



## MORPHOMETRIC ANALYSIS OF THORACOLUMBAR JUNCTION PEDICLE DIAMETERS IN DIFFERENT ADULT AGE GROUPS

### TORAKOLOMBER BİLEŞKE PEDİKÜL ÇAPLARININ FARKLI ERİŞKİN YAŞ GRUPLARINA GÖRE MORFOMETRİK ANALİZİ

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#### SUMMARY

**Objective:** The aim of this study is to determine the normal diameter range of the T12 and L1 vertebrae in adults in groups of different gender and age.

**Materials and Methods:** 300 adult patients who had no pathology in the thoracolumbar junction were examined in this study. 150 male and 150 female patients were divided into 18–30, 31–50, and 51–70 age groups. In computed tomography images of the patients, the T12 and L1 vertebral pedicle diameters were calculated based on bilateral millimeter dimensions in axial sections. The statistical data were presented as mean and standard deviation. The Kruskal-Wallis and Mann-Whitney U tests were used for comparisons between the groups. The PASW Statistics v18 program was used for statistical analysis.

**Results:** The mean pedicle diameters of the T12 and L1 vertebrae in men were calculated as 6.06 mm and 5.76 mm, respectively, in the 18–30 age group, as 6.10 mm and 6.10 mm, respectively, in the 31–50 age group, and as 5.57 mm and 5.59 mm, respectively, in the 51–70 age group. The mean pedicle diameters of the T12 and L1 vertebrae in women were calculated as 4.83 mm and 4.77 mm, respectively, in the 18–30 age group, as 4.61 mm and 4.52 mm, respectively, in the 31–50 age group, and as 4.62 mm and 4.19 mm, respectively, in the 51–70 age group. The T12 and L1 pedicle diameters were also compared bilaterally in males and females in each age group, but there were no statistically significant differences. In terms of gender, the pedicle diameters of males were found to be greater than the pedicle diameters of females, and this was statistically significant.

**Conclusion:** The range of thoracolumbar pedicle diameters of adult males was between 4 mm and 8 mm, while this ranged between 2 mm and 7 mm in females. Based on these results, patients who will receive surgery using a pedicle screw instrumentation technique must be evaluated beforehand with an anatomical and morphometric analysis of the vertebral pedicles, in order to decrease the complication rates.

**Key words:** Pedicle diameter, thoracolumbar junction, thoracolumbar instrumentation.

**Level of evidence:** Retrospective clinical study, Level III.

#### ÖZET

**Amaç:** Bu çalışmanın amacı erişkin yaş gurubunda torako lomber bileşkenin pedikül çaplarının ölçülmesidir.

**Materyal-metod:** Bu çalışmada torakolomber bölgede herhangi bir patolojisi bulunmayan 300 hasta incelendi. 150 erkek ve 150 kadın hasta 18-30, 31-50, 51-70 yaş gruplarına ayrıldı. Hastaların bilgisayarlı tomografi görüntülerinde T12 ve L1 vertebra pedikül çapları aksiyel kesitlerde iki taraflı milimetrik ölçü baz alınarak hesaplandı. İstatistiksel veriler ortanca değerler ve standart sapmalar ile sunulmuştur. Gruplar arasındaki karşılaştırmalarda Kruskal-Wallis ve Mann-Whitney U testleri kullanılmıştır. İstatistiksel analizde PASW Statistics v18 programı kullanılmıştır.

