Correlation of Spinopelvic Parameters in Lumbar Spine Instability

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Abstract

Introduction: Sagittal spino-pelvic instability is the most common cause for chronic low back pain. Legaye stated that the pelvic incidence (PI) is an anatomical parameter for assessing spinal stability. Pelvic incidence can be calculated by adding pelvic tilt and sacral slope. Sacral table angle (STA) is the angle between the superior sacral endplate and the trailing edge line of sacrum. This article aims to prove the temporal association of pelvic incidence and sacral table angle and lumbar instability in patients with chronic low back pain.

Objective: To prove the temporal association of pelvic incidence and sacral table angle and lumbar instability in patients with chronic low back pain.

Materials and methods: A total of 191 cases with nonspecific low back pain with or without lumbar instability were analysed with spinal radiographs. The pelvic incidence and sacral table angle were calculated for L3 – L4, L4 – L5 and L5 – S1 levels.

Results: Out of 191 cases, the levels of L5 – S1 cases showed 5% translation and 10° angulation. We observed a significantly statistical difference between two groups in terms of pelvic incidence (p<0.01) and sacral table angle (p<0.01). The lumbar instability of L5 – S1 segment is associated with lower pelvic incidence and increased sacral table angle. The Spearman’s Rank correlation coefficient (rho ρ) for the study was 0.745 which imply highly positive correlation between pelvic incidence and sacral table angle and lumbar instability.

Conclusion: The spino-pelvic parameters influence the evolution of spinal degenerative disease. We observed that the patients with chronic low back pain without lumbar instability showed normal or decreased PI and increased STA whereas patients with chronic low back pain with lumbar instability showed increased PI and decreased STA. The cases with increased PI and decreased STA are prone to develop degenerative spinal pathology or discogenic pathology which alters the postural balance of spinal column.

Keywords: Low back pain; Pelvic incidence; Sacral table angle; Lumbar spine instability.

Abbreviations: PI: Pelvic Incidence, STA: Sacral Table Angle.

Introduction

There is an increasing recognition of the clinical importance of the sagittal plane alignment of the spine. Sagittal spino-pelvic instability is the most common cause for chronic low back pain. Spinal stability is defined as inability of spine to maintain the orientation under physiological loads which is diagnosed by lumbar flexion and extension radiography [1]. Legaye described “Pelvic Incidence” (PI) as “the angle between the line perpendicular to the superior sacral endplate and the line joining the midpoint of superior sacral endplate and the femoral head’s axis” [2]. He stated PI as an anatomical parameter for assessing spinal stability. Pelvic incidence can be calculated by adding pelvic tilt and sacral slope. Sacral table angle (STA) is the angle between the superior sacral endplate and the trailing edge line of sacrum. This article aims to prove the temporal association of pelvic incidence and lumbar instability in patients with chronic low back pain.

Materials and Methods

This prospective cohort study was conducted in 229 cases of chronic low back pain in JMJ Medical College, Davangere, a tertiary care hospital from June 2016 to June 2018. A total of 191 cases with low back pain for 3 or more than 3 months duration were identified and 21 cases are excluded from the study who failed to satisfy the inclusion criteria and 17 cases declined to participate the study. The remaining 191 cases were taken up for this study and analysed statistically as per our study protocol. Chronic low back pain was considered as a positive history of constant or intermittent low back pain for more than 3 months; or any pain onset less than one year, having at least 2 episodes of disabling low back pain during the past year (Figure 1).

Inclusion criteria

a) Patients aged more than 20 years and less than 70 years.
b) Patients with low back pain of duration for 3 months or more.
c) Patients with low back pain of duration for 3 months or more.
d) Patients with slip percentage within 30% of spondylolisthesis.
e) Patients with radiological evidence of spondylolysis.
f) Patients who are willing to participate the study as per our protocol.

