THE INFLUENCE OF COMORBIDITY ON THE RESULTS OF SURGICAL TREATMENT OF ELDERLY AND SENILE PATIENTS WITH DEGENERATIVE LUMBAR SPINAL STENOSIS

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Objective. To analyze the influence of somatic comorbidity on the results of surgical treatment of elderly and senile patients with degenerative lumbar spinal stenosis.
Material and Methods. The study design corresponds to a single-center non-randomized retrospective cohort study with level 3 evidence (OCEBM Levels of Evidence Working Group. "The Oxford 2011 Levels of Evidence"). The influence of somatic comorbidity on quality of life after surgery for degenerative lumbar spinal stenosis was analyzed in 962 patients 60–85 years old. Analysis and evaluation of the results of the study was carried out in two groups of patients with radicular compression syndrome: Group 1 (less than 5 points according to White – Panjabi criteria) included 625 (65%) patients, and Group 2 (5 or more points according to White – Panjabi criteria) – 337 (35%) patients.
Results. Body mass index of patients in Group 1 was statistically significantly lower than in Group 2. Repeated surgical interventions performed during the first year after the primary operation were statistically significantly more frequent in Group 1, and those performed after 3–4 years were more frequent in Group 2 (BMI ≥ 30) due to the development of adjacent level disease. In obese patients, the duration of surgery, blood loss and postoperative hospital stay are statistically significantly increased. One year after surgery, a statistically significant negative effect of increase in BMI on the parameters of back pain, lower limb pain, functional adaptation, and quality of life was revealed in both groups of patients. No association of obesity and complication rates was noted. In Group 2, the incidence of adjacent level disease 2–5 years after the primary operation was higher in patients with BMI ≥ 30 compared with patients with BMI < 30 and with patients in Group 1. It was found that somatic comorbidity and the age of patients statistically significantly prolonged postoperative hospital stay in Group 1 and did not affect its duration in Group 2. No effect of the comorbidity index on the quality of life was noted. Osteoporosis was statistically significantly associated with an increase in the frequency of technical complications during surgery (malposition of pedicle screws, cage migration, and damage to the vertebral endplates).
Conclusion. Obesity is statistically significantly associated with an increase in postoperative hospital stay, surgery duration and blood loss, and is a predictor of the development of instability of the spinal motion segment and adjacent level disease. Obese patients have higher levels of back and lower limb pain and worse quality of life parameters after surgical interventions than patients with normal body weight. When using minimally invasive technologies in the surgical treatment of degenerative lumbar spine pathology, the number of complications in obese patients is not higher than in patients with normal body weight. The effect of comorbidity on the results of minimally invasive surgery for degenerative lumbar pathology was not detected. Osteoporosis affects the frequency of technical complications during surgery.
Key Words: spinal stenosis, lumbar spine, obesity, comorbidity, osteoporosis, surgical treatment, elderly and senile patients.
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Degenerative lumbar spinal stenosis is the most common cause of surgical interventions in patients over 60 years of age [1]. At least one somatic disease occurs in 60–88 % of cases in this age group [1].

Surgical interventions are associated with a risk of intraoperative and postoperative complications, the frequency of which is expected to increase with age and the presence of a comorbidity; however, the data on this relationship are inconsistent [3–8]. A number of studies are devoted to identifying the predictors of adverse surgical outcomes in elderly patients with degenerative spinal stenosis; however, the data on the effects of obesity, comorbidity, and psychological status of the patients are also ambiguous [2, 7, 9–13].

The aim of the study was to analyze the effect of comorbidity, including obesity and osteoporosis, on the results of surgical treatment of elderly and senile patients operated on for degenerative lumbar spinal stenosis.

Material and Methods

The current work presents a single-center non-randomized retrospective cohort study with level 3 evidence (OCEBM Levels of Evidence Working Group. The Oxford 2011 Levels of Evidence). We have studied the results of surgical treatment of 962 elderly and senile patients with degenerative lumbar stenosis primarily operated on using minimally invasive technologies at the Department of Spinal Neurosurgery of the Federal Center of Neurosurgery (Novosibirsk) in the period of 2013 to 2017.

The inclusion criteria were as follows: elderly and senile age (60–75 and 75–90 years of age according to the WHO criteria), degenerative central or lateral one-, two-, or three-level stenosis of the lumbar spine confirmed by neuroimaging studies (SCT, CT myelography with 3D reconstruction, MRI) with clinical manifestations of radicular compression and ineffective 2-month conservative treatment.

Functional spondylography of the lumbar spine in lateral projection and White–Panjabi criteria were used to determine instability of the spinal motion segment. The White–Panjabi score of 5 or more points was considered as segmental instability.

The exclusion criteria were as follows: the history of previous spine surgeries, spinal comorbidities (infection, tumor, and injury), mental diseases, scoliotic curvature with the Cobb angle greater than 10° [14].

The mean age of the patients was 66 (60–85) years.

