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Sagittal Balance Improvement in Surgical Treatment of Low-Grade Isthmic Lumbosacral Spondylolisthesis

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Abstract

Background Data: The role of surgical correction of sagittal plane deformity in cases of lytic spondylolisthesis is essential. While evidence is emerging of the possible short- and long-term benefits of restoring spinal balance, some surgeons have been concerned about the associated risks especially if instrumentation has to be used for reduction of the slipping.

Purpose: To evaluate the Sagittal Balance improvement in surgical Treated Low-grade Isthmic Lumbosacral Spondylolisthesis

Study Design: Prospective clinical case study

Patients and Methods: Twenty two patients with low-grades (<50%) of isthmic spondylolisthesis of lumbosacral junction (L5-S1) were managed by a surgical intervention aiming for correction of the deformity even with partial reduction of the slipping. Sagittal alignment at the lumbosacral junction was tried to be achieved by appropriate positioning of the patient during the surgery and by rod contouring. Posterior decompression of nerve structures by laminectomy in conjunction with posterior instrumented fusion from L5 to sacrum were also done. They were fourteen females and eight males with a mean age of 40.45 years. The mean follow up period was 20 months.

Results: All patients achieved satisfactory results as regards the back pain, radicular pain and neurologic deficits. The mean preoperative estimated values of slip percentage, L1-S1 lordosis, sacral inclination angle and lumbosacral kyphosis were 30.2%, 48.8°, 46.04°, and 35°. The mean reconstructed values were 25%, 34.9°, 36.86°, and 28° postoperative. Pelvic version improved in patients with unbalanced spondylolisthesis as evidenced by decreased sacral slope [from 46.04 degrees to 36.86 degrees] (P<0.5). All patients could return to their normal activities of daily living.

Conclusion: This study suggests that, the described technique can yield satisfactory clinical outcomes and substantial deformity correction using single posterior approach with proper patient position before surgery. (2013ESJ040)

Key Words: isthmic spondylolisthesis, low grade, lumbosacral

Introduction

Spondylolisthesis has been recognized as a clinical entity since Herbiniaux, a Belgian obstetrician, first described it in 1782. Since then, progress has been made in defining the etiology and in treating different grades of slipping.[9] The development of isthmic spondylolisthesis is influenced by forces across the lumbosacral region of the spine.

Abnormalities of spinal curvatures frequently accompany the presence of a spondylolisthesis and they may play a significant role in the pathogenesis of the disease. Also, spinopelvic morphology and dysplasia have a role and can determine progression.[18] Patients with sagittal imbalance cannot walk or stand erect without overwork of musculature and the result is muscle fatigue and activity-related pain.[10] Spondylolisthesis had always been manifested by combined axial and radicular symptoms and its treatment protocols are based on age, symptomatology and slippage degree.[6] Anyhow, spinal surgery for this disorder has to focus on both neurologic objectives and segmental mechanical factors.[5]

Despite achieving strong fusion as a fundamental goal for treatment of this spinal problem, sagittal malalignment of the fused segment was suggested to be associated with degeneration of the adjacent segment.[12] Some authors, however, have reported harmful effects of poorly aligned spinal fusion.[1,7,16] Sagittal alignment should be done with the goal of minimizing muscle work during posture maintenance and avoidance of implant failure.[14] Normal sagittal alignment is difficult to define and the optimal degree of lumbar lordosis has not yet been determined.[8] So, meticulous surgical technique and particular attention to hardware positioning with the aim to restore segmental balance at the fusion level have been recommended to achieve better long-term clinical outcomes.

The objective of this study was the achievement of optimal spinal alignment in lumbosacral fusion of spondylolisthesis and to determine whether the focal kyphosis associated with a lytic lumbosacral spondylolisthesis can be safely and effectively corrected using effective positioning of the patient during single-stage posterior approach with partial reduction of the slipping, posterior decompression and L5-S1 posterior pedicle screw instrumented fusion by autogenous iliac bone grafting.

