



A MORPHOMETRIC STUDY OF THE PEDICLES IN DRY HUMAN TYPICAL THORACIC VERTEBRAE

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ABSTRACT

Background: Pedicle screw fixation in the thoracic spine remains a technical challenge. Knowledge of the pedicle diameter and chord length is essential for choosing the appropriate pedicle screw, whereas the pedicle angle is important for accurate screw placement.

Objective: To measure the various dimensions of pedicles in typical thoracic vertebrae.

Material and methods: Two hundred dry human typical thoracic vertebrae of undetermined gender and age were selected for the study. The various parameters of pedicles were measured.

Results: The mean pedicle width at the midpoint of the pedicle on the left was 4.33 ± 1.03 mm and on the right side was 4.29 ± 0.97 mm. The mean pedicle height at the midpoint of the pedicle on the left side was 10.54 ± 1.17 mm and on the right side was 10.6 ± 1.1 mm. The mean transverse pedicle angle on the left side was 14.37 ± 5.25 degrees and on the right side was 14.52 ± 5.3 degrees. The mean sagittal pedicle angle on the left side was 13.81 ± 3.27 degrees and on the right side was 13.82 ± 3.26 degrees. The mean chord length on the left was 35.94 ± 3.94 mm and on the right side was 35.83 ± 3.97 mm.

Conclusion: Thus, a comprehensive data set has been presented which will help in development of pedicle instruments for Indian population.

Key Words: Typical thoracic vertebra, Pedicle width, Pedicle angle, Chord length

INTRODUCTION

Vertebral column morphology is influenced externally by mechanical and environmental factors and internally by genetic, metabolic and hormonal factors. These all affect its ability to react to the dynamic forces of everyday life, such as compression, traction and shear. These dynamic forces can vary in magnitude and are much influenced by occupation, locomotion and posture¹. Thus, the vertebrae can be involved in various conditions such as developmental anomalies, injuries, infections and tumours. In recent years there have been considerable developments in instrumentation designed to stabilize and correct the thoracic and lumbar spine in various clinical disorders. Transpedicular screw insertion has been a popular method for spinal fixation at the level of lumbar vertebrae. However, its use in the thoracic vertebrae remains restricted due to the technical and anatomical pitfall. Use of wrong size of screw may result in cortex perforation of pedicle or fracture of pedicle with resultant injury to

nerve roots. According to McLain RF et al², the longest screw with the largest thread area and thickest minor diameter will provide the best pullout strength and the best screw bending resistance. The present study was conducted to define morphometric characteristics of the thoracic pedicle in an Indian population and compare our data with the other studies.

MATERIAL AND METHODS

The study was conducted on dry human typical thoracic vertebrae. The vertebrae were obtained from the bone collection of the department of Anatomy of a tertiary care hospital. Of the total collection of thoracic vertebrae in the department, 200 undamaged typical thoracic vertebrae were selected for the study. The vertebrae were of undetermined gender and age. Each vertebra was assigned a serial number. Anatomical measurements were taken on these specimens using a vernier caliper

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(0-150mm with a precision of 0.02 mm). The vertebrae were photographed with a digital camera and the angular measurements were recorded using MB ruler software. MB (Markus-Bader) ruler is a software which is free to use for non-commercial purposes.³ (Fig. 1-2). The following parameters were recorded in a proforma:

Pedicle width at the midpoint of the pedicle- It is the distance between medial and lateral surfaces of pedicle at its midpoint, measured at right angles to the long axis of the pedicle. (Fig. 3)

Pedicle height at the midpoint of the pedicle- It is the vertical distance between superior and inferior border of pedicle at its midpoint.

Transverse pedicle angle- It is the angle between a line passing through the pedicle axis and a line parallel to the vertebral midline in the transverse plane. (Fig. 4)

Sagittal pedicle angle- It is the angle between a line passing through the pedicle axis and superior vertebral body border in the sagittal plane.

Chord length (Screw path length) - It is the distance from the most posterior aspect of the junction of the superior facet and the transverse process to the anterior cortex of the vertebral body along the pedicle axis.

RESULTS

The pedicle width at the midpoint of the pedicle on the left side ranged from 1.96 - 7.96 mm with a mean of 4.33 ± 1.03 mm and on the right side ranged from 1.98 - 8.02 mm with a mean of 4.29 ± 0.97 mm.

