

# Correlation of Pelvic Parameters with Isthmic Spondylolisthesis

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## ABSTRACT

### Background

Spondylolisthesis is one of the major causes of low back pain. The anterior shift of the vertebra is mostly at L4 and L5 levels. Several types have been described, most common being the isthmic type. Pelvic parameters are said to be associated with development and progression of listhesis, and should be evaluated while treating it.

### Objective

To study the correlation of Pelvic parameters with isthmic spondylolisthesis.

### Method

It was a cross sectional case control study. In 68 cases with Isthmic Spondylolisthesis and of 34 cases with low back pain without listhesis (control), the spinopelvic parameters like lumbar lordosis, pelvic incidence, pelvic tilt and sacral slopes were measured together with degree of slip with lateral radiographs. Findings were analyzed and compared with control group.

### Result

In control group, the pelvic incidence was  $50.44 \pm 4.78^\circ$ , the sacral slope was  $34.38 \pm 6.79^\circ$ , the pelvic tilt was  $15.97 \pm 5.31^\circ$ , and the lumbar lordosis was  $46.76 \pm 6.78^\circ$ . In Isthmic Spondylolisthesis group, the pelvic incidence was  $60.85 \pm 6.79^\circ$ , the sacral slope was  $40.40 \pm 6.91^\circ$ , the pelvic tilt was  $20.63 \pm 7.51^\circ$ , and the lumbar lordosis was  $57.31 \pm 7.11^\circ$ . The difference in spinopelvic parameters amongst control and Isthmic Spondylolisthesis group was statistically significant ( $p < 0.001$ ). The degree of slip was directly proportional to the pelvic incidence angle (grade I= $52^\circ$ , II= $62^\circ$  and III= $72.5^\circ$ ).

### Conclusion

Spino-pelvic parameters are higher in isthmic spondylolisthesis group and is significantly associated with severity of the slip.

## KEY WORDS

*Isthmic spondylolisthesis, Lumbar lordosis, Pelvic incidence, Pelvic tilt, Sacral slope*

## INTRODUCTION

Almost 5-10% of the patients with low back pain coming to orthopedics OPD will have either a spondylolysis or isthmic spondylolisthesis.<sup>1</sup> The association of increased pelvic incidence (PI) with development and progression of spondylolisthesis has been recently of interest.<sup>2-6</sup> Similarly, pelvic parameters-pelvic tilt (PT) and sacral slope (SS), and lumbar lordosis (LL), which are related to PI have also been studied in relation to progression of spondylolisthesis.<sup>2,7,8</sup> There has been relatively few studies in our part of the world on the the topic.

An increased lumbar lordosis increases the shear stress at L4-L5 level and can cause the progression of Isthmic Spondylolisthesis (IS).<sup>9</sup> Pelvic incidence can be a factor on the slip progression in patients with L4-L5 and L5-S1 IS.<sup>4,10</sup> Preoperative evaluation of these parameters are important for operation plan and thus in outcome.

The purpose of the study was to compare the pelvic parameters of Nepalese people with and without isthmic spondylolisthesis, and to observe whether increase in PI is related with increased grades of IS.

## METHODS

This was a cross-sectional case-control study carried out in patients with low back pain who visited the Outpatient Department (OPD) of Tribhuvan University Teaching Hospital from June 2017 to May 2018. It was commenced after taking approval from institutional review board of Institute of Medicine, Nepal. All adult patients, 18 years or older, complaining of low back pain with or without clinical signs of spondylolisthesis and had given consent were included in the study. Using G \*Power 3.1.9.2 software, at 95% confidence level, 80% power and effect size of 0.7, the minimum sample size to be calculated is 34 per group.  $n = \{2(z_{\alpha} + z_{\beta})^2\} / (\text{effect size})^2 = 34$  per group. Samples were taken by consecutive sampling till the sample size of 34 patients with L4-5 IS, 34 patients with L5-S1 IS and 34 patients with no listhesis were taken.

Cases with spondylolysis without listhesis were not taken. Polytrauma cases, patients unable to stand, infective/inflammatory back pain and patients who have contraindications for a radiological examination were excluded from the study.