Minimally invasive microsurgical decompression of the nerve root was performed if no segmental instability according to the White–Panjabi criteria was noted [15]. Microsurgical nerve root decompression was performed unilaterally in the lateral root pocket in case of clinical manifestations of radicular compression associated with lateral stenosis; minimally invasive bilateral microsurgical decompression of the nerve roots was conducted by unilateral approach in case of clinical manifestations of the nerve root compression due to central spinal stenosis. If instability was detected, spinal root decompression was supplemented with interbody fusion surgery using the TLIF technique (270 patients). If direct nerve root decompression was required, the PLIF technique was used in conjunction with minimally invasive percutaneous pedicle screw fixation (24 patients). Indirect decompression using ALIF was conducted in 23 patients. In case of osteoporosis (T-criterion, -2.5 and below), pedicle screw fixation was supplemented by vertebral augmentation with polymethyl methacrylate.

The follow-up period after surgical intervention ranged from 4 to 74 months (mean duration, 24 months).

To objectify and standardize clinical manifestations of the disease before and after surgery, standard scales and questionnaires were used: VAS score for pain assessment [16], Oswestry index (ODI) [17], SF-36 (psychological and physical health factors) for assessing the quality of life [18], and the Charlson Comorbidity Index (CCI) score for evaluating the physical status [19], which expresses the percentage of 10-year survival of the patients of this age with the comorbidity. The CCI model is a reliable method for assessing somatic pathology in clinical trials [20].

An analysis and a comprehensive assessment of the results were carried out in two groups of patients defined based on the dominant clinical neurological syndrome: in Group 1, the clinical manifestations of degenerative stenosis were predominantly represented by the nerve root compression syndromes without segmental instability; spinal pain syndrome due to segmental instability was predominant, while nerve root compression syndromes were less pronounced in Group 2 patients (Table 1).

We have studied the effect of obesity and comorbidity on the outcomes of surgical treatment (quality of life, physical functioning and pain, duration of surgery and postoperative hospital stay, blood loss, number of repeated surgeries, as well as frequency and nature of complications). We also compared the results in the Groups 1 and 2 with each other.

Statistical processing of the data was carried out using the R software (version 3.6.1) [21]. The p-value of 0.05 was considered as the level of statistical significance.

Since most of the data were not characterized by a normal distribution, we used the following format for their presentation: average/median [1; 3 quartile]. Further analysis was performed using non-parametric statistical methods. The Mann–Whitney two-sided and Fisher's exact tests were used to compare the two groups. Spearman's rank correlation was used to describe the relationship between the variables.

To illustrate the results, Box-and-whisker plots with the interquartile range, minimum and maximum values within the 1.5 interquartile range, and outliers were used.

Results

Group 1 included 625 patients (277 men, 348 women) aged 66/64 [61; 69] years; Group 2 included 337 patients (83 men, 254 women) aged 65/64 [61; 67] years.

BMI was 30.6/30.1 [26.8; 33.6] in Group 1 and 33.2/32.9 [28.8; 36.7] in Group 2, which turned out to be statistically significant ($p < 0.001$). This indicates a higher risk of segmental instability in obesity. Fig. 1 shows an estimate of the BMI distribution in the studied groups.

A BMI of ⩾ 30 was observed in 546 (57 %) patients: 50 % (n = 317) of Group 1 patients and 68 % (n = 229) of Group 2 patients. Analysis of the relationship between the rate of repeated interventions and BMI revealed the following: repeated surgical interventions during the first year after the primary surgery were statistically significantly more often performed in Group 1 patients with a BMI above 30 ($p = 0.023$); no statistically significant difference in the rate of repeated surgeries was detected between the Groups 1 and 2 in the period of 1–3 years after the initial surgery; 3–4 years after the primary operation, repeated interventions were more often performed in Group 2 ($p = 0.006$) with a BMI of ⩾ 30, which was due to the adjacent level disease.

We compared the relationship between the rate of repeated surgical interventions and BMI in the two groups of patients and found that patients of both groups with a BMI of ⩾30 were more likely to undergo repeated surgeries; however, no statistically significant difference was found.

A study of the correlation between BMI and the period of repeated interventions for the study groups showed that repeated surgeries in the period of one year after the initial operation are not associated with increased BMI (Table 2). However, in the period of two and three years after the initial surgery, repeated surgeries are more often performed in patients with increased BMI. A statistically significant increase in the BMI of the patients with and without repeated operations was noted only for Group 1 in the period of 2–3 years after the initial intervention ($p = 0.026$). Further observation of a larger sample of patients is required in order to obtain more significant results.

No statistically significant relationship was found between preoperative pain in the lower limb and lumbar spine, functional adaptation index, quality of life, and MBI, with the exception of pain in the lower limb ($p = 0.006$) in Group 2.

