



COMPARATIVE ANALYSIS OF ALIF AND TLIF IN RECURRENT L5–S1 INTERVERTEBRAL DISC DISEASE

Sh.Kh. Gizatullin^{1,3}, N.A. Pestov¹, I.S. Lysenko², V.Yu. Kurnosenko¹, I.P. Dubinin¹, M.T. Sampiev²

¹Main Military Clinical Hospital n.a. N.N. Burdenko, Moscow, Russia;

²Peoples' Friendship University of Russia, Moscow, Russia;

³Russian Medical Academy of Continuous Professional Education, Moscow, Russia

Objective. To analyze the immediate and long-term results of surgical treatment of recurrent single-level herniated L5–S1 intervertebral disc using the methods of total removal of the affected disc through anterior approach with spondylodesis (ALIF) and discectomy from the posterior approach with transforaminal spondylodesis (TLIF).

Material and Methods. A total of 180 patients (ALIF group – 87, TLIF group – 93) were operated on for recurrent single-level lumbosacral L5–S1 intervertebral disc disease. The average time to recurrence was 3 years \pm 5 months.

Results. The average duration of surgery for ALIF was 92 ± 14 min, for TLIF – 120 ± 18 min ($p < 0.05$). Comparison of preoperative and postoperative VAS scores showed that pain syndrome reliably regressed almost completely in patients of the ALIF group. In the TLIF group ($n = 93$), pain syndrome also regressed, but to a lesser extent. Functional assessment according to ODI revealed positive dynamics after surgery in all patients. Despite the positive dynamics in both groups, the difference in the degree of improvement was statistically significant in favor of ALIF ($p < 0.05$). In accordance with the modified MacNab scale, the overwhelming majority of patients in the ALIF group rated the outcome as excellent, while in the TLIF group – as good. In the ALIF and TLIF groups, a comparable high percentage of a complete bone block formation was recorded. Insufficient fusion was recorded in four patients. Better restoration of lumbar lordosis was noted in the ALIF group. The average increase in the lordosis angle in the ALIF group was $11.5^\circ \pm 2.1^\circ$, in the TLIF group – $3.9^\circ \pm 0.8^\circ$ ($p < 0.01$).

Conclusion. ALIF and TLIF are effective methods of surgical treatment for recurrent single-level L5–S1 intervertebral disc disease. Despite the technical complexity and certain limitations of the anterior approach, ALIF can be considered as a preferred surgical approach for recurrent L5–S1 disc herniation, especially in patients with sagittal profile abnormalities, severe pain, and the need to restore the height of the intervertebral space.

Key Words: recurrent disc herniation; ALIF; TLIF; fusion.

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Recurrence of intervertebral disc herniation of the lumbar spine remains one of the problems in spinal neurosurgery, occurring, according to various data [1, 2], in 5–15% of cases. Repeated interventions are traditionally carried out through a posterior approach, however, technical difficulties caused by cicatricial adhesive changes, an increased risk of damage to the dura mater and possible damage to spinal roots, often become the cause of unsatisfactory outcomes [3]. In this context, there is a growing interest in alternative methods – anterior and lateral approaches (ALIF, OLIF, LLIF), which provide a safe and effective pathway for revision intervention with the ability to minimize interaction with scar tissue and, as a consequence, reduce trauma to neural structures [4].

To date, classic methods of surgical treatment include posterior interbody spinal fusions, such as PLIF (Posterior Lumbar Interbody Fusion) and TLIF (Transforaminal Lumbar Interbody Fusion). These methods allow directly eliminating compression of the neural structures of the spinal canal and stabilizing the affected segment using interbody cages and posterior fixation [5, 6]. However, during repeated interventions, such approaches demonstrate limited effectiveness and are fraught with a number of difficulties. Cicatricial adhesive changes in the spinal canal significantly complicate access to the disc, increase the risk of damage to the dura mater and roots, and also contribute to the development of postoperative complications, the most common

of which is recurrent pain [7, 8]. Furthermore, in a number of reviews it is emphasized that with PLIF and TLIF it is more difficult to achieve adequate restoration of lumbar lordosis, especially in patients with a pronounced decrease in the interbody space [9, 10]. This prompts researchers and clinicians to search for less invasive and more anatomically grounded approaches.

