THE INFLUENCE OF COMPLETE VERTEBRA REDUCTION ON THE DEVELOPMENT OF NEUROLOGICAL COMPLICATIONS AFTER SURGICAL TREATMENT FOR THE L5 SPONDYLOLYTIC SPONDYLOLISTHESIS WITH HIGH DEGREE OF DISLOCATION

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Objective. To perform retrospective analysis of the dynamics of neurological symptoms following complete reduction of the L5 vertebra in groups of patients with low-grade (I–II) and high-grade (III–V, ptosis) L5 spondylolytic spondylolisthesis.
Material and Methods. The study included 158 patients who underwent surgical treatment for the L5 spondylolytic spondylolisthesis.
Results. A pronounced positive dynamics was observed in the postoperative period after using the same surgical tactics in the treatment of both low- and high-degree spondylolisthesis. In isthmic spondylolisthesis, regression of pain syndrome and neurological deficit was longer in patients with high-grade spondylolisthesis in the early postoperative period. At 6 month and 1 year follow-up examination, there was no reliable difference between low- and high-grade spondylolisthesis.
Conclusion. The complete reduction of the L5 vertebra does not significantly impair the patient's neurological status. The complete reduction of the displaced vertebra and the correction of the lumbar spine can predict the restoration of the sagittal balance with respect to the lumbar lordosis angle and the pelvic tilt, which results in restoration of the patient's ability to work and early social adaptation.
Key Words: spondylolytic spondylolisthesis, neurological complications, L5 reduction.

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Spondylolysis is defined as a defect in the pars interarticularis of the vertebral arch on one or both sides. Fujiwara et al. [8, 9] defined segmental instability as a condition in which the loss of stiffness in the spine occurs when normal physical load results in pain. Spondylolytic spondylolisthesis occurs in 3–6 % of cases in the general population [24, 26], most often it is localized at L5–S1 (85–95 %) and L4–L5 (5–15 %) levels [26]. Multilevel spondylolytic spondylolisthesis is relatively less common. According to the literature [18], the incidence of multilevel spondylolytic spondylolisthesis accounts for about 1.5 % of the total pathology.

The complexity of the surgical treatment of L5 spondylolisthesis is due to a number of morphological changes: pronounced instability or, on the contrary, stiffness of the segment, dysplastic changes in the lumbosacral spine (spondylolysis and underdevelopment of the vertebral arch, trapezoid deformity of the first sacral vertebra, underdevelopment of the L5 pedicle, hypoplasia or aplasia of vertebral pedicles), secondary degenerative changes in adjacent discs [1–3, 11, 14, 20, 21, 27–29].

The aim of the study is a retrospective analysis of the dynamics of neurological symptoms following complete reduction of the L5 vertebra in the groups of patients with low-grade (I–II) and high-grade (III–V, ptosis) L5 spondylolytic spondylolisthesis.

Material and Methods

The study included 158 patients (53 males, 105 females) who underwent surgical treatment for L5 spondylolytic spondylolisthesis in the period of 2010 to 2015. The mean age of males and females was 52.4 and 55.8 years, respectively.

Two study groups were identified: group A included 70 patients with grade I spondylolisthesis, 58 patients with grade II spondylolisthesis; group B contained 16 patients with grade III spondylolisthesis, 8 cases with grade IV spondylolisthesis, and 6 patients with grade V spondylolisthesis and spondyloptosis.

Patient inclusion criteria:

– instability in the segment of the lumbosacral spine confirmed by the data of

SCT, MRI, and X-ray examination with functional tests;

– symptomatic state of the disease (neurological deficit, persistent vertebrogenic pain syndrome, decreased quality of life, patient disability).

Exclusion criteria: severe concomitant pathology, asymptomatic course of the disease, previously operated patients.

Neurological disorders diagnosed in the groups prior to surgical treatment are presented in Table 1.

