Prevalence of lumbar spondylolysis and spondylolisthesis in patients with degenerative spinal disease

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Lumbar spondylolysis generally occurs in adolescent athletes. Bony union can be expected with conservative treatment, however, the fracture does not heal in some cases. When the fracture becomes a pseudoarthrosis, spondylolysis patients have the potential to develop isthmic spondylolisthesis. A cross-sectional study was performed to determine the incidence of spondylolysis and spondylolisthesis, and to elucidate when and how often spondylolisthesis occurs in patients with or without spondylolysis. Patients undergoing computed tomography (CT) scans of abdominal or lumbar regions for reasons other than low back pain were included (n = 580). Reconstruction CT images were obtained, and the prevalence of spondylolysis and spondylolisthesis were evaluated. Of the 580 patients, 37 patients (6.4%) had spondylolysis. Of these 37 patients, 19 patients (51.4%) showed spondylolisthesis, whereas only 7.4% of non-spondylolysis patients showed spondylolisthesis (p < 0.05). When excluding unilateral spondylolysis, 90% (18/20) of spondylolysis patients aged ≥60 years-old showed spondylolisthesis. None of the patients with isthmic spondylolisthesis had received fusion surgery, suggesting that most of these patients didn’t have a severe disability requiring surgical treatment. Our results showed that the majority of bilateral spondylolysis patients aged ≥60 years-old show spondylolisthesis, and suggest that spondylolisthesis occurs very frequently and may develop at a younger age when spondylolysis exists.

Lumbar spondylolysis, which is considered a stress fracture of the pars interarticularis, commonly occurs in adolescent patients1. In adolescent patients with acute lumbar spondylolysis, bony union can be expected with adequate conservative treatment, such as wearing a brace and refraining from sports activity2,3; however, in some cases, the fracture does not heal and it becomes a pseudoarthrosis.

At this moment, there is little information about the long-term prognosis of lumbar spondylolysis in cases where the defect becomes a pseudoarthrosis. Thus, patients may have justified anxiety whether they develop severe lumbar degenerative disease. To clarify the actual long-term prognosis of spondylolysis, a prospective study should be performed. However, because spondylolysis patients are usually adolescent, it is not easy to perform a prospective study requiring over fifty or sixty-year follow-up. We propose that patients need information about the future possibility of lumbar degenerative disease because of the presence of spondylolysis suggested by retrospective or cross-sectional studies.

The purpose of the present study is to clarify the future possibility of lumbar spondylolisthesis in patients with lumbar spondylolysis. Although previous studies demonstrated that spondylolysis patients have higher future incidences of disc degeneration and spondylolisthesis4–7, there is no detailed information regarding when and how often spondylolisthesis occurs in patients with or without spondylolysis. Therefore, we examined the age-specific prevalence of spondylolysis and spondylolisthesis in non-low back pain (LBP) patients.

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Materials and Methods
Consecutive patients undergoing computed tomography (CT) scans of abdominal or lumbar regions between July 2015 and January 2016 in our institution were included. Only patients undergoing CT scan for reasons other than low back disorders were included (n = 580). The study was carried out in accordance with the Declaration of Helsinki, and the study protocol was approved by the Institutional Review Board of Eastern Chiba Medical Center, and all patients had signed the informed consent.

Patients’ age and sex were reviewed, and sagittal multiplanar reconstruction CT images were obtained and evaluated by two independent observers (spine surgeons). If their opinions differed, the final description was determined by a third observer. First, the presence of spondylolysis was examined, and whether it was unilateral or bilateral was evaluated. Second, the presence of vertebral slip (>3 mm) was examined in patients with or without spondylolysis. Finally, levels, sex- and age-specific prevalence of spondylolysis and spondylolisthesis were examined.

Data analysis. To compare the prevalence of spondylolysis and spondylolisthesis, the chi-square test was used. A p value < 0.05 was considered to be statistically significant.

