Signature: © Pol J Radiol, 2017; 82: 287-292
DOI: 10.12659/PJR.899975

Polish Journal of Radiology
www.PolRadiol.com
CASE REPORT

Received: 2016.06.08
Accepted: 2016.09.05
Published: 2017.05.28

Importance of Radiological Evaluation of Global Spinal Balance Together with Lower Limb Alignment in Planning Lumbar Spine Deformity Surgery – Illustrative Case Presentation

Mariusz Głowacki[1,2ABCDEF], **Jerzy Walecki**[3ACDEF], **Przemysław Kołakowski**[2ABDE], **Danuta Kolońska**[4BDE]

[1] Department of Neurosurgery, Mossakowski Medical Research Centre, Polish Academy of Sciences, Warsaw, Poland
[2] Department of Neurosurgery, St. Elisabeth Hospital, Warsaw, Poland
[3] Department of Radiology, Medical Centre for Postgraduate Education, Warsaw, Poland
[4] Department of Neurosurgery, 2nd Medical Faculty, Medical University of Warsaw, Warsaw, Poland

Author's address: Mariusz Głowacki, Department of Neurosurgery, St. Elisabeth Hospital, Goszczynskiego 1 Str., 02-616 Warsaw, Poland, e-mail: mariuszglowacki71@gmail.com

Authors' Contribution:
A Study Design
B Data Collection
C Statistical Analysis
D Data Interpretation
E Manuscript Preparation
F Literature Search
G Funds Collection

Summary

Background: The presented case illustrates the critical role of a detailed preoperative radiological evaluation in complex spine surgery.

Case Report: A 49-year-old patient was admitted for a revision surgery after L3–L5 fusion. Preoperative assessment showed preserved sagittal balance, coronal imbalance and valgus knee deformity. The patient reported pain of 8–10 in VAS (Visual Analogue Scale) and had an ODI (Oswestry Disability Index) of 60%. The first step of the surgery was L2–S1 fusion with decompression and spine deformity correction. The second step involved anti-valgus osteotomy of the right tibial bone.

Conclusions: The assessment of global spinal balance together with lower extremity alignment should be strongly recommended.

MeSH Keywords: Joint Deformities, Acquired • Pelvis • Spine

PDF file: http://www.polradiol.com/abstract/index/idArt/899975

Background

Global spinal balance depends on both lumbar lordosis and thoracic kyphosis, when taking into account the anatomy of the pelvis, its shape and position defined by pelvic parameters. As regards pelvic parameters, the analysis of lower limb alignment is also very important for the final result of spinal deformity surgery. In the case of a pathological spinal shape, different mechanical compensations may be activated. When the spine remains flexible, it can compensate for the pathology on its own (i.e. hyperextension above or below). When the spine is rigid, the only way of compensation is pelvic rotation. Hip extension is a limiting factor. Flexion of the knees may occur when hip extension is overpassed [3]. Currently, a detailed preoperative radiological analysis of pelvic parameters, as defined by pelvic incidence (PI), pelvic tilt (PT) and sacral slope (SS), has become a standard practice in spine surgery. In our opinion, the alignment of lower limbs should also be included in this analysis.

The presented case shows that spine surgery in some patients should be coupled with a surgical correction of lower limb alignment, for which preoperative radiological evaluation is critical.

Case Report

Patient

49 years of age, operated in another centre due to L4/L5, L5/S1 disc herniation with spinal stenosis and deformation

in the form of rotation and scoliosis. Figure 1 shows a spine radiograph before the first surgical treatment. The first surgery included transpedicular L3–L5 stabilization with a decompression at L4/L5 and L5/S1 levels, without interbody fusion. After 2 months, the patient reported to our centre with severe lumbar pain radiating to the right lower limb (Figure 2). The imaging studies (CT, MR) showed loosening around all screws that was causing damage of the L4 and L5 vertebral bodies and progression of the deformity. To evaluate pain and the level of disability, two commonly used scales were applied. Visual Analogue Scale (VAS) is the most common scale used to evaluate the level of pain. VAS is presented as a 100-cm long, straight horizontal line, where higher scores indicate a greater pain intensity (no pain – 0, worst possible pain – 10). Oswestry Disability Index (ODI) is the gold standard for measuring the level of disability in patients with low back pain. This self-completed questionnaire contains 10 topics concerning different aspects of life. Each question is scored, all answers are summed and then multiplied by two to obtain the index (0–100). Zero means no disability and 100 is the maximal possible disability. On admission, the clinical evaluation revealed a VAS score of 8–10 (the highest scores of pain), ODI was 60% (severe disability), and there was a motor deficit in the right lower extremity (4/5 in Lovett scale) along with sensory impairment mainly in the L5 dermatome.

