Trauma Monthly 2025; 30(6): 1609-1616

10.30491/tm.2025.490610.1785

Trauma Monthly

Research Article

Dimensions of Intervertebral Discs, Bodies, and Foramina of Lumbar Vertebrae Based on Gender and Ethnicity Using Computed Tomography in North of Iran

Sakineh Momeni[1], Kamran Haidari[2], MohammadHadi Gharib[3], Mohammad Reza Mohammadi [4], MohammadJafar Golalipour [5*]

[1] MSc, Department of Anatomical Sciences, Golestan University of Medical Sciences, Gorgan, Iran.
[2] Associate Professor, Department of Anatomical Sciences Golestan University of Medical Sciences, Gorgan, Iran.
[3] Assistant Professor, Department of Radiology, Golestan University of Medical Sciences, Gorgan, Iran.
[4] Associate Professor, Department of Neurosurgery, Golestan University of Medical Sciences, Gorgan, Iran.
[5] Professor, Gorgan Congenital Malformations Research Center, Department of Anatomical Sciences, Golestan University of Medical Sciences, Gorgan, Iran.

***Corresponding Author**: Prof. Mohammad Jafar Golalipour, Gorgan Congenital Malformations Research Center, Department of Anatomical Sciences, Golestan University of Medical Sciences, Gorgan, Iran. P.O. Box: 49175-553; E-mail: mjgolalipour@yahoo.com

Received 2024-04-05; **Accepted** 2025-10-25; **Online Published** 2025-12-29

Abstract

Introduction: Physical anthropometry, which includes the measurement of human anatomical structures such as lumbar vertebrae, is generally used to evaluate and measure human body dimensions. Its morphometry branch is used to define these structures. Today, the best standard for fusion inside the spine uses pedicular screw fixation.

Objectives: This study aimed to analyze the three-dimensional tomography of the lumbar vertebrae based on gender and ethnicity in Gorgan, North of Iran.

Methods: This descriptive-analytical study was performed on three different ethnical populations: Native Fars, Turkmen, and Sistani, which included 120 participants divided into three groups of 40 cases (20 females and 20 male), in the age group of 18-45 years, with the average heights of 165-180 cm for men and 165-170 cm for women. The dimensions of the intervertebral discs, bodies, and foramina of lumbar vertebrae were determined from the main axial view by coronal and sagittal reconstruction in 1.5 mm slices by a Computed Tomography (CT) scan.

Results: Based on the findings, differences were observed in the dimensions of intervertebral discs, bodies, and foramina of lumbar vertebrae based on gender and ethnicity using CT between the two genders ($P<0.05$). The above dimensions were higher in men than in women. The evaluation of the height and width of the vertebral body based on ethnicity showed a difference only in the width of the L1 lumbar vertebrae between Native Fars and Turkmen ($P<0.05$). Also, there were differences in the width of the foramina in the L3, L4, and L5 vertebrae among the Native Fars, Turkmen, and Sistani groups.

Conclusion: The present study found that dimensions of the intervertebral discs, bodies, and foramina of lumbar vertebrae were different based on gender and ethnicity, though, in terms of the lumbar disc, the difference was only observed in the two genders

Keywords: Lumbar vertebrae, Gender, Ethnicity, Computed Tomography, Morphometry

Introduction

Evaluation and measurement of human body dimensions are generally undertaken using physical anthropometry, and its morphometry branch is the measurement of human anatomical structures, such as

lumbar vertebrae, defined [1]. Many diseases, such as spinal cord injuries, fractures, degenerative diseases, tumors, and spine infections, may require spinal fusion. Using pedicular screw fixation has been widely accepted as a method of spinal instrumentation, which is widely used in the therapy of Scoliosis, instabilities, and spinal tumors [2, 3].

Nowadays, the best standard for fusion inside the spine uses pedicular screw fixation. In this method, the pedicle screw should be placed in its ideal position, i.e., inside the pedicle [4]. The safest procedure requires correct anatomical points and the size of the pedicle to minimize possible neurological complications. Studies have also shown that the best way to measure the pedicle of the lumbar vertebrae is to use Computed Tomography (CT) [5].

