COMPARATIVE ANALYSIS OF TREATMENT RESULTS IN PATIENTS WITH DISC HERNIATION OF DIFFERENT AGE GROUPS

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Objective. To perform comparative analysis of the results of surgical treatment of patients with intervertebral disc herniation of different age groups.
Material and Methods. The results of treatment of 2,448 patients (1,307 men and 1,141 women) with lumbar intervertebral disc herniation were analyzed. Out of them, 393 (16 %) people were elderly and senile patients with a mean age of 66 years. Evaluation of the treatment results in patients with herniated intervertebral discs was carried out in two groups: Group I – young and middle-aged patients; and Group II – elderly and senile patients. Mandatory preoperative evaluation included clinical and neurological examination, radiation diagnostic methods (X-ray, CT, CT-myelography, MRI), and survey using scales and questionnaires (VAS, ODI, CCI).
Results. Body mass index (BMI), blood loss, duration of surgery, and length of hospital stay were statistically significantly greater in patients of Group II. In terms of pain, quality of life before and within 5 years after surgical treatment, patients of groups I and II have no statistically significant differences. The total complication rate was 4.9 %, while in patients of Group II complications developed statistically significantly more often (1.7 times) than in patients of Group I ($p = 0.02$). The most common complication was unintentional durotomy, which occurred in 3.6 % of cases, without statistically significant differences between groups. Epidural hematomas requiring revision intervention were observed in 13 patients, statistically significantly more often in patients of Group II ($p = 0.04$). The volume of blood loss in patients of Group II is significantly greater ($p < 0.001$). The cumulative index of reoperations over the 5-year follow-up period in Group I was 11.5 %, in Group II – 13.6 %. During the first year, reoperations in Group I amounted to 6.0 %, in Group II – 8.7 % ($p = 0.05$), which indicates the possible effect of age on the frequency of repeated operations. Convincing data on the effect of BMI and the comorbidity index on this indicator have not been obtained. The most common cause of reoperation in patients with herniated discs in both groups was hernia recurrence at the operated level, while the relapse rate in Group II was slightly higher – 46 % ($n = 37$) compared with 36 % ($n = 168$) in Group I.
Conclusion. No difference was found between the clinical outcomes of surgical treatment of herniated intervertebral discs in patients of different age groups during a 5-year follow-up period. Elderly and senile age is a predictor of a higher frequency of early and intraoperative complications, an increase in the surgery duration and in the volume of intraoperative blood loss. Obesity and concomitant somatic pathology do not affect the clinical outcomes of surgical treatment and the cumulative index of repeated operations in patients with herniated discs of the lumbar spine.
Key Words: lumbar disc herniation, complications, elderly and senile age, microdiscectomy, lumbar spine surgery.
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According to large-scale epidemiological studies, almost 400 million new cases of symptomatic degenerative pathology of the lumbar spine are diagnosed annually in the world, which comprises 5.5 % of the world's population [1]. Of these, degenerative changes are accompanied by persistent vertebral and/or radicular pain in 266 million people. Degenerative lumbar spinal stenosis is the most common cause of surgical interventions in elderly patients [2]. Currently, more than 600 million people on Earth are older than 60 years of age. At least one somatic disease occurs in 60–88 % of cases in this age group. The frequency rate of surgeries for degenerative diseases among all interventions on the spine is 59.9–71.4 % [3].

Modern authoritative epidemiological studies also indicate an increase in the number of elderly patients with a degenerative pathology of the lumbar spine [4, 5]. Lumbar microdiscectomy is the most frequently performed operation in patients with back pain accompanied by radicular pain; in particular, more than 300,000 such interventions are performed annually in the USA [6, 7].

Osteoporosis, multilevel degenerative lesions of the spine, thin dura mater, the presence of concomitant somatic pathology and degenerative scoliotic deformities, as well as dysfunction of blood coagulation caused by the intake of anticoagulants, are typical of elderly and senile patients, which makes a certain contribution to the specificity of their surgical treatment [8].

The strategy of surgical treatment of elderly patients with intervertebral disc herniation does not differ from that for patients of young and middle age; conventional microsurgical discectomy is the method of choice in such cases [9, 10]. The preference should be given to minimally invasive surgical treatment options, since these methods allow preserving paravertebral muscles, as well as osseous and ligamentous structures of the lumbar spine. This, in turn, results in improved treatment outcomes, decreased pain, as well as reduced risk of intraoperative complications, relapses, and instability of the operated spinal motion segment [11, 12]. There are very few data in the literature on the early and long-term results of surgical treatment of elderly and senile patients with intervertebral disc herniation [12–14]. All the information, as well as the data on the rate of complications (unintentional durotomy, epidural hematoma, recurrent disc herniation, and instability of the operated or adjacent segment), are scattered and contradictory.

Preoperative diagnosis of intervertebral disc herniation in elderly people causes additional difficulties since narrowing of the spinal canal in this category of patients is caused by the presence of not only hernia sequestration but also other intervertebral disc elements, hypertrophied facet joints, and ligaments, as well as osteophytes [15]. The lack of unified approaches to the surgical treatment of intervertebral disc herniation in elderly and senile patients complicated by lumbar spinal stenosis indicates the urgency of the problem and requires further research [16]. It should be noted that there are no comparative studies on the age effect on the long-term treatment outcomes in a large number of patients of various age groups with intervertebral disc herniation, which has prompted us to conduct this research.

The study aims to perform a comparative analysis of the results of surgical treatment in patients of different age groups with intervertebral disc herniation.

The study presents a monocentric retrospective non-randomized cohort analysis with level IIIC evidence (outcome assessment, UK Oxford, v. 2009).

Material and Methods

The results of the treatment of 2,448 patients (1,307 (53.4 %) men and 1,141 (46.6 %) women) with lumbar disc herniation operated on at the Federal Center of Neurosurgery (Novosibirsk) from 2013 to 2017 were analyzed. The patients' age was 45/43 [35; 55] years (hereinafter data format: mean/median [1; 3 quartile]). Of these, 393 (16 %) were elderly and senile patients (60–75 and 75–90 years old according to the WHO criteria, 1963).

The inclusion criteria are the following: radiculopathy with the VAS pain score of ⩾5, the presence of a morphological substrate for compression in the form of intervertebral disc herniation based on neuroimaging data according to the Michigan State University (MSU) classification for herniated intervertebral discs [15], and no positive effect of conservative treatment for more than 12 weeks.

The study did not include patients with central and lateral stenosis of the spinal canal with clinical manifestations of neurogenic intermittent claudication, scoliotic deformity of the lumbar spine with a Cobb angle of more than 10°, instability of the spinal motion segment, as well as a previous history of surgery on the spine. The exclusion criteria were also tumor and inflammatory lesions of the spine, as well as decompensation of somatic pathology.

The set of mandatory preoperative examination procedures included clinical and neurological data, general spondylography in frontal and lateral projections, functional spondylography, SCT, CT myelography, MRI, and questionnaires. VAS score was used to assess the severity of pain in the back and lower extremities [17]. Quality of life was evaluated using the Oswestry Disability Index (ODI) [18, 19]. The CCI (Charlson Comorbidity Index) score [20], which reflects the 10-year survival rate of patients with concomitant somatic pathology taking into account the age [21], was used to assess the somatic status.

