



Analysis of Lumbar Canal dimensions using CT Morphometry in south Indian population – A Cross sectional study

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ABSTRACT:

Introduction: Lower back pain is increasingly common among younger individuals, likely due to lifestyle changes. Radiological evaluations are essential for diagnosing spine pathologies, including lumbar spondylosis, lumbar disc disease, and spinal canal stenosis. Lumbar canal stenosis is characterized by reduced antero-posterior and lateral dimensions of the spinal canal. CT scans are preferred for studying vertebral morphometry.

Objectives: This study aims to establish normative lumbar canal dimensions for the South Indian population, considering age and sex demographics, to aid in clinical diagnosis and management.

Methods: This cross-sectional study included 247 patients aged 20-40 years, conducted at Department of Orthopedics in SRM Medical College and Hospital from September 2023 to February 2024. CT scans (64-slice and 128-slice) were used to measure lumbar vertebral dimensions including upper and lower vertebral width, upper and lower vertebral depth, and intervertebral disc height and Canal dimensions including spinal canal AP diameter, intervertebral foramen diameter, and inter-facet distance. Data was analyzed using SPSS version 25.0, comparing dimensions across genders and age groups to identify significant differences.

Results: The study included 247 patients, with 157 males (63.6%) and 90 females (36.4%). The highest number of patients were in the 36-40 age group (76 patients), followed by those under 25 years (70 patients). The lowest number of patients were in the 25-30 age group (46 patients). Vertebral dimensions showed that the upper vertebral width (UVW) increased from L1 to L5 in both genders, with minimum UVW at L1 and maximum at L5. Lower vertebral width (LVW) increased from L1 to L4, then slightly decreased at L5. Upper vertebral depth (UVD) and lower vertebral depth (LVD) both increased from L1 to L5, with UVD decreasing in the 36-40 age group. Intervertebral disc height (IVDH) increased from L1 to L4, then decreased at L5, showing an increase with age. Canal dimensions revealed that spinal canal AP diameter (SCD) decreased from L1 to L3, then increased from L4 to L5, with SCD decreasing with age. Intervertebral foramen diameter (IVFD) increased from L1 to L3, then decreased from L3 to L5, showing a decrease with age, then an increase in the 36-40 age group. Inter-facet diameter (IFD) increased from L1 to L5, with IFD decreasing in the 36-40 age group.

Conclusions: In our study of 247 South Indian patients, we measured vertebral and canal dimensions from L1 to L5 using CT morphometry. Significant differences were found across gender and age groups. Vertebral dimensions generally increased from L1 to L5 and from under 25 to 31-35 years, but decreased in the 36-40 age group, except for UVW. Spinal canal AP



diameters decreased from L1 to L3, then increased from L4 to L5, with variations across age groups. Intervertebral foramen and inter-facet diameters showed similar trends. Dimensions were higher in males, and notable differences were observed in the 31-40 age group, indicating early degenerative changes. This data provides baseline normative values for diagnosing lower back pain and lumbar canal stenosis in the South Indian population.

1. Introduction

In our general population, elderly individuals are commonly associated with lower back pain. But younger individuals are more frequently presented with lower back pain, likely due to lifestyle changes in the recent times. Radiological evaluations are crucial for diagnosing and managing spine pathologies. Patients develop lower back pain due to multiple reasons, most commonly due to degenerative conditions including lumbar spondylosis, lumbar disc disease or spinal canal stenosis. Multiple factors contribute to these conditions and its management changes if spinal canal stenosis is present. In lumbar canal stenosis, the antero-posterior (AP) and lateral dimensions of the bony spinal canal are smaller than normal for the individual's age and sex. Therefore, lumbar vertebrae dimensions are vital for diagnosing lumbar canal stenosis. Computed tomography (CT) scans are preferred over radiographs for studying lumbar vertebrae, as CT provides better evaluation of vertebral morphometry. Although many studies have examined lumbar vertebrae morphometry in Western populations, [2,3,8] there is a lack of research on the Indian population. [1,5] Existing studies often have adequate sample sizes but lack demographic data such as age and sex. This study aims to establish a normal range of lumbar canal dimensions for the South Indian population, considering various demographics like age and sex.

2. Objectives

This study aims to establish normative lumbar canal dimensions for the South Indian population, considering age and sex demographics, to aid in clinical diagnosis and management.

3. Methods

This prospective cross-sectional study included patients who underwent diagnostic CT scans for abdominal or genitourinary complaints, as well as those who underwent CT scans for regions other than vertebral column pathology. The study excluded individuals aged under 20 years or over 40 years, and patients with gross spinal pathology or neurological deficits due to spinal conditions. Study included 247 patients and conducted over a period of six months, from August 2023 to January 2024. The study took place at SRM Medical College and Hospital and research centre.

