MINIMALLY INVASIVE SPINAL CANAL RECONSTRUCTION FOR DEGENERATIVE LUMBAR SPINAL STENOSIS

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Objective. To analyze early results of surgical treatment in patients with lumbar spinal stenosis using minimally invasive techniques for reconstruction of the spinal canal and fixation of the spine.
Material and Methods. A total of 168 patients were treated with minimally invasive unilateral microsurgical decompression for spinal stenosis at the lumbar level.
Results. The average length of post-operative inpatient care was 5.8 ± 2.8 days. When assessing the pain intensity in the legs and lumbar spine, as well as in daily activity, positive dynamics was noted after 1 and 6 months. Of the installed 732 screws, 18 (2.4 %) screws were displaced into the spinal canal by less than 2 mm and 4 (0.5 %) — by less than 4 mm. Signs of persistent subcompensated spinal stenosis at the operated level were detected in 5 (2.9 %) patients. The average intraoperative blood loss was 121.1 ± 22.0 ml. All patients were activated at the first day after surgery.
Conclusion. Minimally invasive unilateral decompression, if necessary in combination with correction and fixation with percutaneous pedicle screw system and TLIF, eliminates factors causing compression of neural structures, reduces intraoperative blood loss, allows early activation of patients and shortens the length of hospital stay.
Key Words: minimally invasive spine surgery, spinal stenosis, minimally invasive decompression, transforaminal lumbar interbody fusion (TLIF).

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Most researchers use the term "spinal stenosis" to describe symptoms caused by the anatomic narrowing of the spinal canal size. Stenosis at the lumbar spine occurs in 74–86 % of patients and is one of the most common causes of vertebrogenic pain syndrome ensuing temporary, and in some cases, permanent disability [10, 11]. Conservative therapy yields the long-lasting success rates in only 44 to 69 % of patients [4, 9, 16, 22, 23]. For this reason, the number of surgical interventions in patients with spinal stenosis increases annually. Despite the comparatively rare arch level spinal canal stenosis, laminectomy followed by an additional resection of the posterior supporting elements (the hypertrophied facets of intervertebral joints and ligamentum flava) causing compression of neural structures remains the most popular method of decompression in spinal canal stenosis [1, 16].

One of the main trends of modern surgery is the most effective and radical operation with the minimal iatrogenic effect. Based on these principles, in 1988, Young et al. [23] developed and described unilateral foraminotomy for bilateral microdecompression in spinal canal stenosis. McCulloch et al. [12] modified the approach in 1991 and represented it as microsurgical fenestration. Foley et al. [5] developed later the TLIF combined with bilateral decompression through a unilateral intermuscular approach [3, 5, 12, 23]. This procedure finds increasing numbers of adepts among surgeons.

Current diagnostic tools (MRI, CT) facilitate the identification of all the factors that lead to the narrowing of the spinal canal and help to plan an operation on the elimination of pathological components contributing to spinal stenosis, with a minimal resection of structures of the spinal motion segment. A use of the method of sequential myodilation, tubular retraction systems, and percutaneous pedicle screws limit injury to the adjacent soft tissues [9, 15, 16, 21].

The purpose of the study is to analyze the early surgical outcomes in patients with spinal canal stenosis operated on using minimally invasive procedures for spinal canal reconstruction and spinal fixation.

Material and Methods

A total of 168 patients (91 men and 77 women) were operated on at the Department of Neurosurgery, Pirogov National Medical and Surgical Center, in 2013–2015 using a minimally invasive approach. The most common indications for surgery included degenerative spondylolisthesis (n = 69), central stenosis (n = 78), and foraminal stenosis (n = 21). The mean age was 66.3 ± 4.8 years.

The main clinical manifestations of the disease: leg and buttocks pain, impaired sensation in the legs, chronic pain in the lumbar spine, and static disorders. All patients showed signs of spinal canal narrowing on MRI and CT scans. The inclusion criteria for surgical treatment were clinical manifestations confirmed by CT and MRI and failed complex conservative therapy over at least three months.

