Minimally invasive transforaminal lumbar interbody fusion through a unilateral approach and percutaneous osteosynthesis

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Accepted: 6 May 2011

Summary
Objectives: To assess a surgical technique and the postoperative outcomes of a consecutive series of 22 patients treated for degenerative lumbar spondylolisthesis (DLS) through a minimally invasive unilateral approach associating interbody fusion and percutaneous osteosynthesis.

Patients and methods: Twenty-two patients were included in this study, with a mean age of 60 years (range, 35–77 years). All had low-grade single-level DLS. In all cases, the technique included a posterior unilateral paramedial approach through a tubular retractor that decompressed the vertebral canal and transforaminal intervertebral cage arthrodesis. Osteosynthesis was then systematically put in place. The evaluation criteria were clinical (pain, spinal symptoms, duration of hospital stay) and radiological. The entire series was followed up for a mean of 24 months.

Results: In this series, the procedure was performed with no technical problems. The mean hospital stay lasted 4.5 days. Postoperative pain assessment showed a mean VAS of 2/10 at discharge and 75% of the patients were asymptomatic at 6 months. The radiological exams showed no extrapedicular screws and the fusion rate was 95% at the last follow-up (with one patient needing surgical revision for malunion).

Conclusion: Transforaminal lumbar interbody fusion through a unilateral approach associated with percutaneous osteosynthesis is a reliable and effective technique in DLS surgery. The clinical and radiological results are encouraging, with low morbidity and a fusion rate comparable to conventional techniques. However, a longer follow-up will be necessary so as to assess the long-term results of this surgical strategy.

Level of evidence: Level IV. Retrospective study.

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doi:10.1016/j.otsr.2011.05.002
Introduction

Degenerative lumbar spondylolisthesis (DLS) is defined as vertebral sliding most often located on the next to last mobile lumbar segment, resulting from arthritic failure of the posterior joint apophyses instigated by discal degeneration and the associated muscle deficiency. The true prevalence of this type of pathology is difficult to establish; however, in general, the different types of spondylolisthesis affect 3—7% of the general population [1]. The mean age at surgical management is usually around 60 years, but because of the aging of the population, increasingly older and more fragile patients are consulting.

Surgical treatment of DLS should provide a response to two imperatives: nerve decompression and spinal segment stabilization. The need for complete reduction of the sliding motion and the approach to use are, on the other hand, subject to controversy.

This debate opposes partisans of a single anterior or posterior approach and those who recommend a combined approach. However, the posterior approach seems to win the support of many authors [2—5]. This is also encouraged by the development of minimally invasive posterior techniques over the past decade. The existence of specific and adapted instrumentation responds to surgical imperatives (decompression, stabilization, and fusion) while minimizing muscle injury, the skin incision, and blood loss, making the minimally invasive approach particularly seductive in DLS surgery. The literature describing these minimally invasive techniques is currently in full expansion [3,6—9]. The good results reported by many authors on these minimally invasive techniques compared to the classic techniques [3,10—12] seem to indicate a turning point in DLS surgery via the posterior approach.

The objective of this study was to assess the postoperative results of a series of 22 patients operated for a unilateral approach DLS through a tubular muscle retraction system that allows decompression and transfornaminal arthrodesis associated with percutaneous osteosynthesis.

Patients and methods

A total of 22 patients (12 females and ten males), with a mean age of 60 years (range, 35—77 years) were included in this retrospective study between January 2007 and September 2009. All of the patients presented symptomatic DLS. The study’s exclusion criteria were high-slippage spondylolisthesis (Meyerding stage 3 and 4) and patients presenting isolated lumbago with no radiculalgia. A history of surgery for degenerative spondylolisthesis in all the patients.

The side of the incision was determined based on the data from the clinical exam and the imaging studies. The incision was made on the symptomatic side in cases of unilateral involvement and on the side on which the clinical and radiological signs were predominant in cases of bilateral symptoms. In cases of bilateral symmetrical clinical and radiological involvement, the choice was made according to the operator’s preferences.

All of the patients included in this study were managed by a single operator using the technique described and were followed up after surgery on clinical criteria (neurological symptoms, pain, duration of hospital stay, and complications) and radiological criteria (verification of implant position and achievement of intervertebral fusion) with a mean follow-up of 24 months (range, 8—40 months).

Surgical technique

The patients were positioned in the ventral decubitus position on a radiotransparent table with blocks under the thorax and the iliac crests so as to prevent abdominal compression and install the spine in lordosis.

The entry points for the pedicular screws were identified (AP and lateral) using the C-arm to precisely determine the operative field.

