Section: Anatomy

Original Research Article

# A STUDY OF THE LUMBAR SPINAL CANAL IN THE TAMIL NADU POPULATION

**K. Savithri[1], V. Dharani[2], S. Subramaniam[3], J. Sreevidya[4]**

[1]Associate Professor, Department of Anatomy, Coimbatore Medical College, Tamilnadu, India
[2]Associate Professor, Department of Anatomy, Government Villupuram Medical College, Tamilnadu, India
[3]Senior Assistant Professor, Department of Anesthesia, Madras Medical College, Tamilnadu, India
[4]Associate Professor, Institute of Anatomy, Madras Medical College, Tamilnadu, India

*Received* : 20/01/2023
*Received in revised form* : 25/02/2023
*Accepted* : 10/03/2023

*Keywords:*
*Lumbar vertebra; Dimensions of the spinal canal; Anteroposterior diameter; Transverse diameter.*

Corresponding Author:
**Dr. J.Sreevidya,**
Email: sreevi711@gmail.com

DOI: 10.47009/jamp.2023.5.3.249

Source of Support: Nil,
Conflict of Interest: None declared

*Int J Acad Med Pharm*
2023; 5 (3); 1220-1224

## Abstract

**Background:** The lumbar part of the spinal canal lodges the conus medullaris and the cauda equina within the meninges. Knowledge of the dimensions of the spinal canal will help manage spinal stenosis and low backache, which is one of the common manifestations among the general public. Hence, a morphometry evaluation of the spinal canal of the lumbar region by the people of Tamilnadu was undertaken. **Materials and Methods:** Twenty adult embalmed cadavers and CT images of 50 living subjects were studied. Antero-posterior (APD) and transverse diameters (TD) of the spinal canal were measured from the cadaveric bones, CT images of the retrieved bones, and 50 CT images of living subjects from the archives. **Result:** The TD from $L_1$ to $L_5$ was 20.0 to 25.9 mm in direct measurement, 20.3 to 25.6 mm in CT of the specimen, and 19.9 to 27.0 mm in CT images of living subjects. Regarding the APD, indirect measurement gradually decreased from 14.0 mm to 13.2 mm from $L_1$ to $L_3$ and increased to 13.5 mm in $L_4$ and 14.6 mm in $L_5$. The corresponding measurement in the CT image of the same specimens was 14.6 mm to 13.9 mm from $L_1$ to $L_3$ and increased to 14 mm in $L_4$ and 14.9 mm in $L_5$. The measurement in CT images of living subjects was 14.4 mm to 12.6 mm from $L_1$ to $L_3$ and increased to 12.9 mm in $L_4$ and 14.3 mm in $L_5$. **Conclusion:** CT scanning will help clinicians determine accurate clinical and intraoperative management.

## INTRODUCTION

The spinal cord is enclosed within the spinal canal. The largest lumbar vertebrae take the maximum brunt in transmitting body weight and exhibit greater degenerative changes. Any intervention planned to manage these changes is aimed at the lumbar region, for which the knowledge of morphometry of this part of the spinal canal is essential. The lumbar part of the spinal canal lodges the conus medullaris and the cauda equina within the meninges. The inter-pedicular distance (Transverse Diameter (TD)) of the spinal canal increases from L1 to L5, whereas the Aantero-Posterior diameter (APD) decreases.[1] The obliteration of the spinal canal space may induce clinical symptoms in older persons and patients suffering from developmental or acquired lumbar spinal diseases. Knowledge of the dimensions of the spinal canal will help diagnose spinal stenosis. Spinal stenosis is classified into two major types: developmental stenosis and Acquired stenosis.[2]

In vertebrae with developmentally short pedicles or borderline dimensions of the vertebral canal, slight compromise by functional or structural degenerative lesions, fracture fragments, or segmental translation may cause compromise of the intraspinal blood vessels and nerve structures.[3] Apart from this, low back ache is one of the common manifestations among the general public, more so in recent times, which is also linked to the spinal canal dimensions.
Dimensions of the spinal canal have been widely documented in various journals in literature among different racial populations. However, only a few studies are on the Indian people, especially in South India and Tamilnadu. As differences in dimensions have been reported both between races and within the same population, this study on the spinal canal among the people of Tamilnadu is undertaken. Moreover, studies have been conducted in cadaver specimens, dried bones, radiographs, or other imaging technologies. However, a morphometry comparison between the cadaveric specimens and computed tomographic study has not been undertaken elsewhere. Hence, this study was done.


