LOCAL FORAMINOTOMY FOR DECOMPRESSION AS A FACTOR OF THE SPINAL MOTION SEGMENT INSTABILITY DEVELOPMENT IN ELDERLY PATIENTS WITH DEGENERATIVE SCOLIOSIS

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Objective. To identify the risk of the spinal motion segment instability after local foraminotomy in elderly and senile patients with lumbar spinal stenosis associated with degenerative scoliosis.

Material and Methods. A prospective study included data on 50 patients treated by surgery and 50 patients who underwent conservative treatment in 2013—2017 for leg pain associated with degenerative scoliosis and secondary spinal stenosis. All patients were older than 60 years. Conservative treatment was carried out using vascular drugs, NSAIDs, analgesics, decongestants, and various blockades. In surgery group, patients underwent local foraminotomy for decompression at the involved levels. The average postoperative follow-up period was 3.8 years (from 6 months to 4 years). The study was performed using four-field tables to determine the relative risk.

Results. The performed studies showed that there is no statistically significant risk of instability of the spinal motion segment after foraminotomy in the lumbar spine.

Conclusion. Local foraminotomy in the lumbar spine is not a risk factor for instability in the spinal motion segment. Local foraminotomy in the area of lumbar spinal stenosis combined with degenerative scoliosis can be recommended for the treatment of patients only in the absence of proven instability in the involved spinal motion segment at the preoperative stage.

Key Words: adult degenerative scoliosis, spinal deformity, spinal stenosis, sagittal balance, frontal balance, foraminotomy, instability.

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The spine is a complex three-dimensional structure that enables movement in any of the three planes, both separately and simultaneously [1, 2]. To date, the issues of treatment of elderly patients with degenerative spinal deformities accompanied by instability, spinal stenosis, and a sharp decrease in the quality of life remain topical [3, 4]. The prevalence of spinal deformities in the adult population reaches 65 % [5, 6].

The main complaint, for which elderly patients with spinal deformities seek medical care, is pain. Pain can be localized in the lower extremities, back, or in both the lower extremities and the back simultaneously. The cause of this suffering is usually degenerative stenosis of the spinal canal, which leads to the need for surgical intervention. In this case, there is a direct correlation between the age and the development and progression of spinal stenosis [2, 5, 6].

The main surgical techniques for treatment of this pathology are laminectomy and foraminotomy. However, approximately one third of patients treated in this way are not satisfied with the results of surgery [7–9]. There are many treatment options, including the use of metallic hardware to stabilize and correct deformities. In this case, increasing invasiveness of treatment elevates the risk of complications to 70%, which is especially important in elderly patients [9–11].

Given the whole variety of serious concomitant somatic pathologies, the amount of surgical intervention in elderly patients should be as minimal as necessary. Surgical treatment should be aimed at preservation of the patient's ability for self-care and social activity. This concept calls on the surgeon to clearly understand the adequacy of a surgery amount and choose the appropriate treatment options [11–13].

The objective of this study was to assess the risk of spinal motion segment instability in elderly and senile patients with lumbar stenosis and degenerative scoliosis after local foraminotomy.

Material and Methods

A prospective study was performed at the Department of Neuro-Orthopedics and Bone Oncology of the Vreden Russian Research Institute of Traumatology and Orthopaedics and included 100 patients older than 60 years of age with lumbar stenosis and degenerative scoliosis who were treated in 2013–2017.

The mean postoperative follow-up period was 3.8 years (from 6 months to 4 years), with 45 patients being followed-up for more than three years.

Patients underwent X-ray examination (functional radiographs with forward, backward, right, and left flexions), teleradiography, MRI, and CT of the spine, as well as classical neurological and orthopedic examination. Patients were initially recruited into the group after undergoing a course of conservative treatment using vascular drugs, NSAIDs, analgesics, decongestants, and paravertebral and epidural blockades, which had no clinical effect. Subsequently, local decompressive foraminotomy was performed at the levels of interest in the lumbar spine. The study group included 50 patients. Additionally, a group of 50 patients treated conservatively was monitored. In this group, spinal motion segment stability was monitored in order to further assess the relative risk of instability after foraminotomy.