The longer duration of surgery in Groups 1 and 2 was statistically significantly associated with BMI ⩾ 30 (Group 1, $p < 0.0001$; Group 2, $p = 0.006$), blood loss (Group 1, $p < 0.0001$; Group 2, $p = 0.004$), and duration of postoperative hospital stay in Group 1 ($p < 0.0001$). However, no effect of BMI on the duration of hospital stay was noted in Group 2 ($p = 0.44$; Table 3).

An analysis of the correlation between the quality of life, functional adaptation index, pain in the lower extremity and lumbar spine, as well as BMI in the first year after surgery shows the absence of a relationship between BMI and the considered parameters. However, a statistically significant negative effect of increased BMI on the parameters of back and lower limb pain, functional adaptation, and quality of life in both groups of patients is determined starting from the second year after surgery (Table 4).

A total of 14 % (n = 135) of complications were recorded. No statistically significant effect of obesity on the frequency of complications was observed in our study (Table 5).

Figures 2 and 3 present data on the influence of the type of surgical intervention and BMI at the time of primary surgery on the development of the adjacent level disease. In Group 1, the frequency of the adjacent level disease is higher in patients with a BMI of ⩾ 30 compared to patients with a BMI of < 30 in the first two years and five years after the initial surgery. In Group 2, the frequency of adjacent level disease in patients with BMI ⩾ 30 is higher than in patients with BMI < 30 and control group in the period of 2–5 years after the primary intervention.

We evaluated the impact of the CCI on the outcomes of surgical treatment of patients with degenerative pathology of the lumbar spine.

All 962 patients had comorbidities: there were 57 (5.6 %) cases of an isolated comorbidity and 905 (94.4 %) patients with concomitant comorbidities.

The mean CCI value was 65.6 % and 63.6 % in Groups 1 and 2, respectively. The presence of comorbidity and elderly age were found to statistically significantly lengthen the duration of postoperative hospital stay in Group 1 and not affect the duration in Group 2.

We analyzed the effect of pain, functional adaptation index, the presence of comorbidity, and age on the quality of the patient's life (Table 6).

It can be seen that the quality of life and functional adaptation index are associated with pain in the leg and back in Group 1 and 2 patients after surgery with a high level of statistical significance. No impact of CCI on the quality of life has been noted. The effect of BMI on the quality of life is observed only in the period of 1–2 years after surgery.

The effect of osteoporosis on the quality of life and the results of surgical treatment was evaluated in the group of patients who had decompression and -stabilization interventions. Osteoporosis was observed in 19 (12 %) out of 163 patients who underwent decompression and stabilization interventions supplemented with polymethyl methacrylate augmentation. Osteoporosis was observed mostly in women: 89 % (n = 17) of the cases. No effect of osteoporosis on the quality of life was noted after surgery. The frequency of technical complications during surgery such as malposition of pedicle screws, cage migration, and damage to the vertebral endplates ($p = 0.042$; Fig. 5, 6) was statistically significantly associated with osteoporosis.

Discussion

The impact of obesity (BMI ⩾ 30) on the outcomes of lumbar spine surgery and the quality of life in elderly patients is ambiguous. For instance, studies by Aalto and Devine [9], as well as Elsayed et al. [12], revealed no negative effect of obesity on the quality of life and outcomes of surgical treatment in such patients. Jackson et al. [22] believe that obesity is a predictor of accelerated degenerative changes in the intervertebral discs and back pain. Meanwhile, the data by Castle-Kirzbaum et al. [13] indicate no difference in the outcomes of minimally invasive surgeries for degenerative spine disease in obese and non-obese patients. However, additional studies are required. Open traumatic surgeries have worse outcomes and more

Table 1

Characterization of the comparison group patients using the White — Panjabi and VAS scores

Parameters	Group 1 (n = 625)	Group 2 (n = 337)
White — Panjabi instability score	<5	≥5
VAS score: leg pain	6.60	6.40
VAS score: back pain	5.40	7.02

complications in obese patients [22, 23]. In our study, all patients underwent only minimally invasive interventions, which allowed reducing the number of complications and achieving good results even in overweight elderly patients with comorbidities due to minor surgical trauma and the earliest possible activation of patients. No effects of obesity on the quality of life and pain were observed in the first year after surgery. A statistically significant deterioration in the quality of life of patients with increased BMI is noted starting from the second year after surgery. This deterioration is caused by enhanced pain in the back and lower limb, as well as decreased functional adaptation index in both groups of patients (Table 6), which, in its turn, is associated with progressive degeneration of the operated segment (more typical of Group 1 patients) or development of the adjacent level disease (typical of Group 2) two or more years after the initial surgery. This is confirmed by the data presented in Table 2: the mean BMI value was 30.6 for Group 1 patients at the time of primary surgery, it was statistically significantly increased to 35.0 at the time of the second intervention. Repeated operations are more often performed in patients of the both groups with a BMI of ⩾ 30.

We found that obese patients (BMI ⩾ 30) are more likely to have decompression and stabilization interventions (68 %) compared to patients with a BMI of < 30 (52 %), which may indicate that obesity is a predictor of segmental instability in elderly patients with clinically significant spinal stenosis.

