# PEDICULAR DIMENSIONS AND ANGLES OF THE LOWER FOUR THORACIC AND ALL THE LUMBAR VERTEBRAE IN EGYPTIAN ADULT MALES

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# PEDICULAR DIMENSIONS AND ANGLES OF THE LOWER FOUR THORACIC AND ALL THE LUMBAR VERTEBRAE IN EGYPTIAN ADULT MALES

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## ABSTRACT

The dimensions and angles of the vertebral pedicles are very important for surgeons who perform transpedicular screw fixation.

In this study, the dimensions (transverse diameter TD, sagittal diameter SD and total pedicular length TPL) and angles ( transverse angle TA and sagittal angle SA ) of the pedicles of the lower four thoracic and all the lumbar vertebrae were measured.

Direct measurements were performed on twenty vertebral columns from museum of Anatomy, Mansoura faculty of medicine.

Radiological and CT measurements, were done on twenty adult vol-

unteers from Orthopedic surgery department, Mansoura University hospital.

The results of the different methods were compared with each other and with the results of previous studies.

Statistical analysis including the mean(M),range(R) and standered deviation(SD) for each pedicular parameter were performed and recorded in a table.

It was evident, from the study, that there was no accepted universal method for measurement and CT scans are the most accurate method for measuring the pedicular dimensions and angles.

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## INTRODUCTION

Transpedicular screw fixation of the spines has become an increasing popular form of spinal fixation Cohen et al., (1989) and Geiger et al., (1989).Many authors had investigated the pedicular dimensions using different methods. Saillant (1976) , Berry et al., (1987) and Krag et al., (1988) used the direct method however their measurements were looking at selected pedicular dimensions. Saillant et al., (1976), Dick et al., (1985) Berry and Moran(1987), Moran et al., (1987), Zendrick et al.,(1987), Butler et al.,(1991) and Ebrahim et al., (1996) obtained their results from radiological and / or CT scan examination of the vertebral columns.

This study was undertaken to gain a detailed knowledge of most of the pedicular dimensions and angles, and to compare between the results of the direct , the radiological and the CT scan methods in the measurement of the dimensions of the vertebral pedicles.

The obtained data may be of value

in instrumentation techniques on the pedicles of the lower thoracic and the lumbar vertebrae.

## MATERIAL AND METHODS

In this study, the dimensions of both  pedicles of the lower four thoracic and all the lumbar vertebrae (T 9 to L5 ) were measured directly, radiologically and by CT scans.

The mean value [M], ranges [R] and the standered of deviation [SD] for each level were determined for statistical studies.

All the data for each vertebral level were recorded in a table. (Table 1 ).

Direct measurements were done on the pedicles of  twenty vertebral columns obtained  from the museum of Anatomy, Mansoura faculty of medicine.

Plain X-ray and CT scans of the the lower dorsal and the lumbar vertebrae were done on twenty adult apparently healthy volunteers from outpatient clinic of Orthopedic Surgery department, Mansoura university hospital.

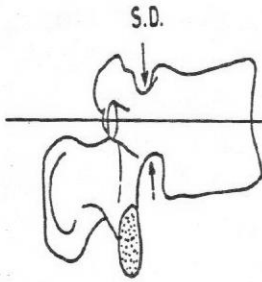A- Direct measurements: On both vertebral pedicles the following measurements were done (Figures 1&2).



Figure [1] : A diagram of lumbar ver-tebra showing the lines by which the sagittal diameter SD is measured.
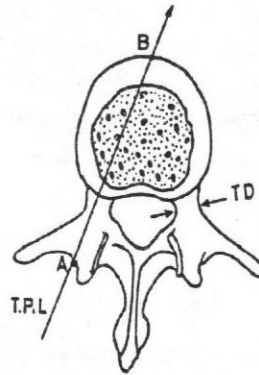


Figure [2] : A diagram of thoracic vertebra showing the lines by which the transverse di-ameter TD and the total pedicular length TPL are measured.

1- The transverse diameter (TD) and the sagittal diameter (SD) were determined by measuring the nar-rowest isthmic dimensions in the transverse and the sagittal planes of the pedicles. These diameteres were measured with vernier cali-prator ( precission ± 1). Zendrick et al.(1986) and Panjapi et al. (1991).

2- The total pedicular length (TPL) was measured from the posterior aspect of the laminar cortex to the anterior aspect of the cortex of the vertebral body in a line passing through the middle of the pedicle after drilling by drill pit 3.5 mm.using depth gauge (Krag et al.(1988) and Michael et al. (1986).

