The Journal of Turkish Spinal Surgery 2010; 21 (2): 129-136

ORIGINAL ARTICLE / *ORJİNAL ÇALIŞMA*

PEDICLE WALL THICKNESS OF THE LUMBAR SPINE AND ITS IMPORTANCE IN THE LUMBAR SPINE INSTRUMENTATION PROCEDURES: A RADIOANATOMICAL STUDY

LOMBER OMURGANIN PEDİKÜL VİDA ENSTRÜMANTASYONUNDA PEDİKÜL DUVARININ KALINLIĞININ ÖNEMİ: RADYOLOJİK ANATOMİ ÇALIŞMASI

KADİR KOTİL*, AHMET ŞENGÖZ*

ABSTRACT:

Purpose: *The pedicle anatomy is the most important point during lumbar pedicle screw fixation. The pedicle measurements provide the spine surgeon additional useful information in order to place safer and stronger pedicle screws. Although several studies of pedicle anatomy have been published, pedicle wall thickness has not been studied before such as radiologic anatomy in Turkish people.*

Methods: *In this radio-anatomical study, we aimed to measure the medial and lateral cortical walls of each lumbar pedicle to obtain quantitative data and to demonstrate if there are any differences between lateral and medial pedicle walls. A total of 500 pedicle in 50 patients (mean age: 45.2) were measured from L1 to L5 by computed tomography (CT) scanning. We investigated and measured both lateral and medial aspects of pedicle walls by thin-section CT.*

Results: *In all levels, the medial wall of the pedicle was found to be thicker than lateral wall ($p<0.001$).*

Conclusion: *Medial pedicle wall is thicker than lateral wall in the lumbar pedicles in the Turkish population. The medial wall should not purchase to preserve the nerve root. It is also important to preserve the integrity of this wall for biomechanical stability.*

Key words: *lumbar spine, pedicle wall thicknesses, pedicle screw*

Level of Evidence: *Retrospective clinical study, Level III*

(*) *Istanbul Educational and Research Hospital, Department of Neurosurgery, İstanbul - Turkey*

Corresponding Address: *Bağdat Caddesi, Hasan Ali Yücel Sokak, Senil Apartmanı, 34/14, Çiftehavuzlar 34728 İstanbul*
Phone: *+90 (212) 530 60 38*
Fax: *+90 (212) 529 44 60*
E-mail: *kadirkotil@gmail.com*

ÖZET:

Amaç: *Lomber pediküler vida ile fiksasyonunda pedikül anatomisi çok önemlidir. Güçlü ve emniyetli pedikül vidalaması için pedikül ölçümü önemli bilgi vermektedir. Birçok pedikül anatomisi ile ilgili çalışma olmasına rağmen Türk nüfusunda bugüne kadar yapılmış bir radyolojik anatomi çalışması yoktur.*

Gereç ve yöntem: *Bu radioanatomik çalışmada, her lomber vertebranın iç ve dış pedikül duvarının kalınlıkları ölçülerek arasındaki kalınlık farkının ölçülmesi amaçlanmıştır. Toplam 50 hastanın (ortalama yaş 45.2) L1-L5 arası 500 pedikülünün lateral ve medial duvarları ince kesit tomografi ile ölçülerek incelenmiştir.*

Sonuç: *Tüm L1-L5 vertebralarda medial duvar, lateral duvardan daha kalın bulunmuştur ($p<0.001$).*

Tartışma: *Türk toplumunda lomber pedikül medial duvar kalınlığı laterale göre daha kalın bulunmuştur. Pedikülün medial duvarı sinir köklerinin korunması için feda edilmemelidir. Biyomekanik stabilite için bu duvarın bütünlüğü ayrıca önemlidir.*

Anahtar Kelimeler: *Lomber omurga, pedikül duvar kalınlığı, pedikül vidası*

Kanıt Düzeyi: *Retrospektif klinik çalışma, Düzey III*

INTRODUCTION:

There is still considerable controversy regarding the benefits of the pedicle screw fixation of the spine surgery [4, 14]. However, the pedicle screw has become popular instruments in treating spinal deformity and diseases [13]. If pedicle screws are to be inserted, the detailed anatomy of the pedicles is needed to be known in detail. Many articles were published about thoracic and lumbar pedicle morphometric analysis [3,5,8,13].

