Original Research Article

Effect of sagittal imbalance on functional disability in patients with degenerative spondylolisthesis

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ABSTRACT

Background: Deformity of spine in sagittal plane is a major cause of pain and disability among patients presenting with low back pain to spine clinic. We have studied the effect of spinal sagittal imbalance on functional disability in these patients.

Methods: Cross sectional observational study in 50 patients with degenerative spondylolisthesis of more than 45 years age group study done in period of 1 years. Subjects underwent standing lateral radiographs of the spine in a relaxed position, facing forward, with their knees maximally extended and their arms raised horizontally forward resting on a support. 2 radiographic films are stitched at baseline using digital radiograph operating console (DROC) software.

Results: In our study out of 50 patients we observed female preponderance, female:male 3:1, degenerative spondylolisthesis more commonly involves L4-L5 level (46 patients). 58% of patients with severe degenerative spondylolisthesis. There is significant correlation between sagittal vertical axis (SVA) and severity ($p=0.015$) in both grade 1 and grade 2 DS, there is significant correlation between PI and functional disability ($p=0.001$ and 0.010 respectively) it is found that pelvic tilt with $p=0.02$ and sagittal vertical axis with p value 0.036 are the two most significant variables at the end of backward elimination analysis.

Conclusions: Sagittal imbalance is seen in degenerative spondylolisthesis which needs further evaluation with spinopelvic parameters. Pelvic incidence and sagittal vertebral axis are important determinants of functional disability in patients with degenerative spondylolisthesis. Individuals with high pelvic incidence and more lumbo pelvic kyphosis showed more functional disability compared to others.

Keywords: Spondylolisthesis, Sagittal imbalance, Lumbar lordosis

INTRODUCTION

Deformity of the spine in sagittal plane is nowadays being a major cause of pain and disability among patients presenting to spine clinic. Normal sagittal spinal balance is a result of mutual articulation of the spine in sagittal plane and the pelvis.¹

Spinal sagittal imbalance is mainly related to any underlying pathology causing variations in lumbar lordosis and thoracic kyphosis such as osteoporosis, tumour, trauma or infection and degenerative spondylolisthesis. Secondary causes include iatrogenic flat back syndrome following spinal fusion surgery.²

Degenerative spondylolisthesis is the one of the common type of spondylolisthesis. Defined as slipping of one vertebra over another due to degenerative changes in the disc and facet joints leading to longstanding intersegmental instability and further causing spondylolisthesis. Seen more in females with a ratio of M:F as 1:6.4. Here there is absence of pars interarticularis defect with an intact neural arch hence even a minimum progression in slip can result in various symptoms like radiculopathy leading to functional disability. Hamstring contracture disturbed gait, and rarely cauda equina syndrome.

The roentgenograms are still used as initial form of imaging for evaluation of patients with spondylolisthesis. In all suspected cases of spondylolisthesis lateral radiographs of whole spine should be taken in standing position facing forward with their knees maximally extended and their arms raised horizontally forward resting on a support to look for sagittal alignment of spine.^{3,4}

Sagittal alignment when within normal limits, allows balanced posture, minimum energy expenditure and appropriate tension on perispinal ligaments. Variations in the spinal sagittal alignment can be compensated by compensatory mechanisms occurring in the spine; pelvis and lower limb areas.⁴

Recent studies have shown sagittal imbalance to be the most important and reliable radiographic predictor of functional disability in a patient presenting with spinal deformity. There was clear evidence of decreased function as the magnitude of positive sagittal balance increased. Functional disability is studied using Oswestry Disability Index.⁵ We studied to find out whether sagittal imbalance is seen in patients with degenerative spondylolisthesis and of evaluate the effect of sagittal imbalance over functional disability in patients with degenerative spondylolisthesis.

