Spine Deformity
www.spine-deformity.org

Spine Deformity xx (2017) 1–7

The Berbeo-Sardi Angle (BSA): An Innovative Method to Effectively Estimate Pelvic Retroversion in Anteroposterior Radiographs—A Correlation With Traditional Parameters

Juan P. Sardi, MD[a,b,*], Jorge E. Camacho, MD[a], Roberto C. Diaz, MD[a,b], Miguel E. Berbeo, MD[a,b]

[a]*Hospital Universitario San Ignacio, Carrera 7a No. 40-62, Bogotá, Colombia*
[b]*Facultad de Medicina, Pontificia Universidad Javeriana, Carrera 7a No. 40-62, Bogotá, Colombia*

Received 18 August 2017; accepted 26 August 2017

Abstract

Study: Design: Diagnostic studies—concordance between diagnostic tests.
Objectives: The purpose of this study was to develop a novel spinopelvic parameter (Berbeo-Sardi angle [BSA], the angle formed at the intersection of a line that connects the inferior margin of the sacroiliac joint to the midpoint of a horizontal line joining both femoral heads) measurable in anteroposterior radiographs that indirectly estimates pelvic retroversion and correlates with traditional measurements like pelvic tilt (PT).
Summary: Sagittal balance appraisal and surgical planning rely on the interpretation of spinopelvic parameters. An increased PT reflects pelvic retroversion as a compensatory mechanism to limit sagittal imbalance and correlates with increased pain and disability. However, poor imaging techniques and incorrect patient positioning frequently hamper landmark identification in lateral radiographs, and with no measurable angles in anteroposterior radiographs, it is often impossible to determine PT and pelvic retroversion.
Methods: Whole-spine radiographs from 105 consecutive patients were used to retrospectively measure conventional spinopelvic parameters and the BSA. Intraclass correlation coefficient was used to assess a quantitative correlation between the PT and BSA as indirect measures of pelvic retroversion.
Results: Average values for pelvic incidence, lumbar lordosis, sacral slope, PT, and BSA were 46.5° (±10.23), 48.56° (±12.30), 29.97° (±9.77), 16.94° (±8.03), and 54.47° (±4.05), respectively. We encountered a moderately strong correlation ($r = -0.66$) between PT and BSA. Receiver operating characteristic plot analysis revealed that a BSA threshold of 46° has a sensitivity of 90% to identify pathologic PT values (>20°), whereas a BSA ⩾60° has a specificity of 90% to rule out pelvic retroversion using anteroposterior radiographs.
Conclusions: There is a moderately strong correlation between the BSA, an innovative spinopelvic parameter measurable in anteroposterior radiographs, and PT. BSA seems to show great promise in simplifying spinopelvic appraisal by easily estimating pelvic retroversion associated with sagittal imbalance, while avoiding image-quality issues often encountered in lateral radiographs.
Level of Evidence: Level III.

Keywords: Spine; Spinal deformity; Pelvic tilt; Pelvic retroversion; Sagittal balance

Introduction

Sagittal balance is now considered one of the most important predictors of surgical and health-related quality-of-life (HRQoL) outcomes [1-5]. The pelvis, which serves as foundation to the human spine, has been broadly studied because of its fundamental role in global alignment. Duval-Beaupere described pelvic incidence and its close relationship with lumbar lordosis in the early nineties [6]. This would set the grounds for others like Dubousset who years later would coin the term ''pelvic vertebra'' [7-9]. Several authors have since investigated spinopelvic parameters to define the ideal spinal balance for each individual. Pelvic incidence (PI), a fixed parameter, will determine ideal lumbar lordosis (LL) and reproduce the relationship of the

Author disclosures: none.

*Corresponding author. Carrera 7a No. 40-62, Hospital Universitario San Ignacio, Piso 6 Neurociencias, Bogotá, Colombia. Tel.: +573104297104; fax: +5713230996.
E-mail address: jsardi2@hotmail.com (J.P. Sardi).

2212-134X/$ - see front matter
https://doi.org/10.1016/j.jspd.2017.08.011

sacrum to the pelvis [4,10]. It is defined by the sum of sacral slope (SS) and pelvic tilt (PT), dynamic parameters that change inversely proportional to one another in order to preserve the constant PI [5,11].

