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Original Investigation

Minimally Invasive Transforaminal Lumbar Interbody Fusion with Percutaneous Bilateral Pedicle Screw Fixation for Lumbosacral Spine Degenerative Diseases. A Retrospective Database of 40 Consecutive Cases and Literature Review

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ABSTRACT

AIM: To report our results about minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) with bilateral pedicle screw fixation, in patients with degenerative lumbosacral spine disease. To describe the indications, surgical technique and results of a consecutive series of 40 patients who had undergone MI-TLIF. Despite the limited number of clinical studies, published data suggest tremendous potential advantages of this technique.

MATERIAL and METHODS: Forty patients with radiological findings of degenerative lumbosacral spine disease had undergone MI-TLIF between July 2012 and January 2015. Clinical outcomes were assessed by means of Oswestry Disability Index (ODI) and Health Survey Scoring (SF36) before surgery and at first year follow-up. Furthermore, the following parameters were retrospectively reviewed: age, sex, working activity, body mass index (BMI), type of degenerative disease, number of levels of fusion, operative time, blood loss, length of hospital stay.

RESULTS: Average operative time was 230 minutes, mean estimated blood loss 170 mL, average length of hospital stay 5 days. The ODI improved from a score of 59, preoperatively, to post-operative score of 20 at first year follow-up. Average SF36 score increased from 36 to 54 (Physical Health) and from 29 to 50 (Mental Health) at first year outcome evaluation.

CONCLUSION: MI-TLIF with bilateral pedicle screw fixation is an excellent choice for selected patients suffering from symptomatic degenerative lumbosacral spine disease, especially secondary to recurrent disc herniations.

KEYWORDS: Transforaminal lumbar interbody fusion, Minimally invasive spine surgery, Pedicle screw fixation, Lumbosacral spine degenerative disease, Percutaneous surgery

INTRODUCTION

Minimally invasive surgery has gained popularity over the last decades. In 1982, Harms and Rolinger developed the transforaminal lumbar interbody fusion (TLIF) technique aimed to reduce the amount of thecal sac and nerve root retraction thanks to the laterality of the approach (4). In 2002, Foley and Lefkowitz enhanced the same concept by means of the implementation of a minimally invasive TLIF (MI-TLIF) with the goal to reduce tissue damages, at the same time achieving both neural decompression and adequate interbody fusion (2).

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In 2005, Schwender et al. performed one of the earliest study on MI-TLIF, based upon a cohort of 49 patients, and found a tremendous improvement in terms of Oswestry Disability Index (ODI) that passed from a mean preoperative score of 46 to an average postoperative score of 14. They reported a fusion rate of 100% (15).

Compared with open procedures, MI-TLIF appears to have lowered post-operative pain (13) and need for narcotics (6), lowered infectios rate (10), diminished blood loss, reduced soft tissue trauma and shorter hospital stay, all these aspects justifying the cost-effective core of this technique (22). MI-TLIF seems to have the same fusion rate of the open procedures (18). Conversely, TLIF itself involves a complete facetectomy with a subsequent high risk for iatrogenic instability and additional need for posterior screw fixation (1,8,9).

The main indications for MI-TLIF in degenerative lumbosacral spine disease (DLSD) are unstable grade I-II spondylolisthesis with foraminal stenosis and radiculopathy, severe degenerative disc disease with mechanical low back pain, post-discectomy collapse with radiculopathy, and recurrent disc herniation with severe low back pain (12). In the latter case, MI-TLIF seems to be burdened by a lower incidence of post-operative scarring, cerebrospinal fluid leaks and nerve injuries due to laterality of the approach (3,5).

MI-TLIF is contraindicated in cases of severe scoliosis, high-grade spondylolisthesis and gross traumatic instability (11). Greater than two multilevel procedures, and severe osteoporosis are considered as relative contraindications for MI-TLIF due to a higher risk of graft subsidence and implant's failure (11).

The purpose of the study is to report the indications, surgical technique and results of MI-TLIF on a cohort of 40 consecutive patients treated for DLSD.

