Acta Orthop Scand *56*, 253–255, 1985

The etiology of spondylolysis

A retrospective radiographic study

Helena Saraste

Department of Orthopedics, Karolinska Hospital, S-104 01 Stockholm, Sweden

One hundred and thirty-five patients with lysis in the fifth (lowest) lumbar vertebra and 24 patients with L4 lysis were compared retrospectively with respect to radiographic variables and the occurrence of trauma before symptom onset.

Hypoplasia occurred only in the L5 lysis group, whereas trauma as a symptom-precipitating factor was frequent in the L4 group. These observations suggest the possibility of different etiologies: trauma may contribute to lysis in a normal L4 vertebra, and inherited hypoplasia of the lumbosacral junction may lead to L5 lysis.

A number of theories have been advanced concerning the etiology and pathogenesis of spondylolysis, among them heredity and fatigue fracture (Batts 1939, Friberg 1939, Rowe & Roche 1953, Stewart 1953, Wiltse et al. 1975, Jackson et al. 1976, Haukipuro et al. 1978, Wynne-Davies & Scott 1979, Ichikawa et al. 1982). Hypoplastic dysplasia of the lumbosacral junction, as defined by Wiltse et al. (1976), is common in spondylolisthesis, and has been used in the classification of spondylolysis and olisthesis.

I have compared the lumbar spine radiographs of patients with L4 and L5 spondylolysis with respect to evidence of trauma and hypoplasia.

Patients and methods

Clinical reports and radiographic lumbar spine examinations at the time of diagnosis were studied in 159 patients with isthmic spondylolysis, seen at the Department of Orthopedics, Karolinska Hospital. The mean age of the patients was 24 (9–40) years. One hundred and thirty-five persons had their lysis in the fifth (lowest) lumbar vertebra, and 24 persons in the fourth.

The following radiographic variables from the time of diagnosis were studied (Saraste et al. 1984c).

Lumbosacral angle. The angle between the caudal border of the third lumbar vertebral body and the cranial border of the first sacral vertebral body.

Sacral inclination. The angle between the vertical plane and a line through the posterior border of the first sacral vertebral body.

Slipping angle. The angle between the caudal border of the fifth lumbar vertebral body and the cranial border of the first sacral vertebral body.

Lumbar index. For the evaluation of the degree of wedging of the spondylolytic vertebra, which is an expression of dysplasia, a lumbar index was calculated as the ratio (in percent) of its posterior and anterior heights.

The lengths of the transverse processes of the fifth, fourth, and third lumbar vertebrae, measured as the distance between the tips of the processes and the midline of the vertebral body. The length thus defined was divided by the width of the third lumbar vertebra to form a "relative length". This was done in order to minimize, in group comparisons, the distorting effect of variation in vertebral body size.

The lengths of the iliolumbar ligaments, measured as the shortest distance from the tips of the fifth lumbar transverse processes to the crista iliaca posterior, and analogously expressed as a "relative distance".

Disc degeneration, expressed as disc height reduction, at the lysis level. A semi-quantitative assessment of disk height was made with classification into four subgroups: Class 0, normal disc height; Class 1, disc height decreased by less than 50%; Class 2, disc height decreased by at least 50% but not completely eliminated; Class 3, disc completely eliminated.

Spondylolisthesis. Vertebral slipping was measured as the distance from the posterior caudal limit of the spondylolytic vertebra to a line through the posterior border of the vertebra below.

Age at diagnosis and at symptom onset, and occurrence of light or heavy trauma immediately prior to the onset of back pain were also studied.

From a follow-up examination of these patients 20–44 years after diagnosis, the following variables were studied: occurrence of disc degeneration at the lysis level, degree of vertebral slipping, and progression of slipping during the observation period.

Results

Lumbosacral angle, sacral inclination and slipping angle did not differ between the two groups (Table 1). The lumbar index was much lower in the L5 than in the L4 group.

The mean values of the relative lengths of transverse processes of the three lowest lumbar vertebrae were the same for both groups. The iliolumbar ligament was longer in the L5 than in the L4 group.

During the observation period, there was a considerably larger increase in disc height reduction in the L4 than in the L5 group. The frequency of severely reduced disk height at the lysis level increased from 20 to 70 per cent in the L4 group, and from 20 to 50 per cent in the L5 group. At the L3 reference level, the progression in disc height reduction was equal in the two groups.

The mean value in the L5 group of the degree of vertebral slipping at the time of diagnosis (8 mm) was twice that of the L4 group. At the follow-up examination there were no group mean differences in this variable. Thus, the L4 group showed more progression in slipping during the observation period than the L5 lysis group.

The mean age at symptom onset was the same in the two groups. The mean age at the time of diagnosis, however, was considerably higher in the L4 than in the L5 group (30 and 23 years). The sex distribution was the same in both groups.

Trauma preceded the onset of symptoms in 54 per cent in the L4 group and 22 per cent in the L5 group.

Table 1. Radiographic and clinical variables in spondylolysis

	L5[a] (n=135)	L4 (n=24)	p-value[b]
Radiographic variables			
Lumbosacral angle (degrees)	42±12	38±9	ns
Sacral inclination (degrees)	50±10	51±8	ns
Slipping angle (degrees)	3±5	5±6	ns
Lumbar index	74±8	89±8	<0.001
Relative length			
Transverse processes	1.3±0.1	1.3±0.1	ns
Iliolumbar ligaments	0.4±0.2	0.3±0.2	<0.05
Disk height reduction >50% at lysis level			
At diagnosis	20%	20%	ns
At follow-up	50%	70%	<0.01
Degree of slipping at diagnosis (mm)	8±8	4±4	<0.001
Progression of slipping during observation time (mm)	4±4	7±6	<0.001
Age at symptom onset	19±8	20±8	ns
Age at diagnosis	23±8	30±10	<0.001
Sex ratio (male/female)	1.3	1.3	ns
Frequency of trauma before symptom onset	22%	54%	p<0.01

[a] The fifth or the lowest lumbar vertebra.
[b] Chi-square or *t*-test, two-tailed probability.

