Orthopaedics & Traumatology: Surgery & Research xxx (2018) xxx–xxx

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Original article

Radiographic analysis of the listhesis associated with lumbar isthmic spondylolysis

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ARTICLE INFO

Article history:
Received 26 May 2017
Accepted 13 February 2018

Keywords:
Spondylolysis
Spondylolisthesis
Dysplasia
Hypoplasia
Vertebral body

ABSTRACT

Background: In cases of spondylolysis, hypoplasia of L5 mimicking spondylolisthesis has been described, mainly based on MRI; however, the treatment implications have not been analyzed specifically.
Objective: Assess the impact of hypoplasia of the L5 vertebral body in the constitution of the spondylolisthesis associated with isthmic spondylolysis.
Material and methods: A retrospective radiographic study in the standing position was performed with 104 patients with L5 isthmic spondylolysis and 24 control subjects.
Results: Measurements of vertebral endplate length showed that the standard apparent posterior listhesis (APL) is made up of true listhesis (TL) and false listhesis (FL). FL is induced by hypoplasia of the L5 vertebral body relative to the S1 endplate. TL results from disk failure and leads to anterior listhesis (AL), which alters the balance of spinal curvatures.
Conclusions: By integrating the potential for false listhesis into the classification systems for spondylolisthesis, we can adapt the treatment algorithms.
Type of study: Retrospective radiography study.
Level of evidence: IV Retrospective review of cases.

1. Introduction

Spondylolysis corresponds to a loss of continuity (fracture) of the pars interaticularis located between the upper and lower facet joints of the posterior vertebral arch. It mainly occurs in L5 but sometimes also in L4. In some cases, the vertebral body slides forward with its pedicles and transverse processes. This sliding is called spondylolisthesis. It is typically measured on lateral radiographs as the offset between the posterior corner of the superior S1 endplate and that of the inferior L5 endplate. The most commonly used classification systems take into account the magnitude of this offset. Taillard expresses it as a percentage of the length of the inferior endplate [1]. Meyerding uses a five-grade system in which the fifth grade corresponds to spondyloptosis [2]. Measuring the degree of listhesis is critical because it is considered evidence of failure of the disk's mechanical properties [3–6].

Moreover, various types of dysplasia have been described in combination with spondylolysis. They affect the sacrum (dome deformity, marked curvature) and the posterior vertebral arch and joints. In some cases, posterior wedging of the vertebral body can occur along with hypoplasia of the vertebra in question. Normally, the size of the vertebral body increases gradually from C1 to L5. This hypoplasia is defined as the length of the inferior L5 endplate being shorter than that of the superior S1 endplate [7–10]. This difference in size induces a false impression of listhesis called "pseudolisthesis". (Fig. 1) Frank and Miller were the first to describe this phenomenon using plain radiographs in 1979 [11]. They found pseudolisthesis in 45% of cases of spondylolysis (always at L5, never at L4). Hypoplasia of L5 in patients with spondylolysis was confirmed by Saraste et al. on radiographs in 1985 [12]. Wilms and colleagues described this phenomenon on MRI in 2009, but only measured the length of the vertebral bodies at their midline [13]. They reported that the anteroposterior length of the L5 vertebral body was on average shorter than L4 (3.75 mm or 10.6%) and that of the superior endplate of S1 (4.25 mm or 11.9%). Niggemann performed these measurements with MRI in 2012 [14]. In 42% of cases of L5 spondylolysis, the inferior L5 endplate was 5 mm shorter on average than that of S1 (from 3 to 13 mm). They did not speculate on the implications of their findings.

The drawback of these studies is that they were performed with the patient lying down. This negates the effect of shear forces induced by the trunk's weight on the L5/S1 disk space, which is known to be more angled in cases of spondylolysis [15,16]. Hence, spondylolisthesis is said to result from failure of the disk's stabi-

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https://doi.org/10.1016/j.otsr.2018.02.017
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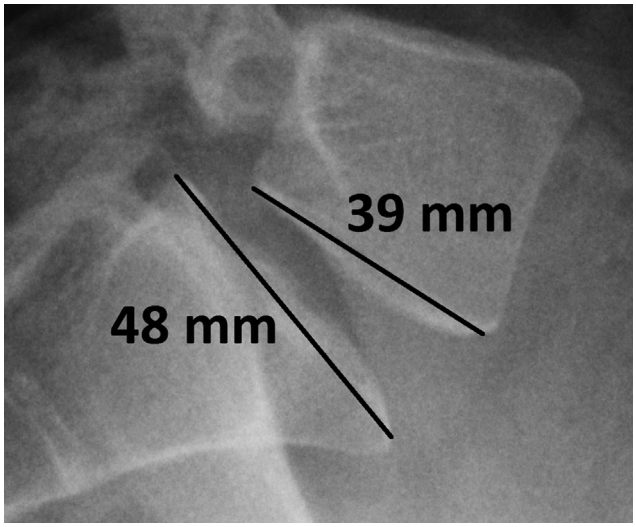

Fig. 1. Pseudospondylolisthesis in a case of L5 isthmic spondylolysis: the difference in length between the superior S1 endplate (EPL S1 sup = 48 mm) and inferior L5 endplate (EPL L5 inf = 39 mm) induces a false impression of posterior listhesis when there is no true slippage within the intervertebral disk. APL = FL, TL = 0, AL = 0.

lizing effects due to these forces and thus is evidence of instability [17–19].