A standing plain radiograph of the lumbosacral spine with hip joints of the 102 patients was taken using a standardized procedure. Each patient was placed in the same relaxed standing position with arms in the fists-on-clavicles position and knees and hips fully extended.<sup>11</sup> All the radiographs were taken using a digital radiography system with a distance of 120 cm between the flat panel and the radiation source. Poor quality radiographs with invisibility of hip joints were excluded. Patient's information was gathered in a proforma separately. Different spinopelvic

parameters were measured in 68 cases with radiological signs of listhesis (34 at L4-5 and 34 at L5-S1 level) and compared with that of 34 cases without radiological signs of spondylolisthesis as control. The patients presenting with isthmic spondylolisthesis (anterior "slippage" of a vertebra in relation to an adjacent vertebra with spondylolysis) were taken as cases.<sup>1</sup>

Pelvic incidence (PI), pelvic tilt (PT), and sacral slope (SS) were assessed by the method of Duval-Beaupere et al.<sup>9</sup> The SS was defined as the angle between the horizontal reference line and sacral upper end plate. PT was defined as the angle between the vertical reference line and line joining the midpoint of the sacral upper endplate and the axis of the femoral heads. PI was defined as the angle between a line joining the center of the upper endplate of S1 to axis of femoral heads and a line perpendicular to the upper endplate of S1. According to the geometrical analysis, the PI is summation of SS and the PT. Degree of lumbar lordosis was assessed by Cobb's method from the upper endplate of L1 to upper end plate of S1 (fig. 1).



**Figure 1.** Calculation of PI, PT, SS and LL

Isthmic Spondylolisthesis patients were graded by using Meyerding grading.<sup>12</sup> SPSS (Statistical Package for the Social Sciences) version 22 was used for data analysis. The mean differences in different groups were analyzed by student t test. Difference in percentage of categorical variables in different groups were analyzed by chi square test. This is not case control study, but comparison was made between groups.

## RESULTS

There were 68 patients cases and 34 control included in this study. Among them, 27(18) of the cases are males 73(50) of the cases are females, to 61.8(21) of control were males and 38.2(13) in controls were females. The mean age was  $46.96 \pm 10.80$  in cases and  $39.12 \pm 8.79$  in controls. The mean age and sex distribution are significantly different in cases and controls.

In control group, the PI was  $50.44 \pm 4.78^\circ$ , the SS was  $34.38 \pm 6.79^\circ$ , the PT was  $15.97 \pm 5.31^\circ$ , the LL was

46.76±6.78°, and in IS group the PI was 60.85±6.79°, the SS was 40.40±6.91°, the PT was 20.63±7.51°, and the LL was 57.31±7.11°. Of these parameters, the PI (p < 0.001), SS (p < 0.001), PT (p < 0.001) and LL (p < 0.001) showed significant statistical differences (table 1).

**Table 1. Comparison between the isthmic spondylolisthesis (IS) group and the control group for pelvic parameters**

	Case and Control	Mean	Std. Deviation	t	P
Pelvic Incidence	Case	60.85	6.97	8.85	< 0.001
	Control	50.44	4.78		
Pelvic Tilt	Case	20.63	7.51	3.62	< 0.001
	Control	15.97	5.31		
Sacral Slope	Case	40.40	6.91	4.17	< 0.001
	Control	34.38	6.79		
Lumbar Lordosis	Case	57.31	7.11	7.17	< 0.001
	Control	46.76	6.78		

The median PI for grade 1 was 52, for grade 2 was 62 and for grade 3 was 72.5. The distribution of PI in three grades was significantly different (p < 0.001, table 3).

