REVISION PROCEDURES IN THE SURGICAL TREATMENT OF THORACIC AND LUMBAR SPINE INJURIES*

A.A. Afaunov[1, 2], I.V. Basankin1, A.V. Mishagin[2], A.V. Kuzmenko[1, 2], K.K. Takhmazyan[1, 2]
[1]*Kuban State Medical University, Krasnodar*
[2]*S.V. Ochapovskiyi Regional Clinical Hospital No. 1, Krasnodar*

Objective. To systematize technical and tactical options of revision procedures in the surgical treatment for lower thoracic and lumbar spine injuries in order to reduce their invasiveness and technical complexity and to improve vertebral metric parameters of correction of injured spinal motion segments.
Material and Methods. Treatment results of 62 patients re-operated on for injuries of the lower thoracic and lumbar spine were examined.
Results. Good long-term results of treatment were obtained in 72.7 % of patients, and satisfactory ones, in 27.3 %.
Conclusion. The proposed differentiated tactics of revision surgery in the treatment of injuries of the thoracic and lumbar spine allowed to reduce invasiveness and technical difficulty of revision surgery as well as to improve vertebral metric parameters of correction of injured spinal motion segments.
Key Words: spine, injury, mistakes, revision surgery.

**Afaunov AA, Basankin IV, Mishagin AV, Kuzmenko AV, Takhmazyan KK. Revision procedures in the surgical treatment of thoracic and lumbar spine injuries. Hirurgia pozvonocnika. 2015;12(4):8–16. In Russian. DOI: http://dx.doi.org/10.14531/ss2015.4.8-16.*

Revision surgery for thoracic and lumbar spine injuries is one of the most complex and urgent issues of modern vertebrology [1, 4, 7, 8, 10]. Surgical treatment of such patients is insufficiently covered in the Russian and foreign literature. The revision surgery may be required for various reasons [4, 7, 8, 10]. In such situations, standard well-developed technical and tactical approaches to spinal injuries treatment are often ineffective [1, 7]. At the same time, repeated operations always increase invasiveness, technical complexity and risk associated with surgical treatment, duration of stationary phase, likelihood of severe and irreversible complications, and duration of rehabilitation period. The increasing number of young surgeons trained in modern high-tech methods of treatment of thoracic and lumbar spine injuries and widespread introduction of these methods into clinical practice of regional health facilities require a study of causes and establishment of the basic technical aspects of revision procedures in the surgical treatment of the lower thoracic and lumbar spine injuries.

The purpose of the study is to systematize technical and tactical options of revision procedures in the surgical treatment for lower thoracic and lumbar spine injuries in order to reduce their invasiveness and technical complexity and to improve vertebral metric parameters of correction of injured spinal motion segments (SMS).

Material and Methods

Clinical material for the study was collected in 2005–2014: 62 patients were re-operated on for the thoracic and lumbar spine injuries (35 men and 27 women aged from 18 to 54 years). A total of 19 patients initially had a vertebral-cerebrospinal injury (VCSI); 16 patients had neurological deficit at the time of revision procedures (4 of them, iatrogenic).

Sixteen patients sustained injury at the level of T6–T11, 13, at the level of T12–L1, 19 at the level of L2–L5. One SMS was affected in 33 patients, two, in 24, three, in 5. At admission, all patients complained of persistent progressing pain in the area of prior surgery for spinal injury. Examination revealed neurological deficits of varying severity in 16 patients: radiculopathy (5 patients), a lower paraparesis with dysfunction of the pelvic organs (8), lower paraplegia (3). The causes of re-operations can be divided into three groups. The first group includes initial use of deliberately inefficient and outdated surgical techniques, the second one includes incorrect application of modern high-tech means of correction and stabilization of the spine (in this case, the term “incorrect” implies not only a technical error during installation of metal structures, but also violations of indications for the chosen method), the third one includes circumstances unrelated to the quality of the initial surgery, which in this group had been carried out in accordance with the requirements for the chosen techniques.