The objective of the study was analysis of immediate and long-term results of surgical treatment of recurrent single-level intervertebral disc herniation of L5–S1 vertebrae by methods of total removal of the affected disc via anterior approach with spinal fusion (ALIF) and discectomy via posterior approach with transforaminal fusion (TLIF).

Material and Methods

The study was conducted at the clinical base of the N.N. Burdenko Main Military Clinical Hospital (Moscow). The study was approved by the local ethics committee of the N.N. Burdenko Main Military Clinical Hospital (protocol No. 297 dated September 04, 2025). All study participants voluntarily signed the informed consent form for inclusion in the study. Study design: comparison of two groups in a retrospective-prospective cohort material collection.

The study included 180 patients operated on for recurrent single-level intervertebral disc lesion of the lumbosacral spine at L5–S1 level. All patients had previously undergone microdiscectomy of the L5–S1 vertebrae, and subsequently developed a recurrence of the herniation, which required an interbody spinal fusion. The average time of recurrence onset was 3 years \pm 5 months.

Inclusion criteria:

- history of microdiscectomy at the L5–S1 level;
- recurrence of intervertebral disc herniation at the L5–S1 level confirmed by instrumental examination methods;
- ineffectiveness of conservative therapy for 8–12 weeks;
- performance of spinal fusion using ALIF or TLIF method; and
- availability of a complete set of pre- and postoperative clinical and instrumental data.

Preoperative assessment. All patients underwent preoperative imaging of the lumbar spine (MRI, CT, functional radiography). Preoperative analysis of the sagittal balance was carried out, including spinopelvic parameters, for the purpose of optimal selection of the interbody implant.

Surgical technique. As interbody implants, a lumbar interbody cage was used in the ALIF group. Characteristics: inclination angle of 10–12–15°, length of 26 millimeters, height of 10, 12, 14, 16 mm (height and inclination angle of the implant were selected individually taking into account preoperative radiography). In the TLIF group, a lumbar interbody cage was used. Characteristics: inclina-

tion angle of 4°, length of 22 mm, height of 8, 10, 12, 14 mm.

During each intervention, the cages were filled with a synthetic bone tissue substitute based on a mixture of 60% hydroxyapatite and 40% tricalcium phosphate.

Postoperative assessment. Clinical efficacy was assessed using standardized scales: Visual Analogue Scale, Oswestry Disability Index, modified MacNab scale.

Radiological assessment of spinal fusion was performed according to CT data using the Brantigan and Steffee classification [11], based on key anatomical criteria [12]. Grades 1 and 2 were interpreted as absence of fusion, grades 3–5 as its presence, consolidation. Analysis of images and assignment to one or another category were performed by 2 independent researchers using the visual assessment.

Analysis of key spinopelvic parameters was conducted according to radiography data in the patient's standing position. Pelvic indicators were evaluated: Sacral Slope (SS), Pelvic Tilt (PT) and Pelvic Incidence (PI), as well as the magnitude of total Lumbar Lordosis (L1–S1, LL). Measurements were performed in accordance with generally accepted methods described in current literature [13–15].

Results

Evaluation of pain syndrome (VAS)

Analysis of the dynamics of the pain syndrome showed its significant decrease after surgical intervention in both samples. In the ALIF group ($n = 87$), when comparing the average preoperative and postoperative VAS scores, the pain syndrome significantly completely regressed. In the TLIF group ($n = 93$), when comparing the average preoperative and postoperative VAS scores, the pain syndrome significantly regressed, but to a lesser extent (Table 1). Thus, the degree of pain reduction after ALIF was significantly higher compared to TLIF ($p < 0.01$), especially regarding pain in the lumbar region. Both methods effectively eliminated radiculopathy, but ALIF provided a more pronounced reduction in axial back pain.

Functional outcomes (ODI)

Functional assessment of disability according to the ODI (Oswestry Disability Index) revealed positive dynamics in all patients after surgery. In the ALIF group, the preoperative ODI value corresponded to a severe impairment of daily activity. After surgery, the indicator decreased, demonstrating a restoration of work capacity and a high level of quality of life. In the TLIF group, the initial ODI level was similar to the ALIF patient group, but in the postoperative period it decreased less significantly than in the ALIF group (Table 1). Despite positive dynamics in both groups, the difference in the degree of improvement was statistically significant in favor of ALIF ($p < 0.05$).