Patients and Methods

Twenty two patients with low grades (<50%) spondylolisthesis according to Meyerding's classification[11] were managed at the Suez Canal University Hospital. According to this classification, 11 patients were grade I, and 11 were grade II. Inclusion criteria, All patients had isthmic spondylolisthesis of L5/S1 level. High grades (>50%) of slipping were excluded from the study. All of patients failed to respond to non-operative treatment which consisted of administration of non-steriodal anti-inflammatory medications, narcotics, restriction of activities and the use of lumbosacral orthosis. There were 14 female and 8 male patients. The age of the patients at the time of surgery ranged from 20 to 55 years, with a mean of 40.45 years. Back or buttock pain, the constant symptom, was rated from 1 to 10 points on a visual analogue scale (VAS). The mean pre-operative back pain VAS score was 8.2 points.

Fifteen patients had radicular pain down to the thigh, leg, or foot. Radicular pain was along the fifth lumbar dermatome in 17 patients and along first sacral dermatome in 3 patients. It was bilateral in nine patients, right unilateral in four patients and left unilateral in two patients. Neural abnormalities were noted on examination in eight patients *(36* per cent). The findings were a decreased ankle reflex in three patients, a weak extensor hallucis longus in two, hyposthesia along the S1 dermatome in two and along L5 dermatome in five patients. One female patient had urgency of micturition. Positive tension signs were elicited bilaterally in three patients and in the right side in one patient.

Anteroposterior, lateral neutral standing and oblique radiograms were taken pre-operatively. The radiographic measurements included the percentage slip, lumbar lordosis (L1-S1), sacral inclination measured by sacral tilt angle (ST angle), and the lumbosacral kyphosis measured by lumbosacral angle (LSA angle). MRI study was performed all patients.

Mean preoperative slip percentage was 30.2 % (range: 15 to 50%). Mean preoperative lumbar lordosis (L1-S1) was 48.8 degrees (range: 28 to 60 degrees). The sacral tilt (inclination) angle (ST^0), measures the degree of vertical orientation of the sacrum and was defined as the angle formed by the

line tangent to the upper edge of S1 (transecting the anterior and posterior corners of S1) and the horizontal plane. A smaller ST angle indicates a more vertical sacrum and a larger ST angle indicates a more horizontal sacrum. It ranged pre-operatively from 23 to 71 degrees with an average of 46.04 degrees.

The angle of slipping (lumbosacral kyphosis or the gibbus at the level of the slipping) measures the degree of forward tilting of the fifth lumbar vertebral body over the first sacral vertebral body. The angle is formed by a line drawn parallel to the inferior aspect of the fifth lumbar vertebral body and a line drawn perpendicular to the posterior aspect of the body of the first sacral vertebra. Preoperative lumbosacral kyphosis angle ranged from 11 to 42 degrees with an average of 35°.

Surgical technique:

Under general anaethesia, the patient was placed prone on bolsters. Postural alignment of the lumbosacral segment of the spine was adjusted by appropriate flexion of both hips and knees with suitable rotation of the pelvis till an improvement of sagittal alignment was achieved and detected by x-ray. The facet joints, transverse process of L5, and the ala of the sacrum were exposed. Pedicle screw instrumentation from L5 to S1 was done and their position was checked by image intensifier. Decompressive laminectomy was performed in all patients. Bilateral L5 and S1 roots were adequately decompressed from soft tissues and bony ridges. Discectomy and adequate decortication were done to prepare the bed of interbody graft placement. Autogenous cancellous bone graft was obtained from the posterior part of the iliac crest and placed within the disc cavity. Two contoured rods were fixed to the pedicle screws after checking the position of the sacrum by an image intensifier aiming at improving sacral tilt and lumbosacral angles. (Figure 1)

The operative time ranged from 100 to 170 with an average was 115 minutes, and the blood loss ranged from 350 to 800 with an average was 400 milliliters. All patients were allowed to walk on the day after surgery using a lumbosacral brace. All patients included in this study were examined clinically and radiologically at six weeks, twelve weeks and then at three months intervals. Preoperative versus postoperative versus final follow-up values were compared using paired samples t test.