Clinical and diagnostic evaluation criteria were the following:

1) during the clinical and neurological examination, radiculopathy syndrome (radicular pain, muscle weakness and/or altered reflexes in a myotome and/or sensory disturbances in a dermatome) was assessed [22];

2) instability of the spinal motion segment was excluded by performing functional spondylography using the criteria of White and Panjabi [23]; the spinal motion segment was considered unstable in case of a score of 5 or more;

3) SCT was used to assess the condition of the facet joints, reveal the presence of osteophytes and ossification of the posterior longitudinal ligament to exclude central and lateral stenosis. Lumbar spinal stenosis was defined as a circumscribed osteoligamentous narrowing of the spinal canal with clinical manifestations including back pain and clinical symptoms in the legs that deteriorate upon standing and walking (neurogenic claudication) [24]. The criteria for stenosis of the lateral recess were a decrease in its angle (less than 30°) or depth (less than 3 mm) [25]. Criteria for central stenosis of the spinal canal were the following: the sagittal size of the spinal canal is less than 13 mm, the sagittal dimension of the dural sac is less than 10 mm, the transverse length of the spinal canal is less than 15 mm, the interfacet distance is less than 15 mm, and the cross-section

area of the dural sac is less than 130 mm^2 [26];

4) the pathomorphological substrate in the form of a herniated intervertebral disc was assessed using MRI data; disc herniation was defined as a local displacement of the disc material (nucleus pulposus, cartilage, the fragmented apophyseal region of the vertebral body, or fragmented annular tissue) beyond the disc space [27] causing a disco-radicular conflict, as seen on T1- and T2-weighted MRI images (1.5 Tesla) in the sagittal, axial, and coronal planes with a slice thickness of 1–3 mm. Hernias were classified according to the MSU classification system by measuring the axial slice in a T2-weighted image, which was used to determine the causes of surgical treatment [15];

5) CT myelography was used mainly in cases when the data of X-ray, SCT, and MRI examinations did not allow to clearly and unambiguously identify the pathomorphological substrate that causes nerve root compression, mainly in multilevel degenerative changes.

These evaluation criteria were used to plan the level and extent of surgery based on the principle of clinical and morphological compliance, according to which the operation should be aimed at eliminating the pathomorphological substrate that determines the persistent disco-radicular conflict while minimizing anatomical destruction of the supporting structures of the spine [16, 28]. Body mass index (BMI) scores were also evaluated. The BMI of the studied patients was 28.6/28.1 [24.6; 31.6]. Besides, the duration of surgery, intraoperative complications and blood loss, length of hospital stay, and recurrence of disc herniation were analyzed in the operated patients. The following complications were taken into account: unintentional durotomy, postoperative hematoma, residual compression, increased neurological deficits, and surgical site infections [29, 30]. The follow-up period ranged from 12 months to six years, the mean follow-up was 2.7 years.

The surgical treatment aimed to eliminate nerve root compression caused by the pathomorphological substrate in the form of disc herniation. All patients underwent conventional microdiscectomy: resection of the herniated part of an intervertebral disc through the posterior approach using a surgical microscope and microsurgical instruments based on the general principles of microsurgery through a limited skin incision [31]. If a hernia was located laterally to the external pedicular line, extraforaminal microdiscectomy was performed using the standard technique through the modified Wiltse's approach [32, 33].

Results of the treatment of patients with intervertebral disc herniation were assessed in two groups of patients. Age was used as a stratification criterion according to the WHO classification.

Group I included young and middle-aged patients: 2,055 patients in total (1,128 (55 %) men and 927 (45 %) women); age equaled 41/41 [34; 50] years; BMI was 28.3/27.7 [24.3; 31.5].

Group II consisted of elderly and senile patients: 393 patients in total (179 (46 %) men and 214 (54 %) women); age equaled 66/64 [62; 69] years; BMI was 30.2/29.7 [26.4; 32.8].

The follow-up period for Group II was more than 12 months; the follow-up was collected from 233 (59 %) patients. Some patients were invited for examination; most of them were interviewed by telephone.

For Group I, the follow-up data was collected according to the algorithm described below. All data from the follow-up for Group II were divided into blocks according to the time elapsed after the operation: 1–2 years, 2–3 years, etc. The number of patients in each block has been registered. Approximately the same number of patients was randomly selected from Group I patients, whose follow-up made it possible to form groups comparable in size by observation periods. There were 246 patients in Group I with a follow-up of more than 12 months. An additional survey was carried out to ensure that the subgroup of patients with a follow-up did not differ from the main group in input parameters: age, gender, BMI, comorbidity index, duration of surgery, and intraoperative blood loss. Detailed information on the number of patients in each period is presented in the Results section.

Primary data was collected at a federal medical institution where medical care is provided mainly to non-resident patients (in our case, they constituted more than 60 %), including the most remote regions of the Russian Federation. For this reason, the following assumptions were made during the analysis of repeated interventions: in most cases, patients who experienced recurrent pain syndrome at different time intervals after primary surgery sought treatment at the same hospital where the primary surgery had been performed; the dropout of patients due to the diseases that made it impossible to perform a repeated intervention (including the death of elderly patients) was not taken into account. There is no doubt that this imposes certain restrictions on the possibility of generalizing the results. However, it should be noted that the figures obtained allow one to calculate a lower estimate for the frequency of reoperations and draw appropriate conclusions. This method of assessing long-term treatment outcomes is widely used in the medical literature [9]. The issue of correct patient selection remains very difficult, especially for medical institutions with a heavy workload of medical staff. Another approach can be applied to eliminate systematic bias in patient selection: it is to use the Propensity Score Matching (PSM) index when conducting retrospective studies [34, 35]. However, we did not use it in our study, since we wanted to ensure maximum representation of different patients in both groups.

Statistical processing of the data was conducted using the R software v. 3.6.2 [36]. To compare pre- and postoperative parameters, a two-sided Wilcoxon test was used. Two independent groups were compared using the two-sided Mann-Whitney test or Fisher's exact test. P = 0.05 was considered the level of statistical significance.

Results

Table 1 presents the results of the comparison of group I and II patients by age, BMI, intraoperative blood loss, as well as the duration of surgery and hospital stay. Intraoperative blood loss and duration of surgery were statistically significantly higher in Group II patients; the same was noted for the duration of hospital stay and BMI ($p < 0.001$).

The difference in the BMI scores between the groups merits consideration: it is significantly higher in Group II (Fig. 1).

The disco-radicular conflict was mostly determined at the L5–S1 level in Group I (53.9 %) and at L4–L5 in Group II (63.8 %). Table 2 shows data on the levels of intervertebral disc herniation in the studied groups.

Disc herniation was found in the spinal canal in 96.8 % of Group I patients and only 92.6 % of Group II patients. Hernias were classified as types 2A and 2AB according to the MSU classification. According to neuroimaging data, a herniated disc that caused nerve root compression was statistically significantly more often ($p = 0.001$) located laterally to the external pedicular line in Group II patients (7.4 % in Group II and 3.2 % in Group I), which is type 2C (extraforaminal disc herniation) according to the MSU classification. These patients underwent extraforaminal microdiscectomy through the modified Wiltse approach.

Initial scores reflecting the patients' condition based on the results of questionnaires before surgery are as follows: 6.4/7.0 [4; 9] VAS (back pain), 8.3/9.0 [7; 10] VAS (leg pain), and 54/56 [40; 68] ODI in Group I; 5.5/6.0 [4; 7] VAS (back pain), 6.9/7.0 [6; 8] VAS (leg pain), and 56/56 [44; 70] ODI in Group II.

The results were evaluated 12 and more months after surgical treatment. The values are the following: 1.0/0.0 [0; 2] VAS (back pain), 1.0/0.0 [0; 2] VAS (leg pain), and 7.0/4.0 [4; 9] ODI in Group I; 2.2/2.0 [0; 3] VAS (back pain), 1.8/1.5 [0; 2] VAS (leg pain), and 18.0/17.0 [4; 25] ODI in Group II. The follow-up lasted for up to 72 months. Data on the number of patients in the subgroups with the follow-up are provided for various periods of the survey (according to the questionnaires) in Table 3.

Fig. 2 shows the results of the comparison of the following parameters between the groups: VAS (back pain) and VAS (leg pain) before and after surgery.

The severity of pain in the back and leg according to VAS before surgery was statistically significantly higher in Group I patients than in individuals of Group II ($p < 0.001$). No statistically significant differences were found in the postoperative period and at follow-up.

The results of the comparison of life quality indicators in groups I and II are shown in Fig. 3.

No statistically significant differences in the quality of life (ODI) before and within five years after surgery were found between groups I and II. However, indicators of the quality of life were statistically significantly worse in Group I than in Group II by the sixth year of the follow-up ($p = 0.03$).

