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Computed tomographic morphometry of thoracic and lumbar pedicles in South Indian population

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ABSTRACT

Pedicular fixation of the lumbar spine with screws is becoming increasingly popular. Anatomy of pedicle has become important because of accelerated use of pedicle fixation devices. Pedicle width and chord length are limiting factors for the transpedicular screw diameter and length. The present study desires to record the surgical relevant parameters of the thoracic and lumbar pedicles in South Indian population and also to compare results with similar studies among the global population. Total 100 computed tomographic [CT] scans of the lower thoracic and lumbar vertebrae using a scanner with 1.5mm cuts were reviewed in the study. Pedicle width, pedicle inclination in transverse plain and chord length of vertebrae from T9 to L5 were measured and mean values were calculated for each levels and both sexes separately. The study showed pedicle width increases from T9 to L5. Pedicle inclination angle and chord length was lowest at T12 and largest at L5 vertebrae. All measured pedicle parameters were larger in males compared to females. Pedicle morphometric parameters vary from values of other populations, hence knowledge of surgically relevant parameters of pedicles is necessary for success of transpedicular fixations.

INTRODUCTION

Spinal pedicle screw fixation represents the so called gold standards of spinal internal fixation [1]. Pedicle screw systems engage all three columns of the spine and can prevent motion in all planes. Study of several studies suggests that pedicle screw fixation is a safe and effective treatment for many spinal disorders [2]. The pedicle screw-bone junction provides the strongest point of attachment of the instrument to the spine. Hence, pedicle screw fixation systems can prevent motion in all planes [3].Several systems of internal fixation that attach through the pedicles are currently available. Accurate anatomical descriptions of the shape and orientation of pedicles are necessary for the development and use of implantable devices and spinal instruments. The detail of pedicle morphology becomes important as it helps in the selection of most suited pedicle screw. If the dimensions of pedicles change at each vertebral level and vary according to the sex and age of patients, information on these variations might help to prevent failure of fixation and injury to vital structures. It is important to distinguish differences in the morphology of pedicles in men and women. Several studies have investigated the morphology of pedicles. Most of the studies are based on white populations. Previous studies had shown significant interracial differences of thoracic pedicle morphometry [4]. They used various techniques, such as direct cadeveric measurement and measurement on plain radiographs or computerized tomographic scans. Computed Tomography scan is the best means of evaluating the pedicle morphology. Various authors have shown that no significant statistical difference exists between data obtained from Computed tomographic scans and direct cadaveric measurements [4]. The aim of the present study is to assess pedicle morphology in South Indian population based on CT scans.

MATERIALS AND METHODS

The present study was a cross sectional study done between January 2010 to January 2011 in Kasturba Medical college hospitals, Mangalore. The institutional ethical committee clearance was obtained before the study and written informed consent was taken from all study subjects. Sample size of 100 was calculated with confidence level of 95%. Convenient sampling method was followed.100 CT Scans of in patients admitted in the hospitals for surgical and medical diseases were studied using a

