

Original article

Study of Lumbar Vertebrae with respect to the dimensions of the pedicle in South Indian population

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ABSTRACT

Introduction: A morphometry study of the lumbar vertebra specifically with respect to the dimensions of the pedicle was done with 20 adult cadavers of both male and females.

Methods: Pedicle length, height, width were measured. The angulation between the lateral aspect of the root of the pedicle and body of vertebra was measured as pedicle angle and the distance between the point of junction of mammillary process and point of angulation of vertebral body also were measured. The measurements were taken directly from the specimen and also from the CT image of the same specimens.

Observations: In direct measurement of the lumbar vertebrae, the pedicle width was ranging between 7.2 -13.9 mm from L1 to L5. The height of the pedicle ranged between 13.7 to 13.1mm and the length was 7.1 to 5.1 mm. The same measurements in CT evaluation were 6.7 to 12.5 mm for pedicle width, 12.4 to 10.9 mm for pedicle height and 7.4 to 5.4 mm for pedicle height.

Results & Conclusion: There was no statistically significant difference between the measurements in male and female cadaver specimens and also between the direct and CT measurements. However the dimensions as a whole were slightly lower when compared to studies in other populations reiterating the existence of racial differences in the pedicle dimensions which will help clinically to select appropriate pedicle screw.

Key words: Lumbar vertebra, dimensions of pedicle, pedicle screw, South Indian

Introduction

The lumbar vertebrae are the largest vertebrae in the dynamic part of the spinal column. They support the maximum body weight and exhibit the greatest degree of degenerative changes. As the maximum degenerative changes occur in the lumbar spine level the interventions aimed to alleviate the disease is also more commonly done at this level.

Among the interventions for the diseases affecting the lumbar spine, pedicle screw fixation is one of the

important and widely used interventions. Vertebral pedicle forms an important part in weight transmission⁽¹⁾. Vertebral pedicle has also been used as an access port for procedures performed inside the vertebral body, such as biopsies, vertebroplasties or kyphoplasties.

Pedicle screw fixation is a technically demanding procedure that requires a thorough understanding of spinal anatomy. The success of this technique mainly depends on the ability of the screw to maintain

purchase within the body of the vertebra like the size of screw which in turn depends on the minimum width of the pedicle because anything larger will cut through the pedicle and liable to cause injury⁽²⁾. Also, the length of the screw is dependent on the length of the pedicle and the distance from the point of entry of the screw (which is usually the junction of the superior articular facet and the transverse process) to the place where the vertebral body angulates. Thus, it is imperative that for proper design of the screw and correct placement of the pedicle screw, detailed and correct knowledge of anatomy of lumbar vertebra is essential. The choice of the pedicular screw is determined by the minimum diameter of the pedicle. According to Krogman⁽³⁾, racial differences in the skeleton are well known. The dimensions of the pedicle are not much detailed in the literature because they vary in different populations. The studies that have come up with these dimensions also mostly pertain to the Caucasian population. The dimensions of pedicle in South Indian population have not been much documented.

AIM & OBJECTIVES

The aim of this study is to document the dimensions of the pedicle in the South Indian Population as studies pertaining to them are very limited.

MATERIALS AND METHODS

Twenty adult embalmed human cadavers were selected from the cadavers in the Institute of Anatomy, Madras Medical College, Chennai

STUDY METHODS

- A. Dissection Method
- B. Radiological study- CT study of dissected Lumbar Spine

A. DISSECTION METHOD

The lumbar vertebrae were removed from the cadavers enbloc and then chemically treated with caustic soda solution to remove the soft tissue. The remnants of soft tissue following chemical treatment were removed by manual dissection and then immersed in hydrogen peroxide solution. They were then air dried and taken up for measurements.

Morphometric measurements were done on the individual vertebrae with the use of digital vernier calipers and the modified protractor as follows:

1. Pedicle Width (Transverse Diameter of the pedicle)

Measured between the closest points in the lateral and medial aspects of the upper surface of the pedicle (Fig: 1A & 1B).

