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Study of pedicles and spinal canal diameters at the level of lumbar vertebral in normal adult Saudi population using computed tomography

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Abstract

The values of normal transverse (interpedicular) and sagittal (midsagittal) diameters are different at various levels of lumbar spinal canal in individuals of the same race and differ at identical levels in individuals of various races.

The aim of the study was to determine normal reference range of the lumbar spinal canal dimensions and to evaluate lumbar pedicle dimensions with respect to spinal level, age, gender in Saudi population by using Computed Tomography.

This study was conducted in Najran province (K.S.A), archival abdominal CT scan images from PACS in hospitals were used. The data of this study was collected from 210 (102 male and 108 female) normal Saudi adults individuals with different ages, gender over a period of 20 months (2019 - 2021).

The mean spinal canal transverse distance (SCTR) showed steady decrease from L1 to L4, as there was an increasing in (SCTR) at L5 relative to L4, The mean spinal canal anteroposterior diameter (SCAP) showed a decrease from L1 to L3, and then a gradual increase from L4 to L5 (Fig.4-10). This pattern was observed in males only as there was an increase of female (SCAP) at L2 and L5, and no significant gender difference was noted at any lumbar level for (SCAP)

The mean pedicle width (PW) showed steady increase from L1 to L5. While the mean pedicle height (PH) showed a gradual decrease from L1 to L5.

The study conclude that Computed tomography is a reliable method for determining the morphological measurements of the spinal canal and pedicles diameter.

Keywords: Spinal canal; Pedicles; CT; Lumbar Vertebra

1. Introduction

The spinal canal is made up of the canals of individual vertebrae so that bony segments alternate with inter-vertebral and articular segments. The shape of the transverse section changes from round at L1 to triangular at L3 and slightly trefoil at L5 [1].

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The margins of the canal are formed by an anterior wall and a posterior wall, connected through pedicles and inter-vertebral foramina [2].

The anterior wall consists of the alternating posterior aspects of the vertebral bodies and the annulus of the inter-vertebral discs. In the midline these structures are covered by the posterior longitudinal ligament, which widens over each inter-vertebral disc [2].

The posterior wall is formed by the uppermost portions of the laminae and the ligament flava. Because the supero-inferior dimensions of the laminae tend to decrease at the L4 and L5 levels, the ligamenta flava consequently occupy a greater percentage of the posterior wall at these levels [3]. The postero-lateral borders of the posterior wall are formed by the anterior capsule of the facet joint and the superior articular process, which is located well anterior of the articulating inferior articular process [2].

The lumbar spinal canal contains the conus medullaris and the qauda equine with in a dural sac as well as epidural vessels with a variable amount of fat outside the dura. The bony wall of the canal is unyielding and there is a normally a certain minimal free space between the canal and the contents. this space is allows for the free movements of the contents of the canal without tension or pressure during these movements. Therefore, the normal size of the canal is important. An abnormal reduction of the size of lumbar spinal canal could predispose the individual to lower back pain [4]. It has been shown that there is a relation between age, weight, body stature, ethnic differences and the size of the spinal canal [5]. In addition, it has been suggested that many environmental factors (i.e. placental weight, loe birth weight, low socio-economic status) may affect the development of the canal [6]. Christenson reported that transverse diameter of the canal (interpedicular distance) is a reliable index for the assessing size of the canal [7]. A stenosis of the lumbar spinal canal maybe related to the progressive degeneration of the lumbar vertebrae [8]. The lumbar spinal canal sagital diameter ranges from 15 to 25 mm, the diameters ≤ 15 were considered abnormal, and diameters ≤ 12 mm suggests a stenosis of the canal [9].

The values of normal transverse (interpedicular) and sagittal (midsagittal) diameters are different at various levels of lumbar spinal canal in individuals of the same race and differ at identical levels in individuals of various races [10].

The lumbar vertebrae are irregular bones consisting of various named parts. The anterior part of each vertebra is a large block of bone called the vertebral body. Projecting from the back of the vertebral body are two stout pillars of bone. Each of these is called a pedicle. The pedicles attach to the upper part of the back of the vertebral body. The word 'pedicle' is derived from the Latin pediculus meaning little foot; the reason for this nomenclature is apparent when the vertebra is viewed from above [2].

Lower lumbar pedicle size differs between ethnic race. Knowledge of pedicle dimensions and surface landmarks is crucial for the safe placement of screws [11].

The aim of the study was to determine normal reference range of the lumbar spinal canal dimensions and to evaluate lumbar pedicle dimensions with respect to spinal level, age, gender in Saudi population by using Computed Tomography.

