THE NEW ARMENIAN MEDICAL JOURNAL
Vol.11 (2017), No 1, p.33-39

OUTCOME ANALYSIS OF DIRECT LATERAL INTERBODY FUSION IN THE TREATMENT OF PATIENTS WITH DEGENERATIVE DISC DISEASES OF LUMBAR SPINE

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Received 25/07/2015; accepted for printing 20/01/2017

Abstract

Spinal fusion has been used in the surgery for the treatment of degenerative diseases of the lumbar spine: herniated intervertebral discs, segmental instability and spinal stenosis. A new minimally invasive technique of direct lateral interbody fusion has been proposed as an alternative to anterior, posterior and transforaminal methods of stabilization.

The study was aimed to analyze the results of using direct lateral interbody fusion in the treatment of patients with degenerative disc diseases of the lumbar spine.

A retrospective analysis was performed from prospectively collected data on the surgical treatment results of 45 patients, who underwent lateral interbody fusion and percutaneous pedicle screw fixation for degenerative disc diseases of the lumbar spine. Clinical and radiological outcomes were analyzed before and after surgery, at discharge and during follow-up visits in 6, 12 and 18 months.

Significant decrease in pain intensity by visual analogue scale from 64±1.8 mm to 23±11 mm ($p<0.05$) and a significant improvement of functional state by Oswestry Disability Index from 40.2±6.9% to 12.2±5.7% ($p<0.05$) were revealed after direct lateral interbody fusion. Magnetic resonance imaging showed an increase in reserve spaces at the operated segments: increased foraminal area from 98.7±32.3 mm^2 to 156.8±45.1 mm^2 ($p<0.05$) on the right and from 99.7±37.3 mm^2 to 153.4±38.7 mm^2 ($p<0.05$) on the left. Intervertebral disc height increased significantly from 8.6±3.1 mm to 15.7±4.2 mm after surgery ($p<0.05$).

Lateral interbody fusion technique combined with minimally invasive pedicle screw fixation has a high clinical efficacy, confirmed by decreased pain intensity and improved life quality and also allows for efficient stabilization of the spinal motion segments, increase of the interbody space height and foraminal area. Further comparative studies with known minimally invasive fusion approaches are needed to assess if direct lateral interbody fusion may be the method of choice for patients with degenerative disc diseases of the lumbar spine.

Keywords: *lumbar spine, intervertebral disc degeneration, minimally invasive surgery, direct lateral interbody fusion.*

Introduction

Spinal fusion has been used in the surgery for the treatment of degenerative diseases of the lumbar spine: herniated intervertebral discs, segmental instability and spinal stenosis [*Acosta F et al., 2011*]. Recent achievements in the minimally invasive spine surgery decreased the risks for potential complications of anterior retroperitoneal approaches, such as vascular damage, retrograde ejaculation, postoperative ileus, lymphocele, injury to the sympathetic chain [*Anand N et al., 2010; Byvaltsev V et*

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al., 2015], as well as potential complications of the posterior approaches, such as paraspinal muscle denervation, damage to the dura and nerve roots due to incorrect conduction of the retaining elements or excessive soft tissue retraction [*Bridwell K et al., 1995; Cheng L et al., 2009; Cappuccino A et al., 2010; Kalinin A, Byvaltsev V, 2015*].

In 2001 L. Pimenta and co-authors proposed a new minimally-invasive method for lateral lumbar interbody fusion as an alternative to the ventral and dorsal surgical approaches [*Cummock M et al., 2011*]. Lateral lumbar interbody fusion is marketing under different names: XLIF (NuVasive Inc., San Diego, CA), ARIA (Stryker, Inc., Kalamazoo, MI), COUGAR (Depuy Spine Inc., Rynham, MA), Ravine (K2M, Inc., Leesburg, VA), DLIF (Medtronic, Inc., Minneapolis, MN), Transcontinental (Globus Medical Inc., Audubon, PA). The concept of this surgical method is to perform a lateral retroperitoneal approach to the lumbar intervertebral discs through the psoas muscles. The key aspect of this approach is a necessity for a realtime neuromonitoring to ensure a safe passage through the psoas muscle, avoiding injury to the lumbar plexus [*Dooris A et al., 2001; Dehoux E et al., 2004; Dakwar E et al., 2010*].

