Original Article

Spinopelvic parameters in patients with lumbar degenerative disc disease, spondylolisthesis, and failed back syndrome: Comparison vis-à-vis normal asymptomatic population and treatment implications

ABSTRACT

Background: Most of the literature on role of spinopelvic parameters in various lumbar spine pathologies has been based on studies done on Caucasian population.

Aims and Objectives: The present study attempts to establish a database of measurements of the sagittal profile of spine in asymptomatic Indian population and their comparison with subjects having various lumbar spine pathologies.

Materials and Methods: We performed a prospective case control study at All India Institute of Medical Sciences, New Delhi in which we enrolled 109 patients and 22 healthy asymptomatic subjects in 2 years from 2015 to 2017. All patients underwent standing lateral radiographs of the pelvis and the entire spine and various spino-pelvic parameters were measured using Surgimap software.

Results: The mean Pelvic incidence (PI) in the asymptomatic individuals was 49.29 ± 5.95 which was significantly lower when compared with patients of chronic low backache (53.96 ± 9.47, *P*-<0.001), lumbar listhesis (59.4 ± 21.33, *P*-<0.001) and failed back surgery syndrome (56.7 ± 8.21, *P*-<0.001). The mean Pelvic Tilt (PT) in healthy subjects was 14.3±4.08 which was significantly lower when compared with patients of lumbar listhesis (23.35 ± 14.03, *P*-<0.001) and failed back surgery syndrome (22.8 ± 8.09, *P*-<0.001). Sacral slope (SS) and sagittal vertical axis (SVA) offset did not show any statistically significant difference. The mean Lumbar lordosis (LL) measured in healthy individuals was 42.5 ± 7.89 which was significantly lower when compared with patients of lumbar listhesis (46.24 ± 19.24, *P*-0.04) and failed back surgery syndrome (45.12 ± 6.87, *P*-0.05).

Conclusion: PT and PI showed statistically significant difference in subjects having lumbar spondylolisthesis and failed back surgery syndrome as compared to healthy asymptomatic subjects.

Keywords: Failed back syndrome, lumbar degenerative disc disease, lumbar spine disorders, lumbar spondylolisthesis, pelvic incidence, pelvic tilt, spinopelvic parameters

INTRODUCTION

There has been an increased emphasis in the recent years, on the preservation and restoration of sagittal alignment of the spine in patients with chronic low backache and lumbar degenerative diseases (LDD) and in those patients who have not improved following spinal surgical procedures for these problems. The preservation of a normal sagittal balance of the spine has been reported to prevent the development of recurrent symptoms in the postoperative period.[1]

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The ignorance about the sagittal profile of the spine could potentially lead to inferior clinical results in treatment, and hence, it should always be assessed.[2] The only way to have a clearer understanding is for study groups to work together and standardize terminology and for more studies to emerge evaluating spinal problems and pathologies taking into consideration the global sagittal profile of the human body. Besides, all the previous studies have been from the Western world, and there has been no attempt to study normal sagittal profiles in the Indian population and the impact of such concept on the treatment of various spinal problems. The present study is such an attempt to contribute to the already existing sparse literature on this subject and to establish a database of normal ideal measures of the sagittal profile of the spine in the Indian population. The study further intends to study these parameters in patients suffering from various spinal disorders such as chronic low backache and LDD.

MATERIALS AND METHODS

Study design and population

We performed a prospective case–control study at the All India Institute of Medical Sciences, New Delhi, in which we enrolled 109 patients in 2 years from 2015 to 2017. We also recruited 22 healthy asymptomatic controls over the same duration.

Patient inclusion criteria

- Patients' age 18–45 years
- Patients with chronic low backache and lumbar degenerative disorders at L4, L5, and L5S1 levels (L4-5/L5-S1 disc degeneration, herniation, and L4-5/L5-S1 spondylolisthesis)
- Patients who have been operated for the above-mentioned pathology and are in the category of failed back syndrome, either because of persistent pain or requiring revision surgery or removal of the implant.

