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# Spinopelvic parameters in postfusion flatback deformity patients

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**Abstract**

**BACKGROUND CONTEXT:** Fixed sagittal imbalance (FSI) may result from loss of adequate lumbar lordosis (LL) after spinal fusion. Pelvic incidence (PI) is a fixed anatomical parameter that determines LL and overall spinal sagittal alignment.

**PURPOSE:** We describe the spinopelvic parameters in a series of patients with postfusion FSI. We hypothesize that patients who develop postfusion FSI may have a high PI and are thus more at risk from a loss of adequate LL.

**STUDY DESIGN:** Retrospective chart and image review.

**PATIENT SAMPLE:** Consecutive patients with degenerative spine disease with clinically significant postoperative FSI after fusion.

**METHODS/OUTCOME MEASURES:** We evaluated 36-in full spine films for PI, LL, pelvic tilt (PT), thoracic kyphosis (TK), and C7 plumb line.

**RESULTS:** Fifteen patients with clinically significant FSI were identified: 13 women and 2 men (mean age, 63.3 years). They had undergone a mean of 2.9 prior spine surgeries. The mean PI was elevated at 66.7° (normal 48–55°), mean PT was elevated at 35.5° (normal 12–18°), mean LL was reduced at 11.8° (normal 43–61°), mean TK was reduced at 19.3° (normal 41–48°), and mean C7 plumb line was elevated at 13.1 cm (normal <3 cm).

**CONCLUSIONS:** In the current series, patients with FSI after spinal fusion had an elevated PI and inadequate LL. They attempted to compensate for FSI with reduced TK and with increased pelvic retroversion (PT). Overall, it is important to identify sagittal spinopelvic parameters and promote sagittal balance when performing lumbar fusions. 

*Keywords:* Fixed sagittal imbalance; Flatback deformity; Lumbar lordosis; Pelvic incidence; Spinopelvic parameters

## Introduction

Fixed sagittal imbalance (FSI), also known as flatback deformity or kyphotic decompensation syndrome, occurs in patients who have lost their normal lumbar curvature or lordosis, resulting in positive sagittal balance with forward inclination of the trunk, anterior displacement of the center of gravity, difficulty or inability to stand upright, difficulties with walking, and compensatory mechanisms including cervical and thoracic segment hyperextension, and crouching with knee flexion and hip retroversion [1–11]. Multiple causes of FSI have been identified, including loss of lordosis after spine fusion [1–4,12]. The ideal treatment approach of postfusion FSI is prevention, with identification, maintenance, and promotion of adequate lumbar lordosis (LL) for sagittal balance [1,5,9,13]. The difficulty lies in determining the amount of LL that each patient requires to maintain optimal sagittal balance. Sagittal alignment has traditionally been described as being a balance of reciprocal curves of thoracic kyphosis (TK) and LL [14], but recent studies demonstrate the importance of pelvic morphology and orientation in regulating sagittal alignment [15–18].

Pelvic incidence (PI), the key spinopelvic parameter for sagittal balance, is a constant anatomical value that is independent of pelvic positioning (see Table 1 for definitions of

FDA device/drug status: no direct device discussed; indirectly pedicle screws (approved).

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EVIDENCE & METHODS

**Context**
Fixed sagittal imbalance (FSI) is increasingly being recognized as a source of spinal problems.

**Contribution**
The authors describe the association between abnormal spino-pelvic measurements in patients with post-fusion sagittal imbalance.

**Implications**
This article contributes to the growing literature aimed at the conceptual consideration of the pelvis and hips as important factors in overall spinal alignment after extended lumbar area fusion. The compensatory changes in pelvic attitude and forced thoracic extension may have significant functional and clinical impact. Despite the usual limitations of this kind of study (retrospective review of a small number of subjects), these data may direct prospective study to correlate pre- and intra-operative attention to pelvic/overall spine alignment with improved clinical outcomes.

