SCOLIOSIS AND SPONDYLOLISTHESIS: A SOLUTION TO THE PROBLEM

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Objective. To evaluate the results of surgical correction of scoliotic deformities in patients with spondylolisthesis.

Material and Methods. A total of 51 patients with scoliosis and spondylolisthesis were observed in 1998—2016. Spondylolisthesis was asymptomatic in 49 cases. Most patients had grade I spondylolisthesis. Surgical correction of scoliotic deformity of the spine with segmental instrumentation was performed in 31 cases.

Results. The average magnitude of the initial scoliotic curve before surgery was 67.2°, after surgery — 33.4°, and correction was 50.3 %. The magnitude of countercurve before surgery was 28.1°, after surgery — 11.1°, and correction was 35.5 %. In all cases, the L5 vertebra was not included in the spinal fusion zone. Progression of the degree of the L5 vertebra displacement in the postoperative period was not revealed. Neurological deficit was not observed. The average follow-up period was 5.4 ± 3.3 years.

Conclusion. Correction of idiopathic scoliosis in the presence of L5 spondylolisthesis can be carried out with good and satisfactory results and minimal risk of listhesis progression, and with preservation of the achieved result in the long-term period.

Key Words: scoliosis, spondylolisthesis, scoliosis surgery.

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Scoliosis and spondylolisthesis are independent nosological forms. The etiology of these pathological conditions has not been finally determined and surgical correction is based on various principles.

The incidence of spondylolisthesis in patients with scoliosis ranges from 2.4 to 6.2 % [11, 13], accounting for 6 % in the general population [5, 15], and sometimes increases to 17 % in the second decade of life and even to 51 % in the sixth decade [16]. Spondylolisthesis can accompany not only idiopathic scoliosis but also syndromal deformities, such as Marfan disease and neurofibromatosis [7, 31].

The incidence of scoliosis (at least 5°) in patients with spondylolisthesis is up to 36–48 % [11, 18, 22]. Srivastava et al. [28] developed a classification aimed at determining the optimal surgical tactics, which included 3 types of scoliotic deformities:

1) sciatic scoliosis, tension of L5 root with radiculopathy and antalgic deformity. It is mobile and has no significant torsion [10, 22];

2) olisthetic scoliosis (it was described by Neugebauer in 1888), resulting from rotation of the body of the displaced vertebra in the case of asymmetric spondylolisthesis, which occurs in 30 % of cases [20];

3) typical idiopathic scoliosis [28]. In the case of the first two types, spontaneous resolution of scoliotic deformity is possible with adequate treatment of spondylolisthesis. For example, Zhou et al. [31] and Srivastava et al. [28] reported the cases when scoliosis was almost completely cured after correction of spondylolisthesis, with the initial scoliotic curve up to 50° [24, 28–31].

Combinations of these two diseases sometimes occur and pose a special challenge to spine surgeons, which has no unambiguous solution. The only opinion shared by all researchers is that in the case of idiopathic scoliosis (usually thoracic one) in combination with spondylolisthesis, both pathologies should be considered separately, which determines indications for surgical treatment [8, 14, 29]. Some surgeons believe that lumbosacral spine should be stabilized, especially in the case of severe listhesis, followed by correction of scoliotic deformity [23, 29, 31]; others believe that fusion of L5–S1 is not mandatory and only the overlying deformity should be corrected [8, 15, 19]. In most cases, surgeons strive to preserve as many intact spinal motion segments distal to the spinal fusion zone as possible and maintain the maximum possible range of motion in the lumbar spine [15]. The choice of treatment is also complicated by the absence of proved spondylolisthesis progression factors in adolescence [9, 30]. Progression of spondylolisthesis is believed to be a rare phenomenon and occurs only in 4–5 % of patients [12, 26].

The study was aimed at analyzing the results of surgical correction of scoliotic

spinal deformities in patients with spondylolisthesis.

Material and Methods

We carried out a retrospective analysis of the cases of concomitant scoliotic deformity and spondylolisthesis in patients, evaluated the dynamics of radiological parameters, complaints of patients, and data of SRS-24 questionnaire.