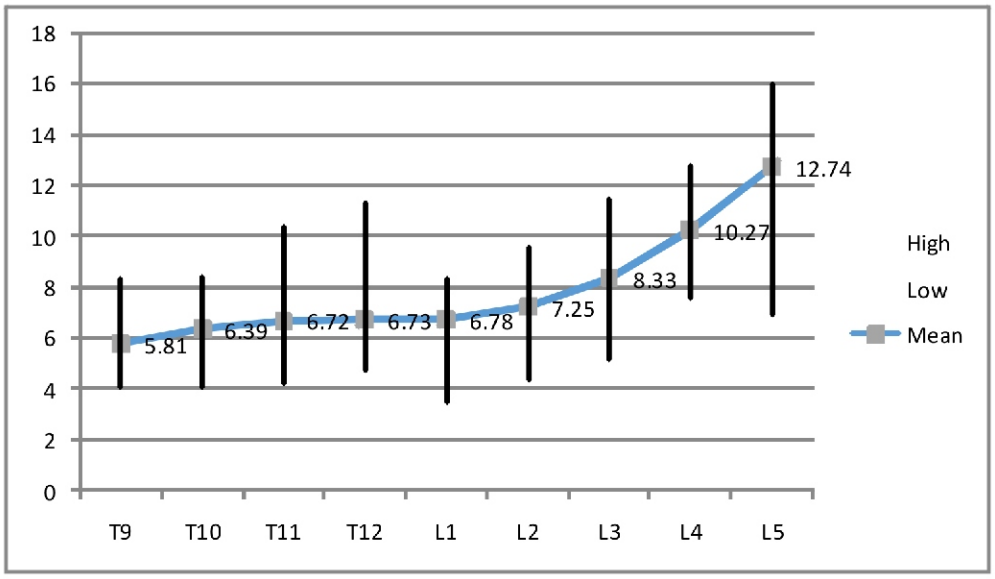


Fig 1. Pedicle width (mean and range)

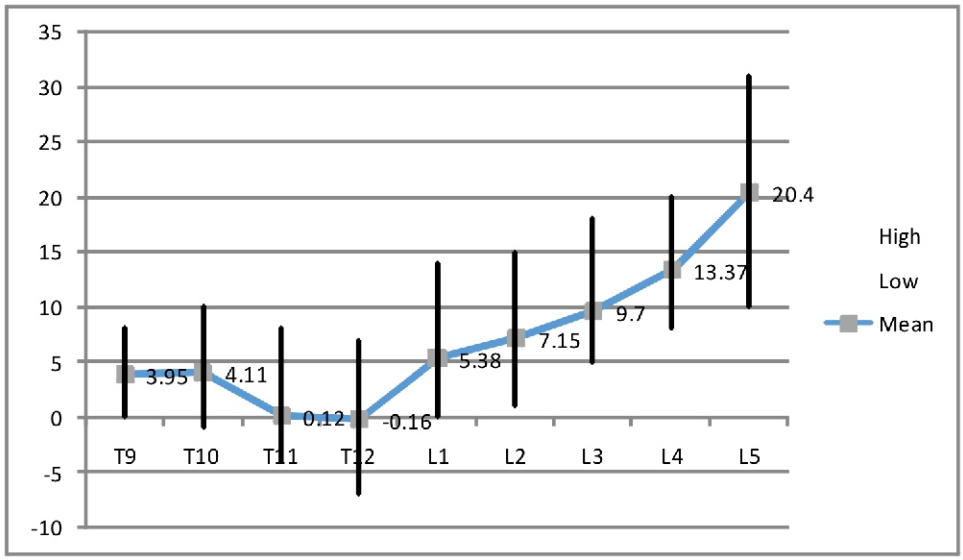


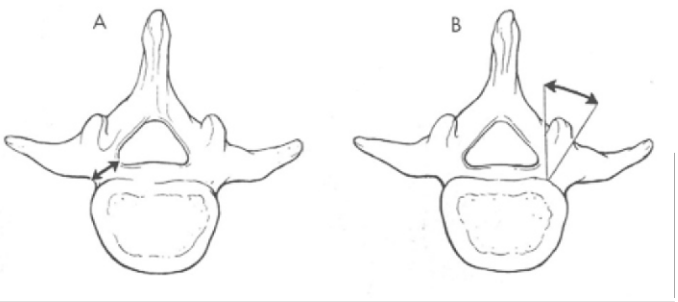
Fig 2. Pedicle inclination (mean and range)

scanner with 1.5mm cuts. Vertebrae from 9th thoracic level to 5th lumbar vertebrae are included. Only vertebrae with complete fusion of ossification centres were included. All the pathologic vertebrae were excluded from the study. All the measurements are made directly from the scanner software using bone window setting. All measurements are made by same investigator to avoid inter observer discrepancy. Using the bone window the cut section of CT where the left and right pedicles appear largest is selected. The following measurements are made.

1. **Pedicle width(PDW):** This is measured as distance between outer cortex to outer cortex at the narrowest part of the pedicle to the accuracy of 0.1mm (Fig A).