The pedicle height at the midpoint of the pedicle on the left side ranged from 7.14 - 13.42 mm with a mean of 10.54 ± 1.17 mm and on the right side ranged from 7.18 - 13.56 mm with a mean of 10.6 ± 1.1 mm.

The transverse pedicle angle on the left side ranged from 5.11 - 28.14 degrees with a mean of 14.37 ± 5.25 degrees and on the right side ranged from 5.55 - 29.93 degrees with a mean of 14.52 ± 5.3 degrees.

The sagittal pedicle angle on the left side ranged from 4.71 - 22.07 degrees with a mean of 13.81 ± 3.27 degrees and on the right side ranged from 5 - 21.57 degrees with a mean of 13.82 ± 3.26 degrees.

The chord length on the left side ranged from 26.64 - 47.28 mm with a mean of 35.94 ± 3.94 mm and on the right side ranged from 26.8 - 47.34 mm with a mean of 35.83 ± 3.97 mm.

DISCUSSION

Several quantitative anatomical studies have been carried out for thoracic vertebrae in different countries. Many authors have studied the pedicles of vertebrae using different methods such as computed tomography (CT) scans, Magnetic Resonance Imaging (MRI) scans, plain radiographs, direct specimen measurements and quantitative 3-dimensional anatomic techniques. The following tables present the comparison of means of the various parameters obtained from previous studies with that of the present study.

1. PEDICLE WIDTH AT THE MIDPOINT OF THE PEDICLE (Table 1)

Pedicle width is important as it determines the diameter of screw that can be accommodated safely in a pedicle without breaching its medial and lateral cortex.

Pai BS et al⁴ noted that the pedicle width ranged between 3.5 - 7.9 mm for typical thoracic vertebrae as compared to 1.96 - 8.02 mm in the present study.

2. PEDICLE HEIGHT AT THE MIDPOINT OF THE PEDICLE (Table 2)

Pedicle height also influences pedicle screw selection. However, in all studies, it has been established that the pedicle height is always greater than the pedicle width. The present study agrees with this finding. Thus, from a practical point of view, pedicle height carries lesser importance in deciding pedicular screw diameter.

According to Pai BS et al⁴, the pedicle height ranged between 6 - 14.3 mm for typical thoracic vertebrae as compared to 7.14 - 13.56 mm in the present study.

3. TRANSVERSE PEDICLE ANGLE (Table 3)

Knowledge of transverse pedicle angle is important while placing screws because any inadvertent medial perforation due to wrong placement of the pedicle screw can put the spinal cord at risk or cause vascular injury. According to Table 3, the mean transverse pedicle angle in the present study is in correspondence with that of Berry JL et al⁵, Roop Singh et al¹¹ and Pai BS et al⁴.

4. SAGITTAL PEDICLE ANGLE (Table 4)

Sagittal pedicle angle is important in accurate screw placement as inferior migration of the screw may result in injury to the nerve root. Table 4 indicates that the mean sagittal pedicle angle in the present study is greater than the findings of Datir SP et al⁸ and Panjabi MM et al⁷ but smaller than those of Shiu-Bii Lien et al¹⁰, Roop Singh et al¹¹ and Zindrick MR et al⁶.

5. CHORD LENGTH (SCREW PATH LENGTH) (Table 5)

Chord length determines the safest length of any screw that can be used for pedicular fixation. It is important in preventing anterior cortex perforation and therefore consequent injury to vital organs and major blood vessels which lie anterior to the vertebral body. Table 5 indicates that the mean chord length in the present study is lesser than the values of the study by Pai BS et al⁴ and McLain RF et al² and is greater than that of Datir SP et al⁸, Tan et al⁹ and Roop Singh et al¹¹. Pai BS et al⁴ noted the range of chord length for typical thoracic vertebrae as 26.1 - 49.9 mm as compared to 26.64 - 47.34 mm in the present study.