**Table 2. Comparison between L4 IS group and the L5 IS group for pelvic parameters**

	Diagnosis	Mean	Std. Deviation	p
Pelvic Incidence	L4-L5 Spondylolisthesis	61.76	6.88	.284
	L5-S1 Spondylolisthesis	59.94	7.05	
Pelvic Tilt	L4-L5 Spondylolisthesis	23.59	7.22	.001
	L5-S1 Spondylolisthesis	17.68	6.66	
Sacral Slope	L4-L5 Spondylolisthesis	38.62	7.50	.033
	L5-S1 Spondylolisthesis	42.18	5.84	
Lumbar Lordosis	L4-L5 Spondylolisthesis	58.24	5.99	.286

**Table 3. Median PI in different grades of IS**

	Pelvic Incidence			Chi square	p
	Median	Q1	Q3		
Grade I	52	50	60	23.69	< 0.001
Grade II	62	60	67		
Grade III	72.5	64	78.8		

**DISCUSSION**

The causes of spondylolysis are considered to be multifactorial, and they include a hereditary predisposition and biomechanical factors. The precise mechanism of slippage after the development of an isthmic defect is unknown, but slip angle, slip grade, sacral inclination and

Schwab et al. sagittal pelvic tilt index are some of the parameters that have been reported by which we can predict slip progression.<sup>7,13</sup>

The pelvic incidence was suggested by Duval-Beaupere et al. to be an anatomical parameter that is correlated with positional parameters as the sacral slope and pelvic tilt.<sup>9</sup> As the PI is increased, the PT and SS will be increased. Generally, the normal range of the PT is very narrow from 10 to 15 degrees, so if the PI is increased, the SS will be increased relatively much more than the PT and it will be the cause of increasing lordosis. If the lordosis is increased, there will be a large load to the posterior complex that will produce a spondylolysis and possible progression of spondylolisthesis. Progression of spondylolisthesis displaces the center of gravity of the pelvis anteriorly, which increases the PT and decreases the SS to compensate.<sup>7</sup>

In our study, on comparison of the pelvic parameters between subjects with isthmic spondylolisthesis and normal subjects, the SS, PT and PI in the spondylolisthesis group were significantly higher than those values in the normal group. This is similar to the findings of Rajnics et al.<sup>14</sup> In study of Oh et al. statistically significant difference was found in PT and PI in between the two groups while such difference was not found in SS.<sup>7</sup>

In a study done by Hanson et al., which measured PI in patients with mild isthmic spondylolisthesis (Meyerding Newman Grade 1 and 2), high grade spondylolisthesis (Meyerding-Newman Grade 3 and 4), and in normal children and adults, it was found that PI of the high grade spondylolisthesis was greatest, PI of mild spondylolisthesis was second greatest followed by that of adult group and then by the children’s group.<sup>15</sup>

Labelle et al. measured pelvic parameters in patients with L5 spondylolisthesis, which were grouped into 5 groups by Meyerding’s classification, along with control group of normal subjects.<sup>5</sup> They found PI, SS, PT and LL were higher in the isthmic spondylolisthesis and also that as the degree of spondylolisthesis increased, the LL, PI and PT increased as well. This is in accordance with our study where PI, SS, PT and LL are higher in isthmic spondylolisthesis. The studies by Oh et al., Rajnics et al. and Hanson et al. also reported a correlation between the slip percentage and the PI according to the Meyerding grade.<sup>7,14,15</sup> In our study, we analyzed the correlations of PI with the grades of spondylolisthesis in 68 spondylolisthesis subjects by chi-square test and found that the PI increased with increasing grades of spondylolisthesis, and the difference in PI in different grades of spondylolisthesis was statistically significant.

High PI will necessarily predispose to a high SS and PT as PI is the arithmetic summation of SS and PT. High SS, in turn, predisposes to a high LL in an attempt of the trunk to compensate and maintain the trunk centered over the femoral heads. We thus believe that this higher than

normal LL associated with spondylolisthesis is secondary to the high PI and is an important factor causing high shear stresses at the pars interarticularis, causing progression of spondylolisthesis.

There were some limitations in our study. The duration of study was short and it was a non-randomised study. The comparison was with individuals without spondylolysis as controls; the study with non-progressed spondylolysis patients as control would be a better one to see the progression of spondylolisthesis based on pelvic

parameters. The study with age and gender matched control would also be a better one.

## CONCLUSION

Pelvic incidence (PI) was found higher in patients with IS than in patient without Spondylolisthesis. This shows high pelvic incidence (PI) can be related with development of IS. Individuals with high PI has high risk of developing higher grade IS.

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