Objective. To demonstrate opportunities of minimally invasive surgery in the treatment of deformities in patients with degenerative disease of the spine.

Material and Methods. The clinical case of a 53-year-old female patient with adult degenerative scoliosis accompanied by foraminal stenosis and foraminal disc herniation at the L4–L5 level on the left with L5 root compression was considered. The clinical picture of the disease was carefully analyzed for compliance with the criteria for possibility of minimally invasive intervention as opposed to reconstructive surgery using instrumentation. The nature of the pain syndrome and its intensity according to VAS were determined, preoperative CT and MRI studies were carried out, and functional radiographs to detect signs of instability and the whole spine radiographs to calculate sagittal and coronal balance parameters were taken. A retrospective dynamic assessment of radiological data throughout the disease course was carried out to determine the dynamics of the deformity development. Postoperative follow-up was performed during 6 months. Pain syndrome was assessed according to VAS, and quality of life – according to Oswestry questionnaire. Postoperative CT and MRI studies were performed, and spinal radiographs were taken to calculate sagittal and coronal balance parameters. PubMed data and a number of meta-analyses were considered to substantiate the choice of treatment.

Results. Six months after surgery, the patient does not complain, is physically active, fully resumed work. She has no pain syndrome (VAS score 0), the Oswestry index is 8 points, neurological and static-dynamic statuses are without negative dynamics. The parameters of coronal and sagittal balance are stable.

Conclusion. Endoscopic foraminal decompression may be the method of choice in the treatment of patients with adult degenerative scoliosis with a dominant clinical picture of monoradicular syndrome and compensated sagittal balance.

Key Words: endoscopy, minimally invasive surgery, adult degenerative scoliosis, scoliosis, radiculopathy.

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Minimally invasive technologies are widely used in spine surgery and demonstrate their new possibilities. More and more, they serve as alternative surgeries (radical, palliative), as well as intermediate surgeries.

Nowadays, a special attention is paid to local punctual surgeries with maximum clinical performance in different spheres of spine surgery. This is also relevant to such pathology as degenerative scoliosis that used to be conventionally treated by a combination of decompression and spinal fusion with different variants of instrumented stabilization. Thus, Anand et al. [1] analyzed the quality of minimally invasive surgeries carried out for the treatment of degenerative scoliosis, and came to a conclusion that 61.3% of surgeons practiced such operations. The surgeons preferred, first of all, such stabilization operations as ALIF and XLIF (70.6%) and short-segment percutaneous transpedicular stabilization (58.8%). There are rare publications describing the use of minimally invasive interventions in treatment of degenerative scoliosis without instrumentation.

The objective of the study was to demonstrate possibilities of minimally invasive surgery without using stabilizing tools in the treatment of deformities in patients with degenerative scoliosis and to review current tendencies in minimally invasive methods in surgery of degenerative disc diseases.

The study design included a clinical case and literature review.

A female patient of 53 years old was admitted to the Neurosurgical Center of the Burdenko Main Military Clinical Hospital in February, 2019. She complained of a pain in the lumbosacral spine with radiation along the posterolateral surface of the left thigh and anterolateral surface of the left lower leg. She complained also of the numbness of the anterior surface of the left lower leg and toes of the left foot. The patient had not been earlier operated on the spine. She had been suffering a moderate back pain for 10 years, however, the condition of the patient worsened significantly during the last year, including pain irradiation and
numbness in the mentioned areas. The conservative treatment being conducted during more than three months demonstrated no significant clinical effect.

On examination, the restriction of movement in the lumbar spine was pronounced because of pain syndrome, the patient evaluated its intensity as 9 on the 0-10 VAS. Neurological examination revealed a hypoesthesia of the anterior surface of the left lower leg and toes of the left foot, and a positive Lasegue sign at an angle of 30° on the left, with preserved reflexes, strength, and range of motion in both legs.

Earlier (three years before the hospitalization), spinal radiographs were taken to reveal scoliosis because of back pain.