Lenz et al. [24] noted increased frequency of adjacent segment disease in

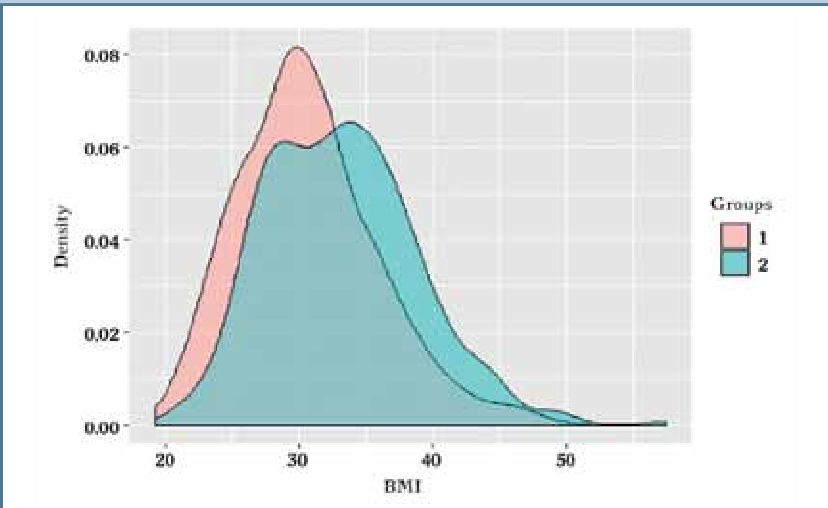

Fig. 1
Density of the distribution of body mass index (BMI) in the groups of patients

Table 2
Comparison of body mass index (BMI) in the patients with and without repeated surgeries

Postoperative period	BMI at the time of the first surgery in patients without repeated interventions before the considered period (1)	BMI at the time of the first surgery in patients with repeated interventions (2)	BMI at the time of the second surgery in patients with repeated interventions (3)	Level of statistical significance p, comparison (1) – (3)	Level of statistical significance p, comparison (1) – (2)
Group 1					
<1 year	30.6/30.0 [26.7; 33.6]	31.2/30.5 [27.9; 34.7]	30.5/30.1 [26.8; 34.0]	0.94	0.55
1–2 years	30.6/30.1 [27.0; 33.6]	32.4/32.1 [28.8; 35.8]	32.5/32.5 [28.0; 35.9]	0.19	0.20
2–3 years	30.6/30.3 [27.0; 33.7]	34.6/35.3 [30.5; 38.2]	35.0/35.8 [31.9; 37.3]	0.026	0.06
Group 2					
<1 year	33.2/32.9 [28.8; 36.6]	32.7/32.8 [29.2; 36.6]	32.2/31.5 [27.6; 36.6]	0.67	0.95
1–2 years	33.2/32.9 [29.0; 36.3]	36.2/37.4 [36.6; 39.2]	34.8/36.1 [35.1; 37.9]	0.25	0.10
2–3 years	33.3/33.1 [29.0; 36.2]	36.7/36.3 [34.2; 38.9]	36.7/38.6 [35.1; 40.2]	0.19	0.21

patients with obesity after pedicle screw fixation, which is also consistent with our data. In our study, the incidence rate of adjacent level disease in Group 2 patients with a BMI of ≥30 is higher compared to patients with a BMI of <30 in the period of 2–5 years after the initial surgery (Fig. 2, 3). There was no statistically significant difference in the frequency rate of adjacent level disease in obese and non-obese patients. However, trend lines indicate an increase in the frequency of adjacent level disease with an increase in BMI. Further accumulation of the clinical data is required.

A number of studies [7, 13, 22] stated that obesity statistically significantly increases the frequency of repeated operations due to progressive degeneration of the operated segment and adjacent level disease. In our study, repeated surgeries were performed more often in Group 1 patients in the first two years after the primary surgery due to progressive degeneration of the operated segment. However, in Group 2, repeated interventions are more often performed starting from the third year after the primary surgery, which is due to adjacent segment disease.

McClendon et al., Castle-Kirzbaum et al., Jackson et al., and Aleksanyan et al. [7, 13, 19, 25] noted in their studies that obesity statistically significantly increases postoperative hospital stay, blood loss, and surgery duration, which is also consistent with our data: obesity (BMI > 30) significantly increases blood loss and the duration of surgery in both groups of patients (Table 3). In our study, obesity statistically significantly ($p < 0.0001$) increased the duration of postoperative hospital stay only in the group with decompressive interventions, while no such dependence was found in the group with decompression and stabilization interventions. Apparently, this is due to a longer hospital stay of patients after instrumented stabilization, while patients who have had decompression interventions usually have a shorter postoperative hospital stay and increased BMI, which can reduce the patient's physical activity, increase pain in the early postoperative period, and lengthen the hospital stay.