Results

The prevalence of spondylolysis. Of the 580 general population patients (mean age: 64.4 ± 18.9 years old; 336 male/244 female, Table 1), 37 patients (6.4%; 26 male and 11 female) had spondylolysis (Tables 1 and 2). One patient had spondylolysis at 2 levels. Levels of spondylolysis were 1 at L1, 3 at L4 and 34 at the L5 vertebrae. As shown in Table 2, male showed higher incidence of spondylolysis (7.7%: 26/336 patients) than female (4.5%: 11/244 patients), although a significant difference was not observed (Table 2). Five of 37 patients had unilateral spondylolysis, and the remaining 32 patients had bilateral spondylolysis (Table 2).

The prevalence of spondylolisthesis. Of the 37 patients with spondylolysis, 19 (51.4%) patients showed spondylolisthesis (Table 3). None of the five patients with unilateral spondylolysis showed spondylolisthesis. Of the remaining 32 patients with bilateral spondylolysis, the incidence of spondylolisthesis was 59.4%. Because the defect of pars interarticularis causes instability between the vertebra with spondylolysis and one level caudal to that vertebra, all spondylolisthesis events occurred at one level caudal to the spondylolysis, except one case showing spondylolisthesis at one level cranial to the spondylolysis. Of the 19 spondylolysis patients showing spondylolisthesis, 7 patients (36.8%) had Meyerding grade 2 spondylolisthesis; however, no patient showed spondylolisthesis greater than Meyerding grade 2.

In patients showing no spondylolysis, a significantly lower prevalence of spondylolisthesis (7.4%: 40/543 patients, p < 0.001) was observed when compared with patients with spondylolysis. None of the patients showed vertebral slip greater than Meyerding grade I. The prevalence of Meyerding grade spondylolisthesis was significantly higher in spondylolysis patients (7/19) than in non-spondylolysis patients (0/40, p < 0.001). Female showed significantly higher prevalence of spondylolisthesis (11.6%) than male (4.2%) in patients without spondylolysis (Table 3). None of the patients with isthmic spondylolisthesis had received fusion surgery, suggesting that most of these patients did not have a severe disability requiring surgical treatment.

### Table 1. Characteristics of patients undergoing computed tomography (n = 580). M = male, F = female.

| Age (years) | 64.4 ± 18.9 (9–95) |
| Sex (M/F) | 336 / 244 |
| Spondylolysis (%) | 6.38% (37cases) |

### Table 2. The prevalence of spondylolysis in male and female.

| % of spondylolysis | Male (26/336) | Female (11/244) | Total (37/580) |
|-------------------|---------------|-----------------|---------------|
| Unilateral: Bilateral | 4: 22 | 1: 10 | 5: 32 |

### Table 3. The prevalence of spondylolisthesis in patients with or without spondylolysis (lysis). Parenthesis indicates number of unilateral spondylolysis. *Significant difference between male and female.

| Age (yr) | Lysis (+) | Lysis (−) | Lysis (+) | Lysis (−) | Lysis (+) | Lysis (−) |
|----------|-----------|-----------|-----------|-----------|-----------|-----------|
| −49      | 0/9 (2)   | 0/113     | 0/4 (1)   | 0/70      | 0/5 (1)   | 0/43      |
| 50–59    | 1/5       | 1/65      | 1/5       | 1/45      | 0/0       | 0/20      |
| 60–69    | 5/5       | 7/117     | 4/4       | 1/66      | 1/1       | 6/51      |
| 70–79    | 4/7 (2)   | 14/118    | 2/5 (2)   | 4/66      | 2/2       | 10/52     |
| 80–     | 9/11 (1)  | 18/130    | 6/8 (1)   | 7/63      | 3/3       | 11/67     |
| Total    | 19/37 (5) | 40/543    | 13/26 (4) | 13/310*   | 6/11 (1)  | 27/233*   |

*Significant difference between male and female.
The age-specific prevalence of spondylolisthesis with or without spondylolysis. In both patient
groups with or without spondylolysis, no patient younger than 50 years-old had spondylolisthesis. The prevalence
of spondylolisthesis showed an age-dependent increase in spondylolysis patients, as well as in non-spondylolysis
patients (Table 3). When excluding unilateral spondylolysis patients, the majority of spondylolysis patients (90%:
18/20) aged ≥60 years-old showed spondylolisthesis, whereas only 8.3% (1/12) of patients ≥60 years-old showed
spondylolisthesis (p = 0.02). In the non-spondylolysis patients, the prevalence of spondylolisthesis in patients
≥60 years-old (10.7%: 39/365) was significantly lower than in spondylolysis patients ≥60 years-old (78.3%: 18/23,
p < 0.001).