Patients who satisfied the inclusion criteria underwent CT scanning from the diaphragm to the pubic symphysis. We used 64-slice and 128-slice CT scan and 1mm thick sections were analysed. The measurements were made from reformatted bone windows in axial, coronal and sagittal planes. The study collected patient demographics and various measurements, including vertebral and canal dimensions. The data was processed and analysed using SPSS version 25.0 (SPSS Inc., Chicago, IL, USA), with a significance level set at a p-value of 0.05. The study compared the dimensions of lumbar vertebrae between male and female groups as well as different age groups to identify any differences.

Vertebral dimensions measured included upper and lower vertebral width, upper and lower vertebral depth, and intervertebral disc height (table/figure/table 1 & 2). Canal dimensions measured included spinal canal AP diameter, intervertebral foramen diameter, and inter-facet distance (table/Figure 3, 4 & 5).



4. Results

Our study included a total of 247 patients, of which 157 were males (63.6%) and 90 were females (36.4%). The age group with the highest number of patients was 36 to 40 years (76 patients), followed by those under 25 years (70 patients). The age group with the lowest patients was 25 to 30 years, with 46 patients.

1. Vertebral dimensions (table/figure: 6)

In Vertebral dimension's upper vertebral width (UVW) increased gradually from L1 to L5 in both male and female, minimum UVW was measured at L1 in females 38 mm (39.9mm in males) maximum UVW was measured at L5 in males 48.4mm(43.2mm in females) this was also reflected in analysis according age which also showed increasing trend. At L5 level UVW was measured 45.2mm in age group less than 25 and increased to 46.8 in 36 to 40 category, (table/figure 8-12). Lower vertebral width (LVW) increased from L1 to L4 and slightly decreased in L5, lowest LVW noted in L1 in females 37.1mm (42.0 mm in males) and maximum noted at L4 48.1mm in males (47.0mm at L5). LVW increased gradually in all age groups but from L4 to L5 slight drop was noted. LVW was 46.4mm at L5 in 31-35 age group but decreased to 45.4mm in 36-40 group.

Upper vertebral depth (UVD) gradually increased from L1 to L5 in both men and women, Lowest measured 24.5mm at L1 in females (28.2mm in males) and maximum noted at L5 32.0mm in males (29.5mm in females). UVD increased gradually from less than 25 age to 31-35 age group but then decreased in 36-40 age group. All values were significantly larger in men at all levels ($p < 0.05$). Lower vertebral depth (LVD) also increased from L1 to L5 and values were significantly higher in males $p < 0.001$. lowest LVD was noted in females at L1 26.2mm (28.9mm in males) highest in males at L5 31.7mm (29.8mm in females). LVD also decreased from 31-35 age group to 36-40 age group.

Intervertebral disc height (IVDH) gradually increased from L1 to L4, but decreased in L5 in both men and women, Lowest measuring 5.6mm in females at L1(6.5mm in males) and highest in males at L4 is 9.4mm (8.5mm at L5). Intervertebral disc height (IVDH) increased with age. For example, at the L5 level, IVDH was 7mm in individuals under 25 years old but increased to 8.7mm in the 36-40 age group.

2. Canal dimensions (table/figure: 7)

We found that spinal canal AP diameter (SCD) gradually decreased from L1 to L3, followed by an increase from L4 to L5 in both men and women, The largest spinal canal diameter (SCD) in males was found at L1 (14.2mm), while the smallest was at L3 (12.3mm). Generally, SCD gradually decreased from less than 25 age group to 36-40 age groups at all levels, (table/figure 8-12).

Intervertebral foramen diameter (IVFD) increased from L1 to L3 in both men and women, then gradually decreased from L3 to L5. IVDF was minimum at L1 in females (14.9mm) and maximum at L3 in males (17.0mm) IVDF gradually decreased from less than 25 age group to 31-35 age group but increased in 36-40 age group to L5.

Inter-facet diameter (IFD) increased from L1 to L5 for both males and females maximum measuring 28.5mm in males at L5 and minimum of 15.9mm in females at L1. Similar results were seen in . IFD increased from less than 25 age group to 31-35 age group but decreased in 36-40 age group. In L5 IFD was 26.8mm for less than 25 age group and increased to 28.4mm in 31-35 age group but decreased to 26.2mm in 36-40 age group.