So, this study aimed to analyze the three-dimensional tomography of the lumbar vertebrae based on gender and ethnicity to help better understand the mechanism of movement in the spine and the spinal cord injury, and provide essential information for manufacturers of spinal instruments. It is also a guide for surgeons who use these instruments to know the correct anatomical data of the lumbar spine pedicle for safer surgery [6, 7]. A lumbar vertebra includes the body in the anterior part and the vertebral arch in the posterior part. Pedicles are bony columns that connect the vertebral arch to the vertebral body and form the vertebral foramina [8].

The word “Ethno” refers to a group of people who consider themselves to have different identities from other ethnic groups in terms of ethnicity, i.e., origin, race, history, land, culture, religion, literature, music, language, traditions, marriage traditions, feasts, collective rituals, clothing, food, and shared destiny [9].

The three principal ethnic groups living in this area are the Native Fars, Turkmen, and Sistani groups. Native Fars are the major ethnic group in this region. Turkmen migrated from Central Asia three centuries ago, and Sistani migrated to this province from the southeastern area of Iran about seventy years ago [10].

2. Objectives

Different ethnic groups live in the Golestan province, north of Iran. So far, no studies have been conducted on the role of ethnicity and gender in determining the dimensions of intervertebral discs, bodies, and foramina of lumbar vertebrae.

Due to its importance, this study aimed to analyze the three-dimensional tomography of the lumbar vertebrae based on gender and ethnicity in Gorgan, Iran.

Methods

This descriptive-analytical study was conducted on three ethnic groups: Native Fars, Turkmen, and Sistani. It involved 120 participants (in three groups of 40 samples, 20 women and 20 men) in the 18-45 age group, with an average height of 165-180 cm for men and 165-170 cm for women. The study was approved by the Medical Ethics Committee of the Deputy Research of Golestan University of Medical Sciences (Code: IR.GOUMS.REC.1397.158).

This study was performed at 5-Azar Hospital of Gorgan, Golestan, north of Iran, during 2018. First, written informed consent was obtained from the participants. Then, for each participant, the identical dimensions of the intervertebral discs, bodies, and foramina of lumbar vertebrae were determined from the main axial view by coronal and sagittal reconstruction in 1.5 mm slices by CT scan. The subjects in this one-blinded study were named by code and analyzed only by the specified code, so their names and CT-Scan information were not disclosed. A CT scan was not performed for asymptomatic individuals or extreme cases.

Inclusion criteria included patients who underwent a CT scan of the lumbar vertebrae with symptoms of low back pain, tumor, spondylolisthesis, infection, spondylolysis, and trauma. Analyses were performed only on healthy vertebrae. The vertebrae with fractures, infections, spondylolysis (spinal arthritis), tumors, etc., which cause vertebral deformation, were excluded from the study. Evaluating the height and width of the vertebral body and lumbar disc, and the size of the anterior-posterior diameter and transverse diameter of lumbar vertebral foramina was obtained from three axial, coronal, and sagittal views in 1.5 mm slices by CT (scanner SOMATOM Emotion) multi-slice model of SIEMENS Co. with 16 detectors using Osirix software (Osirix MD version).

Figure 1 shows the size of the anterior-posterior diameter with “H” and “G” for the transverse diameter of the lumbar vertebral foramina.

Figure 2 shows an example of lumbar disc width “ST”, and Figure 3 shows an example of the height of the vertebral body “FE”, disc height “MN”, and width of the lumbar vertebral body “KL”.

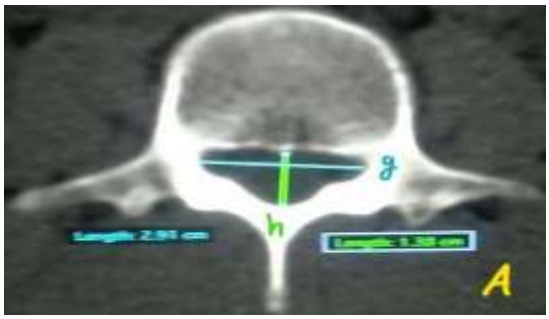

Figure 1: the size of the anterior-posterior diameter and the transverse diameter of the lumbar vertebral foramina.