Analysis of complications in the perioperative period. The total number of diagnosed complications was 120 (4.9 %) cases, with complications developing statistically significantly more often in Group II than in Group I patients ($p = 0.02$). The most frequent intraoperative complication was unintentional durotomy (89 cases, 3.6 %); there were no statistically significant differences between the groups. Postoperative epidural hematomas requiring revision surgeries were observed in 13 (0.5 %) patients and statistically significantly more often in Group II ($p = 0.04$). Other early postoperative complications such as residual compression with clinical manifestations (8 cases, 0.3 %) and late complications in the form of surgical site infection (5 patients, 0.2 %) requiring revision of the postoperative wound did not have statistically significant differences between groups I and II. There was a lethal outcome in one case due to hemorrhagic shock as a result of an extremely rare surgical complication (injury to the left common iliac artery). Thus, the rate of postoperative complications was 1.7 times higher in Group II patients (4.4 % in Group I and 7.4 % in Group II, $p = 0.02$).

The distribution of complications in the groups is presented in Table 4.

Repeated surgical interventions. The frequency of reoperations in patients after microsurgical discectomy and the cumulative index of reoperations for the 5-years are presented in Table 5.

Reoperations were mostly performed in the first year after the primary surgery. Moreover, their frequency was statistically significantly lower ($p = 0.05$) in Group I than in Group II. The cumulative index of reoperations over 5 years period was 13.6 % in Group II, which is 2.1 % higher than in Group I.

There were no repeated surgical interventions after a 3-year follow-up period in Group II patients. The frequency of repeated surgeries by year is presented in Fig. 4.

The reoperations were analyzed, which allowed us to determine the main reasons for seeking repeated surgical care (Fig. 5).

The main causes of repeated surgeries after removal of herniated discs are the following (surgeries due to complications were excluded):

1) relapses: 71 (3.5 %) cases in Group I and 17 (4.3 %) patients in Group II;

2) instability: 56 (2.7 %) cases in Group I and 11 (2.8 %) patients in Group II;

3) adjacent level disease: 43 (2.1 %) cases in Group I and 12 (3.1 %) patients in Group II;

4) FBSS: 23 (1.1 %) cases in Group I and 1 (0.3 %) patient in Group II.

Recurrent disc herniation. Recurrence of disc herniation is the repeated occurrence of a hernia at the same level in the absence of radicular symptoms within six months after surgical treatment [37]. The occurrence of a disc herniation within six months is considered an early relapse, which is attributed to surgical complications by some authors [38].

Early recurrences of intervertebral disc hernias were detected in 20 (1.0 %) patients of Group I and in six (1.5 %) patients of Group II. They were regarded as surgical complications. Thus, all recurrent hernias requiring surgical revision, including early cases, were detected in 71 (3.5 %) patients of Group I and in 17 (4.3 %) individuals of Group II, which amounted to 36 % and 46 % of all repeated operations, respectively.

Table 1

Comparison of body mass index (BMI), blood loss, surgery duration, and length of hospital stay between groups I and II

Parameter	Group I (n = 2,055)		Group II (n = 393)	
	value	range	value	range
BMI	28.3/27.7 [24.3; 31.5]	15.8; 58.0	30.2/29.7 [26.4; 32.8]	19.2; 49.5
Blood loss, ml	69.4/50.0 [50.0; 50.0]	5.0; 870.0	119.2/50.0 [50.0; 100.0]	5.0; 1000.0
Duration of surgery, min	69.9/65.0 [55.0; 80.0]	20.0; 245.0	76.4/70.0 [60.0; 90.0]	30.0; 315.0
Length of hospital stay, days	4.8/5.0 [3.0; 6.0]	1.0; 30.0	5.5/5.0 [4.0; 6.0]	2.0; 16.0

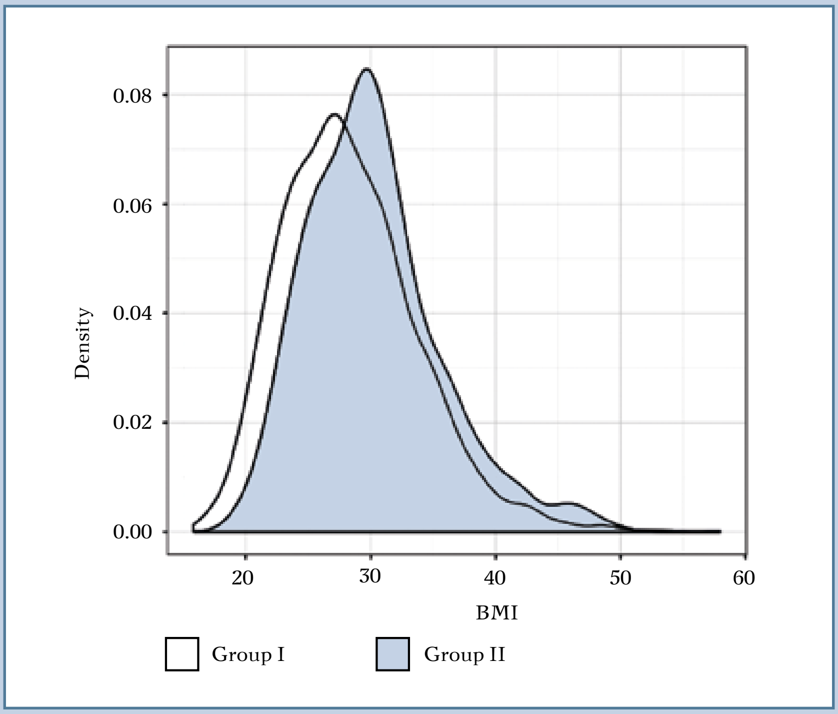

Fig. 1
Density of the distribution of body mass index in group I and II patients

Instability of the spinal motion segments with a score of more than 5 (according to the criteria of White and Panjabi) at the level of surgical intervention was diagnosed in 56 (2.7 %) patients of Group I and in 11 (2.8 %) patients of Group II over the entire follow-up period. All of these patients underwent decompression and stabilization surgeries.

The distribution of the types of repeated surgical interventions at the operated segment by years is presented in Fig. 6.

Long-term degenerative changes at the adjacent level (adjacent segment disease (ASD)) were detected in 43 (2.1 %) patients in Group I and in 12 (3.1 %) cases in Group II.

Continued degeneration of the adjacent segment in the form of intervertebral disc herniation was diagnosed in nine (0.4 %) and three (0.8 %) patients in groups I and II, respectively. All of these patients underwent conventional microdiscectomy.

Instability of the adjacent segment was revealed only in Group I patients (4 cases, 0.2 %). They underwent decompression and stabilization surgeries. Degenerative changes in the adjacent segment manifested themselves as clinical symptoms of facet joint inflammation in 30 (1.5 %) and nine (2.3 %) cases in groups I and II, respectively, and required radiofrequency ablation of the medial branch of the recurrent meningeal nerve.

Failed back surgery syndrome (FBSS) was detected in 16 (0.7 %) patients of Group I. A total of 23 surgeries were performed. A system for chronic epidural stimulation was installed in seven (0.3 %) cases based on the results of test epidural stimulation (16 surgical interventions). In Group II, FBSS was detected in only one (0.3 %) patient. Surgical intervention in the form of a test epidural stimulation was performed: the test turned out to be negative.

All data on the distribution of repeated surgeries, including complications, are provided in Table 6.

Table 2

Distribution of patients by the level of intervertebral disc herniation, n (%)

Level	Group I	Group II
L1–L2	4 (0.2)	3 (0.9)
L2–L3	17 (0.8)	19 (4.8)
L3–L4	65 (3.2)	41 (10.4)
L4–L5	861 (41.9)	251 (63.8)
L5–S1	1108 (53.9)	79 (20.1)
Total	2055 (100.0)	393 (100.0)

Table 3

Number of patients in the groups for each follow-up period, n

Group	Follow-up period				
	1–2 years	2–3 years	3–4 years	4–5 years	5–6 years
I	100	49	50	41	15
II	107	45	52	38	16

Thus, the main reasons for repeated seeking of surgical care in patients of both groups are problems with the operated segment (8.2 % and 9.4 % of all primary operations in groups I and II, respectively) versus interventions at an adjacent level (2.1 % and 3.1 % in Group I and Group II, respectively).