A discrepancy between pedicle width and screw diameter can lead to an expansion or even fracture of the pedicle wall [7,15]. Penetration and breaking of the pedicle walls by pedicle screw may result in disastrous consequences such as biomechanical insufficiency because the pedicles of the lumbar spine are the strongest part of the vertebrae. The pedicles are intimately related to the neural elements which are particularly susceptible to injury by violation of the medial, inferior and lateral cortex. Thus nerve roots and dura can be injured by pedicle screws [9].

The literature has been presented both anatomical and biomechanical studies about pedicle internal structure especially of the thoracic spine [2,6,10,12]. The description of the lumbar pedicle usually includes information about pedicle height and width, and orientation of the pedicle axis in the transverse and sagittal planes, but the investigation of pedicle walls thicknesses in the lumbar vertebra is not reported before. The purpose of this study was to quantify the internal architecture of the medial and lateral pedicle wall thicknesses in the lumbar spine.

MATERIAL AND METHODS:

A total of 500 pedicles in 50 patients were measured from first to fifth lumbar vertebrae in the Turkish population. The mean age was 45.2 years (range, 36-51), with a male/female ratio of 25/25. We investigated each pedicle with three dimensionals computed tomography (3D-CT). First, 2 mm axial images were taken from the whole pedicles (Figures-1.a and b). The mid pedicle section was determined by using the section with median number from these images and this image was also controlled to have the widest pedicle diameter. Pedicle diameters, medial wall and lateral wall of the pedicles were measured from the screen by a blinded radiologist. The measurements were repeated three times by same radiologist. The images were kept digitally and re-measured by another independent radiologist. The means and standard deviations for each thickness were evaluated. Medial and lateral wall thickness was compared. Right and left sides were also compared. The following parameters were taken as mentioned: medial and lateral wall thickness of the right side (RM and RL, respectively), medial and lateral wall thickness of the left side (LM and LL, respectively). All these measurements were taken in millimeters. To compare another side which was lateral wall or cortex, we calculated the medial and lateral wall thickness as a percentage of either the pedicle thickness. This may be an advantage that the medial wall has close approximated to the spinal nerve. Thus medial wall should not purchase to preserve the nerve root.

