



Treatment of high-grade spondylolisthesis by posterior lumbosacral transfixation with transdiscal screws : Surgical technique and preliminary results in four cases

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In high-grade spondylolisthesis, the surgical treatment should be aimed at achieving good stability to allow solid fusion in the face of high biomechanical forces at the lumbosacral junction. A 360° fusion seems to be able to provide this stability. This is however extensive surgery and many problems and complications have been reported.

In order to overcome these difficulties, various new procedures have been published. Most of these techniques aim for a good anterior column support, allowing primary stability and a large bony surface area for fusion.

Transfixation of the lumbosacral disc space using a fibular strut graft was published decades ago. Several modifications have been reported since, including the use of threaded cages filled with bone graft. In contrast to the number of these surgical techniques, only few biomechanical test results and small-size clinical studies have been reported in the literature.

An interesting technique of lumbosacral transfixation includes the use of transdiscal pedicle screws, described by Abdu *et al* in 1994. This allows for the use of standard instruments and implants, while biomechanical testing recently has shown improved stability equal to classic PLIF constructs by providing three-column support. Moreover, in high-grade slips this technique is easier to perform than other methods.

We have treated four consecutive patients according to this technique with good clinical and radiographic results. The surgical technique is described in detail and a review of the literature is provided.

INTRODUCTION

Posterolateral fusion with or without instrumentation has been proven successful in the treatment of symptomatic or progressive isthmic spondylolisthesis.

The surgical stabilisation of high-grade spondylolisthesis (Meyerding grade III or higher) however remains more problematic. Many approaches to high-grade slips have been reported, including posterolateral uninstrumented fusion, posterior instrumented fusion, anterior fusion and 360° circumferential fusion (either through a combined anterior and posterior approach in 2 stages or through a single-stage posterior approach). The debate about whether or not reduction of high-grade slips is necessary adds even more confusion.

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The reported results from all these techniques have been generally favourable, although complications and failure to stabilise the slip certainly do occur.

In an effort to determine a simple and safe, yet satisfactory treatment for patients with high-grade L5-S1 spondylolisthesis, the authors decided to review the available literature on the subject with a special interest for the biomechanical testing of lumbosacral fixation techniques.

In contrast to the panacea of surgical approaches and techniques, only few biomechanical test results have been published on the subject. A technique of transdiscal pedicle screw fixation was selected because of successful biomechanical testing, technical ease and previously reported favourable clinical and radiographic results.

In this paper we present the surgical technique of transdiscal lumbosacral fixation, our experience and results in four consecutively treated patients with a minimum follow-up period of one year and a review of the literature on the subject of lumbosacral transfixation.

SURGICAL TECHNIQUE

The patient is placed prone on a Jackson table, which allows easy fluoroscopic control both in the lateral and frontal plane. Furthermore a good lordotic position of the lumbar spine is preserved, with the legs fully extended, allowing slight to moderate reduction of the spondylolisthesis.

After routine midline incision, subperiosteal exposure of the posterior elements is carried out from the fourth lumbar to the second sacral vertebra. Pedicle screws (6.25 mm diameter) are placed in the pedicle of L4 in the usual way. No pedicle screws are inserted at the level of L5. The crucial step in the procedure is the placement of both sacral screws. The technique of S1 pedicle screw insertion starts with the use of the pedicle probe. It is advocated to direct the probe parallel to the orientation of the L4 pedicle screws in the lateral plane, as this will direct the screw trajectory towards the superior end plate of S1 (fig 1). At this stage, fluoroscopic guidance is mandatory. The pedicle probe is now being replaced by the sacral

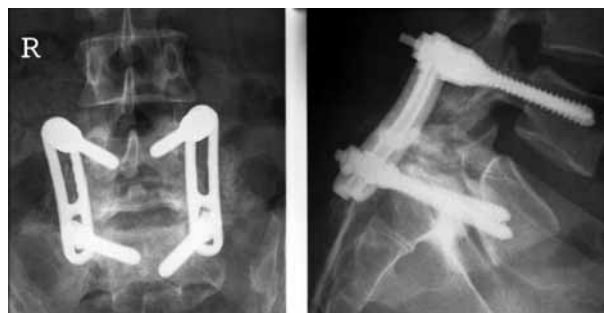


Fig. 1. — AP (left) and lateral (right) radiograph taken one week postoperatively. Pedicle screws in L4 and S1 are introduced in a parallel orientation. The S1 screws penetrate the endplate of S1, cross the disc space and enter into the vertebral body of L5.