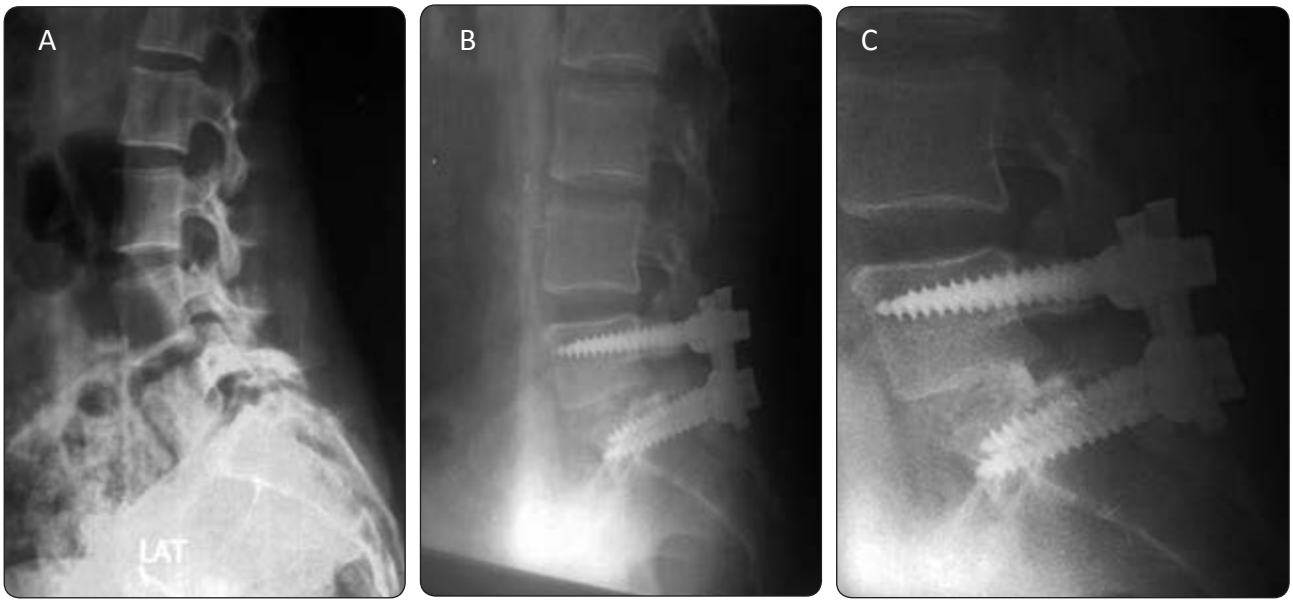

Figure 1. A: Plain X-ray lateral standing view of case with grade II isthmic spondylolisthesis of L5-S1 junction. Preoperative estimated values of lumbar lordosis, sacral tilt and slip angles were, 35, 32 and 11 degrees.
B: Postoperative X-ray lateral view with reconstructed values 29, 24, 10 degrees.
C: Plain lateral view showed intrbody bridging bone masses after 12-months postoperatively.

Results

Clinical Evaluation:

The average follow-up period was 20 months (range: 9 to 42 months). At the most recent follow-up evaluation, the mean visual score of pain was 1.59±0.157 (range: 1 to 3 points) with significant improvement (P0.001>) compared with the mean preoperative score (8.18±0.182). Fourteen of the fifteen patients with pre-operative radicular pain had complete relief and the remaining patient had only partial relief. The patients with decreased ankle reflex, a weak extensor hallucis longus and hyposthesia along the S1 dermatome showed partial improvement of the neural deficit. The female patient who had urgency of micturition showed moderate recovery.

Radiological Evaluation:

Nineteen patients evidenced solid fusion by the 6 months follow-up (based on oblique radiographs showing interbody bridging bone). No progression of the slip angle or percentage slip was noted on the follow-up radiographs. Mean preoperative slip percentage reduced from 30.2% to 25% postoperative (P=0.001), while the slip angle was improved from 35 (range 11-42 degrees) to 28 (range 18-35 degrees) postoperative (P<0.5). (Table 1)

Pelvic version improved as evidenced by decreased sacral slope. The mean postoperative ST angle in the lateral standing view 36.86 degrees (range from 29 to 45 degrees) with significant difference (P0.05<) compared with the mean preoperative ST angle 46.045 (range from 23 to 71 degrees). (Table 1) The mean sacral slope improved by 9.2 degrees. Lumbar lordosi s (L1-S1) reduced from 48.8 (range 28-60 degrees) to 34.9 (range 25-44 degrees) (p=.02) tab (2).

Complications:

There was no serious implant or procedural complications. Complications included two intraoperative dural tears that were identified and repaired. There were no neurologic complications. Two patients developed superficial wound infection which responded to daily dressing and appropriate antibiotic therapy. In one patient, one of the pedicle screws had broken without any drawback. In another patient, the rod had slipped off the pedicle screw. In this case, the patient was re-operated with fixation of the rod. There was no clinical or radiological evidence of pseudo-arthrosis. All of the patients returned to their normal activities of daily living.