A total of 51 patients (35 females and 16 males, mean age at admission 16 ± 3 years) with scoliosis and spondylolisthesis were followed up at the clinic of children and adolescent spine surgery of the Novosibirsk Research Institute of the Traumatology and Orthopedics n.a. Ya.L. Tsivyan in 1998–2016, which accounted for 1.4 % of the total number of patients. Spondylolisthesis was asymptomatic in 49 (96.1 %) cases. Complaints about pain in the lumbar spine, increased fatigue, and discomfort were the same as those in patients without spondylolisthesis. All patients were admitted to the clinic for correction of scoliotic deformities, and therefore they were examined according to the standard procedure. X-ray examination of the spine was carried out in frontal and lateral projections including the iliac crest; functional X-ray examination was carried out in patient's prone position with lateral bend. Unfortunately, inclusion of the femoral heads in the lateral radiographs have become a mandatory requirement only since recently, and therefore reliable evaluation of the lumbar pelvic balance is not possible. X-ray examination of the extremities in the lateral projection aimed at detecting pelvic shift was not carried out as well [1], since it was now required during clinical examinations in the vast majority of cases. The data of the clinical examination showed no signs of severe imbalance between the pelvis and lower limbs. The patients underwent MRI of that department of the spine, where the top of the main scoliotic curve was located; additionally, MRI of the lumbar spine was carried out in patients with neurologic symptoms resulting from spondylolisthesis. All patients were examined by a neurologist and orthopedist.

In two cases, patients suffered from severe pain, they had clinical signs of spondylolisthesis, and the diagnosis was made at a prehospital stage. In other cases, antelisthesis was detected at the stage of preoperative examination as an accidental finding. The patients who underwent primary correction of scoliotic deformity in other clinics, including those cases where the MEDILAR instrumentation was used, were excluded from further studies, as well as patients who underwent spondylolisthesis surgery at the first stage. We did not consider patients who underwent scoliotic deformity correction with the ANTARES instrumentation and one patient in whum the metal structure was removed after the segmental instrumentation due to wound suppuration.

Results

Surgical correction of scoliotic spinal deformity with segmental instrumentation without inclusion of L5 and S1 segments in the spinal fusion zone was carried out in 31 cases (11 boys and 20 girls). The postoperative follow-up period averaged 5.4 ± 3.3 years.

The main curve was localized in the thoracolumbar spine in five cases and in the thoracic or lower thoracic spine in the rest of cases.

The mean primary scoliotic curve was 67.2° before surgery, 33.4° after surgery; correction was 50.3%, postoperative loss of correction was 2.0° (5.9 %).

The average lumbar scoliotic curve was 28.1° before surgery and 11.1° after surgery; correction was 35.5%, postoperative loss of correction was about 1.0° (4.1 %).

The average thoracic kyphosis was 40.5° before surgery, 29.1° after surgery, and 32.4° at the last control examination.

The average lumbar lordosis was 65.1° before surgery, 52.9° after surgery, and 53.5° at the last control examination.

The magnitude of preoperative displacement of the L5 vertebra averaged 6 mm (2 to 24 mm), which in most cases corresponded to Meyerding grade I (29 patients). One case of each of grade II and III spondylolisthesis were detected. The average postoperative displacement was 7 mm (2 to 26 mm).

Global sagittal balance (SVA) averaged 15.1 mm before surgery, 11.7 mm immediately after surgery, and 9.8 mm at the end of the follow-up period.

The number of free segments between the lower instrumented vertebra and sacrum was 3 or more in 17 patients, 2 in 12 patients, and 1 in 2 patients. Thus, the lower instrumented vertebra was in most cases at the level of L3 or higher, spinal fusion area reached the level of L4 in 12 cases and the level of L5 vertebra only in two cases.

Questioning (SRS-24) was carried out before surgery, after surgery, and at the last follow-up examination. There was a statistically significant improvement in appearance, postoperative function, general and professional activity. For the other domains, the results of questionnaire were without significant changes. Interestingly, the results of the questionnaire survey did not differ significantly from those in patients without spondylolisthesis [2].

Correction of scoliotic deformity restored global sagittal balance of the spine and reduced lumbar lordosis and therefore provided conditions to minimize the risks of progression of spondylolisthesis. In the postoperative period, pain relief was observed in all cases. There was no worsening of neurological symptoms.