Pain intensity on the VAS scale was assessed separately for the legs and the lumbar spine before surgery, on the 5th day, and 1 and 6 months post-surgery. The Oswestry disability index and the intensity of neurogenic intermittent claudication were analyzed preoperatively, 6 and 12 months postoperatively. The number of injured levels, the volume of intraoperative blood loss, the operative time, the number of surgical complications, and the length of hospital stay were taken into account in the assessment of the conducted treatment. The signs of consolidation at the fixation level, narrowing of the spinal canal and spinal deformities were evaluated from CT, MRI, and radiography findings 12 months postoperatively.

Surgical technique. Surgery was performed through a unilateral paramedian approach 3–5 cm laterally from the spinous line. An intervertebral joint and the space between the arches were accessed through a transmuscular approach. The lower margin of the upper vertebral hemiarch was resected partially, and the upper margin of the lower vertebral hemiarch was excised to a lesser extent. Medial facetectomy on the ipsilateral side was performed. With the ligamentum flavum left in place for protection of the dura mater, using a high speed drill and bone cutters, resection of the base of the spinous process and medial facetectomy on the contralateral side were performed (Fig. 1). The ligamentum flava were then resected and decompression at the spinal root canal was conducted (Fig. 2). Patients with signs of instability underwent fixation with percutaneous pedicle screw system and TLIF (n = 104). The percutaneous transpedicular fixation alone was performed in 47 (28.0 %) patients without preoperative clinical and radiological signs of instability and in whom more than 50 % of the articular process surface was preserved during resection. The signs of the formed spontaneous bone block were noted on preoperative CT in 17 (10.1 %) patients and thus fixation was not performed.

Results

Vertebrogenic pain syndrome (n = 168) and neurogenic intermittent claudication (n = 139) were the most common clinical symptoms at hospitalization. Preoperatively, leg pain was noted in 144 (85.7 %) of patients, impaired sensation – in 96 (57.1 %), paresis – in 38 (22.6 %), and impaired function of the pelvic organs – in 6 (3.6 %).

Decompression at one level was performed in 93 (55.4 %) cases, at two levels – in 66 (39.3 %), and at three – in 9 (5.4 %). The operative time averaged 193.0 ± 9.2 min (range, 115 to 315 min), the mean blood loss was 121.1 ± 22.0 ml (range, 50 to 650 ml). Perioperative blood transfusion was performed in 3 (1.8 %) patients. In all cases requiring transfusion of blood components, decompression was conducted at three levels. The size of the spinal canal and the correctness of inserting transpedicular screws were evaluated on control CT within 24 h after the operation.

When assessing the quality of the spinal canal reconstruction, signs of persistent subclinical subcompensated stenosis were detected in 5 (5.8 %) patients. In the absence of clinical manifestations, repeated surgery was not performed. On CT 12 months after surgery, 9 patients had no signs of the formed interbody bone block and 1 patient developed instability of the fixation system requiring reoperation.

Of 732 screws installed, 18 (2.4 %) were displaced into the spinal canal by less than 2 mm and 4 (0.5 %) – by less than 4 mm. A transpedicular screw was re-installed in 2 patients because of the clinical symptoms of nerve root irritation.

There was an intraoperative injury to the dura matter in 9 (5.4 %) patients. Two patients developed infectious complications in postoperative wounds, 1 of them required revision surgery that involved debridement of the suppuration focus followed by irrigation and suction drainage without removal of the fixation system.

The length of inpatient care averaged 5.8–2.8 days. The majority of patients reported alleviation in the intensity of leg pain in the early postoperative period. At control examination 6 months post-surgery, leg pain aggravated by physical activity was revealed in 5 (5.8 %) patients. Pain in the lumbar spine remained in patients for a longer time. Thus, 6 weeks after the operation 24 (27.9 %) patients reported a moderate lumbar pain and 3 (3.5 %) – strong. Six months after surgery, 16 (18.6 %) patients complained of moderate pain in the lumbar region. There was a trend towards a significant improvement in the Oswestry disability scores with time (Table).