MATERIAL and METHODS

Patient Population

Forty consecutive patients, with radiological findings of DLSD, underwent MI-TLIF between July 2012 and January 2015. Radiological evaluation included magnetic resonance imaging (MRI) and computed tomography (CT) scan, as well as standard and dynamic radiographs. Electromyography was also performed. The following parameters were retrospectively reviewed: age, sex, working activity, body mass index (BMI), type of degenerative disease, number of levels of fusion, operative time, blood loss, length of hospital stay. Postoperative CT scan was obtained on postoperative day 2 and at first year follow-up in all patients. Clinical outcome was assessed through ODI and Health Survey Scoring (SF36) before surgery and at first year follow-up.

Surgical Technique

All patients were operated by A.R. with the aid of an assistant. Under general anesthesia, the patient is placed in the prone position on a radiotransparent Jackson-type table with all of the pressure points appropriately padded (Figure 1). Before the draping, lateral (LL) and antero-posterior (AP) initial fluoroscopic C-arm images are acquired to mark the skin incision points at the level of the junction between the facet complex and transverse process of the target vertebrae. A 1 cm skin incision, usually 3 cm lateral to the midline, is made and a Jamshidi needle (JN) is gently advanced through the pedicle under AP fluoroscopic guidance until the tip of the needle has reached the medial border of the pedicle. C-arm is then turned of 90° to obtain an LL projection. At this checkpoint, the tip of the JN must be located at the level of the junction between the pedicle and vertebral body to be assured that the needle is inside the pedicle. The needle is then passed to one-quarter or one-half the depth of the vertebral body. A Kirschner wire (K-wire) is now passed inside the JN. The K-wire is passed a little further to seat it into the bone and the JN is then removed (Figure 2). We prefer to place the pedicle K-wire before proceeding with tubular retractor because, in our opinion, this sequence allows for a better anatomical and spatial orientation.

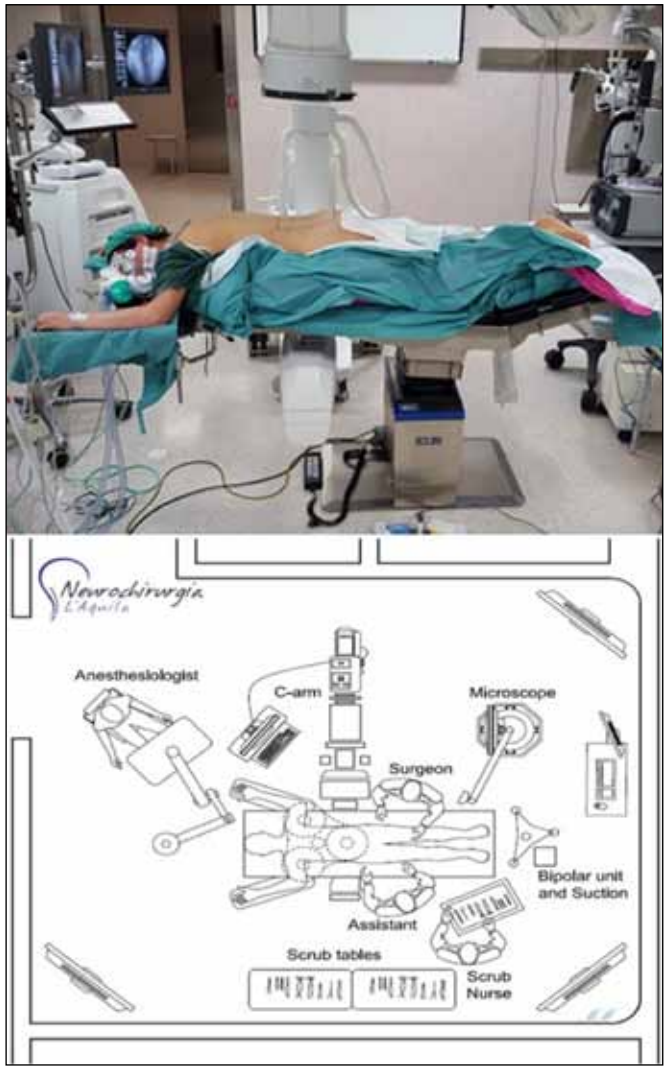

Figure 1: Patient's position and operative room setup.