Since the study included patients who were treated when laminar structures were used in the clinic, we can state that correction of scoliotic curves corresponds to that in patients with idiopathic scoliosis without spondylolisthesis. When using hybrid and total transpedicular structures, the percentage of correction increases, while the percentage of correction loss decreases, but the position of L5–S1 segment remains stable [2].

Fig. 1–3 shows clinical cases of surgical correction of scoliosis in patients with spondylolisthesis.

Discussion

Analysis of the literature shows the ambiguity of approaches to this problem. For some surgeons, low grade spondylolisthesis associated with risk factors for progression is a motivation for action. In this case, surgical treatment results in favorable outcome [3, 6].

Other researchers report that the quality of life does not significantly differ between the patients who underwent surgical treatment for low-grade spondylolisthesis and those who have been conservatively treated for this pathology [21, 30].

The authors agree that surgical treatment is required in patients with neurologic deficiency or proven progression of the listhesis.

There are reports that isolated correction of spondylolisthesis result in indications for surgical correction of scoliosis, even though scoliosis was presumably caused by asymmetric slippage of the L5 vertebra or was regarded as antalgic [29].

There are many reports, where the approach to the treatment of these pathologies was close to that used at the department of pediatric orthopedics of the Novosibirsk Research Institute of Traumatology and Orthopedics.

Arlet et al. [8] reported 82 cases of concomitant scoliosis and spondylolisthesis. Of these, 26 patients were followed without any treatment, brace therapy of scoliotic deformities was carried out in 23 cases, where the position of the displaced vertebra remained stable, and correction of progressive scoliosis was carried out in 15 cases. Spondylolisthesis, in turn, does not inhibit bone block formation. Correction of scoliosis does not aggravate the course of spondylolisthesis. Lumbosacral fusion was carried out in 13 cases, reconstruction of the spinal fusion area in 2 cases, lumbosacral fusion followed by correction of scoliotic deformity in a few months in 3 cases. The later treatment option was used in the case of proven progression of both spondylolisthesis and scoliosis [8].

According to Crostelli and Mazza [10], in the case of concomitant scoliosis and spondylolisthesis, listhesed vertebra should be included in the spinal fusion area only when listhesis reaches grade IV. In other cases, it is recommended to consider progressive scoliosis in combination with spondylolisthesis as idiopathic and apply surgical treatment in accordance with modern views on this process. They followed twenty patients with a combination of these diseases. The scoliosis averaged 62° (44 to 83°). The average age of patients was 14 years. There were 7 cases of grade I spondylolisthesis, 9 of grade II, and 4 of grade III. According to Lenke classification, type 5 was observed in 14 patients, type 1 in 1 patient, and type 2 in 5 patients. L1 was the lowest instrumented vertebra in 1 case, L3 in 10 cases, and L4 in 9 cases. The average follow-up period was 5 years and 3

