Journal of Spine

Jeyaraman et al., J Spine 2019, S8
DOI: 10.4172/2165-7939.S8-004

Research Article | Open Access

Correlation of Spinopelvic Parameters in Lumbar Spine Instability

Madhan Jeyaraman[1], Vijay Kumar K[1], Naveen Jeyaraman[2], Amarendra Singh[3], Lokesh Sharma[4] and Kartheek Aradhyula[5]

[1]*Department of Orthopaedics, JJM Medical College, Davangere, Karnataka, India.*
[2]*Department of Orthopaedics, Kasturba Medical College, Manipal, Karnataka, India.*
[3]*Department of Orthopaedics, Nethaji Subash Chandra Bose Medical College, Jabalpur, Madhya Pradesh, India.*
[4]*Department of Orthopaedics, Guntur Medical College, Guntur Andhra Pradesh, India.*
[5]*Department of Radiodiagnosis, JJM Medical College, Davangere, Karnataka, India.*

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.

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 JJM 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 without any congenital deformities of lower limb, neuromuscular disorders and disco-vertebral pathologies.
- **d)** Patients with radiological evidence of spondylolysis.
- **e)** Patients with slip percentage within 30% of spondylolisthesis.
- **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.

***Corresponding author:** Madhan Jeyaraman, Department of Orthopaedics, JJM Medical College, Davangere – 577004, Karnataka, India, Tel: +918310600785; E-mail: madhanjeyaraman@gmail.com

Received May 22, 2019; **Accepted** June 03, 2019; **Published** June 10, 2019

Citation: Jeyaraman M, Vijay Kumar K, Jeyaraman N, Singh A, Sharma L, et al. (2019) Correlation of Spinopelvic Parameters in Lumbar Spine Instability. J Spine S8: 004.

d) Patients with slip percentage more than 30% of spondylolisthesis.

e) Patients who refused to participate in the study as per our protocol.

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

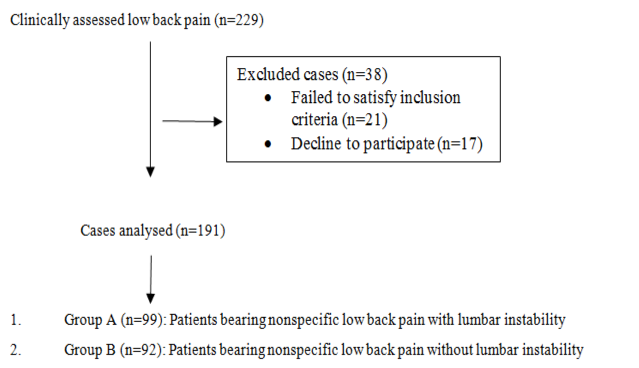


Figure 1: Patient's allocation into Groups A and B.

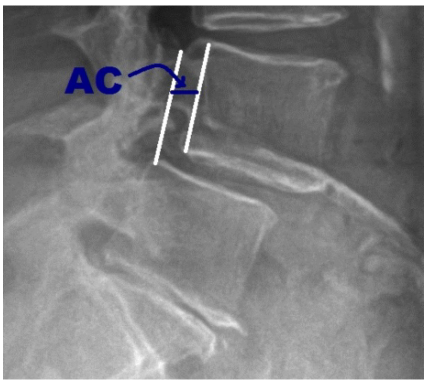


Figure 2: AC length describes absolute value of L4 translation over L5 in extension position.

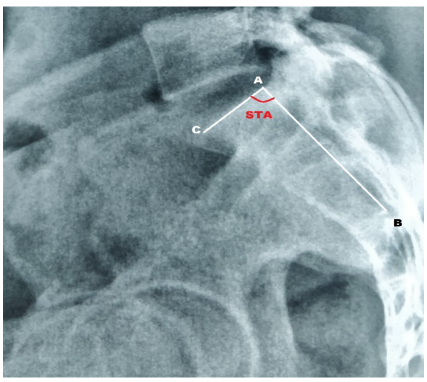


Figure 3: Sacral table angle (STA).

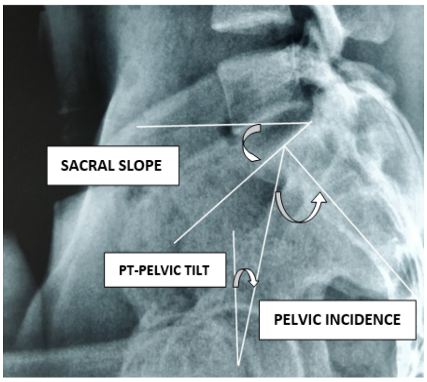


Figure 4: Sacral slope, pelvic tilt and pelvic incidence.

Group	Mean age (years)	Male	Female	Height (m)	Mean weight (Kg)	Mean BMI (kg/m²)
Group A	41.56	48	51	1.69	73.1	25.64
Group B	37.72	46	46	1.67	76.6	27.55
P-value	0.31	0.23	0.30	0.41	0.50	0.93

Table 1: Demographic data of cases according to groups.