2. **Pedicle inclination (PDIt)** in transverse plane: This is the angle formed by the longitudinal axis of the pedicle to the midline of the vertebral body.(Fig B). Angulation anteromedially is referred to as positive and that towards anterolaterally is referred to as negative.

3. **Chord length (CL):** It is the depth to anterior cortex along the axis of the pedicle. It is measured along the axis of the pedicle from the flattest portion of the posterior cortex of lamina to anterior cortex these are measured to the accuracy of 0.1mm.



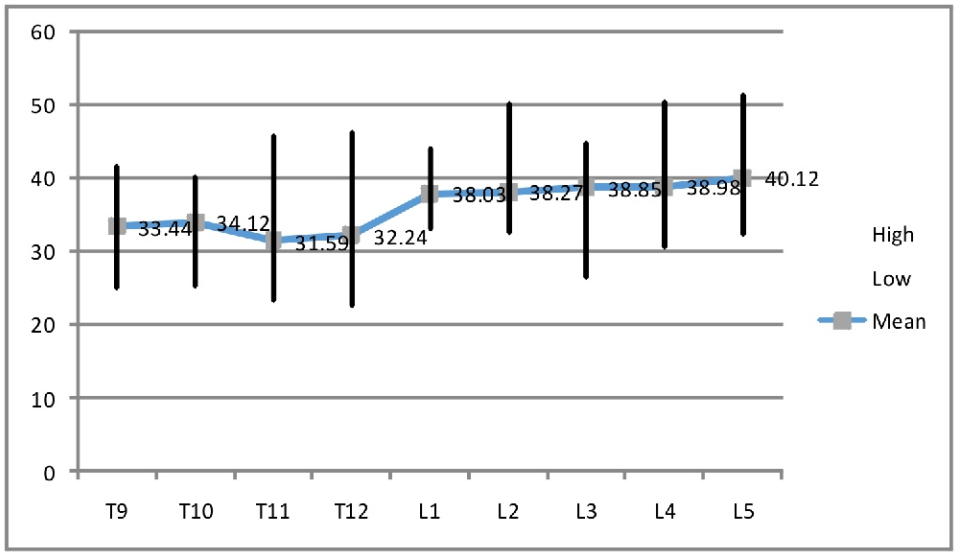


Fig 3. Chord length(mean and range)

These measurements are made at each level starting from T9 to L5. Data collected from study was compiled in excel spread sheets. Descriptive statics such as mean, percentage and range were used and analyzed separately for pedicle width, pedicle inclination and chord length at all levels from T9 to L5 in both male and female patients and results were tabulated. Further results were then compared with previous literatures.

RESULTS

The patients ranged in age from 29-68 years. 6% are below 30yrs of age, followed by 30% between 31-40yrs of age, 40% falling in 41-50yrs age group, 14% in 51-60yrs age group and 10% above 60yrs. In the present study there are 67 males and 33 females. Pedicle width ranged from 3.5mm to 16mm with lowest at L1 and largest at L5 vertebrae. On average, the smallest mean transverse pedicle width was at T9 (5.81mm) and largest was at L5 (12.74mm). The mean transverse pedicle width increases from T9-L5,as depicted in Figure1. In females pedicle width is smaller than that of males at all levels except T12 (Male-6.62mm, Female-6.96mm)as depicted in Table1. Pedicle inclination angle ranged from -7º to +31º with lowest atT12 vertebrae and highest at L5 vertebrae. The smallest mean pedicle inclination in transverse plane was at T12 (-0.16º) and largest was at L5 (20.4º)as depicted in Figure2. Pedicle inclination in transverse plane was slightly more in males compared to females as shown in Table 2. Chord length ranged from 23.4mm to 45.7mm with shortest distance at T12 vertebrae and longest distance at L5 vertebrae .The shortest mean chord length (along the pedicle axis)was at T11(31.59mm) and the longest was at L5 (40.12mm) as illustrated inFigure3.Chord length was more in Males compared to females as shown in Table3.