Radiological evaluation

Radiographs in the free-standing position encompassing the area from the C1 vertebra to the femoral heads in the AP (anteroposterior) and lateral views were taken. Moreover, a full radiograph of the lower extremities was taken. The sagittal balance assessment revealed PT (Pelvic Tilt) of 11, PI (Pelvic Incidence) of 40, LL (Lumbar Lordosis) of 50 (before surgery app. 47), Cobb angle of 13 with incorrect pelvis positioning (Figure 2). An additional radiological assessment showed a valgus knee deformity (Figure 3A).

Surgery

Initially, the patient was qualified for a revision spine surgery. Instrumented L2–S1 fusion, restorative surgery with interbody fusion (TLIF – Transforaminal Lumbar Interbody Fusion) and a partial correction of the spine in the coronal plane had been performed. Osteotomy of the right lower extremity was performed 7 months after the spine surgery (Figure 3B).

Results

Six months after the surgery, the patient improved partially with a VAS score of 5–6 and an ODI of 40% (moderate disability). There were episodes of severe back pain with a VAS score up to 10. The coronal imbalance of the spine was maintained with an incorrect pelvis position. At that moment, the patient underwent osteotomy of the right lower extremity to correct the valgus deformity. Twelve months after the revision surgery, the patient fully recovered with a VAS score of 0–1 (almost no pain) and an ODI of 10% (minimal disability). A follow-up radiograph showed a preserved optimal sagittal balance (PT 11, PI 41, LL 48) and improved coronal balance (Figure 4)

Discussion

Recently, there has been a growing interest regarding the importance of sagittal balance in clinical practice [3,6–8]