Decompression and stabilization interventions in groups I and II were performed using various surgical approaches and techniques; their distribution is shown in Fig. 7.

There were no statistically significant differences in the frequency of repeated stabilization surgeries due to instability at the operated level in patients of both groups: 56 (2.7 %) cases in Group I and 11 (2.8 %) cases in Group II.

Assessment of the effect of BMI on the frequency of repeated interventions revealed statistically significant differences only in Group I patients in the first year of the follow-up (p = 0.028). It is noteworthy that the highest frequency of repeated surgeries was observed during the first year after the initial surgery: 6.0 % in Group I and 8.7 % in Group II patients; while reoperations during the 2-to-5-year period accounted for only 5.5 % and 4.9 % of all reoperations in groups I and II, respectively (Table 7).

Even though there was a statistically significant difference in the effect of BMI on the frequency of reoperations in Group I during the first year, we do not consider it clinically significant

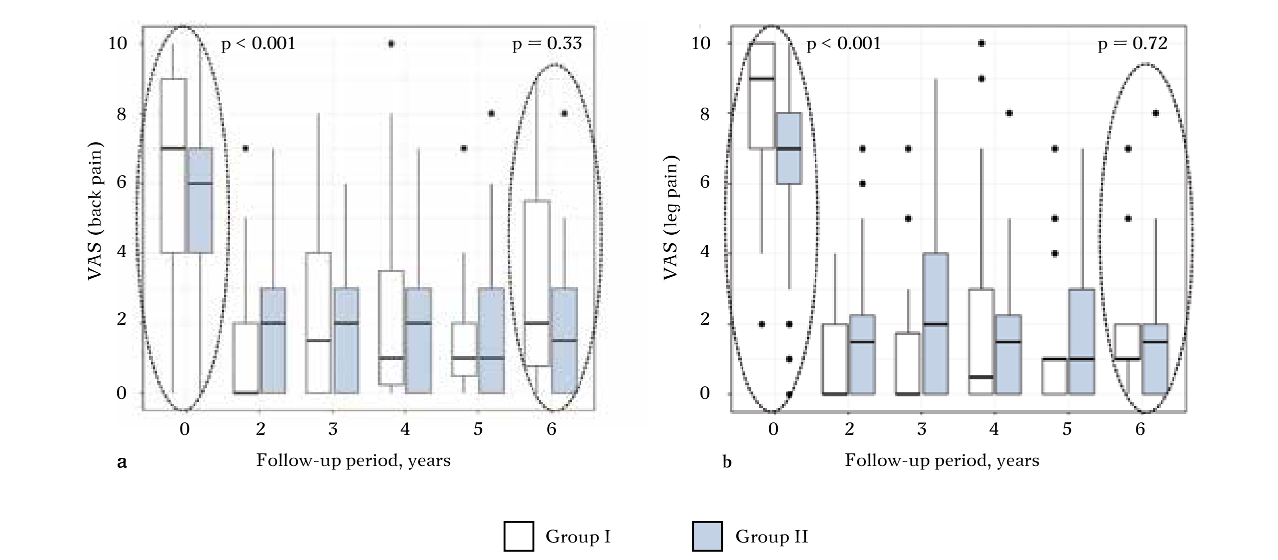

Fig. 2
Surgery outcomes according to the VAS: back pain (a), VAS: leg pain (b); X-axis: 0 – values before surgery, 2 – values in the period of 1–2 years, etc.

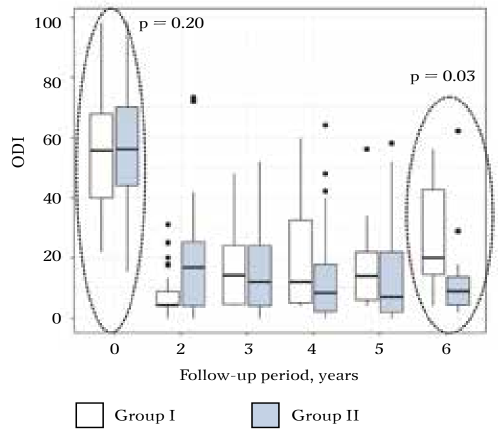

Fig. 3
Surgery outcomes according to the quality of life (ODI); X-axis: 0 – values before surgery, 2 – values in the period of 1–2 years, etc.

Table 4
Complications in the two group of patients, n (%)

Type of complication	Group I	Group II	Total	p (I–II)
Unintentional durotomy	71 (3.50)	18 (4.60)	89 (3.60)	0.30
Postoperative hematomas (revision surgery)	8 (0.40)	5 (1.30)	13 (0.50)	0.04
Residual compression	7 (0.30)	1 (0.30)	8 (0.30)	1.00
Neurological disorder	1 (0.05)	3 (0.80)	4 (0.20)	0.01
Surgical site infection (revision surgery)	3 (0.10)	2 (0.50)	5 (0.20)	0.18
Rare complication (blood loss and injury to the great vessels)	1 (0.05)	–	–	1.00
Total:	91 (4.40)	29 (7.40)	120 (4.90)	0.02

(since the difference between the mean and medians does not exceed “1”).

No statistically significant differences were found in both groups when assessing the effect of the comorbidity index (CCI) on the number of reoperations (Table 8).

Discussion

The distribution of Group I patients according to the levels affected and localization of the morphological substrate for compression that causes a stable disco-radicular conflict corresponds to the available literature data. For instance, in young and middle-aged patients, the L5–S1 level is most often affected (53.9 %), while L4–L5 is the least affected (41.9 %). The location of hernias in such patients mostly corresponds to the MSU types 2A and 2AB. According to N.A. Konovalov et al. [39], disc herniation occurs in 67 % cases at the L5–S1 level and in 31 % cases at L4–L5, with a predominant paramedian location of hernias (mean patient age, 45 years; 87 % of the patients were below 60 years of age). It is noteworthy that L4–L5 is the most affected level in Group II (63.8 % of cases), while only 20.1 % of hernias were located at the L5–S1 level in these patients. Furthermore, a tendency for the processes of intervertebral disc degeneration to shift in the cranial direction was observed in elderly patients: disc herniation was detected in 10.4 % of patients at L3–L4 and in 4.8 % of cases at L2–L3, which is not typical of younger patients at all. Such a tendency

Table 5
Incidence of reoperations after microsurgical discectomy and a 5-year cumulative incidence of reoperations, n (%)

Follow-up period	Group I (repeated surgeries with a sufficient follow-up period)	Group II (repeated surgeries with a sufficient follow-up period)	Comparison (p)
0–1 year	123 (6.0) out of 2055	34 (8.7) out of 393	0.05
1–2 years	45 (2.5) out of 1779	11 (3.3) out of 331	0.45
2–3 years	18 (1.3) out of 1368	4 (1.6) out of 255	0.77
3–4 years	11 (1.2) out of 913	0 (0.0) out of 169	0.23
4–5 years	2 (0.5) out of 426	0 (0.0) out of 77	1.00
Total:	211 (11.5)	49 (13.6)	–

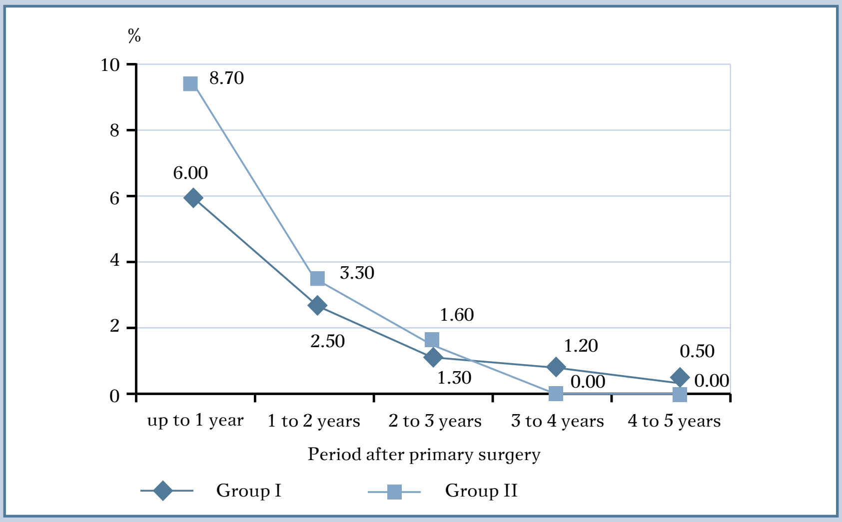

Fig. 4
Incidence of reoperations (% of the number of patients with a sufficient follow-up period)