The following stages were successively followed:

- 2 cm vertical paramedial skin incision located approximately 3—4 cm from the medial line of the side of the approach;
- the lumbar fascia was then incised, allowing dissection using the finger fracture technique, dissociating the muscle fibers until contact with the facet joint;
- introduction of progressively large dilating bougies and retractor placement (Quadrant®, Medtronic, Memphis, TN, USA) (Fig. 1a, b);
- ipsilateral laminooarthrectomy removing the isthmus, unilateral posterior arch of the vertebrae and the inferior joint facet of the subjacent vertebra using a reaming technique or an osteotome, then using curettes and gougers. Ablation of the ligamentum flavum. At the end of this stage, the pedicles, the passing and exiting roots, as well as the intervertebral disc were exposed. Contra lateral recalibration was performed, if necessary, after partial resection of the base of the spinous process. The entire procedure was carried out under the surgical microscope with variable magnification, providing three-dimensional vision and sufficient lighting of the operative field;
- exeresis of the disc until contact was made with the anterior longitudinal ligament;
- progressive intervertebral distraction using increasingly large dilating bougies (Fig. 2a—c);
- transfornaminal insertion of a PEEK cage (Capstone®, Medtronic, Memphis, TN, USA) filled with cancellous bone harvested from the posterior vertebral arch or the ipsilateral iliac crest. Complementary intervertebral grafting was systematically performed by placing bone around the cage so as to increase the intervertebral fusion rate;
- osteosynthesis through the Quadrant retractor on the ipsilateral side, to apply compression on the cage, then contralateral percutaneous osteosynthesis (Sextant®,
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Figure 1  Intraoperative introduction of muscular dilatators (a) before installation of the unilateral retractor (b).

Figure 2  Intraoperative X-rays showing the retractor in its initial position (a) and the operative access after distraction for performing the discectomy (b) and insertion of the intervertebral cage (c).

Medtronic, Memphis, TN, USA or Mantis®, Stryker, Montreux, Switzerland). In cases requiring reduction or sliding, the percutaneous osteosynthesis was performed first on the opposite side of the approach so that reduction could be performed by applying distraction force on the osteosynthesis material simultaneously to the contralateral intervertebral procedure.

Following surgery, no drainage, contention, or brace was placed.

All of the patients were followed up prospectively (case—control type) at regular intervals (3, 6, 12, and 24 months postoperative). The clinical follow-up included assessment of pain using a visual analogic scale (VAS) and a neurological exam at each visit. The radiological assessment included a systematic CT exam immediately postoperative to verify that the implants were properly positioned and at the sixth month postoperative to evaluate interbody fusion.

Comparisons between the pre- and postoperative evaluations were made using the Chi² test with a significance threshold set at 5% ($P < 0.05$).

Results

For the overall series, the mean duration of surgery was 120 min (range, 62–180 min), corresponding to the most recent patients and the first patients in the experiment, respectively, showing the necessary learning time required by the technique. No dural breach or postoperative neurological lesions were found. Intraoperative blood loss was systematically evaluated at less than 200 mL, and none of the patients presented signs of postoperative anemia or required a blood transfusion.

During the hospitalization and up to the last follow-up, no cases of hematoma or scar infection were found.

Postoperative pain evaluation based on the VAS (Fig. 3) showed a clinically significant improvement ($P < 0.05$) between the preoperative period (mean, 7/10) and the day of discharge from the hospital (mean, 2/10). Postoperative analgesics included only paracetamol and nonsteroidal anti-inflammatory drugs in absence of contraindications lasting 24 h with step II analgesics at the most given at discharge. None of the patients required step III anal-
gesics postoperatively, which obviated the need for urinary catheterization in all cases. All of the patients were on their feet the day after the intervention without contention or a brace after the follow-up CT had been performed to verify proper implant position (Fig. 4 a–c). The mean postoperative hospital stay was 4.5 days.

During the follow-up consultations and with a mean follow-up of 24 months, disappearance of the initial clinical symptoms was observed in 19 patients, with complete disappearance of radiculalgia a mean 6 months after surgery. In addition, one patient presented residual lumbago with little disability and two patients who had had preoperative sensorimotor deficit only presented partial recuperation at the last follow-up.

On the successive radiological assessments, no cases of extrapedicular interference or implant malposition were observed. The radiological intervertebral fusion rate was 95% on the follow-up CT taken at 6 months postoperative. One patient required surgical revision with an open conventional technique for malunion, revealed by disabling mechanical lumbago.

**Discussion**

The transforaminal approach for circumferential arthrodesis has been known for many years, since its description using the medial posterior approach [13,14]; however, its adaptation to minimally invasive techniques is more recent [15,16]. The association of the development of a specific instrumentation designed to limit muscle damage and the good results reported on bilateral recalibration via a unilateral approach in lumbar canal stenosis [6,7,9] are a new approach to DLS. Today, few studies have described the results of unilateral transforaminal lumbar fusion associated with bilateral recalibration [10], but these techniques are in constant expansion.