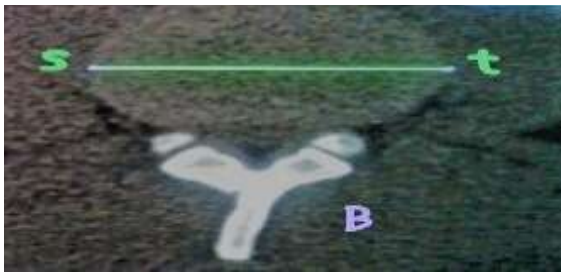

Figure 2: the width of the disc in lumbar vertebra

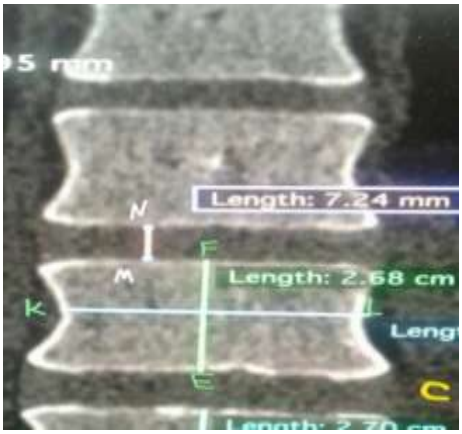

Figure 3: the height of the vertebral body and the disc and the width of the vertebral body

The results were analyzed using SPSS V.18, Chi-square for qualitative variables, and independent t-test and ANOVA for quantitative variables. P<0.05 was considered significant.

Results

The difference in the vertebral body "FE" height and the lumbar vertebral body "KL" width in the lumbar vertebral body was observed between men and women (figure C) (P<0.05). This difference was greater in men than in women (Table 1).

Table 1: Differences between vertebral body dimensions, height, and width of lumbar vertebrae based on gender; (N=60)

Vertebra	Gender	Mean± SD	P-Value
Width B. L1	male	40.045±3.8297	.001*
	female	34.518±3.1271	.001*
width B. L2	male	42.015±3.7215	.001*
	female	36.757±3.0899	.001*
width B. L3	male	43.792±3.4870	.001*
	female	38.737±2.9413	.001*
width B. L4	male	45.577±3.1789	.001*
	female	40.795±3.1183	.001*
width B. L5	male	48.798±3.4999	.001*
	female	45.157±3.6980	.001*
high B. L1	male	26.242±1.8821	.001*
	Female	24.470±1.8420	.001*
high B. L2	Male	27.083±1.8936	.001*
	Female	25.473±1.8340	.001*
high B. L3	Male	27.215±2.0402	.001*
	Female	25.898±1.9633	.001*
high B. L4	Male	26.986±2.2178	.001*
	Female	25.743±2.0833	.001*
high B. L5	Male	28.172±2.5595	.001*
	Female	26.470±2.0614	.001*

* Indicates the difference in the size of the vertebral body, height, and width of the lumbar vertebrae based on gender. Width, Height, B (body), L (lumbar vertebra).

Table 2 shows the comparison of the heights and widths of the vertebral bodies based on ethnicity, showing that the differences in the width of the vertebral body were only observed in the L1 (Table 2) (P<0.05).

Table 2: Lumbar vertebral body dimensions based on ethnicity; (N=40)

Vertebral L	Ethnicity	Mean± Std. Deviation	p-value
Width B. L1	Turkmen	38.707±4.1876	0.043*
	Native Fars	36.420±4.6497	
	Sistani	36.717±4.2601	
Width B. L2	Turkmen	40.468±3.9907	0.132
	Native Fars	38.595±4.2628	
	Sistani	39.095±4.5431	
Width B. L3	Turkmen	42.258±4.3094	0.172
	Native Fars	40.777±4.0688	
	Sistani	40.758±4.4986	
width B. L4	Turkmen	44.023±3.6547	0.252
	Native Fars	42.643±3.9355	
	Sistani	42.893±4.1991	
width B. L5	Turkmen	47.963±3.6097	0.163
	Native Fars	46.403±4.1030	
	Sistani	46.568±4.2483	
* Indicates the difference in the size of the vertebral body based on ethnicity Width, B (body), L (lumbar vertebra).			

The difference in the width of the vertebral body of the L1 was only between the Fras and Turkmen ethnic groups (P<0.05) (Table 3). Regarding the height and width of the lumbar disc from L1 to L5, the difference was only observed in the width of the vertebral disc between the two genders. Based on the results in Table 4, vertebral discs of L1 to L5 were higher in men than in women (P<0.05).