The diagnostic complex included medical history data, neurological examination, the data of neuroimaging, MRI, CT, and X-ray imaging in two planes with functional tests. In case of severe displacement, teleradiography of the spine in standing position was performed in two planes. Differential diagnosis included ENMG of lower extremities. The obtained data were analyzed, the degree of vertebral displacement was evaluated according to the Meyerding classification [15] modified by Junge and Kuhl in 1956 [12]. Oswestry (ODI) and Roland-Morris (RDQ) scales were used for assessment of the quality of life in spine pathology, while the VAS scale was used to evaluate pain. Effectiveness of surgical treatment was assessed using the MacNab scale. A modified version of the Nurick scale was used for evaluation of the neurological state dynamics. Indications for surgery: vertebral displacement, vertebrogenic pain syndrome, neurological disorders (radiculoischemia, radiculopathy). All patients underwent complete reduction of the displaced vertebra (Fig. 1–3).

Results

The collected clinical and laboratory data on all patients demonstrated that the main neurological symptoms are mostly represented by segmental mono- or polyradicular compression, neurogenic intermittent claudication symptoms, vertebrogenic pain syndrome, lower limb paresis, impaired sensitivity, and pelvic organ disorders.

Evaluation of the results of surgical treatment was performed at days 3, 5, and 7, at months 3 and 6, as well as 1 year after surgical treatment.

Assessment of the quality of life on the RDQ scale in the period before surgery, in the early postoperative period, 3, 6 months and 1 year after surgery is presented in Fig. 4, 5.

Decrease in parameters in the early postoperative period, 3, 6 months and 1 year after surgery reflects regressed neurological deficit and improved quality of life. A clear tendency to restoration of neurological deficit is seen in the postoperative period.

Evaluation of the effectiveness of surgical treatment using the MacNab scale is presented in Table 2.

A criterion for an excellent result is the absence of neurological deficit in the postoperative period, while regressed neurological deficit by the day of discharge is assumed as good result, satisfactory result is regression of neurological deficit a week after discharge, and unsatisfactory result is persistent pain syndrome in the postoperative period that is not cured by conservative treatment.

Patients with unsatisfactory result of surgical treatment according to the MacNab scale were reoperated due to persistent radicular pain syndrome in the early postoperative period, which was not cured by conservative treatment. Reoperation involved decompression of the neural structures by additional resection of the vertebra along the neural root for its loosening.

Impairment of functional activity according to Oswestry was comparable in both groups within a period of up to 1 year. Biomechanical parameters were not assessed in this study.

Assessment of pain before surgery and in the postoperative period according to the VAS is presented in Table 3. The neurological status was analyzed using the modified Nurick scale immediately after surgery as well as 3, 6 months and 1 year after surgery. Pain syndrome significantly decreased in both groups; there was no significant difference in the follow-up up to a year. Neurological disorders in the form of persistent radicular pain syndrome were revealed immediately after surgery in four cases after complete reduction of the L5 vertebra. Neurological symptoms persisted during intensive conservative treatment. Regressed neurological deficit was noted after reoperation and additional foraminal decompression of neural structures. No neurological disorders were noted in the patients at a control examination after 3 months. There was no significant difference in the neurological status

Table 1

Neurological disorders in the groups of patients before surgery, n

Neurological disorder	Group A (n = 128)	Group B (n = 30)
Vertebrogenic syndrome	15	0
Vertebrogenic syndrome, radicular pain syndrome	54	2
Vertebrogenic syndrome, radicular pain syndrome, impaired sensitivity	35	3
Vertebrogenic syndrome, radicular pain syndrome, lower para- or monoparesis, neurogenic intermittent claudication	16	6
Vertebrogenic syndrome, radicular pain syndrome, impaired sensitivity, lower para- or monoparesis, neurogenic intermittent claudication	8	13
Vertebrogenic syndrome, radicular pain syndrome, impaired sensitivity, lower para- or monoparesis, neurogenic intermittent claudication, impaired pelvic organ function	0	6

Fig. 1
SCT of the lumbosacral spine: spondylolysis of the interarticular part of the L5 arch, ptosis of the L5 vertebra

Fig. 2
Functional radiographs of the patient in a standing position with maximum flexion and maximum extension: rigid dysplastic spondylolysis of the L5 vertebra (grade V, spondyloptosis)

Fig. 3
Radiographs demonstrating the state after surgery: eliminated dislocations of the L5 vertebra (grade V, spondyloptosis) by its complete reduction with transpedicular fixation of L5, S1 and wings of the iliac bones

between the two groups of patients one year after surgery.