The study inclusion criteria were as follows:

– scoliotic deformity (Cobb angle of not less than 30°);

– grade I–II sagittal profile changes (Schwab–SRS Adult Spinal Deformity classification);

– radicular pain syndrome (VAS score of not less than 6);

– neurological disorders (paresis, neurogenic claudication);

– degenerative changes of the spine, spinal stenosis, and spinal canal deformities topically corresponding to the level and features of clinical manifestations, which were determined using instrumental examination methods;

– no instability of the operated spinal motion segment.

The exclusion criteria were as follows:

– cancerous diseases;

– recent vertebral body fractures in the setting of osteoporosis (up to 6 months);

– consequences of spinal cord injuries, less than 6 months;

– demyelinating radiculopathies;

– exacerbation of chronic somatic pathology;

– mental disorders;

– ARVI;

– immunodeficiency (HIV);

– neuromuscular scoliosis;

– spinal motion segment instability in the spinal stenosis area.

All patients met parameters defined in the inclusion criteria (Table 1).

The treatment outcomes at different times after surgery were compared in the following parameters:

1) development of instability in the postoperative period (after a course of conservative treatment) in the same patients in both groups throughout the follow-up period at the planned control time points;

2) quality of life (ODI, SRS-24);

3) degree of pain relief in the lower extremities (VAS).

Assessment of segmental instability was based on the following criteria:

– functional radiographs according to White and Panjabi: sagittal translational instability at a displacement of more than 4.5 mm (15 %); sagittal rotational instability of 15° at L1–L2, L2–L3, L3–L4 levels, 20° at the L4–L5 level, and 25° at the L5–S1 level;

– degenerative changes: MRI (Modic endplate changes, Pfirrmann intervertebral disc degeneration, Weishaupt facet joint degeneration).

The obtained data, namely detection of spinal instability after treatment, were used to calculate the relative risk of instability using four-fold tables and a 95 % confidence interval.

For assessment of the studied parameters, we used the Wilcoxon test - a nonparametric statistical test (criterion) used to check the differences between two samples of paired measurements in space of the R programming language. There were no statistically significant differences among patients at the preoperative stage ($p > 0.05$; Table 1).

The spinal deformity criteria were assessed according to the Schwab–SRS Adult Spinal Deformity classification [6]. Cumulative data on the deformity types in patients are presented in Table 2.

A comprehensive analysis of the patients' examination results before treatment revealed that the results in all cases were comparable in both the pain level and the severity of deformity and life quality impairment, which necessitated a comparative analysis of the treatment results in patients.

The immediate, mid-term, and long-term treatment outcomes were assessed using VAS and Oswestry questionnaire.

The degree of neurological impairment was assessed by classical neurological examination. The effect of intermittent neurogenic claudication was reflected in questionnaires on the quality of life of patients.

We systematized manifestations of spinal motion segment instability detected in patients (100 subjects) during the study: 14 (14 %) cases of sagittal vertebral translation, 7 (7 %) cases of sagittal rotational instability of 20° at the L4–L5 level, and 5 (5 %) cases of sagittal rotational instability of 15° at the L1–L2, L2–L3, and L3–L4 levels. According to the MRI data, Modic type II endplate changes occurred in 26 (26 %) patients, i.e. in 100 % of patients with detected spinal motion segment instability. Pfirrmann grade III and IV intervertebral disc degeneration and Weishaupt facet joint degeneration were detected in 21 and 19 cases, respectively (Table 3).

X-ray follow-up examination was performed at 3, 6, 12, and 18 months and then annually; MRI examination was carried out every 6 months. Also, patients completed VAS and ODI questionnaires.

The results were assessed in comparison with the baseline data and between the data obtained at different follow-up times 3, 6, 12, and 18 months, 2, 3, and 4 years after surgery.