On admission, panoramic radiography of the spine was performed in the frontal and lateral projections, including the femoral heads, as well as functional radiographies to detect signs of instability of the lumbosacral spine segments. The spinal balance was defined on the basis of radiographs taken on admission (Fig. 1) using the Sagittal Meter Pro (Version: 2.0.305) software. The results are listed in Table 1.

MRI revealed foraminal disc herniation at the L4–L5 level and neural foraminal stenosis on the left (Fig. 2).

The retrospective analysis of the radiographs taken in 2019 and 2016 showed no changes in the lumbar curve parameters. The functional studies did not show any signs of the segmental spinal instability, so it was possible to consider the deformity to be stable, without any signs of imbalance. The following diagnosis was determined: adult degenerative scoliosis accompanied with foraminal stenosis and foraminal disc herniation at the L4–L5 level on the left, with the L5 root compression; spondylosis, spondyloarthrosis of the lumbosacral spine. At the same time, basing on the character and intensity of the subjective complaints related to stable deformity, it was decided to perform a minimally invasive surgery by the TESSYS® method via a transforaminal approach with endoscopic extended reconstructive foraminotomy and microdiscectomy at the L4–L5 level on the left with the decompression of the L5 root and double-side ablation at the L5–S1 level.

The surgery (February, 2019) was carried out in the prone position of the patient. A reconstructive extended foraminotomy with decompressive resection of a fragment of the facet joint up to 1.4 cm was performed through the minimal approach using a milling cutter. The scar tissue of hypertrophied yellow ligation was dissected. A fragmentary dissection of the nucleus pulposus was performed through an operation tubus, the L4 spinal nerve root was visualized, and the dural sac and the root were decompressed. Hemostasis was performed using unipolar coagulation.

The L5 nerve of Luschka and S1 roots were ablated on two sides through additional incisions in the projection of the bases of the L5 vertebral transverse processes under endoscopic control.

The operation time was one hour and 10 minutes and blood loss was less than 20 ml. There were no intraoperative complications.

The patient noted a pain syndrome regression two hours after the surgery and ranked it as 4–5 on the VAS scale. The patient was activated during the first postoperative day, and her physical activity was being increased daily to her usual activity, including walking within the department, self-care, performing everyday actions, without lifting heavy things. In the postoperative period, physical therapy, symptomatic and analgesic treatment was carried out. The surgical wounds were healed by primary intention. By the time of discharge (the 10th day after the surgery), the patient had no pain (VAS score was 0). The radicular symptoms were gradually improved.

The follow-up examination in six months demonstrated that the scoliotic deformities and sagittal balance (Fig. 4, and Table 2) were completely aligned with the preoperative ones.

The patient had no complaints, was physically active, returned to labor activity, there was no pain syndrome (VAS score 0), the Oswestry index was 8 points, neurological and static-dynamic statuses were without negative dynamics.

Discussion

The PubMed database was searched with the following key words: endoscopy, minimally invasive surgery, adult degenerative scoliosis, endoscopic spine surgery, radiculopathy, and scoliosis. The search demonstrated that the prevalence of syndromes (axial, associated with facet arthrosis, or signs of sagittal and/or coronal imbalance, or radicular symptoms resulting from spinal stenosis) should be taken into consideration in order to choose a proper treatment of degenerative scoliosis. However, Epstein et al. [2], Simmons [3], Schwab et al. [4], and Lafage et al. [5] point to the choice between the following three options: isolated, minimally invasive endoscopic decompression, a combination of decompression and partial spine stabilization at the decompression level, and extended instrumented deformity correction.

Ploumis et al. [6] assessed patients with de novo degenerative scoliosis and came to a conclusion that yellow ligation hypertrophy, disc herniation, and facet arthrosis were more likely to contribute to changes in the neural canal dimensions than the scoliotic curve deformity. So they recommended isolated decompression without scoliosis correction in such patients.