Patient exclusion criteria

- Patients with any other spinal pathology other than the above-mentioned (e.g.- spinal tuberculosis, spinal cancer, etc)
- Patients unwilling to give consent
- Patients operated previously for any other spinal pathology.

The study was approved by the Institutional Ethics Committee. After obtaining a proper written informed consent, these participants were examined clinically by two independent spine surgeons and underwent radiographic examination to establish the normal values.

Radiographic evaluation

X-rays were done in the Department of Radiology, AIIMS, New Delhi. In all these participants, left-to-right standing 36″ lateral radiographs of the pelvis and the entire spine were taken by the same radiographer using the same X-ray machine and with a fixed cassette to X-ray source distance of 185 cm.

Measured variables

The measured variables were divided into two groups: pelvic and spinal parameters. The assessed landmarks were the superior endplates of T1, L1, S1, center of C7 body, anterosuperior plate of T1, L1, and anteroinferior plate of T12, L5, center of the sacral plate, and center of femoral heads. If both femoral heads are seen separately, the midpoint of the connecting line was selected. The spinal parameters were measured: (i) thoracic kyphosis (T1–T12) and (ii) lumbar lordosis (L1–L5). The pelvic parameters were measured: (i) pelvic tilt (PT), (ii) pelvic incidence (PI), (iii) sacral slope (SS), and (iv) sagittal vertical axis (SVA) offset. Pelvic, lumbar, and thoracic tilts were assumed positive if directed forward and negative if directed backward.

After scanning the lateral radiographs, Surgimap spine software (Nemaris Inc, New York, NY, USA) was used to analyze all the above-mentioned independent variables. The Surgimap Spine is a free computer program (http://www.surgimap.com; Nemaris Inc., New York, NY, USA) that integrates the spine-related measurements and tools for surgical planning in combination with knowledge gained from the published literature. After importing preoperative digital radiographs into a Surgimap Spine customizable database, realignment planning was executed. The software program calculates angles in degrees. The measurement of spinopelvic parameters using Surgimap is illustrated in Figure 1.

Statistical analysis

Statistical analysis was carried out using STATA software (version 11.0; StataCorp., College Station, TX). Data were

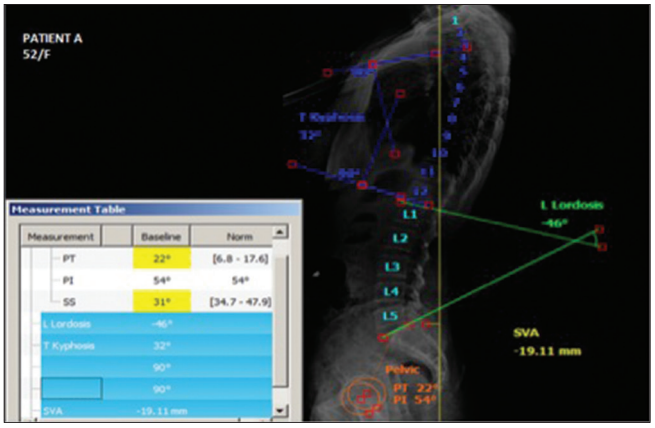

Figure 1: Measurement of spinopelvic parameters using Surgimap

presented as number (percentage) and mean ± standard deviation. The comparative data analysis of all the groups was performed using the one-way ANOVA/Kruskal–Wallis test. The repeated-measures ANOVA test was applied to ascertain changes within the group in each group. The overall difference between the groups was assessed using a generalized estimating equation. Statistical significance was accepted at $P \leq 0.05$.

RESULTS

One-hundred and thirty-one participants have been recruited for 2 years.

i. Healthy asymptomatic controls: 22 (16.8%)
ii. Patients with chronic low backache: 30 (22.9%)
iii. Patients with lumbar degenerative disc disease (LDD): 49 (37.4%)
iv. Patients with lumbar listhesis: 20 (15.3%)
v. Patients with failed back syndrome after lumbar spinal surgery for the herniated lumbar disc: 10 (7.6%).

The baseline characteristics of the patients study are summarized in Table 1.

