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# Lumbar spinal bony canal measurement in a Palestinian population using CT scan: a retrospective study

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## ABSTRACT

***Purpose:*** Establishing the normal range of lumbar spinal canal in the Palestinian population helps provide a quantitative method for assessing spinal canal abnormalities in the lumbar region. ***Materials and Methods:*** The data was gathered from Governmental Hospital in Nablus from January to July 2018. It is a cross-sectional descriptive study among 400 patients (201 males, 199 females), ranging from 20 to 60 years. CT scan radiographs were used to measure the canal and the vertebral body diameters to obtain the canal body ratio. ***Results:*** The results represent the normal ratio of dimensions at each level of the bony lumbar spinal canal. The measurements presented are taken at the level of each lumbar vertebra starting from the 1st down to the fifth lumbar vertebra. It was found that the mean ratio of the spinal canal increases from L1 down to L5. ***Conclusion:*** After analyzing each lumbar level's results, the mean ratio of the spinal canal increases from L1 to L5. In addition, there were no significant differences between males and females regarding the measurement tool.

**Keywords:** Lumbar Spinal Canal; CT scan; Canal Body Ratio; Bony; Palestinian.

## INTRODUCTION

The spinal canal is primarily formed by the vertebral foramen of the adjacent vertebrae, which is bordered anteriorly by the vertebral body, laterally by the pedicles, posterlaterally by the laminae, and posteriorly by the base of the spinous process. In the intervertebral space, the canal is enclosed posteriorly by the ligamentum flavum and anteriorly posterior longitudinal ligament [1].

Changes in the lumbar canal area can cause diminished space available for the neural and vascular elements in the lumbar spine, which will lead to compression on the nerve roots, resulting in leg pain, especially calf pain known as neurogenic claudication, also tingling, numbness, and even difficulty walking [2]. These changes can be generally attributed to degenerative processes, trauma, infection, surgery, bony overgrowth, or metabolic and endocrine disorders [3].

Ethnicity, race, and geographical background play a significant role in the discrepancy of spinal canal measurement [4], which is of great importance for physicians dealing with spinal canal problems. Therefore, it is crucial to determine the specific diameters for each race, and that is why there is a worldwide trend to assess the measurement variation regarding the spinal canal [5].

Previous studies have shown that the lumbar canal is marginally less capacious in African Americans than in Caucasoid [5]. Those with smaller canals are more likely to have symptoms from nerve root compression [6].

Various techniques are used to evaluate the dimensions of the lumbar spinal canal. The most frequently applied radiologic parameters of the spinal canal are mid-sagittal, axial diameters, and the canal-to-body ratio [7]. These diameters can be obtained using Magnetic resonance imaging (MRI) or computed tomography (CT) scan, both of which have the advantage of direct visualization of the canal. However, CT is better than MRI in showing bony details [8]. Our study used abdominal CT radiographs to measure the spinal canal dimensions.

The purpose of this study is to develop a range for bony lumbar spinal canal dimensions using a template that can be applied to all other Palestinian populations and to evaluate the normal size of the bony lumbar spinal canal in both males and females of the population, so that baseline data is available for the specialists in Palestine. This study is the first done to establish the normal measurements of the bony lumbar spinal canal within the Palestinian population.

## MATERIALS AND METHODS

### *Study design: a descriptive cross-sectional study*

*Study population*: patients attending to Radiology Department at a Governmental Hospital in Nablus, considered one of North West Bank's leading hospitals. All analyzed subjects reside in the same geographical area, i.e., Nablus and the surrounding regions considered the Northern regions of West Bank; they are all considered Caucasian. Subjects in this study were male and female Palestinian patients aged 20-60 years, undergoing abdominal CT for various medical indications. Cases related to cysts, neoplasm, and degenerative diseases were not included in the study

### *Measurement tools*

1. CT scanner supplied by (Phillips Medical System, Cleveland, Ohio, USA), brilliance 16 model, configuration type multislice with slice thickness is 0.6 to 1.2mm, 100 scans time seconds and 162cm Max volume. The scanner is approved to be valid and reliable by Philips Company.
2. RadiAnt DICOM viewer, version 4.2.1, was used to measure the spinal canal and vertebral body diameters, designed to provide physicians with radiographs that they can review.