The first group included 18 cases of direct causes of revision surgery: instability of the injured SMS after its fixation with wire loops (n = 6), instability of the injured SMS after laminectomy without fixation (n = 5), destabilization of the injured SMS after its fixation with TsI-

TO and HNIITO plates, laminar systems (n = 4), destabilization of the injured SMS after extended fixation with a laminar system (n = 1), progressive post-traumatic deformation after autocorporodesis without metal fixation (n = 2). The second group included 25 cases: destabilization of NiTi structures with thermomechanical memory (n = 5), incorrect implantation of screws for transpedicular fixation (n = 9), migration of interbody and body-replacing implants installed without transpedicular fixation (n = 4), inadequate decompression of the dural sac during transpedicular fixation (n = 3), post-traumatic deformities after ventral metal fixation (n = 4). The third group of direct causes of revision procedures included 19 cases: fractures of transpedicular systems screws (n = 7), unlocking of transpedicular systems connectors (n = 3), migration of transpedicular systems screws with subsequent destabilization (n = 7), fractures of ventral spinal systems screws (n = 1), progressive spondyloptosis as a result of postoperative suppurations, osteomyelitis and resection of the posterior elements of L5 and S1 (n = 1).

The timing of revision procedures varied. Eight patients were re-operated on within 3–12 days after the injury. These surgeries were performed due to improper implantation of transpedicular system screws, revealed by the control X-ray in the early postoperative period. The screws were re-implanted in all these cases. Eleven revision procedures were performed within the period of 2–12 weeks. Among them, there were 8 cases of transpedicular fixation after prior decompressive laminectomies in the absence of fixation or with inadequate fixation by wire loop, 3 cases of anterior decompression and corporodesis following the migration of previously installed interbody or body-replacing implants. The majority of patients (43) were re-operated on more than 3 months after the previously performed surgeries. These patients underwent re-osteosynthesis of the spine due to destabilization of the injured SMS, transpedicular fixation of greater extent, including cemented implantation of screws, staged surgical treatment of post-traumatic deformities with transpedicular external fixation. Forty-five patients who underwent revision surgery were initially treated in other clinics, while 17 patients were initial treated in the RCH No 1.

Vertebral metric parameters of deformations in these groups of patients were assessed using conventional methods [3, 5, 6, 9], based on the results of X-ray, CT and MRI examinations.

In 51 (82.2 %) of the 62 patients the initial damage to SMS was reliably classified based on X-rays scans performed immediately after the injury. In 11 (17.8 %) patients, who were operated on at later stages, the initial X-rays scans were not available and the systematization of injuries was based on the results of later X-ray examinations. Thoracic and lumbar spine injuries were classified according to Magerl.

A total of 5 (9.8 %) patients had compression fractures of type A1, 8 (15.7 %) of type A2, 6 (11.8 %) of type A3; 4 (7.8 %) had distraction injuries of type B1, 3 of type B2 (5.9 %), there were no cases of type B3. A total of 25 patients had the most severe rotational injuries: 13 (25.5 %) of type C1, 10 (19.6 %) of type C2, and 2 (3.9 %) of type C3.

In all cases, the decisions were made based on the assumption that surgical treatment should achieve four main objectives: elimination or prevention of vertebra-medullar conflict, normalization of anatomical relationships in the injured SMS, stabilization of the injured section of the spine and osteoplastic reconstruction of ventral sections of the injured SMS.

We employed various tactical and technical options for revision procedures in the treatment of the lower thoracic and lumbar spine injuries. Their systematization was based on a combination of main criteria, which defined the choice of technique for individual surgical treatments and overall treatment tactics. The following parameters were taken into account: number of surgical stages, order of execution of ventral and dorsal surgeries, dural sac decompression method, length of the inner metal fixation of the spine, number of SMS for interbody fusion, feasibility of using external transpedicular osteosynthesis and spinal systems for dorsal or ventral internal stabilization.