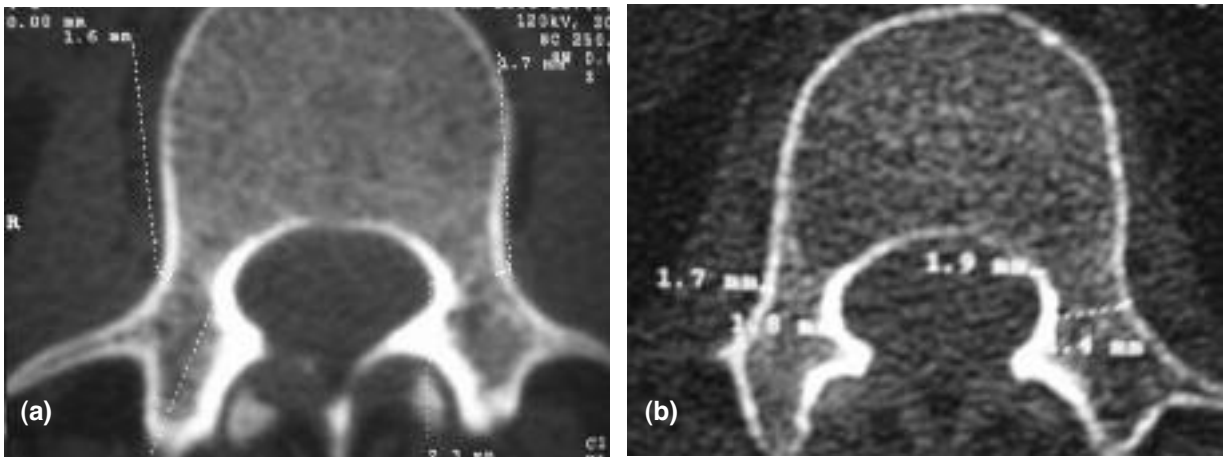

Figure-1. a.-b. Axial CT show the pedicles, the medial pedicle cortical walls are more thicker than their lateral walls.

Statistical analysis was performed by using the student-t test for determining statistical significant difference between males and females. To compare the results between the left and right pedicles, as well as between the different anatomic wall thicknesses, two tailed t test with significance set at a 95 % confidence level was used. The demographic properties of the patients in each group was evaluated and the results were analyzed by Kruskal-Wallis test, which revealed no significant differences ($p>0.05$). Therefore sampling bias was limited to minimum. Friedman test was used for statistical analysis of the difference between men and women.

RESULTS:

All ten pedicles of the one patient were calculated from L1 to L5. A total of 50 vertebrae with 500 pedicles of 50 patients were investigated with axial and coronal CT (Figures-2.a and b). There was significant difference between the medial wall and the lateral wall of the lumbar vertebra both in men and in women ($p<0.001$ for both). The results are shown in Table-1. The average accuracy or standard deviation was 0.1764 mm (0.12822-0.2523 mm). There were no statistically significant differences by means of the age, sex and weight. There was no significant difference between man and women (Table-2). There was no difference between two observers, thus average results were used. The medial wall was thicker than the lateral wall (Table-3). The mean thickness of lateral walls of the pedicle was found to be most at L5 level (1.5076 mm), and the mean thickness of medial walls of the pedicle was found to be most at L5 level (1.96626 mm) in both males and females.

DISCUSSION:

The thickness of the pedicle wall in the lumbar vertebrae is very important to insert safe and strong pedicle screws. The pedicle measurements provide the spine surgeon additional useful information in order to place correct screw insertion during posterior lumbar pedicle instrumentation.

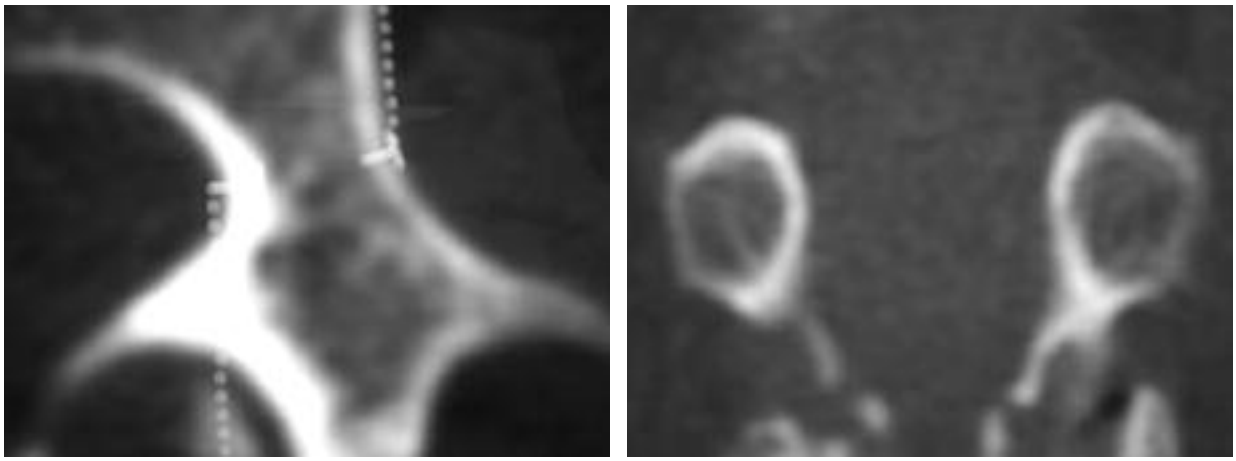

Figure-2. a. Axial pedicle CT and **b.** Coronal CT were showing the both left and right pedicles, medial wall is thicker than the lateral wall.