Clinical case. Patient B. aged 74 years complained of pain in the lumbosacral spine (VAS pain intensity score of 6) aggravated by mild physical activity (walk less than 100 m long), leg pain (VAS pain intensity score of 8), numbness in the lower legs and feet (Fig. 3).

The conducted treatment resulted in a positive dynamics: there was a significant decline in the intensity of pain in the lumbar spine (score of 2) and leg pain relief (Figs. 4, 5).

Discussion

Laminectomy followed by the elimination of all factors causing compression of neural structures, interbody fusion and transpedicular screw fixation is the gold standard of surgical treatment in degenerative spinal canal stenosis at the lumber spine. According to the data of studies, laminectomy is an effective treatment for patients with the spinal canal stenosis and allows solving all the issues related to canal reconstruction, disc height restoration and the formation of bone block. Nevertheless, this amount of the operation is rather traumatic and increases intraoperative blood loss, causes a significant injury to paravertebral muscles and a large number (18 to 55 %) of postoperative complications [4, 6, 12, 14–17, 20, 21, 22]. This motivates scientists to search for less invasive techniques to reduce iatrogenic injury.

The main purpose of minimally invasive surgical interventions is to reduce the traumatization degree of manipulations. This is especially relevant for elderly and senile-aged patients since they present with a high number of comorbidities and thus intraoperative blood loss, postoperative mobility, and wound healing are very crucial for this category of people. The data of studies in recent years demonstrate that the number of postoperative complications falls by 28–55 % with minimally invasive surgical procedures [1, 3, 9, 12]. The lower level of intraoperative injury permits earlier patient activation and shorter hospital stay [2, 12, 15, 22]. In our study, the mean length of inpatient care was 5.8 ± 2.8 days. The literature presents similar results: the average length of hospital stay ranges 2.2 to 9.8 days [5, 6, 9, 12, 13, 17].

Another important factor is maintaining the stability of spinal motion segment during a decompressive intervention. According to some authors [7, 8, 19], bilateral decompression through a unilateral approach helps to maintain the stability at the operated segment that permits a surgical intervention on apparently stable levels without using fixation and much shorter operative time, in contrast to conventional open laminectomy and facetectomy. Other researchers noted that the installation of percutaneous pedicle screws and decompression through a minimally invasive approach increase the duration of surgery resulting in the longer times of general anesthesia and the higher likelihood of postoperative complications [2, 3, 6, 22]. In our study, the operative time (193.0 ± 9.2 min) did not differ significantly from the standard techniques. In minimally invasive operations, the adjacent anatomical structures are visualized considerably less raising the requirements to the surgeon's knowledge of surgical anatomy [4, 17]. Some common complications of spine surgery, including liquorrhea, injury to blood vessels and neural structures more often occur in minimally invasive surgery and require harder efforts for their elimination [17, 22]. In our study, the number of complications did not exceed those for standard open surgical procedures.

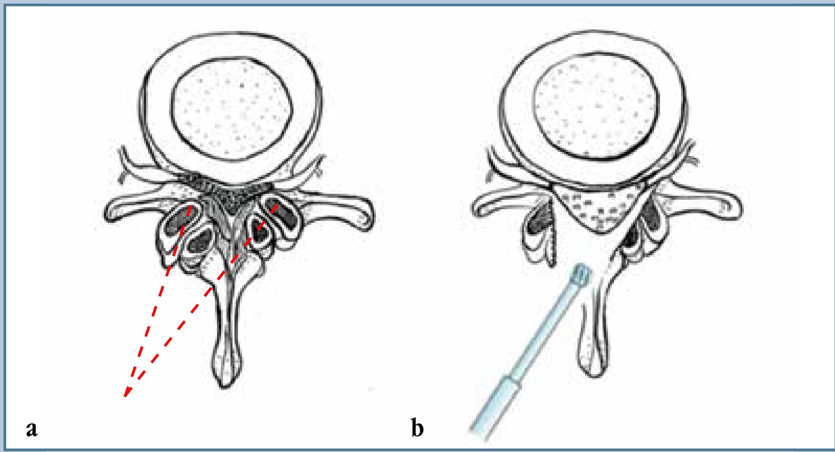

Fig. 1
Spinal canal reconstruction: **a** – the amount of the planned resection and the feasibility of visual control during minimally invasive decompression; **b** – a stage of microsurgical decompression using a high-speed drill