In 13 patients surgeries were performed from posterior accesses (replacement of broken or incorrectly implanted screws), in 9 patients from anterior accesses (anterior decompression and corporodesis), including preliminary repositioning with external fixation device in 5 patients; in 19 patients dorsoventral surgical interventions were performed (replacement of metal construction in 6 patients, its removal in 13 patients, and anterior spondylosyndesis in 19 patients), with additional ventral stabilization systems in 13 patients, including preliminary repositioning with external fixation device; dorsoventrodorsal surgical interventions were performed in 12 patients (removal of the dorsal metal construction, anterior spondylosyndesis, TPF in 13 patients), including preliminary repositioning with external fixation device in 6 patients; ventral stabilization systems were used in 6 patients (metal fixture 360°); ventrodorsal surgical interventions were performed in 9 patients (anterior mobilization, decompression, corporodesis, TPF, including preliminary repositioning with external fixation device, in 5 patients ventro-dorsoventral).

Results

Well-known clinical criteria and vertebral metric parameters were used to assess treatment outcomes [1, 3, 5–7, 9]. The characterization of the anatomic relationships in the injured SMS was made based on local kyphosis, vertical dimension of the injured SMS, translational dislocation, traumatic spinal canal stenosis. Vertebrogenous neurological deficit was assessed using Frankel scale with an additional point estimate of muscle strength and sensation in limbs. In patients re-operated on at the later stages for posttraumatic deformities of the spine, the clinical manifestations prior to the revision surgery as well as in the immediate and late postoperative periods were evaluated using the VAS and ODI indicators. Short-term

outcomes of up to 3 months after the surgery were studied in all patients. Good results were achieved in 46 (74.2 %) patients, and satisfactory ones, in 16 (25.8 %), who reported continued moderate pain up to 2–3 points on the VAS, residual deformation with compensated support function of the spinal column, lack of positive the dynamics of the neurological status. Six out of 16 patients with post-traumatic neurological deficits displayed positive dynamics to Frankel grade I–II. No changes in neurological status were observed for 10 patients.

Long-term outcomes with the follow-up of more than 1 year were recorded for 44 (71.0 %) patients: 32 (72.7 %) achieved good long-term outcomes, 12 (27.3 %) achieved satisfactory ones.

Discussion

The examination of cases of transpedicular spinal systems destabilization, including 7 cases of damaged screws, 3 cases of unlocked connectors and 7 cases of metal structures migration, revealed that the anterior corporodesis was not performed in 14 out of 17 such cases. Therefore, in most cases the destabilization of the dorsal metal fixator occurred in the absence of supportive ventral column for the injured SMS.

The analysis of technical features of the performed revision surgeries revealed their most characteristic differences compared to the primary surgeries performed for the thoracic and lumbar spine injuries. For example, in surgeries from posterior access the greatest technical difficulties were associated with the removal of previously installed transpedicular or laminar systems in the absence of appropriate original set of tools. Such situations were encountered in the two patients who had no medical documentation on the earlier surgical treatment of their spinal injuries and no information on the implanted spinal metal constructions. At the pre-surgery planning stage these structures have been misidentified based on X-ray data. During the surgery undertaken to remove the unidentified spinal systems, the available toolkits did not enable correct release of the fasteners, which led to expansion of the surgical access and rough fragmentation of the long metal constructions using massive metal-cutting tools. This significantly increased the duration and invasiveness of the revision surgery, and in both cases the volume of intraoperative blood loss exceeded 1 liter.

There were also some technical difficulties in transpedicular re-osteosynthesis after the removal of the broken elements of the previously installed transpedicular system. Frontal parts of the screws that remained in the vertebral bodies prevented installation of the new screws using the optimal trajectory. In such cases, the screws were installed extrapediculary following improvised trajectories, and the total length of the spinal system tended to increase. Similar technical difficulties were encountered when transpedicular fixation was performed after the removal of the previously installed destabilized or migrated screws due to significant volume of bone in the vertebral bodies being affected.