Subjective assessment of outcomes (MacNab scale)

Subjective assessment of the effectiveness of surgical treatment according to the modified MacNab scale showed the following: in the ALIF group, the overwhelming majority of patients evaluated the outcome as excellent. In the TLIF group, survey data indicate a positive effect, however less dynamic than in the ALIF group. The larger part of the patient cohort evaluated the outcome as good (Table 2).

Radiological parameters and quality of spinal fusion

For an objective assessment of the effectiveness of ALIF and TLIF methods, a comprehensive analysis of radiological data was performed, including an assessment of consolidation in the spinal fusion zone and measurement of key spinopelvic parameters.

The quality of spinal fusion, assessed according to CT data using the Brantigan and Steffee classification [11] 12 months after surgery, demonstrated a high frequency of bone block formation in both groups. However, in the ALIF group, a significantly higher percentage of successful consolidation was registered compared to the TLIF group (96.6% vs. 89.2%; $p < 0.05$; Table 3).

Analysis of the spinopelvic balance revealed statistically significant differences between the groups in the ability to restore sagittal parameters. In the ALIF

Table 1
Characteristics of patients of the studied groups and assessment of pain syndrome according to the VAS and ODI

Group	Sex (male/female), n	Average age, years	VAS (pain before surgery), points	VAS (back before surgery), points	VAS (leg before surgery), points	ODI (before surgery), %	VAS (pain after surgery), points	VAS (back after surgery), points	VAS (leg after surgery), points	ODI (after surgery), %
Total (n = 180)	103/77	55.80	7.55 ± 0.55	7.50 ± 0.55	8.00 ± 0.55	55.00 ± 3.80	2.00 ± 0.90	1.70 ± 0.50	0.20 ± 0.25	7.00 ± 1.90
ALIF (n = 87)	52/35	52.14	7.30 ± 0.50	7.30 ± 0.50	8.00 ± 0.50	54.00 ± 4.40	0.15 ± 0.50	0.20 ± 0.40	0.10 ± 0.20	4.00 ± 1.50
TLIF (n = 93)	51/42	55.26	7.80 ± 0.60	7.80 ± 0.60	8.00 ± 0.60	56.00 ± 3.20	2.09 ± 0.70	3.00 ± 0.60	0.30 ± 0.30	10.00 ± 2.30

Table 2

Comparative assessment of the effectiveness of surgical treatment in the studied groups according to the MacNab scale, %

Group	Outcome		
	excellent	good	satisfactory
ALIF	87.9	12.1	0.0
TLIF	8.1	64.9	27.0

Table 3

Indicators of bone block formation in the studied groups after 12 months, %

Group	Consolidation (grades 3–5 according to Brantigan and Steffee)	Absence of fusion (grades 1–2 according to Brantigan and Steffee)
ALIF (n = 87)	96.6 (n = 84)	3.4 (n = 3)
TLIF (n = 93)	89.2 (n = 83)	10.8 (n = 10)

group, a significantly better restoration of lumbar lordosis was noted, due to the use of large implants with an anatomically preset angle (10–12°). The average increase in the angle (LL, L1–S1) in the ALIF group was $11.5^\circ \pm 2.1^\circ$, which significantly exceeded the analogous indicator in the TLIF group ($3.9^\circ \pm 0.8^\circ$; $p < 0.01$).

As Table 4 demonstrates, more pronounced correction in the ALIF group also led to a significant improvement in pelvic parameters. A significant increase in SS and a decrease in PT was observed, which indicates a retroversion of the pelvis and a decrease in the compensatory tension of the muscles to maintain a vertical posture.

Thus, ALIF method demonstrated not only a higher percentage of successful bone block formation, but also significant advantages in the correction and restoration of physiological spinopelvic relationships, which is a key factor for a long-term favorable functional outcome.

Intra- and postoperative parameters

A comparative analysis of intra- and postoperative parameters showed statistically significant differences between the ALIF and TLIF groups. The average duration of surgical intervention when performing ALIF was 92 ± 14 minutes, whereas for TLIF – 120 ± 18 minutes ($p < 0.05$), which indicates a faster techni-

cal pace with the anterior approach. The volume of intraoperative blood loss also turned out to be significantly lower in the ALIF group (180 ± 40 milliliters) compared to TLIF (290 ± 60 mL; $p < 0.01$). Furthermore, in patients operated on by the ALIF method, a shorter duration of hospitalization was recorded – on average 5.4 ± 1.2 days vs. 7.1 ± 1.5 days in the TLIF group ($p < 0.05$).