Table - 1. Group statistics is demonstrated for the both women and men

Wall side	Number	Mean	Standart deviation	Standart error mean
Lateral	500	1.5076	0.205296	0.009181
Medial	500	1.9626	0.18489	0.008269

Table - 2. All Group Statistics is demonstrated for the both women and men.

	All groups	Number	Mean	Standart. Deviation	Standart. Error Mean
men	Lateral wall	250	1,4612	0,12822	0,008109
	Medial wall	250	1,9732	0,176426	0,011158
Group Statistics					
	Grup	N	Mean	Standart. Deviation	Standart. Error Mean
women	Lateral wall	250	1,554	0,252386	0,015962
	Medial wall	250	1,9508	0,192686	0,012187

Table - 3. The all pedicle walls thickness is demonstrated in the lumbar spine region.

Level	Medial wall thickness Right (MR)	Medial wall thickness Left (ML)	Lateral wall Thickness Right (LR)	Lateral wall Thickness Left (LL)	P
L1	1.96	1.97	1.46	1.50	0.001
L2	1.86	1.97	1.35	1.45	0.001
L3	1.85	1.99	1.45	1.48	0.001
L4	1.78	2.1	1.56	1.52	0.001
L5	2.1	2.2	1.61	1.43	0.001

There are limited studies documented about anatomic structures of the pedicle walls of the lumbar spine. Mitra et al. reported measurements of the lumbar and thoracic peduncles in the Indian population [3, 8]. Although several studies of pedicle anatomy have been published, pedicle wall thickness has not been studied before and very limited quantitative data is exist in which the thickness of medial and lateral walls of pedicle were determined.

In this study, we present quantitative information about the wall thickness of the pedicle, which is especially important for pedicle screw fixation in the lumbar spine. Since the medial wall is significantly thicker, it is important to preserve the biomechanical stability of the medial wall and to avoid nerve root damage which has close approximated to medial wall. Misplaced pedicle screws may lead to instability or neurologic problems. Since neurological problems are only described with screws perforating the pedicle medially by at least 4 mm, this question has great relevance concerning the definition of pedicle disposition [14].

The pedicle screw needs to fit precisely into the pedicle diameter, because mismatched screw size may perforate the medial or lateral cortex or even may fracture the pedicle. A discrepancy between pedicle width and screw diameter can lead to an expansion or even fracture of the pedicle wall [7,15]. Sjostrom et al. investigated that the width increased in 65 % of the pedicles, and in 29 % there was even a fracture of the lateral pedicle wall [15]. The complications associated with oversized pedicle screw are dural tears, leakage of cerebrospinal fluid and injuries to nerve roots from the medial wall [1,11]. Thus, an insertion of the pedicle screw of the medial wall of the pedicle may be dangerous. Regardless of the different external dimensions, the cortical thickness of the lateral wall was significantly thinner then medial wall, as previously described Kothe et al. for the thoracic region [6]. This article is unique about wall thickness of the pedicle, but describes the thoracic vertebrae. This first study which compares medial and lateral walls of the thoracic pedicles is well correlated with the present study. Thus medial vertebral wall is thicker than lateral vertebra in the thoracolumbar region.

It is a common clinical finding that most of the pedicle fractures related to pedicle screws occur at the lateral wall of the pedicle [15]. In an in vitro study, Misenheimer at al. inserted screws of the different diameters into thoracic and lumbar pedicles [7]. With increasing screw diameter, they found changes on the pedicle structure. Although there were as many lateral cutouts as there were medial, indicating that the entrance points for the screws were in the center of the pedicle, they saw 72 % pedicle fractures laterally and only 28 % medially. This could be explained by our findings which show that the medial wall is thicker than lateral wall. This fact should be considered by the surgeon, particularly when a screw is inserted in a pedicle that is only slightly larger than the screw diameter.