B-Plain X-Ray measurements : Lateral views were taken to the lower thoracic and the lumbar vertebrae. From the radiographs, the sagittal di-ameter as well as the sagittal angle were determined ( figure5). Magnifi-cation on the radiograph was correct-ed by making a radiograph of a stan-dard device at the same distance. A correction factor 0.93rnm.was used for the sagittal diameter.

C- CT measurements : Scans in contigious increments of 4mm. cuts were made parallel to the plane of the

superior end plate of the vertebral body through the middle of the pedicle. The guntry of the scanner was adjusted to align it parallel to the end plate as accurately as possible.From CT scans, transverse pedicular diameter (T.D.), transverse pedicular angle (T.A.) and the total pedicular length (T.P.L) were measured (figure 6 ).

## RESULTS

A- Direct measurements: ( Figures 3&4 & Table 1).

1- *Transverse diameter T.D.* : The widest T.D. was found at L5 level with a mean of 12 mm (range 9-17mm). The narrowest .T.D. was found at T9 level with a mean width 6.1mm (range 3.7-9.1mm).

2- *Sagittal diameter S.D.* : The widest S.D. was found at T11 with a mean value of 17.3mm (range 15.5-22.1mm). The narrowest S.D. was found at T9 level with a mean 13.7mm (range 10.6-15.5mm ).

3- *Total pedicular length T.P.L.* : The longest distance to the anterior cortex was found at L5 with a mean of 51.8mm ( range 43-60mm ).The shortest T.P.L. was found at T9 with a mean of 41.2mm ( range 35-46mm ).

B-Radiological measurements: (Figure 5 & Table 1).

1- *Sagittal diameter* : The widest diameter was recorded at L5 level with a mean of 13.7mm (range 10-23mm). The narrowest S.D. was found at T9 level with a mean of 6.8mm. (range 4.6-11mm.).

2- *Sagittal angle S.A.* : The largest angle was found at L5 level with a mean of 14.50 (range 10-25)0. The narrowest angle was found at T9 level with a mean of 6.50 (range 3-90).

C- CT measurements: ( Fig 6 & Table 1).

1- *Transverse diameter T.D.* : The widest diameter was found at L5 level with a mean of 13.5mm. (range 7-19mm).The narrowest diameter was found at T9 level with a mean of 8.4mm. (range 6-12mm).

2-Transverse angle T.A.: The largest T.A .was found at L5 level with a mean of 230 (range 20-34 )0. The narrowest angle was found at T11 level with a mean of 3.20 (range 2-6.50).

3-Total pedicular length T.P.L.: The largest length was found at L5 level with a mean of 52mm. ( range 42-62mm. ). The shortest length was found at T9 level with a mean of 43mm.( range 35-50mm ).