Table 3: The Dimentins of the lumbar vertebral body between the Native Fars and Turkmen ethnic groups

Ethnicity		Mean	P-value
Turkmen	Native Fars	2.2875	0.054*
	Sistani	0.19900	0.108
Native Fars	Turkmen	2.2875	0.054*
	Sistani	0.2975	0.950
Sistani	Turkmen	1.9900	0.108
	Native Fars	0.2975	0.950
* Indicates the difference in the size of the vertebral body based on ethnicity			

There was no difference in the size of the lumbar disc in ethnicities. Dimensions of the lumbar vertebral foramina based on gender and ethnicity showed that there was a difference in the size of the anterior-posterior diameter of h between men and women. This difference in all three ethnic groups (Native Fars, Turkmen, and Sistani) was only seen in the L5 vertebra between men and women (P<0.05) (Table 5). The comparison of the transverse diameter of the lumbar vertebral foramina based on gender in three ethnic groups showed that there were differences in all five lumbar vertebrae (P<0.05) (Table 5).

Table 4: Size of lumbar disc width by gender; (N=60)

Vertebral L	Gender	Mean ± SD	P-Value
width.d.L1	male	49.148±3.6432	.001*
	female	43.610±3.4840	.001*
width.d.L2	male	52.155±3.4068	.001*
	female	46.807±3.3089	.001*
width.d.L3	male	53.855±7.1391	.001*
	female	49.615±3.4742	.001*
width.d.L4	male	55.770±2.8015	.001*
	female	50.273±6.9143	.001*
width.d.L5	Male	53.172±4.3018	.001*
	female	47.358±5.9175	.001*
* Indicates the difference in the size of lumbar disc width by gender			

The results indicated that the width of the lumbar vertebral foramina was increased from L1 to L5, while the anterior-posterior diameter of the lumbar vertebral foramina was decreased from L1 to L4 (P<0.05).

Also, Table 5 displayed that the anterior-posterior diameter and transverse diameter were higher in men than in women. In terms of the differences in size based on ethnicities, the results showed that the width of the lumbar vertebral foramina of Native Fars was different from that of Turkmen in L3 and from that of Sistani in L5.

The difference in the width of lumbar vertebral foramina L4 was only observed between Native Fars and Sistani (P <0.05) (Table 6).

This study demonstrated that the width of the lumbar vertebral foramina of L3, L4, and L5 in Native Fars was greater than in Turkmen, and in Turkmen was lower than in Sistani (Table 7).

Table 5: Dimensions of lumbar vertebral foramina based on gender; (N=60)

Vertebra	Gender	Mean ± SD	P-Value
DIA.VF.AP.L1	Male	16.687±1.2885	.130
	female	16.273±1.6551	.130
DIA.VF.AP.L2	male	15.278±1.3136	.632
	female	15.152±1.5645	.632
DIA.VF.AP.L3	male	14.397±2.8293	.632
	female	13.957±1.7431	.308
DIA.VF.AP.L4	male	14.537±2.1647	.500
	female	14.247±2.5171	.500
DIA.VF.AP.L5	male	16.007±2.5390	.002*
	female	14.637±2.0915	.002*
DIA.VF.IP.L1	male	22.987±1.6148	.001*
	female	21.102±1.8443	.001*
DIA.VF.IP.L2	male	23.967±1.9672	.001*
	female	21.767±2.0017	.001*
DIA.VF.IP.L3	male	23.967±3.1152	.001*
	female	23.943±2.4624	.001*
DIA.VF.IP.L4	male	29.310±3.6852	.001*
	female	26.375±3.6237	.001*
DIA.VF.IP.L5	male	35.360±4.0456	.011*
	Female	33.413±4.2352	.011*
* Indicates the difference in the size of lumbar vertebral foramina based on gender. DIA (diameter), VF (vertebral foramina), IP (width of the vertebral foramina or distance between pedicles)			

Table 6: Width of lumbar vertebral foramina by ethnicity; (N=40)