The quality of life, functional adaptation index, as well as pain in the lower limb and lumbar spine do not depend on BMI in the first year after surgery. However, a statistically significant negative effect of increased BMI on the pain in the back and lower limb, functional adaptation, and the quality of life is noted in both groups of patients starting from the second year after surgery [7, 10, 13, 22, 23, 25].

In the work of Chapin et al. [11], the outcomes of surgical treatment in patients with BMI = 30–40 did not differ from those for no-obese patients; however, morbid obesity (BMI > 40) statistically significantly worsened the surgery outcome. Works by Castle-Kirzbaum et al. [13], Jackson et al. [22], and Aleksanyan et al. [25] indicate an increase in the frequency of surgical site infection (SSI) to 15 %, the risk of major and minor somatic complications, surgical complications (intraoperative durotomy and epidural hematoma) in obesity and open surgery up to 4.9%. However, the data obtained by Senker et al. [26] suggest that obesity does not affect the incidence of surgical

Table 3

The effect of body mass index (BMI) on postoperative hospital stay, blood loss, and surgery duration

Parameter	BMI correlations in Group 1		BMI correlations in Group 2	
	Spearman correlation (r)	Level of statistical significance (p)	Spearman correlation (r)	Level of statistical significance (p)
Hospital stay, days	0.16	0.0001	0.04	0.4400
Duration of surgery	0.26	0.0001	0.15	0.0060
Blood loss	0.22	0.0001	0.16	0.0040

Table 4

Effect of body mass index (BMI) on pain in the lower limb, lumbar spine, physical activity, and quality of life during the second year after surgery

Parameter	BMI correlations in Group 1		BMI correlations in Group 2	
	Spearman correlation (r)	Level of statistical significance (p)	Spearman correlation (r)	Level of statistical significance (p)
VAS score: back pain	0.21	0.042	0.10	0.420
VAS score: leg pain	0.27	0.009	0.29	0.022
ODI	0.18	0.080	0.27	0.034
SF-36 PH	-0.27	0.024	-0.36	0.021
SF-36 MH	-0.19	0.110	-0.35	0.024

Table 5

Frequency of complications depending on the patient's body mass index (BMI)

Complications	Group 1		Group 2		Level of statistical significance (p)
	BMI < 30 (n = 308)	BMI ≥ 30 (n = 317)	BMI < 30 (n = 108)	BMI ≥ 30 (n = 229)	
Increased neurological deficit after surgery	1	1	2	4	1.00
Dura mater injury	23	24	8	10	0.30
Postoperative CSF leakage	0	1	0	1	1.00
Endplate damage	0	0	3	4	0.68
Pneumonia, bronchitis	0	0	0	0	0
Vein thrombosis of the lower extremities, PATE	3	0	1	0	0.32
Urinary infection	0	0	0	1	1.00
Pedicle screw malposition	0	0	5	19	0.26
Cage migration	0	0	0	2	1.00
Incomplete decompression	1	6	0	0	0.12
Epidural hematoma	4	2	0	2	1.00
Wound failure, SSI	2	0	0	1	1.00
Major artery damage	1	0	0	0	1.00
Myocardial infarction	0	0	1	0	0.32
Pseudarthrosis	0	0	0	2	1.00
Screw breakage	0	0	1	1	0.54
Recurrence of stenosis	9	15	4	6	0.30

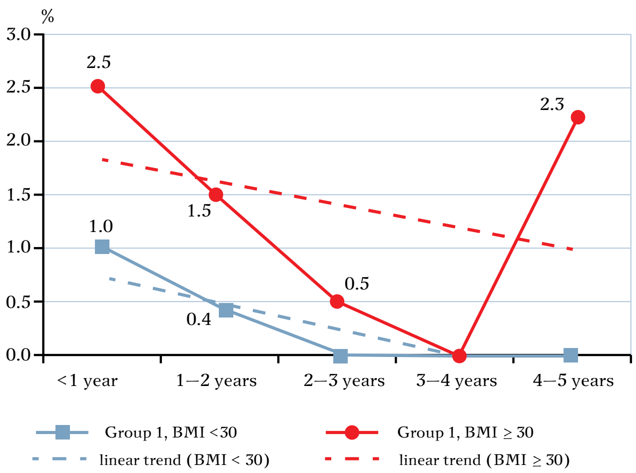

Fig. 2
Development of adjacent level disease in Group 1 patients depending on the period after the initial surgery and body mass index (BMI), trend lines

complications. No increase in the frequency of infection and other surgical complications in obese patients were noted in our study. Apparently, this is due to the minimally invasive and single-level nature of operations associated with minimal surgical trauma, while in the studied literature, surgical interventions on the spine were either multilevel or open [7, 13, 22].

Repeated surgical interventions in obese patients were performed more often in Group 1 in the first two years after the initial operation due to progressive degeneration of the operated segment. However, repeated interventions were more common in Group 2 patients starting from the third year after primary surgery due to the development of adjacent segment disease.