ISSN (O): 2687-5365; ISSN (P): 2753-6556

The study aims to determine the dimensions of the spinal canal of the lumbar region among the people of Tamilnadu, especially by comparing the dimensions in cadaveric specimens and CT images of the specimens and living subjects. Studies of this nature have not been documented until now.

## MATERIALS AND METHODS

For the study of cadaveric specimens, twenty adult human cadavers were selected from the Institute of Anatomy, Madras Medical College. In addition, 50 Computerized Tomographic (CT) abdominal scan images with lumbar vertebrae - (64 slices) from Barnard Institute of Radiology, attached to Rajiv Gandhi Govt. General Hospital, MMC, from 2012 to 2015, were studied. Ethical approval from the Institutional Ethics Committee (Ref No 15022012) was obtained for the study.

**Inclusion Criteria**

Adult cadavers of age between 40 to 60 years were included.

**Exclusion Criteria**

Cadavers with spinal abnormalities were excluded from the study.

**Dissection Method**

The cadavers selected were of similar body dimensions and age. Then the lumbar vertebrae were subjected to chemicals after removing them from the cadavers to remove the attached soft tissue remnants. Caustic soda solution was prepared by adding 400gm of sodium hydroxide crystals dissolved in 4 litres of water, in which the dissected lumbar vertebrae were immersed for 24 hours. Subsequently, further meticulous dissection was done to remove the loosened soft tissue remnants. Then they were immersed in hydrogen peroxide solution for three days for further cleaning. They were then dried in sunlight, and digital vernier calliper measurements were taken.

This study was undertaken when no references were available for the extraction of bones from embalmed cadavers except for burial. As it was a time-bound study, we adopted a trial-and-error method with multiple vertebrae and arrived at the specified methodology for extracting bones from the cadavers. The vertebrae assembled as a set of 5 of the same cadavers were then imaged through computed tomography. Bone reconstruction was done after taking images of 0.9 mm slices. The TD and APD of the lumbar spinal canal were then measured directly and from the CT images.

**Radiological Study**

Apart from the dissected cadaveric specimen study, 50 CT images of living subjects with similar age and height as that of cadavers were chosen from the archives of the Radiology department for the study. TD of the spinal canal was measured between the medial surfaces of the vertebra's pedicles [Figures 1A & 1B]. APD (sagittal) of the spinal canal was measured between the posterior upper margin of the lumbar vertebral body and the junction of the two halves of vertebral arches behind the spinous process attachment [Figures 2A & 2B]. Measurements were taken from radiographs, as in [Figure 3].