Vertebral L	Ethnicity	Mean & SD	P-Value
DIA.VF.IP.L1	Turkmen	22.0 55 ± 1.7694	
	Native Fars	22.155 ± 2.2194	
	Sistani	21.923 ± 1.9338	.871
DIA.VF.IP.L2	Turkmen	22.728 ± 1.7500	.161
	Native Fars	22.468 ± 2.5421	
	Sistani	23.405 ± 2.3736	
DIA.VF.IP.L3	Turkmen	25.085 ± 2.5377	.001*
	Native Fars	23.402 ± 3.2372	
	Sistani	26.380 ± 2.3488	
DIA.VF.IP.L4	Turkmen	27.945 ± 3.4025	.002*
	Native Fars	26.268 ± 3.6648	
	Sistani	29.315 ± 4.1533	
DIA.VF.IP.L5	Turkmen	34.895 ± 3.7622	.001*
	Native Fars	32.315 ± 4.4508	
	Sistani	35.950 ± 3.6977	
* Indicates the difference in the size of lumbar vertebral foramina based on ethnicity. DIA (diameter), VF (vertebral foramina), IP (width of the vertebral foramina or distance between pedicles)			

Table 7: Width of L3, L4, and L5 of the lumbar vertebral foramina by ethnicity

Vertebral L	Ethnicity		Mean± Std. Deviation	P-Value
DIA.VF.IP.L3	Turkmen	Native Fars	1.68±.061	.019*
		Sistani	1.29±.61	.091
	Native Fars	Turkmen	1.68±.61	.019*
		Sistani	2.97±.61	.001*
	Sistani	Native Fars	2.97±.61	.001*
		Turkmen	1.29±.61	.091
DIA.VF.IP.L4	Turkmen	Native Fars	1.67±.83	.117
		Sistani	1.37±.83	.236
	Native Fars	Turkmen	1.67±.83	.117
		Sistani	3.04±.83	.001*
	Sistani	Native Fars	3.04±.83	.001*
		Turkmen	1.37±.83	.236
DIA.VF.IP.L5	Turkmen	Native Fars	2.58±.89	.012*
		Sistani	1.05±.89	.465
	Native Fars	Turkmen	2.58±.89	.012*
		Sistani	3.63±.89	.001*
	Sistani	Native Fars	3.63±.89	.001*
		Turkmen	1.05±.89	.465

* Indicates the difference in the size of lumbar vertebral foramina based on ethnicity. DIA (diameter), VF (vertebral foramina), IP (width of the vertebral foramina or distance between pedicles)

Discussion

The present study compared the size of intervertebral discs, bodies, and foramina of lumbar vertebrae dimensions based on gender (male and female) and ethnicity (Native Fars, Turkmen, and Sistani) in Gorgan, north of Iran, using a CT scan, which is the best tool for morphometric evaluation of lumbar vertebrae.

Different studies have performed morphometric measurements of the vertebral pedicle by CT scan, and some significant differences were found in the size of the lumbar pedicle in terms of gender and ethnic groups [11, 12].

Based on the results of the present study, there was a difference in the dimensions of the lumbar vertebral body based on gender (P<0.05), which was higher in men than in women. The difference in the width of the lumbar vertebrae based on ethnicity was only observed in the width of the L1 vertebrae between the Turkmen and Native Fars (P<0.05).

However, the difference in height of the lumbar vertebrae was not found in any of the ethnic groups. Assessment of lumbar disc height and width indicated the difference in disc size between men and women was statistically significant (P<0.05), which means the size of the lumbar disc was higher in men than in women. No difference was found in the size of the lumbar disc in ethnic groups; examining the size of the vertebral foramina based on ethnicity showed that there was no difference in the size of the anterior-posterior diameter of the lumbar vertebral foramina based on ethnicity. However, there was a difference in the width of the lumbar vertebral foramina in L4, L3, and L5 based on ethnicity.

Examination of the size in the transverse diameter of the lumbar vertebral foramina based on ethnicity showed that there was a difference in L3 and L5 vertebrae between Native Fars with Turkmen and Native Fars with Sistani; this difference in L4 vertebra was observed only in Native Fars with Sistani. There was no difference in the size of the anterior-posterior diameter of the lumbar vertebral foramina in the ethnicities; by gender, there was only a difference in the anterior-posterior diameter of the L5 vertebral foramina. Regarding the size of transverse diameter, the difference between genders was found in all five lumbar vertebrae, so the transverse diameter of the vertebral foramina was higher in men than in women.

Gulec et al. studied the size of lumbar vertebrae based on age, gender, and height using CT scans, which

showed that transverse pedicle diameter (TPD), vertical pedicle diameter (VPD), and pedicle axis length (PAL) varied in different individuals, and transverse pedicle angle (TPA) varies based on age. However, they found no difference in terms of gender and height. Also, the comparison of Turkey with European and Asian countries showed that these measurements in the population of Turkey were similar to those of European countries [2].