Exclusion criteria

a) Patients aged less than 20 years and more than 70 years.
b) Patients with low back pain of duration less than 3 months.
c) Patients who received epidural steroid injection within 3 months of start of study.
After obtaining the informed and written consent from the cases enrolled in our study, they are subjected to thorough clinical examination to rule out the other causes of low back pain. All the cases were subjected for radiograph of lumbosacral spine – AP and lateral view. The dynamic translations of vertebra over each other and their rotations were computed in 3 different levels: L5-S1, L4-L5 and L3-L4 (Figure 2). The amount of translation was obtained from calculating absolute values of translation in both flexion and extension positions. After eliminating the magnification effect of radiographs, we measured the width of L3, L4 and L5 vertebral body. The vertebral width translation was expressed in percentage. Any translation more than 8% from the neutral lateral view or the sum of any angulations more than 11° in flexion and extension lateral views were considered as lumbar spinal instability. Concurrently, the pelvic incidences were measured following Legaye’s description (Figure 3).

Lumbosacral parameters

All cases were subjected for lumbosacral lateral radiographs in the following position: an erect posture with extension of knees and hips, forward flexion of arms, elbows flexed and hands centered in midway between the suprasternal notch and acromion. The radiographs must contain bilateral femoral heads. All radiographic parameters were assessed by a single author throughout the study period (Figure 4).

The following radiographic lumbosacral parameters were as follows [1,2]:

- Pelvic incidence (PI): The angle between the line perpendicular to the superior sacral endplate and the line joining the midpoint of superior sacral endplate and the femoral head’s axis
- Pelvic tilt (PT): The angle between the line connecting the midpoint of the superior sacral endplate to the femoral head’s axis and the vertical axis
- Sacral slope (SS): The angle between the superior sacral endplate and a horizontal line,
- Lumbar lordosis (LL): The angle between the superior sacral endplate and the superior endplate of L1 and
- Sacral table angle (STA): The angle between the superior sacral endplate and the trailing edge line of sacrum.

Among these all parameters, only pelvic incidence and sacral table angle are calculated in our cases and the results are tabulated.

Statistical Analysis

All statistical tests were performed using IBM SPSS Statistics for Windows, Version 20.0, IBM Corp, Chicago, IL, USA. All the continuous variables were described by the formula of mean ± standard deviation (SD). Student t-test was performed for comparisons. A comparison was considered significant at a value of p<0.05. The correlation and regression analysis was considered as highly significant at a value of r=0.7.

Results

Out of 191 cases, 94 cases (49.21%) were males and 97 cases (50.78%) were females with a mean age of 45.71 years (range: 21 – 70 years). All cases were segregated according to presence of lumbar instability namely group A (n=99): patients bearing nonspecific low back pain with lumbar instability (51.83%) and group B (n=92): patients bearing nonspecific low back pain without lumbar instability (48.16%). The demographic data of both the groups were statistically insignificant (Table 1).

The mean vertebral width of L3, L4 and L5 were 42.17 ± 1.91, 43.43 ± 1.76 and 44.19 ± 1.97 respectively and without any significant difference between two groups (P=0.07). We observed translations and angulations for each spinal level separately. We observed the maximum translation of 65% and angulation of 45° occur at L4 – L5 level followed by 20% translation and 33° angulation at L3 – L4 level and least translation of 5% and angulation of 10° at L5 – S1 level (Table 2).

The mean pelvic incidence were calculated for both groups which set to 52.58 ± 1.18 in group A and 52.92 ± 1.67 in group B without any
Discussion

A normal lumbar spine movement follows a complex pattern during flexion and extension. The researchers have used various criteria for identifying abnormal kinematics in the patients with chronic low back pain, with the most common criteria being radiographically measurable abnormalities in the magnitude of sagittal plane rotation and translation [3]. The aberrant motion and dysfunction from structural lumbar segmental instability exist at end range and during midrange spinal movements. Flexion – extension radiographs simply assess vertebral displacement statically at end range which would detect the function of the passive stabilizing subsystem [4,5]. This leads to have significant limitations in detecting dysfunction from structural lumbar segmental instability that occurs within the neutral zone [6].

Berthonnaud et al. reported the linear correlations which were stronger between shape and orientation variables at the pelvic and lumbar areas and weaker at the thoracic level and between the thoracolumbar areas. They considered the sagittal plane between pelvis and spine as a linear chain linking the head to the pelvis and the adjacent segment to maintain a stable posture with a minimum of energy expenditure. The minimal changes in shape or orientation at one level of spinal segment will have a direct influence on the adjacent segment which leads to spinal instability [7].