2. Material and methods

This study was a quantitative, descriptive, and cross-sectional study performed in Najran province (K.S.A), archival abdominal CT scan images from PACS in hospitals were used. The data of this study was collected from 210 (102 male and 108 female) normal Saudi adults individuals with different ages, gender over a period of (2016 - 2021). Each pedicle height (PH) was measured in millimeters and was obtained in sagital plane of CT scan images from the mean values of the right and left pedicles height at the level of each pedicle.

Each pedicle width (PW) was measured in millimeters and was obtained in axial plane of CT scan images from the mean values of the right and left pedicles height at the level of each pedicle.

Spinal canal transverse (SCTR) and antero-posterior (SCAP) diameter were measured in millimeters and was obtained in axial plane of CT scan images at the center of spinal canal at each corresponding lumbar vertebra.

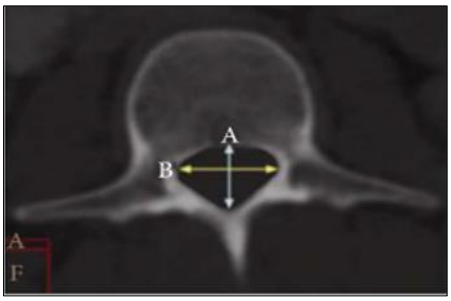

Figure 1 (A) Anteroposterior diameter of the spinal canal (B) Transverse diameter of the spinal canal

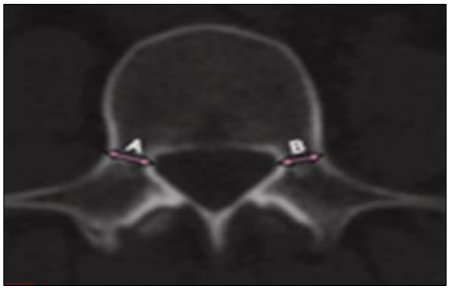

Figure 2 (A) Rigt pedicle width (B) Left pedicle width

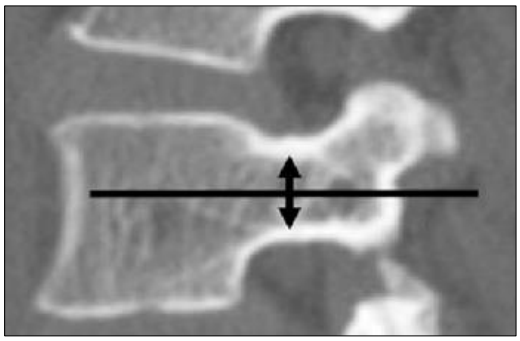

Figure 3 Pedicle height (double head arrow) in one side

3. Results and discussion

Table 1 The mean value and the standard deviation of the pedicles and spinal canal dimensions

	lumber vertebra	1st	2nd	3rd	4th	5th
Variables	PW	5.6±1.8	6.3±1.9	7.7±2.0	9.2±2.1	11.8±2.4
	PH	10±1.6	9.4±1.5	9.2±1.3	8.5±1.5	7.4±1.3
	SCTR	20.3±2.0	20.1±1.5	19.6±1.6	18.9±1.9	19.5±2.6
	SCAP	15.4±1.3	14.5±1.4	13.9±1.5	14.2±2.0	15±2.9

Table 2 Significance independent t-test between gender for lumber vertebral pedicle width (PW)

Independent Samples Test		
	t-test for Equality of Means	
	t	Sig. (2-tailed)
PW1	7.731	0.000
PW2	8.120	0.000
PW3	6.707	0.000
PW4	5.643	0.000
PW5	5.796	0.000

p<0.05 consider as significant

Table 3 Significance independent t-test between gender for lumber vertebral pedicle height (PH)

Independent Samples Test		
	t-test for Equality of Means	
	t	Sig. (2-tailed)
PH1	4.095	0.000
PH2	5.454	0.000
PH3	4.463	0.000
PH4	5.364	0.000
PH5	4.058	0.000

Table 4 Significance independent t-test between gender for lumber vertebral spinal canal transverse (SCTR)

Independent Samples Test		
	t-test for Equality of Means	
	T	Sig. (2-tailed)
SCTR1	2.243	0.028
SCTR2	0.099	0.921
SCTR3	-0.255	0.800
SCTR4	-1.142	0.257
SCTR5	-1.523	0.132

Table 5 Significance independent t-test between gender for lumber vertebral spinal canal anteroposterior (SCAP)

Independent Samples Test		
	t-test for Equality of Means	
	t	**Sig. (2-tailed)**
SCAP1	0.064	0.949
SCAP2	-0.648	0.519
SCAP3	0.157	0.876
SCAP4	-0.078	0.938
SCAP5	-0.409	0.684