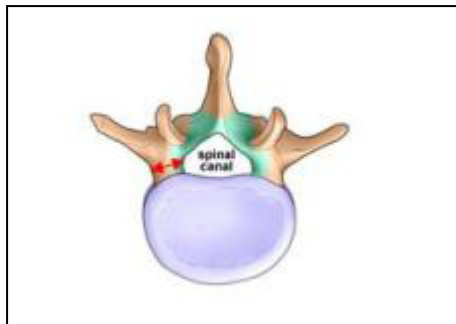


Fig:1A



Fig:1 B

2. Pedicle Height (Vertical Diameter of the pedicle)

Measured between the closest points in the upper and lower margins of the pedicle in the vertical plane on its lateral aspect (Fig: 2A & 2B)

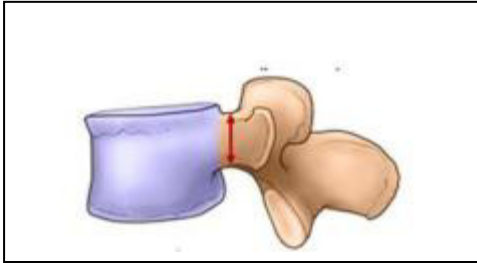


Fig:2A



Fig:2B

3. Pedicle Length

Measured between the point of attachment of pedicle to the body of the vertebra and the junction of the pedicle to the transverse process. (Fig: 3A & 3B)



Fig:3A



Fig:3B

4. Pedicle Angle

Measured between the lateral aspect of the root of the pedicle to the body of the vertebra. (Fig: 4A & 4B)

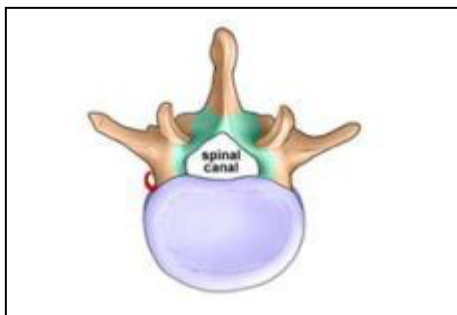


Fig:4A



Fig:4B

5.Distance of the pedicle from the junction of the mamillary process to point where vertebral body angulates.(Fig: 5A & 5B)

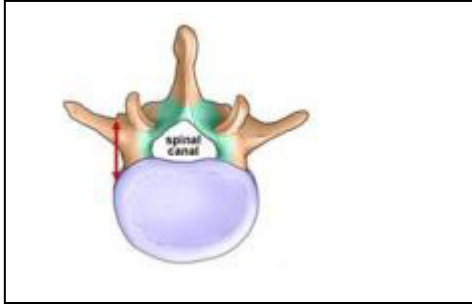


Fig:5A



Fig:5B

RADIOLOGICAL STUDY

The individual dissected vertebrae were assembled in corresponding sets and were subjected to CT imaging. Images were taken at 0.9 mm slices following which bone reconstruction was done. The measurements were then taken from the CT images in both sides for the same parameters as measured directly.

OBSERVATIONS

The findings of the measurements were recorded in the statistical software SPSS under two groups as follows:

Measurements taken directly with digital vernier calipers of the specimens

(bones) obtained from cadavers. Totally twenty sets of lumbar vertebrae i.e., 100 vertebrae are measured comprising of 10 male and 10 Female cadavers.(Denoted as Direct)

Measurements taken from computerized tomography scan images of the specimens (bones) taken from cadaver.(Denoted as CT)

The findings were analyzed with SPSS software version 16.0. Analysis of the recordings of the right and left measurements by ANOVA 2 test showed no significant difference. Hence, pooling of data of both right and left sides was done and single measurements were recorded for each individual vertebra under each group.

TABLE:1 Direct Measurement of Lumbar Pedicles from cadaveric specimens*

No. of Lumbar Vertebra	Pedicle Width (in mm)		Pedicle Height (in mm)		Pedicle Length (in mm)		Pedicle Angle (in Degrees)		Distance between Mamillary process & Vertebral Body Angulation(in mm)	
	M	F	M	F	M	F	M	F	M	F
L ₁	8.2±2.9	6.2±1.1	13.7±1.3	13.7±0.9	6.5±1.1	7.8±0.7	141.1±12.7	153.7±07.4	29.8±2.5	30.9±4.6
L ₂	8.0±1.7	6.2±1.7	13.5±1.0	13.1±0.7	6.5±0.5	6.5±0.6	144.1±12.5	151.1±07.6	31.6±5.5	31.1±3.0
L ₃	8.5±1.8	7.3±1.3	12.8±1.6	13.1±0.6	6.4±0.9	7.1±0.3	146.0±9.6	146.8±6.7	30.2±5.1	31.1±2.4
L ₄	10.2±1.4	9.1±1.0	11.9±1.1	12.1±1.2	5.7±1.0	6.6±0.2	145.3±9.1	153.5±3.7	29.3±2.9	29.5±1.4
L ₅	13.1±2.5	14.8±3.7	12.7±3.2	13.4±3.3	4.9±0.8	5.3±1.0	147.4±9.4	148.3±12.7	29.4±2.7	28.3±1.3

*Data are given as mean with standard deviation;