Table 1. Radiological Parameters in our Study Patients.

Parameters	Preoperative	Postoperative
Slip percentage	30.2%	% 25
Slip angle	35°	28°
(Sacral tilt angle (ST^0	°46.04	°36.8
Lumbar (L1-S1) lordosis	°48.8	°34.9

Discussion

The goals of surgery for any spinal deformity include reasonable correction of the deformity, prevention of further deformation, improvement of sagittal and coronal balances, optimization of cosmetic issues, and restoration/preservation of function. The failure to consider all these factors appropriately may result in a suboptimal outcome. So, understanding of fundamental biomechanical principles involved in the formation, progression and treatment of spinal deformities is essential in the clinical decision-making process.[15]

The importance of global sagittal balance of the spine and pelvis in patients with spondylolisthesis has been emphasized recently because patients with this condition may develop abnormal sagittal spinopelvic balance; and that is why, during reconstructive surgery, restoration of optimal sagittal balance is crucial for obtaining satisfactory clinical results and improvement of patient's health-related quality of life.[8]

Upright posture is secondary to hip extension and lumbar lordosis. An optimal and economic standing posture is obtained when balance between these two phenomena is correct [3]. Alterations of the lordotic lumbar curvature are frequently observed accompanying spondylolisthesis. A large sacrohorizontal angle (equivalent to the ST angle)

and increased lumbar lordosis were reported among the risk factors for progression of an isthmic spondylolisthesis.[17] During surgery of this condition, the main risk is to fix the sacrum in malposition or to cause excessive retroversion of it, i.e. verticallization of the sacrum, a situation that often is accompanied by loss of lumbar lordosis and subsequently increasing of hip extension. The latter position occurs to reduce loads through the adjacent spinal levels and to protect the lumbopelvic complex, most notably the sacroiliac joints. This results in pain in the standing position because of undue stress on the sacroiliac joints and on the hips.[2] The development of pathology at the mobile segment next to a lumbar or lumbosacral spinal fusion (adjacent segment disease), is considered a potential late complication of spinal fusion that can necessitate further surgical intervention and adversely affect outcomes.[12]

The main merit of this study is that, it highlighted the importance of the spinal balance in cases of spondylolisthesis and it described a method of achievement of better sacral alignment under the lumbar column during lumbosacral fusion in the treatment of this condition.[8]

In this study, alignment was obtained by appropriate adjustment of the position of the patient during the operation and by the rods inserted between pedicular screws. This was achieved by placing the patient prone with flexion of the hips and knees, until optimum lumbosacral alignment checked by the image intensifier was achieved. We flexed both knees and hips till we get correction of the local kyphosis. Lazennec et al,[7] suggested a prone position with the hips flexed to 45 degrees and the knees to 90 degrees, while Peterson et al,[13] used 90/90 position. The principle of using prebent contoured rods was also used in this study to help for correction of the lumbosacral kyphosis.

It is our belief that, neural decompression should be performed in conjunction with arthrodesis whenever a focal deficit is present and correlates with a positive imaging study at the slip level. On the contrary, some surgeons do not perform decompression claiming that in situ fusion alone is sufficient and will lead to relief of the neural deficit.[6] In this study, there was marked improvement in the radicular pain and the neurological deficits. Esses et al,[4] in their series have also reported improvement in most patients with radicular pain and neurological deficits.

Hanely and Levy[6] suggested L4/S1 fusion to be done on all moderate (grade1, 2) isthmic lumbosacral spondylolisthesis cases. In this study, eleven patients were grade I, and 11 were grade II according to Meyerding's classification. Fusion was done at L5-S1 for all patients. We believe that including L4 toL5 and S1 fixation will add more stress on adjacent segment (L3-L4), and may increase the risk failure and limit range of motion.

In this series, the post-operative average visual score of pain was 1.59±0.157 (ranged from 1 to 3). This was a significant improvement (P0.001<) compared to the average pre-operative score of 8.18±0.182. This coincides with the study of Esses et al,[4] which reported similar results.