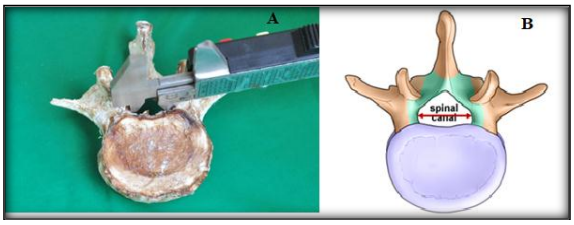


**Figure 1: Measurement of Transverse diameter of the lumbar spinal canal**


**Figure 2: Measurement of Antero-posterior diameter of the lumbar spinal canal**

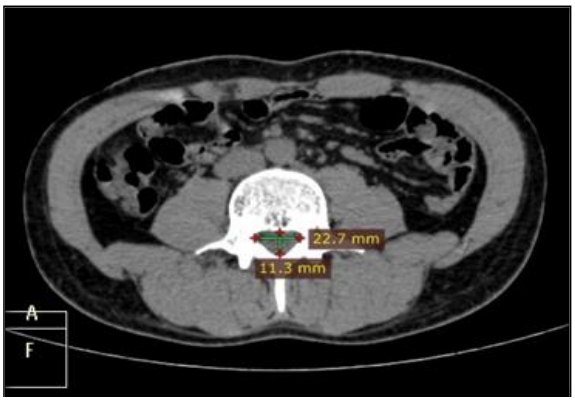


**Figure 3: Measurement of the spinal canal in CT of living subjects**

The study recordings are done through SPSS statistical software under the following groups: Direct measurement of vertebrae extracted from cadavers constituting 100 lumbar vertebrae from 20 cadavers comprising equally of both sexes (Denoted as Direct). CT measurement of bones extracted from a cadaver (Denoted as CT- Specimen (CT Sp) group). CT measurement from images of living subjects (Denoted as CT image group). Total images of 50 subjects are chosen- 25 males and 25 females.

SPSS software version 26.0 has been used to analyse the study results. As per ANOVA 2 testing, the difference between right and left lumbar vertebrae is not statistically significant. Hence, data is pooled from both right and left and presented as a single measurement for each vertebra under the three groups.


ISSN (O): 2687-5365; ISSN (P): 2753-6556

## RESULTS

[Table 1] shows a gradual increase in the transverse diameter of the spinal canal from L1 to L5 in all three groups.

[Table 2] shows a gradual decrease in the APD of the spinal canal from L1 to L3 and then an increase from L4 in all three groups.

The increase in the depth of the spinal canal in the lower lumbar levels is attributed to accommodating the sacral nerves during the angular movements of the spine, as this region is the junction between mobile lumbar vertebrae and immobile sacral vertebrae.

**Table 1: TD of the spinal canal (in mm)**

| Lumbar Vertebra | Specimen direct -N-20 | | | CT specimen N-20 | | | CT image in living subjects N-50 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range |
| $L_1$ | 20.0 | 1.6 | 17.5-22.7 | 20.3 | 1.6 | 17.9-22.9 | 19.9 | 2.1 | 15.7-24.7 |
| $L_2$ | 20.5 | 1.5 | 18.1-23.6 | 20.4 | 1.3 | 18.2-22.7 | 20.3 | 2.0 | 16.2-24.7 |
| $L_3$ | 21.2 | 2.3 | 18.8-26.1 | 21.1 | 1.7 | 19.3-24.3 | 21.5 | 2.1 | 17.1-26.4 |
| $L_4$ | 21.8 | 2.9 | 18.8-27.8 | 21.5 | 2.6 | 17.1-25.5 | 23.0 | 3.7 | 12.5-30.4 |
| $L_5$ | 25.9 | 3.9 | 20.5-33.8 | 25.6 | 3.5 | 20.3-31.5 | 27.0 | 3.8 | 19.3-33.5 |

**Table 2: APD of the spinal canal (in mm)**

| Lumbar Vertebra | Specimen direct-N-20 | | | CT Specimen - N-20 | | | CT image in living subjects - N-50 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Range | Mean | SD | Range | Mean | SD | Range |
| $L_1$ | 14.0 | 1.4 | 12.2-16.8 | 14.6 | 1.1 | 13.2-16.6 | 14.4 | 1.9 | 11.2-19.4 |
| $L_2$ | 13.8 | 1.3 | 11.5-15.6 | 14.0 | 2.5 | 7.8-16.4 | 13.5 | 1.6 | 11.0-18.3 |
| $L_3$ | 13.2 | 2.2 | 9.5-17.2 | 13.9 | 1.7 | 10.8-17.4 | 12.6 | 1.6 | 10.0-16.7 |
| $L_4$ | 13.5 | 2.7 | 9.7-19.4 | 14.0 | 2.9 | 10.4-20.1 | 12.9 | 2.0 | 8.8-16.9 |
| $L_5$ | 14.6 | 2.1 | 11.5-18.8 | 14.9 | 2.0 | 11.1-17.7 | 14.3 | 3.2 | 10.0-25.1 |