As per student t test ('p' value ≤0.05), no stastically significant difference was found between male and female specimens

TABLE:2 Comparison between Direct Measurement of Lumbar Pedicles from cadaveric specimens and Radiographic Measurement*

No. of Lumbar Vertebra	Pedicle Width (in mm)		Pedicle Height (in mm)		Pedicle Length (in mm)		Pedicle Angle (in Degrees)		Distance between Mamillary process & Vertebral Body Angulation(in mm)	
	Direct	CT	Direct	CT	Direct	CT	Direct	CT	Direct	CT
L ₁	7.2±2.3	6.7±2.0	13.7±1.1	12.4±1.5	7.1±1.1	7.4±1.2	147.4±11.8	148.9±9.5	30.4±3.6	29.5±2.3
L ₂	7.1±1.7	6.8±1.6	13.3±0.8	12.1±1.7	6.5±0.6	6.8±0.9	147.6±10.5	150.2±8.5	31.3±4.2	29.3±1.8
L ₃	7.9±1.6	7.8±1.0	13.0±1.1	12.8±1.8	6.7±0.7	6.8±0.8	146.4±7.8	149.3±6.4	30.7±3.8	29.9±1.4
L ₄	9.7±1.3	9.9±1.3	12.0±1.1	12.2±2.5	6.1±0.9	6.9±1.9	149.4±7.9	150.1±8.0	29.4±2.2	30.5±1.8
L ₅	13.9±3.1	12.5±2.8	13.1±3.1	10.9±1.4	5.1±0.9	5.4±0.8	147.9±10.5	150.8±8.8	28.9±2.1	31.3±2.2

*Data are given as mean with standard deviation;

As per student t test ('p' value ≤0.05), no stastically significant difference was found between measurements taken with the specimens directly and through CT.

DISCUSSION

The findings of the present study are helpful in determining the dimensions of pedicle in the South Indian population. It was observed that the pedicle width was increasing in size from L1 to L5 vertebral levels.