Vialle et al. outlined the physiological spinal sagittal balance serve as a baseline in evaluation of pathological spinal disorders associated with abnormal translation and angular parameters of spinal segments. They suggested by calculating the angular and translational deformities of the spinal segments will decrease the further degeneration of adjacent spinal segments [8]. Wong et al. developed a continuous dynamic lumbar intervertebral flexion-extension which was assessed by a video fluoroscopy with a new auto-tracking system. They reported normal movement of lumbar spine occurs via simultaneous segmental motion [9].

There are wide variations in the spinopelvic parameters in children and adolescents. Due to age progression, there is a slight tendency for thoracic kyphosis and lumbar lordosis to occur. Pelvic incidence and pelvic tilt also tend to increase during growth, while sacral slope remains relatively stable. The spatial and temporal relationships between adjacent spinal segment and sacropelvis are the key in the evaluation and interpretation of the sagittal spinopelvic alignment. These parameters are preserved to maintain postural balance. The progressive forward displacement of C7 plumbline should raise a suspicion for the risk of developing spinal pathology [10].

Rajnics et al. used a special software program to measure spinopelvic parameters on 50 patients with lumbar disc herniation (group A) and compared with 30 healthy subjects (group B). Group A patients had a relatively straight spine in the sagittal plane with more vertical sacral plate and lower lumbar lordosis while comparing with group B. They concluded that the higher gravitational compressive force lead to progressive degeneration of the discs. The imbalance between the shifts
of the line of gravity may cause spinopelvic instability and contraction of the posterior spinal may produce discogenic back pain [11] (Graph 1).

Labelle et al. reported pelvic incidence as the constant anatomic pelvic variable which determine sacral slope, pelvic tilt and lumbar lordosis being position dependent variables. They concluded increased pelvic incidence predispose in the progression of developmental spondylolisthesis [12]. Schuller et al. reported with increased BMI and increased pelvic tilt lead to increased pelvic incidence and hence degenerative spondylolisthesis result [13]. Ashok concluded that spinal instability would result from rotational component in sagittal plane when the patients with spondylolisthesis were excluded from the study [14].

Yoshimoto et al. suggested increased pelvic incidence in the younger individual lead to the development of hip osteoarthritis in later life without the development of lumbar kyphosis and acetabular dysplasia [15]. Barrey et al. claimed decreased pelvic incidence in younger patients with any disc and degenerative diseases [16]. Waris et al. showed a higher concurrence of degenerative disk diseases among low back pain patients and added segmental hypomobility lead to the development of discogenic low back pain [17]. Leone intimated disk shears are initially painful and can be presented as low back pain when pelvic incidence is increased [18].

In our study, we have analysed the radiographic evaluation of pelvic incidence and sacral table angle in 191 cases with chronic low back pain. Out of 191 cases, the levels of L5 – S1 cases showed 5% translation and 10° angulation. We observed a significantly statistical difference between two groups in terms of pelvic incidence (p=0.01) and sacral table angle (p<0.001). The lumbar instability of L5 – S1 segment is associated with lower pelvic incidence with higher sacral table angle. The Spearman’s Rank correlation coefficient (rho ρ) for the study was 0.7 which imply highly positive correlation between pelvic incidence and sacral table angle and lumbar instability. The limitations of the study are the non-usage of other parameters such as sacral slope and pelvic tilt in calculating the spinal instability.

Conclusion

The shape of the pelvis and spino-pelvic parameters influence the evolution of spinal degenerative disease. We observed that the patients with chronic low back pain with lumbar instability (Group A) showed increased pelvic incidence and decreased sacral table angle whereas patients with chronic low back pain without lumbar instability (Group B) showed decreased pelvic incidence and increased sacral table angle. The cases with increased pelvic incidence and decreased sacral table angle are prone to develop degenerative spinal pathology or discogenic pathology which alters the postural balance of spinal column. Thus, the temporal association between pelvic incidence and sacral table angle and lumbar stability was proved in our study.

Conflicts of Interest

The authors declare no conflicts of interest.

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References