Complications

Postoperative complications were recorded in 4 (5.7%) cases (Table 5).

Discussion

One of the most noticeable trends of the last decade in revision surgery of the lumbar spine is the active introduction of minimally invasive anterior (ALIF), anterolateral (OLIF) and lateral (LLIF, XLIF) approaches, which can be considered as an alternative to classic posterior approaches [4, 16, 17]. However, there is a natural anatomical barrier when using OLIF and LLIF at the L5–S1 level – the crest of the ilium, which limits the possibilities of manipulating instrumentation and does not allow setting an adequate angle of approach to the zone of interest [18, 19]. In connection with this, it is specifically ALIF that remains

Table 4

Dynamics of spinopelvic parameters in the studied groups after surgical intervention

Parameter	ALIF (<i>n</i> = 87)	TLIF (<i>n</i> = 93)	<i>p</i> -value (intergroup)
Angle of pelvic sagittal plane, degrees	55.2 ± 4.1	54.8 ± 3.9	>0.05
Preoperative pelvic tilt, degrees	25.8 ± 3.5	24.9 ± 4.1	>0.05
Postoperative pelvic tilt, degrees	19.1 ± 2.8*	23.5 ± 3.2*	<0.01
Preoperative sacral slope, degrees	30.5 ± 3.8	31.2 ± 4.0	>0.05
Postoperative sacral slope, degrees	37.8 ± 3.1*	32.4 ± 3.5*	<0.01
Preoperative lumbar lordosis, degrees	38.5 ± 5.2	39.1 ± 5.5	>0.05
Postoperative lumbar lordosis, degrees	50.0 ± 4.1*	43.0 ± 4.8*	<0.01
Increase in lumbar lordosis, degrees	11.5 ± 2.1	3.9 ± 0.8	<0.01

* Statistically significant changes within the group (*p* < 0.01) compared with the preoperative value.

the most preferred access option at the the L5–S1 level [20, 21].

When choosing surgical tactics, it is necessary to clearly distinguish indications and limitations to performing ALIF in recurrent intervertebral disc herniations. This choice must be strictly individualized taking into account the anatomic-functional state of the spine and the previous surgical intervention [21–23]. Among the main indications for ALIF in revision surgery are severe degeneration with loss of disc height (<6–8 mL), disruption of lumbar lordosis (LL <40°), the need to restore the sagittal balance (PI–LL mismatch >10°), as well as the impossibility of posterior access due to the cicatricial adhesive process [1, 6].

Additionally, ALIF can be indicated for patients with instability after TLIF or PLIF [21, 24]. One of the justified indications for the anterior approach remains repeated interventions after unsuccessful posterior operations [25, 26]. ALIF showed the best results in patients with two or more previous interventions: lower complication rate, better tolerability, and clinical effect [27].

Nevertheless, ALIF has limitations. The method is contraindicated in inflammatory changes of the vertebral bodies (for example, osteomyelitis) due to the high risk of implant infection and the impossibility of bone block formation [28]. Moreover, ALIF is not recommended in grade II–III spondylolisthesis [22, 25] and anatomical vascular features, such as bifurcation of the aorta at L5 level, pronounced calcification, or deviation of the vessels [29]. Preoperative assessment of these risks is conducted using CT angiography, MR I, and 3D modeling [27, 30].

Pronounced adhesions in the abdominal cavity are encountered in 8–12% of patients with previous abdominal interventions and complicate the mobilization of vessels [9]. Intraoperative navigation and three-dimensional planning reduce these risks [30, 31].

From an anatomo-functional point of view, ALIF allows avoiding repeated contact with neural structures, which is especially important in cases of pronounced scarring after previous interventions. Direct visualization of the disc and the installation of large implants ensure

stability and the formation of a reliable interbody block [17, 20, 21].

Rao et al. [19] report that the implant area in ALIF reaches 350–450 mm² vs. 120–180 mm² in TLIF, which improves stability. In the study by Moses et al. [21], a restoration of lordosis by 13.5° was noted with ALIF vs. 6.1° with TLIF.

According to the meta-analysis [18], ALIF demonstrates better clinical results in revision surgery: blood loss — 145 mL vs. 280 mL in TLIF, operation duration — 98 vs. 125 min, ODI decrease by 45% vs. 31%, frequency of repeated interventions — 3.8% vs. 9.2%.