The main advantage of the lateral approach is the avoidance of complications, usually observed in the anterior or posterior approaches, as well as good visualization of the operative field and wound depths sufficient to safely perform the necessary manipulations [*Faundez A et al., 2009*]. It is known that lateral approaches leave anterior and posterior longitudinal ligaments intact, which contributes to the stability and effective formation of interbody fusion [*Glassman S et al., 2007*]. Moreover, cage installation increases the size of intervertebral foramen leading to indirect decompression of the neural structures [*Moller D et al., 2011*] and correction of the frontal and sagittal balance [*Hsieh P et al., 2007; Isaacs R et al., 2010*].

Taking into account the poor self-fixation of cages in the interbody space, the fusion is augmented by the obligatory posterior stabilization [*Son S et al., 2012*]. Traditional open techniques of pedicle screw fixation significantly increase the severity of postoperative pain in the surgical wound and the risk of spinal and soft tissue fibrosis due to the damage to the surrounding soft tissues. In addition, such open interventions are associated with significant blood loss and higher risk of postoperative infections [*Thomsen K et al., 1997*]. Percutaneous transpedicular screw fixation considerably decreases the risks of the above mentioned adverse outcomes and significantly reduces the surgical trauma [*Styf J, Willen J, 1998*].

The use of interbody fusion for degenerative lesions of the lumbar spine from the anterior, lateral and posterior approaches contributes to the accumulation of significant clinical experience. However, the lack of theoretical knowledge and practical skills of neurosurgeons in the implementation of new surgical procedures on the spine, are the factors hindering the development of new methods of surgical treatment. Also, currently, there are no generally accepted indications and contraindications for performing direct lateral interbody fusion.

Present study was aimed to analyze the results of direct lateral interbody fusion in the treatment of patients with degenerative disc diseases of the lumbar spine.

Material and methods

A retrospective analysis was performed from prospectively collected data on the surgical treatment outcomes of 45 patients (29 men, 16 women) aged from 29 to 68 years (mean age 46.1±9.7 years) operated in the Neurosurgery Center of Road Clinical Hospital at Irkutsk-Passenger station JSC “Russian Railways”. All surgeries were performed for intervertebral disc degeneration on a single lumbar level using a direct lateral interbody fusion technique with Oracle intervertebral cage (Synthes, Switzerland), followed by percutaneous pedicle screw fixation with Viper II system (DePuy Spine, USA).

Surgical time and blood loss, activation time and overall length of hospital stay were assessed. Evaluation of the clinical efficacy was performed on the basis of pain severity by visual analogue scale and life quality assessment using Oswestry Disability Index. Patients were assessed before surgery, at discharge and at follow-up visits, recommended 6, 12 and 18 months after surgery. The study of interbody space height and foraminal area in the operated segment was conducted according to magnetic resonance imaging data Magnetom Essenza 1.5 *T* (Siemens, Germany) on sagittal projection using OsiriX Lite® software (USA).

Statistical analysis was performed using Microsoft Excel 2010 software packages. Descriptive statistics are presented as M±SD, where M – mean value, SD – standard deviation. Paired Student t-test and Wilcoxon test were used for the comparison of clinical and radiological data before and after direct lateral interbody fusion. Kruskall-Wallis test was used for the comparison of visual analogue scale and Oswestry Disability Index scores. The differences were considered as statistically significant at $p<0.05$.

Results

The ratio of male and female operated patients was 2:1. The average height and weight of the patients was 172.8±8.7 *cm* and 66.7±8.2 *kg*, respectively. Surgery was performed most often at L_{III}-L_{IV} segment (n=30, 67%). Mean operative time was 92.6±3.2 *min*. The average blood loss was 159.3±36.4 *ml*. All patients were allowed to stand and walk in a brace the next day after surgery. The mean hospital stay was 9.2±1.5 days. After surgery, all patients achieved a significant relief in pain. Assessment of pain by visual analogue scale allowed to reveal a significant reduction in pain intensity after surgery on average from 64±18 *mm* to 23±11 *mm*, (p=0.002) (Fig. 1).