Measurement of Pedicle Width Directly in both Males and Females combined

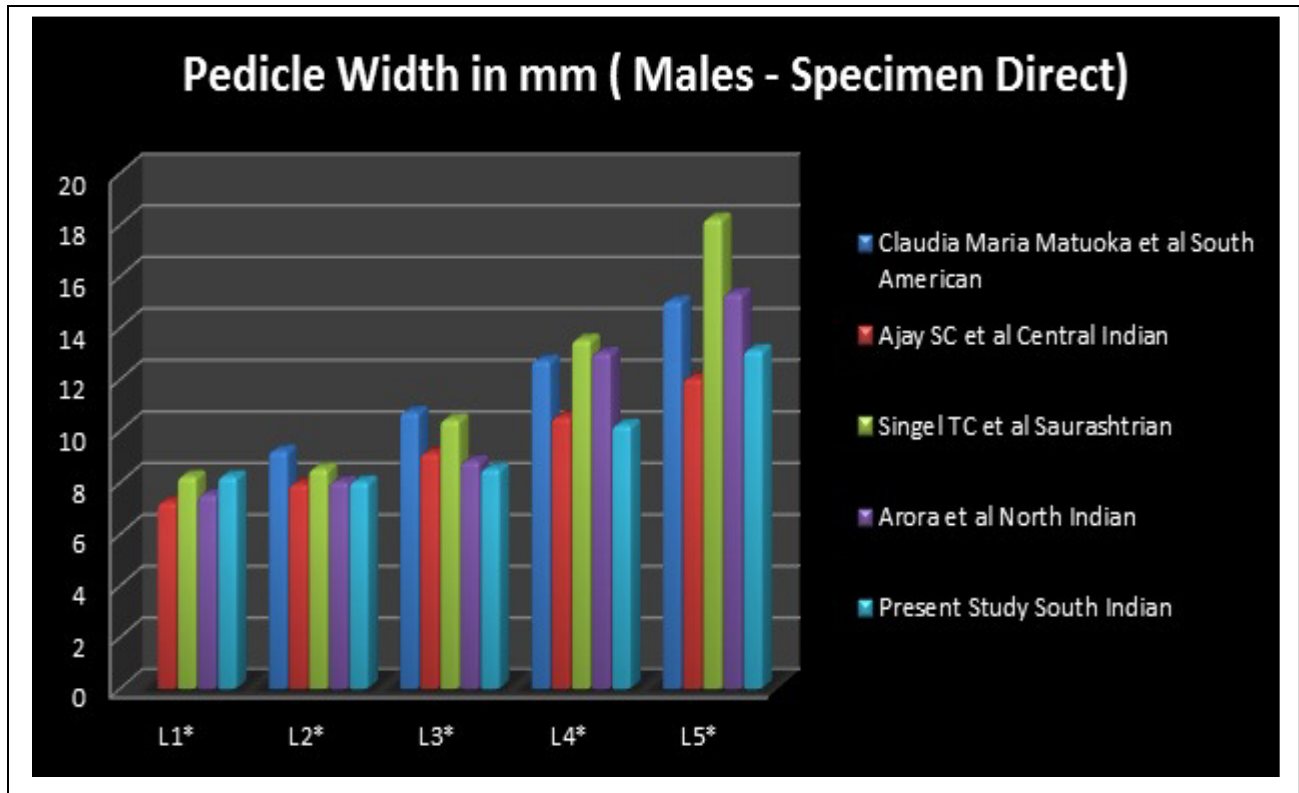
Table: 3

Study	Population	Type of Specimen	L ₁ *	L ₂ *	L ₃ *	L ₄ *	L ₅ *
Aruna.N et al (2011) ⁽⁴⁾	Bangalore	Dried Bones	7.4	7.9	9.9	11.4	12.3
Tan S.H et al (2003) ⁽⁵⁾	Chinese Singaporean	Bones from cadavers	5.6	6.3	7.6	8.9	11.7
Present Study	South Indians	Bones from cadavers	8.2	8.0	8.5	10.2	13.1

*Measurements in mm

It is seen from the Table given above (Table: 3) that the pedicle width increases from L₁ to L₅ in all the studies which corresponds with the present study. The dimensions recorded in the present study are closer to the Bangalore study whose population also represents the South Indian Population.

Fig:6



The various studies on width of the pedicle measurements represented in the chart (Fig:6) above also reiterate the same findings. The dimensions are greater among the South Americans, whereas the dimensions in the present study are closer to the values observed in Indians especially Central Indian population. The dimensions of the vertebra in the present study being closer to the above study can also be attributed to the fact that both the studies are done with the bones extracted from cadavers, in

comparison to other Indian studies where measurements are taken from dried bones. However, differences observed in the dimensions within the Indian population corroborates with the fact that the dimensions of the pedicle width does differ among the different sub populations within the same race as evinced by the other authors.

With regards to the pedicle height, as seen from the table below (Table :4), the height of the pedicle reduces from L1 to L4, except L5.

TABLE:4

Direct Measurement of Pedicle Height in both Males and Females combined:

Study	Population	Type of Specimen	L ₁ *	L ₂ *	L ₃ *	L ₄ *	L ₅ *
Aruna.N et al (2011) ⁽⁴⁾	Bangalore	Dried Bones	14.8	14.4	14.2	13.9	17.5
Tan S.H et al (2003) ⁽⁵⁾	Chinese Singaporean	Bones from cadavers	13.1	12.8	12.5	13.2	17.3
Present Study	South Indians	Bones from cadavers	13.7	13.3	13.0	12.0	13.1

*Measurements in mm

With respect to the pedicle length, it has been observed that the pedicle length decreases from L1 to L5 with the mean length of 7.1 mm for L1 and 5.1 mm for L5. This corresponds to the study of **H.H.Kadioglu et al(2003)⁽⁶⁾** who studied in 16 sets of cadaveric bones and reported that the pedicle length is longest at L1 and shortest at L5.

The other parameters taken up for measurement in this study were specifically measured for practical use in determining the dimensions of screw for fixation. These measurements were hitherto not available in other research studies and so comparative studies are not available.

It had also been observed that the difference in dimensions between males and females were not

statistically significant, though overall the measurements are lower when compared to males. However, the study will help to determine the dimensions of pedicular screw for an average South Indian woman. Also, it was observed that there was no stastically significant difference between measurements taken directly and that of the CT of the same specimen. This contradicts the studies that there is significant difference in measurements between CT of living subjects and cadaveric specimens. It can be deciphered that the soft tissues around the vertebrae are responsible for the difference which was not there when CT was taken with the same cadaveric specimen.

Conclusion

The dimensions of the adult lumbar vertebrae belonging to South Indian population are studied with respect to width, length and height of the pedicle, distance between the mamillary process and the vertebral body angulation, angle between the root of the pedicle and the body of the vertebrae. Knowledge of the dimensions of the pedicle among the South Indian population will help the Clinicians plan their surgery better especially pedicle screw fixation. As

seen from above, there is no statistically significant difference between the measurements taken directly from the specimen and from that of the CT of the same specimen and also between male and female specimens. Other dimensions with reference to pedicle like distance from mamillary process to vertebral body angulation, pedicle angle have not been done in the previous studies, which will be further helpful in planning for pedicle screw fixation.

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