Clinical Example 1. Patient Sch., female, aged 30, sustained a VCSI in traffic accident in 1999: comminuted dislocation fracture at L4 with fractures of arches and articular processes (type C2) with deep lower paraparesis (group C on a Frankel scale) and dysfunction of the pelvic organs. She was operated on at the place of residence in the early period after the VCSI: decompressive L4–L5 laminectomy. She was on bedrest for long time. Two months after the surgery she began to sit down in bed using rigid lumbar corset, after 3 months she was able to move independently in a wheelchair, after 5 months, the functions of the pelvic organs were restored in full. Muscle strength in the hips reached 4 points, in the calf muscles, 2 points. The patient was allowed to be active in hard strain relief corset with additional support on crutches. In 2001, she gained a lot of weight. The stabilizing function of the lumbar corset had become insufficient. There was a constant pain in the back. In 2002 she was operated on in a Moscow clinic, due to increasing lumbodynia and signs of post-traumatic deformation, with installation of L3–S1 transpedicular fixation, using 4-screw system with implantation of screws in the lateral masses of the sacral bone. The progression of post-traumatic strain had been stopped for the time. There was a significant decrease in the intensity of lumbodynia. The patient had adapted to her physical condition. She moved around by using lightweight elbow crutches. In 2011, she noticed changes in the external contours of the waist and periodic appearance of moderate lumbodynia. These symptoms gradually progressed. X-rays and CT scans performed in 2012 and 2014 revealed destabilization of the transpedicular system and progressive post-traumatic deformation of the lumbar spine (Fig. 1). The collapse of the L4 body had reached 100 %, local kyphosis in segments L3–L5 was 43°, anterior dislocation of L3 was 95 %.

In September 2014 the patient was hospitalized to the RCH No 1 for surgical treatment. In view of the gravity of the existing deformation, 14-year period from the date of the injury and revision character of the upcoming surgical intervention, a staged surgical treatment was suggested to restore the balance of the spine and stabilize the lumbar spine, including gradual normalization of the anatomical relationships in the lumbosacral SMS using external fixation followed by formation of bone-metal block at the level of L2–S1. In the pre-operative period, it was not possible to identify with certainty the origin of the transpedicular system installed in 2002, since the medical records had not been preserved. On September 16, 2014 the unidentified transpedicular system was removed. During the surgery, none of the transpedicular fixation toolkits available in the RCH No 1 fit the connectors of the system. The system was removed incorrectly, using cutting tools that require a significant expansion of surgical access. There were no intra- and postoperative complications. Given the high invasiveness of the surgery and the lack of emergency indications for deformity correction and decompression of the dural sac, the patient was discharged and hospitalized again in November 2014.