**Sonuçlar:** Erkeklerde 18-30 yaş arasında; T12 pedikül çap ortalaması 6.06 mm, L1 pedikül çap ortalaması 5.76 mm, 31-50 yaş arasında; T12 pedikül çap ortalaması 6.10 mm, L1 pedikül çap ortalaması 6.10 mm, 51-70 yaş arasında; T12 pedikül çap ortalaması 5.57 mm, L1 pedikül çap ortalaması 5.59 mm olarak bulunmuştur. Kadınlarda 18-30 yaş arasında; T12 pedikül çap ortalaması 4.83 mm, L1 pedikül çap ortalaması 4.77 mm, 31-50 yaş arasında; T12 pedikül çap ortalaması 4.61 mm, L1 pedikül çap ortalaması 4.52 mm, 51-70 yaş arasında; T12 pedikül çap ortalaması 4.62 mm, L1 pedikül çap ortalaması 4.19 mm olarak bulunmuştur. T12 ve L1 pedikül çapları iki taraflı olarak erkek ve kadınlarda kendi yaş grupları içerisinde de karşılaştırılmış fakat istatistiksel anlamlı bir fark bulunamamıştır. Bulunan değerler cinsiyet yönünden ise erkeklerin pedikül çapları istatistiksel anlamlı olarak kadınların pedikül çaplarından büyük bulunmuştur.

**Çıkarım:** Erişkin erkeklerde tüm yaş gruplarında torakolomber bileşke pediküllerinin çap aralığı 4mm ile 8mm arasında hesaplanırken, kadınlarda ise çap aralığının 2mm ile 7mm aralığında değiştiği görülmüştür. Bu bilgiler göz önünde bulundurularak pedikül vidalama tekniğinde ameliyat edilecek hastanın omurlarının anatomik-morfometrik özelliklerine dikkat edilmeli ve bu sayede karşılaşılabilecek komplikasyonlar en aza indirgenmelidir.

**Anahtar Kelimeler:** Pedikül çapı, torakolomber bileşke, tora- kolomber enstrümantasyon.

**Kanıt Düzeyi:** Retrospektif klinik çalışma, Level III

## INTRODUCTION:

The thoracolumbar region is the region in which most spinal pathology is seen, as it is a biomechanical movement transition zone. These pathologies include traumas, degenerative diseases, osteoporotic compression fractures, instabilities, neoplastic diseases, and infections<sup>5,7,16</sup>. Thoracolumbar instrumentation constitutes the majority of the treatment options.

Pedicle screwing technology was described by Harrington and Tullos in 1969<sup>8</sup>. Equipment used for the application of instrumentation has developed in parallel with technological developments over the last 20 years, and has become advanced enough to use robotic technology<sup>19</sup>. No matter how advanced the techniques become, a full knowledge of the spine anatomy is required. If the right screw is not selected and it is not set at the right angle, serious complications can occur. These complications include pedicle fracture, nerve damage, and neurological and vascular injuries. Knowledge of the pedicle anatomy

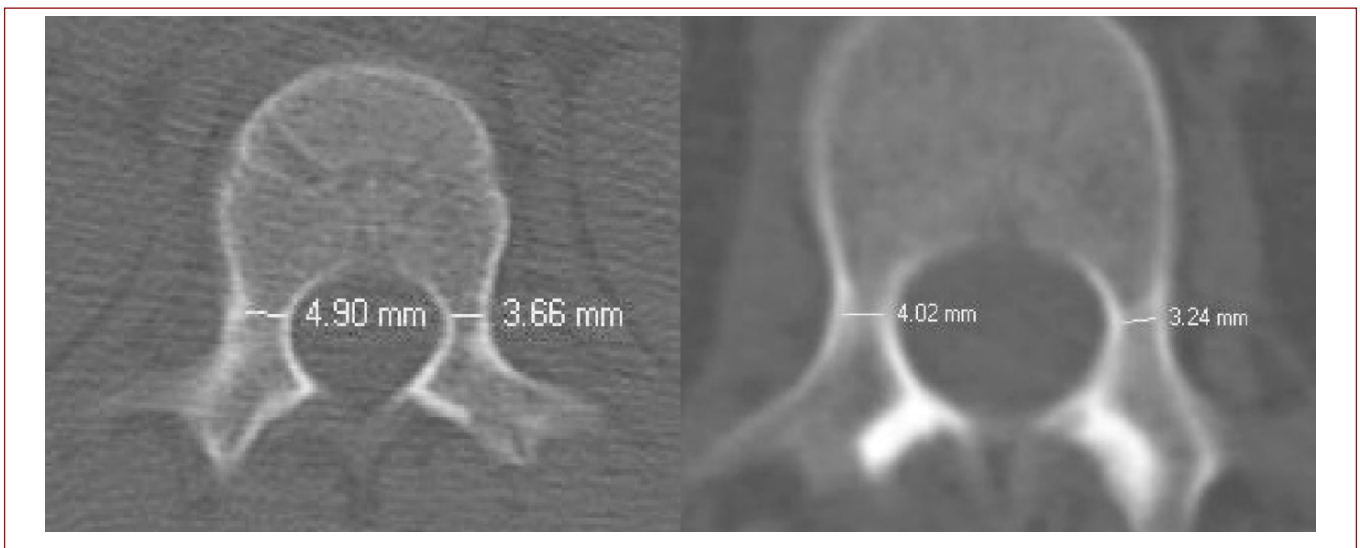
and calculation of the best pedicle diameter are required to select the correct screw.