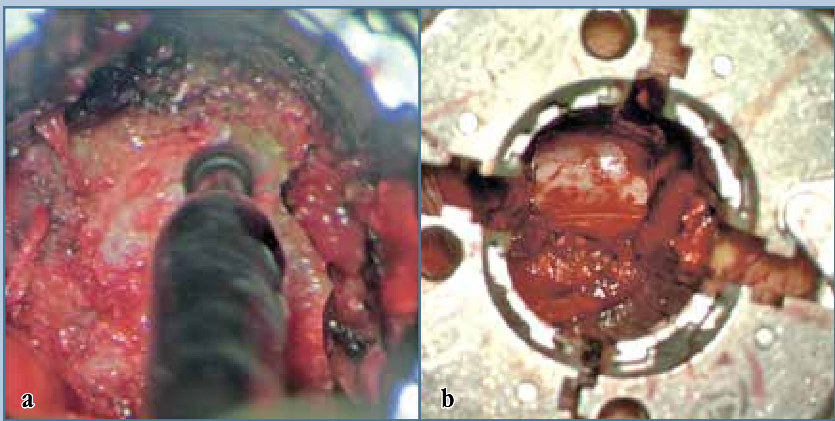

Fig. 2
Intraoperative photographs: **a** – medial facetectomy using a high-speed drill; **b** – the condition of spinal roots after decompression

Conclusions

Minimally invasive unilateral decompression, when necessary in combination with correction and fixation with percutaneous transpedicular system and TLIF, eliminates factors causing compression of neural structures and allows performing the correction of spinal deformities and spinal fusion. The lesser injury to muscles and the mostly preserved structures of the posterior supporting spinal complex help to cut down intraoperative blood loss, permit an early patient activation and reduce the length of hospital stay.

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Table

Pain intensity in patients pre- and postoperatively

Scale	Period	Intensity
VAS (lumbar spine), scores	Preoperative	6.8 ± 2.3
	5 days postoperative	5.2 ± 2.4
	1 month postoperative	4.2 ± 1.9
	6 months postoperative	3.1 ± 1.8
VAS (legs), scores	Preoperative	6.3 ± 2.4
	5 days postoperative	3.4 ± 2.2
	1 month postoperative	2.6 ± 2.1
	6 months postoperative	1.9 ± 2.2
Oswestry disability index	Preoperative	34.8 ± 11.5
	6 months postoperative	19.2 ± 17.4

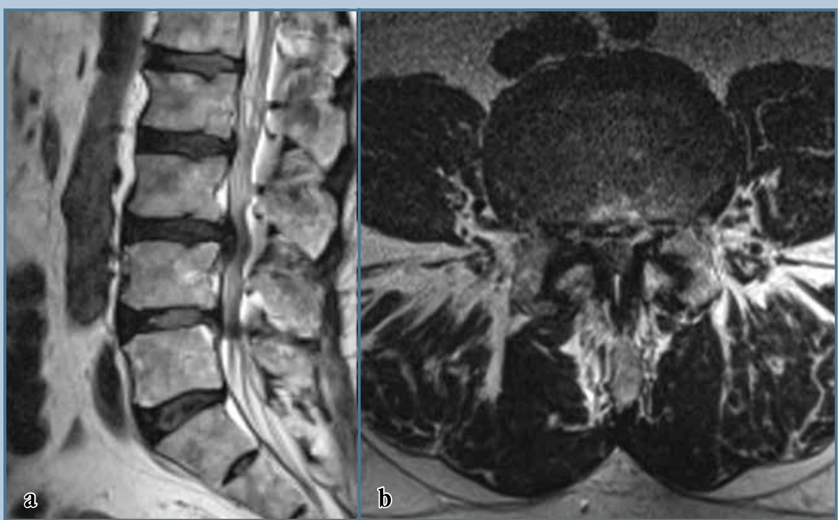

Fig. 3
T2-weighted MRI scans of the lumbar spine of a patient B. aged 74 years on sagittal **(a)** and axial **(b)** slices demonstrate the narrowing of spinal canal at the L3–L4, L4–L5 levels associated with the hypertrophy of articular facets of intervertebral joints and ligamentum flava