At this point, under fluoroscopic guidance, a further K-wire is advanced into the side chosen for the TLIF approach entering 3 cm paramedially and with a trajectory parallel to the intervertebral disc. A 3 cm skin incision is made over the K-wire entry and fascia is opened. Sequential dilators with an increasing diameter are placed pointing the facet joint and spreading the muscles. Once the largest dilator has been positioned, a tubular retractor (Insight Access Tube Set - DePuy Synthes®) is lowered onto the dilators and locked by a table-mounted flexible arm. The dilators are now removed (Figure 3). Under microscopic view, a total facetectomy is performed with Kerrison rongeurs. Ligamentum flavum is removed taking care to leave a leaflet reflected over the dural sac and nerve roots as protective barrier. If needed, the tubular retractor can be angled more medially for a more extensive decompression. A complete discectomy is then performed with straight and angled curettes, and with different sized Love-Gruenwald rongeurs. An endplate scraper is utilized to complete the discectomy (Figure 4). A trial interbody spacer cage is then placed into the disc space to check the appropriate height before to insert the definitive cage passing beneath the neural elements. In all cases, a 5° lordotic interbody PEEK cage spacer (T-PAL DePuy Synthes ®) was utilized. Final AP and LL views are obtained before to remove the tubular retractor (Figure 5).

For pedicle screw instrumentation, a cannulated probe is then placed over the pedicle K-wires to enlarge the space around the wire for the insertion of the tapper and screw. The pedicle is now tappered by-means of a cannulated tapper inserted following the wire and a cannulated polyaxial screw is downed under fluoroscopic guidance. Axial diameter and length of each screw are chosen preoperatively on axial and sagittal CT scan. Before to complete the screwing, the K-wire is removed. In the final stage, two lordotic rods of equal length are lowered onto the tulip head of the screws (Figure 6), the screw extenders are compressed, and buttons placed onto the cup of each screw to secure the implant (Viper 2 - DePuy Synthes®). For each wound, a single 0-0 Vicryl stitch was used to close the fascia and 4-0 Vicryl subcuticular resorbable stitches to close the skin. Final AP and LL fluoroscopic image are obtained (Figure 7).

■ RESULTS

Demographic data of all treated patients are reported in Table I. Mechanical low back pain with lower limb radiculopathy was the most frequent finding (37 patients), while only 3 patients had mechanical back pain alone. In twenty-two cases (55%), recurrent disc herniation, approximately within 6 months from discectomy, was the indication for MI-TLIF. Most of the surgeries were performed at the L4-L5 (n=20) and L5-S1 (n=17) level. In three cases, a multiple level MI-TLIF was performed. There was no conversion from MI-TLIF to open surgery. The average operative time was 230 minutes. The mean estimated