Fig. 2. — CT scan performed before discharge shows transfixation of the L5S1 disc space. Note the absence of bone graft in the interspace and the vertebral body of L5 in front of the sacrum.

depth sounder, which is hammered through the upper end plate of S1, through the lumbosacral disc space, into the anterior and inferior aspect of the vertebral body of L5. The depth sounder tells the surgeon what length of screw is required. Both with the pedicle probe and the sacral depth sounder, it is essential to converge about 30 degrees in order to get the screw tip into the vertebral body of L5 (fig 2). A pedicle screw (7 mm in diameter) of the

Table I. — Summary of patient data and radiographic outcome

Patient	Age	Sex	Presenting symptoms	Slip (%)	Slip (angle)	Complications	Fusion after 1 year ?
1	33 y	f	backache sciatica right leg	pre-op 72% post-op 67%	pre-op 30° post-op 25°	none	yes
2	74 y	m	backache weakness in both legs	pre-op 65% post-op 65%	pre-op 30° post-op 30°	cervical myelopathy diagnosed afterwards	yes
3	39y	f	backache sciatica bilateral	pre-op 51% post-op 39%	pre-op 16° post-op 4°	none	yes
4	30y	f	backache	pre-op 52% post-op 54%	pre-op 18° post-op 11°	none	yes

appropriate length can now safely be inserted through the pedicle of S1, into the body of L5. These screws offer very good purchase, through the endplates of S1 and L5.

After decortication of the transverse processes of L4 and L5, the sacral ala and the L4L5 and L5S1 facet joints, a standard posterolateral fusion is performed using autologous bone graft. These bone grafts can be harvested from the posterior iliac crest.

The use of washers on the L4 pedicle screws facilitates connection and instrumentation.

The lumbosacral fascia and skin are carefully closed, leaving one subfascial drain which is removed on the second postoperative day.

Postoperatively patients are mobilised during the first few days according to the pain. Orthoses are not routinely used in our department.

PATIENTS AND RESULTS

Patient data and radiographic results are summarised in table I.

No clinical outcome scores are provided, since these are only short-term results. This paper focuses on the surgical technique, complications and radiographic outcomes.

The fusion rate was assessed by an independent reviewer with experience in spinal surgery.

Radiographs as well as CT scanning were obtained for all patients at 6 months and one year post-operatively. Interestingly, bone formation in the L5-S1 intervertebral disc space was noted in all

patients, although no formal discectomy or interbody fusion was performed at the time of surgery (fig 3).

DISCUSSION

Symptomatic isthmic spondylolisthesis can be successfully treated by postero-lateral fusion *in situ* (42). Good results can be achieved with or without instrumentation (20), although a rate of up to 45% of pseudarthrosis has been reported in the literature (5, 6, 21, 30, 31, 36, 40).

As the slip rate and angle increase, biomechanical forces are altered. In the presence of these severe biomechanical forces, it becomes more problematic to achieve a good, rigid fixation using conventional fixation systems and techniques. A higher risk of pseudarthrosis and slip progression has been reported in high-grade spondylolisthesis (grades III and above). Pseudarthrosis can result in persistent low back pain and sciatica, progression of the slip and occasionally failure of the implanted hardware, making revision surgery in these cases difficult (5, 6, 19).

In order to overcome the difficult biomechanical forces at the lumbosacral segment in high-grade slips, some authors have tried to reduce the slipped L5 vertebra back onto the sacrum. Good results have been published with this strategy. However, this remains very demanding surgery and very often an anterior release is needed in order to get a good reduction (5, 7, 11, 19, 20). This necessitates a two-stage approach, resulting in longer and more