Pelvic parameters

The mean PI in the asymptomatic individuals was 49.29° ± 5.95°, which was significantly lower when compared with patients of chronic low backache (53.96° ± 9.47°, $P < 0.001$), lumbar listhesis (59.4° ± 21.33°, $P < 0.001$), and failed back surgery syndrome (56.7° ± 8.21°, $P < 0.001$). The mean PT in healthy controls was 14.3° ± 4.08°, which was significantly lower when compared with patients of lumbar listhesis (23.35° ± 14.03°, $P < 0.001$) and failed back surgery syndrome (22.8° ± 8.09°, $P < 0.001$), whereas SS and SVA offset did not show any statistically significant difference. The comparison of pelvic parameters among different groups is described in Table 2.

Spinal parameters

The mean thoracic kyphosis in asymptomatic individuals was 40.95° ± 8.03° and did not show a statistically significant difference when compared with the other four groups. The mean lumbar lordosis measured in healthy individuals was 42.5° ± 7.89°, which was significantly lower when compared with patients having lumbar listhesis (46.24° ± 19.24°, $P = 0.04$) and failed back surgery syndrome (45.12° ± 6.87°, $P = 0.05$). The spinal parameters among different groups are compared in Table 3.

DISCUSSION

To the author's knowledge, this is the first study to calculate spinopelvic parameters and their association in different types of degenerative spine diseases in the Indian population. Preoperative assessment of spinopelvic parameters should be considered for surgical planning or for

Table 1: The baseline characteristics of all the five groups

	Healthy asymptomatic (*n*=22)	Chronic low backache (*n*=30)	Lumbar disc degenerative disease (*n*=49)	Lumbar listhesis (*n*=20)	Failed back syndrome after lumbar spinal surgery for the herniated lumbar disc (*n*=10)
Percentage	16.8	22.9	37.4	15.3	7.6
Age (mean±SD)	28.8±4.83	39.6±13.8	42.9±13.3	47.8±13.8	45.8±8.4
Sex (male:female)	68:32	43:57	75:25	35:65	50:50

SD - Standard deviation

Table 2: Comparison of pelvic parameters between all the five groups

Pelvic parameters	Healthy asymptomatic (*n*=22)	Chronic low backache (*n*=30)	Lumbar disc degenerative disease (*n*=49)	Lumbar listhesis (*n*=20)	Failed back syndrome after lumbar spinal surgery for the herniated lumbar disc (*n*=10)	*P*
Pelvic tilt	14.3±4.08	15.63±7.51	15.87±11.21	23.35±14.03	22.8±8.09	0.11[@] 0.102[#] <0.001[$] <0.001*
Pelvic incidence	49.29±5.95	53.96±9.47	48.42±16.31	59.4±21.33	56.7±8.21	<0.001[@] 0.107[#] 0.005[$] <0.001*
Sacral slope	36.72±3.81	37.56±9.73	34.51±10.56	36.6±13.31	34.31±5.53	0.167[@] 0.858[#] 0.57[$] 0.812*

Values are expressed as mean±SD. [@]Healthy asymptomatic versus chronic low backache; [#]Healthy asymptomatic versus lumbar disc degenerative disease; [$]Healthy asymptomatic versus lumbar listhesis; *Healthy asymptomatic versus failed back syndrome after lumbar spinal surgery for the herniated lumbar disc. SD - Standard deviation

Table 3: Comparison of spinal parameters between all the five groups

Spinal parameters	Healthy asymptomatic (*n*=22)	Chronic low backache (*n*=30)	Lumbar disc degenerative disease (*n*=49)	Lumbar listhesis (*n*=20)	Failed back syndrome after lumbar spinal surgery for the herniated lumbar disc (*n*=10)	*P*
Thoracic kyphosis	40.95±8.03	46.83±13.59	46.02±11.57	41.87±14.59	44.8±6.14	0.067[@] 0.077[#] 0.841[$] 0.083*
Lumbar lordosis	42.5±7.89	44.06±13.94	41.63±14.45	46.24±19.34	45.12±6.87	0.08[@] 0.09[#] 0.044[$] 0.05*