In terms of length of hospital stay, antalgesic consumption, infection, and postoperative anemia, the present results are comparable to similar series found in the literature [10,15,17]. Compared to the conventional techniques, the duration of surgery seems similar. However, this surgical time has tended to decrease since the beginning of our experience, illustration of the necessary learning time, even though it is quite short, both in our experience and in the literature [18]. On the other hand, morbidity seems lower [4,5,19,20], as other comparative series have demonstrated [12,14,21,22]. The short-term benefits are therefore substantial for patients. Early mobilization and rehabilitation, notably in the oldest patients, is possible because the intervention is not highly painful, thus minimizing the complications related to prolonged decubitus. The infection rate of the surgical site reported is also low [19,20,22,23]. These results seem related to several factors together, notably the absence of significant blood loss, a small surgi-

![Figure 3](image.png)

**Figure 3** Mean pre- and postoperative (on the day of discharge) pain evaluated using the visual analog scale.

![Figure 4](image.png)

**Figure 4** Preoperative CT scan with neural opacification showing the L4–L5 slip and stenosis (a), then the postoperative aspect of the intervertebral graft (b) and the whole instrumentation (c) (same patient).
Minimally invasive transforaminal lumbar interbody fusion techniques used [2, 12, 19, 20, 24—29], thus demonstrating comparable to the data reported in the literature, for all assessed.

The symptom resolution rate observed in this series is comparable to the data reported in the literature, for all techniques used [2, 12, 19, 20, 24—29], thus demonstrating the quality of bilateral spinal cord decompression via a unilateral approach. When contralateral decompression is not entirely satisfactory intraoperatively, notably in cases of severe symmetrical bilateral compression, a complementary contralateral approach using the same technique remains possible. This lengthens the duration of the intervention but provides the opportunity to insert a contralateral cage and thus obtain a better fusion rate [30—32]. The intervertebral fusion rate reported in this series is comparable to that reported in minimally invasive series and conventional techniques, with, however, a margin of error inherent to the use of X-rays rather than CT to confirm fusion [33, 34]. The success of intervertebral arthrodesis is related to the quality of the graft, but it is crucial that the grafting procedure be carried out meticulously and that one not hesitate to place bone around the cage to increase the fusion rate. In addition, it is also valuable to note that these minimally invasive techniques can be performed at two levels for patients presenting multi-segment involvement, with satisfactory results [18, 35].

The minimally invasive unilateral approach (Fig. 5) preserves the patient’s paravertebral musculature, which is quite often deficient [36, 37], but further studies will be necessary to assess whether keeping this musculature intact makes it possible over the long term to prevent postoperative destabilization and the diseases of the adjacent discs. The minimally invasive unilateral approach associated with percutaneous osteosynthesis nevertheless has its limitations. Operator and patient irradiation is one of the potential disadvantages of this technique, and even if Bindal et al. [38] measured acceptable rates for both operator and patient, the use of fluoroscopically guided navigation would minimize it [8, 39, 40] even though its use is not as reliable for percutaneous techniques. To ensure the safest possible implantation of the instrumentation, the most reliable guidance technique seems to be the O-arm, at the price, however, of irradiation for the patient although not for the surgical team [41, 42]. One of the other limitations is related to current ancillary instrumentation, which allows limited reduction by application of distraction force on the material and which cannot be integrated into a treatment strategy for cases of grades 3 and 4 spondylolisthesis. Finally, the importance of analyzing the patient’s overall sagittal equilibrium should not be neglected when performing a minimally invasive lumbar procedure; certain failures of the technique may be related to a balance defect that was not corrected by the surgery and not related to a local cause.

Conclusion

The unilateral approach and minimally invasive transforaminal lumbar fusion associated with percutaneous osteosynthesis is a reliable technique in the management of low slippage lumbar spondylolisthesis. The results obtained in terms of fusion are similar to the results obtained with conventional techniques. The benefits of this technique lie in the low morbidity and in the reduction of infectious risks related to the minimally invasive procedure. The low level of pain resulting from the procedure and the absence of blood loss allow rapid rehabilitation of these patients, who are often elderly with comorbidities. Preservation of the paravertebral muscle mass certainly contributes to preventing postoperative destabilization. However, this technique has limitations and requires an indispensable learning period. Furthermore, the long-term benefits remain to be evaluated and these patients must be followed up to ensure the absence of delayed complications with this type of technique.

This surgical strategy is presented as a therapeutic alternative in the management of low-grade DLS but is not a substitute for conventional techniques, which maintain their place in high-slippage spondylolisthesis requiring reduction or severe spinal deformities.

Disclosure of interest

The authors declare that they have no conflicts of interest concerning this article.

References


Figure 5 Clinical aspect after the procedure with a unilateral approach and other incisions related to the percutaneous osteosynthesis.