CONCLUSION

Thus, a comprehensive data set has been presented which provides quantitative anatomy of pedicles of typical thoracic vertebrae. The differences in the results of the present study and those of the previous studies with respect to some of the parameters may be due to differences in race, ethnicity, environmental factors as well as methods used for the studies. These findings strengthen the recommendations by Roop Singh et al¹¹ for modification in spinal surgery instrumentations (screw/hooks/cages) in accordance with the morphometric data obtained from Indian population. In the future, the scope of the study can be further extended to study the vertebral column with respect to individual vertebral levels.

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TABLE 1: Comparison of mean pedicle width at the midpoint of the pedicle in typical thoracic vertebrae with other studies

Study	Year	Country	Material for study	Mean (in mm)
Berry JL et al ⁵	1987	USA	Dry bones	5.6 (T2,T7)
Zindrick MR et al ⁶	1987	USA	CT scans, radiographs	5.46
Panjabi MM et al ⁷	1991	USA	Dry bones	Left: 6.43 Right: 6.61
McLain RF et al ²	2002	USA	Dry bones	5.87 (T2 to T6)
Datir SP et al ⁸	2004	India	Cadaveric	5.26
Tan et al ⁹	2004	Singapore	Dry bones	Left: 4.54 Right: 4.56
Shiu-Bii Lien et al ¹⁰	2007	Taiwan	Dry bones, cadaveric	Left: 4.3 Right: 4.24
Pai BS et al ⁴	2010	India	Cadaveric, radiographic	5.09
Roop Singh et al ¹¹	2011	India	Dry bones	4.88
Present study		India	Dry bones	Left: 4.33 Right: 4.29

TABLE 2: Comparison of mean pedicle height at the midpoint of the pedicle in typical thoracic vertebrae with other studies

Study	Year	Country	Material for study	Mean (in mm)
Roop Singh et al ¹¹	2011	India	Dry bones	11.1
McLain RF et al ²	2002	USA	Dry bones	11.61(T2 to T6)
Panjabi MM et al ⁷	1991	USA	Dry bones	Left: 11.93 Right: 11.76
Berry JL et al ⁵	1987	USA	Dry bones	11.9(T2,T7)
Zindrick MR et al ⁶	1987	USA	CT scans, radiographs	12.21
Tan et al ⁹	2004	Singapore	Dry bones	Left: 9.41 Right: 9.53
Shiu-Bii Lien et al ¹⁰	2007	Taiwan	Dry bones, cadaveric	Left: 10.37 Right: 10.49
Pai BS et al ⁴	2010	India	Cadaveric, radiographic	10.37
Datir SP et al ⁸	2004	India	Cadaveric	12.16
Present study		India	Dry bones	Left: 10.54 Right: 10.6

TABLE 3: Comparison of mean transverse pedicle angle in typical thoracic vertebrae with other studies

Study	Year	Country	Material for study	Mean (in degrees)
Zindrick MR et al ⁶	1987	USA	CT scans, radiographs	11.73
Berry JL et al ⁵	1987	USA	Dry bones	15.25 (T2,T7)
Panjabi MM et al ⁷	1991	USA	Dry bones	Left: 17.26 Right: 22.67
Datir SP et al ⁸	2004	India	Cadaveric	6.57
Shiu-Bii Lien et al ¹⁰	2007	Taiwan	Dry bones, cadaveric	Left: 18.74 Right: 19.17
Pai BS et al ⁴	2010	India	Cadaveric, radiographic	13.74
Roop Singh et al ¹¹	2011	India	Dry bones	13.81
Present study		India	Dry bones	Left: 14.37 Right: 14.52

TABLE 4: Comparison of mean sagittal pedicle angle in typical thoracic vertebrae with other studies

Study	Year	Country	Material for study	Mean (In degrees)
Zindrick MR et al ⁶	1987	USA	CT scans, radiographs	16.2
Panjabi MM et al ⁷	1991	USA	Dry bones	Left: 11.36 Right: 9.94
Datir SP et al ⁸	2004	India	Cadaveric	9.5
Shiu-Bii Lien et al ¹⁰	2007	Taiwan	Dry bones, cadaveric	Left: 16.01 Right: 16.1
Roop Singh et al ¹¹	2011	India	Dry bones	16.37
Present study		India	Dry bones	Left: 13.81 Right: 13.82

TABLE 5: Comparison of mean chord length in typical thoracic vertebrae with other studies