Assessment of life quality by Oswestry index revealed significant improvement in postoperative period compared with the preoperative levels on average from 40.2±6.9 to 12.2±5.7 (p=0.003) (Fig. 2).

Within a follow-up period (at average 18 months) no migration or breakage of the fusion elements, as well as signs of segmental instability were encountered on plain lateral lumbar X-rays.

Analysis of the preoperative and postoperative MRI studies showed a significant increase in the reserve spaces at the operated segment both in heights of interbody space and foraminal area ($p<0.05$) (Table).

Table

Analysis of intervertebral disc height and foraminal area at the operated segment

Indices		Before surgery M±SD	After surgery M±SD
Interbody space height (*mm*)		8.6±3.1	15.7±4.2
Foraminal area (mm^2)	Right side	99.7±37.3	153.4±38.7
	Left side	98.7±32.3	156.8±45.1

While performing direct lateral interbody fusion complications were observed in 4 (8.8%) patients. There were 2 cases of local wound infections on the background of intramuscular hematoma that healed well after the course of antibiotic therapy without increasing the length of hospital stay.

There were two cases (4.4 %) of temporary postoperative neurological disorders resulted from the intraoperative damage of the lumbar plexus (genitofemoral and lateral femoral cutaneous nerves). In both cases symptoms of nerve damage regressed within 2 months after conservative therapy.

Clinical example

Patient B., aged 49 years, was admitted to the Neurosurgical Center complaining of severe pain

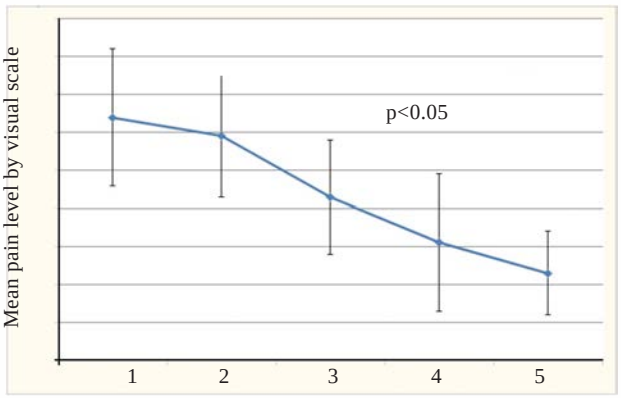

Figure 1. *Dynamics of the pain level according to visual analogue scale in study group patients in preoperative (1), postoperative (2), 6-month (3), 12-month (4), 18-month (5) periods*

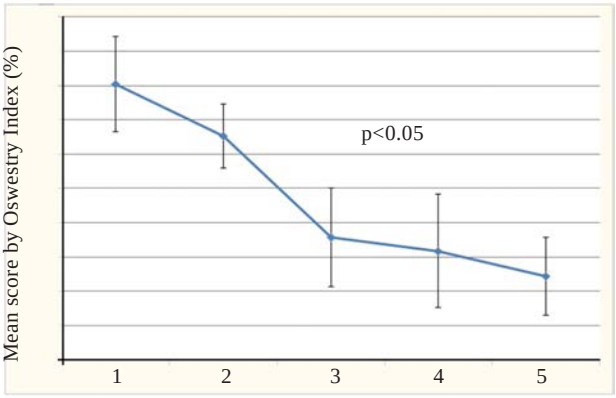

Figure 2. *Dynamics of the functional state of study group patients by Oswestry Disability Index in preoperative (1), postoperative (2), 6-month (3), 12-month (4), 18-month (5) periods*

in the lumbar spine, that increased during dynamic loads and irradiated to the left buttock and left lower leg, producing numbness in this areas. The low back pain and left leg pain bothered the patient during the last three years.

