



The Influence of Posteriorosteotomy on Spinopelvic Parameters Indegenerative Lumbar Kyphosis Patients

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Abstract

Objective: To investigate the influence of posterior osteotomy on spinopelvic parameters in degenerative lumbar kyphosis (DLK) patients.

Methods: 15 cases from January 2010 to June 2015 who had undergone osteotomy were retrospectively analyzed, 4 cases were male, 11 cases were female; average age were 62 years (55 to 73 years), all patients had taken preoperative hole line spinal X-ray, spinopelvic parameters were analyzed.

Results: 15 patients were operated successfully, the average operative time was 190 min (160 to 220 min), the average intraoperative blood loss 1000 ml (800 to 1900 ml). Mean preoperative lumbar lordosis (LL) improved from $1.7 \pm 9.2^\circ$ to $33.7 \pm 7.2^\circ$, and thoracic kyphosis (TK) improved from $25.9 \pm 9.2^\circ$ to $31.2 \pm 10.7^\circ$. Mean pelvic tilt (PT) reduced from $33.6 \pm 9.4^\circ$ to $26.1 \pm 8.2^\circ$, and sacral slope (SS) improved from $14.1 \pm 9.3^\circ$ to $26.7 \pm 11.2^\circ$. Sagittal balance improved from 11.5 ± 9.0 cm to 3.3 ± 2.9 cm. There was significant difference of spinopelvic parameters between preoperation and postoperation ($P < 0.05$).

Conclusion: The change of spinopelvic parameters following posterior osteotomy in DLK patients is closely related with the reconstruction of LL and SS.

Keywords: Degenerative; Lumbar kyphosis; Osteotomy; Spinopelvic parameters

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Introduction

Degenerative lumbar kyphosis (DLK) is considered a sagittal imbalance due to lumbar kyphosis or marked loss of lumbar lordosis, caused by lumbar degenerative changes [1]. Disruption of the normal sagittal alignment can impair walking and cause pain as a result of spinal imbalance. Increased stress is placed on the spinal dynamic stabilizers, resulting in muscle fatigue and increased energy consumption during walking. Many different factors need to be addressed to determine the treatment of imbalance of the spine in the sagittal plane, including the degree of imbalance, flexibility of the curve, and whether the deformity is segmental or global [2,3]. The spinopelvic parameters play an important role in reconstruction of sagittal balance [4]. To our knowledge, few reports to analyze the influence of posterior osteotomy on spinopelvic parameters in DLK patients. We retrospectively reviewed 15 cases with DLK from January 2010 to June 2015 who had undergone osteotomy in our hospital, to investigate the influence of posterior osteotomy on spinopelvic parameters in DLK patients.

Materials and Methods

Patient population

A retrospective study was performed on 15 adult patients (4 men and 11 women). Average age was 62 years (range, 55-73 yr). All patients had persistent or frequently recurring back pain and unstable gait. Complete radiographic evaluations of the 15 patients using standing lateral, dynamic and bending radiograph of the entire spine, computed tomography and magnetic resonance imaging.

Measurements of spinopelvic parameters

The following parameters were measured on standing lateral radiographs [5,6] (Figure 1). Sagittal vertical axis (SVA) was defined as horizontal distance between the posterior corner of the sacrum and the C7 plumb line (C7PL). Thoracic kyphosis (TK) was measured using the Cobb