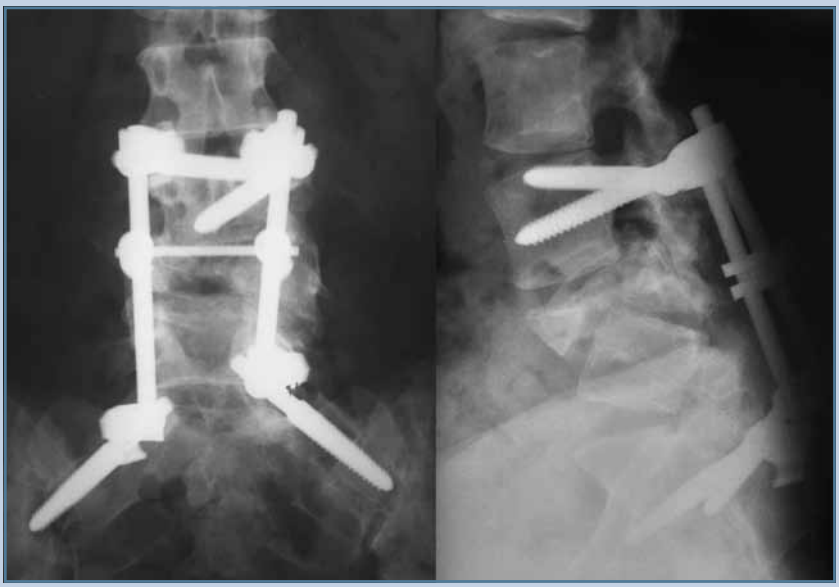

Fig. 1
Spondylogram of the patient Sch. at admission to the clinic

On November 10, 2014 transpedicular osteosynthesis was performed at the L2–S1 level using external fixation device of V.D. Usikov's design. Eight external transpedicular screws were installed percutaneously: two in each of L2, L3, L5, and S1. The exterior unit was mounted on two supports. The top support was fixed at the L2 and L3 level with 4 screws, the bottom one at the L5 and S1 level with 4 screws. The supports were interconnected by four longitudinal bars. The position of the support was selected taking into account the existing deformation and the upcoming correction procedure. Gradual correction of the anatomic relationships in the injured SMS had been started intraoperatively and continued in the postoperative period for 13 days (Fig. 2). The correction was carried out by controlled change of relative positions of the upper and lower supports of the external device. The rate of the correction was limited by pain intensity and gradually decreased from 3–5 mm per day in the first days to 2–3 mm per day by the end of the reduction. During this period the patient was allowed to be active, she moved on her own within the hospital. The correction process was divided into two periods. During the first period, the lumbus has been elongated using vertical traction of the upper lumbar spine in relation to the pelvic ring in the cranial direction. This had been achieved by gradual increase in the distance between the upper and lower supports of the external device while maintaining the angular relationship between them. During the second period, the reduction of the remaining elements of L4 was carried out simultaneously with eliminating local kyphosis at the level of L3–L5, which had been achieved by gradual rotation of the lower support arc of the external device in the sagittal plane.

On November 24, 2014, after X-ray confirmation of normalization of anatomical relationships in the injured SMS, the following interventions were performed: subtotal L4 corporectomy from the left retroperitoneal access, L3–L5 corporodesis using container type implant with autologous bone and additional L3–L5 ventral fixation with two «Medtronic Legasi» screws, locked on one longitudinal bar. The operation was performed before the removal of the external transpedicular device with the patient on the right side of the operating table, rotated 35° to the left. After the closure of the operation wound, the patient had been laid on her stomach. The external device was dismantled and internal transpedicular L2–S1 osteosynthesis was performed, using 8-screw «Medtronic Legasi» system. The screws, 6.5 mm in diameter and 50 mm in length, were implanted to replace the 6-mm removed screws of the external device (Fig. 3). Postoperatively, the patient was allowed to be active on day 5. Wound healed by primary intention. There were no complications.

The surgical treatment resulted in normalization of anatomical relationships in the lumbar spine, L2–S1 segments were securely stabilized, body proportions were restored, the patient's height was increased by 4 cm. According to the control spondylography 7 months after the surgery, the achieved anatomical relationships in the lumbosacral spine were preserved, the spinal system was stable, L3–L5 interbody bone block was forming. The functionality of the spine was restored, the lumbodynia was arrested, the vertebral neurological deficit was at the preoperative level. The patient's follow up continues.

In most cases of ventral accesses surgeries we faced with adhesive processes, which greatly complicated the anatomical separation of tissues in the pleural cavities and retroperitoneal space during the approach to the injured section of the spine. In two cases, it resulted in significant intraoperative trauma of the lung, and in one case, in bleeding from the common iliac vein due to its parietal wound in scar conglomerate. There were no complications at the stage of ventral metalwork removal. Re-implantation of ventral systems could be complicated by the remains of screws from previously installed constructions in the vertebral bodies. In such cases, the positioning of new ventral systems was non-standard, with introduction of their screws into the bone mass of the vertebral bodies on the improvised paths. We tried to guide the screws closer to the endplates in the cranial or caudal sections, which has maximum bone tissue strength in the vertebral bodies [2].