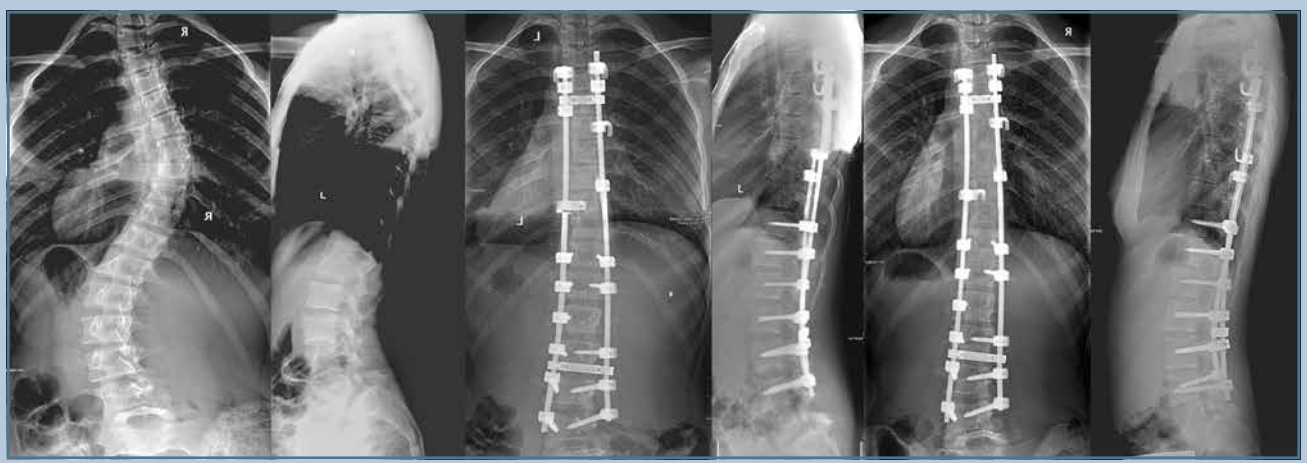

Fig. 1
Patient A., aged 13 years, complained of fatigue and pain in the thoracic and lumbar spine after vertical loads, X-ray examination showed thoracic scoliotic curve of 49°, lumbar counter curve of 44°, thoracic kyphosis of 21°, lumbar lordosis of 73°; X-ray images showed grade I isthmic spondylolisthesis of the L5 vertebra (7 mm), hypoplasia of the twelfth rib pair; the patient was neurologically intact. Scoliotic deformity was corrected using hybrid instrumentation with fusion involving T4–L4. Intraoperatively, hypoplasia of the pedicle of L1 vertebral arch was detected, which caused technical difficulties with insertion of transpedicular screws at this level; postoperative primary curve was 6°, counter curve 10°, kyphosis 20°, lordosis 53°; spondylolisthesis of the C5 vertebra was 8 mm; there are no complaints 5 years after the operation, the primary curve is 8°, counter curve 11 °, kyphosis 20°, lordosis 59°; spondylolisthesis of the C5 vertebra 8 mm

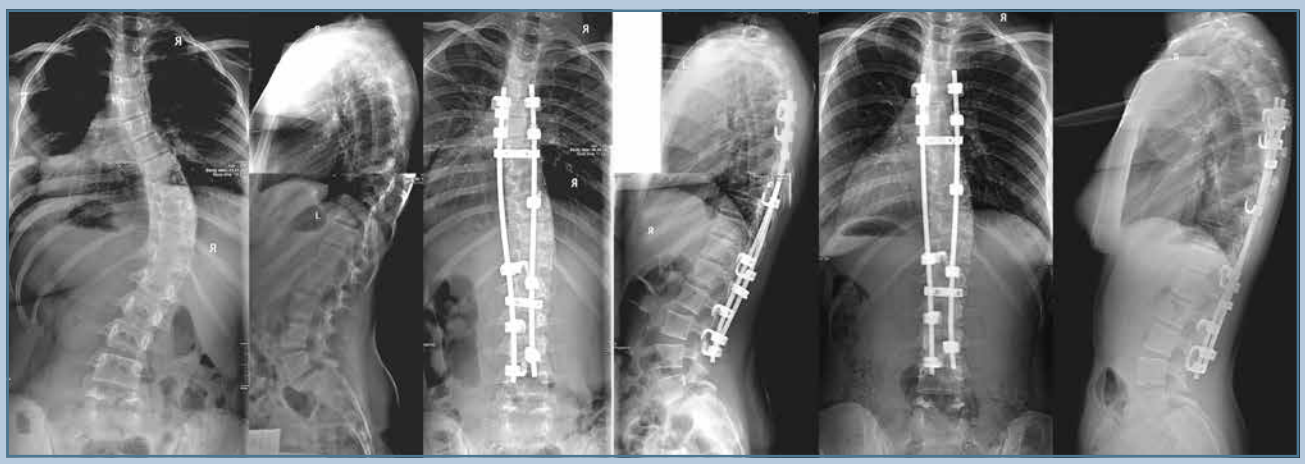

Fig. 2
Patient K., aged 14 years, complained of fatigue and pain in the thoracic and lumbar spine after vertical loads; X-ray examination showed lower thoracic scoliotic curve of 51°, upper thoracic counter curve of 36°, thoracic kyphosis of 45°, lumbar lordosis of 74°; X-ray images showed grade I isthmic spondylolisthesis of the L5 vertebra (4 mm), the patient was neurologically intact. Scoliotic deformity was corrected using laminar construction with spinal fusion involving T5–L2. Surgical treatment was uneventful. Postoperative primary curve was 11°, counter curve 25°, kyphosis 29°, lordosis 42°. Spondylolisthesis of the L5 vertebra was 4 mm. There are no complaints 5 years after the operation, the primary curve is 12°, counter curve 25°, kyphosis 38°, lordosis 51°; spondylolisthesis of the L5 vertebra 4 mm