METHODS

It was an observational study done in 50 patients above 45 years of age with lower back pain attending OPD. Purposive sampling techniques were done for period of one year from Jan 2017 to December 2017. Patients above 45 yrs of age with degenerative spondylolisthesis, single level involvement, with or without neurological deficits were included in the study. Those patients with isthmus / lytic spondylolisthesis, degenerative scoliosis, specific spine diseases like tuberculosis tumors, traumatic fractures were excluded. Document regarding the study was given to each of the candidate in advance and explaining the purpose of this study, as well as the risk of radiological exposure was explained. All subjects were informed that data obtained in the study from the case would be submitted for publication, and consent was taken.

Clinical examination of spine, hip and knee along with horizontal and downward gaze. Spine specific functional assessment scoring is done using:

Oswestry disability index score

Radiological evaluation was done. All patients will be undergoing a lateral radiograph of the spine in standing position, facing forward, with knees in maximal extension and arms raised horizontally forward resting on a support. Two X-rays will be stitched at baseline using digital radiograph operating console (DROC) software. The spino-pelvic angles such as pelvic incidence, pelvic tilt, sacral slope, c7 plumb line, sagittal vertical axis, thoracic kyphosis, lumbar lordosis.

SPSS (version 22) software was used for data recording and analysis of results.

RESULTS

A cross sectional observational study with 50 patients with degenerative spondylolisthesis is undertaken to evaluate the spino-pelvic parameters in degenerative spondylolisthesis and to study the effect of sagittal imbalance over functional disability in this group of patients (Table 1).

Table 1: Demographic details in study.

Demographic data	Number of patients	%
Age group in years		
45-50	17	34
51-60	23	46
>60	10	20
Sex distribution		
Males	13	26
Females	37	74
Spinal level involved		
L5-S1	4	8
L4-L5	46	92
Grading of degenerative spondylolisthesis		
Grade-1	32	64
Grade-2	18	36

Majority of patients belonged to the age group 51-60 yrs (46%). 37 out of 50 (74%) were female patients. Female preponderance is seen in these patients with degenerative spondylolisthesis. In most of the patients lesion was seen at L4-L5 level (92%). 64% of patients had Grade 1 slippage (according at Meyerding classification).

According to Oswestry Disability index scoring system, 58% (29 out of 50) of patients presented with severe functional disability (Figure 1).

Radiculopathy was seen in 22 patients (44%). 14 patients out of 50 had motor deficits like extensor hallucis longus weakness, weakness in ankle dorsiflexor, with grade 4/5

power and none of them had less than grade 3/5 (Table 2).

Figure 1: Functional disability score using Oswestry disability index.

Pelvic incidence of >60 was seen in 54% (27 out of 50) of patients with degenerative spondylolisthesis (Figure 2).

Figure 2: Pelvic incidence in study.

Table 2: Radiculopathy and motor deficit in study.

	Frequency	%
Radiculopathy		
No	28	56
Yes	22	44
Total	50	100
Motor deficit		
Absent	36	72.0
Present	14	28.0
Total	50	100.0

Figure 3: Sagittal vertical axis in patients.

Table 3: Correlation between pelvic incidence and sagittal vertical axis and ODI score.

Variables		ODI		
		Moderate	Severe	Total
PI	45-60	17	6	23
		73.90%	26.10%	100%
		81%	20.70%	46%
	>60	4	23	27
		14.80%	85.20%	100%
		19%	79.30%	54%
Total		21	29.%	50%
		42%	58%	100%
		100%	100%	100%
SVA	Backward	6	8	14
		42.90%	57.10%	100%
		28.90%	27.60%	28%
	Neutral	9	5	14
		64.30%	35.70%	100%
		42.90%	17.20%	28%
	Forward	6	16	22
		27.30%	72.70%	100%
		28.90%	55.20%	44%
Total		21	29	50
		42%	58%	100%
		100%	100%	100%

Table 4: Correlation between functional disability and spino-pelvic parameters.

