Delayed vertebral slip and adjacent disc degeneration with an isthmic defect of the fifth lumbar vertebra

Y. Ishida, K. Ohmori, H. Inoue, K. Suzuki

From the Nagoya Daini Red Cross Hospital, Nagoya, Japan

We reviewed the radiographs of 325 unselected patients with defects in the pars interarticularis of L5 to study whether the incidence of vertebral slip in spondylolysis of L5 remained unchanged after the age of 20 years. MRI was also carried out on 111 of the patients to investigate the relationship between the shape of the transverse process of L5 and the degeneration of the discs adjacent to this level.

The incidence of spondylolisthesis increased with age from 17% in the second decade to 51% in the sixth. The transverse process was significantly more slender in patients with less degeneration at L4/5 and advanced degeneration at L5/S1 than in patients with advanced degeneration at L4/5 and less degeneration at L5/S1. Vertebral slip secondary to an isthmic defect of L5 after the age of 20 years was confirmed and the adjacent disc degeneration was significantly related to the vertical thickness of the transverse process of L5.

Spondylolysis is an acquired defect of the pars interarticularis which occurs most commonly in the fifth lumbar vertebra. The lesion is never present at birth and is considered to develop before the end of adolescence. Although there are differences in athletic individuals and in certain racial groups, the incidence of spondylolysis is reported to be 4.4% at six years of age and to increase to 6% in the general population by skeletal maturity. Isthmic spondylolisthesis is the vertebral slip secondary to spondylolysis. It had been thought that the incidence of isthmic spondylolisthesis did not increase after the age of 20 years. Postacchini, however, described five patients with spondylolysis who developed spondylolisthesis as adults. Ohmori et al also reported patients with spondylolysis and spondylolisthesis of L5 showing a further progression of vertebral slip after long-term follow-up. There was a significant correlation between the vertical thickness of the transverse process of L5 and the ventral slip.

The aetiology of isthmic spondylolisthesis is not yet entirely clear. The torsional and shear forces on the lower lumbar levels were considered to be a probable cause of disc failure. The defect of the pars interarticularis is thought to increase rotational and sagittal loading on the subjacent disc. This may lead to degeneration and spondylolisthesis. Not all patients with spondylolysis, however, develop spondylolisthesis. It is common to see patients with spondylolysis of L5 who have a lesion of the disc at L4/5, although the L5/S1 disc is thought to be the one at risk of degeneration due to the decreased stability after disruption of the pars interarticularis.

Our aim was to investigate whether the incidence of a slip in spondylolysis of L5 remained unchanged after the age of 20 years, and also to study the relationship between the shape of the transverse process of L5 and the degeneration of the discs adjacent to it.

**Patients and Methods**

We reviewed the radiographs of all patients with a defect in the pars interarticularis of L5 who had been seen between 1989 and 1997. Plain radiographs of a quality compatible with accurate measurements were examined from 325 patients aged between 15 and 59 years, without any anomaly other than spina bifida occulta. There were 122 women and 203 men with a mean age of 35.6 years. There was no history of spinal trauma or back surgery. MRI of the lumbar spine had been performed with a 1.5 T scanner (SMT-150; Shimadzu, Kyoto, Japan) in 111 of the patients, 40 women and 71 men, with a mean age of 33.1 years.

On the lateral radiographs, the degree of slip was measured by the method recommended by Taillard. A slip of less than 5% was labelled as spondylolysis without slip. Spondylolisthesis was defined as a vertebral slip of greater than 10%, because of the uncertainty of diagnosis of a very
The incidence of spondylolisthesis among all patients with a defect in the pars interarticularis was examined for each decade.

On the anteroposterior radiographs of the L5 vertebra we measured the interpedicular distance (A), the length of the transverse process from the medial margin of the pedicle to the tip (B), and the vertical thickness of the transverse process at the junction of the middle and lateral thirds of measurement B (C) (Fig. 1). Relative thickness (RT) was determined as the mean of the right and left thickness (C/A × 100) (Reprinted with permission from Ohnori et al.12).