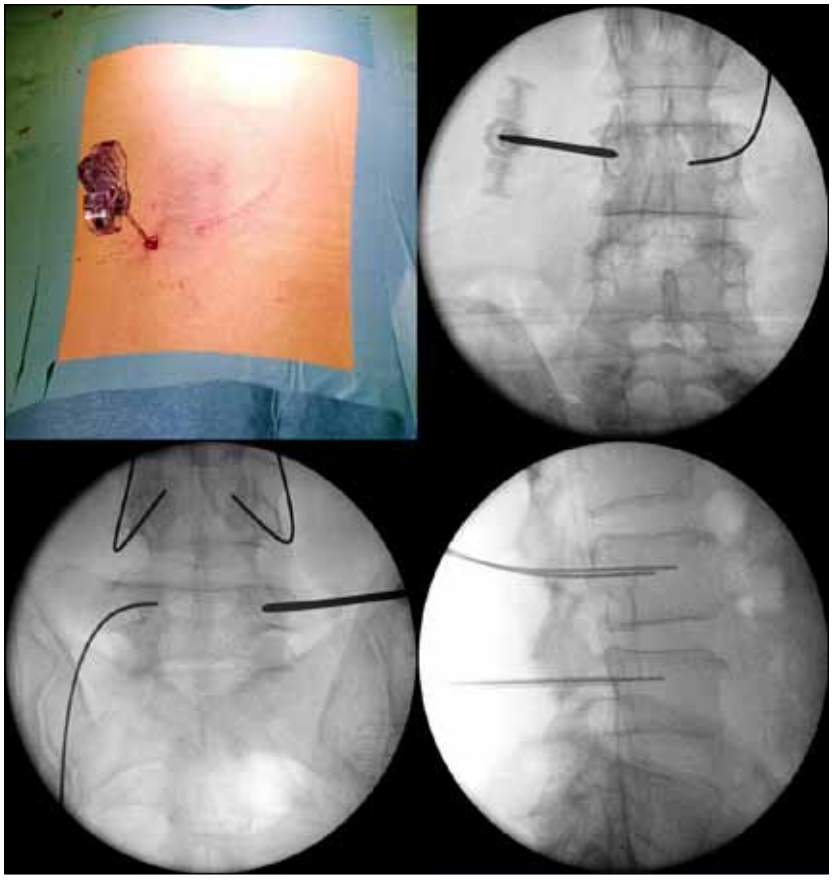

Figure 2: Intraoperative photograph and fluoroscopic images showing placement of Jamshidi needle and pedicle K-wires.

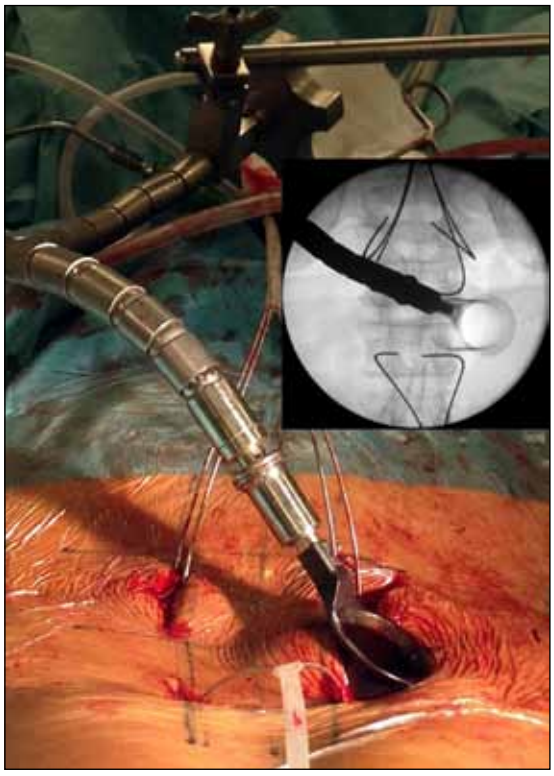

Figure 3: Intraoperative photograph and fluoroscopic images showing placement of tubular retractor.