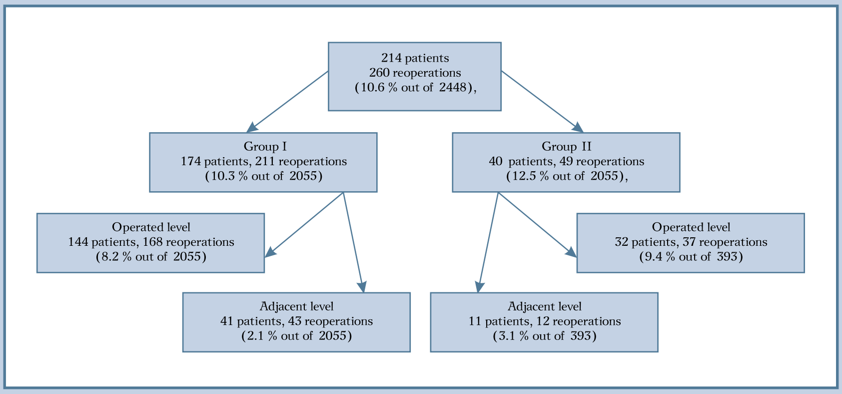

Fig. 5
Distribution of repeated surgeries: several patients had reoperations both at the operated and adjacent levels

was also noted in the study by Hoggett et al. [9]. Furthermore, an intervertebral disc herniation that caused nerve root compression was statistically significantly more often ($p = 0.001$) located laterally to the external pedicular line in Group II (7.4 %) than in Group I (3.2 %), which is classified as type 2C according to the MSU classification system.

Nie et al. [10] compared the results of treatment of middle-aged individuals and patients over 80 years of age with intervertebral disc hernias and revealed high-efficiency rates and satisfaction with the results of surgical treatment among patients of all age groups. This is consistent with the data we obtained 24 months after the initial surgery: 1.0/0.0 [0; 2] VAS (back pain), 1.0/0.0 [0; 2] VAS (leg pain), and 7.0/4.0 [4; 9] ODI in Group I; 2.2/2.0 [0; 3] VAS (back pain), 1.8/1.5 [0; 2] VAS (leg pain), and 18.0/17.0 [4; 25] ODI in Group II.

The data obtained by S.O. Arestov et al. [40] indicate the effectiveness of the treatment (more than 90 % in terms of subjective assessment of the results). It should be noted that clinical outcomes according to VAS and ODI in the long-term follow-up period in patients with lumbar disc herniation are not affected by surgery duration and the average hospital stay, as well as the surgical methods used, since the results of treatment after endoscopic and conventional open operations have no statistically significant differences [41]. To improve the treatment outcomes in patients with disc herniation, G.I. Nazarenko et al. [42] propose the simultaneous use of radiofrequency denervation of facet joints and open microsurgery, especially in patients with spondyloarthritis, since it provides the possibility of regression of not only radicular symptoms in the postoperative period, but also vertebral pain syndrome. In our study, the need for radiofrequency denervation of facet joints due to the progression of arthrosis at adjacent levels arose in 39 patients: in 30 (1.5 %) patients of Group I and in nine (2.3 %) patients of Group II.

Aleem et al. [43] compared postoperative ODI scores in young, elderly, and senile patients. The authors noted the same improvement in the early postoperative period and within one year in all the analyzed groups [43]. We have also noted no statistically significant differences in the quality of life (ODI) scores before and after surgical treatment in patients of groups I and II in the 5-year follow-up period in our study. The comparability of clinical outcomes of surgical treatment of elderly and senile patients with the results in younger patients in the early postoperative period is also evidenced by the data of other studies [9, 16, 44]. However, the indicators of the quality of life in Group I patients deteriorate by the sixth year of the follow-up; and the difference becomes statistically significant ($p = 0.03$). This is due to the progression of degenerative changes in the lumbar spine with an increase in VAS (back pain). VAS (back pain) and ODI scores are 3.2/2.0 [1.0; 5.5] and

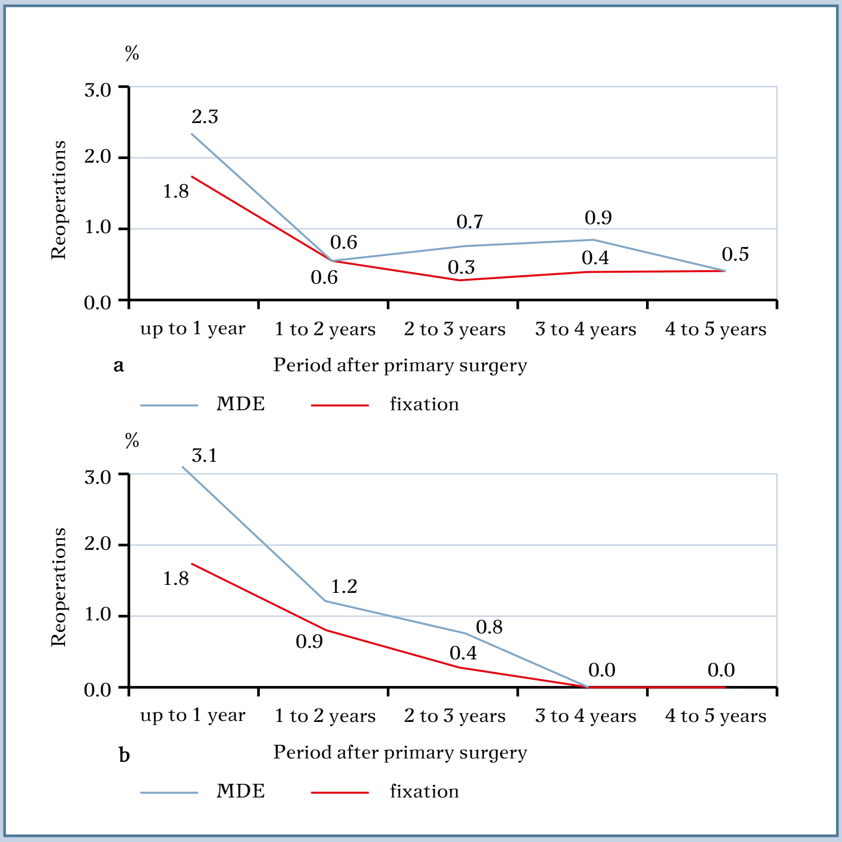

Fig. 6
Incidence of repeated interventions at the operated segment (% of the number of patients with a sufficient follow-up period): **a** – Group I; **b** – Group II; MDE – microdiscectomy

27.2/20.0 [14.5; 42.5] in Group I and 1.9/1.0 [0; 2.5] and 13.0/8.0 [4.4; 14.5] in Group II, respectively.

The incidence of complications after lumbar microdiscectomy remains quite high; according to various estimates, it varies from 15 % to 30 % and does not show a steady downward trend in any country in the world [28, 45]. A study has demonstrated that 13,000 out of 79,000 patients (16.4 %) who had undergone surgical treatment on the spine experienced various types of complications [46]. In our study, the total number of complications in both groups was 4.9 % (120 cases), since it included only patients who had underwent microdiscectomy. The impact of the type of surgery on the lumbar spine on the number of complications is also evidenced by the study of Saleh et al. [12].