Hansraj et al. [7] recommend decompression without arthrodesis in case patients do not have surgeries on the lumbar spine in their history, and if there is no instability with a curve greater than 20°; at the same time they admit its possibility even at the greater angle, they consider such patients to have possible follow-up revision surgeries with instrumented arthrodesis.
Degenerative diseases of the spine

Sh. Kh. Gizatullin et al. Minimally invasive endoscopic foraminal decompression for adult degenerative scoliosis

Telfeian et al. [8] refer scoliosis more than 25°, disturbance of spinal-pelvic parameters (PI-LL >35°), and scoliosis progression by more than 3° per year to factors predisposing to adverse outcomes of isolated endoscopic decompression. At the same time, according to Pritchett and Bortel [9], degenerative scoliosis with progressive deformity has developed in 73% of patients over a 5-year follow-up period. Isolated, endoscopic decompressions do not increase the speed of degenerative scoliosis progression and ensure release of nerve roots, without destabilization of posterior support structures, including the vertebral arch, spinous processes, interspinous ligaments, facet joints, the necessity to preserve them has been proved by biomechanical and clinical studies [10].

In the last decades, the interest to the assessment of sagittal balance parameters in planning a surgery for degenerative scoliosis has sharply risen; that is important to argue a prevailing mechanism of pain syndrome. Bridwell et al. [11] and Smith et al. [12] prefer reconstructive surgery in cases of a pronounced sagittal imbalance, while Jackson and Hales [13] note that isolated endoscopic decompression ensures satisfactory long-term results, if the PI-LL value is less than 30°. Schwab et al. [4] consider this modifier to be the key one for prognosticating a patient’s quality of life. According to their opinion, its value in the range from 0 to 20° correlates with a satisfactory quality of life, and such patients do not need reconstructive surgery. At the same time, Fujii et al. [14] have proved that isolated endoscopic decompression could positively induce a reactive improvement in the lumbar and sagittal alignment in patients with degenerative scoliosis; this can be explained by a compensatory mechanism of disease symptoms relief.

Comparing the literature data with our own clinical observations, we have come to the following conclusions:

- the patient S., who had not been earlier operated on the spine, demonstrated that symptoms of radiculopathy caused by a nerve root compression sufficiently prevailed over mechanical axial pain caused by the deformity.

Fig. 1
Radiographs of the whole spine of patient S., including the skull base and femoral heads, on admission to the hospital (February, 2019)

Table 1
Integrated assessment of the deformity parameters by radiological data of patient S., on admission (February, 2019)

<table>
<thead>
<tr>
<th>Estimated parameters</th>
<th>Value</th>
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<tbody>
<tr>
<td>Pelvic parameters</td>
<td></td>
</tr>
<tr>
<td>Pelvic incidence (PI)</td>
<td>50°</td>
</tr>
<tr>
<td>Pelvic tilt (PT)</td>
<td>12° (norm: 11°)</td>
</tr>
<tr>
<td>Sacral slope</td>
<td>38° (norm: 40°)</td>
</tr>
<tr>
<td>Spinal parameters</td>
<td></td>
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<tr>
<td>Lumbar lordosis L1–S1</td>
<td>48° (norm: 55°)</td>
</tr>
<tr>
<td>Lumbosacral angle L4–S1</td>
<td>45° (norm: 36°)</td>
</tr>
<tr>
<td>Linear deviation of sagittal vertical axis</td>
<td>2 cm</td>
</tr>
<tr>
<td>Modifier (PI-LL)</td>
<td>2°</td>
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<tr>
<td>Scoliotic curve (L1–L4)</td>
<td>25°</td>
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</tbody>
</table>
– according to the radiological data, the patient did not have signs of sagittal imbalance and instability of the spinal motion segments of the lumbar spine, and the comparison with 3-year-old spondylograms pointed to a stable scoliotic curve (25°);
– MRI-examination demonstrated a pronounced foraminal stenosis, involving soft-tissue and bone components.

Basing on the above mentioned aspects, it was possible to choose an isolated, minimally invasive endoscopic decompression without instrumented fusion and deformity correction; the 6-month postoperative follow-up proved the choice of the treatment method.

The importance of a large-scale implementation of minimally invasive technologies to treat degenerative spine diseases is beyond all questions. That is why the latest publications devoted to this issue are of particular interest.