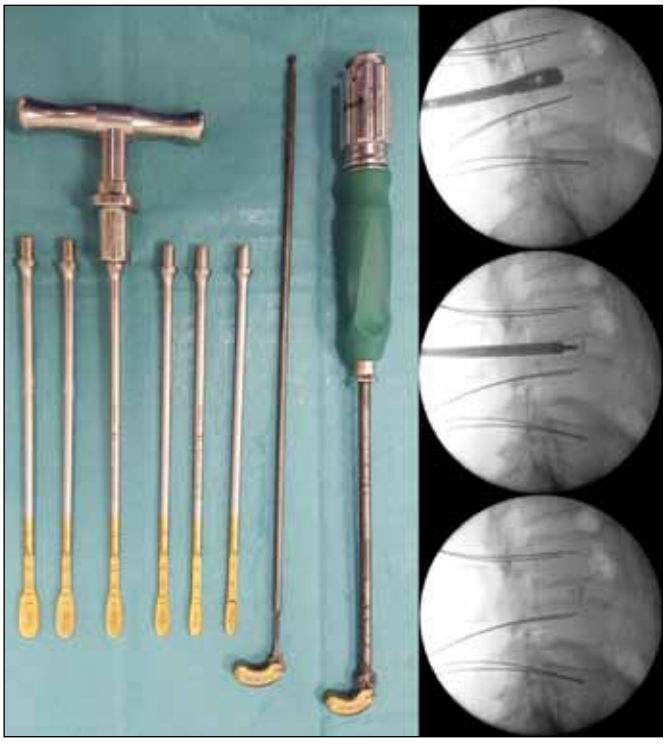

Figure 5: Photograph showing trial interbody cage spacers. Fluoroscopic images showing positioning and release a 7 mm height, 5° lordotic, interbody PEEK cage spacer.

blood loss was 170 mL and the average length of hospital stay was 5 days. All patients had complete recover of their radiculopathy postoperatively. Patients with mechanical low back pain improved significantly. No intraprocedural or postoperative complication occurred. Postoperative CT scan confirmed an optimal decompression and a correct positioning of the implant in all cases (Figure 8). All patients were mobilized on postoperative day 1 and returned to walking on day 2. The patients were generally discharged on

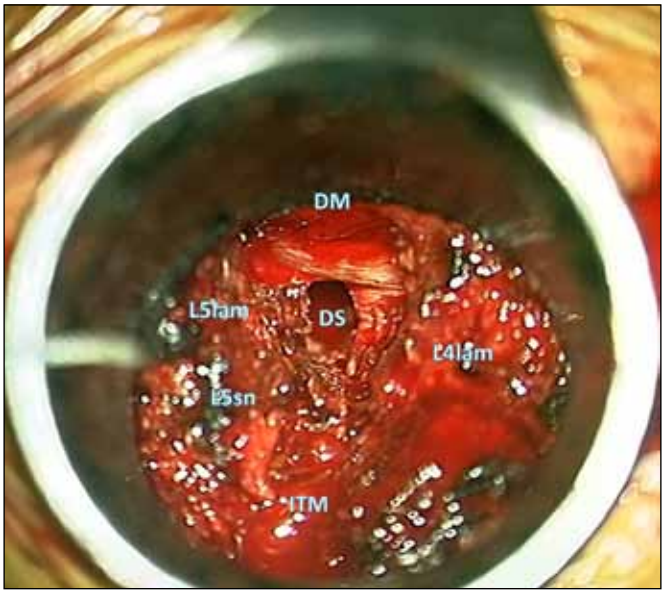

Figure 4: Intraoperative microscopic image showing the surgical field after micro-discectomy. Dura mater (DM), L4 lamina (L4lam), L5 lamina (L5lam), L5 spinal nerve (L5sn), disc space (DS) and intertransverse membrane and muscle (ITM).

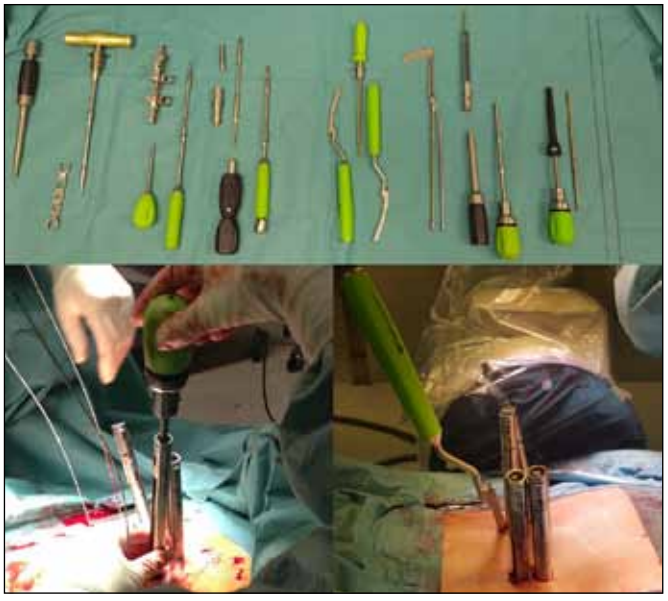

Figure 6: Intraoperative photograph showing instrument set (Viper 2 - DePuy Synthes®) and placement of percutaneous screws and rods.

