Original Article

Morphometric Study of Dorsal and Lumbar Pedicles in the Indian Population — A Retrosepctive Study of 150 Cases

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Abstract

Background : The use of various sizes, types of pedicle screws in thoracic and lumbar spine is guided by the morphometry of the pedicles.

Aims and Objectives : To study the dimensions and orientation of pedicles in the thoracic and lumbar spine in Konkan region in India.

Materials and Methods : Pedicle dimensions of thoracic and lumbar spine of 150 people visiting a tertiary care hospital in Goa were studied.

Results : The transverse diameter of pedicles from D5 to L5 varied from 4.51 to 10.1 mm, sagittal diameter ranged from 5.4 to 11.69 mm. Transverse angle ranged from 3.27 to 21.09, sagittal angle varied between 2.19 to 16.51.

Conclusion : This study provides database of morphometric characteristics of thoracic and lumbar pedicles from D5 to L5 in population along Konkan coast of India and can provide information for future comparative studies.

Key words : Spine, Pedicle Size.

Transpedicular screw implantation techniques have been popular for years. Pedicular screw fixation gives stable and rigid construct in case of spinal injuries, therefore allowing early ambulation, preventing complications of immobility. Accurate insertion of pedicle screws is challenging and it has a steep learning curve and requires training to prevent complications. The challenges posed are the variable height, width, orientation of pedicles and nerve roots which are in proximity to the path of insertion.

Misdirected pedicular screw may injure pedicle cortex, nerve root, zygapophyseal joints and other vital structures including pleura, oesophagus, segmental and intercostal vessels[1,2]. Since the margin of error for inserting the pedicle screws is very low especially in thoracic pedicles the practice of measuring the size of transverse diameter of pedicles at the isthmus is imperative in preventing complications. Data obtained by linear and angular parameters of pedicle can help surgeons for safer screw placement in circumventing damage to nerve root, meninges and nearby vascular structures during surgeries. Pedicle sizes of different population around the world have been studied[3-5]. There are studies involving various parts of India[6-9].

Editor's Comment :

- This study provides morphometric data on thoracic and lumbar pedicles aiding surgeon safer pedicle screw placement.

Use of intraoperative fluoroscopy is the most commonly used method for correct placement of screws. Intraoperative CT navigation and robot assisted[10] methods are used but not available in all centres.

Materials and Methods

The study was carried out in Department of Orthopaedics, Goa Medical College. Scans were done using PHILIPS MX16 Slice CT scanner. Computed Tomographic scans of 150 random patients are taken into account with the help of Radiology Department software. Patient with obvious spine deformity and fractures are excluded from this study. A total of 3900 pedicles were studied for parameters like Transverse Diameter (TDP), Transverse Angle (TPA), Sagittal Diameter (SDP) and sagittal angle (SAP). The data was analysed and Paired t-test was used for comparison of parameters between sides (right *versus* left) and between sex (male *versus* female). One way ANOVA test was used to compare the data among various age groups. P

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value of <0.05 was considered statistically significant.

Transverse Diameter (TDP):

Thickness of pedicles measured by marking the deepest point in the medial and lateral aspect of each pedicle (both right and left) at right angles to the long axis of pedicle.

Transverse Angle (TPA) :

Angle between pedicle axis and a line parallel to the vertebral midline measured in transverse plane (Fig 1).

Sagittal Diameter (SDP) :

Vertical height of each pedicle from D5 to L5 measured at points just opposite to each other on upper and lower margins of pedicles at the point of maximum diameter in the vertical plane on its lateral aspect.

Sagittal Angle (SAP) :

Angle between pedicle axis and superior part of vertebral body in the sagittal plane (Figs 2.1 & 2.2).

Observation and Results

The age range of the participants is from 19-65 years with mean age of 48.01 years. There is no statistically significant difference in morphology in various age groups ($p>0.05$ in one-way ANOVA test), between pedicles of either side in all the vertebrae studied and also no statistically significant difference between male and female participants in our study ($p>0.05$ in independent t test). The ratio for male to female participants is 51:49 (Tables 1-3).

Transverse diameter of pedicles increased from higher to lower levels constantly. D5 vertebra had the least mean transverse diameter of 4.5mm and L5 with maximum diameter of 10.1mm. But the sagittal diameter of the pedicles did not show a similar trend with the maximum size measured at L2 vertebra with a mean of 14.1mm.

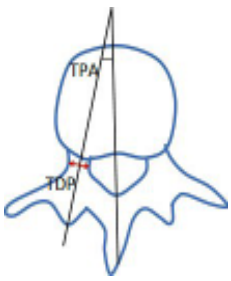
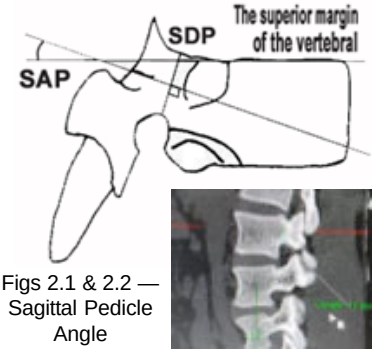