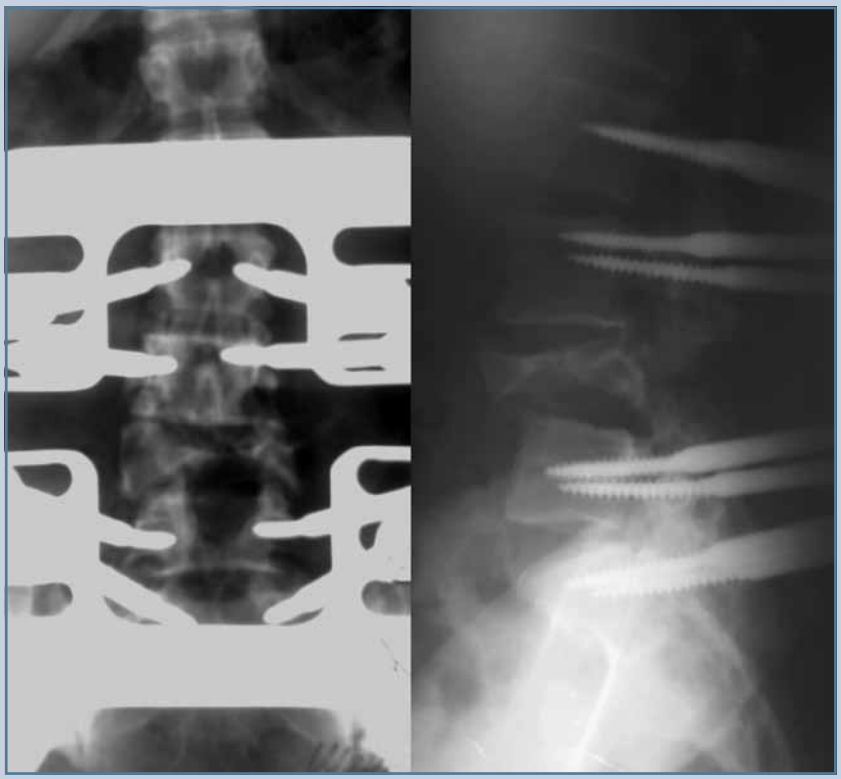

Fig. 2
Spondylograms of the patient Sch. during the correction of posttraumatic deformities of the lumbar spine using external transpedicular device

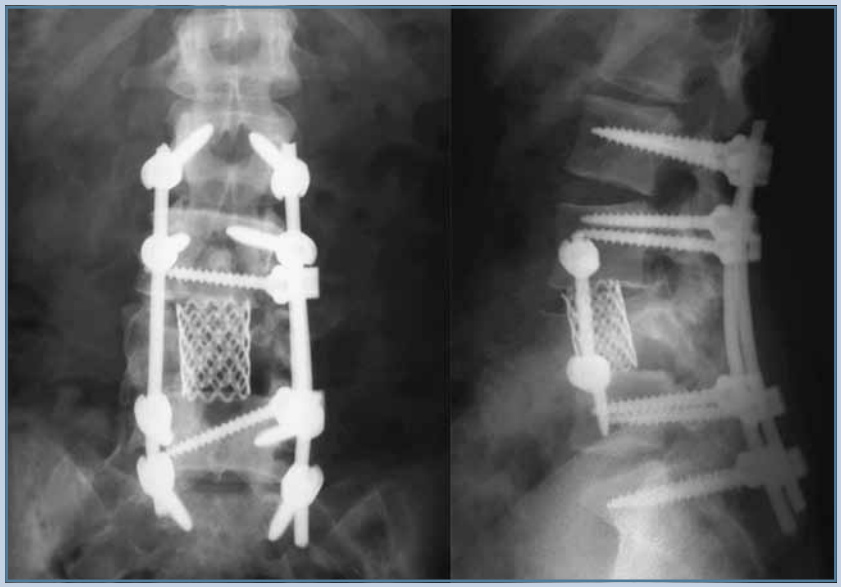

Fig. 3
Spondylograms of patient Sch. after the surgery in the clinic (see explanation in the text)

Clinical Example 2. Patient S., male, 16 years old, hospitalized in a clinic on December 1, 2008 with post-traumatic deformity of the spine at the T12–L1 level. According to his medical history, in July 2006 at the age of 14 years while on vacation he dropped from a height and sustained a VCSI: comminuted fracture of the L1 body, lower paraparesis with dysfunction of the pelvic organs. He was hospitalized in the neurosurgery department of the city hospital and underwent emergency decompressive T12–L2 laminectomy. He had been on bedrest for 2.5 months. Neurological complications of VCSI had regressed. He has been allowed to be active. He used corset for 6 months and underwent physical therapy to strengthen the muscles of the waist. Nevertheless, local kyphosis started to progress at the level of the post-laminectomic defect. At the time of the admission to the hospital on December 1, 2008, he complained of a constant feeling of tension in the muscles of the back in the lower thoracic and lumbar regions and periodically appearing lumbodynia. No signs of neurological deficits were found. Visually examination revealed a Gibbus deformity at T12–L2 (Fig. 4). According to the X-ray scans, the patient had post-laminectomic T12–L2 defect, wedge-shaped deformation of the T12 and L1 bodies with local kyphosis at this level of 48° (Fig. 5). On December 5, 2008 the patient underwent left thoracotomy, anterior autocorporodesis of T11–L1 with fixation using «Antares» ventral system («Medtronik»). Local kyphosis was corrected to 13°. There were no complications. The patient was allowed to be active on day 5 after the surgery and was discharged under the supervision of local trauma specialist. Despite incomplete correction of the deformity, the short-term outcome of the treatment was considered to be good.