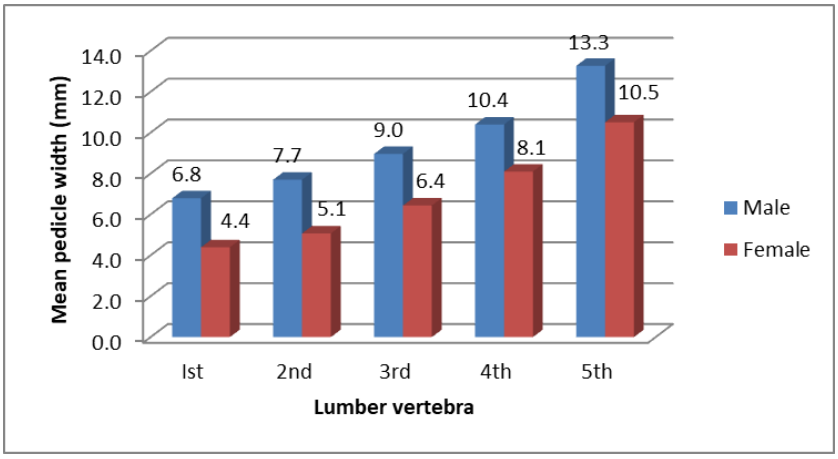

Figure 4 Bar graph show the mean value of pedicle width of lumber vertebra for male and female

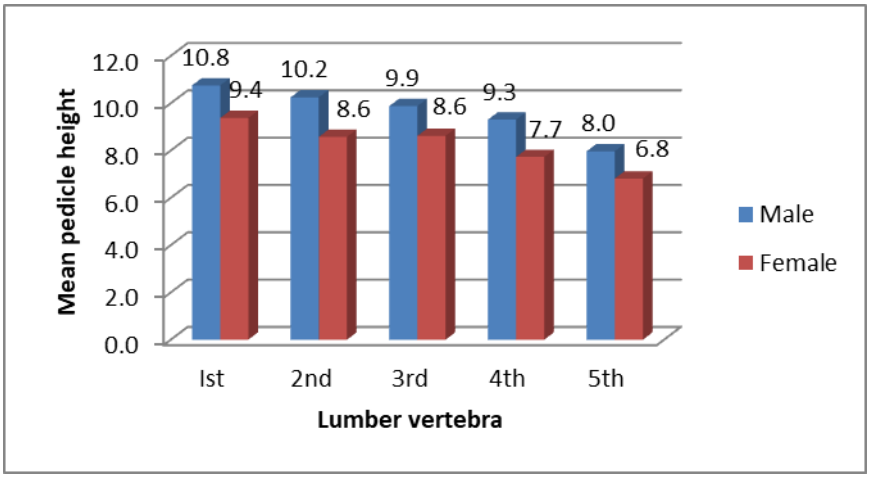

Figure 5 Bar graph show the mean value of pedicle height of lumber vertebra for male and female

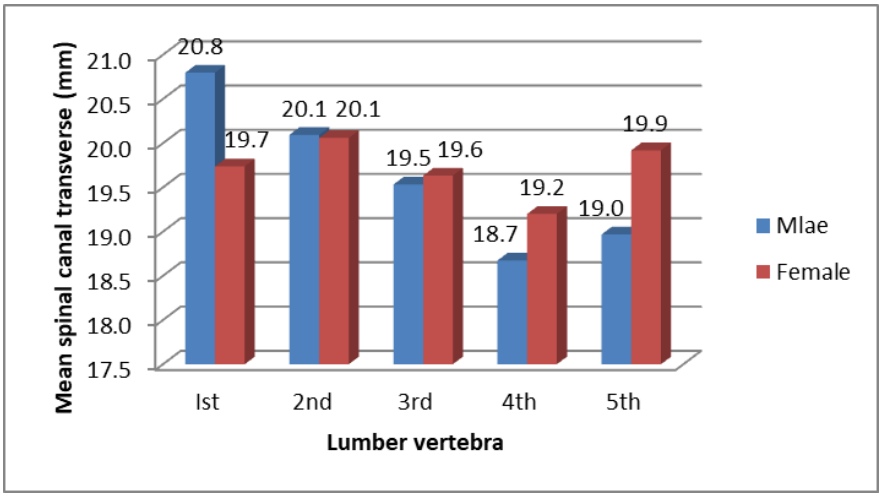

Figure 6 Bar graph show the mean value of spinal canal transverse of lumber vertebra for male and female