We sought to study the listhesis associated with L5 spondylolysis on radiographs of standing patients by measuring the length of the vertebral and sacral endplates. The aim was to show the relative contribution of pseudolisthesis to the make-up of spondylolisthesis images and to determine how the classifications systems can be adjusted. Treatment algorithm may need to be adapted based on our findings.

2. Material and methods

Digital lateral radiographs of standing subjects were used. The standing position was standardized based on the literature, with subjects placing their fingers on their clavicles, arms hanging down, elbows flexed and gaze horizontal. The length of the vertebral bodies was measured by the same person after calibration using processing and image analysis software (TM-Reception-HE, Telemis S.A., France). Our hospital's ethics committee approved the use of anonymized data (reference number NUB: BO39201731735).

The radiographs were taken during a standard assessment for low back pain in the context of office visits. No additional irradiation was used. We analyzed 128 radiographs (Fig. 2). The adult volunteers used as control subjects had common low back pain with no spinal ailments. Excluded were subjects with spinal deformity, degenerative spondylolisthesis, fracture sequelae, infection, tumor or any rheumatism. The patients in our cohort had bilateral L5 spondylolysis graded as 0 to 3. Patients were excluded who had unilateral disease or L4-specific disease, along with those graded as 4 or 5 because of sacral dome deformity altering the measurements and degree of slip.

The Meyerding classification, which divides the S1 upper endplate into four quarters, was used to define the spondylolisthesis grades [2].

The following variables (in mm) were measured (Fig. 3):

- Apparent posterior listhesis (APL): perpendicular distance between the posterior inferior corner of the cephalad vertebra and the posterior superior corner of the caudal vertebra. This is the standard measurement for spondylolisthesis;
- Anterior listhesis (AL): perpendicular distance between the anterior corner of the caudal vertebra and the anterior corner of the cephalad vertebra. Osteophytes were present occasionally and did not affect the measurement precision;
- length of superior S1 endplate (EPL S1 sup);
- length of inferior L5 endplate (EPL L5 inf).

The following variables were calculated for each subject:

- False listhesis (FL) induced by sagittal hypoplasia: difference in length of the superior S1 endplate and the inferior L5 endplate: EPL S1 sup–EPL L5 inf. This value is nearly zero when there is no

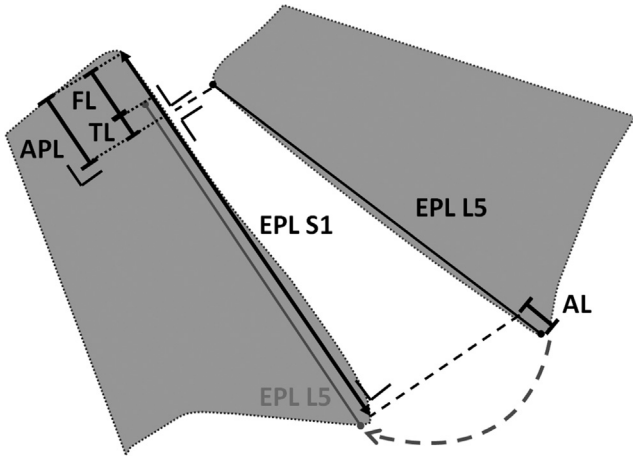

Fig. 3. Measurement of listhesis on radiographs: Apparent posterior listhesis (APL), false or pseudo listhesis (FL), true listhesis (TL) and anterior listhesis (AL).

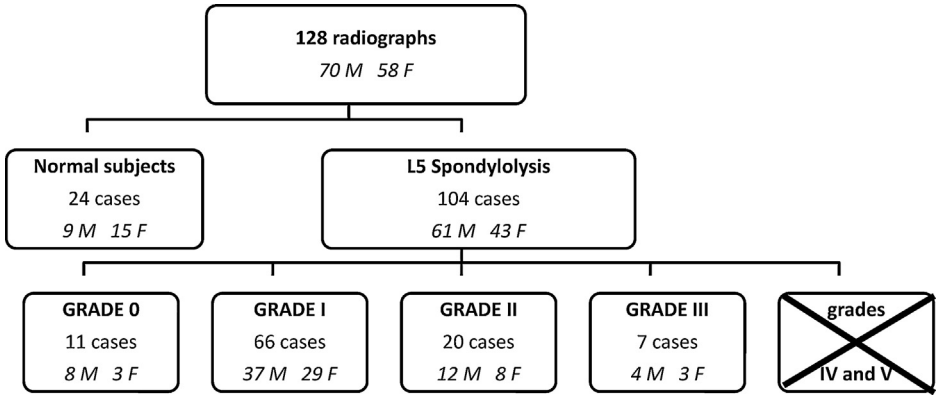

Fig. 2. Flow chart for the radiographs of patients with L5 isthmic spondylolysis by Meyerding grade and of the healthy controls. M: male, F: female.

Please cite this article in press as: Legaye J. Radiographic analysis of the listhesis associated with lumbar isthmic spondylolysis. Orthop Traumatol Surg Res (2018), https://doi.org/10.1016/j.otsr.2018.02.017