Neurological status: Patient distinguishes fragrances, the sight fields are normal, eye movements are full. Pupils D=S, with live reaction to the light and convergence, no diplopia and nystagmus. Trigeminal points are painless. Face is symmetrical. Hearing is fine. No abnormal bulbar signs. Patient's position is forced, antalgic. Moves with the help of a walking stick, spares left leg. Lumbar lordosis is smoothed; movements in the lumbar spine are restricted and painful. Défense of paravertebral muscles of II-III degree is revealed. Reflexes: biceps D=S, triceps D=S, carporadial D=S, alive. Knee-jerk reflex D≥S, Achilles reflex D≥S are reduced. Lasegue sign on the right (55°) and on the left (45°) is positive. No pathological reflexes. Muscle tone in the upper extremities is normal. Muscle strength in the upper and lower extremities is 5 points. The patient had hypoesthesia in the left L3 and L4 dermatomes. Pain intensity degree according to visual analogue scale was 9.5 *cm*, life quality level by Oswestry questionnaire – 70%.

Magnetic resonance imaging of lumbosacral spine revealed signs of osteochondrosis, left-sided L_{III}-L_{IV} disc herniation, intervertebral disc protrusion at L_{IV}-L_V, L_V-S_1 levels (Fig. 3 A-C). With the help of OsiriX Lite® (USA) software the intervertebral disc height and intervertebral foramen area were calculated before and after surgery.

Lumbar spondylography with functional tests showed osteochondrosis and spondylarthrosis without signs of segmental instability.

After discussion of possible treatment options the patient decided to proceed with minimally invasive surgery by direct lateral interbody fusion technique: left sided lumbotomy followed by retroperitoneal access to the intervertebral disc at L_{III}-L_{IV} levels, discectomy L_{III}-L_{IV}, interbody fusion by Oracle cage (Synthes, Switzerland) and percutaneous pedicle screw fixation of L_{III}-L_{IV} segments by Viper II system (Depuy Spine, USA).

Surgery was performed under the intravenous anesthesia with the use of mechanical ventilation. The patient was positioned on the right side with a roller under the waist for body alignment (Fig. 4 A). After the X-ray guided marking of the trajectory, the skin and subcutaneous fat was incised in the projection of L_{III}-L_{IV} vertebral bodies. External and internal oblique abdominal muscles and their fascia was bluntly dissected and spread using the retractor, abdominal organs were retracted in the ventral direction. The L_{III}-L_{IV} space was located under a fluoroscopic guidance for precise blind dissection of the psoas major and minor muscles overlying the disc space. After additional fluoroscopic verification, the Oracle retractor was introduced with its petals fixed anterior, superior and inferior to L_{III}-L_{IV} intervertebral disc (Fig. 4 B, C). Interbody fusion was then performed after a microsurgical discectomy using Oracle interbody