Rihn et al. and Djurasovic et al. [27, 28] did not reveal a deterioration in the quality of life of obese patients after surgery. However, other studies [25, 29, 30] reported decreased quality of life after surgery in obese patients. In our study, ODI and SF-36 questionnaires revealed no negative impact of obesity on the quality of life in the first year after surgery. However, a statistically significant negative effect of obesity on the pain in the back and lower limb, as well as functional adaptation, and the quality of life was found in both groups starting from the second year after surgery.

Deyo et al. [5] established the following major predictors of complications in elderly patients who underwent surgery for spinal stenosis: age, severe comorbidity, the use of steroid hormones, planned multilevel stabilization surgery, and insulin-dependent diabetes mellitus.

Other studies indicate a slight effect of comorbidity and age on the surgery outcome [3, 4, 6, 8, 11]. The authors emphasize that a comorbidity practically does not affect the results of surgical intervention in case if effective drug treatment is used, which is also confirmed by our data. No effect of CCI on the quality of life was observed in both groups of patients.

We did not reveal any negative effect of comorbidity on the quality of the patients' life after surgery. We found that the presence of comorbidity and elderly age statistically significantly lengthen the duration of postoperative hospital stay in Group 1.

This dependence is due to the fact that the period of postoperative hospital stay is less in Group 1 than in Group 2 due to less surgical trauma received. Hence, decompensated comorbidity can lengthen the hospital stay after surgery. In Group 2, the period of postoperative hospital stay is longer due to the greater invasiveness of surgical intervention and intense pain. For this reason, even decompensated comorbidity does not significantly affect the length of hospital stay.

The incidence of osteoporosis in elderly and senile patients is 28 % [31]. In our patients, the frequency of osteoporosis was 23.8 %. However, the effect of osteoporosis on the results of decom-

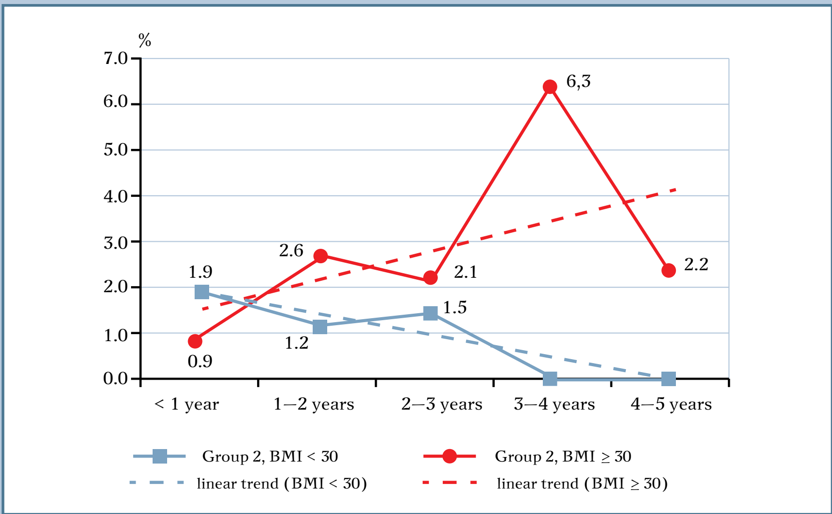

Рис. 3
Development of adjacent level disease in Group 2 patients depending on the period after the initial surgery and body mass index (BMI), trend lines

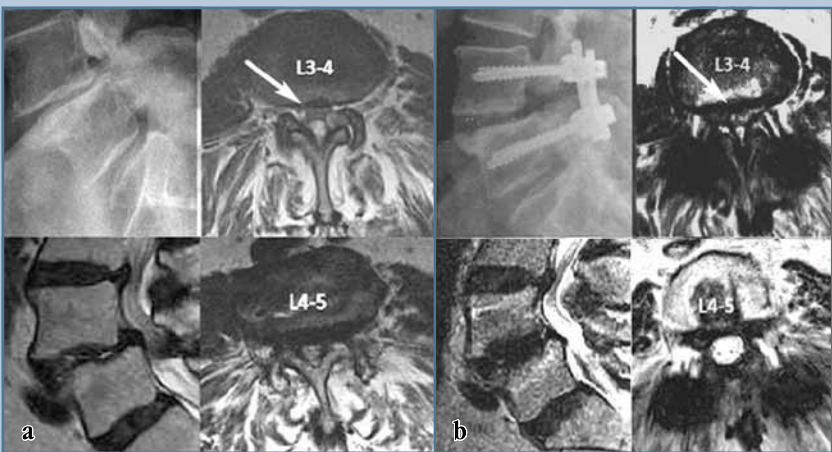

Fig. 4
Radiographs, CT and MRI scans of the patient D., aged 73 years, with spondylolisthesis of the L4 vertebra, central stenosis of L4–L5, and neurogenic intermittent claudication; transforaminal bilateral decompression of the nerve roots, interbody fusion surgery using the TLIF technique, and pedicle fixation at the L4–L5 level were performed: **a** – before surgery; **b** – two years after surgery: adjacent level disease in the form of degenerative central stenosis at the L3–L4 level and neurogenic intermittent claudication