Values are expressed as mean±SD. [@]Healthy asymptomatic versus chronic low backache; [#]Healthy asymptomatic versus lumbar disc degenerative disease; [$]Healthy asymptomatic versus lumbar listhesis; *Healthy asymptomatic versus failed back syndrome after lumbar spinal surgery for the herniated lumbar disc. SD - Standard deviation

Table 4: Previous studies showing values of pelvic parameters in the asymptomatic healthy Indian population

Study	Pelvic tilt	Pelvic incidence	Sacral slope
Sudhir *et al*.[5], 2015 (*n*=101)	17.97±7.167	55.48±5.31	35.99±7.53
Siddiqui *et al*.[6], 2015 (*n*=84)	13.9±5.8	49.04±7.6	37.4±6.6
Present study (*n*=22)	14.3±4.08	49.29±5.95	36.72±3.81

restoring sagittal balance after surgery to improve the clinical outcome.[1] Glassman *et al*.[2] demonstrated the importance of calculating parameters of sagittal balance both in the evaluation of patients with complaints of backache and for the outcome of surgical treatment. Spinopelvic parameters help in understanding the transmission of biomechanical stress across the lumbosacral junction and thus provide insight into the pathophysiological basis of lumbar spinal disorders.[3] These parameters have been described in detail for the Caucasian population,[1,3,4] but the current literature on the Indian population is sparse.[5,6] This is the first study attempting to quantitatively define spinopelvic parameters and sagittal alignment in the Indian population with lumbar spine disorders in comparison to healthy asymptomatic controls.

Our results showed that among the pelvic parameters, PI showed a statistically significant difference in the lumbar spondylolisthesis and failed back surgery syndrome patients as compared to a healthy asymptomatic group, whereas SS and SVA offset did not show any statistically significant difference. These results were comparable to the study conducted by Barrey *et al*.[4] Lim and Kim[7] also reported that PI is based on the morphology of the pelvis, and they found significant differences in PI between lumbar spondylolisthesis and lumbar spinal stenosis. They reported that the PI in patients with lumbar spondylolisthesis was significantly greater than that of lumbar spinal stenosis and asymptomatic participants in concordance with our study. In addition to PI, PT also showed a significant difference between the asymptomatic and in patients with lumbar spine disorders. The PI initially described by Duval-Beaupère *et al*.[8] is the important determinant of sagittal spine balance in an individual. It is an important anatomical parameter that reflects the configuration of the pelvis and greatly influences the sagittal balance of the whole spine.[9] Oh *et al*.[10] demonstrated the spinopelvic parameters in the Korean population which showed that PI is positively correlated with SS and PT and in patients with large PI, PT, and SS are also high in concordance to the present study. The role of PI in the sagittal spine balance has been well established with PI being higher in lumbar spondylolisthesis patients, and high PI is associated with poor clinical outcome following surgery.[11-13]

In the Indian population, very few studies in the literature described the spinopelvic parameters, but none of the studies focused on the spinopelvic parameters among different diseases of the lumbar spine.

The pelvic parameters of the healthy asymptomatic controls have been compared with the previous two studies[5,6] published on pelvic parameters in the asymptomatic Indian population, as shown in Table 4.

There are a few limitations of the present study. This study gives preoperative assessment of spinopelvic parameters only, and further large prospective studies are needed to show the impact of these preoperative parameters on the outcome following surgery and impact on the quality of life following surgery. This will help us identify the predictors of poor outcome following lumbar decompression and or fusion.

CONCLUSION

The ignorance about the sagittal plane of the spine could potentially lead to inferior clinical results in treatment, and hence, it should always be assessed. This is the first study attempting to quantitatively define spinopelvic parameters and sagittal alignment in the Indian population with lumbar

spine disorders in comparison to healthy asymptomatic controls. PT and PI showed a statistically significant difference in participants having lumbar spondylolisthesis and failed back surgery syndrome as compared to healthy asymptomatic controls.

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Conflicts of interest

There are no conflicts of interest.

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