Spinal levels	Translations	Angulations
L3 – L4	20%	33°
L4 – L5	65%	45°
L5 – S1	5%	10°

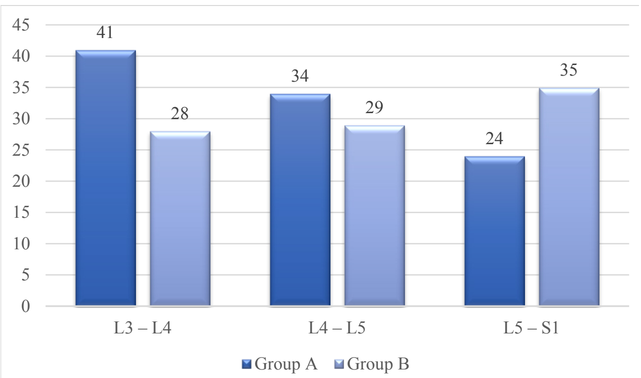
Table 2: Translation and angulation for each level.

Spinal levels	Mean Pelvic Incidence (PI)		p-value
	Group A	Group B	
L3 – L4	52.63 ± 1.02	55.71 ± 2.01	0.41
L4 – L5	51.49 ± 1.62	55.67 ± 1.28	0.06
L5 – S1	53.62 ± 0.91	47.38 ± 1.73	0.01

Table 3: Mean pelvic incidence of both groups in different levels.

Variable	Group A	Group B	p-value
Pelvic Incidence (PI)	53.62 ± 0.91	47.38 ± 1.73	0.01
Mean Sacral Table Angle (STA)	85.91 ± 7.19	94.17 ± 8.67	<0.001

Table 4: Mean pelvic incidence and sacral table angles of both groups in L5 – S1 level.



Graph 1: Distribution of cases among spinal levels.

significant difference in both groups. The evaluation of pelvic incidence separately for each level showed significantly lower in patients with lumbar instability of L5 – S1 origin (*P*=0.01) (Table 3). The mean evaluation of pelvic incidence and sacral table angle for L5 – S1 level showed significantly higher pelvic incidence and lower sacral table angle in patients with lumbar instability (Table 4).

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.

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 interpretion 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].

Yoshimito 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.

Acknowledgement

None to acknowledge.

Funding Sources

There is no funding.

References

1. Boulay C, Tardieu C, Hecquet J, Benaim C, Mouilleseaux B, et al. (2006) Sagittal alignment of spine and pelvis regulated by pelvic incidence: standard values and prediction of lordosis. Eur Spine J 15: 415-422.
2. Legaye J, Duval-Beaupère G, Hecquet J, Marty C (1998) Pelvic incidence: A fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. Eur Spine J 7: 99-103.
3. Abbott JH, Fritz JM, McCane B, Shultz B, Herbison P, et al. (2006) Lumbar segmental mobility disorders: comparison of two methods of defining abnormal displacement kinematics in a cohort of patients with non-specific mechanical low back pain. BMC Musculoskelet Disord 7: 45.
4. Knutsson F (1944) The instability associated with disk degeneration in the lumbar spine. Acta Radiol 25: 593-609.
5. Fritz JM, Erhard RE, Hagen BF (1998) Segmental instability of the lumbar spine. Phys Ther 78:889-896.
6. Panjabi MM (1992) The stabilizing system of the spine. Part II. Neutral zone and instability hypothesis. J Spinal Disord 5: 390-397.
7. Berthonnaud E, Dimnet J, Roussouly P, Labelle H (2005) Analysis of the sagittal balance of the spine and pelvis using shape and orientation parameters. J Spinal Disord Tech 18: 40-47.
8. Vialle R, Levassor N, Rillardon L, Templier A, Skalli W, et al. (2005) Radiographic analysis of the sagittal alignment and balance of the spine in asymptomatic subjects. J Bone Joint Surg Am 87: 260-267.
9. Wong KW, Luk KD, Leong JC, Wong SF, Wong KK (2006) Continuous dynamic spinal motion analysis. Spine 31: 414-419.
10. Mac-Thiong JM, Labelle H, Roussouly P (2011) Pediatric sagittal alignment. Eur Spine J 20: 586-590.
11. Rajnics P, Templier A, Skalli W, Lavaste F, Illes T (2002) The importance of spinopelvic parameters in patients with lumbar disc lesions. Int Orthop 26: 104-108.
12. Labelle H, Roussouly P, Berthonnaud E, Transfeldt E, O'Brien M, et al. (2004) Spondylolisthesis, pelvic incidence, and spinopelvic balance: a correlation study. Spine 29: 2049-2054.
13. Schuller S, Charles YP, Steib JP (2011) Sagittal spinopelvic alignment and body mass index in patients with degenerative spondylolisthesis. Eur Spine J 20: 713-719.
14. Rathod AK, Rakesh P (2018) Radiographic incidence of lumbar spinal instability in patients with non-spondylolisthetic low backache. Cureus 10: e2420.
15. Yoshimoto H, Sato S, Masuda T, Kanno T, Shundo M, et al. (2005) Spinopelvic alignment in patients with osteoarthrosis of the hip: A radiographic comparison to patients with low back pain. Spine 30: 1650-1657.
16. Barrey C, Jund J, Noseda O, Roussouly P (2007) Sagittal balance of the pelvis-spine complex and lumbar degenerative diseases. A comparative study about 85 cases. Eur Spine J 16: 1459-1467.
17. Waris E, Eskelin M, Hermunen H, Kiviluoto O, Paajanen H (2007) Disc degeneration in low back pain: A 17-year follow-up study using magnetic resonance imaging. Spine 32: 681-684.
18. Leone A, Guglielmi G, Cassar-Pullicino VN, Bonomo L (2007) Lumbar intervertebral instability: A review. Radiology 245: 62-77.