	ODI	N	Median	IQR	Mann Whitney value	P value
Pelvic parameter						
Pelvic incidence	Moderate	21	52.00	48.50, 56.50	4.4	0.000 (HS)
	Severe	29	66.00	61.50, 71.50		
Pelvic tilt	Moderate	21	16.00	8.00, 20.50	3.54	0.000 (HS)
	Severe	29	23.00	18.50, 26.00		
Sacral slope	Moderate	21	39.00	35.50, 43.00	1.5	0.134 (NS)
	Severe	29	43.00	37.00, 50.50		
Spinal parameters						
Thoracic kyphosis	Moderate	21	27.00	17.50, 31.50	0.99	0.320 (NS)
	Severe	29	24.00	19.00, 30.00		
Lumbar lordosis	Moderate	21	-56.00	-60.00, -45.5	1.18	0.238 (NS)
	Severe	29	-56.00	-67.5, -48.0		
Global parameters						
Sagittal vertical axis	Moderate	21	35.05	11.95, 40.10	2.43	0.015 (Sig)
	Severe	29	43.90	28.45, 68.33		

Table 5: Correlation between pelvic incidence and ODI in various grades of degenerative spondylolisthesis.

Grade	ODI	N	PI median	PI-IQR	PI mean	P value
Grade 1	Moderate	16	50.50	48, 55.75	53.25	0.001
	Severe	16	63.00	56.50, 72.75	64.50	
Grade 2	Moderate	3	56.00	52, 61	56.40	0.010
	Severe	15	68.00	64.50, 71	67.62	

Anterior translation of C7 plumb line was seen in 22 out of 50 (44%) patients.

In the group with pelvic incidence above 60, 79.3% (23 out of 27) of patients had severe functional disability compared to the group with PI between 45-60 where in 26.1% (6 out of 23) of patients were in the severe group.

Shift in sagittal vertical axis (SVA) (anterior translation or posterior translation) was seen in 24 out of 29 patients (82.75%) with severe disability and in 12 out of 21 patients (57.14%) in moderate disability group. 22 out of 50 (44%) patients had forward shift in SVA and 14 out of 50 (28%) patients had backward shift (Figure 3, Table 3).

In the group with anterior translation of C7 plumb line (forward SVA) 72.7% of patients (16 out of 22) had severe disability compared to 57.1% of patients (8 out of 14) with posterior translation of C7 plumb line (backward SVA)

There is highly significant correlation between pelvic incidence and severity with p value 0.000 which is less than 0.05. And also highly significant correlation is seen between pelvic tilt and severity with p value 0.000 which is less than 0.05. However there is no correlation between sacral slope and severity with p value 0.134. There is no correlation between spinal parameters such as thoracic kyphosis and lumbar lordosis with severity with p value 0.320 and 0.238 respectively. There is significant

correlation between sagittal vertical axis and severity with p value 0.015 which is less than 0.05 (Table 4).

In patients with both grade 1 and grade 2 degenerative spondylolisthesis there was significant correlation between functional disability and pelvic incidence with p value 0.001 and 0.010 respectively.

On further analysis to find the effect of individual variables in the presence of other variables over ODI, multivariate analysis using regression module (backward elimination) was done. Effect of all independent variables on functional disability was seen in the beginning. The non-significant variables were individually eliminated in stepwise manner. It was found that pelvic tilt with p value 0.02 and sagittal vertical axis with p value 0.036 were the two most significant variables at the end of backward elimination analysis (Table 5).

DISCUSSION

Sagittal imbalance of spine, deformity of spine in sagittal plane, is nowadays becoming a major cause of pain and disability among patients presenting to spine clinic. Degenerative spondylolisthesis is the one of the common type of spondylolisthesis. Results due to long standing intersegmental instability at the lumbar motion segment. Recent studies have shown sagittal imbalance to be the most important and reliable radiographic predictor of functional disability in a patient presenting with spinal

deformity. There was clear evidence of increased pain and decreased function as the magnitude of positive sagittal balance increased.⁴

We did a study at Menakshi Medical College, Kanchipuram, Chennai with 50 subjects to find out whether sagittal imbalance is seen in patients with degenerative spondylolisthesis and to evaluate the effect of sagittal imbalance over functional disability in this group of patients.