In our study, a greater intraoperative blood loss was obtained in Group II patients ($p < 0.001$). E.M. Fadeev et al. [30] analyzed the volume of intraoperative blood loss during surgical interventions on the spine and established that it depends on many reasons, in particular, on bone mineral density. According to M.M. Alexanyan et al. [47], the volume of blood loss was also higher in patients with increased BMI. The authors attribute it to the

Table 6
Distribution of patients by types of complications that led to repeated surgery, n (%)

Complication	Operated level			Adjacent level		
	Group I	Group II	p	Group I	Group II	p
Early recurrence of IVD herniation	20 (1.0)	6 (1.5)	0.29	–	–	–
IVD herniation recurrence	51(2.5)	11(2.8)	0.73	–	–	–
Instability	56 (2.7)	11 (2.8)	0.87	4 (0.2)	–	1.00
IVD herniation	–	–	–	9 (0.4)	3 (0.8)	0.42
Denervation	–	–	–	30 (1.5)	9 (2.3)	0.27
Residual compression	7 (0.3)	1 (0.3)	1.00	–	–	–
Removal of hematoma	8 (0.4)	5 (1.3)	0.04	–	–	–
SSI	3 (0.1)	2 (0.5)	0.18	–	–	–
FBSS	23 (1.1)	1 (0.3)	0.16	–	–	–
Total:	168 (8.2)	37 (9.4)	0.43	43 (2.1)	12 (3.1)	0.26

Percentage ratio is calculated relative to primary interventions (2,055 for group I; 393 for group II). IVD — intervertebral disc; SSI — surgical site infection; FBSS — Failed Back Surgery Syndrome.

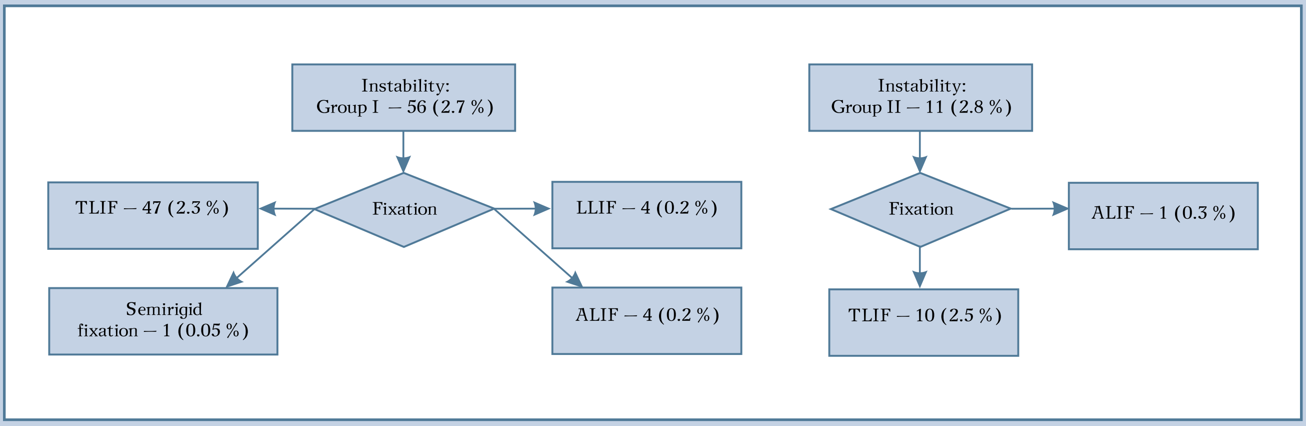

Fig. 7
Distribution of repeated surgeries due to instability of the operated spinal motion segment

Table 7
Body mass index in the study groups depending on the presence of repeated interventions

Follow-up period	Group I			Group II		
	no reoperation	reoperation	p	no reoperation	reoperation	p
0–1 year	28.3/27.7 [24.3; 31.4]	29.5/28.7 [24.9; 32.7]	0.028	30.1/29.6 [26.3; 32.8]	31.4/30.6 [28.7; 35.0]	0.203
1–2 years	28.4/27.8 [24.5; 31.5]	29.4/28.6 [25.4; 33.7]	0.312	30.1/29.6 [26.4; 32.7]	31.7/30.3 [28.5; 33.9]	0.390
2–3 years	28.5/27.9 [24.6; 31.6]	29.0/28.1 [25.9; 30.3]	0.857	30.2/29.6 [26.5; 32.8]	32.8/31.3 [29.4; 34.7]	0.276

Table 8
Correlation between the presence of repeated surgeries and the Charlson Comorbidity Index (CCI)

Follow-up period	Group I			Group II		
	no reoperation	reoperation	p	no reoperation	reoperation	p
0–1 year	0.95/0.98 [0.96; 0.98]	0.94/0.98 [0.96; 0.98]	0.525	0.68/0.77 [0.53; 0.90]	0.73/0.90 [0.53; 0.90]	0.156
1–2 years	0.95/0.98 [0.96; 0.98]	0.95/0.98 [0.93; 0.98]	0.503	0.69/0.77 [0.53; 0.90]	0.72/0.77 [0.77; 0.90]	0.586
2–3 years	0.95/0.98 [0.96; 0.98]	0.95/0.98 [0.96; 0.98]	0.857	0.70/0.77 [0.53; 0.90]	0.80/0.77 [0.77; 0.80]	0.837

presence of varicose (dilated) vertebral venous plexuses. In our study, the patients in Group II predominantly had an increased BMI and, apparently, a decreased bone mineral density, which we did not take into account. A significant volume of intraoperative blood loss in elderly and senile patients, in whom the need for blood transfusions arises, is observed in 10.0 % of patients during operations on the lumbar spine, while intraoperative blood loss comprises 50.0 % of all complications and 62.5 % of all minor surgical complications [12]. The authors consider the duration of surgery of more than 120 minutes and the complexity of the surgical procedure to be the predictors of complications in geriatric patients. For this reason, they suggest minimizing the extent of surgery to reduce the volume of intraoperative blood loss in elderly patients.

The most common complication in elderly and senile patients is unintentional durotomy, which is caused by thinning of the dura mater and atrophy of epidural adipose tissue. For instance, Chen et al. [8] conducted a retrospective study of 2,184 patients who had undergone microdiscectomy and found that the elderly age was the risk factor for unintentional durotomy in 4.6 % of cases [8]. In our study, unintentional durotomy in Group II patients was the same (4.6 %). Albayrak et al. came to the same conclusion [14]. Based on the analysis of treatment outcomes in 1,159 patients after microdiscectomy, the authors established the overall incidence of durotomies (1.2 %) and suggested age and female gender as predictors.

Aono et al. [48] revealed that 26 (0.41 %) out of 6,356 surgical interventions on the lumbar spine were accompanied by postoperative symptomatic epidural hematomas. Awad et al. [49] conducted a retrospective analysis of 15,000 surgeries and identified 32 (0.2 %) cases of symptomatic spinal epidural hematomas, with the age of over 60 years being one of the risk factors. In our study, postoperative symptomatic epidural hematomas requiring revision intervention were detected in 13 (0.5 %) patients. Besides, their frequency was three times higher in elderly patients than in Group I patients: eight (0.4 %) cases in Group I and five (1.3 %) cases in Group II.

The cumulative index of reoperations over 5 years was 13.6 % in Group II, which is 2.1 % higher than in Group I (11.5 %). During the first year after the initial surgery, reoperations amounted to 6.0 % in Group I and 8.7 % in Group II ($p = 0.05$), which indicates a possible effect of age on the incidence of reoperations. According to the literature [44], the index of reoperations in elderly and senile patients ranges from 6.9 % to 9.8 %. However, there are no significant differences between various age groups. Also, we did not receive any convincing data on the effect of BMI and CCI on this indicator, which confirms the results of the previous studies [12, 45].

The most frequent cause of reoperations in patients with intervertebral disc herniation in both groups was hernia recurrence at the operating level; with the recurrence rate being slightly higher in Group II (46 % ($n = 37$) versus 36 % ($n = 168$) cases in Group I). Continued degeneration at the operated level with the development of instability of the spinal motion segment was noted in 33 % of cases in the young and middle-aged group and 29 % of elderly patients. There were no statistically significant differences between the groups.