**Table 3: Comparison of both TD & APD of spinal canal between specimen direct, CT specimens and CT image of living subjects**

| No. of Lumbar Vertebra | Sp. Dir & CT Sp. | | Sp. Dir & CT Image | | CT Sp & CT Image | |
|---|---|---|---|---|---|---|
| | TD | APD | TD | APD | TD | APD |
| $L_1$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| $L_2$ | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| $L_3$ | 1.000 | 1.000 | 1.000 | 0.089 | 1.000 | 0.922 |
| $L_4$ | 1.000 | 1.000 | 0.655 | 0.534 | 1.000 | 1.000 |
| $L_5$ | 0.566 | 1.000 | 0.040 | 1.000 | 1.000 | 1.000 |

**Table 4: Manual measurement of TD & APD of the spinal canal in cadaveric retrieved specimens (in mm)**

| Study | Population | Type of Specimen | $L_1$ | | $L_2$ | | $L_3$ | | $L_4$ | | $L_5$ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TD | APD | TD | APD | TD | APD | TD | APD | TD | APD |
| Gupta et al,[8] (2011) | North India | Bones from cadavers | 21.8 | 17.5 | 22.0 | 16.9 | 22.5 | 16.2 | 23.2 | 16.6 | 24.7 | 17.4 |
| Rema devi et al,[7] (2003) | Bangalore | Dried bones | 19.6 | 13.3 | 19.8 | 13.2 | 20.4 | 12.4 | 22.9 | 12.2 | 24.6 | 11.6 |
| El Rakhawy et al,[4] (2009) | Egypt | Dried bones | 21.6 | 14.9 | 22.5 | 15.0 | 21.4 | 13.4 | 23.5 | 15.4 | D.1 | 15.6 |
| Tan et al,[9] (2003) | Chinese Singaporean | Bones from Cadavers | 19.4 | 12.5 | 19.5 | 11.7 | 19.4 | 11.2 | 20.2 | 11.2 | 23.4 | 11.4 |
| Londhe B et al,[10] (2020) | Indian | Dried bones | 19.7 | 15.2 | 20.0 | 14.6 | 20.4 | 13.1 | 21.6 | 13.0 | 24.3 | 13.0 |
| Present Study | Tamilnadu | Bones from cadavers | 20.0 | 14.0 | 20.5 | 13.8 | 21.2 | 13.2 | 21.8 | 13.5 | 25.9 | 14.6 |

**Table 5: TD & APD of the spinal canal in CT images of living subjects (in mm)**

| Study | Population | Sex | L1 | | L2 | | L3 | | L4 | | L5 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | TD | APD | TD | APD | TD | APD | TD | APD | TD | APD |
| Karantanas AH et al,[13] (1998) | Greece | Composite (M &F) | - | - | - | - | 23.6 | 16.5 | 24.6 | 17 | 28.9 | 18.3 |
| Zhou SH et al,[15] (2000) | London | Males | - | - | - | - | 25.2 | 16.1 | 24.7 | 16.9 | 29.0 | 17.8 |
| | | Females | - | - | - | - | 23.5 | 16.0 | 22.8 | 16.6 | 27.2 | 16.6 |
| Rapala et al,[16] (2009) | Poland | Composite (M &F) | - | - | - | - | 24.8 | - | - | - | 34.6 | - |
| Abdul Rahman et al,[17] (2009) | Saudi Arabia | Males | - | - | - | - | - | 16.6 | - | 16.7 | - | 17.8 |
| | | Females | - | - | - | - | - | 16.2 | - | 16.9 | - | 17.7 |
| Kumar et al,[18] (2016) | Telengana | Males | - | 16.4 | - | 15.2 | - | 14.8 | - | 13.8 | - | 15.4 |
| | | Females | - | 16.7 | - | 16.6 | - | 15.9 | - | 14.5 | - | 14.3 |
| Yadav U et | Indian | Males | - | 15.7 | - | 14.6 | - | 13.5 | - | 13.3 | - | 14.7 |