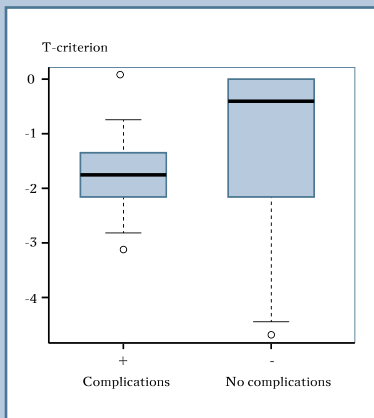

Fig. 5
T-criterion values in the group with complications: -1.41/-1.45 [-1.8; -1.13] and in the group without complications: -0.92/-0.45 [-1.8; 0.0]; p = 0.042

Table 6

Relation between the quality of the patient's life and body mass index (BMI), somatic state (CCI), and pain syndrome (VAS)

Postoperative period	r correlation value (level of statistical significance, p)			
	VAS score: back pain	VAS score: leg pain	CCI	BMI
ODI (Group 1)				
<1 year	$r = 0.60$ ($p \leq 10^{-15}$)	$r = 0.56$ ($p \leq 10^{-15}$)	$r = -0.17$ ($p = 0.01$)	$r = 0.11$ ($p = 0.09$)
1–2 years	$r = 0.71$ ($p \leq 10^{-10}$)	$r = 0.61$ ($p \leq 10^{-10}$)	$r = 0.05$ ($p = 0.64$)	$r = 0.20$ ($p = 0.04$)
2–3 years	$r = 0.64$ ($p \leq 10^{-7}$)	$r = 0.71$ ($p \leq 10^{-10}$)	$r = -0.07$ ($p = 0.58$)	$r = 0.13$ ($p = 0.31$)
ODI (Group 2)				
<1 year	$r = 0.55$ ($p \leq 10^{-12}$)	$r = 0.63$ ($p \leq 10^{-15}$)	$r = -0.09$ ($p = 0.28$)	$r = 0.02$ ($p = 0.83$)
1–2 years	$r = 0.60$ ($p \leq 10^{-6}$)	$r = 0.79$ ($p \leq 10^{-14}$)	$r = -0.16$ ($p = 0.23$)	$r = 0.30$ ($p = 0.02$)
2–3 years	$r = 0.85$ ($p \leq 10^{-4}$)	$r = 0.20$ ($p = 0.50$)/ $r = 0.32$ ($p = 0.10$)	$r = -0.30$ ($p = 0.35$)	$r = 0.31$ ($p = 0.28$)
SF-36 PH + SF-36 MH (Group 1)				
<1 year	$r = -0.56$ ($p \leq 10^{-15}$)	$r = -0.55$ ($p \leq 10^{-15}$)	$r = 0.13$ ($p = 0.07$)	$r = -0.05$ ($p = 0.47$)
1–2 years	$r = -0.63$ ($p \leq 10^{-9}$)	$r = -0.56$ ($p \leq 10^{-7}$)	$r = -0.01$ ($p = 0.90$)	$r = -0.30$ ($p = 0.02$)
2–3 years	$r = -0.55$ ($p \leq 10^{-3}$)	$r = -0.70$ ($p \leq 10^{-5}$)	$r = -0.21$ ($p = 0.24$)	$r = -0.08$ ($p = 0.68$)
SF-36 PH + SF-36 MH (Group 2)				
<1 years	$r = -0.56$ ($p \leq 10^{-8}$)	$r = -0.61$ ($p \leq 10^{-10}$)	$r = 0.15$ ($p = 0.15$)	$r = -0.04$ ($p=0.66$)
1–2 years	$r = -0.55$ ($p \leq 10^{-4}$)	$r = -0.75$ ($p \leq 10^{-8}$)	$r = 0.08$ ($p = 0.63$)	$r = -0.37$ ($p = 0.02$)
2–3 years	$r = -0.77$ ($p = 0.001$)	$r = -0.16$ ($p = 0.59$)/ $r = 0.09$ ($p = 0.66$)	$r = 0.03$ ($p = 0.93$)	$r = -0.37$ ($p = 0.20$)

pression and stabilization interventions in patients with degenerative changes in the spine, which are characterized by the failure of pedicle screw instrumentation, formation of pseudarthrosis, and increased spinal pain syndrome, has been established in the literature [32–34].

In our study, augmented pedicle screws were installed in all patients with osteoporosis (T-criterion of -2.5 and below), which allowed avoiding failure of pedicle screw instrumentation, pseudarthrosis, and the negative effect of the results of surgery on the quality of life, which is consistent with the data by Dai et al., Fischer et al., and Tome-Bernejo et al. [32–34]. We noted a statistically significant impact of osteoporosis on the frequency of technical complications, such as malposition of pedicle screws, cage migration, and damage to the vertebral endplates in our patients ($p < 0.05$).