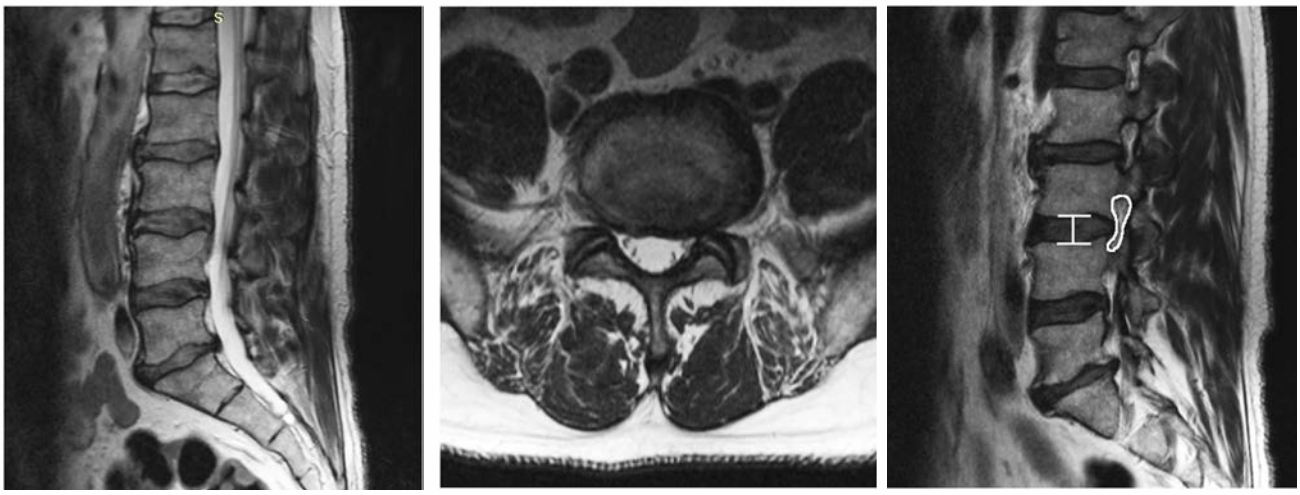

Figure 3. *Preoperative MRI of the lumbosacral spine showing the herniated disc on L_{III}-L_{IV} level with caudal fragment migration.* ***(A)*** *– sagittal T2-weighted image;* ***(B)*** *– axial T2-weighted image;* ***(C)*** *– intervertebral disc height (9.4 mm) and foraminal area on the sagittal image (107 mm^2)*

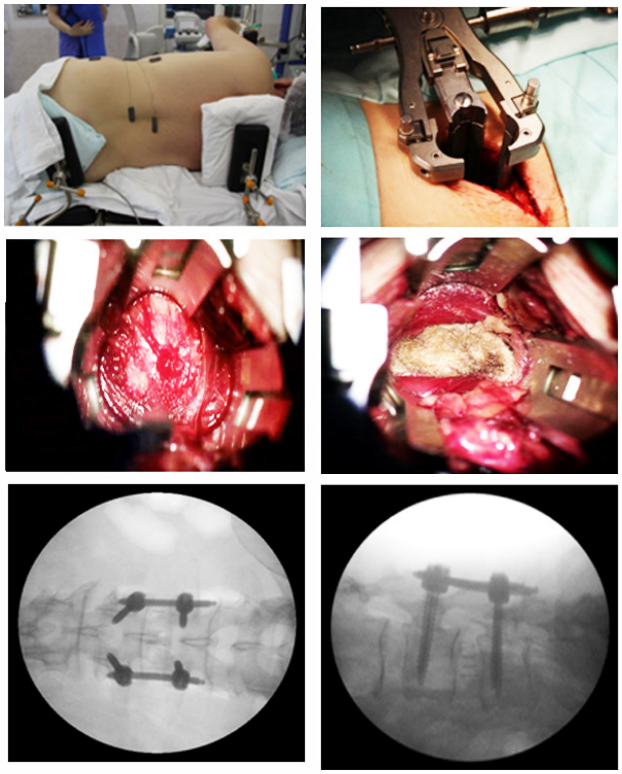

Figure 4. *Intraoperative images:* ***(A)*** *– position of the patient on the operating table;* ***(B)*** *– installation of Oracle retractor;* ***(C)*** *– type of surgical wound with visualization of the front and middle parts of L_{III}-L_{IV} intervertebral disc;* ***(D)*** *– view of the surgical wound after discectomy, cage installation and laying of hemostatic material. X-ray position control of design elements using electrooptical converter;* ***(E)*** *– in frontal projection;* ***(F)*** *– in lateral projection*

cage implant. X-ray confirmed appropriate cage location. Hemostasis was achieved with bipolar coagulation and Surgicel (Ethicon Johnson & Johnson, USA) (Fig. 4 D). Surgical wound was sutured in layers with active drainage of the retroperitoneal space and aseptic dressing on the skin.