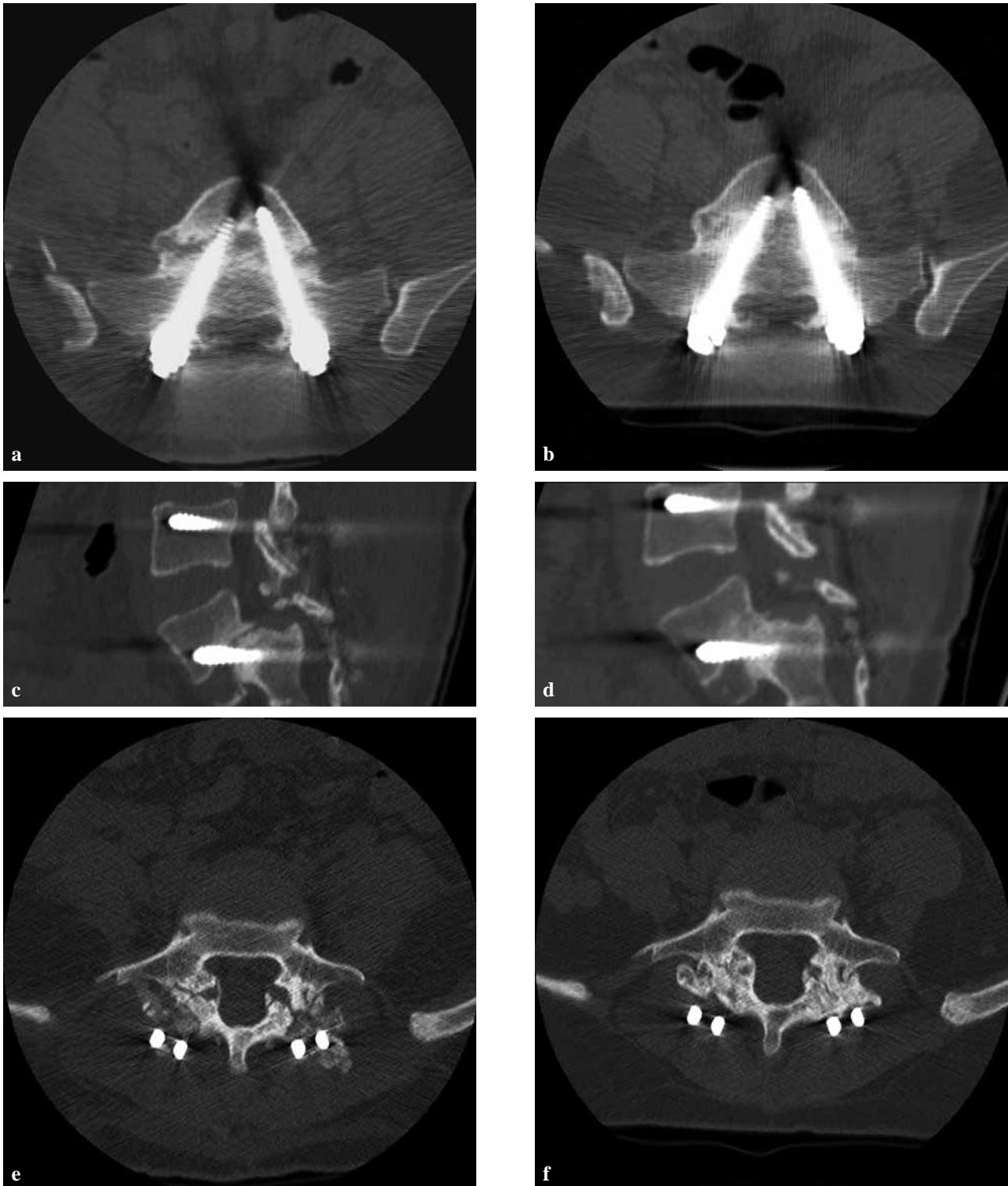


Fig. 3. — **a & b**) Axial CT scan 1 week post-op (a) and 1 year post-op (b) illustrating bone formation in the L5S1 disc space, **c & d**) Sagittal CT reconstruction images 1 week (c) and 1 year (d) post-operatively, showing intervertebral fusion of the L5S1 disc space, **e & f**) Axial CT scan 1 week (e) and 1 year (f) post-operatively illustrating incorporation of posterolateral bone grafts and fusion.

complex surgery. Complications due to the anterior approach have been reported extensively (15, 16, 29, 33, 34, 41). Additionally, neurological problems do occur regularly when complete reduction is pursued (8, 16, 21).

To avoid the cited drawbacks of a complete reduction, partial reduction of the slip has been advocated as well (7, 39). In partial reduction of a high-grade spondylolisthesis, the first objective is to reduce the slip angle more than the amount of slip (3). This restores a more physiologic sagittal balance and improves the lumbosacral shear forces. Less neurological complications have been reported with this approach.

However, the reduction of a slipped vertebra adds another problem to the biomechanics of the spine as this creates an anterior void, putting more stress on the posterior instrumentation (17, 24, 32).

Even when no reduction of the slip is performed, anterior column support has been advocated by numerous authors in order to improve the fusion results of surgically treated high-grade slips (14, 17, 24, 28, 32, 40).

Molinari *et al* (28) have shown, through the use of a 360° fusion, that an anterior load sharing construct can improve the fusion rate after reduction of a spondylolisthesis. Interbody fusion can augment a posterolateral fusion by providing more bony surface area for ingrowth of the graft material and by adding stability to the posterior instrumentation (24).

Although interbody fusions seem to yield better results than classical postero-lateral fusions, it is important to remember that biomechanical testing in a calf spine model of lumbosacral isthmic spondylolisthesis by Shirado *et al* (37) revealed that anterior column support without instrumentation is the least rigid construct and seems to have no stabilising effect immediately after the procedure. Posterior pedicle screw fixation proved to be the most rigid construct, whether or not a posterior interbody fusion had been associated. Therefore, a classic stand-alone interbody fusion should not be performed, especially in the face of high biomechanical forces (9, 10, 26).