ISSN (O): 2687-5365; ISSN (P): 2753-6556

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| al,[19] (2020) | | Females | - | 15.9 | - | 14.7 | - | 13.7 | - | 13.4 | - | 14.7 |
| Siraj N et al,[20] (2021) | Bangladesh | Males | - | - | - | - | 23.7 | 13.6 | 26.4 | 13.8 | 29.9 | 14.9 |
| | | Females | - | - | - | - | 23.9 | 13.6 | 25.4 | 13.6 | 27.9 | 14.0 |
| Alonge OJ et al,[21] (2021) | Africa | Males | 23.3 | 16.4 | 23.6 | 15.4 | 25 | 14.9 | 27.6 | 15.3 | 33.5 | 16.1 |
| | | Females | 21.7 | 16.1 | 22.3 | 15.8 | 23.7 | 15.2 | 26.4 | 16 | 31.4 | 16.4 |
| Mohamed Elfadil et al,[11] (2021) | Saudi Arabia | Males | 20.8 | 15.4 | 20.1 | 14.4 | 19.5 | 13.9 | 18.7 | 14.1 | 19.0 | 14.9 |
| | | Females | 19.7 | 15.4 | 20.1 | 14.7 | 19.6 | 13.8 | 19.2 | 14.2 | 19.9 | 15.2 |
| Irshad F et al,[14] (2022) | Pakistan | Males | 19.8 | 15.2 | 21.6 | 15.6 | 23.3 | 15.5 | 25.7 | 16.1 | 27.9 | 16.7 |
| | | Females | 19.2 | 15.1 | 19.8 | 15.2 | 21.6 | 15.4 | 23.7 | 16.2 | 25.4 | 16.3 |
| Present Study | Tamilnadu | Males | 20.4 | 15.1 | 20.9 | 13.7 | 22.0 | 12.6 | 23.8 | 12.9 | 27.3 | 14.5 |
| | | Females | 19.3 | 13.6 | 19.6 | 13.2 | 20.8 | 12.6 | 22.1 | 12.8 | 26.6 | 14.0 |
| | | Composite (M &F) | 19.9 | 14.4 | 20.3 | 13.5 | 21.5 | 12.6 | 23.0 | 12.9 | 27.0 | 14.3 |

[Table 3] shows that both TD and APD was statistically insignificant differences between the groups. As evident from [Table 3], the measurements did not differ between the three groups. Hence, routine CT scanning will help clinicians determine proper pre-operative management planning of intra-operative management with pre-operative CT will help avoid post-op complications and give better patient results.

## DISCUSSION

There are minimal studies on the measurements of the spinal canal among South Indians and specifically Tamilnadu. The parameters measured in this study are in the cadavers from among the people of Tamilnadu, which will help manage diseases in this region. It is seen from [Table 4] that the TD of the lumbar spinal canal in both sexes combined shows a gradual increase from the first lumbar vertebra to a fifth lumbar vertebra in all the studies of cadaver specimens/dried bones, which span from countries like Egypt,[4] and regions within India from both Northern and Southern parts.[5,6] The measurements are higher than the present study concerning the people of Egypt 4, whereas the measurements are lower than the present study. This difference in measurement is owing to the difference in the stature of the people of these countries. That is why we must have studies from our region to know about our population. Suppose we observe the studies undertaken in the Indian race, though the measurements are similar. In that case, the dimensions of the present study are closest to Devi R et al,[7] study, which elaborates on the difference among the people of North-South regions.

Regarding the APD of the spinal canal in cadaver specimens, though the diameter initially shows a downward trend from the first lumbar vertebra to the third lumbar vertebra, it starts increasing from the fourth to the fifth lumbar vertebra in almost all the studies, as evidenced in the measurements in the present study. However, this pattern is absent in Devi R et al,[7] study and Londhe B et al study.[10] The measurements decrease from the first to fifth lumbar vertebra. Both these studies were undertaken in dried bones, unlike the present study, which is from the bones extracted from the cadavers. Possibly that could be the factor determining this difference in the pattern. Suppose the absolute measurements of the bones are considered as in TD. In that case, the APD is higher in the Egyptian race 4, lower in Chinese Singaporeans1 and closest to the Devi R et al,[7] study conducted in Bangalore. There is a marked difference between the morphometric measurements in studies among the people from North Indian and Southern parts of India.