Discussion

We identified population-specific variations in the measurements of body segments. It underscored the importance of possessing an extensive data collection for comparison with radiographic assessments, with the objective of establishing a reference standard for lumbar dimensions in Indian population. The study also



sought correlate this data set with multiple variables, including age and gender.

In our study found that vertebral body dimensions gradually increased from L1 to L5 in both men and women, except for lower vertebral width. LVW increased from L1 to L4 and slightly decreased in L5. Similar results were observed in studies by Alam et al. [7] on the Pakistani population and Kang et al. [6] on the Korean population using CT morphometry. Alam et al. conducted study on 49 patients and found vertebral body dimensions increased from L1 to L5 in both male and female population, except in LVW from L4 to L5 which was also statistically significant [7]. A similar study by Singh et al. [5] on 20 cadavers from a North Indian population noted that lower vertebral width increased from L1 to L2, then decreased at L3, followed by an increase from L3 to L5.

We also concluded that vertebral body dimensions generally increased from L1 to L5 from less than 25 years to 31-35 years, but decreased in 36-40 age group except in UVW. Similar results of increasing vertebral body dimensions according age were found in a study by Sevinci O et al. [11]

Our study found that intervertebral disc height (IVDH) gradually increased from L1 to L4, followed by a decrease in L5 in both men and women. The minimum and maximum IVDH were noted at the L1 and L4 levels respectively. Intervertebral disc height was significantly larger in men at all levels. IVDH also increased according to age. IVDH was 7.7mm in less than 25 age group at L5 but increased to 8.7mm in 36-40 age group. Similar trends were noted in a study conducted by Spahn G et al. in 2023 [9]. In this study “The height of the intervertebral discs increases significantly until the age of 40, but beyond the age of 40, the height of the intervertebral discs either remains constant or falls off slightly, but not significantly”.

Spinal canal AP diameters gradually decreased from L1 to L3, followed by an increase from L4 to L5 in both men and women. The values

of the AP diameter of the spinal canal were greater in women than in men from L2 to L4. A study conducted by Kumar et al.[10], which examined CT-scan–based measurements of the lumbar spine in 61 adult patients, found that AP diameters of the spinal canal gradually decreased from D12 to L4 but marginally increased at L5. In a similar study by Yadav U et al. found that AP diameters of the spinal canal gradually decreased from D12 to L4 but marginally increased at L5 and then decreased from L5 to S1 in both men and women [1]. In our study SCD also decreased from L1 to L5 with age, except an increase was noted from the 31-35 to 36-40 age group At L4.

Intervertebral foramen diameter increased from L1 to L3 in both men and women, then gradually decreased from L4 to L5. In contrast, a study conducted by Yadav et al. on 302 patients using CT morphometry found that intervertebral foramen diameter constantly decreased from D12 to S1 in both men and women. This pattern was not observed in our study. In our study IVFD gradually decreased from less than 25 age group to 31-35 age group but increased in 36-40 age group at all levels.

Inter-facet diameter (IFD) increased from L1 to L5 for both males and females. Which was statistically significant with a p-value was <0.05. IFD increased from less than 25 age group to 31-35 age then decreased to 35-40 age, except at L2 were It increased according to age.

Conclusion

In our study, we measured various parameters, including vertebral and canal diameters, of vertebrae from L1 to L5 in a South Indian population using CT morphometry in 247 patients. We also compared these measurements across gender and age finding significant differences in various dimensions of the lumbar vertebrae. Vertebral body dimensions progressively increased from L1 to L5, consistent with other studies. We also concluded that vertebral body dimensions generally increased from L1 to L5 from less than 25 years to 31-35 years but decreased in 36-40 age group except in UVW.



Spinal canal AP diameters gradually decreased from L1 to L3, followed by an increase from L4 to L5 in both men and women. SCD also decreased from L1 to L5 with age, except an increase was noted from the 31-35 to 36-40 age group At L4. Intervertebral foramen diameter increased from L1 to L3 in both men and women, then gradually decreased from L4 to L5, study IVFD gradually decreased from less than 25 age group to 31-35 age group but increased in 36-40 age group at all levels. Inter-facet diameter (IFD) increased from L1 to L5 for both males and females. IFD increased with age but decreased in 31-40 age group.

Vertebral and canal dimensions are statistically higher in males at all levels and another important finding we observed was statistical difference of canal and vertebral dimensions in 31-40 age group. This can be presumed as this age is becoming more prone for developing degenerative changes as compared to other younger groups.

While similar trends were noted in comparison with other studies, the values were lower in our research. The data obtained from this study will provide baseline normative data for evaluating patients presenting with lower back pain and lumbar canal stenosis in a South Indian population.

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