Thus, despite the wide availability of posterior approaches, in recurrent herniations they do not always provide optimal conditions. ALIF remains an effective alternative with less traumatization, better deformity correction, and functional restoration, provided the surgeon is highly qualified and there is detailed preoperative preparation.

Conclusion

ALIF and TLIF demonstrated high clinical efficacy in the treatment of recurrent single-level intervertebral disc lesion of the L5–S1 vertebrae and can be successfully applied depending on the specific clinical situation.

ALIF showed statistically significant advantages in the restoration of sagittal balance, which is confirmed by instrumental data: the average increase in lumbar lordosis angle was 11.5° ± 2.1° vs. 3.9° ± 0.8° in the TLIF group (*p* < 0.01). Radio-

Table 5

Postoperative complications in patients of the studied groups, *n* (%)

Type of complication	ALIF (<i>n</i> = 87)	TLIF (<i>n</i> = 93)
Overall frequency	1 (3.0)	3 (8.1)
Damage to the lymphatic vessel	1 (3.0)	0 (0.0)
Radicular pain syndrome	0 (0.0)	2 (5.4)
Seroma	0 (0.0)	1 (2.7)

logical assessment also revealed a higher percentage of successful bone block formation with ALIF (96.6% vs. 89.2%; $p < 0.05$). In the clinical outcomes of patients, the ALIF group demonstrated

a more pronounced reduction of pain syndrome according to the VAS and a better functional restoration according to the ODI.

At the same time, TLIF remains a reliable alternative, especially valuable in contraindications to the anterior approach.