In this study, we classified the pedicle diameters of the T12 and L1 vertebrae of the thoracolumbar junction according to age and gender in adults, by two-sided measurements.

## MATERIALS AND METHODS:

300 adult patients who had no pathology in the thoracolumbar junction were examined for this study. 150 males and 150 females were divided into 18–30, 31–50, and 51–70 age groups. In computed tomography images of patients, the T12 and L1 vertebral pedicle diameters were calculated based on bilateral millimeter dimensions in an axial section (Figures-1,2).

Statistical data were presented as the mean and standard deviation. The Kruskal-Wallis test and Mann-Whitney U test were used for comparisons between groups. The PASW Statistics v18 program was used for the statistical analysis. P-values lower than 0.05 were taken to show statistical significance between the groups.



**Fig-1.** Measurement of T12 pedicle diameters by CT axial slices

**Fig-2.** Measurement of L2 pedicle diameters by CT axial slices

## RESULTS:

The T12 and L1 pedicle diameters were also compared bilaterally in males (Table-1) and females (Table-2) in each age group, but there were no statistically significant differences.

In terms of gender, the pedicle diameters of males were found to be greater than the pedicle diameters of females, which was statistically significant. The results of the analysis are given in Table-3.

**Table-1.** Data analysis of pedicle diameters of male patients

	18-30 Age		31-50 Age		51-70 Age		p
	Median	StdDev	Median	StdDev	Median	StdDev	
T12 Right	6.00	0.97	5.99	0.95	5.47	1.29	0.189
T12 Left	6.12	1.21	6.22	1.05	5.68	0.92	0.141
L1 Right	5.55	1.16	6.26	1.01	5.39	1.38	0.055
L1 Left	5.97	1.20	5.95	1.07	5.79	1.37	0.902

**Table-2.** Data analysis of pedicle diameters of female patients

	18-30 Age		31-50 Age		51-70 Age		p
	Median	StdDev	Median	StdDev	Median	StdDev	
T12 Right	4.67	1.45	4.65	1.20	4.48	1.09	0.710
T12 Left	5.00	1.29	4.57	1.10	4.76	1.16	0.562
L1 Right	4.58	1.81	4.32	1.45	4.18	0.76	0.689
L1 Left	4.96	1.67	4.72	1.37	4.21	0.80	0.169

**Table-3.** Comparison of the pedicle diameter data by gender

	18-30 Age					31-50 Age					51-70 Age				
	Male		Female		p	Male		Female		p	Male		Female		p
	Mean	StdDev	Mean	StdDev		Mean	S.D.	Mean	StdDev		Mean	StdDev	Mean	StdDev	
T12 Right	6.00	0.97	4.67	1.45	0.001	5.99	0.95	4.65	1.20	<0.001	5.47	1.29	4.48	1.09	0.012
T12 Left	6.12	1.21	5.00	1.29	0.002	6.22	1.05	4.57	1.10	<0.001	5.68	0.92	4.76	1.16	0.004
L1 Right	5.55	1.16	4.58	1.81	0.052	6.26	1.01	4.32	1.45	<0.001	5.39	1.38	4.18	0.76	<0.001
L1 Left	5.97	1.20	4.96	1.67	0.021	5.95	1.07	4.72	1.37	<0.002	5.79	1.37	4.21	0.80	<0.001