Discussion

With the introduction of transpedicular fixation and the method of anterior spinal fusion with transforaminal access it became possible to perform the maximum reduction of the displaced vertebra, even at high degrees of displacement [10]. Correction with the creation of a reliable bone-metal block made it possible to obtain good orthopedic results. Nevertheless, according to some data [10], 50 % of patients developed segmental neurologic deficit after complete vertebral reduction in the postoperative period, which was not always cured by conservative therapy, and it was necessary to perform revision surgery and reduce the reduction degree. Schoenecker et al. report the development of cauda equina syndrome in the postoperative

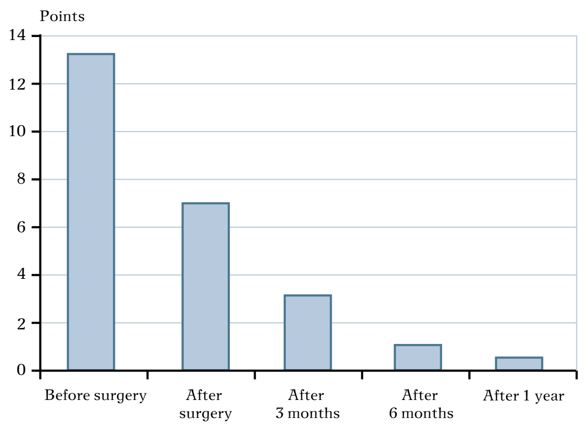

Fig. 4
Data on the quality of life according to the Roland-Morris scale in group A (mean values) before surgery (13.8 points) and in the postoperative period (0.9 points after 1 year)

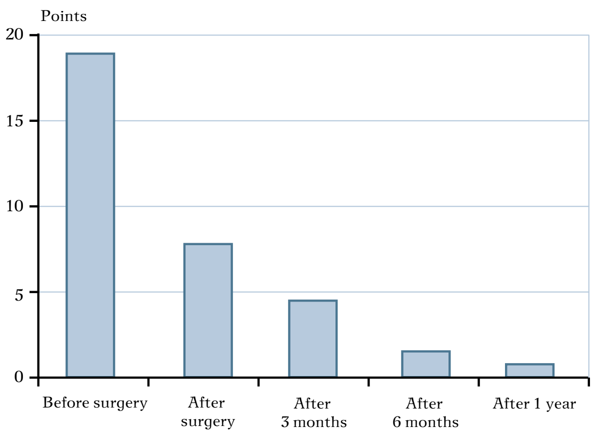

Fig. 5
Data on the quality of life according to the Roland-Morris scale in group B (mean values) before surgery (19.8 points) and in the postoperative period (1.2 points after 1 year)

period after correction of grade IV L5 spondylolisthesis [25]. They revealed this complication in 12 patients in total for the period of 18 years. The mechanism of complication development remained unclear [7]. Noack and Kirgis [19] did not find any obvious compression of segmental roots during surgical revision in neurological disorders in the postoperative period and suggested that the cause of neurologic deficit after reduction of the displaced vertebra is associated with extraforaminal compression of the neural root by the iliolumbar ligament. The data from topographic and anatomical studies by Kleihues et al. [13] published in 2001 confirmed the fact of compression of the L5 root between the notch of the lateral mass of the sacrum on one side and the iliolumbar ligament in the front. High incidence rate of neurological complications in complete elimination of grade III–V displacement compels surgeons to limit the amount of reduction. In this regard, the opinion was formed in the 2000s that complete reduction of the vertebra is required in grade I–II displacement, while reduction not exceeding two degrees is necessary in case of a greater displacement (grade III–IV and higher) [16]. For instance, Boachie-Adjei et al. [6] performed partial reduction and elimination of lumbosacral kyphosis, posterolateral spinal fusion, and transpedicular fixation. Thus, in their opinion, it is possible to avoid the tension of the roots and at the same time improve the vertebral pelvic balance, achieve sufficient contact of the vertebrae for bone block formation [6]. According to A. Rott [5], it is safe to conduct the reduction of the displaced vertebra at the magnitude of its instability

Table 2
Distribution of patients by the effectiveness of surgical treatment according to the MacNab scale, n

Result	Group A (n = 128)		Group B (n = 30)		
	Stage I (n = 70)	Stage II (n = 58)	Stage III (n = 16)	Stage IV (n = 8)	Stage V (n = 6)
Good	59	43	11	5	4
Excellent	14	9	4	3	2
Satisfactory	0	0	0	0	0
Unsatisfactory	0	3	1	0	0

Table 3

Pain assessment according to VAS before and after surgery in the groups of patients, scores

Period	Group A (n = 128)	Group B (n = 30)
Before surgery	913 (mean, 7.1)	237 (mean, 7.9)
Day 3	744 (5.8)	160 (7.9)
Day 5	340 (2.7)	85 (2.8)
Day 7	128 (1.0)	45 (1.5)

in functional images, while reduction of no more than one degree is safe in stable spondylolisthesis.