Interestingly, most authors describing a new technique for interbody fusion in high-grade

spondylolisthesis, actually use transfixing techniques bridging the disc space between the L5 vertebra and the sacrum. Numerous variations on this concept of transfixation of the disc space have been reported and good results have been published regardless of the way this was achieved.

Early modifications of interbody fusion in high-grade spondylolisthesis have used a fibular strut graft across the middle of the segment to be fused (4, 13, 22, 23, 43). Both anterior and posterior approaches can be used. Several authors however have reported fractures of these fibular grafts, even with the use of posterior instrumentation or brace immobilisation (22, 35, 43). Certainly, the dense cortical bone of these grafts is not ideally suited for the purpose of graft incorporation. Donor site morbidity at the fibular harvest site should not be neglected either (23).

The use of cages filled with cancellous bone grafts seems more appropriate for this purpose (38). Transfixing titanium threaded cages have been introduced either from the front (38), or from the back (2, 12). Some of these authors have been adding transdiscal pedicle screw fixation at the L5-S1 level to improve the strength and rigidity of the construct (2, 38).

Markwalder *et al* (25) have published a single-stage anterior fusion technique in the treatment of spondylolisthesis, using a custom made carbon ALIF cage and a screw which is inserted from the anterior border of the L5 vertebra, through the cage into the sacral body. This “Wilhelm Tell” technique, as they named it, is technically quite demanding and this kind of anterior transfixation technique without the use of posterior instrumentation has not been tested biomechanically.

The use of transdiscal pedicle screws was first described by Abdu and Wilber in 1994 in order to obtain a more rigid distal fixation in instrumented posterolateral and interbody fusion (1).

Transdiscal monosegmental screw fixation has been described by Grob *et al* (18), although only moderate grade (II-III) degenerative spondylolisthesis was considered an indication by the author.

Among the total number of publications about lumbosacral transfixation, only two biomechanical studies could be retrieved in the literature.

Minamide *et al* (27) recently published an interesting study testing the strength of several lumbosacral constructs in the presence of a high-grade slip (average slippage : 41.3%). They concluded that transdiscal pedicle screw fixation is as strong as the more classic interbody fusion combined with posterior instrumentation. Cunningham *et al* (9) demonstrated that transvertebral threaded titanium cages can have stiffness levels equivalent to posterior pedicle screw fixation. The combination of posterior instrumentation from L4 to S1 with transvertebral L5-S1 fixation provided significantly more stability than either construction alone. Transdiscal pedicle screw fixation however was not tested in this study.

Transdiscal constructs thus seem to be as strong as classic 360° circumferential fusion techniques previously used in the surgical treatment of high-grade spondylolisthesis. While classic interbody fusions are difficult procedures in the presence of a high-grade slip, transdiscal constructs are much easier to perform due to the presence of the vertebral body of L5 in front of the sacrum and the high inclination of the disc space. Our observation of bone formation in the L5S1 disc space without formal discectomy or intervertebral bone grafting supports the biomechanical data that this type of construction allows for a very rigid fixation and can be done safely without additional anterior column support.

In addition, transdiscal pedicle screw fixation allows for the use of standard instruments and implants without the need for special, customised or even experimental devices. The single stage posterior approach can provide a good posterior decompression and access to the foraminae and nerve roots if necessary.

In our opinion the use of transdiscal pedicle screws obviates the use of anterior release procedures and potentially dangerous reduction manoeuvres in most cases of low- to high-grade spondylolisthesis. However, in the presence of severe slip angles and lumbosacral kyphosis, reduction may still be necessary to obtain a good sagittal balance and improve fusion chances by reducing high shear forces.

CONCLUSION

Although in recent years several new techniques for the surgical treatment of high-grade spondylolisthesis have been presented in the literature, only few of them have been supported by biomechanical testing. Transdiscal pedicle screws are easy to introduce in the presence of high-grade spondylolisthesis. Standard equipment can be used without the need for new, experimental or expensive devices. The results of our limited series show fusion in all four cases with the appearance of bone formation in the L5-S1 intervertebral disc space, providing additional anterior column support and even intervertebral fusion.

In case of mechanical failure, loosening or non-union with the technique described above, revision surgery with circumferential fusion is still an option and remains technically feasible.

Lumbosacral transfixation by transdiscal pedicle screws thus appears to be a relatively simple, safe and biomechanically supported alternative to the overall accepted 360° fusion after (partial) reduction, in the surgical treatment for moderate to high-grade spondylolisthesis. The technical ease, low cost and encouraging early results warrant further investigation of this technique.

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