postoperative day 3. At first year follow-up, the mean ODI score was 20, the mean SF36 Physical Health was 54 and the mean Mental Health was 50 (Table I). All patients reported having stopped narcotics within three weeks from surgery. In all treated cases, first year postoperative CT scan confirmed a solid radiographic fusion, as judged by the presence of trabecular bony bridging at the intervertebral disc spaces. No failure of the implants was documented.

DISCUSSION

Several studies support the need for arthrodesis to alleviate pain in DLSD (5,8,11,16,19). The main goal of minimally invasive spinal surgery is to achieve a less traumatic approach, compared with open procedures, to the lumbar spine, especially regarding the postero-lateral arthrodesis (15). However, open posterior fusion techniques are still commonly

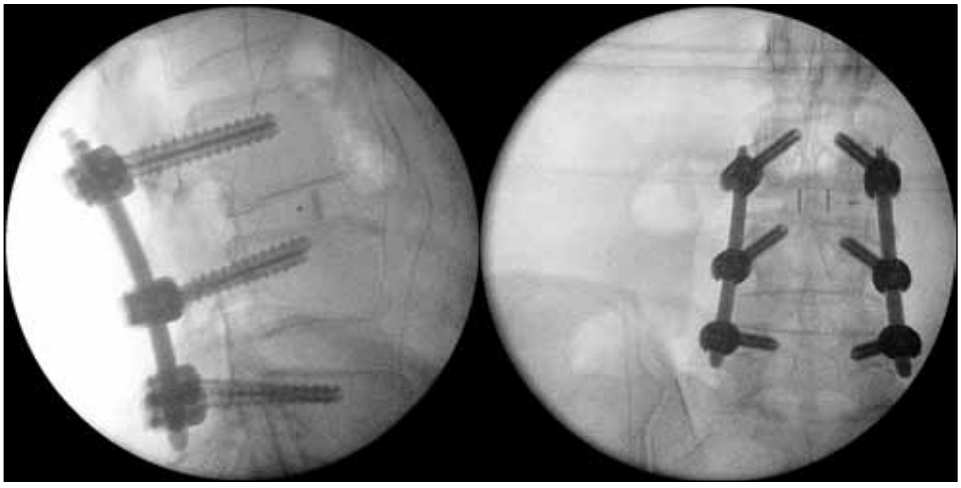

Figure 7: Final lateral and anteroposterior fluoroscopic images.