It is seen from Table 5 that, in the present study, the TD of the spinal canal of the lumbar region measured from CT images of living subjects' shows an increase from the first lumbar vertebra to the fifth lumbar vertebra. This pattern is also observed in the measurements taken directly from the cadaveric specimens. However, the Mohamed Elfadil et al,[11] study's dimensions show a decreasing trend from the first lumbar vertebra to a fifth lumbar vertebra in males and an irregular pattern in females. Interestingly, the absolute dimensions of the TD of the spinal canal of the first to fifth lumbar vertebrae taken from cadaveric specimens and CT images of living subjects are comparable among the Indian studies. Also, among the measurements taken from CT images of living subjects, it is seen that the absolute dimensions of TD are almost similar among the people of different countries, with an exception among the people of Saudi Arabia. The values are slightly higher among people of Africa and Greece and lower in Pakistan (comparable to the Indian population).[12-14]

Regarding the APD taken from CT Images of living subjects, initially, the diameter reduces from the first to the third lumbar vertebra. Then it shows an increasing trend in the fourth and fifth lumbar vertebrae. This is similar to not only the studies like Zhou et al,[15] (London), Abdul Rahman et al,[17] (Saudi Arabia), Karantanas AH et al,[13] (Greece), Siraj N et al,[20] (Bangladesh), Alonge OJ et al,[12] (Africa), Mohamed Elfadil et al,[11] (Saudi Arabia) undertaken in CT images of living subjects, but also measurements taken from cadaveric specimens. However, in the Indian studies of Kumar et al,[18] and Yadav U et al,[19] the increase is observed at the level of the fifth lumbar vertebra alone. In the study by Irshad et al,[14] the APD is increasing from L1 to L5. Except for this study done in Pakistan, all other studies correlate with the present study's pattern. The slight difference in the pattern of APD of the spinal canal of the two Indian studies shows a


ISSN (O): 2687-5365; ISSN (P): 2753-6556

definitive difference among the people in different regions within India. This study will help in knowing about the lumbar vertebrae among the people of Tamilnadu.

Suppose we observe the absolute dimensions of APD among the various races. In that case, the values are similar among Greece, Pakistan, London, Poland, and Saudi Arabia races.[13-17] In contrast, the morphometry is similar among the people of India in various studies, including the present study and Bangladesh.[20] This again shows that the difference in the build of the humans in the different regions impacts the morphometry. So, region-specific research will be more useful in determining clinical management than generalizing. Also, the absolute dimensions of APD in the Devi R et al study,[7] Londhe B et al,[10] and the present study of the cadaveric specimens correlate with the measurements from CT images of living subjects.

## CONCLUSION

The dimensions of the lumbar spinal canal of the population of Tamilnadu are studied to their anteroposterior and transverse diameters. These measurements taken from the people of Tamilnadu will help orthopaedic surgeons better manage diseases of the spinal canal. It will also help plan rehabilitation therapy for chronic low back aches patients. Moreover, it was also found that statistical comparison between the three groups showed no significant difference in the recordings taken from the bones directly, in the CT images of the extracted cadaveric vertebrae and CT images of the living subjects for both males and females. Hence, routine CT scanning will help clinicians determine accurate clinical and intraoperative management.