Study	Year	Country	Material for study	Mean (in mm)
McLain RF et al ²	2002	USA	Dry bones	37.37(T2 to T6)
Datir SP et al ⁸	2004	India	Cadaveric	32.78
Tan et al ⁹	2004	Singapore	Dry bones	30.64
Pai BS et al ⁴	2010	India	Cadaveric, radiographic	37.29
Roop Singh et al ¹¹	2011	India	Dry bones	29.18
Present study		India	Dry bones	Left: 35.94 Right: 35.83

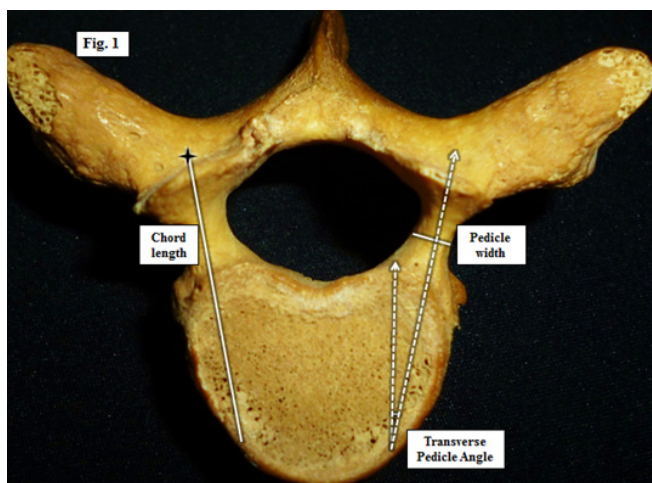
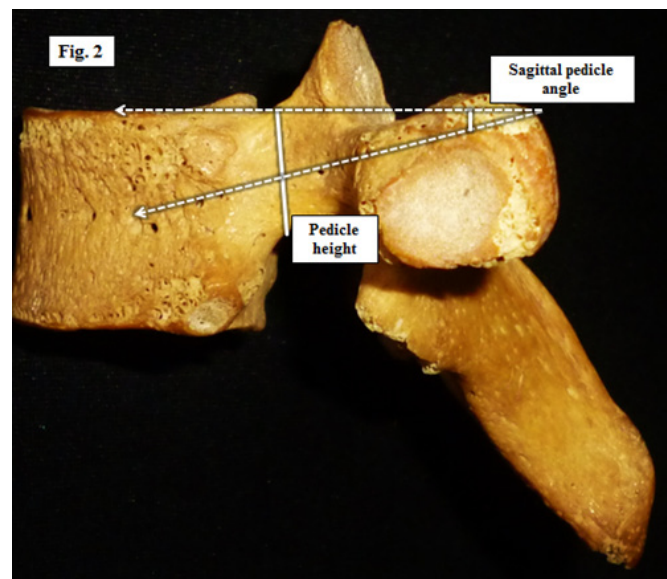
**Figure 1: Illustration showing measurement of various parameters in typical thoracic vertebra****Figure 2: Illustration showing measurement of various parameters in typical thoracic vertebra**



Figure 3: Illustration showing measurement of pedicle width at the midpoint of the pedicle

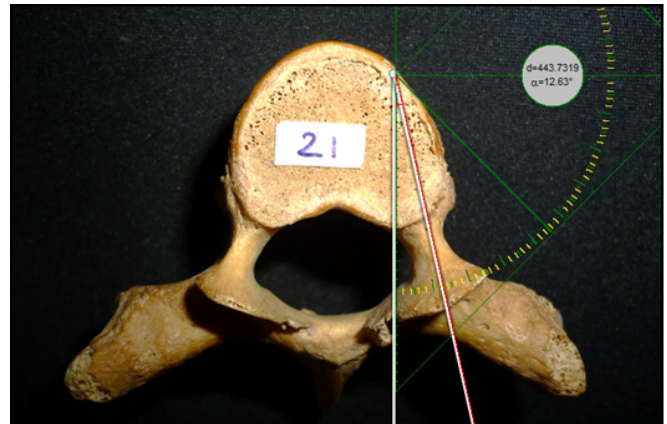


Figure 4: Illustration showing measurement of transverse pedicle angle using MB Ruler software (α : Angle in degrees)