Table I. The number of patients and their mean (±SD) age related to percentage slip

<table>
<thead>
<tr>
<th>Number of patients (Female/male)</th>
<th>Age (yr)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spondyloysis without slip (&lt;5%)</td>
<td>196 (64/132) 32.3 ± 12.3</td>
</tr>
<tr>
<td>Spondyloysisis (&gt;10%)</td>
<td>104 (49/55) 41.3 ± 13.1</td>
</tr>
<tr>
<td>Very mild slip (5% to 10%)</td>
<td>25 (9/16) 37.9 ± 12.2</td>
</tr>
<tr>
<td>Total</td>
<td>325 (122/203) 35.6 ± 13.2</td>
</tr>
</tbody>
</table>

mild slip (5% to 10%). The incidence of spondylolisthesis among all patients with a defect in the pars interarticularis was examined for each decade.

On the anteroposterior radiographs of the L5 vertebra we measured the interpedicular distance (A), the length of the transverse process from the medial margin of the pedicle to the tip (B), and the vertical thickness of the transverse process at the junction of the middle and lateral thirds of measurement B (C)12 (Fig. 1). Relative thickness (RT) was determined as the mean of the right and left thickness (C/A × 100) of the transverse process.

The appearance of the lumbar disc on T2-weighted MR images was classified into four grades based on Buirski’s patterns.15 Grade 0 was defined as normal signal intensity and disc height without evidence of nuclear protrusion, grade 1 as slight reduction in signal intensity with a prominent, thickened intranuclear cleft, but without narrowing of the disc height, grade 2 as significant reduction in signal intensity associated with loss of disc height and grade 3 as marked loss of disc height with no signal intensity. In order to simplify the statistical analysis, these grades were further classified into two categories. A ‘slight degeneration’ group was formed from grades 0 and 1 and an ‘advanced degeneration’ group from grades 2 and 3.

We examined the relationship between disc degeneration and RT. The data were evaluated statistically by the Mann-Whitney U test, with the level of significance being set at p = 0.01.

Results

Of 325 patients 196 were judged as having spondylolysis without a slip. A slip greater than 10% was observed in 104. The remaining 25 patients had a very mild olisthesis of between 5% and 10% (Table I). The percentage slip for the patients with spondylolysisis ranged from 10.2% to 33.3%. The 325 patients were classified according to their age in decades. The number with spondylolysisis without slip and with spondylolysisis in each decade is shown in Table II. The incidence of spondylolisthesis increased with ageing from 17% in the second decade to 51% in the sixth decade.

The mean RT in spondylolysisis without slip was 63.0 ± 11.5 compared with 55.1 ± 10.7 in spondylolysisis alone (p < 0.001), indicating that the transverse process of L5 was significantly more slender in spondylolisthesis than in spondylolysisis without slip.

The number of patients with disc degeneration at L4/5 and L5/S1 is shown in Table III. In young patients, the degeneration was not severe at L5/S1 even with minor spondylolisthesis. In patients with spondylolysisis without slip, advanced degeneration was seen in 23 discs at L4/5 and 7 at L5/S1. Conversely, three discs at L4/5 and 28 at L5/S1 showed advanced degeneration in spondylolisthesis.

The relationship between disc degeneration and the shape of the transverse process of L5 was examined by comparing the RT for patients with advanced degeneration at L4/5 and slight degeneration at L5/S1 (Fig. 2), with that for patients with advanced degeneration at L5/S1 and slight degeneration at L4/5 (Fig. 3). Patients with slight degeneration at L4/5 and advanced degeneration at L5/S1 had a significantly smaller RT than those with advanced degeneration at L4/5 and slight degeneration at L5/S1 (p < 0.01) (Table III).

Table II. The number of cases of a defect in the pars interarticularis first seen in each decade and the percentage with spondylolisthesis, defined as more than 10% slip

<table>
<thead>
<tr>
<th>Age decade</th>
<th>Second</th>
<th>Third</th>
<th>Fourth</th>
<th>Fifth</th>
<th>Sixth</th>
</tr>
</thead>
<tbody>
<tr>
<td>Isthmic defect</td>
<td>41</td>
<td>88</td>
<td>59</td>
<td>74</td>
<td>63</td>
</tr>
<tr>
<td>Spondylolisthesis (%)</td>
<td>7 (17)</td>
<td>16 (18)</td>
<td>18 (31)</td>
<td>31 (42)</td>
<td>32 (51)</td>
</tr>
</tbody>
</table>
Discussion

It has been generally recognised that spondylolysis develops in childhood as a fatigue fracture, and that some patients may develop a vertebral slip up to the age of 20 years. After skeletal maturity, further slipping or a new slip was thought to be rare. The transverse process of L5 has the insertion of the iliolumbar ligaments which serve to stabilise the lumbosacral junction by controlling forward flexion. The iliolumbar ligaments undergo gradual fatty infiltration, myxoid deposition and hyalinisation from the fifth decade. We considered that the vertebral slip in patients with an isthmic defect may increase with ageing, and that the shape of the transverse process of L5 may affect the patterns of disc degeneration at the adjacent levels.