### *Timeline: during the period January 2018 to July 2018*

*Sample size:* consists of 400 patients (201 males and 199 females) having age variation between early adulthood and middle adulthood (20-60 years old).

*Technique:* bone windows were used in mid-sagittal and axial planes by using a multiplanar reconstruction option at the mid- pedicular level for each vertebral body of the lumbar spine (L1 to L5), as shown in (figure 1a) and (figure 1b).

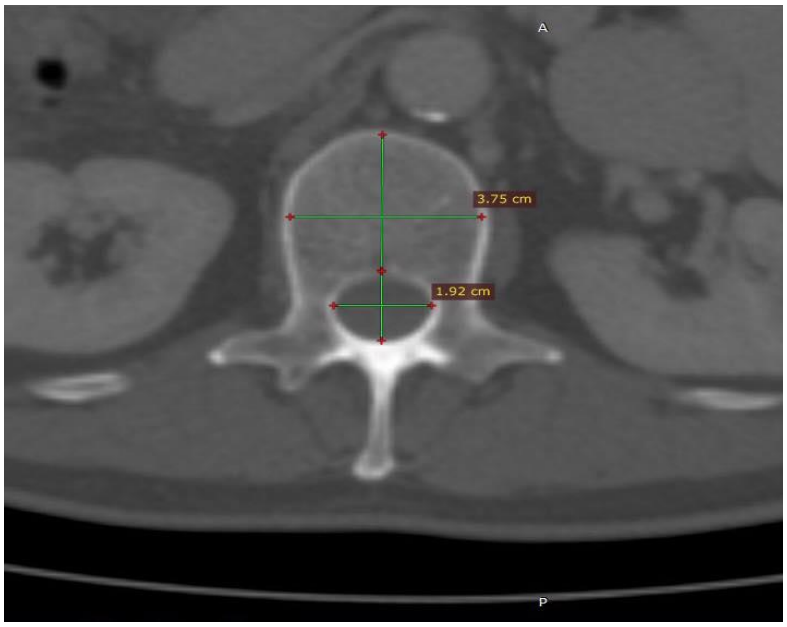


**Figure (1a)**: Dimensions of first lumbar vertebrae in the axial plane of 42- year- old male.


**Figure (1b)**: Dimensions of first lumbar vertebrae in the mid-sagittal plane of 42- year- old male.

There are several ways to measure these diameters for the five lumbar vertebrae, such as obtaining mid-sagittal canal diameter or the canal body ratio C/B ratio; previous studies showed that the C/B ratio is more reliable [9], which is also known as Jones and Thomson index [10] known as C/B ratio, defined as

(a*b)/(c*d), where a = transverse diameter between the lateral recesses, b = anteroposterior diameter of the spinal canal, c = transverse diameter of the vertebral body and d = anteroposterior diameter of the vertebral body as shown in (figure 2).