| Vertebral level | | T9 | T10 | T11 | T12 | L1 | L2 | L3 | L4 | L5 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Direct Measurements** — T.D | M | 6.1 mm | 6.3 | 6.4 | 6.9 | 7 | 8.1 | 9.1 | 10.3 | 12 |
| | R | 3.7 – 9 | 3.1 – 8.5 | 3.1 – 12.1 | 3 – 11 | 4.5 – 13 | 4.13 | 5.3 – 16 | 8.1 – 17 | 9.1 – 17 |
| | SD | ±1.8 mm | ±2.6 | ±2.6 | ±2.2 | ±2.3 | ±2.3 | ±2 | ±1.7 | ±1.5 |
| S.D | M | 13.7 | 15.2 | 17.3 | 15.7 | 15.5 | 15.1 | 14 | 14 | 14 |
| | R | 10.6 – 15.5 | 11 – 21.6 | 12.5 – 22.1 | 12.4 – 20 | 11 – 20.2 | 10 – 18 | 8.3 – 18.5 | 9 – 19 | 9.5 – 19.5 |
| | SD | ± 1.3 mm | ± 2.5 | ± 2.5 | ± 2.4 | ± 2.8 | ± 1.5 | ± 2.4 | ± 2.1 | ± 2.3 |
| T.P.L. | M | 41.2 mm | 44 | 45 | 47.6 | 50 | 50.2 | 50.9 | 51.8 | 51.8 |
| | R | 35 – 46 | 36 – 52 | 38 – 46 | 36 – 49 | 42 – 57 | 45 – 58 | 42 – 62 | 43 – 60 | 42 – 62 |
| | SD | ± 2.3 mm | ± 3 | ± 3.2 | ± 4.1 | ± 4.3 | ± 3.7 | ± 4.6 | ± 4.4 | ± 3.1 |
| **Radiological Measurements** — S.D | M | 6.8 mm | 10.5 | 10.5 | 11 | 12.5 | 13 | 13.1 | 13.2 | 13.7 |
| | R | 4.6 – 11 | 7 – 13 | 9 – 18 | 8 – 18 | 8 – 20 | 9 – 22 | 9 – 21 | 10 – 20 | 10 – 32 |
| | SD | ± 1.7 mm | ± 1.8 | ± 1.8 | ± 1.8 | ± 2 | ± 3.2 | ± 3.2 | ± 2.6 | ± 2.8 |
| S.A | M | 6.5° | 6.5° | 8° | 9° | 12° | 12.2° | 12.3° | 13.7° | 14.5° |
| | R | 3 – 9 | 4 – 8 | 6 – 10 | 6 – 13 | 6 – 18 | 7 – 20 | 8 – 22 | 9 – 23 | 10 – 25 |
| | SD | ± 1.3° | ± 1.5° | ± 1.9° | ± 1.2° | ± 1.6° | ± 1.5° | ± 1.6° | ± 1.4° | 1.5° |
| **C.T. Measurements** — T.D | M | 8.4 mm | 8.9 | 9.4 | 10.4 | 11.3 | 10.9 | 11.2 | 11.9 | 13.5 |
| | R | 6 – 12 | 5 – 11 | 6 – 12 | 5 – 15 | 7 – 20 | 8 – 19 | 8 – 22 | 6 – 20 | 7 – 19 |
| | SD | ± 1.5 mm | ± 1.1 | ± 1.3 | ± 1.3 | ± 1.4 | ± 1.4 | ± 1.3 | ± 1.7 | ± 1.7 |
| T.A | M | 8.1° | 4.9° | 3.2° | 4.6° | 10.9° | 12.2° | 14.4° | 17.7° | 23° |
| | R | 6.5 – 1.5 | 3.1 – 8.5 | 2 – 6.5 | 4 – 7 | 6.5 – 19 | 9 – 17 | 8.5 – 20 | 12.5 – 22.5 | 20 – 34 |
| | SD | ± 2.8° | ± 2.6° | ± 2.4° | ± 2.5° | ± 2.2° | ± 3.5° | ± 3.8° | ± 3.2° | ± 3.3° |
| T.P.L. | M | 43 mm | 44 | 47 | 49 | 50.1 | 50.4 | 49.7 | 51.9 | 52 |
| | R | 35 – 50 | 36 – 55 | 44 – 56 | 43 – 60 | 43 – 60 | 43 – 61 | 44 – 62 | 44 – 62 | 42 – 62 |
| | SD | ± 2.1 mm | ± 2.2 | ± 2.3 | ± 2.5 | ± 3 | ± 3.4 | ± 3.5 | ± 4 | ± 4.2 |

**Table (1): Pedicular dimensions of the lower four thoracic and all the lumbar vertebrae**

TD: Transverse diameter　　SD: sagittal diameter　　T.P.L: total pedicular length　　S.A:　sagittal angle

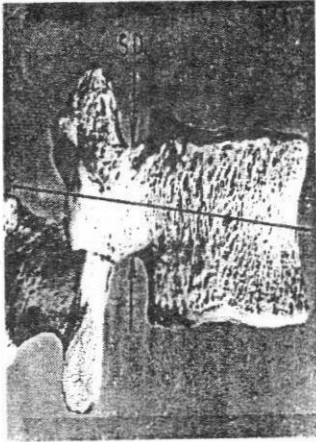T.A: Transverse angle　　M: mean　　R: range　　SD: standard of Deviation　　T: Thoracic　　L: lumbar

**Figure [3]** : A photomicrograph of lumbar vertebra showing the lines by which the sagittal diameter is measured.
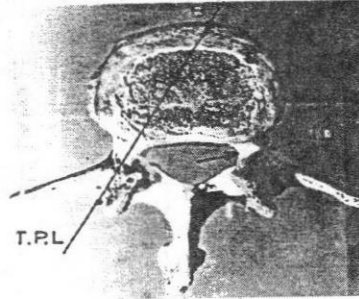


