Raphaël Vialle
Sebastian Charosky
Jean-Paul Padovani
Pierre Rigault
Christophe Glorion

Surgical treatment of high-grade lumbosacral spondylolisthesis in childhood, adolescent and young adult by the “double-plate” technique: a past experience

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R. Vialle · J.-P. Padovani
P. Rigault · C. Glorion
Department of Pediatric Orthopaedics,
Necker Enfants-Malades Hospital,
Paris, France

R. Vialle (✉)
Department of Pediatric Orthopaedics,
Armand Trousseau Hospital, Paris, France
E-mail: ravialle@noos.fr
Tel.: +33-1-47121365
Fax: +33-1-47121365

S. Charosky
Department of Orthopaedic Surgery, Calot
Institute, Berck-sur-mer, France

Abstract Between 1979 and 1996, 40 patients with high-grade lumbosacral spondylolisthesis were treated in our institution using a newly designed osteosynthesis device. The mean age was 13 years and 6 months, and the mean follow-up was 18 years. Combined posterior decompression and anterior reduction, instrumentation and fusion of the slippage were performed in all cases. The technique includes reduction of the slippage by means of an anteriorly placed plate that engages two screws, previously placed during the posterior approach, going through the S1 vertebra. Progressive compression applied on the plate by the screws achieves reduction. Complete fusion was obtained in all 40 patients. Twelve patients presented a post-

operative radiculopathy, from which only ten recovered completely. There were six L4–L5 annulus lesions, responsible for instability, produced by the plate. We report five late infections. Thirty-five of the forty patients were asymptomatic at the latest follow-up. The double compressive plate technique proved to be effective in obtaining lumbosacral fusion and optimal slippage reduction. However, the high rates of neurological and infectious complications preclude recommendation of this technique in its present form.

Keywords Lumbosacral spondylolisthesis · High-grade spondylolisthesis · Reduction technique · Neurological complication · Double-plate technique

Introduction

High-grade lumbosacral spondylolisthesis can be the consequence of a defect of the pars interarticularis in the *Isthmic* type, but also of a congenital deficiency of the posterior arch of L5 or S1 (*Dysplastic* type). Symptoms range from minor clinical findings, even in some high-grade slips that are well tolerated, to severe radicular pain with neurological deficit.

The treatment of these severe forms remains controversial. While lumbosacral fusion is considered to be the gold standard of surgical treatment, the need for decompression and reduction of the deformity are still a matter of discussion.

The objective of this study is to review and evaluate a consecutive series of 40 patients treated for a high-grade

spondylolisthesis between 1979 and 1996. A technique, based on an, at that time newly designed, anterior plate is presented.

Materials and methods

The files of 40 patients who received surgical treatment for a grade 3 or 4 spondylolisthesis (from 50 to 100% of L5 anterior slippage) [15] were reviewed. This was a consecutive series of patients treated in our hospital from 1979 to 1996. There were 15 males and 25 females, aged from 6 to 18 years at the time of diagnosis. For each patient, clinical evolution from diagnosis to the latest follow-up was noted. There were no patients lost to follow-up.

The treatment included traction and suspension in a hammock for 8 days prior to surgery, to obtain progressive reduction of the lumbosacral kyphosis (Fig. 1).

Fig. 1 Progressive reduction of the deformation by progressive traction and hyper-lordosis in a “hammock”

Fig. 2 The first stage of surgical technique: By posterior route, two threaded rods are pushed anteriorly through the first sacral vertebra and fixed on iliac wing by a screwed plate. Preoperative lateral view (a). Intraoperative lateral (b) and frontal (c) view. d Drawing representing the forces applied on the sacrum (2 and 3) and L5 (1) intraoperatively by means of both plates

Surgical treatment consisted in a same day, staged posterior–anterior surgery. Removal of the posterior arch of L5, and decompression of L5 and S1 nerve roots were

done during the posterior approach. At the same time, two screws were inserted through the S1 vertebra and fixed by means of two plates to the iliac wings (Fig. 2). No grafting was done during the posterior approach. The patient was then placed in supine position and the lumbosacral junction exposed through a transperitoneal approach. The two screws previously inserted were then exposed in the anterior aspect of the sacrum. After L5–S1 disc excision, the anterior plate was placed against the anterior wall of L5 engaging the tip of the screws. Reduction was obtained by progressive tightening of the screws with two bolts, pushing back the plate and the L5 vertebra (Fig. 3). Iliac bone grafting of the L5–S1 disc was then performed through a specially designed window in the plate.

Immediately postoperatively, patients were kept in the supine position with their knees flexed. To prevent nerve root stretching, progressive extension of the knees was achieved during the first 3 weeks, and the standing position allowed only at the third postoperative month.

Functional status was evaluated pre- and postoperatively using the Beaujon and Japanese Orthopedic Association Scores [7, 26].

Radiographic assessment of the lumbosacral fusion was done by an independent observer using lateral standing and flexion–extension X-rays. The lumbosacral kyphosis was measured using a complementary angle of the slip angle described by Boxall [2] (Fig. 4).