*—The Editors*

spinopelvic sagittal parameters and values observed in normal subjects; also see Fig. 1 and Fig. 2) [17–21]. PI increases during childhood, and this increase is central to humans being able to stand upright, becoming bipedal, and developing LL, but the PI does not change after adolescence [22–24]. PI defines the extent of sacral slope (SS) and pelvic tilt (PT) (PI=SS+PT), and SS and PT vary based on pelvic position [17,18,25]. Strong correlation exists between PI, SS, and LL (SS and PI, r=.8; LL and SS, r=.86; PI and LL, r=.60) [7,14,17,18]. Overall, the spine adapts to pelvic morphology (PI) mostly through LL but also through the adaptability of all other spinopelvic parameters [15,18]. On the basis of formulas provided by Legaye and Duval-Beaupere [17], a PI of 53 will have an LL of 65 for sagittal balance, but a higher PI of 80 will require a LL of 83 to remain balanced. Thus, a patient with an elevated PI requires a greater than normal LL for optimal sagittal balance and may be more vulnerable to any loss of LL.

High PI and abnormal spinopelvic parameters have also been found to contribute to multiple spine conditions, including spondylolysis and subsequent progressive spondylolisthesis [19,26–30], degenerative spondylolisthesis [31,32], junctional kyphosis [33], postoperative pain [16], adjacent segment degeneration [17], and even nonspinal conditions including hip osteoarthritis [34]. The role of spinopelvic imbalance in the development of FSI has not been described previously. Therefore, we determined the spinopelvic profile in 15 patients with postfusion sagittal imbalance. Also, we evaluated the hypothesis that patients in whom FSI develops after spinal fusion have a high PI and are therefore may be more susceptible to a loss of LL.

## Methods

### *Study population*

This study was a retrospective chart and image review to evaluate spinopelvic parameters in a series of patients with degenerative spine disease with clinically significant postfusion FSI. Study criteria required that all patients had an anteroposterior and lateral 36-in cassette, full spine film as part of their preoperative evaluation. This study protocol was accepted by the institutional review board.

We reviewed the charts and imaging of all patients treated at the University of Utah from January 2006 to April 2008 in whom clinically significant FSI developed after spine fusion surgery, with positive sagittal alignment (≥5 cm) [6,22,23,35]. All these patients had pain, subjective and objective gait limitations, inability to maintain an upright posture, and lateral radiographs documenting progressive increase in positive sagittal alignment. They all had failed at least a 12-week course of nonoperative treatment including physical therapy and medications. These search criteria were selected

Table 1
Definitions of spinopelvic sagittal parameters

| Parameter | Definition | Values in asymptomatic adults (°)[a] |
|---|---|---|
| Pelvic incidence (PI)[b] | Angle between the line perpendicular to the S1 end plate at its midpoint and the line connecting this point to the middle axis of the femoral heads | 48–55 |
| Sacral slope (SS) | Angle between the line connecting the superior end plate of S1 and a horizontal line | 36–42 |
| Pelvic tilt (PT) | Angle between the line connecting the midpoint of the sacral plate to the middle axis of femoral heads and a vertical line | 12–18 |
| Lumbar lordosis (LL) | Angle from the superior end plate of L1 to the caudal L5 end plate | 43–61 |
| Thoracic kyphosis (TK) | Angle from the superior end plate of T4 to the inferior end plate of T12 | 41–48 |
| C7 plumb line | Distance from a vertical line drawn from the center of the C7 vertebral body to the inferior-posterior corner of the body of L5 | <3 cm |

[a]Values are means from studies including adult subjects aged 20 to 85 years who did not have any symptoms or history suggestive of spinal disease [1,2,11,12,15,28,29,40,42,46,50,52,53].

[b]Studies evaluating PI in men and women have generally not found a difference in the mean value [33,50]. One found that the mean PI for women was 48° and for men was 53° [29]. Another found a mean PI of 56° for women and 53° for men [53].