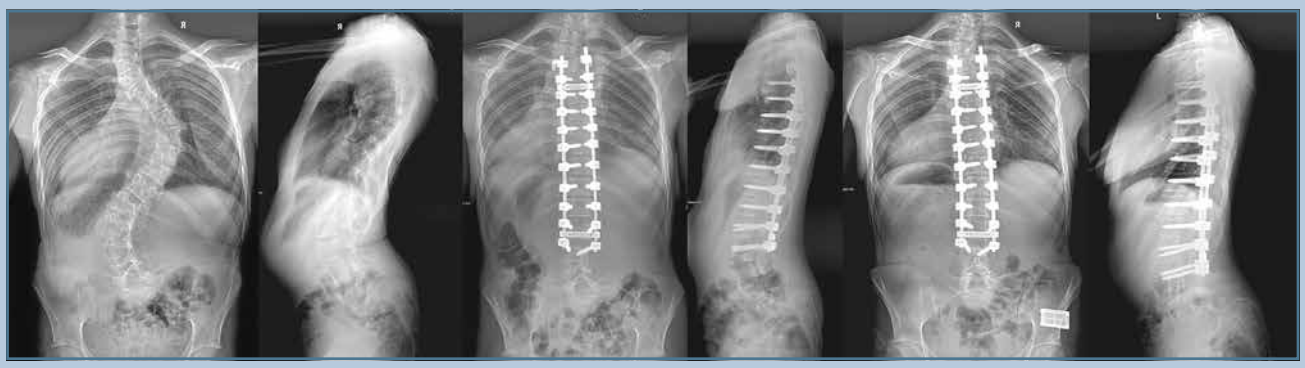

Fig. 3
Patient V., 15 years old, complained of fatigue and pain in the thoracic and lumbar spine after vertical loads; X-ray examination showed thoracic scoliotic curve of 74°, lumbar counter curve of 45°, thoracic kyphosis of 20°, lumbar lordosis of 43°; X-ray images showed grade III–IV isthmic spondylolisthesis of the L5 vertebra (23 mm), the patient was neurologically intact. Scoliotic deformity was corrected using a subtotal transpedicular instrumentation with spinal fusion involving T5–L2, operative treatment was uneventful. Postoperative primary curve was 11°, counter curve was 13°, kyphosis 17°, lordosis 61°, spondylolisthesis of the L5 vertebra was 24 mm; the patient was followed for 2.5 years and had no complaints, the primary curve is 11°, counter curve 15°, kyphosis 21°, lordosis 73°; spondylolisthesis of the L5 vertebra is 26 mm

months. With this approach to treatment, no progression of spondylolisthesis was detected.

According to Hershman et al. [15], the incidence of listhesis in patients with scoliosis is up to 4.6 % (16 of 349 cases). The average scoliosis was 58° (42–85°). The average age was 14.8 years. Grade I–II spondylolisthesis was observed in 13 cases, grade III–IV in 3 cases. The lowest instrumented vertebra was located at the level of T12 in 5 cases, L1 in 4 cases, L2 in 3 cases, and L3 in 4 cases. Follow-up period was 50.8 months. No progression of displacement was observed in patients with grade I–II listhesis.

In all cases of scoliotic deformity correction in patients who were concomi-

tantly diagnosed with spondylolisthesis, the surgeon tried to minimize all risk factors that could necessitate reoperation. If the follow-up examination shows no progression of spondylolisthesis, the causes and factors that prevented progression of L5 displacement are evaluated. Hershman et al. [15] emphasize that the distance between the fusion area and listhesed vertebra of at least three spinal motion segments is a reliable factor associated with the absence of listhesis progression. There is a noticeable fact that there are no patients with fewer free segments in Heermann et al. [15], so the conclusion seems to be not entirely correct.