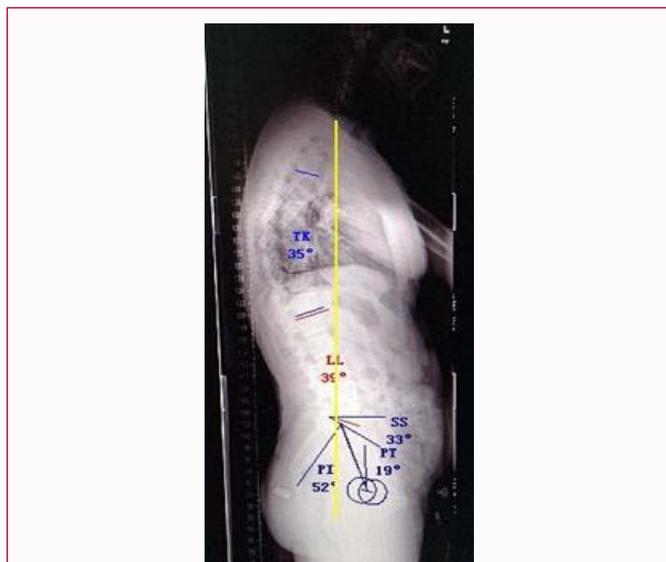


Figure 1: Diagram of spinopelvic parameters measured on spinal lateral X-ray. SVA means the vertical dimension between C7 plumb line and the posterior corner of S1. TK means the Cobb angle from the upper endplate of T5 to the lower endplate of T12. LL means the Cobb angle from the upper endplate of L1 to the upper endplate of S1. PI means the angle between the line connecting the center of the upper endplate of S1 and the center of the femoral head and the line perpendicular to the upper endplate of S1. SS means the angle between the upper endplate of S1 and the horizontal line. PT means the angle between the line connecting the center of the upper endplate of S1 and the center of the femoral head and the plumb line.

method between T5 and T12, and lumbar lordosis (LL) was measured between L1 and S1. Pelvic incidence (PI) was defined as the angle between the perpendicular line from the sacral plate and the line connecting the midpoint of the sacral plate to the bicoxofemoral axis. Pelvic tilt (PT) corresponds to the angle between the line connecting the midpoint of the sacral plate to the bicoxofemoral axis and the vertical plane. Sacral slope (SS) corresponds to the angle between the sacral plate and the horizontal plane.

Operative technique

Six patients were under taken multiple Smith-Petersenosteotomies (SPOs); nine patients were under taken pedicle subtraction osteotomy (PSO). Along, rounded, smooth kyphosis, especially with a previous fusion and malunion, is often an ideal candidate for multiple SPOs, and the ideal candidates for PSO are those patients with a substantial sagittal imbalance, or those patients with a sharp, angular kyphosis [7]. Sometimes a single PSO will not afford enough correction; therein, one might consider coupling this with 1 or 2 SPOs.

Smith-petersen osteotomy

Patients are taken prone position, and midline incision of the

spine are taken to expose the lamina and facet joint of the surgical segment. Before the osteotomy is begun, pedicle screws should be placed cephalad and caudad to the intended osteotomy site because they will be used to help secure and stabilize the spine after the osteotomy. Bone from the upper and lower lamina, facet joint can be removed using high-speed drilling and curette while protecting the thecal sac and nerve roots, 2-3 level SPOs are done by the same way. The osteotomy site can be closed with manual help of an assistant or by hyperextending the chest and legs with operating table. Then rods are been positioned and locked.

Pedicle subtraction osteotomy

The position of the patient, and screws insertion are the same as SPO. The PSO technique requires that all of the posterior elements (spinous process and lamina) at the level of the osteotomy be removed. Bone from the vertebral body can be removed using high-speed drilling and curette while protecting the thecal sac and nerve roots. Osteotomy is done circumferentially including the lateral walls of the vertebral body without violating its ventral aspect. The osteotomy site can be closed with manual help of an assistant or by hyperextending the chest and legs with operating table. Then rods are been positioned and locked.

Statistical analysis

Statistical analysis was carried out using Student *t* test based on SPSS 16.0 software. A *P* value less than 0.05 was considered statistically significant.

Results

Surgical results and complications

Average operative time was 190 minutes (range, 160–220 min). Average blood loss was 1000 mL (range, 800–1900 mL). Overall, there were 3 complications in 3 patients (3/15). Intraoperatively, there were 3 dural tear that was repaired primarily and did not result in adverse sequelae. No early complications, such as neurological deficit, infection, and epidural hematoma, were observed. Delayed complications, such as internal fixation loosening, breakage and pseudarthrosis were not observed in the follow up.

Radiographical results

Mean preoperative lumbar lordosis (LL) improved from 1.7±9.2° to 33.7±7.2°, and thoracic kyphosis (TK) improved from 25.9±9.2° to 31.2±10.7°. Mean pelvic tilt (PT) reduced from 33.6±9.4° to 26.1±8.2°, and sacral slope (SS) improved from 14.1±9.3° to 26.7±11.2°. Sagittal balance improved from 11.5±9.0cm to 3.3±2.9cm. There was significant difference of spinopelvic parameters between preoperation and postoperation (*P*<0.05) (Table 1) (Figure 2).