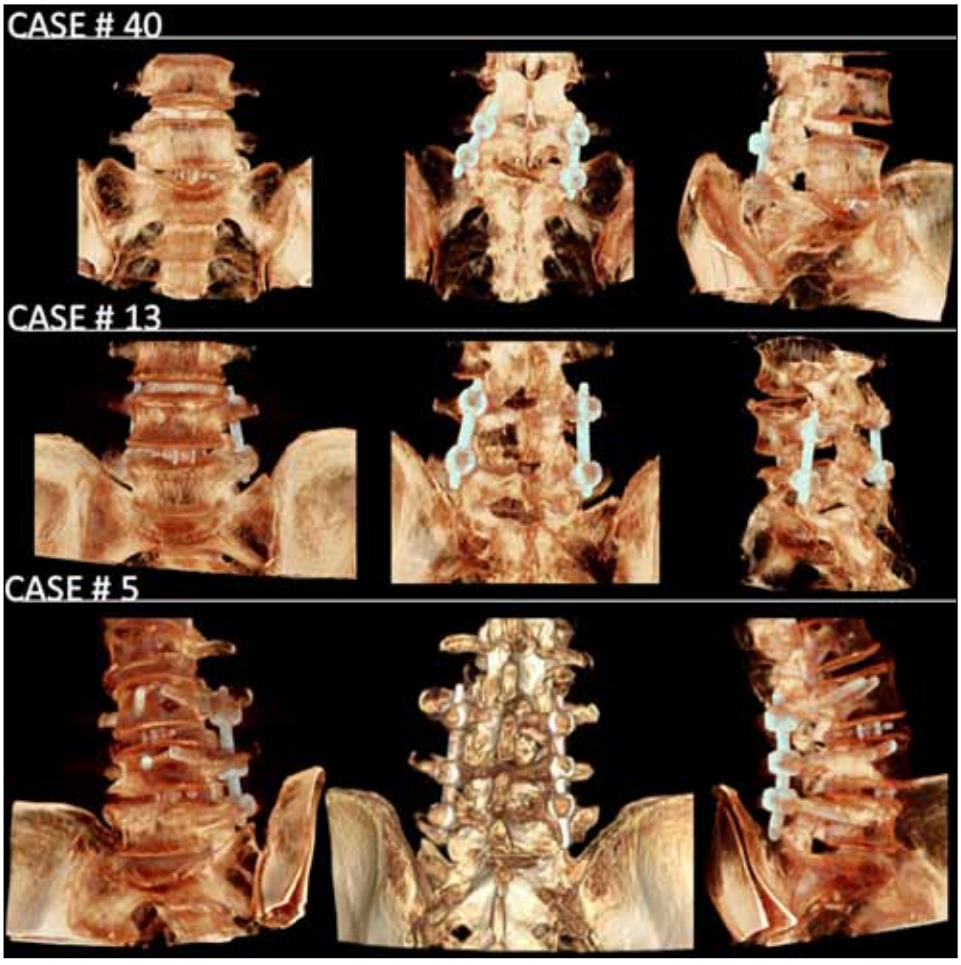

Figure 8: Representative post-operative 3D CT scan of cases n. 40, 13 and 5, performed on postoperative day 2.

used, although decompression, disc preparation, insertion of interbody cage and spinal instrumentation require extensive tissue dissection to gain access to the disc space, and to provide the ideal lateral to medial orientation for screw fixation (7). Also, the high incidence of denervation and atrophy in all the open conventional procedures, with the subsequent high risk for failed back syndrome, due to the excessive intraoperative dissection and retraction of the paraspinal musculature is well known. MI-TLIF was first developed for the minimally invasive micro-discectomy procedure (17). This procedure provides a paramedian, muscle-dilating approach that maintains the normal midline musculoskeletal structures. The small working corridor is in stark contrast to the large midline incision and soft-tissue exposure commonly performed with open TLIF (7). Patients requiring fusion who have undergone a previous lumbar laminectomy for stenosis or multiple discectomies are good candidates for an MI-TLIF because the paramedian approach through naive muscles avoids scar tissue and reduces the risks of nerve injury or spinal fluid leaks (3). The benefits of MI-TLIF have been highlighted in many studies (Table II) where this technique was proven to be associated with decreased intraoperative blood loss, less postoperative pain, and shorter hospital stay.

Schwender et al. performed one of the earlier studies (2005) on 49 patients who had undergone MI-TLIF. Mean operative time was approximately 240 minutes, approximate blood loss was 140 mL, and hospital stays averaged 2 days (15). Schizas et al. examined their institutional experience executing both MI-TLIF and open midline TLIF in 36 patients. The study found that length of surgery, postoperative pain, and the analgesia requirements were not significantly different between the MI-TLIF and open procedures. However, they did find that the MI-TLIF did result in significantly less blood loss and a shorter hospital stay (14). Villavicencio et al. compared safety and effectiveness of MI-TLIF and open TLIF on 63 patients, showing similar long-term outcomes over the course of the 37.5-month follow-up. They found significant improvement in mean estimated blood loss for MI-TLIF (163.0 mL) versus open TLIF (366.8 mL). The study found improvements in mean duration of hospitalization in MI-TLIF (4 days) relative to their open counterparts (4.2 days) (21). Tender and Serban compared MI-TLIF with the tubular technique and MI-TLIF with a screw-based-retractor technique (19). They found, at 4 years follow-up, that for the tubular technique, the average operative time, blood loss, and hospital stay were 189 min, 170 ml, and 3 days, respectively, and for the screw-based-retractor technique, the average operative time, blood loss, and hospital stay were 223 min, 257 ml, and 3.29 days, respectively (19).