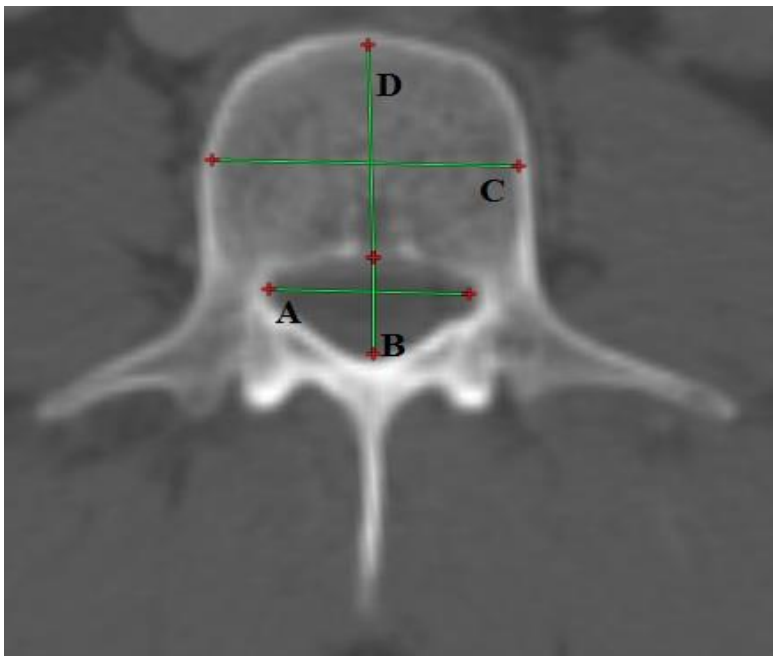


**Figure (2)**: Anatomically normal Lumbar vertebrae of 30- a year-old female, which (A) represents transverse canal diameter, (B) anteroposterior canal, (C) transverse body, and (D) anteroposterior body.

*Analysis plan:* The analysis was done using SPSS. Means and standard deviations were computed and presented using tables to measure each lumbar level. Independent samples t-test was used to compare the mean dimensions of males and females at the same level. A P-value of <0.05 was considered to be significant.

## RESULTS

These results represent the outcomes of examining a total of 400 CT scans (201= males, 199= females) and measuring the diameters of the vertebral body and canal at the mid-pedicular level anterior-posteriorly and transverse in the lumbar region.

(Table 1) represents the diameters above in the anterior-posterior dimensions of the vertebral body and canal. At the first lumbar level, the mean of the anterior-posterior diameter of the vertebral body is 29mm (±3.79), and the mean at the canal at the same level in the same dimension is 14.2mm (±2.21). At the fifth lumbar level, the mean of the anterior-posterior diameter of the vertebral body is 32.3mm (±12.2), and the mean at the canal at the same level in the same dimension is 14.4mm (±2.6).

**Table (1)**: Summary measurements of the anterior-posterior diameters at the 1st, 2nd, 3rd, 4th, and 5th lumbar vertebral levels (n= 400).

| Vertebra | †APD body | | APD Canal | |
|---|---|---|---|---|
| | ***Mean (mm)*** | ***SD*** | ***Mean (mm)*** | ***SD*** |
| L 1 | 29 | 3.79 | 14.26 | 2.21 |
| L2 | 30.18 | 3.4 | 13.5 | 2.37 |
| L3 | 31.68 | 3.61 | 13.1 | 2.07 |
| L4 | 31.9 | 3.7 | 13.79 | 2.5 |
| L5 | 32.8 | 3.28 | 14.4 | 2.6 |

The diameters in the vertebral body and transverse canal dimensions are presented in (table 2). At the first lumbar level, the mean of the transverse diameter of the vertebral body is 37.7mm (±5.01), and the mean at the canal at the same level in the same dimension is 22.5mm (±2.81). At the fifth lumbar level, the mean of the transverse diameter of the vertebral body is 47mm (±5.87), and the mean at the canal at the same level in the same dimension is 28.05mm (±3.78).

**Table (2):** Summary measurements of the transverse diameters at the 1st, 2nd, 3rd, 4th, and 5th lumbar vertebral levels (n= 400). ‡*mld: transvesre diameter.*

| Vertebra | ‡MLD body | | MLD canal | |
|---|---|---|---|---|
| | ***Mean (mm)*** | ***SD*** | ***Mean (mm)*** | ***SD*** |
| L 1 | 37.7 | 5.01 | 22.59 | 2.81 |
| L2 | 38.9 | 5.21 | 23.1 | 2.46 |
| L3 | 40.8 | 4.94 | 24 | 2.83 |
| L4 | 43.1 | 4.65 | 24.9 | 3.48 |
| L5 | 47 | 5.87 | 28.05 | 3.78 |