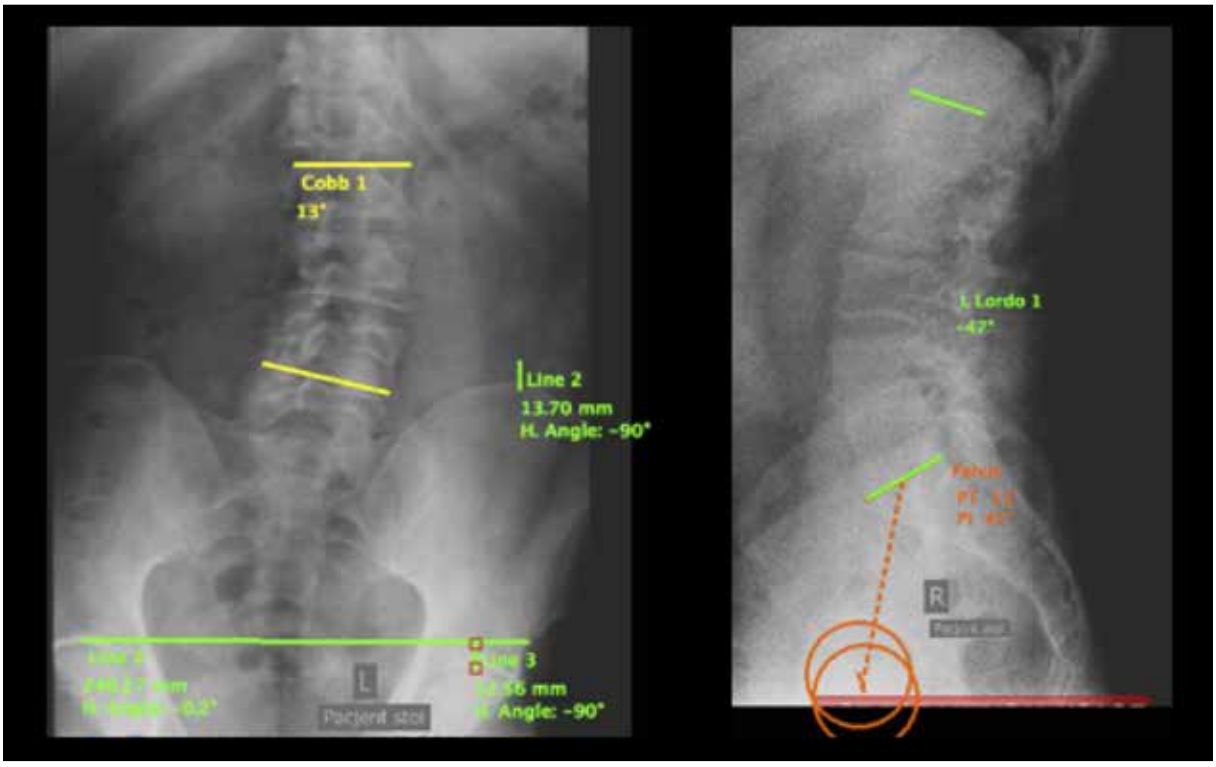

Figure 1. Lumbar spine – lateral and AP radiographs before treatment.