The risk of spinal motion segment instability after foraminotomy was assessed using four-fold tables for relative risk. We compared the data on the development of spinal motion segment instability in patients who underwent foraminotomy and who were treated conservatively. The obtained data revealed no statistically significant risk of spinal motion segment instability after local foraminotomy. The relative risk was RR = 1,500 at a 95 % confidence interval of 0.916–2.456.

Surgical technique. Local decompressive foraminotomy in the lumbar spine at the interested levels was used in 50 patients. For decompressive foraminotomy, we performed an approach using tubular retractors, resected the medial part of the inferior articular process of the superjacent vertebra and the lamina, and removed the hypertrophic yellow ligament. After dural sac visualization, foraminotomy was performed. The apical and ventral parts of the superior articular process and the inferior part of the subjacent articular process of the superjacent vertebra were resected using curved Kerrison rongeurs.

Results

The obtained data are presented in Figures 1 and 2. The level of statistical significance (P) of differences in ODI and VAS in groups at different periods of observation is presented in Tables 4 and 5.

Despite the statistically significant differences in VAS and ODI in the groups, there were no statistically significant differences in the main X-ray parameters (Cobb, PI-LL, PT, SVA), $p > 0.05$ (Fig. 3). There were no surgical complications in the study group.

The comparative results of X-ray examination are presented in Table 6.

The presented data demonstrate that foraminotomy provides positive results within 1 year, on average, with further deterioration in the quality of life and an increase in pain both in the lower extremities and in the back. However, there was progression of degenerative changes in the spinal column with a corresponding increase in the severity of spinal stenosis and the development of spinal motion segment instability.

Assessment of the risk of spinal motion segment instability after foraminotomy showed that there was no statistically significant risk of instability development after local foraminotomy. The relative risk was RR = 0.857 at a 95 % confidence interval of 0.916–2.456 (Tables 7 and 8).

Table 1

Characterization of patients before examination (M ± m)

Parameter	Conservative treatment	Surgical treatment
Age, years	65.6 (60–83)	67.3 (60–81)
Males, n	22	20
Females, n	28	30
VAS pain level, score	8.0 ± 1.9	7.8 ± 1.5
ODI, %	45.9 ± 3.9	46.1 ± 4.2
Mismatch between pelvic incidence and lumbar lordosis, deg.	23.1 ± 3.3	22.7 ± 3.1
Pelvic tilt, deg.	34.1 ± 3.9	33.8 ± 3.9
Lumbar lordosis, deg.	15.3 ± 2.9	13.7 ± 2.3
Thoracic kyphosis, deg.	43.1 ± 4.1	41.8 ± 3.2
Global sagittal balance, deg.	5.9 ± 1.9	5.3 ± 1.4
Frontal balance, cm	3.9 ± 1.6	3.6 ± 1.3
Scoliosis according to Cobb angle, deg.	38.3 ± 3.3	37.9 ± 2.9
Muscle strength for the L1–S1 roots, score	3.9 ± 0.6	3.8 ± 0.5
Spinal motion instability	–	–

Discussion

Treatment of elderly patients with spinal deformities accompanied by instability and spinal stenosis has become increasingly important in recent years. First of all, this is manifestation of a tendency to aging of the world's population, an increase in the level of quality and social security of life, expansion of technological capabilities for health care provision, and the desire of patients themselves to remain socially active [5, 6, 8, 10]. In this case, the proposed conservative treatment is low efficient and does not solve the problem of improving the quality of life of patients [14, 15], which is confirmed by our study.

Accordingly, the main problem is the choice of a surgical option. In this direction, there continue discussions in the literature and at various conferences where a variety of methods and approaches to the treatment of elderly and senile patients with spinal deformities are proposed. The proposed methods are mainly aimed at reducing the rate of surgical complications in patients with this pathology [16–19].