The pre-operative ST angle ranged from 27 to 71 degrees (mean of 46.045 degrees) with a significant difference (P0.05<) compared to the mean postoperative ST angle (36.86). Lazennec et al,[7] reported a mean ST angle of 38.9 degrees (range from 32 to 43 degrees) in a non fusion group of patients and 36.9 degrees (range from 10 to 61 degrees) in a fusion group.

In this study, there were significant differences between estimated and reconstructed values of L1-S1 lordosis and of L5-S1 kyphosis however, there was no significant difference between the estimated and reconstructed of the slipping percentage. This is aim of the surgery, the correction of the malalignment and not the degree of slipping.

Distraction in an attempt to reduce slipping was not tried in this study. Our results reinforce the impression that it is correction of the deformity and restoration of balance even with the partial reduction of the slip percentage that is important in obtaining optimal results. Control of the reconstructed sagittal balance for sagittal imbalance is possible by patient positioning during surgery and by using prebent rods between the pedicular screws. Correctly orienting the pelvis, reconstructed by the restoration of enough L1-S1 lordosis, is a matter of critical importance for optimizing reconstructed sagittal balance.

Conclusion

In low grade isthmic spondylolisthesis of L5-S1 junction, this posterior approach is safe and effective in restoring sagittal balance, obtaining a solid arthrodesis and improving function guided by

prober patient position at surgery. These results reinforce the impression that it is the improvement of the slip angle, sacral tilt angle and lumbar lordosis and not the percentage slip that is important in obtaining optimal results.

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الملخص العربي

تحسن التوازن السهمي عن طريق العلاج الجراحي لحالات التزحلق الفقاري البرزخي ذو الدرجات المنخفضة

خلفية البيانات: يعتبر دور التصحيح الجراحي لتشوهات المستوى السهمي في حالات الانزلاق الفقاري البرزخي أمر ضروري. في حين تظهر أدلة من الفوائد المحتملة قصيرة الأجل وطويلة الأجل لإعادة التوازن في العمود الفقري، وقد يتخوف بعض الجراحين حول المخاطر المرتبطة بها وخاصة الأجهزة التي قد تستخدم لتصحيح الانزلاق.

المرضى والأساليب: شملت الدراسة اثنين وعشرين مريضا الذين يعانون من درجات منخفضة من التزحلق الفقاري البرزخي تم علاجهم جراحيا بهدف تصحيح التزحلق ولو بصورة جزئية. وقد حاولنا المواءمة السهمية بين الفقرات القطنية والعجزية التي يتعين تحقيقها عن طريق وضع الميض بصورة مناسبة اثناء استلقائه في الجراحة وكذلك استخدام القضبان بين الفرات المثبتة بالمسامير لاحداث هذه الموائمة. تم أيضا رفع الضغط على الأعصاب من الخلف عن طريق استئصال الصفائح العظمية مع تثبيت خلفي التي كتبها الثقب بالتزامن مع الخلفي المجهزة الانصهار من L5 للفقرات ولحام ما بين الفقرات القطنية الخامسة والعجزية الاو لى.

كان المرضى أربعة عشر إناث وثمانية ذكور بمتوسط عمر ٤٠ . ٤٥ عاما. متوسط مترة المتابعة فترة ٢٠ شهرا.

النتائج: جميع المرضى حققت نتائج مرضية فيما يتعلق آلام الظهر، آلام جذري والعجز العصبي. متوسط القيم قبل الجراحة بخصوص نسبة التزحلق والانحناء مابين الفقرة القطنية الاولى والخامسة الاولى والميل العجزي والحداب ما بين الفقرات القطنية والعجزية كانت ٣٢,٢٪ و٤٨,٨٪ و٤٦,٠٤٪ و٣٥٪ على التوالى. أما بعد الجراحة فتبدلت هذه القيم كالتالى ٢٥٪ و٣٤,٩٪ و٣٦,٨٦٪ و٢٨٪. تمكن جميع المرضى من العودة إلى ممارسة أنشطتهم العادية من الحياة اليومية بصورة طبيعية.

والخلاصة: تقترح هذه الدراسة أن التقنية المذكورة يمكن أن تسفر عن نتائج سريرية مرضية وتصحيح التشوه بصورة كبيرة عن طريق جراحة واحدة من الخلف مع الوضع في الاعتبار وضع المريض بصورة صحيحة اثناء الجراحة.