The study in Nepal, using plain radiography and CT scan on the lumbar vertebral pedicles, showed an increase in the width and height of the pedicles from vertebrae L1 to L5; comparing Nepal with other countries showed that the size of the lumbar vertebral pedicles in the Nepal population was similar to India [13].

In India, Gosal et al. conducted a study on the pedicle size in the thoracic and lumbar vertebrae, which showed that the width of the pedicles was increased from D9 to L5 [14].

Gosal et al. conducted a study on the size of the pedicles in the thoracic and lumbar vertebrae, which showed that pedicle width increased from D9 to L5 [14]. That study in Mexico on the size of the pedicles of the lumbar vertebrae of cadavers showed that the pedicle width of the lumbar vertebrae from L1 to L5 increased, which is consistent with our results. In our study, the pedicle height was decreased from the lumbar vertebrae L1 to L5, but in the Mexican population, the height was increased from L1 to L4 [5, 15].

Alam et al. studied different dimensions of the lumbar vertebrae, including the vertebral body and pedicle, using CT scans based on gender, which showed that the height of the anterior surface of the vertebral body was increased from L1 to L5, which is consistent with the present study [16].

A study in the population of northwestern India showed that the size of the anterior transverse angle of the lumbar vertebral pedicle was higher in men than in women [3, 17].

Mohamad Tall et al. studied the pedicle and lumbar vertebral foramina using CT scans. They found an increase in the width of the pedicle from L1 to L5 vertebrae, which was higher in men than in women, consistent with the results of the present study [18].

A study in Malaysia, on the size of the lumbar pedicles among the youth and adolescent populations, showed that the different dimensions of the lumbar pedicle were higher in the youth than in the adolescent population [19].

Nojiri et al.'s study in Japan on the pedicle dimensions of the thoracic and lumbar spine using CT showed that the width and length of the pedicles increased from the thoracic vertebra to the lumbar vertebra, and the width and length of the pedicles were higher in men than women [20].

A study in India using CT scans to compare the size of the foramina of lumbar vertebrae in men and women showed that it was higher in men than in women, which was consistent with the results of the present study [21].

Our study was performed in Gorgan, North of Iran. It provided morphometry of the vertebral body, lumbar disc, and lumbar vertebral foramina to help surgeons reduce neurological complications during pedicle screw implantation. This information also helps spinal instrument manufacturers better understand spinal movements.

Conclusion

The results showed a significant difference in the size of the intervertebral discs, bodies, and foramina of lumbar vertebrae in men and women, as well as the role of gender and ethnicity in them. Differences observed in different studies could have been owing to genetic, ethnic, geographical, and nutritional factors.

Acknowledgments

The authors are thankful for the financial support of the Deputy of Research, Golestan University of Medical Sciences, and Gorgan, Iran (Grant number: 110345).

Conflict of Interest Disclosures

The authors declare no competing interest.

Funding Sources

None.

Authors' Contributions

Study concept and design: MS and GMJ; analysis and interpretation of data: GhMH, and MS; drafting of the manuscript: MS, MMR, HK; critical revision of the manuscript for important intellectual content: GMJ, HK and MS; statistical analysis: GhMH, and MS.

Ethical Statement

This study was approved by the Medical Ethics Committee of the Deputy Research of Golestan University of Medical Sciences (Code:

IR.GOUMS.REC.1397.158).

Declaration of Generative AI and AI-assisted technologies

Not used.

References

.1 Jahanshahi M, Golalipour M, Heidari K. The effect of ethnicity on facial anthropometry in Northern Iran. Singapore medical journal. 2008;49(11):940-3.

.2 Gьlez A, Kazıra B, Kütahya H, Özbiner H, Öztürk M, Solbaş Ç, et al. Morphometric analysis of the lumbar vertebrae in the Turkish population using three-dimensional computed tomography: correlation with sex, age, and height. Folia Morphologica. 2017;76(3):433-9.

.3 Llztьrk MF, Gьdek MA, Beyhan M. Morphometric examination of vertebrae prominens with computed tomography images. Journal of Experimental and Clinical Medicine. 2024;41(2):264-70.

.4 Zindrick MR, Wiltse LL, Widell EH, THOMAS JC, Holland WR, FIELD BT, et al. A biomechanical study of intrapeduncular screw fixation in the lumbosacral spine. Clinical Orthopaedics and Related Research (1976-2007). 1986;203:99-112.