Discussion

Pelvic incidence (PI, PT, SS), which considered to effect

Table 1: Pre-op and post-op radiographical data measurement of 15 patients ($\bar{x} \pm s$).

	Pre-operation	Post-operation	P
LL(°)	1.7±9.2	33.7±7.2	<0.05
TK(°)	25.9±9.2	31.2±10.7	<0.05
PI(°)	52.1±12.7	51.5±11.2	NS
PT(°)	33.6±9.4	26.1±8.2	<0.05
SS(°)	14.1±9.3	26.7±11.2	<0.05
SVA(cm)	11.5±9.0	3.3±2.9	<0.05

NS: Not significant.

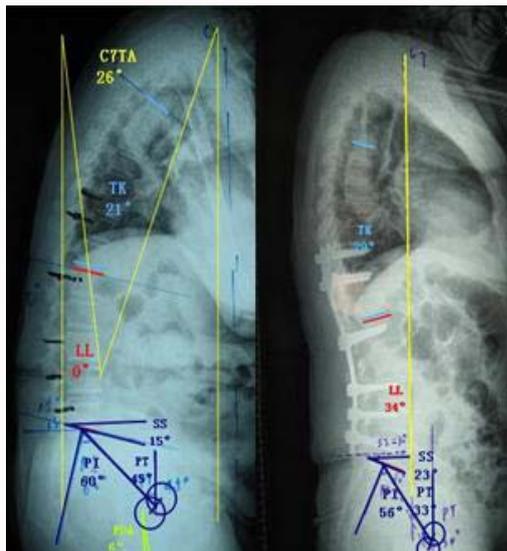


Figure 2: a) 69-year-old woman with degenerative lumbar kyphosis. a. Preoperative lateral view of total line X-ray showed PI, PT, SS, TK, LL and SVA were 60°, 45°, 15°, 21°, 0° and 18cm, respectively. b) Preoperative lateral view of total line X-ray showed PI, PT, SS, TK, LL and SVA were 56°, 33°, 23°, 29°, 34° and 6cm, respectively.

sagittal balance of the spine, was first described by Legaye et al [8]. The importance of pelvic incidence in spinopelvic balance has been emphasized [4-6]. Pelvic incidence (PI) is an anatomic pelvic parameter in describing the anatomic morphology of the pelvis; pelvic tilt (PT) and sacral slope (SS) are postural parameters in describing the position of the pelvis in sagittal plane. Patient with a more anteriorly rotated pelvis have a larger sacral slope and a smaller pelvic tilt, while, a more posteriorly rotated pelvis have a larger pelvic tilt and a smaller sacral slope [9]. In this study, the mean lumbar lordosis and sacral slope of 15 DLK patients were decreased; pelvic tilt and sagittal vertical axis were increased. The pelvis can be retroverted, resulting in a decreased sacral slope, lumbar lordosis and an increased pelvic tilt to compensate for the sagittal imbalance in DLK patients. However, it will be decompensate if beyond its compensatory ability. Our study showed lumbar lordosis (LL) improved from $1.7 \pm 9.2^\circ$ to $33.7 \pm 7.2^\circ$, sacral slope (SS) improved from $14.1 \pm 9.3^\circ$ to $26.7 \pm 11.2^\circ$, pelvic tilt (PT) reduced from $33.6 \pm 9.4^\circ$ to $26.1 \pm 8.2^\circ$, was consistent with Debarge's research [10].

Despite the complex relationship between the spinal sagittal balance and spinopelvic parameters, the general principles to correct sagittal imbalance of the spine is to restore spinal alignment (lumbar lordosis) by osteotomy, in order to obtain nearly normal range of sagittal vertical axis (SVA) and pelvic tilt (PT). Rotation of the pelvis and lumbar lordosis in sagittal plane are an important compensatory mechanism for sagittal balance [11]. Sacral slope indicates the position of the pelvis in sagittal plane. Patients with a more anteriorly rotated pelvis have a larger sacral slope and a greater degree of lumbar lordosis. Patients with a lesser degree sacral slope and a greater degree of lumbar lordosis. Patients with a lesser degree of lumbar lordosis have a decreased sacral slope because of retroversion of the pelvis to maintain sagittal balance. This study showed that surgical restoration of lumbar lordosis would lead to anteroversion of the pelvis. As a result, both the thoracic curve and the sacral angle could return to their normal range after surgically restored lumbar lordosis. Therefore, strong compensatory mechanisms for both the thoracic