All data were collected and analyzed in a database by SPSS® software (SPSS Inc. Headquarters, 233 S. Wacker Drive, 11th floor, Chicago, IL 60606, USA). Statistical correlations were studied using the Pearson correlation coefficient.

Results

The series includes 40 patients, 15 males and 25 females. The mean age at the time of surgery was 13 years and 6 months, ranging from 8 to 20 years. All patients had a grade 3 or 4 slip according to Meyerding's classification [15]. Clinical findings included isolated low-back pain in 12 cases, low-back and unilateral radicular pain in 9, low-back and bilateral leg pain in 11, and isolated radicular pain in 6 cases. Neurological claudication was found in one patient. A lumbosacral kyphosis was found

Fig. 3 The second stage of surgical technique: Reduction of L5 anterior slipping was obtained by progressive tightening of the screws with two bolts, pushing back the plate and the L5 vertebra. Lateral (a) and frontal (b) view. Lateral (c) and frontal (d) drawing represents final positioning of the double-plate device

Fig. 4 The lumbosacral angle, described by Boxall [4] is defined by the tangent to the posterior edge of S1 and the tangent to the cranial end of L5. Its normal values is 110°

in 34 out of 40 patients. The mean lumbosacral angle was 77° (28° – 110°).

Lumbosacral kyphosis reduction during the 8-day traction–suspension period was variable. It ranged from 0° to 36° . The mean improvement of lumbosacral kyphosis was 16° .

We report two intra-operative complications. A left common iliac vein lesion that was repaired in one case, and a technical difficulty in another case, where it was impossible to engage one of the screws through the plate. The slippage was completely reduced in 38 cases. A residual grade 1 slip was found in two patients.

The postoperative complications will be divided into four types: general, neurological, implant related and infectious.

General complications include three cases of intestinal occlusion related to peritoneal adhesions secondary to the transperitoneal approach. Two of these patients required new abdominal surgery.

Neurological complications were noted in 12 patients. An incomplete bilateral L5 motor and sensitive deficit occurred in five patients; unilateral L5 incomplete deficit in six, and one case with unilateral L5 hypoesthesia. One patient presented a bladder dysfunction with associated bilateral L5 radiculopathy. In four out of the twelve cases, the onset of the neurological deficit appeared several days after surgery, during the progressive extension of the lower limbs in the first two postoperative weeks. Ten of the twelve patients recovered completely during the 6 weeks to 18 months that followed surgery. None of the 15 male patients presented retrograde ejaculation secondary to the transperitoneal approach.

Fig. 5 Lesion of the L4–L5 disc by the anterior plate. It was responsible for a moderate and well-tolerated local kyphosis. Postoperative (a) and 11-year-postoperative (b) view

Fig. 6 Lesion of the L4–L5 disc by the anterior plate. It was responsible for local kyphosis requiring a surgical treatment. Preoperative view (a), after initial surgical treatment (b), 2 years after initial treatment (c) and after removing of the material and L4–L5 anterior and posterior fusion (d)

There were nine cases of implant related complications. The length of the plate was responsible for an impingement on the anterior aspect of the L4–L5 annulus, provoking a local kyphosis at that level (Fig. 5). This kyphosis required a surgical treatment in one case (Fig. 6). We found two broken screws in two different cases that were not associated with any clinical or radiological sign of non-union (Fig. 7). In one case, one of the screws could not be engaged in the plate; nevertheless, the stabilization was considered to be sufficient (Fig. 8).

We report five late infections. Onset of clinical symptoms ranged from 8 months to 2.5 years after surgery. Treatment required implant removal in four out of five patients and antibiotic therapy for 6–18 months. Cultures showed *Escherichia coli*

responsible for three cases and *Staphylococcus aureus* for one. For the remaining case, no germ was recovered. In all the cases, fusion already occurred and no secondary loss of correction was noted. All of these patients were asymptomatic at the last follow-up.

Lumbosacral fusion, assessed on lateral standing radiographs, was achieved in all of the 40 patients at the last follow-up (from 25 to 8 years, mean 18.4 years). Two patients presented residual incomplete deficit of the L5 nerve root with a 3/5 paresis of the *extensor hallucis longus* muscle. The mean lumbosacral angle was 96° (40°–125°). The mean correction of the lumbosacral kyphosis was 19° ranging from –5° to 50°. In three cases, the postoperative lumbosacral angle was lower than before the operation due to a

Fig. 7 Rupture of one of the two threaded rods without any clinical or radiological sign of lumbosacral pseudarthrosis. Lateral (a) and frontal (b) view

Fig. 8 In a case, it was not possible to pull the second threaded rod in the anterior plate. Osteosynthesis was, however, considered to be satisfactory. Frontal (a) and lateral (b) view

reduction of the anterior translation without reduction of the kyphosis. There was no residual slip in 38 patients and a residual first-degree (less than 25%) slip in two.