References

1. Patel RS, Suh SW, Kang SH, Nam KY, Siddiqui SS, Chang DG, Yang JH. The radiologic and clinical outcomes of oblique lateral interbody fusion for correction of adult degenerative lumbar deformity. *Indian J Orthop.* 2019;53:502–509. DOI: 10.4103/ortho.IJOrtho_655_17
2. Xu DS, Walker CT, Godzik J, Turner JD, Smith W, Uribe JS. Minimally invasive anterior, lateral, and oblique lumbar interbody fusion: a literature review. *Ann Transl Med.* 2018;6:104. DOI: 10.21037/atm.2018.03.24
3. Gizatullin ShKh, Zhukov DI, Kurnosenko VYu, Kim EA. Comparative analysis of single-level anterior and posterior spinal fusion in degenerative disease of the lumbosacral spine. *Medical Bulletin of the Main Military Clinical Hospital n.a. N.N. Burdenko.* 2021;(2):46–53. DOI: 10.53652/2782-1730-2021-2-2(4)-46-53 EDN: GUGDJQ
4. Lee N, Kim KN, Yi S, Ha Y, Shin DA, Yoon DH, Kim KS. Comparison of outcomes of anterior, posterior, and transforaminal lumbar interbody fusion surgery at a single lumbar level with degenerative spinal disease. *World Neurosurg.* 2017;101:216–226. DOI: 10.1016/j.wneu.2017.01.114
5. Kim JS, Choi WG, Lee SH. Minimally invasive anterior lumbar interbody fusion followed by percutaneous pedicle screw fixation for isthmic spondylolisthesis: minimum 5-year follow-up. *Spine J.* 2010;10:404–409. DOI: 10.1016/j.spinee.2010.02.022
6. Manzur M, Virk SS, Jivanelli B, Vaishnav AS, McAnany SJ, Albert TJ, Iyer S, Gang CH, Qureshi S. The rate of fusion for stand-alone anterior lumbar interbody fusion: a systematic review. *Spine J.* 2019;19:1294–1301. DOI: 10.1016/j.spinee.2019.03.001
7. Kruglov IA, Gizatullin ShKh, Seleznev AS, Vovkogon VB. Experience in surgical treatment of herniated intervertebral discs of the lumbar spine. In: *Proceedings of the Main Military Clinical Hospital n. a. N.N. Burdenko.* Vol. 9, Part 1. Moscow, 2012. P. 71–74. EDN: LUHJWK
8. Abe K, Orita S, Mannoji C, Motegi H, Aramomi M, Ishikawa T, Kotani T, Akazawa T, Morinaga T, Fujiyoshi T, Hasue F, Yamagata M, Hashimoto M, Yamauchi T, Eguchi Y, Suzuki M, Hanaoka E, Inage K, Sato J, Fujimoto K, Shiga Y, Kanamoto H, Yamauchi K, Nakamura J, Suzuki T, Hynes RA, Aoki Y, Takahashi K, Ohtori S. Perioperative complications in 155 patients who underwent oblique lateral interbody fusion surgery: perspectives and indications from a retrospective multicenter survey. *Spine (Phila Pa 1976).* 2017;42:55–62. DOI: 10.1097/BRS.0000000000001650
9. Razzouk J, Cheng D, Carter D, Mehta S, Ramos O, Cheng W. Clinical and radiographic outcomes of anterior lumbar interbody fusion with anterior plate fixation. *Cureus.* 2024;16:e55139. DOI: 10.7759/cureus.55139
10. Mobbs RJ, Phan K, Thayaparan GK, Rao PJ. Anterior lumbar interbody fusion as a salvage technique for pseudarthrosis following posterior lumbar fusion surgery. *Global Spine J.* 2015;6:14–20. DOI: 10.1055/s-0035-1555656
11. Brantigan JW, Steffee AD. A carbon fiber implant to aid interbody lumbar fusion. Two-year clinical results in the first 26 patients. *Spine (Phila Pa 1976).* 1993;18:2106–2107. DOI: 10.1097/00007632-199310001-00030
12. Sanghvi PA, Wiener JM, Meade SM, Boden LM, Shost MD, Steinmetz MP. Development of a unified and comprehensive definition of successful spinal fusion: a systematic review. *J Neurosurg Spine.* 2025;42:403–412. DOI: 10.3171/2024.9.SPINE2465
13. Duboussset J. Three-dimensional analysis of the scoliotic deformity. In: Weinstein SL, ed. *The Pediatric Spine: Principles and Practice.* New York: Raven Press Ltd, 1994:479–496.
14. Le Huec JC, Hasegawa K. Normative values for the spine shape parameters using 3D standing analysis from a database of 268 asymptomatic Caucasian and Japanese subjects. *Eur Spine J.* 2016;25:3630–3637. DOI: 10.1007/s00586-016-4485-5
15. Roussouly P, Gollogly S, Berthonnaud E, Dimnet J. Classification of the normal variation in the sagittal alignment of the human lumbar spine and pelvis in the standing position. *Spine (Phila Pa 1976).* 2005;30:346–353. DOI: 10.1097/01.brs.0000152379.54463.65
16. Gizatullin ShKh, Sychev VA, Kruglov IA. Analysis of the tactics of surgical treatment of degenerative diseases of the lumbar spine complicated by instability of the spinal motion segment. *Medical Bulletin of the Main Military Clinical Hospital n.a. N.N. Burdenko.* 2013;10:93–95. EDN: CEMKGW
17. Gizatullin ShKh, Kurnosenko V, Kristosturov A, Dubinin I. Multilevel anterior lumbar disc replacement: sagittal balance correction. *Global Spine J.* 2019;9 Suppl 2:312S.
18. Phan K, Thayaparan GK, Mobbs RJ. Anterior lumbar interbody fusion versus transforaminal lumbar interbody fusion – systematic review and meta-analysis. *Br J Neurosurg.* 2015;29:705–711. DOI: 10.3109/02688697.2015.1036838
19. Rao PJ, Loganathan A, Yeung V, Mobbs RJ. Outcomes of anterior lumbar interbody fusion surgery based on indication: a prospective study. *Neurosurgery.* 2015;76:7–23; discussion 23–24. DOI: 10.1227/NEU.0000000000000561
20. Allain J, Dufour T. Anterior lumbar fusion techniques: ALIF, OLIF, DLIF, LLIF, IXLIF. *Orthop Traumatol Surg Res.* 2020;106(15):S149–S157. DOI: 10.1016/j.otsr.2019.05.024
21. Moses ZB, Razvi S, Oh SY, Platt A, Keegan KC, Hamati F, Witwi C, David BT, Fontes RBV, Deutsch H, O'Toole JE, Fessler RG. A retrospective comparison of radiographic and clinical outcomes in single-level degenerative lumbar disease undergoing anterior versus transforaminal lumbar interbody fusion. *J Spine Surg.* 2021;7:170–180. DOI: 10.21037/jss-20-673
22. Platz U, Halm H, Thomsen B, Pecci F, K szegvary M, B rger N, Berlin C, Quante M. Anterior Lumbar Interbody Fusion (ALIF) or Transforaminal Lumbar Interbody Fusion (TLIF) for fusion surgery in L5/S1 - What is the best way to restore a physiological alignment? *Z Orthop Unfall.* 2022;160:646–656. DOI: 10.1055/a-1560-3106
23. Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. *J Spine Surg.* 2015;1:2–18. DOI: 10.3978/j.issn.2414-469X.2015.10.05
24. Mobbs RJ, Loganathan A, Yeung V, Rao PJ. Indications for anterior lumbar interbody fusion. *Orthop Surg.* 2013;5:153–163. DOI: 10.1111/os.12048
25. Gizatullin ShKh, Kurnosenko V, Dubinin I, Bitner S, Kazakov S. Diagnostic and surgery for lumbar spine degenerative disease in osteoporotic patients. *Global Spine J.* 2019;9 Suppl 2:315S.