spine and the pelvis could be a favorable factor in the treatment of DLK [12]. Lafage et al [13] noted that 70 patients underwent lumbar PSO surgery for spinal imbalance, found LL was correlated with change in SS and PT. Cho et al [14] compared three or more SPOs to one pedicle subtraction procedure; the correction in lumbar lordosis was nearly identical. In this study, the LL improved from $1.7 \pm 9.2^\circ$ to $33.7 \pm 7.2^\circ$, PT reduced from $33.6 \pm 9.4^\circ$ to $26.1 \pm 8.2^\circ$ and SS improved from $14.1 \pm 9.3^\circ$ to $26.7 \pm 11.2^\circ$ after surgery, indicated that LL could be well reconstructed by SPOs and PSO. For the purpose of accommodate the new sagittal balance of the spine, the body try to reduce PT and increase anteriorly rotation of pelvis to restore the SVA. In this group, all 15 patients were obtained satisfactory sagittal balance, and intractable back pain was significantly relieved after surgery.

The range of fixation in DLK patients can be refer to idiopathic scoliosis theoretically. A fixed area should be usually began with neutral vertebral and end in stable vertebral, avoid inrigid tilt or rotate subluxation of adjacent segment in coronal and sagittal plane. Upper instrumented vertebra (UIV) is still undefined in DLK patients. Generally, fusion should be considered, if there is a structural kyphosis in thoracolumbar, for fear of secondary kyphotic deformities. The UIV should be chosen carefully, particularly in elderly female DLK patients with osteoporosis [15,16]. In long segment fixation, the following issues should be considered in UIV select: risk factors of progression kyphosis in radiographs, such as the Cobb angle is more than 30° , severe osteoporosis; UIV+1 rotation more than 1° , instability in coronal and sagittal plane; UIV+1 disc degeneration. The apex vertebrae of DLK patients often located in L2 or L3; therefore, lower instrumented vertebra (LIV) should not be terminated in L3 or L4. Usually, L5/S1 is with varying degrees of disc degeneration, which makes more difficult to determine the LIV of DLK patients. We usually believe that there is no need to fusion the sacrum. If one of the following situations of L5/S1 is existed, fusion should be down to the sacrum: clinical symptoms or signs; spondylolisthesis; spinal stenosis; disc degeneration; instability; severe facet joint degeneration. Edwards et al. [17,18] observed 27 adult deformity patients that underwent fusion from the thoracic spine to L5, at 5-year follow-up, 67% of L5 patients had radiographic evidence of advanced L5/S1 disc degeneration. Evaluation of the disc height of L5/S1 in elderly DLK patients should be particularly careful, because of high incidence of L5/S1 malunion and pseudarthrosis, by reported from 5% up to 30%. In order to improve L5/S1 fusion rate, Eck et al. [19] suggested: fixation should be done from middle lumbar vertebral to sacrum; S1, S2 pedicle screw and iliac screw fixation should be done to protect S1 screw; bilateral cortical bone screw fixation in S1; sagittal balance should be in neutral or negative status; anterior bone graft should be implanted; autologous bone graft should be used in L5/S1 fusion.

Although, successful in achieving good outcomes of posterior osteotomy in the treatment of DLK patients, postoperative complications should be emphasized. As so far, no serious postoperative complications were observed in these 15 patients, but the potential complications, such as proximal junctional kyphosis (PJK), internal fixation loosening and breakage cannot be ignored in long-term follow-up. PJK may occur in patients with short segmental fixation after surgery. And DLK patients usually with varying degrees of osteoporosis, long segmental fixation will undoubtedly increase the risk of screw loosening, even pseudarthrosis. Therefore, long-term follow-up is needed.