**Figure [4]** :A photomicrograph of thoracic vertebra showing the lines by which the transverse diameter(T.D.) and the total pedicular length (T.P.L.) are measured.
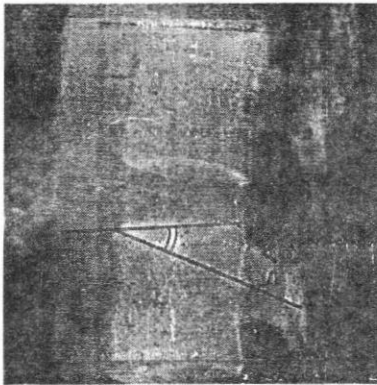


**Figure [5]** : Plain X-Ray- Lateral view - of the lumbar vertebrae showing the lines by which the sagittal diameter S.D. and sagittal angle S.A. are measured .
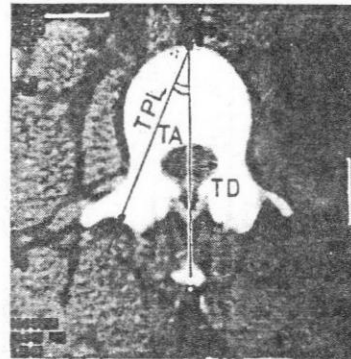


**Figure [6]** : CT scan of lumbar vertebra showing the lines by which the transverse diameter (T.D. ), the transverse angle (T.A.) and the total pedicular length (T.P.L.) are measured

## DISCUSSION

A detailed knowledge of the dimensions and angles of the vertebral pedicles is essential to surgeons performing transpedicular fixation of the thoracic and lumbar spines.So, this study was planned and carried out to provide more information about this subject.

In the direct study, the obtained results of transverse diameter were almost consistent with that of Berry et al,(1987) and Krag et. al, (1988) and there was good agreement in the fact that there was a constant increase in the transverse diameter as we descend from T9 to L5. The mean sagittal diameter was longer than that of earlier studies, Berry et al, (1987) and Elsweski et al, (1987).The sagittal diameter was found to increase from T9 to T11 and decrease gradually from T12 to L5. This may be explained on the basis that T12 is a transient stage between thoracic and lumbar vertebrae.In our opinion ,the reduced sagittal diameter may be due to the relative increase in the width of the intervertebral foramina.

Krag et al, (1988), Panjapi et al., (1991) found that the greatest TPL was at L2, but in this study the greatest TPL was found at L4. The value of this length is very important to determine the depth of the screw, to avoid injury to important structures related to the anterior cortex of the vertebra.

In radiological studies ,the mean values of the sagittal diameter was less than those of Zindrick et al, (1986) and Berry et al, (1987) at all levels.

The sagittal angle was found to increase from T9 to T12 in contrast to the previos studies of Zindrick et al, (1986) and Berry et al, (1987) where this angle was found to decrease from T9 to T12.In the lumbar spines our measurements of the sagittal angle showed an increased values from L1 to L5,but the study of Siallant et al, (1976) showed inconstant variations of the values of this angle.This discrepancies of values may be due to different radiological techniques.

*In CT scans study it was found that :*

1-There was no significant difference between our values of transverse diameter and that of Krag et al, (1986).

2-The largest transverse angle in our study was at L5 with a mean value (330) while in Zindrick study it was also at L5 but with mean value (290 ) with significant difference.

3-The smallest transverse angie in our study was at T11 with a mean value(30),similar to that of Berry et al, (1987).

4-The total pedicular length in the study was nearly consistent with that of other studies e.g. Moran et al,(1987 ), Zindrick et al, (1986) and Ebraheim et al, (1996 ).

*From this work , it was noticed that:*

1- there was no single universal method for measurement of all pedicular dimensions and angles.

2-Logically,direct measurement is not an ideal method for preoperative planning but it was used only for comparison.

3-The most accurate and available method to determine the size and orientation of vertebral pedicles is CT scanning.

# REFERENCES

1- **Berry, J.L., Moran, J.M. and Berg, S (1987)** : Morphometric study of lumbar and selected thoracic spines.

2- **Butler, J., West, J.L.and Ogelvie, J.W. (1991)** : Complications of screw fixation. Spine, 16: 576- 579.

3- **Cohen, J.M., Essess, S.I. and Bednor, D.A (1989)** : Spinal pedicle screw technique. Orthopedic Rev.18: 676-682.

4- **Dick , W., Kluger ,P. and Zach, G. [1985]** : Anew device for internal fixation of thoracolumbar spines. Paraplegia, 33: 225-240.