26. Mayer HM, Heider F. “Slalom”: microsurgical cross-over decompression for multilevel degenerative lumbar stenosis. *Biomed Res Int*. 2016;2016:9074257. DOI: 10.1155/2016/9074257
27. Kolotov EB, Aminov RR, Kolotova EV, Kel'makov VV. The usage of ventral decompressive-stabilizing operations at patients with lumbar radicular compressive syndrome because of combination of spondylarthrosis and diskal hernia. *Russian Journal of Neurosurgery*. 2013;(4):46–52. DOI: 10.17650/1683-3295-2013-0-4-46-52 EDN: SDUUUN
28. Formica M, Vallerga D, Zanirato A, Cavagnaro L, Basso M, Divano S, Mosconi L, Quarto E, Siri G. Fusion rate and influence of surgery-related factors in lumbar interbody arthrodesis for degenerative spine diseases: a meta-analysis and systematic review. *Musculoskelet Surg*. 2020;104:1–15. DOI: 10.1007/s12306-019-00634-x
29. Peng CH, Chen IH, Yu TC, Wang JH, Wu WT, Yeh KT. Risk factors for reoperation after discectomy of lumbar herniated intervertebral disc disease. *Tzu Chi Med J*. 2024;36:298–303. DOI: 10.4103/tcmj.tcmj_206_23
30. Tsalimas G, Galanis A, Vavourakis M, Sakellariou E, Zachariou D, Varsamos I, Patilas C, Kolovos I, Marouglkianis V, Karampinas P, Kaspiris A, Pneumaticos S. Vascular injuries and complications in anterior lumbar interbody fusion: an up-to-date review. *J Med Life*. 2025;18:165–170. DOI: 10.25122/jml-2024-0345
31. Patel NA, Kuo CC, Pennington Z, Brown NJ, Gendreau J, Singh R, Shahrestani S, Boyett C, Diaz-Aguilar LD, Pham MH. Robot-assisted percutaneous pedicle screw placement accuracy compared with alternative guidance in lateral single-position surgery: a systematic review and meta-analysis. *J Neurosurg Spine*. 2023;39:443–451. DOI: 10.3171/2023.3.SPINE2329

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Authors' Info

Shamil Khambalovich Gizatullin, MD, Dr. Sci. (Medicine); eLibrary SPIN: 2722-3355; ORCID: 0000-0002-2953-9902; gizat_sha@mail.ru

Nikolai Aleksandrovich Pestov; eLibrary SPIN: 7429-4228; ORCID: 0009-0000-7039-3653; nkl.dom@yandex.ru

✉ Ivan Stanislavovich Lysenko; 6 Miklukho-Maklaya str., Moscow, Russia, 117198; ORCID: 0000-0003-1434-6742; dr.lysenko@ortopedcenter.ru

Viacheslav Yuryevich Kurnosenko; eLibrary SPIN: 7505-2128; ORCID: 0000-0002-9320-3266; dr.kurnosenko@yandex.ru

Ilya Petrovich Dubinin; eLibrary SPIN: 7452-1424; ORCID: 0000-0002-6902-9798; iliadubinin@yandex.ru

Mukhammad Tablikhanovich Sampiev, MD, Dr. Sci. (Medicine); ORCID: 0000-0002-5766-1737; sampiev@ortopedcenter.ru