In adult patients with degenerative lumbar scoliosis, the pain is usually caused by spinal deformities and multilevel spinal stenosis [10, 14, 20]. Deformity-associated symptoms (neurogenic

Table 2

Types of spinal deformity according to the Schwab–SRS Adult Spinal Deformity classification

Deformity type	Modification			Patients, n (%)	Wald confidence interval limits
	Mismatch between pelvic incidence and lumbar lordosis	Pelvic tilt	Global sagittal balance		
L	A (<10°)	L (<20°)	N (<4 см)	46 (46)	0.0534–0.1207
	B (10–20°)	M (20–30°)	P (4.0–9.5 см)	54 (54)	0.0986–0.1524

Table 3

Distribution of patients by instability indicators identified during the entire follow-up period, n

Criterion of instability	Conservative treatment	Local foraminotomy	Total
X-ray-based dislocation changes			
Sagittal translational instability	6	8	14
Sagittal rotational instability of 15° at levels L1–L2, L2–L3, and L3–L4	2	3	5
Sagittal rotational instability of 20° at level L4–L5	3	4	7
Sagittal rotational instability of 25° at level L5–S1	2	2	4
MRI-based degenerative changes			
Modic type II end plate changes	12	14	26
Pfirrmann grade III and IV disc degeneration	9	12	21
Weishaupt facet joint changes	10	9	19

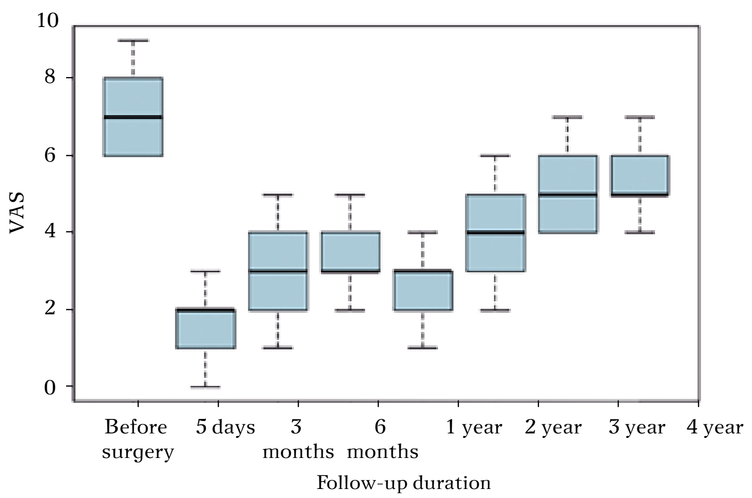

Fig. 1
Changes in the VAS pain level during a 4-year follow-up period in two groups: 10 – the most severe pain; 0 – no pain

claudication, radiculopathy), deformity progression, and spinal stenosis can cause the patient to seek treatment.

There is no consensus on the methods and regimens of treatment for this pathology. However, there is no doubt about the need for surgical treatment of degenerative spinal deformities, especially in the lumbar spine. There are many surgical options, ranging from simple decompression in the stenosis area to multilevel fixation with correction of the sagittal and frontal profiles [5, 6, 20, 21]. Postacchini et al. [22] supposed that patients with neurogenic claudication have almost no back pain, and the deformity is not rigid, so, they proposed using only decompressive interventions in these cases. This work agrees with a multicenter study by Hosogane et al. [14] who did not observe deformity progression after foraminotomy and supposed not using fixation if the patient's pathological condition is associated only with spinal stenosis manifestation.

Vaccaro et al. [23] suppose that decompression may lead to even greater collapse in the spinal motion segment, instability, and worsening of deformity in the lumbar spine, which, in turn, leads to enhanced pain both in the back and in the lower extremities due to increased vertebral stenosis. These authors pursue the approach based on decompression and fixation with deformity correction [23, 24].

Our study is an attempt to elucidate the place of foraminotomy in the treatment of patients with degenerative scoliosis complicated by spinal stenosis and determine whether foraminotomy is a risk factor for progression of deformity, as many authors have indicated. Our data are consistent with those from Postacchini et al. [22] and Hosogane et al. [14]. We obtained good clinical results of treatment in patients who underwent only local decompression at the spinal stenosis level, but the treatment effect retained for one year only. Further, progression of degenerative changes in the spinal motion segment led to pain recurrence and a decrease in the quality of life of patients: dissatisfaction – 60 % (30 patients).