Discussion

In this retrospective comparison between radiographs of persons with L5 and L4 lysis, the radiographic technique had been the same for all cases at both examination times. The errors involved in the measurement of the chosen variables have been studied earlier (Saraste 1984, Saraste et al. 1985). The studied variables, with the possible pathogenetic importance for the development of lysis and olisthesis, have been shown to be stable (Saraste et al. 1984b).

At the time of diagnosis, significant differences in group mean values of the studied variables were observed only for lumbar index and relative length of the iliolumbar ligament. The numerical differences in the last-mentioned variable, however, were small. When measurement inaccuracy is taken into account (Saraste et al. 1985), this difference has no clinical significance. Thus, in the radiographic variables studied here, the only relevant difference was a lower lumbar index in the L5 group, representing a more pronounced wedge form of the spondylolytic vertebra. The lumbar index

values of the L4 group were the same as those earlier presented for a control group from a normal population (Saraste et al. 1984a). Consequently, the hypoplastic form of lysis occurs only in the lowest lumbar vertebra, and other anatomical deviations do not correlate with the level affected by the lysis.

Trauma and fatigue fracture as possible causes of spondylolysis, irrespective of affected level, have been proposed by several authors (Wiltse et al. 1975, Jackson et al. 1976, Ichikawa et al. 1982). In the present work, trauma as a symptom-precipitating factor was much more common in the L4 than in the L5 group. These observations suggest the possibility of different etiologies: trauma contributing to lysis in a normal L4 vertebra, and inherited hypoplasia of the lumbosacral junction leading to L5 lysis.

In an earlier study, hypoplasia of the lumbosacral junction was found to be positively correlated with the degree of vertebral slipping at the time of diagnosis (Saraste et al. 1984b). The results of the present study also demonstrate that the L4 lysis group, which did not show hypoplasia of the posterior part of the spondylolytic vertebra, demonstrated a very small mean value of vertebral slipping at the time of diagnosis (Saraste 1984). The initially smaller olisthesis in the L4 level lysis group, however, progressed more during the observation time than did the slipping in the L5 lysis group. At the time of follow-up, severe disc height reduction at the lysis level was much more frequent in the L4 than in the L5 group. This seems to reflect the well-known circumstance that ageing processes are more pronounced – and disc height reduction is therefore greater – at the L4 than at the L5 level. The progression of olisthesis during the observation time in the L4 group can be considered as due to the disc degeneration. The possible clinical importance with respect to symptomatology of these findings should be studied.

References

Batts, M. Jr. (1939) The etiology of spondylolisthesis. *J. Bone Joint Surg.***21**, 879–884.

Friberg, S. (1939) Studies on spondylolisthesis. *Acta Chir. Scand.* Suppl. 55.

Haukipuro, K., Keränen, N., Koivisto, E., Lindholm, R., Norio, R. & Punto, L. (1978) Familial occurrence of lumbar spondylolysis and olisthesis. *Clin. Genet.* **13**, 471–476.

Ichikawa, N., Ohara, Y., Morishita, T., Taniguichi, Y., Koshikawa, A. & Matsukura, N. (1982) An etiological study on spondylolysis from a biomechanical aspect. *Br. J. Sports Med.* **16**, 135–145.

Jackson, D. W., Wiltse, L. L. & Cirincione, R. J. (1976) Spondylolysis in the female gymnast. *Clin. Orthop.* **117**, 68–73.

Rowe, G. G. & Roche, M. B. (1953) The etiology of separate neural arch. *J. Bone Joint Surg.***35-A**, 102–110.

Saraste, H. (1984) *Spondylolysis and spondylolisthesis. Clinical and radiographic relationships, and prognostic signs.* Thesis, The Karolinska Institute, Stockholm.

Saraste, H., Broström, L.-Å., Aparisi, T. & Axdorph, G. (1985) Radiographic measurement of the lumbar spine. – A clinical and experimental study in man. *Spine*, **10**, 236–241.

Saraste, H., Broström, L.-Å. & Aparisi, T. (1984a) Radiographic assessment of anatomical deviations in lumbar spondylolysis. *Acta Radiol. Diagn.* **25**, 317–323.

Saraste, H., Broström, L.-Å. & Aparisi, T. (1984b) Prognostic radiographic aspects of spondylolisthesis. *Acta Radiol. Diagn.* **25**, 427–432.

Stewart, T. D. (1953) Age incidence of neural arch defects in Alaskan natives, considered from the standpoint of etiology. *J. Bone Joint Surg.***35-A**, 937–950.

Wiltse, L. L., Widell, E. H. & Jackson, D. W. (1975) Fatigue fracture, the basic lesion in isthmic spondylolisthesis. *J. Bone Joint Surg.***57-A**, 17–22.

Wiltse, L. L., Newman, P. H. & MacNab, J. (1976) Classification of spondylolysis and spondylolisthesis. *Clin. Orthop.* **117**, 23–29.

Wynne-Davies, R. & Scott, J. H. S. (1979) Inheritance and spondylolisthesis. A radiographic family survey. *J. Bone Joint Surg.***61-B**, 301–305.