In the recent meta-analyses, Akinduro et al. [15] included 41 studies involving 1810 patients, He et al. [16] included 5 studies involving 501 patients, and Li et al. [17] included 6 trials involving 730 patients, and compared treatment outcomes of degenerative spinal diseases through open and minimally invasive methods.

According to Akinduro et al. [15], good and excellent results were obtained in 97.7% of patients operated because of clinical signs of lumbar osteochondrosis with the use of minimally invasive methods, in comparison, a group of traditional (open) surgeries demonstrated only 82.7%. The decrease of mean values of pain syndrome was 7.3 points (from 8.5 till 2.2) and 6.5 points (from 9.1 till 2.6), respectively, given the equal frequency of intra- and postoperative complications (1%) and reoperations (3 and 4%).
The advantages of minimally invasive surgeries were associated with lower estimated blood loss (39.8 and 78.4 ml), shorter operative time (69.4 and 81.6 min), shorter hospital stay (33.8 and 64.1 hours), and faster return to work (3.4 and 6.7 weeks).

He et al. [16] note a comparable frequency (p > 0.05) of such intra- and postoperative complications as injury of dura mater and roots, recurrent pain syndrome and/or neurological deficit, purulent-inflammatory complications, and reoperations. The advantages of minimally invasive methods are statistically significant in terms of intraoperative estimated blood loss and length of hospital stay.

Li et al. [17] did not reveal significant differences between minimally invasive and open interventions in reoperation rates, dynamics of the Oswestry Disability Index, and appearance of spinal instability (according to radiographic data) (p > 0.05). At the same time, the complication rates were three times as less after minimally invasive surgeries (3.86 % compared with 11.4 % for traditional surgeries), and statistically significant (p < 0.05) advantages of minimally invasive methods were characterized by less intensity of pain syndrome measured by VAS.

The analysis of the literature devoted to surgical treatment of adult degenerative scoliosis also demonstrates that spinal surgeons prefer to use minimally invasive methods.

Eastlack et al. [18] analyzed reoperation rates and complications of degenerative scoliosis treatment with circumferential minimally invasive surgery (cMIS) and hybrid (HYB) techniques. Adult spinal deformity correction was accompanied with necessity of a reoperation in 27.9 and 33.8 % of patients in the groups, respectively, at minimal 2-year follow-up. Inadequate spinal stabilization was more common after HYB method, meanwhile pseudofacet arthrosis was more often with cMIS techniques. Early reoperations were less common than later reoperations in both groups, but cMIS methods demonstrated less risk of early reoperations when compared with HYB techniques.

Bae and Lee [19] performed a systemic search for the literature published in...
PubMed through January, 2018, with the following terms: “minimally invasive spinal surgery”, “adult spinal deformity”, and “degenerative scoliosis”, and selected 138 abstracts and 57 full-text articles. According to the severity of deformities and symptoms, various types of minimally invasive surgery (MIS) were used, such as decompression MIS, circumferential MIS, and hybrid technique. With proper indications, the minimally invasive approach achieved satisfactory clinical and radiological results, with reduced complication rates. The authors recommend future researchers to direct their efforts to define clear indications for the use of various surgical options.

Wegner et al. [20] consider that minimally invasive lateral approaches (XLIF) for the correction of lumbar scoliosis are becoming an increasingly common treatment alternative to posterior osteotomy or surgeries through an open anterior approach. These approaches minimize blood loss and painfulness, which may be important for elderly patients, who often have substantial comorbidities. The anterior column realignment makes it possible to restore lumbar lordosis and sagittal balance and is correlated with improvements in health-related quality of life. Spinal surgeons are recommended to clearly understand the development of, the indications for, the surgical technique for, and also the complications, and early clinical outcomes of XLIF.

Telfeian et al. [21] presented a method of endoscopic treatment of lumbar disc herniation in setting of lateral spondylothesis. They retrospectively analyzed 199 cases of patients who underwent transforaminal endoscopic spine surgery and had a minimum follow-up period of one year. In the presence of lateral subluxation of the vertebral bodies, this surgery was a successful, unique, minimally invasive approach for treatment of lumbar radiculopathy that might be considered as an alternative treatment to degenerative deformity in elderly patients.

