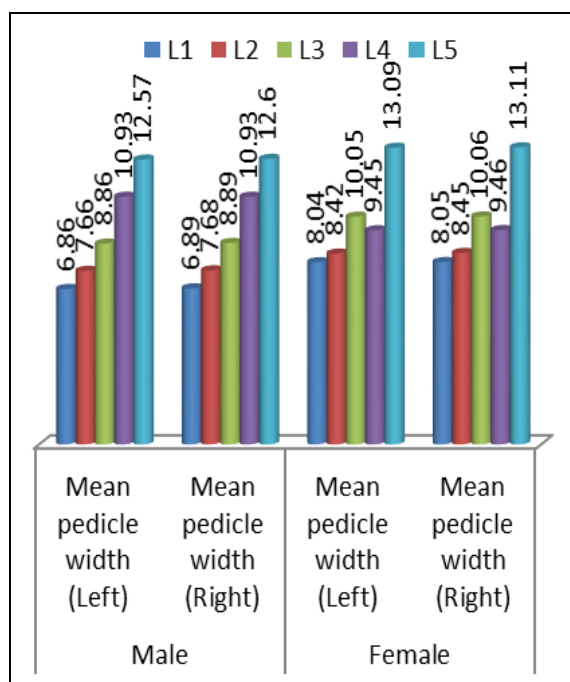


Fig 5: Measurements of lumbar pedicle width

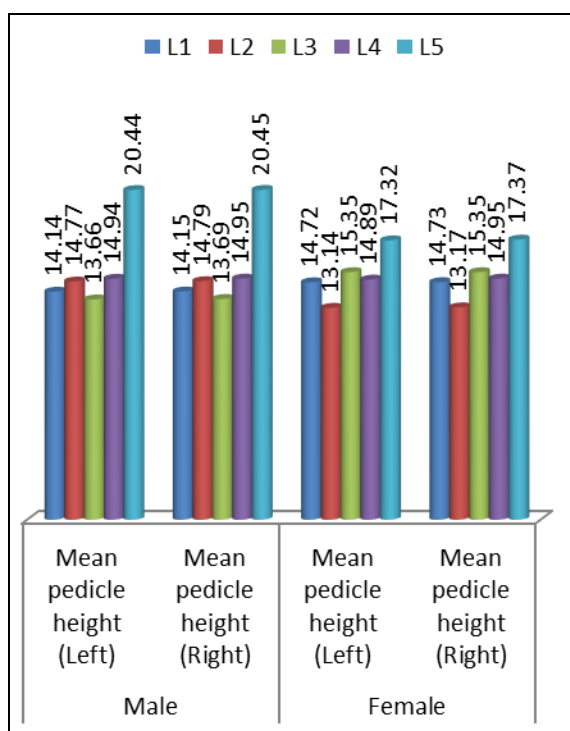


Fig 6: Measurements of lumbar pedicle height

Discussion

The width from left and right side of the pedicle was measured using CT scan on 80 adult lumbar vertebrae. The mean L1 pedicle width from left is 7.20mm and from right side is 7.23, L2 pedicle width from left is 7.88 and from right side is 7.90, L3 pedicle width from left is 9.20 and from right side is 9.23, L4 pedicle width from left is 10.5 and from right side is 10.51 and L5 pedicle width from left is 12.7 and from right side is 12.7mm. The general trend of our measurement of the pedicle dimensions was consistent with that of Olsewski *et al.* in the lumbar spine [5].

In present study, the maximum transverse diameter was found at L5 level. The maximum mean transverse diameter was found at L5 (12.001 mm). The range of maximum transverse diameter was from 9 to 20 mm at L5 level. These findings coincided with different authors’ findings: Amono K. (1995) [6], Scoles 1990 [7], Olsewski (1990) [5], whereas study conducted by Berry (1987) [8] and Mitra (2001) [9] observed the maximum transverse diameter was L1 level.

The present study showed that the width (horizontal) of pedicles increased from L1-L5 in both sexes but the height (vertical) of pedicles decreased from L3-L5 in both sexes, in the lower lumbar pedicles, The mean L1 pedicle width from left is 7.20mm and from right side is 7.23, L2 pedicle width from left is 7.88 and from right side is 7.90, L3 pedicle width from left is 9.20 and from right side is 9.23, L4 pedicle width from left is 10.5 and from right side is 10.51 and L5 pedicle width from left is 12.7 and from right side is 12.7mm. The general trend of our measurement of the pedicle dimensions in the lumbar spine was consistent with that of Olsewski *et al.* [5].

Table 7: Comparison of Present Study with different previous studies (all values in mm)

Parameter	Pedicle width				
	L1	L2	L3	L4	L5
Berry (1987)	7	7.5	9.2	10.4	10.7
Zindrick (1987)	8.7	8.9	10.3	12.9	18
Scoles (1988)	8.3		9.1		9.7
Olsewski (1990)	9.5	9.6	11.7	14.7	21.1
Mitra (2001)	7.05	7.85	9.01	11.6	16.19
Single (2004)	8.2	8.5	10.4	13.3	18.2
Present Study	7.2	7.88	9.2	10.5	12.7
Parameter	Pedicle height				
	L1	L2	L3	L4	L5
Berry (1987)	15.6	15.6	14.5	13.1	13.7
Zindrick (1987)	15.4	15	14.4	14.8	14
Scoles (1988)	13.3		14.1		16.2
Olsewski (1990)	17	16	16	16.4	17.4
Mitra (2001)	15.68	15.27	15.03	14.79	15.6
Single (2004)	14.7	15	14.7	14	13.4
Present Study	14.3	14.33	14.15	14.9	14.5

Conclusion

The present study concludes that, the different dimensions of the pedicle which have been studied would be of great help for successful pedicle screw fixation and also for quantification of spinal stenosis. However our study has thrown up a number of avenues for future research. If our limitations are overcome in larger studies, we would have strong guidelines for efficient surgery of transpedicular screw fixation and also for effective quantification of spinal stenosis.

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