Lumbar offset distance: A simplified metric for evaluation of the lumbar spine alignment

ABSTRACT

Background: A healthy lower back is essential for optimal spinal function and overall wellness. Magnetic resonance imaging (MRI) has become the gold standard in assessing lumbar spine disease. This article aims to evaluate the precision and efficacy of the lumbar offset distance (LOD) as a novel MRI parameter designed to determine the lumbar spine alignment. normally measured as we compared it to a new parameter based on length.

Materials and Methods: Supine sagittal magnetic resonance images of 101 patients who underwent lumbar spine MRI scans were analyzed. We focused on L1–L5 lumbar lordosis angle (LLA) and LOD to assess lumbar spine alignment. Diagnostic cutoff values for LOD measurements were determined, and their diagnostic accuracies were evaluated.

Results: The normal LLA in our dataset was 23 –45 , and the normal LOD was 5–15 mm. Using linear regression, the range of 6–14 mm correlates to the LLA range of 20 –45 , which would define the standard lumbar offset as normal between 6 and 14 mm. Hence, lumbar hypolordosis was defined as <6 mm, and lumbar hyperlordosis was defined as more than 14 mm. Our study showed a good correlation between the LOD and LLA and is particularly useful in identifying cases of normal lumbar lordosis, hypolordosis, and hyperlordosis.

Conclusion: Linear measurements show good diagnostic accuracy of LOD in evaluating lumbar spinal alignment, including normal alignment, hypolordosis, and hyperlordosis.

Keywords: Diagnostic accuracy, lumbar alignment, lumbar spine, magnetic resonance imaging

INTRODUCTION

The lumbar spine is the primary weight-bearing part of the entire spine. Lumbar spinal alignment has mechanical implications on the rest of the spinal and pelvic alignment. Lumbar mobility directly influences the range of motion of the trunk and activities such as raising, twisting, and bending.

Lumbar spine malalignment poses a functional challenge, necessitating precise and reliable measurement parameters. Magnetic resonance imaging (MRI) has gained popularity for lumbar spine assessment. Although the conventional lumbar lordosis angle (LLA) is widely utilized, the LLA may differ depending on the magnitude of two spinal curvatures.[1] In this study, we aim to evaluate the diagnostic accuracy of linear measurement on sagittal MRI sequences, Lumbar offset distance (LOD), a for assessing lumbar spine alignment and compare it to proven measures of LLA and identify the diagnostic cutoff values.

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MATERIALS AND METHODS

Study design and population

The study was registered with the trust's clinical effectiveness unit. After receiving local approval, the hospital's picture archival and communications system was searched to obtain a list of 101 patients who underwent MRI scans of the lumbar spine. The supine sagittal images were used for the study. The study excluded patients with postoperative evaluations, extensive trauma, age above 70, anatomical abnormalities significantly impacting spinal alignment, and images degraded by motion and metallic artifacts.

Cases with lumbosacral transitional vertebra were excluded from this study. The images were assessed by a musculoskeletal radiology consultant and a musculoskeletal radiology fellow over 1 month. The reader repeated measurements after 2 weeks for intraobserver reliability. Patient demographic details, including age and sex, were also recorded.

Measurements

Lumbar alignment measurements focused on L1–L5 using the following parameters:

- Lumbar Lordosis Angle (LLA) was measured as an the angle between the L1 superior endplate (A) and the L5 inferior endplate (B). The LLA was previously defined as normal between 20° and 45°[2]
- Lumbar offset Distance (LOD) was measured in the following way:
    - First, a straight vertical line (line C) was drawn between the posterosuperior corner of the L1 vertebral body and the posterior–inferior corner of the L5 vertebral body
    - Second, the shortest distance (D) between line C and the mid-point of the posterior cortex of the L3 vertebral body was measured [Figures 1 and 2].