In the process of dynamic observation it was noted that the patient continues to grow rapidly (at the time of surgery his height was 171 cm, at the control examination 4 months later, 174 cm, in 8 months, 177 cm, in 1 year, 179 cm). Simultaneously, progressive increase in kyphosis was detected at the

Fig. 4
The appearance of the patient S. at the time of the first appearance at the clinic in 2008

Fig. 5
Spondylograms of the patient S. at the time of the first appearance at the clinic in 2008

level of T11–L1 due to the continued growth of posterior elements of the vertebrae and the lack of growth of the anterior elements which were blocked by the ventral system (Fig. 6). By the end of the growth phase at 182 cm, the local kyphosis was 62°, after which the deformation has not progressed further (Fig. 7). The long-term outcome of the treatment was considered to be unsatisfactory. Since it was impossible to perform corrective surgery from the posterior access without removing the ventral system, on June 8, 2012 the patient underwent left thoracotomy, dismantling of the «Antares» ventral system, transverse osteotomy of the T12–L1 interbody bone block, and external transpedicular osteosynthesis along T9–L3. Gradual correction of the anatomic relationships at the level of the deformation had been performed for 14 days after the surgery. The kyphosis was eliminated (Fig. 8). The patient's height after the correction was 189 cm. At the next stage, on June 22, 2012, the patient underwent front T12–L1 corporodesis with container type implant with autologous bone, ventral metal fixation at the T12–L1 level with two CHM screws on one longitudinal bar, dismantling of the external transpedicular device; on June 30, 2012 the patent underwent additional stabilization of the spine along T10–L2 with a 7-screw CHM transpedicular system (Fig. 9). The patient was allowed to be active on day 4 after the operation. There were no complications. Good short- and long-term outcomes were achieved. Monitoring of the patient continues.

Accumulated experience in revision surgery for thoracic and lumbar spine injuries in later periods after the injury has shown that in most cases the normalization of anatomical relationships in the injured SMS is a complex task. This applies primarily to patients with major posttraumatic deformities with local kyphosis of more than 35° and with angular and translational displacements in different planes, which are consequences of type C damage according to Magerl. In such cases, external transpedicular osteosynthesis [1] is the least traumatic approach and we use it as presurgical stage.

Conclusion

Errors in the treatment of thoracic and lumbar spine injuries which result in the need for revision surgery include: use of deliberately inefficient methods of fixation of the injured SMS, no metal fixation, underestimation of the degree of destabilization of the injured SMS, the choice of inappropriate method of fixation for the injury sustained, incorrect execution of metal fixation of the spine, no corporodesis, fixation of the injured SMS with unfinished repositioning, unreported osteoporosis, failure to comply with the rehabilitation regime.

The proposed differentiated tactics of revision surgery in the treatment of injuries of the thoracic and lumbar spine allowed to reduce invasiveness and technical difficulty of revision surgery as well as to improve vertebral metric parameters of correction of injured spinal motion segments.

The preliminary stage of osteosynthesis of the spine with an external fixation device provides the least traumatic and most effective correction of the anatomic relationships in the deformed SMS, and allows almost complete normalization of the anatomical relationships in the injured section of the spine, regardless of the period of time since the injury and the degree of the original deformation.

