

VERTICALISATION OF THE SACRUM, PELVIC VERSION AND SACRO-PELVIC RELATIONSHIP IN SEVERE SPONDYLOLISTHESIS

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Objective: To study the changes in spatial orientation of the sacrum and pelvis in severe spondylolisthesis.

Study design: Analysis of standing lateral radiographs of the spine in patients with Grades III, IV and V spondylolisthesis. Measurements of angles subtended by (1) each sacral vertebra with the vertical, (2) the pelvic brim with the horizontal and (3) each sacral vertebra with the pelvic brim.

Results: The sacrum verticalises progressively with increasing severity of spondylolisthesis. However the pelvis becomes horizontal by only half the amount of verticalisation, through remodeling by the lateral sacral epiphyses and posterior widening of the upper two intersacral joints.

Conclusion: The study confirms our clinical suspicion that sacral verticalisation is not accompanied by an equal amount of pelvic retroversion. This fact has an important bearing on the technique of manipulative reduction of spondylolisthesis.

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The more severe grades, and certainly spondyloptosis are much less common than spondylolysis and the lower grades of spondylolisthesis. With increasing degree of slippage in lumbosacral spondylolisthesis, the body's centre of gravity becomes displaced anteriorly. To compensate for this displacement, the lumbar spine hyperextends and the upper part of the trunk is thrown backward. The end-results in spondyloptosis are a lumbar lordosis extending into the upper thoracic spine and verticalisation of the sacrum with a kyphosis at the lumbosacral junction¹.

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It is generally thought that as the sacrum verticalises, the pelvis must retrovert by rotation upward about its transverse axis¹. This notion stems from the fact that very little movement occurs at the sacro-iliac joints - the links between the sacrum and pelvis². Hence, both sacrum and pelvis must rotate in concert as one unit. Clinically the pubic tubercle would then protrude higher more anteriorly.

Clinical and surgical observations led us to believe that the degree of verticalisation of the sacrum seen in young patients with severe spondylolisthesis is not accompanied by a corresponding amount of pelvic

retroversion. We therefore set out to study the sacropelvic relationship and orientation of the pelvis in patients with severe spondylolisthesis. Knowledge of these would influence the techniques of reduction of spondylolisthesis.

METHODS

Plain standing radiographs of the spine of patients with Grades III, IV and V spondylolisthesis were obtained from the Children's Hospital of Buffalo, the Twin Cities Scoliosis Clinic, Minnesota and from the Hospital for Sick Children, Toronto. A control group of patients with no spondylolisthesis consisted of 15 adolescents who were referred to our scoliosis clinic from a screening programme and had curves of less than 10 degrees. All radiographs were taken with a plumbline in position.

The grade of spondylolisthesis was determined as described by Meyerding³. Thus there were 12 patients with Grade II, 8 with Grade IV and 17 with Grade V spondylolisthesis.

Radiographic measurements

The pelvic brim and sacro-iliac joints first need to be defined radiologically. Two parallel radio dense lines, crossing the radiological projection of the first sacral vertebra, are constantly seen on a lateral view of the lumbo-sacral spine (Fig 1). Their exact origins have recently been studied, and they have been named pelvic lines⁴. Each represents that part of the medial border of the ilium, which forms the anterosuperior boundary of the sacro-iliac joint, on either side. Each is continuous and collinear anteriorly with the arcuate line of the ilium and pectineal line of the pubis, which form part of the pelvic brim. Hence, anterior extrapolation of the pelvic lines on lateral radiographs will delineate the pelvic brim. The sacro-iliac joints are made up by the auricular surface of the iliac bone and the upper three sacral vertebrae⁵.

The sacral inclination of each of the upper three sacral vertebrae was obtained by measuring the angle subtended with the vertical by a line drawn along the middle of the vertebra. The angle made by the pelvic brim with the horizontal was then measured.

To determine the relationship between sacrum and pelvis, the angles subtended with either of the two pelvic lines by lines drawn along the posterior and anterior margins of the 1st, 2nd and 3rd sacral vertebrae were measured on the standing lateral radiographs of the spine. The angle subtended by each sacral vertebra with the pelvic lines (pelvi-sacral angle) was taken as the average of the angles formed by its anterior and posterior borders.

RESULTS

Table 1 lists the averages of angular measurements obtained in the control group and various grades of spondylolisthesis.

Table 1. Measurements in patients without spondylolisthesis

Case	Angle subtended with pelvic brim by			Pelvic brim with horizontal	Sacral inclination of		
	S1	S2	S3		S1	S2	S3
1	83	81	68	68	50	59	46
2	84	79	64	63	60	52	37

3	83	81	77	58	50	49	45
4	87	69	57	69	53	48	36
5	81	86	78	57	41	53	45
6	82	74	71	66	40	50	47
7	94	85	77	48	38	43	35
Average	84.9	79.3	70.3	61.28	47.4	50.6	41.6

Bradford¹ believes that the normal angle of inclination of the 1st sacral vertebra should be greater than 300. It averages 47.40 in our group of patients without spondylolisthesis. Figure 2 illustrates how each of the upper three sacral vertebrae verticalises with increasing grades of spondylolisthesis. The maximum degree of verticalisation of each segment was calculated as the difference in average inclination angles between the spondyloptosis and control groups. Maximum verticalisation takes place in spondyloptosis at the S3 level (average, 31.630).

The angle made by the pelvic brim with the horizontal is said to vary between 50 and 60 degrees⁵. It ranges from 480 to 680 in the present control group (average, 61.280). Figure 3 shows how this angle gradually diminishes with increasing severity of spondylolisthesis, decreasing by 17.580 in spondyloptosis.

Figure 4 demonstrates a decrease in the average angles subtended by each of the upper 3 sacral vertebrae with the pelvic lines, from normal through Grades III, IV and V spondylolisthesis. The maximum decreases occur in cases of spondyloptosis with a decrease of 9.80 at S1 level, 17.10 at S2 and 21.80 at S3. The average of these changes equals 16.23 degrees.

DISCUSSION

Analysis of standing lateral radiographs of the spine confirms that the sacrum verticalises with increasing degree of spondylolisthesis. Each of the upper 3 sacral vertebrae undergoes a different change in angle of inclination with the vertical, ranging from 210 to 390 in spondyloptosis (average, 31.630).

Because very little motion can take place at the sacro-iliac joint², the pelvic brim should move towards the horizontal by an amount equal to the degree of verticalisation. However, our measurements show that in Grade V spondylolisthesis, the angle made by the pelvic brim with the horizontal decreased on average, by only 17.580, corresponding to 55 % of the average sacral verticalisation.

The lesser than expected degree of pelvic retroversion is explained by the fact that the angle subtended by the upper 3 sacral vertebrae with the pelvic lines also diminished by an average of 16.230 in spondyloptosis. For such an alteration in sacro-pelvic relationship to occur, some form of flexibility must exist within the sacro-iliac joints. This is possible because the bodies of the sacral vertebrae do not unite to one another at their adjacent margins until the twentieth year of life, and the epiphyseal centres of the costal and transverse processes remain open till the twenty-fifth year⁵. Physeal remodeling takes place at the lateral sacral epiphyses, and movement at the intersacral joints (Figure 5).

CONCLUSION

In severe spondylolisthesis, the pelvis does not become horizontal by as much as the sacrum verticalises. This fact is important in the manipulative reduction of spondylolisthesis.

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