In the current study, the authors successfully performed the MI-TLIF procedure in forty consecutive patients. In this procedure, the application of sequential dilators, with an increasing diameter, allows the surgeon to create an operative corridor through the myofascial plane, with a tissue trauma that is minimal (15). As a result, the estimated blood loss in our series averaged 170 mL. Furthermore, a very low incidence of intraoperative and postoperative complications and an early mobilization of the patient with no pain, contributes to a short

Table I: Patient Demographics, Surgical Details and Clinical Outcome

Variable	Data
Number of patients	40
Mean Age (years)	51 (range 30-74)
Sex	
Male	22
Female	18
Mean BMI	27.6 (range 20.1-28)
Working Activity	
Office worker	14
Homemaker	12
Workman	6
Pensioner	6
Student	2
Indication for MI-TLIF	
Recurrent disc herniation	22 (55%)
Degenerative spondylolisthesis	10 (25%)
Lumbar canal stenosis	6 (15%)
Degenerative disc disease	2 (5%)
Level of pathology and fusion	
L4-L5	20 (50%)
L5-S1	17 (42.5%)
L4-L5-S1	2 (5%)
L3-L4-L5	1 (2.5%)
ODI (Oswestry Disability Index)	
Mean preop score	59 (range 48-70)
Mean postop score	20 (range 0-38)
SF 36 (Health Survey Scoring)	
Mean preop PCS (Physical Health)	36 (range 30-40)
Mean postop PCS (Physical Health)	54 (range 50-70)
Mean preop MCS (Mental Health)	29 (range 25-30)
Mean postop MCS (Mental Health)	50 (range 44-67)
Mean Length of hospital stay (days)	5 (range 4-7)
Mean Operative time (min)	230 (range 180-258)
Mean estimated blood loss (mL)	170 (range 90-500)
Complications	None

Table II: Comparative Studies Basic Data

Author	Year	Number of Patients	Mean duration of surgery	Blood loss	Length of hospital stay
Millimaggi et al. (Current series)	2017	40	230 min	170 mL	5 days
Tender and Serban (19)	2014	60	189 min	170 mL	3 days
Tsahtsarlis and Wood (20)	2012	34	173 min	-	3 days
Villavicencio et al. (21)	2010	139	222 min	163 mL	4 days
Shunwu et al. (16)	2010	62	159 min	400 mL	12 days
Schizas et al. (14)	2009	36	348 min	456 mL	8 days
Peng et al. (13)	2008	58	216 min	150 mL	7 days
Schwender et al. (15)	2005	49	240 min	140 mL	2 days

length of stay. Although MI-TLIF has very important potential benefits, the technique does have some drawbacks and limitations. The most important among these are the relative long learning curve, the longer operative time, the difficulty to treat bilateral symptoms via a unilateral approach and a longer exposition to radiations (8,21). The steep learning curve is probably due to the lack of visible landmarks (15). In our opinion, however, the similarity between tubular retractor and Caspar retractor may help the surgeons who start to perform this kind of surgery and who have had, at the same time, a long-lasting experience with microscopic lumbar Caspar discectomy.

CONCLUSION

MI-TLIF with bilateral pedicle screw fixation is an excellent choice for selected patients suffering from symptomatic DLSD, especially secondary to recurrent disc herniation. The main reasons are the preservation of the spinal musculature and midline ligaments with a greater respect of the normal spinal anatomy, thus justifying a very low incidence of intraoperative and postoperative complications, negligible blood loss, early mobilization of the patient and an earlier time to discharge with reduced overall cost. We attribute these results to the minimally invasive nature of the technique, as well as a careful selection of the patients. The present study includes a small number of patients with a limited follow-up period. Randomized comparative clinical trials, with longer observation periods in a larger population, are necessary to confirm our results.

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