Discussion
Our results suggest that an extremely high percentage of spondylolysis patients over 60 years-old have spon-
dylolisthesis at one level caudal to the spondylolysis, particularly if they have bilateral spondylolysis. The
prevalence of spondylolisthesis differs depending on ethnicity and sex. Sakai et al. reported that the prevalence
of spondylolysis in the Japanese general population is 5.9%, and that male (7.9%) showed a higher prevalence than
female (3.9%)8. In our study, we confirmed that the ethnicity of all patients seems to be Japanese, or at least, east
Asia, and showed a prevalence similar to the previous study, suggesting the data of our study may reflect the
general population in Japan. The study of Sakai and others8, as well as our study, showed that unilateral spon-
dylolysis rarely showed spondylolisthesis, whereas bilateral spondylolysis often showed spondylolisthesis. These
results suggest that the prognosis of unilateral spondylolisthesis is more favorable than that of bilateral spondylolysis.
Lemoine et al. reported that the prevalence of bilateral spondylolysis increased after children have learned to
walk9. However, Brooks et al. reported that the prevalence of lumbar spondylolisthesis does not increase in patients
older than 20 years10. Therefore, it is generally recognized that spondylolisthesis occurs in adolescent under the age
of 20 years. In contrast, the prevalence of spondylolisthesis would increase depending on age11,12. Thus, to clarify
the actual prevalence of spondylolisthesis, only elderly patients should be included in the analysis. Our results
suggest that the prevalence of spondylolisthesis patients showing spondylolisthesis rises at the ages of 60–69. When
limited to patients over 60 years-old, the incidence of spondylolisthesis was extremely high (90%: 18/20) in bilat-
eral spondylolysis patients. On the other hand, the incidence of spondylolisthesis in non-spondylolysis patients
was only 10.7% (39/365) even when limited to patients over 60 years-old. These results indicate that bilateral spon-
dylolysis is strongly correlated with the prevalence of spondylolisthesis. Our results showed that spondyloly-
sis patients more often showed Meyerding grade 2 spondylolisthesis. From these observations, it can be seen that
spondylolisthesis develops more often, and more severely in patients with spondylolysis, when compared with
patients without spondylolysis.

Brinjikji et al. reported that spondylolysis is more prevalent in young adults (<50 years-old) with back pain
compared with asymptomatic individuals13, suggesting that spondylolysis patients may have a greater chance to
have LBP during middle age. Spondylolysis patients often develop spondylolisthesis in their old age, and a certain
number of patients may have severe LBP or radicular symptoms14. This study has several limitations. First, the
patients visited our hospital because they had a disease and underwent CT scans for various reasons, including
polytrauma, gastrointestinal symptoms, detailed examination for liver dysfunction, etc. We could not exclude the
possibility that their disease influenced the prevalence of spondylolysis and spondylolisthesis. Second, we did not
have precise information about whether they had LBP and did not perform a follow-up study. However, this study
may help us to understand the prognosis of spondylolysis to some extent.

To clarify the long-term prognosis of spondylolysis more accurately, a prospective study should be performed.
However, it takes a very long time to get results from prospective studies because spondylolisthesis usually occurs
in patients younger than 20 years old15,16. Consequently, we have little current information about the long-term
prognosis of spondylolisthesis elucidated by prospective studies. We, therefore, suggest an estimated prognosis that
the majority of bilateral spondylolysis patients over 60 years-old develop spondylolisthesis from the results of our
cross-sectional study. The results of our study provide information suggesting the long-term prognosis of spon-
dylolysis, and are helpful for spondylolysis patients as well as physicians to make treatment decisions.

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**Author contributions**
Y. Aoki designed the study and drafted the article. H. Takahashi, A. Nakajima, G. Kubota, A. Watanabe, T Nakajima, and H. Fukuchi collected and analyzed the data. Y. Eguchi, S. Orita, and K. Nakagawa designed the study and contributed substantially to the interpretation of the data. N. Yanagawa and S. Ohtori supervised the project.

**Competing interests**
The authors declare no competing interests.

**Additional information**

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