Returning to the data of our study, we should emphasize that only 17 out of 31 study group patients who underwent correction of scoliosis had 3 or more free segments, and the rest of the group had 2 free segments. In two cases, spinal fusion ended at the level of L5, that is, at the displaced vertebra. At the same time, there was no listhesis progression.

There are reports that degeneration of intervertebral discs does not worsen within nine years after scoliotic deformity correction in adolescents, and, therefore, the risk of spondylolisthesis progression is low [19].

More and more authors pay attention to the lumbar-pelvic balance. But it is not effective when these characteristics are considered as isolated factors in the case of concomitant scoliosis and spondylolisthesis. There are studies that prove the correlation between PI (pelvic incidence) and the severity of intervertebral disc and intervertebral joint degeneration. A.I. Prodan et al. [5, 6] believe that the smaller the PI, the greater disc degeneration. And vice versa, the higher PI, the greater the severity of degeneration of the posterior supporting complex, including the arcuate joints. At the same time, the authors point out that there is a correlation between the PI and SS (sacral slope) and correlation between the SS and SVA. Thus, it can be concluded that the degree of degeneration of the posterior and anterior supporting complexes can be predicted not only based on PI, but also based on SVA values.

There are various formulas to calculate the optimal values, but they mainly deal with only local parameters [27]. In our opinion, this approach is more applicable to the treatment of isolated pathologies (spondylolisthesis, *de novo* lumbar scoliosis). The formulas taking into account thoracic kyphosis values are more applicable to assessing the balance in patients with idiopathic scoliosis [17, 25]. At the same time, the effectiveness of evaluation of SVA values is only a little inferior to the aforementioned formulas with one exception: the formulas deal with segment-wise characteristics and therefore enable modelling the data for each particular segment. There is also a pelvic shift value, which is estimated based on the distance between the plumb line drawn from the posterior edge of S1 to the foot. This value, as well as compensatory flexion of the knee joints, correlates with changes in the results of ODI, and, therefore, with the quality of life [1]. The patients with scoliosis often have no signs of disorder in terms of this characteristic as evidenced by clinically normal gait and no complaints of flexion of the lower extremities. However, when considering patients who have degenerative spine lesions, the parameter becomes important, since many patients note that they cannot stay in the vertical position for a long time, and begin to bend their knee joints as a compensatory reaction in order to reduce pain syndrome. Therefore, changes in the pelvic shift value are rather a compensatory reaction.

The question why spondylolisthesis does not progress is still open. The only explanation is that it is not the cause of the development of scoliosis, but a mere factor contributing to spinal deformity progression. Restored sagittal balance after surgery provides an adequate load on the entire vertebral column, preventing the development of degenerative changes. A number of fused segments above the level of spondylolisthesis does not worsen degeneration of the underlying intervertebral discs and joints. This fact was experimentally proved using photoelasticity method. Fusion of segments reduces deformability of the spine. Loading results in decreased displacement of the points of force application with respect to unloaded state. This results in reduced value of the bending moment acting on the discs caudal to the fusion area [4].

Conclusion

The results of treatment obtained at out clinic lead to conclusion that isolated correction of idiopathic scoliosis in patients with spondylolisthesis of the L5 vertebra can be carried out with good and satisfactory outcomes, minimal risk of listhesis progression, and long-term preservation of the result. Follow-up period was 5 years. At the same time, many risk factors should be considered to avoid complications. However, restoration of SVA is usually quite sufficient. Undoubtedly, spondylolisthesis requires surgical treatment, but it is important to keep in mind that the surgery is indicated in the case of neurologic deficit or proven progression of vertebral displacement. In the case of spondylolisthesis progression, it is always possible to expand spinal fusion area. More careful follow-up is required in these patients in the postoperative period. Idiopathic scoliosis and spondylolisthesis should be considered as separate pathologies. Indications for surgical treatment should be selected in accordance with modern views on this process. Our material is limited, and therefore further studies of the problem under discussion is required.

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