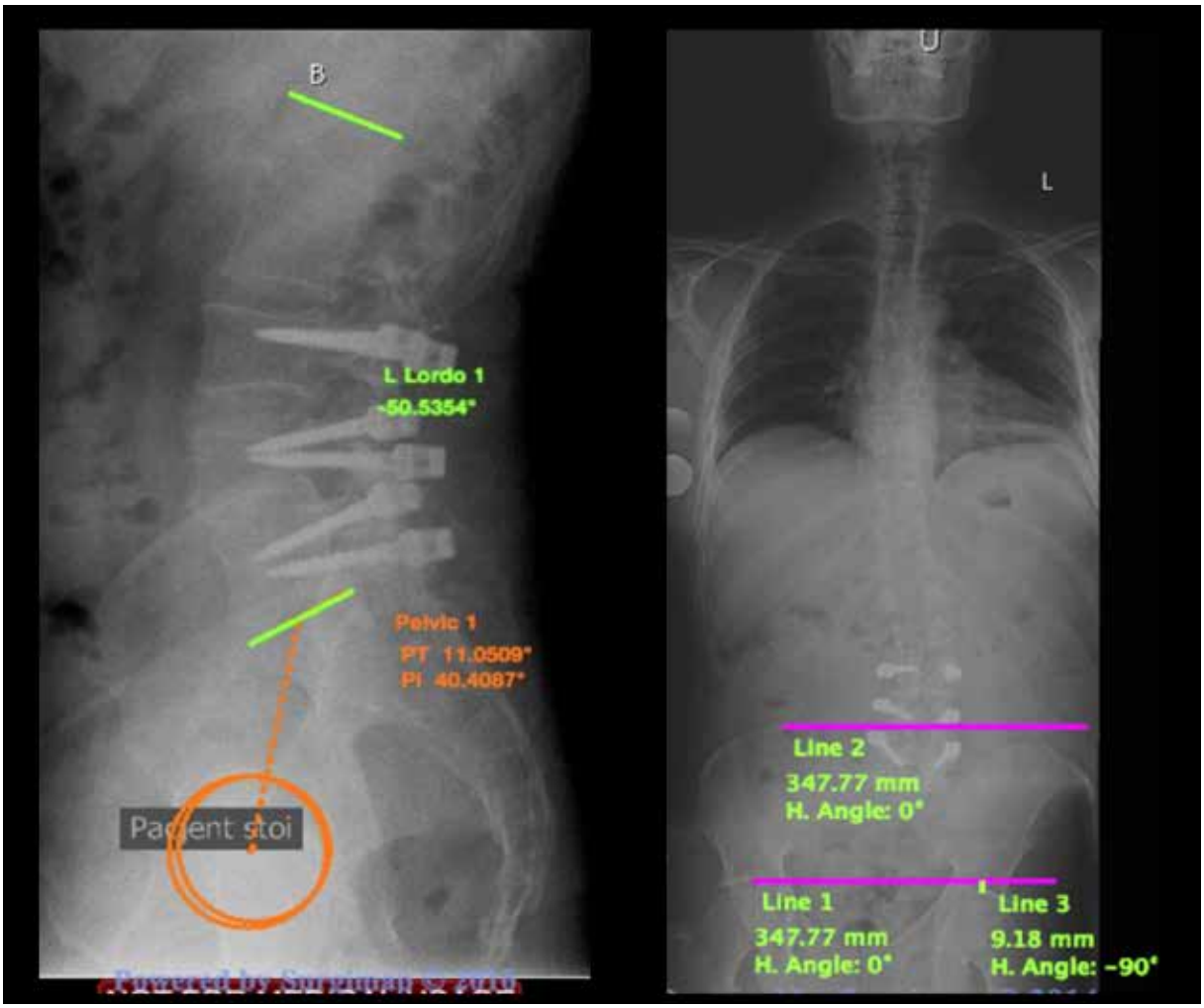

Figure 2. Lumbar spine – lateral and whole spine AP radiographs after the first surgery, before revision.

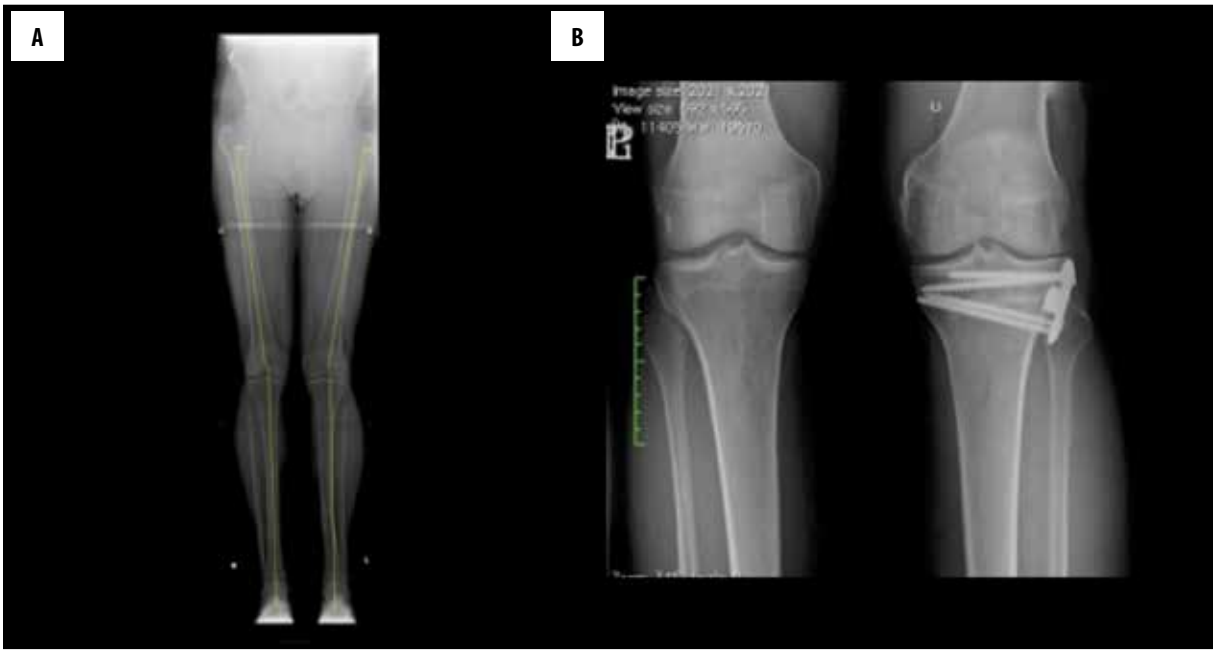

Figure 3. (**A**) Lower limb radiograph before osteotomy. (**B**) Lower limb radiograph after osteotomy.

Figure 4. Whole spine AP and lateral radiographs 14 months after surgery.