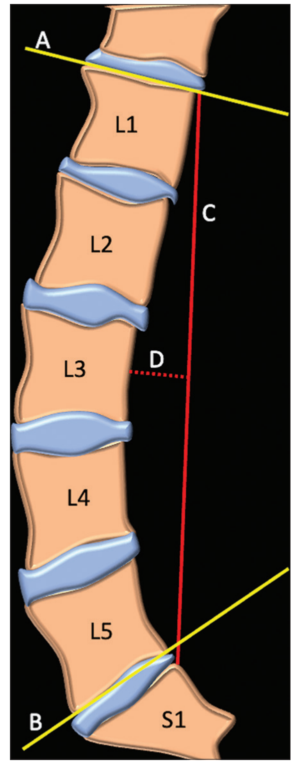

Figure 1: Schematic showing the lumbar lordosis angle (angle between line A (superior end plate of L1) and line B (inferior end plate of L5) and lumbar offset distance (D- distance between C(vertical line drawn between posterosuperior corner of L1 and posteroinfeiror corner of L5) and midpoint of posterior cortex of L3 vertebral body)

Statistical analysis

The data analysis was conducted using STATA (Stata Statistical Software: Release 18, Stata Corp LLC, College Station, TX, USA). Patients were categorized into three groups based on their LLA: loss of lumbar lordosis (20°), normal lordosis (20°–45°), and exaggerated lumbar lordosis (45°). The age was compared using one-way ANOVA in the three groups, while a Chi-squared test was used to compare the gender distribution. A linear regression was executed to examine the correlation between the LOD, LLA, and age. P <0.05 was considered statistically significant.

RESULTS

The study included 101 patients with an average age of 55.2 (standard deviation [SD] = 14.3), of which 51 were male. The average LLA was 34.3° (SD = 11.6), which matched the distribution as described by Lin *et al*.[2] The average offset distance was 10.5 mm (SD = 5.10 mm).

The patients were divided into three groups: normal, exaggerated lordosis, and loss of lordosis. The normal group included 78 patients with an average age of 54.9 years, the exaggerated lordosis group included 16 patients with an average age of 57.3 years, and the loss of lordosis group included seven patients with an average age of 55.1 years. There was no significant difference between the groups regarding age (P = 0.826) or gender composition (P = 0.202). There were good intra- and interobserver reliability with a kappa of 0.8.

In the normal group, the mean LLA and offset were 31.9° (SD = 6.96) and 9.61 mm (SD = 3.63 mm), respectively. In the exaggerated lordosis group, the mean LLA was 54.0° (SD = 6.22), and the mean offset was 17.5 mm (SD = 5.58). In the loss of lordosis group, the mean LLA was 15.9° (SD = 3.0), and the mean offset was 4.9 mm (SD = 2.61). There was a high statistically significant difference between the groups for the LLA (P < 0.0001,

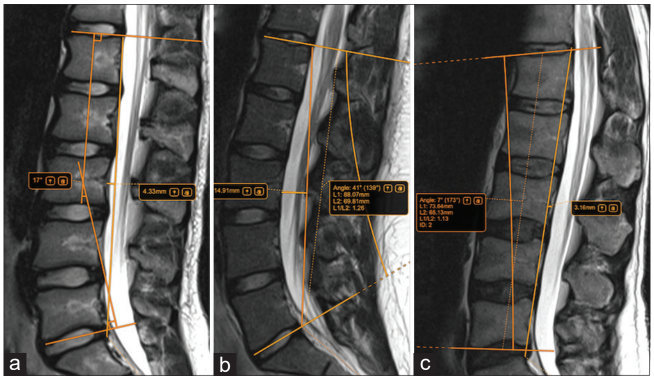

Figure 2: Examples of measurements of lumbar lordosis angle and lumbar offset distance in lordosis of 17° (a), lordosis of 41° (b), and hypolordosis (straightening/kyphosis) (c)

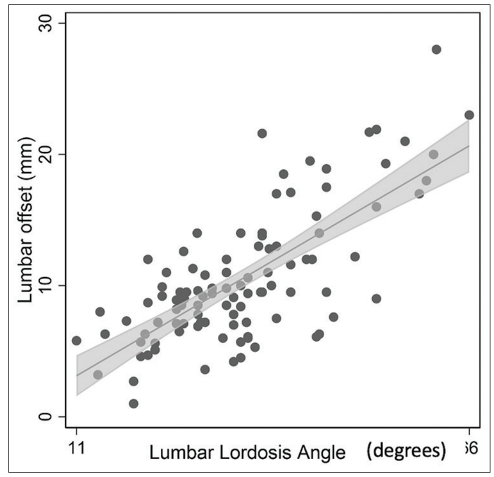

Figure 3: Scatter plot showing lumbar lordosis angle on the X-axis and lumbar offset distance on the Y-axis

expected as a dependent variable) and the lumbar offset ($P < 0.0001$). There was a high correlation between using Pearson's correlation coefficient ($P < 0.0001$). There was no correlation between the age of the patient and the LLA ($P = 0.891$) nor the lumbar offset ($P = 0.562$).