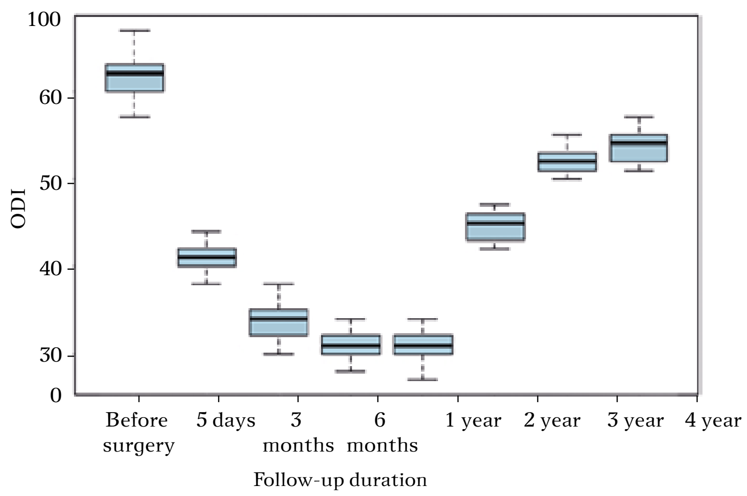

Fig. 2
Changes in the quality of life level according to ODI during a 2-year follow-up period in two groups: 100 – the poorest quality of life; 0 – the best quality of life

The obtained results do not contradict the data of authors who have emphasized the need for fixation of pathologically altered segments with correction of deformity [6, 20, 22, 24]. Progression of degenerative changes in patients after local decompression leads to the need for transpedicular fixation, as a first step, mainly in patients with severe somatic concomitant pathology. Given the fact that, according to our study, foraminotomy is not a risk factor of vertebral motion segment instability (relative risk RR = 0.857 at a confidence interval of 0.916–2.456).

In this case, there were no common surgical and somatic complications, which is important given the patients' age.

These findings partly confirm the opinions of proponents and opponents of spinal column stabilization.

Conclusion

Foraminotomy is not a risk factor of spinal motion segment instability. Foraminotomy is indicated for the treatment of elderly and senile patients with spinal stenosis associated with degenerative scoliosis. In this case, the surgeon should remember that the treatment effect decreases over time, and in the future, another surgical intervention may be required, probably using implants to stabilize the spinal motion segment. Therefore, the patient should be informed about the advantages and disadvantages of minimally invasive decompression surgery and provide consent for this intervention, with allowance for possible repeated stabilization surgery.

Therefore, this study and its results indicate the reasonability of local foraminotomy in elderly and senile patients with spinal stenosis and degenerative scoliosis. This approach provides fast pain relief and improves the quality of life of patients, but only for a short-term period, without an additional risk of progression of spinal motion segment instability due to surgery.

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The authors declare no conflict of interest.

Table 4

Level of statistical significance (P) of ODI differences for the entire follow-up period

Follow-up duration	Before surgery	5 days	3 months	6 months	1 year	2 years	3 years
5 days	2.528e-06	–	–	–	–	–	–
3 months	2.538e-06	2.487e-06	–	–	–	–	–
6 months	2.538e-06	2.528e-06	2.697e-05	–	–	–	–
1 year	2.303e-06	2.465e-06	7.295e-06	0.9512	–	–	–
2 years	2.516e-06	3.588e-06	2.479e-06	2.538e-06	2.531e-06	–	–
3 years	2.538e-06	2.499e-06	2.46e-06	2.128e-06	2.516e-06	2.509e-06	–
4 years	2.495e-06	2.518e-06	2.438e-06	2.578e-06	2.569e-06	2.345e-06	0.0003246

Table 5

Level of statistical significance (P) of VAS differences for the entire follow-up period