Fig 1 — Transverse Pedicle Angle



Figs 2.1 & 2.2 — Sagittal Pedicle Angle

Table 1 — *Data of Transverse Pedicle Diameters*

Transverse Diameter	side	N	Mean±SD	Median (IQR)
D5	Right	150	4.51±0.24	4.5(4.3,4.6)
	Left	150	4.51±0.24	4.5(4.3,4.6)
D6	Right	150	5.1±0.28	5.1(4.9,5.3)
	Left	150	5.11±0.28	5.1(4.9,5.3)
D7	Right	150	5.38±0.26	5.4(5.2,5.5)
	Left	150	5.38±0.26	5.4(5.2,5.5)
D8	Right	150	5.8±0.25	5.8(5.7,5.9)
	Left	150	5.8±0.25	5.8(5.7,5.9)
D9	Right	150	6.2±0.31	6.23(6,6.35)
	Left	150	6.2±0.31	6.23(6,6.35)
D10	Right	150	6.42±0.33	6.5(6.2,6.6)
	Left	150	6.42±0.33	6.5(6.2,6.6)
D11	Right	150	6.67±0.34	6.7(6.5,6.8)
	Left	150	6.67±0.34	6.7(6.5,6.8)
D12	Right	150	6.97±0.35	7(6.8,7.15)
	Left	150	6.97±0.35	7(6.8,7.15)
L1	Right	150	7.3±0.37	7.26(7.1,7.5)
	Left	150	7.3±0.37	7.26(7.12,7.5)
L2	Right	150	7.36±0.35	7.31(7.15,7.5)
	Left	150	7.36±0.35	7.32(7.15,7.52)
L3	Right	150	8.28±0.37	8.34(8.1,8.5)
	Left	150	8.29±0.37	8.34(8.1,8.5)
L4	Right	150	9.26±0.38	9.3(9.05,9.5)
	Left	150	9.26±0.38	9.3(9.05,9.5)
L5	Right	150	10.1±0.36	10.15(9.8,10.4)
	Left	150	10.11±0.36	10.15(9.8,10.4)

Table 2 — *Data of Sagittal Pedicle Diameters*

Sagittal Diameter	Side	N	Mean±SD	Median (IQR)
D5	Right	150	5.4±0.28	5.4(5.2,5.6)
	Left	150	5.4±0.28	5.4(5.2,5.6)
D6	Right	150	6.22±0.32	6.3(6,6.4)
	Left	150	6.22±0.32	6.3(6,6.4)
D7	Right	150	6.98±0.37	7(6.8,7.15)
	Left	150	6.98±0.37	7(6.8,7.15)
D8	Right	150	8.29±0.38	8.34(8.1,8.5)
	Left	150	8.29±0.38	8.34(8.1,8.5)
D9	Right	150	9.26±0.39	9.3(9.05,9.5)
	Left	150	9.26±0.39	9.3(9.05,9.5)
10	Right	150	10.11±0.37	10.18(9.8,10.4)
	Left	150	10.11±0.37	10.18(9.8,10.4)
D11	Right	150	11.04±0.4	11(10.8,11.3)
	Left	150	11.04±0.4	11(10.8,11.3)
D12	Right	150	11.92±0.44	11.9(11.5,12.2)
	Left	150	11.92±0.44	11.9(11.5,12.2)
L1	Right	150	13.2±0.36	13.2(13,13.5)
	Left	150	13.2±0.36	13.2(13,13.5)
L2	Right	150	14.14±0.55	14.2(13.9,14.5)
	Left	150	14.14±0.55	14.2(13.9,14.5)
L3	Right	150	13.26±0.4	13.2(13,13.5)
	Left	150	13.25±0.41	13.2(13,13.5)
L4	Right	150	11.92±0.45	11.9(11.5,12.2)
	Left	150	11.93±0.46	11.9(11.5,12.2)
L5	Right	150	11.69±0.48	11.56(11.4,12)
	Left	150	11.69±0.48	11.56(11.4,12)

The average measured transverse diameter and sagittal diameter of pedicles in our study excludes

Table 3 — *Demographic distribution of study population*

Sex	Frequency	Percent	Age	Frequency	Percent
F	74	49.3	<20	1	0.7
M	76	50.7	21-30	7	4.7
Total	150	100	31-40	27	18
			41-50	42	28
			51-60	63	42
			>60	10	6.7
			Total	150	100

the use of 5.5 mm pedicle screws in vertebrae D5-D7, 6.5mm pedicle screws in D8-D11.

There is no linear trend in both sagittal and transverse angle. The average medial angulation of the pedicles from our study is 5° in T5 to T10, 3° in T11-T12, 10-15° in L1 to L5. Sagittal angle is maximum at D10 (16.5°) and is minimum at L5 (2.19°).

Discussion

Pedicle screw insertion is easier and less dangerous in lumbar vertebrae than in dorsal because of the larger pedicle sizes. Techniques like Cortical Bone Trajectory (CBT) screw placement can be used to increase the stability of fixation and reduce the failures in osteoporotic patients[11]. Percutaneously inserted pedicle screws are reported to produce less complications in experienced hands[12]. Intraoperative use of CT scan/ O-arm will reduce the mal insertion of pedicle screws but is associated with increased radiation.

The limitations of the study are :

(1) Metrics like height, weight were not taken into consideration which would have helped in understanding better the pedicle morphology variations.

(2) Chord length of the vertebrae were not measured.

(3) A relatively small sample size

(4) Even though the study is conducted in Goa, the patient characteristics such as race is not collected, so the findings cannot be attributed to the coastal Konkan population of India.

Conclusion

Preoperative measurement of pedicle size at the isthmus level will reduce the risk of pedicle cortical breach. The axes of thoracic pedicles are directed more inferiorly than lumbar pedicles. The axes of lumbar pedicles are directed more medially than thoracic. The smallest pedicle is of D5 vertebra.

Even though the sagittal angle of L4 and L5 were found to be the least, the inferior angulation of the whole vertebra at the transition of lumbar lordosis to sacral kyphosis necessitates downward angulation of the pedicle screw during insertion.

The difference in the average transverse angle between dorsal and lumbar vertebrae means it will be difficult to use monoaxial screws during the instrumentation of dorso-lumbar junctional pathologies as this will cause difficulties in fixing the connecting rods to the pedicle screws. So, in these cases polyaxial pedicle screws should be used.

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