The evaluation of sagittal balance is based mainly on the measurements of the spinopelvic parameters. The pelvis is the most important link between the lower extremities and the spine and regulates the overall body balance. Being a „pedestal of the spine" [5,6], the measurements of the morphological parameters of the pelvis are crucial [1,3,5,8]. There are 3 parameters used for the evaluation of the pelvis: Pelvic Incidence (PI), Pelvic Tilt (PT) and Sacral Slope (SS) that are interrelated by the following formula: PI=PT+SS. PI is a fixed parameter that defines the orientation of the sacrum to the ilium. In asymptomatic cases, patients with a small PI have a vertical sacrum with a short and small lumbar lordosis (LL). In contrast, patients with a large PI have a horizontal sacrum with a large and long LL. This concept has been widely described in the literature [1,3–5]. The pelvis rotates around the femoral heads and its orientation in the sagittal plane is defined by both PT and SS. Among the very important parameters that have to be measured on spine radiographs are lumbar lordosis (LL) and thoracic kyphosis (TK). To assess the

global sagittal alignment, the measurement of sagittal vertical axis (SVA) is important. This parameter is defined by a horizontal offset from a plumb line dropped from the C7 vertebra to the posterosuperior corner of the sacral plate. SVA is very sensitive to any deviation of spinal curvature but is affected by patient position [9]. Recently, parameters that are not affected by patient position have been introduced. They include the spinosacral angle (SSA), defined as the angle between the C7/S1 vertebrae and the sacral inclination, and the T1 pelvic angle (TPA), which is the angle between a line drawn from the femoral heads to the centre of the T1 vertebra and a line drawn from the femoral heads to the centre of the sacral endplate [10–12].

Lower limbs are of crucial importance to the global body balance and sagittal alignment. There is a chain of actions and counteractions between the elements above and below the pelvis. The femoral heads carry the load from the spine and pelvis. That gives the knees an important role in compensating for spinopelvic malalignments [2,13,14]. The musculoskeletal system uses spinopelvic compensatory abilities in response to a change in segmental or global alignment. Those compensatory mechanisms, including the lower limbs, maintain the gravity line. A common compensation mechanism is knee flexion. Some studies reported of the „knee-spine syndrome" that explains the loss of lumbar lordosis compensating for osteoarthritic knee joints with a loss of extension. The close link between knees and sagittal alignment requires a detailed analysis of knee pathology in order to confirm whether it is primary or secondary [15,16]. In the presented case, when planning the initial surgical treatment, the global spine alignment and the knee joint pathology were not evaluated. It is highly likely that if those pathologies had been addressed at the beginning, the patient would have avoided serious complications and unnecessary surgery.

The analysis of sagittal balance should not be limited to a simple analysis of the free-standing lateral spine images. The position of the hips and knees is essential to the interpretation of global balance and one should integrate the measurements [2,4,7,13–16]. In every patient, a comprehensive assessment of the complex comprising the spine, pelvis and lower limbs is essential for understanding adaptation mechanisms induced by the imbalance secondary to disorders of the spine or lower limbs. Measurements of the radiographic spinopelvic parameters of sagittal balance are used in order to prevent functional disability and are now part of routine practice in planning surgical strategies for degenerative spinal diseases [1–8] As radiographs are fundamental to the analysis of global balance, the position of the patient is essential. In the literature, the free-standing position is recommended with elbows flexed and fingertips cantered in the supraclavicular fossa. The patient should be without external support and with knees relaxed (there are no suggestions to extend the knees). Those rules pertain not only to the assessment of global alignment but also to the evaluation of all compensatory mechanisms used to maintain gravity balance [17]. Currently, the importance of flexion-extension radiographs for quantifying instability is questionable [18] and full body imaging will become more significant. A recently introduced imaging technology, i.e. EOS, provides head-to-toe imaging with a reduced dose of radiation and an improved visibility of all deformities and compensatory mechanisms. It is a new radiological method used for a better and safer evaluation of patients with spinal diseases. The increased use of full body radiographs will significantly improve surgical planning and strategies for the treatment of spinal pathologies.

Conclusions

The presented case study showed the clinical importance of an extended analysis of global body balance in planning spinal interventions.

The assessment of coronal and sagittal balance combined with the evaluation of lower limb alignment helps to achieve better results in the surgical treatment of spine deformities, with a possible avoidance of serious iatrogenic complications. It is strongly recommended to complement the diagnosis and assessment of spinal sagittal and coronal balance with the analysis of the lower limbs, which also have a significant impact on the whole body posture and the global balance of the spine.