(Table 3) shows the slight incremental increase in the means of the C/B ratio in the total population with a mean of 2.1mm (±0.48) at the first lumbar level (L1), a mean of 2.3mm (±0.49) at the second lumbar level (L2), a mean of 2.4mm (±0.5) at the third lumbar level (L3), a mean of 2.5mm (±0.5) at the fourth lumbar level (L4), and a mean of 3.0mm (±0.7) at the fifth lumbar level (L5).

**Table (3):** The mean of C/B ratio lumbar vertebrae in the total population (n= 400).

| Vertebra | C/B Ratio | |
|---|---|---|
| | Total | |
| | Mean (±SD) | Min-Max |
| L 1 | 2.1 (±0.48) | 0.14-5.66 |
| L2 | 2.3 (±0.49) | 0.23-4.63 |
| L3 | 2.4 (±0.5) | 1.28-4.92 |
| L4 | 2.5(±0.5) | 0.23-4.78 |
| L5 | 3.0 (±0.7) | 0.29-6.77 |

When analyzing the mean C/B ratios at the five lumbar vertebral levels in (Table 4) and comparing the results between males (n=201) and females (n=199), slight differences were noted. Testing the significance of these differences using the independent t-test yielded that the differences between males and females are statistically insignificant at all lumbar vertebral levels (P values >0.05).

**Table (4)**: The mean C/B ratio for each lumbar vertebrae compared between the females (199) and males (201).

| Vertebra | C/B Ratio | | P value* | 95% CI§ |
|---|---|---|---|---|
| | Male Mean(±SD) | Female mean (±SD) | | |
| L1 | 2.16(±0.4) | 2.13(±0.8) | .368 | -0.1- 0.16 |
| L2 | 2.61(±2.9) | 2.2(±0.5) | .065 | -0.01- 0.8 |
| L3 | 2.46(±0.5) | 2.36(±0.5) | .843 | -0.04- 0.19 |
| L4 | 2.76(±2.3) | 2.68(±2.6) | .946 | -0.4- 0.57 |
| L5 | 2.9(±0.6) | 3.03(±0.9) | .073 | -.028- 0.01 |

** Independent t-test* §*ci= Confidence Interval.*

## DISCUSSION

The results gathered were satisfying regarding our aim to detect a normal range for each dimension of the lumbar spinal canal. The measurements were taken at the level of each lumbar vertebrae starting from the 1st down to the 5th lumbar vertebra. These measurements were used to calculate the C/B ratio, a reliable index of the spinal canal dimensions [11]. After conducting the C/B ratio at each lumbar vertebral level and analyzing the results above, we noticed that the mean C/B ratio of the spinal canal increases from L1 to L5.

This increasing trend of the mean C/B ratio of the spinal canal is also seen in both sexes; however, the mean values are lower in

females than males. After measuring the statistical significance of this variance using the independent t-test, we conclude that no statistical significance is present at any lumbar level. This can be explained by using the canal ratio and not the dimension measurement as a comparative measure. These results are reassuring regarding the incremental pattern of the canal dimensions in the lumbar area paralleling that of the anatomic reference.

A population reference range for the normal bony size of the spinal canal was developed using data from abdominal CT scans from a large patient cohort (n=400). The reference range developed will help gauge individual spinal canal dimensions and ultimately adopt a more quantitative approach to assessing any bony spinal canal narrowing. The age group selected for this study is similar to those used for earlier studies so the ethnic differences could be well compared. Geographic and racial differences in spinal canal measurements exist, so each region and race should have its reference range [12]. The template used in this study is suited to cross-comparison with CT databases from other populations [13]. After that, it is crucial to determine these measurements for the Palestinian population to have normal ranges specifically costumed to this population. Further studies should have the scope and aim to compare these results with other populations and generate new perspectives on this subject.