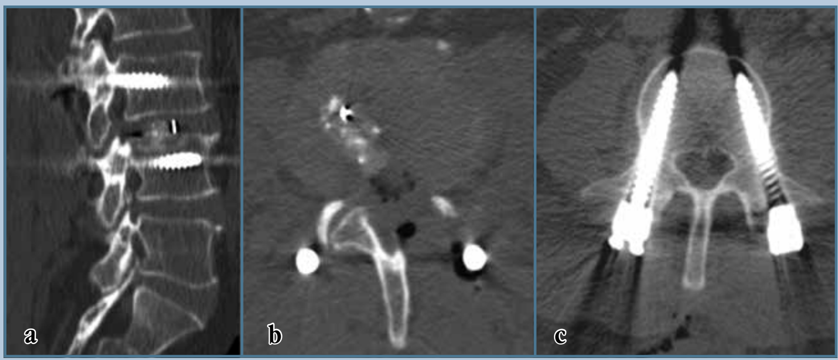

Fig. 4
CT of the lumbar spine of a patient B. aged 74 years one day after TLIF and transpedicular fixation at the L3–L4 level, decompression at the L4–L5 level through a unilateral approach: **(a)** the position of interbody cage and local sagittal profile on sagittal reconstruction, the position of an interbody cage **(b)** and transpedicular screws **(c)** on axial slices

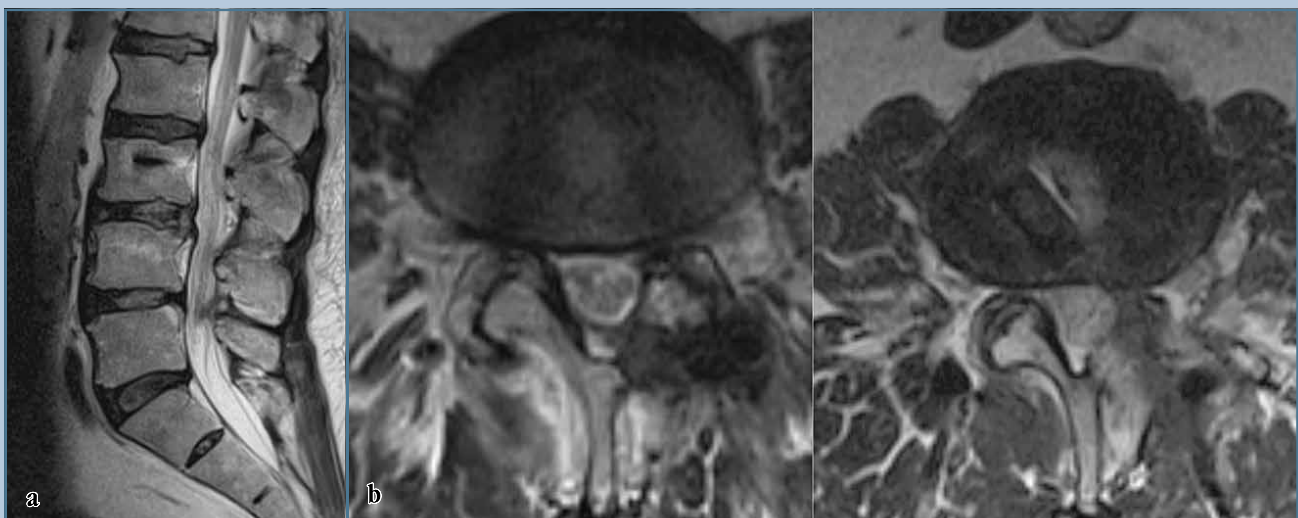

Fig. 5
T2-weighted MRI scans of the lumbar spine of a patient B. aged 74 years, in 6 months postoperatively, the sagittal **(a)** and axial **(b)** view: the signs of spinal canal narrowing are not detected

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