However, partial reduction of the vertebra as a single treatment method in severe degrees of its displacement often leads to the situation when an interbody bone block is not formed as well as overload and fractures of the metal structure, loss of the gained correction with the development of instability and the appearance of late neurological complications. In this connection, Molinari et al. [17] recommend augmentation of proximal fixation in the sacrum by additional installation of screws in the ilium bones in case of severe displacement. The advantages of this fixation were confirmed by the biomechanical studies conducted by Cunningham et al. [7].

Approaches to and principles of surgical management were updated in 2014 at the congress of the American Association of Neurological Surgeons. Surgery was recommended as an effective treatment in spondylolisthesis and stenosis of the spinal canal. However, it was not defined as a standard approach. The need for complete reduction of the displaced vertebra is still debated on, and the algorithm and strategy of the surgical management have not been determined yet.

Surgical tactics should be individual for each patient in order to ensure maximum effectiveness with minimal risk of complications. The strategy of the surgical management should include not only the somatic state, anatomical features of a particular patient, experience of the surgeon in the specific pathology of the spine, but also social conditions of the patient, health insurance system, which results in improved clinical outcomes and the quality of life [18, 23].

Instability of the lumbar spine is a complex multifactorial problem. Due to the lack of a clear algorithm and tactics for treating patients with high-grade isthmic spondylolisthesis in the literature, an individual approach is required with validated tactics of surgical treatment. The goals of surgical interventions are the following: improvement of segmental stability of the spine, decompression of neural structures of the spinal canal and regression of neurological deficit associated with spinal canal stenosis. In our study, an analysis of the surgical treatment of spine pathology in isthmic spondylolisthesis of all degrees of L5 vertebra displacement has been performed.

The effectiveness of surgical treatment according to the MacNab scale in the early postoperative period was 75.4 % in group A and 70.9 % in group B. A clear regression of the pain syndrome was observed in the two groups in the postoperative period upon pain assessment according to VAS before surgery and in the postoperative period. According to the RDQ scale, a decrease in the values in the early postoperative period, 3, 6 months and 1 year after surgery reflects regression of neurological deficit and improvement of the quality of life. The results of the conducted study demonstrate that, using the same surgical tactics in the two groups, there is a pronounced positive dynamics in the postoperative period. Taking into account the complexity of isthmic spondylolisthesis (pain syndrome in the postoperative period), the quality of life and neurological deficit regress longer in the early postoperative period in group B. No reliable difference was observed after 6 months and 1 year.

Conclusion

A retrospective analysis of the surgical treatment of patients with spondylolytic spondylolisthesis allows us to conclude that complete reduction of the L5 vertebra does not significantly impair neurological status of the patient. In our experience, complete vertebral reduction is necessary in the absence of negative indicators of visual and intraoperative electrophysiological control in case of dynamic instability of the lumbar spine and stable listhesis with manifestations of neurological deficit. Complete reduction of the displaced vertebra is vitally important in order to increase the contact area and block formation in the segment, for adequate load distribution between bone structures and the fixation system, as well as for correction of the sagittal balance.

In case if tension of the segmental roots with changes in intraoperative electrophysiological monitoring are noted after complete reduction of the displaced vertebra, then additional decompression of the neural structures (resection of the L5 transverse process, separation of the iliolumbar ligament, resection of the posterior and extraforaminal osteophytes) should be performed. This allows one to perform complete vertebral reduction. Modern studies and diagnosis of the spine pathology can assist in determining the future goals and solving further problems.

Thus, a tendency to complete reduction of the displaced vertebra and correction of the lumbar spine allow one to predict restoration of the sagittal balance with respect to the lumbar lordosis angle and pelvic tilt value, which leads to restoration of the patient’s ability to work and early social adaptation.

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