It should be noted that half of the repeated surgeries at the operated level in both groups (5.3 % out of 11.5 % reoperations in Group I and 6.9 % out of 13.6 % reoperations in Group II over 5 years) was performed during the first two years of the follow-up. According to A.E. Simonovich and A.A. Baikalov [28], 67.7 % of reoperations in patients after removal of intervertebral disc herniation were performed during the first two years of the follow-up, and the most common cause was recurrent herniation at the operating segment.

Limitations. For objective reasons, the main limitation of our study is the lack of the possibility of the comprehensive assessment of long-term results in the entire cohort of patients, especially in the older age group, which is also due to their limited life expectancy. Another limitation should be considered the monocentric nature of the study since the possibility of performing revision surgeries at other hospitals cannot be excluded. This imposes certain limits on the reliable interpretation of the obtained results and makes it possible to present the results of the treatment only within one hospital.

Conclusion

1. Clinical outcomes of the surgical treatment of intervertebral disc herniation in elderly and senile patients with the follow-up of up to five years do not statistically significantly differ from the treatment outcomes in younger patients. However, a tendency to deterioration of indicators of the quality of life in young and middle-aged patients is observed by the sixth year of the follow-up.
2. The most common cause of reoperations in elderly and senile patients operated on for lumbar disc herniation is hernia recurrence caused by continued degeneration in the index segment with a frequency of 4.3 %.
3. Disc herniation is more commonly observed at the L4–L5 level in elderly and senile patients (63.9 %) and at L5–S1 in younger patients (53.8 %). At the same time, the incidence of extraforaminal hernias is significantly higher in patients of the older age group.
4. Elderly and senile age is a predictor of a higher incidence of early and intraoperative complications, increased surgery duration, and the volume of intraoperative blood loss. In this group, the 5-year cumulative index of reoperations constituted 13.6 %, which is 2.1 % higher than in young and middle-aged patients.
5. No effect of obesity and concomitant somatic pathology on the clinical outcomes of surgical treatment was found.

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References

1. **Ravindra VM, Senglaub SS, Rattani A, Dewan MC, Hartl R, Bisson E, Park KB, Shrime MG.** Degenerative lumbar spine disease: estimating global incidence and worldwide volume. Global Spine J. 2018;8:784–794. DOI: 10.1177/2192568218770769.
2. **Adogwa O, Carr RK, Kudyba K, Karikari I, Bagley C, Gokaslan ZL, Theodore N, Cheng JS.** Revision lumbar surgery in elderly patients with symptomatic pseudarthrosis, adjacent-segment disease, or same-level recurrent stenosis. Part 1. Two-year outcomes and clinical efficacy. J Neurosurg Spine. 2013;18:139–146. DOI: 10.3171/2012.11. SPINE12224.
3. **Melloh M, Staub L, Aghayev E, Zweig T, Barz T, Theis JC, Chavanne A, Grob D, Aebi M, Roeder C.** The international spine registry SPINE TANGO: status quo and first results. Eur Spine J. 2008;17:1201–1209. DOI: 10.1007/s00586-008-0665-2.
4. **Buser Z, Ortega B, D'Oro A, Pannell W, Cohen JR, Wang J, Golish R, Reed M, Wang JC.** Spine degenerative conditions and their treatments: national trends in the United States of America. Global Spine J. 2018;8:57–67. DOI: 10.1177/2192568217696688.
5. **Smith E, Hoy D, Cross M, Merriman TR, Vos T, Buchbinder R, Woolf A, March L.** The global burden of gout: estimates from the Global Burden of Disease 2010 study. Ann Rheum Dis. 2014;73:1470–1476. DOI: 10.1136/annrheumdis-2013-204680.
6. **Atlas SJ, Deyo RA, Patrick DL, Convery K, Keller RB, Singer DE.** The Quebec Task Force classification for spinal disorders and the severity, treatment, and outcomes of sciatica and lumbar spinal stenosis. Spine. 1996;21:2885–2892. DOI: 10.1097/00007632-199612150-00020.
7. **Delamarter RB, McCulloch JA.** Microdiscectomy and microsurgical spinal laminotomies. In: Frymoyer JW, ed. The Adult Spine: Principle and Practice, 2nd ed. Philadelphia: Lippincott-Raven, 1997:1961–1989.
8. **Chen Z, Shao P, Sun Q, Zhao D.** Risk factors for incidental durotomy during lumbar surgery: A retrospective study by multivariate analysis. Clin Neurol Neurosurg. 2015;130:101–104. DOI: 10.1016/j.clineuro.2015.01.001.
9. **Hoggett L, Anderton M, Khatri M.** 30-day complication rates and patient-reported outcomes following day case primary lumbar microdiscectomy in a regional NHS spinal centre. Ann R Coll Surg Engl. 2019;101:50–54. DOI: 10.1308/rcsann.2018.0156.
10. **Nie H, Jiang D, Ou Y, Quan Z, Bai C, An H.** Efficacy and safety of surgery for lumbar disc herniation in patients aged 80 and older. Turk Neurosurg. 2011;21:172–176. DOI: 10.5137/1019-5149.JTN.3869-10.0.
11. **Smith ZA, Asgarzadic F, Khoa LT.** Minimally invasive spinal surgical (MISS) techniques for the decompression of lumbar spinal stenosis. In: Yue JJ, Guyer RD, Johnson JP, Khoo LT, Hochschuler SH, eds. The Comprehensive Treatment of the Aging Spine. 1st ed. Philadelphia: Saunders, 2011:388–393.
12. **Saleh A, Thirukumaran C, Mesfin A, Molinari RW.** Complications and readmission after lumbar spine surgery in elderly patients: an analysis of 2,320 patients. Spine J. 2017;17:1106–1112. DOI: 10.1016/j.spinee.2017.03.019.
13. **Shepard N, Cho W.** Recurrent lumbar disc herniation: a review. Global Spine J. 2019;9:202–209. DOI:10.1177/2192568217745063.
14. **Albayrak S, Ozturk S, Ayden O, Ucler N.** Dural tear: a feared complication of lumbar discectomy. Turk Neurosurg. 2016;26:918–921. DOI:10.5137/1019-5149. JTN.14065-15.2.
15. **Mysliwiec LW, Cholewicki J, Winkelpleck MD, Eis GP.** MSU Classification for herniated lumbar discs on MRI: toward developing objective criteria for surgical selection. Eur Spine J. 2010;19:1087–1093. DOI:10.1007/s00586-009-1274-4.
16. **Khyzhnyak MV, Ksenzov AY, Ksenzov TA.** Surgical treatment of the lumbar disc herniation complicated by lumbar spinal stenosis. Ukr Neurosurg J. 2020;26(1):5–12. DOI: 10.25305/unj.182625.
17. **Hawker GA, Mian S, Kendzerska T, French M.** Measures of adult pain: Visual Analog Scale for Pain (VAS Pain), Numeric Rating Scale for Pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short Form McGill Pain Questionnaire (SF MPQ), Chronic Pain Grade Scale (CPGS), Short Form 36 Bodily Pain Scale (SF 36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). Arthritis Care Res (Hoboken). 2011;63(S11):S240–S252. DOI: 10.1002/acr.20543.
18. **Yates M, Shastri-Hurst N.** The Oswestry Disability Index. Occup Med (Chic Ill). 2017;67:241–242. DOI: 10.1093/occmed/kqw051.
19. **Cherepanov EA.** Russian Version of the Oswestry Disability Index: cross-cultural adaptation and validity. Hir. Pozvonoc. 2009;(3):93–98. In Russian. DOI: 10.14531/ss2009.3.93-98.
20. **Charlson ME, Pompei P, Ales KL, MacKenzie CR.** A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis. 1987;40:373–383. DOI: 10.1016/0021-9681(87)90171-8.
21. **De Groot V, Beckerman H, Lankhorst GJ, Bouter LM.** How to measure comorbidity: a critical review of available methods. J Clin Epidemiol. 2003;56:221–229. DOI: 10.1016/s0895-4356(02)00585-1.
22. **Greenberg MS.** Handbook of Neurosurgery, 5th ed. Thieme Medical Publishers, 2001.
23. **White AA, Panjabi MM.** Clinical Biomechanics of the Spine, 2nd ed. Philadelphia: J.B. Lippincott, 1990.
24. **Thome C, Borm W, Meyer F.** Degenerative lumbar spinal stenosis: current strategies in diagnosis and treatment. Dtsch Arztebl Int. 2008;105:373–379. DOI: 10.3238/arztebl.2008.0373.
25. **Mamisch N, Brumann M, Hodler J, Held U, Brunner F, Steurer J.** Radiologic criteria for the diagnosis of spinal stenosis: results of a Delphi survey. Radiology. 2012;264:174–179. DOI: 10.1148/radiol.12111930.
26. **Johnsson KE.** Lumbar spinal stenosis. A retrospective study of 163 cases in southern Sweden. Acta Orthop Scand. 1995;66:403–405. DOI: 10.3109/17453679508995574.
27. **Fardon DF, Milette PC.** Nomenclature and classification of lumbar disc pathology. Recommendations of the Combined task Forces of the North American Spine Society, American Society of Spine Radiology, and American Society of Neuroradiology. Spine. 2001;26:E93–E113. DOI: 10.1097/00007632-200103010-00006.
28. **Simonovich AE, Baikalov AA.** Surgical treatment of pain syndrome recurrence after removal of lumbar intervertebral disc hernia. Hir. Pozvonoc. 2005;3:87–92. In Russian. DOI: 10.14531/ss2005.3.87-92.
29. **Landriel Ibaez FA, Hem S, Ajler P, Vecchi E, Ciraolo C, Baccanelli M, Tramontano R, Knezevich F, Carrizo A.** A new classification of complications in neurosurgery. World Neurosurg. 2011;75:709–715. DOI: 10.1016/j.wneu.2010.11.010.
30. **Fadeev EM, Haydarov VM, Vissarionov SV, Linnik SA, Tkachenko AN, Usikov VV, Mansurov DS, Nur OF.** Rate and structure of complications in spine surgery. Pediatric Traumatology. Orthopaedics and Reconstructive Surgery. 2017;5(2):75–83. In Russian. DOI: 10.17816/PTORS5275-83.
31. **Mayer HM.** Principles of microsurgical discectomy in lumbar disc herniations. In: Mayer HM, ed. Minimally Invasive Spine Surgery. Berlin, Heidelberg: Springer Berlin Heidelberg. 2006:278–282.
32. **Klimov VS, Evsyukov AV, Kosimshoev MA.** The modified Wiltse approach for treatment of extraforaminal disc herniation in the lumar spine. Hir. Pozvonoc. 2016;13(2):62–67. In Russian. DOI: 10.14531/ss2016.2.62-67.
33. **Wiltse LL, Bateman JG, Hutchinson RH, Nelson WE.** The paraspinal sacrospinalis-splitting approach to the lumbar spine. J Bone Joint Surg Am. 1968;50:919–926.
34. **Moskalev AV, Gladkikh VS, Al'shevskaya AA, Kovalevskiy AP, Sakhanenko AI, Orlov KYu, Konovalov NA, Krut'ko AV.** Evidence-based medicine: opportunities of the Propensity Score Matching (PSM) method in eliminating selection bias in retrospective neurosurgical studies. Zh Vopr Neirokhir Im N N Burdenko. 2018;82(1):52–58. In Russian.] DOI: 10.17116/neiro201882152-58.