References

1. Jang JS, Lee SH, Min JH, Han KM. Lumbar degenerative kyphosis: radiologic analysis and classifications. *Spine*. 2007; 32: 2694-2699.
2. Gill JB, Levin A, Burd T, Longley M. Corrective osteotomies in spine surgery. *J Bone Joint Surg Am*. 2008; 90: 2509-2520.
3. Le Huec JC, Aunoble S. Pedicle subtraction osteotomy for sagittal imbalance. *Eur Spine J*. 2012; 21: 1896-1897.
4. Lee JH, Kim KT, Suk KS, Lee SH, Jeong BO, Kim JS, et al. Analysis of spinopelvic parameters in lumbar degenerative kyphosis: correlation with spinal stenosis and spondylolisthesis. *Spine*. 2010; 35: 1386-1391.
5. Rose PS, Bridwell KH, Lenke LG, Cronen GA, Mulconrey DS, Buchowski JM, et al. Role of pelvic incidence, thoracic kyphosis, and patient factors on sagittal plane correction following pedicle subtraction osteotomy. *Spine*. 2009; 34: 785-791.
6. Bae JS, Jang JS, Lee SH, Kim Ju. Radiological analysis of lumbar degenerative kyphosis in relation to pelvic incidence. *Spine J*. 2012; 12: 1045-1051.
7. Bridwell KH. Decision making regarding Smith-Petersen vs. pedicle subtraction osteotomy vs. vertebral column resection for spinal deformity. *Spine*. 2006; 31:171-178.
8. Legaye J, Duval-Beaupère G, Hecquet J, Marty C. Pelvic incidence: a fundamental pelvic parameter for three-dimensional regulation of spinal sagittal curves. *Eur Spine J*. 1998; 7: 99-103.
9. Jang JS, Lee SH, Min JH, Maeng DH. Influence of lumbar lordosis restoration on thoracic curve and sagittal position in lumbar degenerative kyphosis patients. *Spine*. 2009; 34: 280-284.
10. Debarge R, Demey G, Roussouly P. Radiological analysis of ankylosing spondylitis patients with severe kyphosis before and after pedicle subtraction osteotomy. *Eur Spine J*. 2010; 19: 65-70.
11. Barrey C, Roussouly P, Perrin G, Le Huec JC. Sagittal balance disorders in severe degenerative spine. Can we identify the compensatory mechanisms? *Eur Spine J*. 2011; 20: 626-633.
12. Jang JS, Lee SH, Kim JM, Min JH, Han KM, Maeng DH. Can patients with sagittally well-compensated lumbar degenerative kyphosis benefit from surgical treatment for intractable back pain? *Neurosurgery*. 2009; 64: 115-121.
13. Lafage V, Schwab F, Vira S, Hart R, Burton D, Smith JS, et al. Does vertebral level of pedicle subtraction osteotomy correlate with degree of spinopelvic parameter correction? *J Neurosurg Spine*. 2011; 14: 184-191.
14. Cho KJ, Bridwell KH, Lenke LG, Berra Annette BA, Baldus Christy RN. Comparison of Smith-Petersen versus pedicle subtraction osteotomy for the correction of fixed sagittal imbalance. *Spine*. 2005; 30: 2030-2037.
15. Gupta MC. Degenerative scoliosis options for surgical management. *Orthop Clin North Am*. 2003; 34: 269-279.
16. Kwon BK, Elgafy H, Keynan O, Fisher CG, Boyd MC, Paquette SJ, et al. Progressive junctional kyphosis at the caudal end of lumbar instrumented fusion: etiology, predictors, and treatment. *Spine*. 2006; 31: 1943-1951.
17. Edwards CC, Bridwell KH, Patel A, Rinella AS, Berra A, Lenke LG. Long adult deformity fusions to L5 and the sacrum. A matched cohort analysis. *Spine*. 2004; 29: 1996-2005.
18. Bridwell KH, Berven S, Edwards C, Glassman S, Hamill C, Schwab F. The problems and limitations of applying evidence-based medicine to primary surgical treatment of adult spinal deformity. *Spine*. 2007; 32: 135-139.
19. Eck KR, Bridwell KH, Ungacta FF, Riew KD, Lapp MA, Lenke LG, et al. Complications and results of long adult deformity fusions down to L4, L5, and the sacrum. *Spine*. 2001; 26: 182-192.