Spine Deformity
www.spine-deformity.org

Spine Deformity 6 (2018) 358–365

Radiographic Classification for Degenerative Spondylolisthesis of the Lumbar Spine Based on Sagittal Balance: A Reliability Study

Soufiane Ghailane, MD[a,*], Houssam Bouloussa, MD, MS[a], Vincent Challier, MD[a], Claudio Vergari, PhD[b], Go Yoshida, MD, PhD[a], Ibrahim Obeid, MD[a], Louis Boissière, MD[a], Jean-Marc Vital, MD, PhD[a], Simon Mazas, MD[a], Pierre Coudert, MD[a], Olivier Gille, MD, PhD[a]

[a]*Department of Spinal Surgery Unit 1, Université de Bordeaux, Bordeaux University Hospital, C.H.U Tripode Pellegrin, Place Amélie Raba Léon, 33076 Bordeaux, France*

[b]*University of Exeter, School of Physics and Astronomy, Exeter, United Kingdom*

Received 28 August 2017; revised 28 November 2017; accepted 1 December 2017

Abstract

Study Design: Inter- and intraobserver reliability study.
Object: To assess the reliability of a new radiographic classification of degenerative spondylolisthesis of the lumbar spine (DSLS).
Summary of Background Data: DSLS is a common cause of chronic low back and leg pain in adults. To this date, there is no consensus for a comprehensive analysis of DSLS. The reliability of a new DSLS classification system based on sagittal alignment was assessed.
Methods: Ninety-nine patients admitted to our spinal surgery department for surgical treatment of DSLS between January 2012 and December 2015 were included. Three observers measured sagittal alignment parameters with validated software: segmental lordosis (SL), lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), and sagittal vertical axis (SVA). Full body low-dose lateral view radiographs were analyzed and classified according to three main types: Type 1A: preserved LL and SL; Type 1B: preserved LL and reduced SL ($\leqslant 5^\circ$); Type 2A: PI-LL $\geqslant 10^\circ$ without pelvic compensation (PT $< 25^\circ$); Type 2B: PI-LL $\geqslant 10^\circ$ with pelvic compensation (PT $\geqslant 25^\circ$); Type 3: global sagittal malalignment (SVA $\geqslant 40$ mm). The three observers classified radiographs twice with a 3-week interval for intraobserver reproducibility. Interobserver reproducibility was calculated using Fleiss κ and intra-class coefficient. Intraobserver reproducibility was calculated using Cohen κ.
Results: Mean age was 68.8 ± 9.8 years. Mean sagittal alignment parameters values were the following: PI: 60.1° ± 12.7°; PI-LL was 12.2° ± 13.9°, PT: 24.7° ± 8.5°; SVA: 44.9 mm ± 44.6 mm; SL: 16.6° ± 8.4°. Intraobserver repeatability showed an almost perfect agreement (ICC > 0.92 and Cohen κ > 0.89 for each observer). Fleiss κ value for interobserver reproducibility was 0.82, with percentage agreement among observers between 88% and 89%.
Conclusion: This new classification showed an excellent inter- and intraobserver reliability. This simple method could be an additional sagittal balance tool helping surgeons improve their preoperative DSLS analysis.

Keywords: Degenerative spondylolisthesis; Lumbar spine; Classification system; Spondylolisthesis

Introduction

Degenerative spondylolisthesis of the lumbar spine (DSLS) is a common cause of chronic lower back pain, leg pain, and neurogenic claudication in adults. Older age, female gender, high body mass index, increased sagittal orientation of the facet joints, muscle weakness, unrestrained shear forces due to disc degeneration, and loss of spinal alignment were found to be potential causes of

This paper was presented as oral communication at the SRS (Scoliosis Research Society) Annual Meeting in Prague, Czech Republic, September 24, 2016.

Author disclosures: SG (none); HB (personal fees from EOS IMAGING, outside the submitted work); VC (none); CV (none); GY (none); Ibrahim Obeid (none); Louis Boissière (none); JMV (personal fees from LDR, personal fees from EUROS, personal fees from GLOBAL S, outside the submitted work); SM (none); PC (none); OG (none).

IRB Statement: This study was reviewed and approved by Bordeaux University Ethics Board.

*Corresponding author. Department of Spinal Surgery Unit 1, Université de Bordeaux, Bordeaux University Hospital, C.H.U. Tripode Pellegrin, Place Amélie Raba Léon, 33076 Bordeaux, France. Tel.: +33 5 56 79 87 18; fax: + 33 5 56 79 60 43.

E-mail address: soufiane.ghailane@gmail.com (S. Ghailane).