Independent of its cause, sagittal malalignment implies altered spinopelvic parameters to maintain an upright posture within the ''Cone of Economy'' [7,11]. One of the first changes that follow sagittal imbalance is pelvic retroversion. As the pelvis rotates backward, it counters the anterior displacement of mass caused by a positive sagittal vertical axis (SVA), thus keeping the C7 plumb line behind femoral heads [12-14]. This pelvic rotation about the hip axis will turn the sacral endplate into a more horizontal position, decreasing SS but proportionally increasing PT [5].

Increased PT can result from aging, trauma, congenital abnormalities, loss of LL, and augmented thoracic kyphosis—conditions also known to cause pelvic retroversion by recruitment of compensatory mechanisms [4,10]. These changes have been associated with deteriorating quality of life outcomes. Furthermore, surgical restoration of optimal spinopelvic parameters, especially achieving PT values below 20°, has been associated with improved functional status and walking tolerance [1,5,15-17].

Accurate evaluation of global alignment requires that all key radiographic landmarks be clearly visible in 36-inch standing scoliosis films. Nevertheless, it is not uncommon to find inadequate lateral radiographs due to poor imaging technique, flaws in patient positioning and uneven x-ray penetration at different spinal levels. These low-quality lateral radiographs often make it nearly impossible to measure PT and estimate pelvic retroversion, thus altering the reliability of spinopelvic parameters.

There are currently no universally accepted angular spinopelvic parameters that can be measured in anteroposterior (AP) spinal films in order to provide an alternative solution for pelvic version appraisal. In an effort to overcome image-quality issues associated with lateral radiographs and simplify spinopelvic analysis, the purpose of this study was to assess a possible correlation between PT and a novel spinopelvic parameter (ie, the Berbeo-Sardi angle [BSA], the angle formed at the intersection of a line that connects the inferior margin of the sacroiliac joint to the midpoint of a horizontal line joining both femoral heads) as an indirect measure of pelvic retroversion in anteroposterior radiographs.

Materials and Methods

Study design

This study was conducted at a University Hospital and all data were obtained from the databases of the Neurosurgery and Radiology departments. After institutional review board approval, medical records of all patients who had 36-inch standing scoliosis films performed during a two-year period were reviewed. Inclusion criteria were age greater than 13 years and a clinical or radiographic diagnosis of symptomatic spinal deformity, chronic low-back pain, neurogenic claudication, or radicular entrapment. Asymptomatic patients or those with a history of spinopelvic neoplasic disease or surgery were excluded.

Two experts queried the included radiographs to identify minimum radiographic standards defined by the *Spinal Deformity Study Group* [18]. Patients only qualified for inclusion if their images were deemed acceptable by consensus. All studies had to include AP and lateral projections taken with the patient in an upright position with their knees locked, feet apart at shoulder width, looking straight ahead and with less than 1 cm of pelvic asymmetry. Mandatory landmarks that had to be visualized were as follows: vertebral bodies from C2 to the sacrum, both femoral heads, the entire ribcage form right to left, and the sacroiliac joints [18,19]. Four hundred fifty-one consecutive radiographic studies practiced between April 2015 and September 2016 were retrospectively assessed before obtaining the 105 full-length spine radiographs needed for our study.

Radiographic parameters

Two experts independently measured all spinopelvic parameters using the image processing software OsiriX (open-source software; www.osirixviewer.com). The analysis focused on the following traditional parameters measured in lateral films (Fig. 1):

- SVA: Defined as the horizontal distance from the C7 plumbline to the posterosuperior corner of S1.
- PI: Angle between a line perpendicular to the midpoint of the sacral endplate and the line connecting this point to the center of the femoral heads.
- LL: Angle between the upper end plate of L1 and the superior end plate of S1.
- PT: Angle between a line connecting the center of the femoral heads to the midpoint of the sacral end plate and a vertical line from this point.
- SS: Angle between a horizontal line and the superior end plate of S1.

Left and right BSA were measured in AP films. For analysis purposes, we included individual values for each side, as well as their average (Fig. 2).

- BSA: Angle formed at the intersection of a line that connects the inferior margin of the sacroiliac joint to the midpoint of a horizontal line joining both femoral heads.