Follow-up duration	Before surgery	5 days	3 months	6 months	1 year	2 years	3 years
5 days	2.277e-06	–	–	–	–	–	–
3 months	2.281e-06	0.00032	–	–	–	–	–
6 months	2.31e-06	1.337e-05	0.1809	–	–	–	–
1 year	2.062e-06	0.0014	0.3682	0.004369	–	–	–
2 years	2.261e-06	1.185e-05	0.003583	0.01477	1.825e-05	–	–
3 years	6.217e-06	2.103e-06	1.018e-05	2.737e-05	2.099e-06	2.476e-05	–
4 years	6.379e-06	2.047e-06	1.6e-05	4.894e-06	2.994e-06	1.31e-05	0.4764

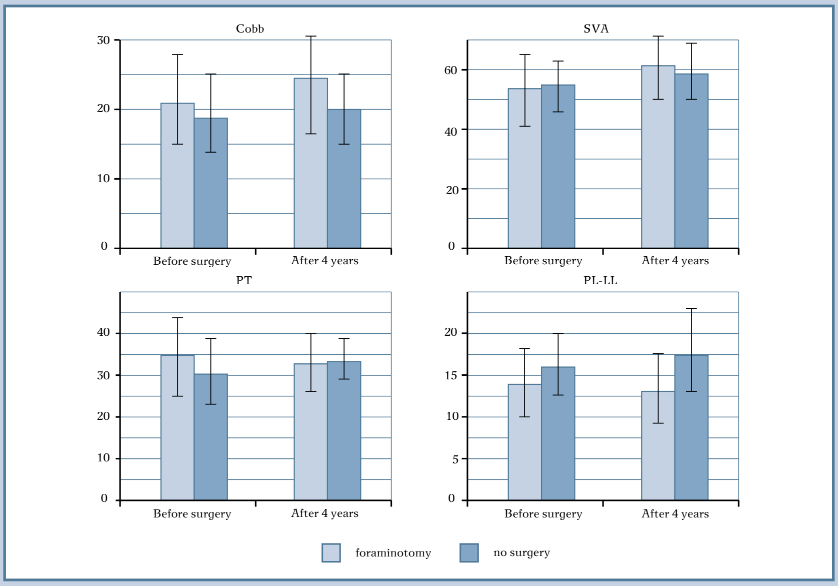

Fig. 3

Changes in X-ray parameters during a 4-year follow-up period in two groups: mean values and 95 % confidence intervals for each group at control time points are indicated: SVA – global sagittal balance; PT – pelvic tilt; PI–LL – mismatch between pelvic incidence and lumbar lordosis

Table 6

Summary table of treatment outcomes in patients after 4 years ($M \pm m$)

Parameters	Conservative treatment		P	Surgical treatment		P
	before surgery	after surgery		before surgery	after surgery	
Cobb angle of lumbar lordosis deg.	15.3 ± 3.2	16.3 ± 3.5	0.237	15.9 ± 3.3	16.5 ± 3.8	0.415
Pelvic tilt, deg.	34.6 ± 5.8	39.4 ± 4.2	0.153	35.3 ± 3.3	35.5 ± 3.8	0.311
Mismatch between pelvic incidence and lumbar lordosis, deg.	23.2 ± 4.8	24.1 ± 3.7	0.107	23.7 ± 3.3	23.9 ± 3.8	0.193
Global sagittal balance, deg.	5.1 ± 1.8	5.4 ± 1.2	0.313	5.3 ± 1.3	5.9 ± 1.1	0.385

Table 7

Four-fold table for calculating the relative risk of spinal instability development

Risk factors	Outcome		
	Yes	No	Total
Yes	12	38	50
No	14	36	50
Total	26	74	100

Table 8

Risk of spinal motion segment instability after foraminotomy

Absolute risk in the study group (EER)	0.240
Absolute risk in the control group (CER)	0.280
Relative risk (RR)	0.857
Standard error of relative risk (S)	0.339
Lower limit of 95 % CI	0.441
Upper limit of 95 % CI	1.665
Relative risk reduction (RRR)	0.143
Risk difference (RD)	0.040
Number of patients to be treated (NNT)	25.000
Sensitivity (Se)	0.462
Specificity (Sp)	0.486

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