Conclusion

1. Obesity is a predictor of segmental instability in elderly patients with clinically significant spinal stenosis.
2. Repeated operations in the group with decompressive interventions in the first two years after the primary surgery is mainly due to the progressive degeneration of the operated segment.
3. Repeated operations in the group of decompression and stabilization interventions 3–4 years after the initial surgery is mainly due to adjacent level disease.
4. Obesity statistically significantly increases the duration of surgery, blood loss, and postoperative hospital stay.
5. Obesity statistically significantly worsens the quality of life of both groups of patients starting from the second year after surgery due to pain in the back and lower extremities.
6. The use of minimally invasive technologies in the treatment of elderly patients with degenerative spinal stenosis provides good and excellent clinical results with a minimum of complications.

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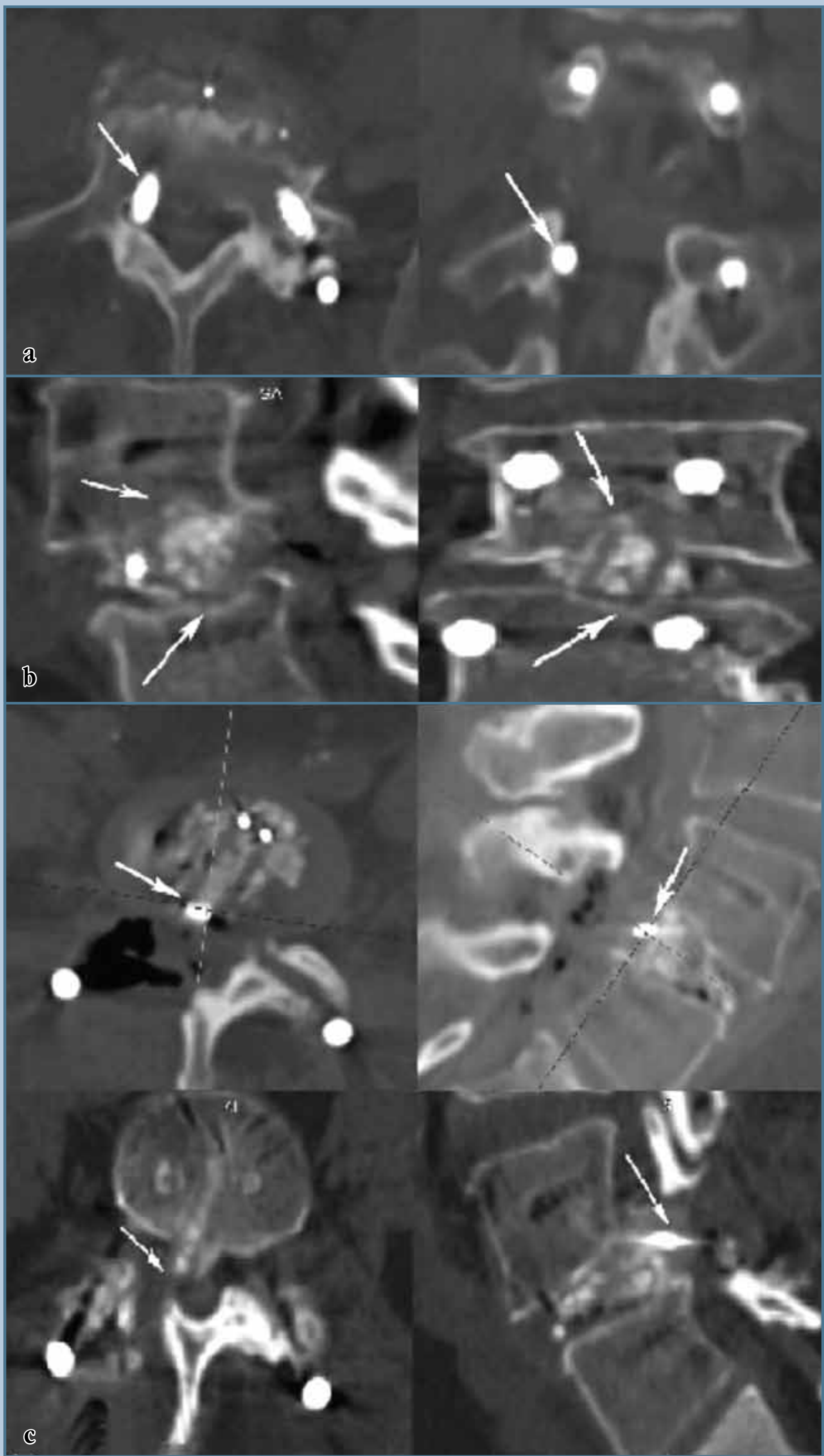

Fig. 6
Technical complications of transforaminal interbody fusion using the TLIF technique and pedicle screw fixation and associated with osteoporosis: **a** – malposition of a pedicle screw; **b** – damage to the vertebral endplate; **c** – cage migration

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