## REFERENCES


1. Susan Standring, Gray's Anatomy, The Anatomical Basis of Clinical Practice, 40th Edition, Elsevier Publications, 2008.
2. Terry S. Canale & James H Beaty, Campbell's Operative Orthopaedics, Vol II, 11th edition, Mosby Publishers, 2008.
3. Krogman WM, Race differences in the human skeleton. In the human skeleton in Forensic Medicine 3rd Edition; Charles C Thomas Publishers, USA; 1978.
4. El-Rakhawy M. Lumbar vertebral canal stenosis: the concept of the morphometric and radiometric study of the human lumbar vertebral canal. Anatomy 2010;4:51–62.
5. Yadav U, Singh V, Bhargava N, Kumar Srivastav A, Neyaz Z, Phadke RV, et al. Lumbar canal diameter evaluation by CT morphometry-study of the Indian population. Int J Spine Surg 2020;14:175–81.
6. Londhe B, Garud R. Anatomical evaluation of lumbar vertebral canal in Indian population. Int J Anat Res. 2020;8:7251-55.
7. Devi R, Rajagopalan N. Dimensions of the lumbar vertebral canal. Indian J Orthop. 2003;37:13.
8. Gupta R, Singla RK. Thoracolumbar neural canal-A morphometric and morphological study in North Indian population. J Pharm Biomed Sci. 2011;11:1-8.
9. Tan SH, Teo EC, Chua HC. Quantitative three-dimensional anatomy of cervical, thoracic and lumbar vertebrae of Chinese Singaporeans. Eur Spine J 2004;13:137–46.
10. Londhe B, Garud R. Anatomical evaluation of lumbar vertebral canal in Indian population. Int J Anat Res. 2020;8:7251-55.
11. Mohamed Elfadil M. Garelnabi, Ahmed AT, Fathelrahman SA, Alqhtani AM, Althaiban SH. Study of pedicles and spinal canal diameters at the lumbar vertebral level in normal adult Saudi population using computed tomography. GSC Adv Res Rev 2021;9:048–55.
12. Alonge OJ, Adeolu AA, Omololu AB, Atalabi OM. Lumbar spinal canal dimensions in Nigerians using computed tomography scan. African J Med & Med Sci. 2021;50:69-76.
13. Karantanas AH, Zibis AH, Papaliaga M, Georgiou E, Rousogiannis S. Dimensions of the lumbar spinal canal: variations and correlations with somatometric parameters using CT. Eur Radiol 1998;8:1581–5.
14. Irshad F, Ahmed S, Saeed H, Saleem A, Abdullah MS, Butt MT, et al. Dimensions of Lumbar Spinal Canal in subjects with and without low back pain. Pak J Med Health Sci 2022;16:235–6.
15. Zhou SH, McCarthy ID, McGregor AH, Coombs RR, Hughes SP. Geometrical dimensions of the lower lumbar vertebrae--analysis of data from digitised CT images. Eur Spine J 2000;9:242–8.
16. Rapała K, Chaberek S, Truszczyńska A, Łukawski S, Walczak P. Assessment of lumbar spinal canal morphology with digital computed tomography. Ortop Traumatol Rehabil 2009;11:156–63.
17. Abdulrahman AA. Sagittal diameter of the lumbar spinal canal and canal/body ratio in normal adult Saudis. Pan-Arab J Neuro Surg 2009; 13:53–56.
18. Kumar AP, Kasturi A, Ramu C, Nadadur S. Morphometric analysis of lumbar vertebrae in tertiary care institutions in Telangana. Ann Int Med Dent Res. 2016;2:157–162.
19. Yadav U, Singh V, Bhargava N, Kumar Srivastav A, Neyaz Z, Phadke RV, et al. Lumbar canal diameter evaluation by CT morphometry-study of the Indian population. Int J Spine Surg 2020;14:175–81.
20. Siraj N, Ghafoor N, Parven JA, Deepa KP, Haque MZ. Spinal canal measurements at the level of lower three lumbar vertebrae by 128-Slice CT scanner in Bangladeshi population. Ibrahim Card Med J 2021; 11: 8-13.
21. Alonge OJ, Adeolu AA, Omololu AB, Atalabi OM. Lumbar spinal canal dimensions in Nigerians using computed tomography scan. African J Med & Med Sci. 2021;50:69-76.




ISSN (O): 2687-5365; ISSN (P): 2753-6556