.5 Momeni-e-Raqla S, Heidari K, Gharib M, Mohammadi M, Golalipour M. The effect of gender on dimensions of lumbar vertebral pedicle using computed tomography. Journal of Babol University of Medical Sciences. 2019;21(1):338-44.

.6 Lotfinia I, Haddadi K, Sayyahmelli S. Computed tomographic evaluation of pedicle dimension and lumbar spinal canal. Neurosurgery Quarterly. 2010;20(3):194-8.

.7 Nguyen K, Razzouk J, Brandt Z, Carlson P, Vyhmeister E, Bouterse A, et al. Anatomic Assessment of L1-S1 Neuroforaminal Dimensions Using Computed Tomography in 1,000 Patients: A Follow-Up Study. Global Spine Journal. 2023:21925682231220043.

.8 Standring S, Gray's Anatomy E. Book: The Anatomical Basis of Clinical Practice. Elsevier Health Sciences; 2015.

.9 Robel RR. John Hutchinson and Anthony D. Smith, eds. Ethnicity. Comparative Civilizations Review. 2000;43(43):10.

.10 Nikyar B, Sedehi M, Qorbani M, Nikyar A, Golalipour MJ. Ethnical variations in the incidence of congenital heart defects in Gorgan, Northern Iran: A single-center study. The Journal of Tehran University Heart Center. 2014;9(1):9.

.11 Hailong Y, Wei L, Zhensheng M, Hongxun S. Computer analysis of the safety of using three different pedicular screw insertion points in the lumbar spine in the Chinese population. European Spine Journal. 2007;16:619-23.

.12 Kim N-H, Lee H-M, Chung I-H, Kim H-J, Kim S-J. Morphometric study of the pedicles of thoracic and lumbar vertebrae in Koreans. Spine. 1994;19(12):1390-4.

.13 Marasini RP, Gautam P, Sherchan B, Gurung G, KC BR. A morphometric study of lumbar spine pedicles in Nepalese population. Journal of College of Medical Sciences-Nepal. 2014;10(4):12-7.

.14 Gosal GS, Boparai A. A Prospective Study to Assess the Morphology of Pedicles of Lower Thoracic and Lumbar Vertebrae using Computerized Tomography Scan Measurements in North-Indian Population. Int J Sci Res. 2015;4(5):2935-6.

.15 Castro-Reyes CD, Morales-Avalos R, Vнlchez-Cavazos F, De La Garza-Castro O, Salinas-Zertuche A, Aguirre P, et al. Morphometric characteristics of lumbar vertebral pedicles in Mexican population. Implications for transpedicular lumbar fusion surgery. Journal of Morphological Sciences. 2015;32(01):037-42.

.16 Alam MM, Waqas M, Shallwani H, Javed G. Lumbar morphometry: a study of lumbar vertebrae from a Pakistani population using computed tomography scans. Asian spine journal. 2014;8(4):421.

.17 Chawla K, Sharma M, Kochhar S, Abhaya A, Sahni D, Gupta R. Importance of transverse pedicle angle & chord length of lumbar pedicle in screw placement: a CT scan study on North West Indian population. Eur J Anat. 2013;17(4):230-6.

.18 Tall M, Sawadogo M, Kassй AN, Ouйdraogo A, Pilabrй H, Savadogo I, et al. Morphometric study of the lumbar spray in the african black west subject: interest in surgery. About a CT scans of 170 cases in Ouagadougou (Burkina Faso). Open journal of Orthopedics. 2018;8(05):190.

.19 Mughir AMA, Yusof MI, Abdullah S, Ahmad S. Morphological comparison between adolescent and adult lumbar pedicles using computerised tomography scanning. Surgical and radiologic anatomy. 2010;32:587-92.

.20 Nojiri K, Matsumoto M, Chiba K, Toyama Y. Morphometric analysis of the thoracic and lumbar spine in Japanese on the use of pedicle screws. Surgical and Radiologic Anatomy. 2005;27:123-8.

21. Yadav U, Singh V, Bhargava N, Srivastav AK, Neyaz Z, Phadke R, et al. Lumbar Canal Diameter Evaluation by CT Morphometry—Study of Indian Population. International journal of spine surgery. 2020;14(2):175-81.