For the second stage of the surgery the patient was placed in prone position. After cleaning of the surgical field with antiseptic solution and dressing, under fluoroscopic guidance, the transcutaneous instruments were introduced and cannulated transpedicular screws were inserted through the pedicles of L_{III} and L_{IV} vertebras bilaterally using Viper II system. The screw heads were aligned and rods mounted on both sides. X-ray control confirmed correct position of the rods and screws (Fig. 4 D, E). Hemostasis was achieved followed by wound closure in layers and aseptic dressing on the skin. Operation time was 130 *min*, blood loss – about 50 *ml*.

The patient was activated the next day. No postoperative complications were found. He was discharged on the 10th day after surgery with a significant improvement in neurological symptoms and pain (pain intensity degree by visual analogue scale – 1.5 c*m*, life quality level by Oswestry Disability Index – 20%).

Patient was advised to gradually increase physical activity in about a month after surgery. Patient regained full social and physical rehabilitation 1 month after surgery. Postoperative MRI of the lumbar spine showed 26.3% increase in the foraminal area (from 107 to 145 *mm*^{2}) and 38.1% increase of the intervertebral disc height (from 9.4 *mm* to 15.2 *mm*) (Fig. 5 A-C).

Conclusion

Direct lateral lumbar interbody fusion technique combined with minimally invasive percutaneous pedicle screw fixation has a high clinical ef-

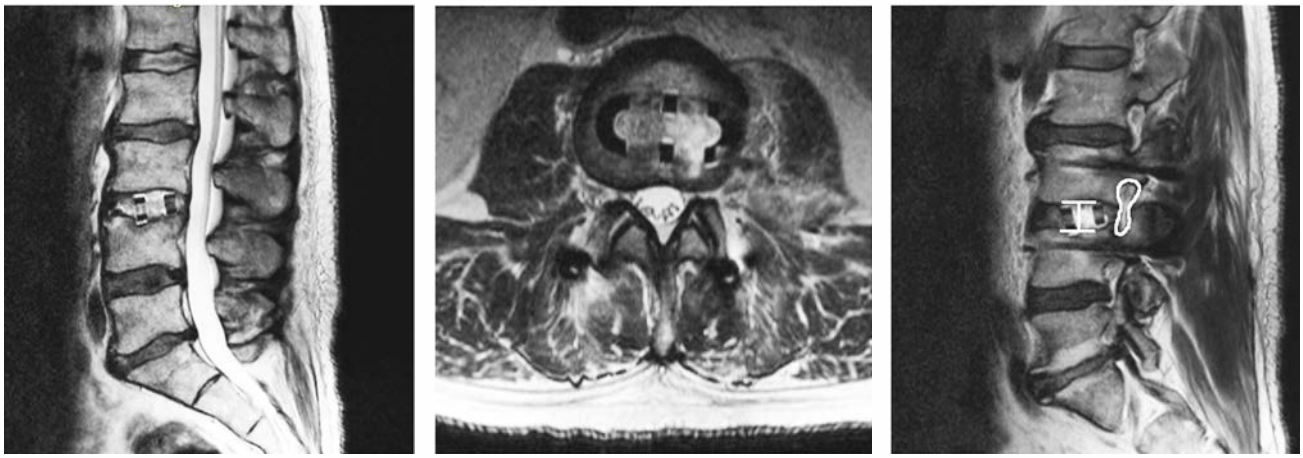

Figure 5. *Postoperative lumbar MRI:* ***(A)*** *– sagittal T2-weighted image;* ***(B)*** *– axial T2-weighted image at L_{III}-L_{IV} level;* ***(C)*** *– intervertebral disc height (15.2 mm) and foraminal area on the sagittal image (145 mm^2)*

ficacy, confirmed by decreased pain intensity and improved life quality, and also allows for effective stabilization of the operated spinal motion segments, increase of the interbody space height and foraminal area and may be a valuable method of choice for patients with degenerative disc diseases of the lumbar spine.

Taking into account the lack of information on the comparison of different minimally invasive techniques in modern literature, it is necessary to conduct multicenter studies aimed at understanding the long-term clinical results of using different methods of fusion, as well as clarification of the indications for their use.

The study was supported by the grant from the Russian Science Foundation (Project No 15-15-30037).

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