2212-134X/$ - see front matter
https://doi.org/10.1016/j.jspd.2017.12.001

development and progression of DSLS [1-9]. However, the pathogenesis of DSLS still remains unclear.

To this date, there is no consensus for a comprehensive analysis of DSLS. Patients with DSLS may have varying presentations, and this depends on slippage severity, degree of spinal stenosis, as well as lumbar lordosis and global sagittal alignment [10]. Few studies have reported the influence of sagittal alignment on DSLS [11,12], although there is a strong body of evidence correlating spinopelvic sagittal alignment with health-related quality of life scores (HRQOLs) in the setting of adult spinal deformity [13,14]. Lafage et al. recently highlighted the importance of spinopelvic parameters and the relationship between pelvic incidence and lumbar lordosis [15,16].

Global sagittal alignment reflects patients' ability to compensate for segmental or multilevel spinal degeneration while alleviating their own pain. Furthermore, global degenerative processes decrease alignment adjustment abilities (disc height loss, loss of disc lordosis, facet degeneration, or spontaneous fusion) [17]. DSLS may have an impact on the entire lumbar spine via compensation mechanisms involving adjacent discs and even pelvic orientation [18,19]. Consequently, it may also affect global alignment [20].

Following the 2013 French Spine Surgery Society roundtable, Gille et al. proposed a new classification system of DSLS based on sagittal alignment. This classification might be a useful tool for the assessment of DSLS and its treatment [21], with a potential role in the decision-making process. Its clinical relevance was recently shown as classification types correlated with age, Short Form 12 (SF12), and the Oswestry disability index (ODI) [22]. The aim of the present study was to assess its inter- and intraobserver reliability.

Methods

Ninety-nine patients admitted to a single spinal surgery department for surgical treatment of DSLS between January 2012 and December 2015 were retrospectively included. The inclusion criteria were as follows: (1) age >40 years; (2) degenerative spondylolisthesis of the lumbar spine; and (3) complete data (demographic information, preoperative lateral full-body biplanar radiographs). Patients were excluded if they presented with (1) a coronal malalignment with coronal Cobb angle $>10°$; (2) other causes of spondylolisthesis (isthmic, congenital, traumatic, iatrogenic); (3) previous lumbar spine surgery; and (4) active infection or neoplasm.

The classification was based on the rating of lateral full-body biplanar radiographs routinely acquired for sagittal alignment analysis in each patient. All data were extracted from a local database.

Classification

The newly proposed classification was based on the following sagittal plane parameters: lumbar lordosis (LL), pelvic incidence (PI), pelvic tilt (PT), segmental lordosis (SL), and sagittal vertical axis (SVA) [23]. A formal description of the classification is given in Table 1. Type 1 corresponds to a harmonious and balanced spine: PI-LL $<10°$ (Fig. 1); Type 2 is a disharmonious spine with compensated spinal alignment: PI-LL $>10°$ (Fig. 2); and Type 3 is an altered global alignment: SVA >40 mm (Fig. 3). Subtypes account for segmental lordosis (Type 1A: SL $>5°$, Type 1B: SL $<5°$), or pelvic compensation (Type 2A: PT $<25°$, Type 2B: PT $>25°$). Patients with double or triple spondylolisthesis were not classified differently because the classification is independent of local characteristics and describes global alignment only. Indeed, the degree of listhesis was not considered. All patients were classified according to this classification system. Figure 4 represents a decision-tree algorithm following measurements.

Radiographic measurements

Three independent observers with more than four years of experience in orthopaedic surgery (one senior surgeon and two senior residents) measured segmental, regional, and global sagittal alignment parameters of each patient, using validated software (Surgimap, Nemaris, Inc, New York, NY) [24].

SL was represented by the angle between the superior endplate of the slipped vertebra and the inferior endplate of

Table 1
Definition of the new classification types.

Type	Description	Parameters	Subtype	Subtype description	Age (years)	Number of patients (females/males)
Type 1	Harmonious and balanced spine (LL adapted to PI) (Fig. 1)	PI-LL $<10°$	1A	Preserved segmental lordosis (SL)	66.4 ± 8.6	34 (42/10)
			1B	Altered SL, with preserved LL	64.3 ± 13.2	2 (1/1)
Type 2	Disharmonious and compensated malalignment (Fig. 2)	PI-LL $>10°$	2A	Preserved global alignment without pelvic compensation (pelvic tilt PT $<25°$)	70.4 ± 10.1	4 (3/1)
			2B	Preserved global alignment with pelvic compensation (PT $>25°$)	69.9 ± 11.1	11 (11/0)
Type 3	Altered global alignment (Fig. 3)	SVA $>$ 40 mm	3		70.3 ± 10.1	48 (32/16)
Average					68.8 ± 9.8	99 (71/28)