Concerning the functional status, the mean preoperative value of the Beaujon score was 14.2 (5–20) for a normal value of 20. The mean preoperative JOA score was 10.1 (2–15) for a normal of 15. Only one case had normal functional scores and no symptoms. This patient

was operated to prevent clinical deterioration and deformity progression.

At follow-up, the Beaujon score was 20 for 35 patients. The remaining five patients had a score between 15 and 19 because of low-back pain in three cases, and intermittent truncated leg pain in two. The JOA score was 15 for the same 35 patients, and between 12 and 14 for the other five. Eighteen patients practise sports regularly and other five do heavy work.

Fig. 9 One case of spinal instability over the fused lumbosacral junction. The progressive kyphosis of L4–L5 space required a surgical treatment with extension of the zone of fusion. Preoperative view (**a**), after initial surgical treatment (**b**), 2 years after initial treatment (**c**) and after extensive fusion and correction (**d**)

Discussion

The prevalence of spondylolisthesis in children aged from 5 to 7 years is 5%, and for the age of 18 years it is

6% [5, 10, 27]. However, slip progression to grade 3 or 4 is rare. High-grade slips represent only 1% of the cases, and are more frequently found in girls [12, 24]. We agree with Marchetti and Bartolozzi [12] that, high-grade slips

Fig. 10 Occurrence of postoperative neurological complications according to the preoperative lumbosacral angle and kyphosis reduction. Most of the neurological complications (represented here by the letter “C”) occurred in the case of severe and reducible lumbosacral kyphosis

are a combination of different congenital malformations resulting in a severe dysplasia of the lumbosacral region. It does not involve one particular structure, but all the stabilizing elements of the lumbosacral junction. The *pars interarticularis* and the articular processes of L5 and S1 are primarily involved, but also the laminae and spinous processes may be affected, as proved by the widening of the canal or the high prevalence of spinal dysraphism [14, 19, 25, 28].

The goals of the surgical treatment should be the following: to relieve pain, to prevent progression and to improve function. All of these goals may be achieved, in theory, by a solid fusion that restores the sagittal alignment.

Although in situ fusion is effective as treatment for lower grades of pediatric spondylolisthesis, we do not consider it to be the procedure of choice for the high-grade slips in patients presenting with severe dysplastic changes of the posterior elements [17, 21]. The non-union rates of non-instrumented posterior fusion are significant, ranging from 8 to 45% according to the published series [6, 16, 18]. Circumferential fusions, even without instrumentation, seem to have a much lower non-union rate, as reported in many studies [1, 9, 11, 16, 22, 23]. For this reason, we designed this technique, that combines reduction of the lumbosacral slip with a rigid 360° instrumentation. The fusion rate in our series proved to be optimal. The functional outcome scores for 35 of the 40 patients were very good. The five remaining patients suffered from occasional back pain.

One of the inherent risks of complete reduction of a high-grade spondylolisthesis is the sagittal imbalance that may result from this correction. In our series, we only noted one case of spontaneous L4–L5 kyphotic

evolution (Fig. 9). The other cases of L4–L5 instability were due to a large implant size that damaged the anterior annulus of the disc. Even though we think the risk of L4–L5 instability exists, it seems to be rare and difficult to predict.

The prevalence of neurological complications in surgically treated patients with posterior reduction and instrumented fusion for high-grade spondylolisthesis ranges from 15 to 30% [3, 8, 13, 16] except for Muschik et al [17] with only one case in a series of 30 patients and Poussa et al. [21] who reported no neurological complication in a small series of 11 patients. In our series, 12 out of 40 patients presented postoperative neurological deficits and two of them had incomplete neurological deficits of the L5 nerve root.

According to the literature [20], correcting the lumbosacral kyphosis protects the L5 nerve root against stretching. In spite of the lumbosacral kyphosis correction, a neurological deficit appeared in several of our patients (Fig. 10). It is our impression that it was not the correction of the lumbosacral kyphosis that caused the neurological deficit, but the associated complete reduction of the anterior translation of L5 that stretched the outgoing nerve root, as demonstrated by Petraco et al [20]. One-third of these deficits occurred during the progressive extension of the lower limbs in the first postoperative weeks, which favors the hypothesis of nerve root stretching. As a consequence, our current surgical strategy is to avoid complete slip reduction in patients with high-grade lumbosacral spondylolisthesis. In such patients, we prefer to perform circumferential fusion by posterior and anterior approaches and lumbosacral immobilization in a modified Boston brace incorporating one thigh.

We report in this study, three cases of approach-related complications in the transperitoneal exposure of the lumbosacral junction. Even though, in the current series there were no complications related to the presacral plexus, we remark the risks of retrograde ejaculation secondary to this procedure.

The unusual high rate of late infections reported in our series may be related to the extent of the dissection needed and the complexity of the procedure.

Even though this technique proved to provide an excellent fusion rate, and satisfactory final functional outcomes, we consider the risk reward ratio to be unacceptable. The objective of this study is to share this experience, but we do not recommend this technique for the treatment of high-grade lumbosacral spondylolisthesis.

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