If new vertebral slips are as rare as has been reported, then the incidence of spondylolisthesis should be unchanged between the decades, but if they are as frequent as
suggested by Ohmori et al the incidence should increase with advanced age. Between 1989 and 1997, 325 of our patients aged between 15 and 59 had radiological evidence of an isthmic defect of L5, with or without a vertebral slip. They showed an increase in the incidence of vertebral slip with ageing. Since this supports the observation of Ohmori et al, we assume that the incidence of vertebral slip associated with spondylolysis increased with age.

MRI showed advanced degeneration of the overlying L4/5 disc more often in spondylolysis without slip and that of the underlying L5/S1 disc more often in spondylolysis of L5. It was clear that spondylolysis of L5 involved advanced degeneration of the L5/S1 disc. A disc lesion at L4/5 was frequently seen in cases of spondylolysis of L5 without slip, although the L5/S1 disc was thought to be more susceptible to degeneration due to the bony defect of the neural arch of L5. Thus, there must be some factors which influence the level of disc degeneration in spondylolysis without slip and spondylolisthesis. Ohmori et al reported that the RT of the transverse process of L5 was closely related to the vertebral slip in lumbar spondylolysis and spondylolisthesis. In our patients, the RT was also significantly less in spondylolysis than in spondylolisthesis of L5 without slip. A reduced thickness was considered to represent functional insufficiency of the iliolumbar ligament. This may be accelerated by degeneration with ageing and result in degeneration of the subjacent L5/S1 disc and vertebral slip of L5.

To clarify the relationship between the RT of the transverse process of L5 and disc degeneration, we studied disc degeneration and RT of the transverse process of L5 in patients with advanced disc degeneration at either L4/5 or L5/S1. The results showed that the greater RT of the transverse process of L5 was related to disc degeneration at L4/5, and that the smaller RT of the transverse process of L5 tended to cause disc degeneration at L5/S1. It seems that because of the greater RT, the L5/S1 disc was supported by the iliolumbar ligaments, even when there was an isthmic defect of L5. This greater stability of the lumbo-sacral junction may lead to a stress concentration on the L4/5 disc and to its degeneration. This accounts for some patients with spondylolysis without olisthesis having a disc lesion at L4/5, and others the vertebral slip at L5/S1. The patients with smaller RT were considered to have less stability at the lumbosacral junction due to the functional insufficiency of the iliolumbar ligaments in combination with a defect in the pars interarticularis, and functional deterioration of these ligaments with ageing. This may initiate degeneration of the L5/S1 disc and result in a vertebral slip. We believe that new slips secondary to the isthmic defect of L5 may occur after the age of 20 years and have termed this condition ‘delayed isthmic spondylolysis’.

Table III. Number of patients, their age and RT of the transverse process of L5 classified by disc degeneration at L4/5 and L5/S1 on MRI

<table>
<thead>
<tr>
<th>Grade of disc degeneration</th>
<th>L4/5; slight</th>
<th>Slight</th>
<th>Advanced</th>
<th>Advanced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spondylolysis without slip (&lt;5%)</td>
<td>41</td>
<td>5</td>
<td>21</td>
<td>2</td>
</tr>
<tr>
<td>Spondylolisthesis (&gt;10%)</td>
<td>5</td>
<td>25</td>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>Very mild slip (5% to 10%)</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>Total</td>
<td>49</td>
<td>32</td>
<td>23</td>
<td>7</td>
</tr>
<tr>
<td>Mean ± SD age (yr)</td>
<td>28.1 ± 11.8</td>
<td>40.4 ± 12.2</td>
<td>33.4 ± 12.3</td>
<td>33.6 ± 14.7</td>
</tr>
<tr>
<td>Mean ± SD RT (%)</td>
<td>59.9 ± 12.0</td>
<td>57.5 ± 10.5*</td>
<td>65.7 ± 11.4*</td>
<td>60.8 ± 12.4</td>
</tr>
</tbody>
</table>

* p < 0.01

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

References