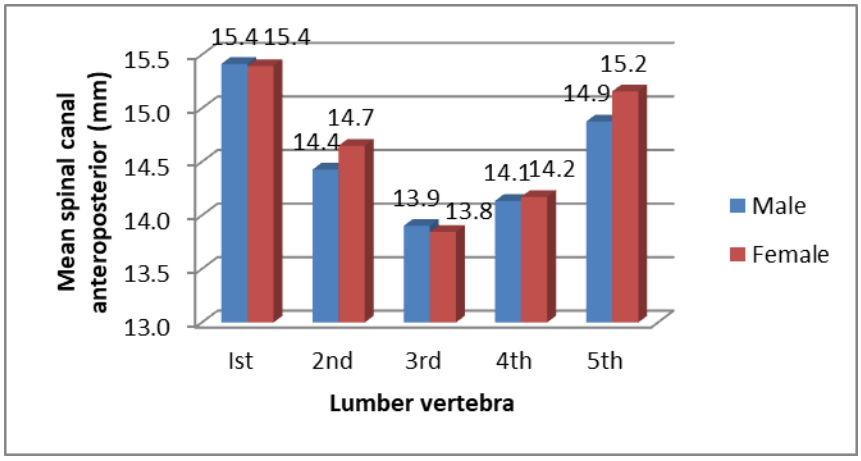

Figure 7 Bar graph show the mean value of spinal canal anteroposterior of lumber vertebra for male and female

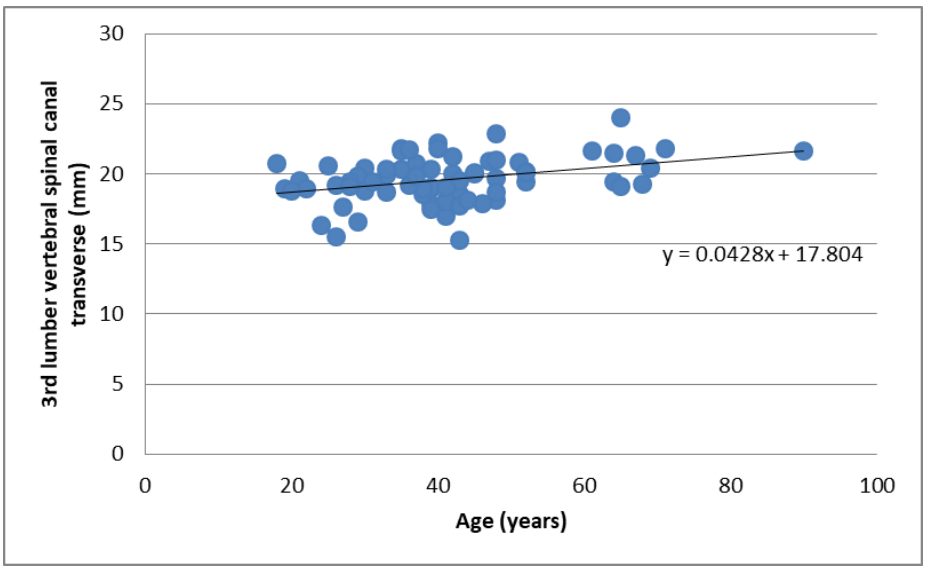

Figure 8 Scatter plot show direct linear relationship between the 3nd lumbar vertebral spinal canal transverse diameter and age; where the spinal canal transverse diameter increases by 0.04 mm/year

4. Discussion

The alignment of spinal canal of lumbar vertebrae is determined by structures that surround the successive spinal foramina and any pathological changes in canal diameter could be related to LBP [12].

Table 1 represents the mean ± the standard deviation of the lumber vertebral pedicles and spinal canal dimensions in normal adult Saudi populations.

The mean pedicle width (PW) showed steady increase from L1 to L5 (L1= 5.6±1.8 mm; L2=6.3±1.9 mm; L3=7.7±2.0 mm; L4=9.2±2.1 mm; L5=11.8±2.4 mm). This increasing pattern was observed in both male and female, the mean values of PW for female were (L1=4.4 mm; L2=5.1 mm; L3=6.4 mm; L4=8.1 mm; L5=10.5 mm) while for male they were (L1=6.8 mm; L2=7.7 mm; L3=9.0 mm; L4=10.4 mm; L5=13.3 mm) as presented in (Fig 4), the mean values of pedicle width (PW) in male was higher than in female and a significant differences were observed between the genders at each lumbar level (Table 2). This result agree with A study conducted by Urrutia Vega E. et al. (2009) "Morphometry of Pedicle and Vertebral Body in a Mexican Population by CT and Fluoroscopy" [13], and with Singh, V. et al, in 2021 (Computed Tomographic Morphometry of Lumbar Spine in Indian Population) [14], their studies conclude that a progressive and

gradual increase in the width of the pedicles from L1 to L5. However the Saudis mean pedicle width (PW) was lower than that in Mexican and Indian Population.