A linear regression was performed to determine the best-fit expression between the LLA and offset results. The best-fit line is presented in Figure 3. The R^2 for the regression is 52.7%, which is considered acceptable. Based on the results, a 20° LLA is correlated with a lumbar offset of 5.99 mm, and a 45° LLA is correlated with an offset of 13.96 mm [Figure 3].

DISCUSSION

Lumbar spondylolysis often causes low back pain in adolescents and young adults.[3] Lumbar spondylolysis results from a combination of factors, such as genetic predisposition, stress fractures, trauma, alterations in sagittal spinopelvic biomechanics, and other contributing elements, resulting in sagittal lumbar malalignment and the initiation of compensatory mechanisms.[3-10]

Lumbar lordosis is defined as the inward curvature of the lumbar spine and varies among different lumbar segments. An adequately aligned lumbar spine ensures the effective distribution of axial loads, preventing undue stress on individual vertebrae and intervertebral discs. Maintaining equilibrium in load distribution is crucial for avoiding degenerative changes and minimizing the risk of disc herniation.

Lumbar hypolordosis, straightening or kyphosis, is characterized by a decreased inward curve, resulting in a greater vertical force on the vertebral endplate, potentially exacerbated by spinal degeneration. Conversely, exaggerated lumbar lordosis or hyperlordosis is characterized by an increased inward lumbar curve that increases the risk of posterior facet arthritis and spondylolisthesis.[11-13]

Alterations in lumbar spine alignment, such as excessive lordosis or kyphosis, are associated with musculoskeletal disorders, such as disc herniation or spinal stenosis, and can lead to nerve compression, resulting in pain, numbness, or weakness. Monitoring and addressing lumbar alignment are essential for scoliosis management to prevent associated complications.

Several studies have found that lumbar lordosis measurements in the supine position in horizontal MRI were comparable to standing MRI.[14-16]

This study introduced a simplified novel measurement, the LOD, to assess the lumbar spine alignment. We compared it to the LLA, an already proven quantitative method of measuring the lumbar spinal alignment, to determine its diagnostic accuracy.

The normal LLA in our dataset was 23°–45°, and the normal LOD was 5–15 mm. Using linear regression, the range of 6–14 mm correlates to the LLA range of 20°–45°, which would define the normal LOD as standard between 6 and 14 mm. Hence, lumbar hypolordosis can be defined as an by an LOD of <6 mm and lumbar hyperlordosis can be defined as an by an LOD of >14 mm. Our study showed that the LOD and LLA showed a good correlation and are particularly useful in identifying cases of normal lumbar lordosis, hypolordosis, and hyperlordosis.

The LOD is particularly adept at identifying subtle changes in lumbar alignment, including straightening of the lumbar spine, which is vital for the early detection of pathologies affecting spinal curvature. The LOD measurements' simplicity and superior efficacy enhances its clinical applicability, by enabling radiologists to easily identify lumbar malalignment with on routine MR imaging and makes it an invalauable tool in the musculoskeletal radiologist armament. LOD also offers valuable insights that can guide therapeutic interventions and surgical decisions. It is also prostulated that measuring a single linear parameter will likely be fraught with less error than measuring an angle.

The study's primary limitation is its small sample cohort size. More extensive studies with larger and more diverse cohorts are essential to establish the validity of the observed trends and generalize the outcomes.

CONCLUSION

This study provides insight into the diagnostic accuracy of a novel LOD measurement in assessing the lumbar spine alignment on supine magnetic resonance sagittal sequences. The MRI measurements of LOD are dependable for determining normal lumbar spinal alignment and identifying cases of normal alignment, hypolordosis, and hyperlordosis. However, since the study was done on a small cohort, more extensive studies are necessary to validate these findings further.

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Conflicts of interest

There are no conflicts of interest.

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