## DISCUSSION:

Spine instrumentation techniques, and the materials used, are developing in parallel with technological developments. These techniques are most commonly used in surgery for spine trauma, degenerative diseases, oncological fractures and masses, deformity correction, and osteoporotic fracture surgery<sup>5,7,16</sup>. Spine surgeries which before were performed with

hooks, wires and rods are now performed using screw techniques<sup>2,13</sup>. The most commonly used technique in screwing operations is the pedicular screwing technique<sup>19</sup>.

To perform a pedicle screwing technique well, a full knowledge of the spine and pedicle anatomy is required. This is the best way to minimize the complication rate.

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The complications that can occur with the pedicular screwing technique include pedicle fracture, entry of the screw into the spinal canal, nerve compression or damage, neurological deficit and vascular damage<sup>6</sup>.

One of the most important factors aside from technique is the use of screws that are suitable for the anatomical and morphological features of the spine region receiving surgery. In our study, the pedicle diameters of the T12 and L1 vertebrae in the thoracolumbar junction region, in which spine pathology is most commonly seen, were examined. These data will be helpful in the selection of the most suitable screw diameter.

One of the most comprehensive morphometric analyses of the thoracolumbar region is a study by Panjabi et al.<sup>17,18</sup>. Kunkel et al. carried out a larger study, which included the results of the study by Panjabi et al.<sup>15</sup>. The results of this study are consistent with the results of our study. There are also other studies in the literature that carried out morphometric analyses of the thoracic and lumbar regions to determine the ideal screw length and diameter<sup>1,3,9,11,12,21</sup>.

Capar et al. examined the T12 and L1 pedicle diameters and the average screw lengths in adolescent and adult patients<sup>4</sup>. They found the diameter to be  $4.90 \pm 1.31$  mm for T12, and  $5.21 \pm 1.56$  mm for L1. Kotil et al. determined that the medial cortex is thicker and safer for screw application than the lateral cortex, by comparing the inner and outer cortical thicknesses of the pedicles in the lumbar spine<sup>14</sup>. Kaptanoglu et al. indicated that the inner diameter is more important in terms of the screw size, and found the average inner diameter of the lower thoracic and lumbar pedicles to be  $5.510$  mm<sup>10</sup>.

The results of our study are in support of these results in the literature.

Pedicle screwing technology was first described by Harrington and Tullos in 1969, and then developed by Roy-Camille et al.<sup>8,20</sup>. Nowadays, percutaneous pedicle screwing accompanied by fluoroscopy is used in minimally invasive spine surgery, and computed tomography-guided robotic pedicular screwing techniques are used as well as pedicle screwing with a free-hand technique<sup>5,16,19</sup>. No matter how advanced the techniques become, full knowledge of the spinal anatomy and morphometric characteristics are required to minimize complications.

Gautschi et al. reported the complications faced with the use of pedicular screwing techniques and their rates in a meta-analysis of 35,630 pedicle screwing surgeries<sup>6</sup>. According to their results, the nerve and spinal cord injury rate was reported as 0.6–0.11%, the dural injury rate per pedicle was reported as 0.18%, the nerve irritation rate per pedicle was reported as 0.19%, pedicle fracture was reported at a rate of 1.1%, and screw fractures were reported at a rate of 3–5.7%. Rare complications that can be encountered include iliac artery, aorta, esophagus and pleural injuries.

In conclusion, the thoracolumbar junction pedicle diameter varies between 4 mm and 8 mm in males and between 3 mm and 7 mm in females. Considering this information, the anatomical and morphometric characteristics of the vertebrae of patients who will receive surgery using a pedicle screwing technique should be assessed, in order to minimize the complications.

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