5- **Ebrahiem, N.A., Rollins, J. R. and Xu, R. [1996]** : Projection of lumbar pedicle and its morphometric analysis.

Spine,21: 1296-1300.

6- Eisenstien Steve. [1977] : Morphometry and pathological Anatomy of spines. Bone and joint surgery , 59 : 173-180.

7- Elsweski, E., Jown, M.and Edward, H. [1990] : Morphometry of lumbar spines Departement of orthopedic surgery and anatomical science. New York university Volume 72 A. No. 4.

8- Geiger, J. M., Berry, J.L. and Moran, J.M. (1989) : Transpedicular screw fixation.Orthopedic Rev.7:107-114.

9- Krag , M. H., Beynnon, B. D. and Pope, M. H.[1986] : Internal fixation for posterior application to short segment of thoracic-lumbar spine. Clinical.Orthop.,203: 75-98.

10- Krag, M.H., Weaver, D.L., Beynnon, B.D. and Haugh, L.D. (1988) : Morphometry of the thoracic and lumbar spines related to transpedicular screw placement for surgical spinal fixation. Spine., 13: 27-32.

11- Michael, R. Zindrick, K. and leon, L. [1986] : Analysis of morphometric characteristics of thoracic and lumbar pedicles. Spine, 8 : 214-222.

12- Moran, J. M., Steffe, A. D. and Steven, J. [1987] : A morphometric study of human lumbar spines. Spine , 12 : 362-367.

13- Panjapi, M. M., Takata, H. and Geol, V. [1991] : Fusion of lumbar and sacral spines by internal fixation with screw plates. Clin. Orthop.,203 : 18-32.

14- Richard, H. An, H.S. and Gokdin, R. [1991] : Anatomic

consideration of plate and screw fixation of cervical spines. Spine, 14 : 234-245.

15- Saiilant,G. [1976] : Anatomic study of vertebral pedicles. Surgical application. Rev Chir Orthop.62 : 151-164.

16- Zindrick, M. R., Wiltse, L.L.and Doorink J. [1987] : Analysis of morphometric characters of the thoracic and lumbar vertebrae. Spine, 12 : 160-166.

# قياس ابعاد وزوايا السويقة فى الفقرات الصدرية السفلى والفقرات القطنية فى المصريين البالغين

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## الملخص العربى

أصبح تثبيت الفقرات الصدرية والقطنية شائعاً فى السنوات الأخيرة وذلك بتثبيت شرائح ومسامير فى سويقات تلك الفقرات. ومن هذا المنطلق كان لابد من معرفة ابعاد السويقة فى هذه الفقرات.

فى هذا البحث تم قياس الابعاد والزوايا للسويقة فى الفقرات السفلية الصدرية (من الفقرة التاسعة إلى الثانية عشرة) وكل الفقرات القطنية فى المصريين البالغين بين سن العشرين والخمسين.

تمت هذه القياسات على عشرين عمود فقرى من متحف قسم التشريح بكلية طب المنصورة وعشرين متطوعاً من المترددين على قسم العظام بمستشفى المنصورة الجامعى.

**أستخدم فى هذا البحث ثلاث طرق للقياس :**

١- الطريقة المباشرة : حيث تتم القياسات مباشرة على كل من عرض السويقة وسمكها وطولها مع جسم الفقرة فى الفقرات الصدرية السفلى والفقرات القطنية وذلك باستخدام القدمة ذات الورنية والمنقلة وشنيور العظام.

٢- الأشعة العادية : حيث يتم أشعة على الفقرات الصدرية السفلى والفقرات القطنية (منظر جانبى) وقياس سمك السويقة والزاوية الراسية لاتحادها مع جسم الفقرة.

٣- الأشعة المقطعية : لنفس الاشخاص السابقين حيث يتم قياس عرض السويقة وزاويتها العرضية

وطولها مع جسم الفقرة فى كل من الفقرات الصدرية السفلى والفقرات القطنية.

وقد تم مقارنة هذه الأبعاد والزوايا بالطرق الثلاثة بعضها البعض ومقارنتها بالنتائج والطرق التى استخدمت فى الأبحاث السابقة وقد دونت هذه النتائج فى جدول يبين القياسات ومتوسطها وانحرافها المعيارى لكل من الفقرات المستخدمة فى البحث .

وقد تبين فى هذا البحث انه لاتوجد طريقة عالمية متفق عليها لقياس الابعاد والزوايا للسويقات وان الاشعة المقطعية هى الأكثر دقة فى تحديد أبعاد وزوايا السويقات.