Degenerative spondylolisthesis is a condition of older people, mostly above 40 yrs. There is racial and sex difference in the incidence of Degenerative spondylolisthesis. It is approximately 4-5 times more common in females than in males.⁶ In our study, majority of patients about 46% were in the age group of 51 to 60 yrs and all are above 45 yrs of age with female preponderance 37 out of 50 patients (74%).

In the lumbar region of spine, the facet joints are inclined to a near vertical orientation and curvilinear. A more of this sagittal orientation might decrease the amount of anterior restraint. This lack of restraint will result in anterior slippage of the superior vertebra in the motion segment. L4-L5 motion segment is most commonly involved when compared to other lumbar motion segments. In our study, L4-L5 lumbar level is involved in 92% of patients and remaining 8% patients has listless at L5-S1 level.

Degenerative spondylolisthesis is a low grade spondylolisthesis with slip not more than 50%. In our study 64% of patients had grade 1 slip and 36% with grade 2. Functional disability in degenerative spondylolisthesis is measured using Oswestry disability index which is a questionnaire specific for back pain. In our study, 58% of the patients are having severe functional disability and 42% with moderate disability. Clinically only 14 out of 50 patients had motor deficits in the form EHL and ankle dorsiflexor weakness, all of them with grade 4/5 power.

Barrey et al in his study demonstrated that patients with degenerative spondylolisthesis have significantly greater PI (60°) when compared to normal adult. It is interesting to note that in our study too, Pelvic incidence of >60 was seen in 54% (27 out of 50) of patients with degenerative spondylolisthesis and the rest 46% of patients has pelvic incidence between 45-60.⁷

When correlated between pelvic incidence and ODI in this study, it was observed that In the group with pelvic incidence above 60, 79.3% (23 out of 27) of patients had severe functional disability compared to the group with PI between 45-60 where in 26.1% (6 out of 23) of patients were in the severe group.

Barrey et al in his study also observed the tendency to anterior sagittal unbalance in degenerative spondylolisthesis subjects. In this study 44% of the subjects (22

out of 50) have anterior translation of C7 plumb line. In these 22 subjects with anterior translation, 16 subjects have severe functional disability (72.7%). Posterior translation is seen in 28% of patients in which 8 patients having severe disability (57.1%).⁸ To study the effect of spino-pelvic parameters on functional disability, we correlated pelvic parameters, spinal parameters and sagittal vertical axis with Oswestry disability index respectively.

In our study, it was found that there is highly significant correlation between pelvic incidence and severity with p value 0.000 which is less than 0.05 and also highly significant correlation is seen between pelvic tilt and severity with p value 0.000 which is less than 0.05. However there is no correlation between sacral slope and severity with p value 0.134

It was also found that there is highly significant correlation between pelvic incidence and severity in both grade 1 and grade 2 of degenerative spondylolisthesis with p value 0.001 and 0.010 respectively.

Glassman et al conducted a study to correlate between sagittal spinal deformity and health status measures and found that there was high degree of correlation between sagittal vertical axis and poor health status scores, but there was no significant correlation between spinal parameters and any of the health status score.⁹ In our study we observed that there is significant correlation between sagittal vertical axis and severity with p value 0.015 which is less than 0.05 and no correlation between spinal parameters such as thoracic kyphosis and lumbar lordosis with severity with p value 0.320 and 0.238 respectively. To find the effect of individual variables in the presence of other variables over functional disability, multivariate analysis was done using backward elimination regression module and found that pelvic tilt with p value 0.02 and sagittal vertical axis with p value 0.036 were found to be most significant variables.

CONCLUSION

Sagittal imbalance is seen in degenerative spondylolisthesis which needs further evaluation with spinopelvic parameters. Pelvic incidence and sagittal vertebral axis are important determinants of functional disability in patients with degenerative spondylolisthesis. Individuals with high pelvic incidence and more lumbopelvic kyphosis showed more functional disability compared to others.

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