Proposed preoperative patient assessment guideline:
- Radiographic sagittal balance analysis – lumbar lordosis, pelvic parameters etc.;
- Coronal balance analysis – Cobb angle, pelvis;
- Lower extremity measurements;
- Functional radiograph – biomechanical assessment – still questionable. In future, an improved accessibility of better imaging methods, e.g., EOS, will help with the assessment of global body balance.

References:

1. Legaye J, Duval-Beaupe're G, Hecquet J et al: Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. Eur Spine J, 1998; 7: 99–103
2. Lazennec JY, Riwan A, Gravez F et al: Hip spine relationships: Application to total hip arthroplasty. Hip Int, 2007; 17: 91–104
3. Roussouly P, Gollogly S, Berthonnaud E, Dimnet J: Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis. Spine, 2005; 30: 346–53
4. Schwab F, Lafage V, Boyce R et al: Gravity line analysis in adult volunteers: Age-related correlation with spinal parameters, pelvic parameters, and foot position. Spine, 2006; 31(25): E959–67
5. Le Huec JC, Aunoble S, Philippe L, Nicolas P: Pelvic parameters: Origin and significance. Eur Spine J, 2011; 20(Suppl. 5): S564–71
6. Le Huec JC, Charosky S, Barrey C et al: Sagittal imbalance cascade for simple degenerative spine and consequences: Algorithm of decision for appropriate treatment. Eur Spine J, 2011; 20(Suppl. 5): 699–703
7. Barrey C, Roussouly P, Le Huec JC et al: Compensatory mechanisms contributing to keep the sagittal balance of the spine. Eur Spine J, 2013; 22(Suppl. 6): S834–41
8. O'Shaughnessy BA, Ondra SL: Measuring, preserving, and restoring sagittal spinal balance. Neurosurg Clin N Am, 2007; 18: 347–56
9. Jackson RP, McManus AC: Radiographic analysis of sagittal plane aligment and balance in standing volunteers and patients with low back pain matched for age, sex and size. A prospective controlled clinical study. Spine (Phila Pa 1976), 1994; 19: 1611–18

10. Roussouly P, Gollogly S, Noseda O et al: The vertical projection of the sum of the ground reactive forces of a standing patient is not the same as the C7 plumb line: A radiographic study of the sagittal alignment of 153 asymptomatic volunteers. Spine (Phila Pa 1976), 2006; 31(11): E320–25
11. Mac-Thiong JM, Roussouly P, Berthonnaud E, Guigui P: Sagittal parameters of global spinal balance: Normative values from a prospective cohort of seven hundred nine Caucasian asymptomatic adults. Spine (Phila Pa 1976), 2010; 35(22): E1193–98
12. Protopsaltis TS, Schwab FJ, Bronsard N et al: The T1 Pelvic Angle (TPA) a novel radiographic measure of global sagittal deformity, accounts both spinal inclination and pelvic tilt and correlates with health-related quality of life. J Bone Joint Surg Am, 2014; 96: 1631–40
13. Sugama R, Minoda Y, Kobayashi A et al: Sagittal alignment of the lower extremity while standing in female. Knee Surg Sports Traumatol Arthrosc, 2011; 19: 74–79
14. Minoda Y, Kobayashi A, Iwaki H et al: Sagittal alignment of the lower extermity while standing in Japanese male. Arch Orthop Trauma Surg, 2008; 128: 435–42
15. Obeid I, Hauger O, Aunoble S et al: Global analysis of sagittal spine alignment in major deformities: correlation between lack of lumbar lordosis and flextion of the knee. Eur Spine J, 2011; Suppl. 5: 681–85
16. Murata Y, Takahashi K, Yamagata M et al: The knee-spine syndrome. J Bone Jt Surg, 2003; 85: 95–99
17. Horton WC, Brown CW, Bridwell KH et al: Is there an optimal patient stance for obtaining a lateral 36″ radiograph? A critical comparison of threetechniques. Spine (Phila Pa 1976), 2005; 30: 427–33
18. Camara JR, Keen JR, Asgarzadie F: Functional radiography in examination of spondylolisthesis. Am J Roentgenol, 2015; 204(4): W461–69