35. **Baikov ES, Krutko AV, Lukinov VL, Sanginov AD, Leonova ON.** The effectiveness of the system for predicting the results of surgical treatment of patients with lumbar disc herniation. Hir. Pozvonoc. 2020;17(1):87–95. In Russian. DOI: 10.14531/ss2020.1.87-95.
36. R Core Team. R: A language and environment for statistical computing. R Foundation for Statistical Computing. [Electronic resource]. Available online at: https://www.r-project.org.
37. **Drazin D, Ugiliweneza B, Al-Khouja L, Yang D, Johnson P, Kim T, Boakye M.** Treatment of recurrent disc herniation: a systematic review. Cureus. 2016;8:e622. DOI: 10.7759/cureus.622.
38. **Suk KS, Lee HM, Moon SH, Kim NH.** Recurrent lumbar disc herniation: results of operative management. Spine. 2001;26:672–676. DOI: 10.1097/00007632-200103150-00024.
39. **Konovalov NA, Asyutin DS, Korolishin VA, Cherkiev IU, Zakirov BA.** Percutaneous endoscopic discectomy in the treatment of patients with degenerative diseases of the lumbosacral spine. Voprosy neirokhirurgii imeni N.N. Burdenko. 2017;81:56–62. In Russian. DOI: 10.17116/neiro201781556-62.
40. **Arestov SO, Vershinin AV, Gushcha AO.** A comparative analysis of the effectiviness and potential of endoscopic and microsurgical resection of disc herniations in the lumbosacral spine. Voprosy neirokhirurgii imeni N.N. Burdenko. 2014;78(6):9–13. In Russian. DOI: 10.17116/neiro20147869-14.
41. **Simonovich AE, Markin SP.** Comparative study of efficiency of Destandau endoscopic discectomy and open microsurgical discectomy for lumbar disc herniation. Hir. Pozvonoc. 2005;(1):63–68. In Russian]. DOI: 10.14531/ss2005.1.63-68.
42. **Nazarenko GI, Cherkashov AM, Shevelev IN, Kuz'min VI, Konovalov NA, Nazarenko AG, Asyutin DS, Gorokhov MA, Sharamko TG.** Effectiveness of one-stage microdiscectomy and radiofrequency denervation of intervertebral joints compared to microdiscectomy in patients with spinal disc herniation. Voprosy neirokhirurgii imeni N.N. Burdenko. 2014;(6):4–8. In Russian]. DOI: 10.17116/neiro20147864-8.
43. **Aleem IS, Rampersaud YR.** Elderly patients have similar outcomes compared to younger patients after minimally invasive surgery for spinal stenosis. Clin Orthop Relat Res. 2014;472:1824–1830. DOI:10.1007/s11999-013-3411-y.
44. **Cloyd JM, Acosta FL, Ames CP.** Complications and outcomes of lumbar spine surgery in elderly people: a review of the literature. J Am Geriatr Soc. 2008;56:1318–1327. DOI:10.1111/j.1532-5415.2008.01771.x.
45. **Quah C, Syme G, Swamy G, Nanjayan S, Fowler A, Calthorpe D.** Obesity and recurrent intervertebral disc prolapse after lumbar microdiscectomy. Ann R Coll Surg Engl. 2014;96:140–143. DOI: 10.1308/003588414X13814021676873.
46. **Kalakoti P, Missios S, Maiti T, Konar S, Bir S, Bollam P, Nanda A.** Inpatient outcomes and postoperative complications after primary versus revision lumbar spinal fusion surgeries for degenerative lumbar disc disease: a national (nationwide) inpatient sample analysis, 2002–2011. World Neurosurg. 2016;85:114–124. DOI: 10.1016/j.wneu.2015.08.020.
47. **Alexanyan MM, Kheilo AL, Mikaelian KP, Gemdzhian EG, Aganesov AG.** Microsurgical discectomy in the lumbar spine: efficiency, pain syndrome and obesity. Hir. Pozvonoc. 2018;15(1):42–48. In Russian]. DOI: 10.14531/ss2018.1.42-48.
48. **Aono H, Ohwada T, Hosono N, Tobimatsu H, Ariga K, Fuji T, Iwasaki M.** Incidence of postoperative symptomatic epidural hematoma in spinal decompression surgery. J Neurosurg Spine. 2011;15:202–205. DOI: 10.3171/2011.3.SPINE10716.
49. **Awad JN, Kebaish KM, Donigan J, Cohen DB, Kostuik JP.** Analysis of the risk factors for the development of post-operative spinal epidural haematoma. J Bone Joint Surg Br. 2005;87:1248–1252. DOI: 10.1302/0301-620X.87B9.16518.

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