The medial wall of the pedicle must be preserved during screw placement into the pedicle to avoid nerve root or dural damage and to preserve biomechanical stability. As we measure pedicle diameters in our preoperative preparation in clinics, measurement of the both medial and lateral pedicle walls by CT is an accurate method. However, a biomechanical study or investigation in the future should focus on as a wall thickness of the pedicle.

REFERANCES:

1. Amonoo-Kuofoi HS. Age-related variations in the horizontal and vertical diameters of the pedicles of the lumbar spine. *J Anat* 1995; 186: 321-328.
2. Buck AM, price RI, Sweetman IM, Oxnard CE. An investigation of thoracic and lumbar cancellous vertebral architecture using power-spectral analysis of plain radiographs. *J Anat* 2002; 200 (5): 445-456.
3. Datir SP, Mitra SR. Morphometric study of the thoracic vertebral pedicle in an Indian population. *Spine* 2004; 29 (11): 1174-1181.
4. France JC, Yaszemski MJ, Lauerman WC, Cain JE, Glover JM, Lawson KJ, Coe JD, Topper SM. A randomized prospective study of posterolateral lumbar fusion. Outcomes with and without pedicle screw instrumentation. *Spine* 1999; 24 (6): 553-560.
5. Kim NH, Lee HM, Chung HI, Kim HJ, Kim SJ. Morphometric study of the pedicles of thoracic and lumbar vertebrae in Koreans. *Spine* 1994; 19 (12): 1390-1394.
6. Kothe R, O'Holeran JD, Liu W, Panjabi MM. Internal architecture of the thoracic pedicle. An anatomic study. *Spine* 1996; 21 (3): 264-270.
7. Misenhimer GR, Peek RD, Wiltse LL, Rohtman SL. Anatomic analysis of pedicle cortical and cancellous diameter as related to screw size. *Spine* 1989; 14 (4): 367-372.
8. Mitra SR, Datir SP, Jadhay SO. Morphometric study of the lumbar pedicle in the Indian population as related to pedicular screw fixation. *Spine* 2002; 27 (5): 453-459.
9. Mulholland RC. Editorial: Pedicle screw fixation in the spine. *J Bone Joint Surg* 1994; 76-B: 517-519.
10. Panjabi MM, O'Holleran JD, Crisco JJ 3rd, Kothe R. Complexity of the thoracic spine pedicle anatomy. *Eur Spine J* 1997; 6 (1): 19-24.
11. Reichle E, Morlock M, Sellenschloh K, Eggers C. Definition of pedicle malposition. Primary stability and loosening characteristics of pedicle screws in relation to position: spongious anchoring, cortical anchoring, perforation and malposition. *Orthopade* 2002; 31 (4): 402-405.
12. Rohlman A, Wilke HJ, Graichen F, Bergmann G. Spinal load bearing during sitting in an office chair with a tilting back. *Biomed Tech* 2002; 47(4): 91-96.
13. Schizas C, Michel J, Kosmopoulos V, Theumann N. Computer tomography assessment of pedicle screw insertion in percutaneous posterior transpedicular stabilization. *Eur Spine J* 2006; 12; 223-227.

14. Singh K, An HS, Samartzis D, Nassr A, Provus J, Hickey M, Andersson GB. A prospective cohort analysis of adjacent vertebral body bone mineral density in lumbar surgery patients with or without instrumented posterolateral fusion: a 9- to 12- year follow-up. *Spine* 2005; 30 (15): 1750-1755.

15. Sjostrom L, Jacobsson O, Karlstrom G, Pech P, Rauschning W. CT analysis of pedicles and screw tracts after implant removal in thoracolumbar fractures. *J Spinal Disord* 1993; 6 (3): 225-231.