The main objective of this study and other similar studies is to obtain population-specific data regarding the measurements of the lumbar spinal canal and to provide physicians with locally and ethnically costumed data. Many other studies have this same objective and represent a template for comparison, but very few in which the comparison was made because it is not the primary aim. The data from each study is sufficient to calculate and compare the C/B ratio or any other measure the investigator desires.

As part of an international trend that aims to record the population-specific normal values and ranges to the measurements of the lumbar spinal canal, this research was compared to other similar research with the same objectives. A large study was conducted on 1080 patients of Chinese ethnic background and was published in 2016 [13], and another one in Switzerland [12] and many others had a similar methodology and the same principle target of this study and yielded specific measurements for each distinct population. For example, a recent study was conducted to evaluate lumbar canal diameter in the Indian population, which showed a gradual decrease in AP diameter from D12 to L4, followed by an increase from L4 to L5[14]. It also showed that the spinal canal diameters were more significant in male patients, which is the opposite in this study. Another study that used the C/B ratio for measuring spinal canal diameters was conducted in the Bangladeshi population; it showed a reasonable difference between L4 and L5 lumbar vertebrae regarding the C/B ratio [15].

All of these studies are participating in expanding the international database that will serve well in other studies directed to compare the results of this population and many genetically, ethnically, and geographically different populations. This study contributes to this objective and provides the Palestinian- specific measurements to serve as a part of this database.

This study is among the first dedicated studies to determine the population-specific

measurements of multiple variances in Palestine. These studies are of utmost importance and of high value to escalate the evolution of a new medical landscape and open the gates to a new research era in Palestine and the Middle East. This new study aims to determine new locally-accepted normal ranges and values for the measurements of the lumbar spinal canal, which will help physicians in their endeavor to provide the best practice to their patients.

This study proposes new values to measurements previously taken from other group populations that are different in geographical influences, genetic components, and race than the Palestinian population. Therefore, these results reflect these differences and the new ranges of the lumbar spinal canal in a Palestinian population.

The Palestinian population-specific measurements of the lumbar spinal canal help provide a quantitative method for assessing spinal canal abnormalities in the lumbar region. This template is suitable to be used in comparison with CT databases from other populations of different races and ethnicity. With these values as a reference, we provide a new platform for physicians to perform the best practice for their patients. It will provide baseline normative data to orthopedic surgeons to evaluate patients with lumbar canal stenosis in the Palestinian population.

We conclude that the mean C/B ratio of the spinal canal increases from L1 down to L5 by conducting the C/B ratio at each lumbar vertebral level and analyzing the measurement above. Moreover, our measurement tool noted no statistically significant variation between males and females.

### *Ethical considerations*

Institutional Review Board (IRB) archived number (9), and the Ministry of Health approval was obtained to preserve the ethical aspect of the study. This study did not need a consent form as the data gathering was retrospective.

### *Consent for publication*

all authors give their consent to publish this manuscript.

### *Availability of data and materials*

all data is available on a hard disk drive.

### *Author's contribution*

**Serin Moghrabi:** Conceptualization, Formal analysis, and investigation, Writing - original draft preparation. **Yousef Ishtay**: Conceptualization, Formal analysis and investigation, Writing - original draft preparation. **Mahmoud Alawneh:** Conceptualization, Supervision. Mosab Mare: Conceptualization, Supervision. **Zaher Nazzal:** Conceptualization, Formal analysis and investigation, Writing - review and editing, Supervision. **Khalil Issa:** Conceptualization, Formal analysis and investigation, Writing - review and editing, Supervision.

### *Competing interests*

The authors declared that there is no competing interest in this research.

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### *Data availability statement*

Raw data were generated at Governmental Hospital. Derived data supporting the findings of this study are available from the corresponding author K.I on request.

### *Disclaimer*

All views expressed in this article are the authors' and do not represent any entity.

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