The mean pedicle heights (PH) showed a gradual decrease from L1 to L5 (L1=10±1.6 mm; L2=9.4±1.5 mm; L3=9.2±1.3 mm; L4=8.5±1.5 mm; L5=7.4±1.3 mm). This decreasing pattern also consistent in male and female. The mean values of PH in male were (L1=10.8 mm; L2=10.2 mm; L3=9.9 mm; L4=9.3 mm; L5=8.0 mm), while in female they were (L1=9.4 mm; L2=8.6 mm; L3=8.6 mm; L4=7.7 mm; L5=6.8 mm) as shown in (Fig.5), the mean values of pedicle height (PH) in male were higher than in females and a significant difference in (PH) was seen between the genders at each lumbar level (Table 3). Same result achieved by Singh, V. et al study. However the Saudis mean pedicle height (PH) was lower than that in Indian Population.

The mean spinal canal transverse distance (SCTR) shows steady decrease from L1 to L4, as there was an increasing in (SCTR) at L5 relative to L4, (L1= 20.3±2.0 mm; L2=20.1±1.5mm; L3=19.6±1.6mm; L4=18.9±1.9mm; L5=19.5±2.6mm). This decreases was observed male rather than in female, the mean values of SCTR in female were (L1=19.7 mm; L2=20.1 mm; L3=19.6 mm; L4=19.2 mm; L5=19.9 mm) where in male the mean they were (L1=20.8 mm; L2=20.1 mm; L3=19.5 mm; L4=18.7 mm; L5=19.0 mm) (Fig. 6). N0 significant difference in (SCTR) was seen between the genders at any lumbar level (Table 4), also Azu, O. O., et al. et al (2013) state no significant difference in (SCTR) between the genders in south Africa population [15], but the result disagree with Aly T et al. (2013), study done in Egyptian population [16], and with Singh, V. et al, (2021) study done in India, where they found steady increase in (SCTR) dimeter from L1 to L5. However spinal canal transverse distance (SCTR) for Saudi was lower than that for Egyptian and Indian population.

The mean spinal canal anteroposterior diameter (SCAP) shows a decrease from L1 to L3 (L1=15.4±1.3 mm; L2=14.5±1.4 mm; L3= 13.9±1.5 mm), and then a gradual increase from L4 to L5 (L4=14.2±2.0 mm; L5=15±2.9 mm) (Fig.7). This pattern was observed in male where the mean values of SCAP were (L1=15.4 mm; L2=14.4 mm; L3=13.9 mm; L4=14.1 mm; L5=14.9 mm) and also in female where the mean values of SCAP were (L1=15.4 mm; L2=14.7 mm; L3=13.8 mm; L4=14.2 mm; L5=15.2 mm), and no significant gender difference was noted at any lumbar vertebral level for (SCAP) (Table 5), this result agree with AZU, KOMOLAFE, et al, Elhassan, Y. et al (2014) studies, however, mean (SCAP) for female and male were lower in our study as compared to means values that were reported in south Africa, Egyptian and Sudanese studies.

Also, direct linear relationship between the 3rd lumber vertebral spinal canal transverse diameter and age was found , where the spinal canal transverse dimeter increases by 0.04 mm/year (Figure -8).

The data presented in this study hence provides relevant morphological information on lumbar vertebral arrangement within the cohort sample. This information may be substantial to anthropologists interested in understanding association between gender, age, and skeletal lumbar stabilities. However, it gives an understanding of the morphological relevance of the lumbar vertebrae to clinical diagnosis of LBP and other abnormalities. Computed tomography is a reliable method for determining the morphological measurements of the spinal canal and pedicles diameter.

5. Conclusion

With assessments of the lumbar region, animated differences were found among races and individual. We conclude that in normal Saudi population there was Significant correlation between certain lumbar dimensions at different levels and age and gender of subjects. The measurements achieved in this study may form a base line for normal adult Saudi population and may give guidance to clinicians for the evaluation and treatment of spinal abnormalities.

Further studies involve patient height and BMI is recommended.

Compliance with ethical standards

Acknowledgments

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Disclosure of conflict of interest

There was no conflict of interest among the authors.

Statement of informed consent

The present research work does not contain any studies performed on animals/humans subjects by any of the authors'.

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