DISCUSSION

Transpedicular fixation offers a better biomechanical instrumentation to manage various pathological conditions of the spine. A knowledge of the pedicle morphometry is compulsory to ensure safe pedicle screw placements, particularly the isthmus, since it is the primary limiting factor for the screw insertion [5]. Anatomic variations can make screw placement challenging, and retrospective studies have demonstrated that even in experienced hands, pedicle wall violations can occur in up to 29% of cases [6].

Table 1. Pedcile width (PDW) male and female

PDW	FEMALE	MALE
T9	5.59	5.73
T10	6.18	6.51
T11	6.43	6.86
T12	6.96	6.62
L1	6.27	7.05
L2	6.65	7.54
L3	7.36	8.8
L4	10.16	10.31
L5	12.26	13.03

An inconsistency between pedicle width and screw diameter can lead to severe complications, such as nerve, vascular, and visceral injuries. Therefore, the success of the technique depends largely on the best knowledge of pedicle morphology.A penetration should ideally be placed along the axis of the pedicle, incorporating the largest available transverse and sagittal pedicle diameters for stable fixation [6].

The present study compared with the previous studies [7-14] showed a similar trend with respect to pedicle width that, it gradual increase from T9 to L5. Zindrick et al [7], Krag et al [8], Berry et al [9] and Hou et al [10] reported a higher pedicle width values, where as our study, Manish Chada et al [11] , Datir and Mitra et al [12,13] and Balaji et al [14] showed similar values from T9 to L5 vertebrae. Pedicle width diameter of less than 6.0mm was most common at T9 (74.12%), followed by T10

Table 2. Pedicle inclination (pdi) male and female

PDI	FEMALE	MALE
T9	3.16	4.4
T10	4.24	4.03
T11	-0.39	0.39
T12	-0.48	0
L1	4.79	5.67
L2	5.67	7.89
L3	8.27	10.4
L4	12.53	13.75
L5	19.2	20.97

Table 3. Chord length (cl) male and female

CL	Male	Female
T9	34.7	31.23
T10	35.18	32.19
T11	32.04	30.72
T12	32.27	32.16
L1	38.7	36.79
L2	39.07	36.63
L3	40.11	36.29
L4	39.03	38.86
L5	40.17	40.01

(23.66%). Pedicle width range is more in lower lumbar vertebrae. Lowest value recorded for pedicle width in the present study is 3.5mm at L1 and highest is 16mm at L5 vertebrae. Pedicle widths in lumbar region are well above 5mm except at L1.

In present study, pedicles are angulated anteromedially at all levels except T11 and T12 where they may face either anteromedially or anterolaterally, so care has to be taken not to penetrate medial cortex inadvertently while placing a screw at these levels. Also this anterolateral angulation is more common in females. 46% of pedicles at T11 and 53% of pedicles at T12 in females are facing anterolateral. One should be careful about the angle of screw insertion while preparing the pedicle in thoracic region as the range is -7 ˚ to +10˚,anterolateral to anteriomedial respectively . Therange in lumbar vertebra is from 0˚-31˚ all facing anteriomedially.

Zindrick et al [7] reported smallest angle at T11 in contrast to present study where T12 has the smallest angle (reversal of angle).Observations of present study are smaller compared to values reported by Zindricket al [7], Krag et al [8] and Berry et al [9]. The results seen in our study with respect to pedicle inclination angle, were consistent with that of Manish chada et al [11], Datir and Mitra [12,13] and Balaji et al[14].

In our study mean chord lengths of all lumbar and thoracic vertebrae are similar, but values of thoracic vertebrae are slightly smaller compared to lumbar vertebrae. Zindrick et al[7] and Datir and Mitra et al [12,13]studies reported higher chord length values compared to present study.

CONCLUSION

Pedicle morphometric parameters show significant variations in different studies and this can be due to different characteristics of population studied .Proper pre-operative evaluation should be done to precisely ascertain pedicle size before surgery so that improper use of screws can be avoided. Pre-operative Computed tomography scan is recommended before pedicular screw fixation to choose an appropriately sized implant and avoid complications.

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