According to Fontes and Fessler [22], minimally invasive surgery in degenerative scoliosis is becoming an efficient treatment alternative to the traditional methods which in some cases are not able to stop the natural disease development with possible negative dynamics. In mild-to-adult spinal deformity balanced in the sagittal plane, there are situations in which an ordinary decompression through a foraminotomy or laminectomy, or even a short-segment spinal fusion may be sufficiently effective. The authors present a clinical case and their treatment rationale, and a review of the limited available literature describing the topic discussed.

It is commonly known that not all patients with degenerative scoliosis are psychologically ready to a radical surgical treatment. S.V. Kolesov [23] considers that it especially refers to patients of mature, elderly, and gerontic age, whose quality of life has reduced, first of all, because of pain syndrome, but not of a cosmetic defect in the form of a deformity (contrary to teenagers and young adult patients). Such patients could be proposed a minimally invasive treatment due to the following reasons:

- stopping or reducing of pain syndrome, without correcting the very deformity, may satisfy them completely;
- a minimally invasive intervention can be considered as a stage of the treatment, postponing a classical deformity correction in case of its inefficiency;
- a cautious attitude towards methods of a prolonged general anaesthesia, as well as their somatic state anxiety are subjectively considered by the patient as unsatisfactory for a classical surgery with deformity correction;
- objective contraindications are possible for large-scale surgeries, first of all, in terms of cardiovascular, respiratory, and other systems.

It should be taken into consideration that minimally invasive methods in degenerative scoliosis are, for the time being, an unconventional approach; and clear understanding of the indications and use of which are possible only if there is confidence in improving a patient’s quality of life with positive treatment outcomes.

So, the proved advantages of minimally invasive methods in comparison with traditional open ones are as follows:

- less estimated blood loss in the intra- and postoperative periods;
- a shorter period of hospital stay;
- less intensive postoperative pain syndrome (assessed by VAS);
- less frequency of intra- and postoperative complications.

Open surgeries with deformity correction and spondylodesis with metal rods are risky of greater surgical injury and, consequently, minimally invasive surgeries are alternative to them in case it is possible to conduct them [23]. Drawbacks of minimally invasive surgeries are high requirements to a surgeon's experience and technological infrastructure of the operation room [24–28].

<table>
<thead>
<tr>
<th>Table 2</th>
<th>Integrated assessment of the deformity parameters by radiological data of patient S., six months after the surgery (August, 2019)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Estimated parameters</td>
<td>Value</td>
</tr>
<tr>
<td><strong>Pelvic parameters</strong></td>
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</table>
Conclusion

A possibility to use minimally invasive surgeries in the treatment of scoliotic deformities accompanied with pain syndrome in adult patients, to our opinion, deserves a sustained attention. Minimally invasive interventions may be not only intermediate, palliative surgeries, but also radical interventions; that is why they may be a method of choice with consideration to traumaicity of a multi-level scoliosis correction and a prolonged period of rehabilitation after a traditional surgery. A special attention should be paid to the fact that an extended reconstructive foraminal decompression may be considered as a variant of an individual surgical intervention in patients with degenerative scoliosis with a dominant clinical picture of monaradicul syndrome and compensated sagittal balance.

The widening of possibilities of minimally invasive surgeries requires not only a specification of clear indications, but also a proper dialogue with the patient, who should be provided with detailed information on advantages, limitations, and results of the method. There is a group of patients with degenerative scoliosis, who have a subjective desire and/or objective indications to a minimally invasive intervention, and deformity correction is not a priority for them. Stopping of pain syndrome in such cases may be absolutely enough as a clinical treatment outcome.

Limitations and level of evidence. While presenting their own clinical observation, the authors realize that a favorable 6-month postoperative period does not guarantee the absence of complication development and reduction of the patient’s satisfaction with the results during further follow-up period.

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References


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