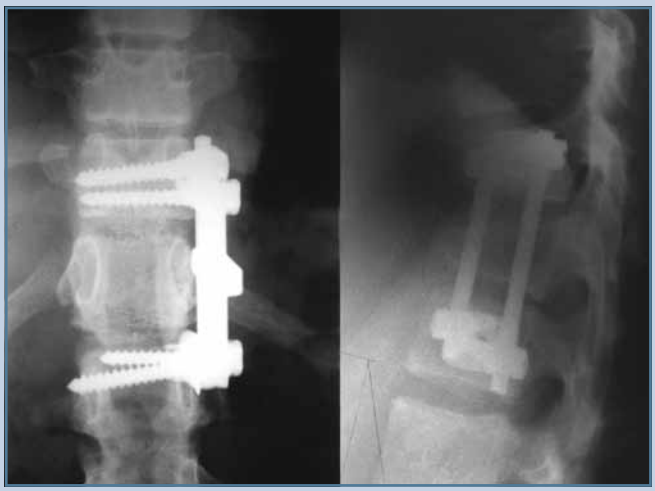

Fig. 6
Spondylograms of the patient S. after surgical correction and stabilization of the spine

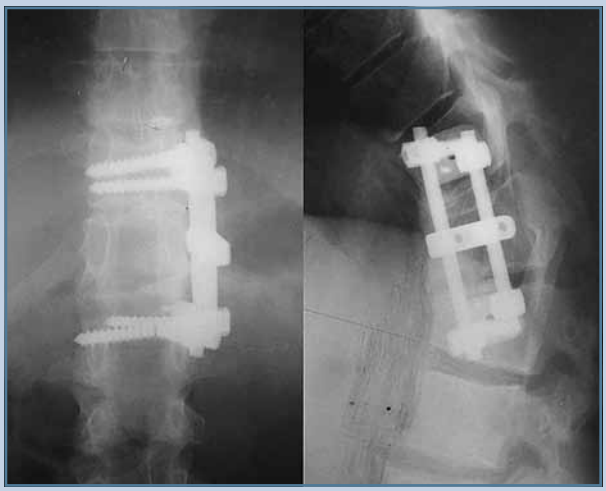

Fig. 7
Spondylograms of the patient S. by the end of growth phase (2012): a relapse of posttraumatic deformation at the level of T11–L1

Fig. 8
Spondylograms of the patient S. during the correction period for the post-traumatic deformity of the spine using external transpedicular device

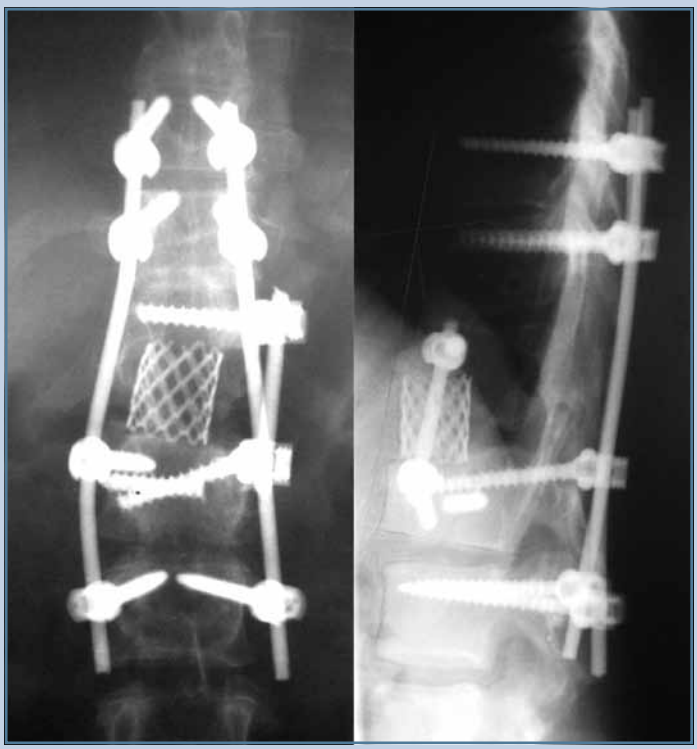

Fig. 9
Spondylograms of the patient S. after the conclusion of the surgical treatment at the clinic

References

1. **Afaunov AA, Polyukhovich EM, Afaunov AI, Mishagin AV, Vasilchenko PP.** Surgical treatment of posttraumatic deformities in the thoracic and lumbar spine. Hir Pozvonoc. 2007;(3):8–15. In Russian.
2. **Afaunov AA, Usikov VD, Afaunov AI, Mishagin AV, Takhmazian KK.** The experimental study of local strength of vertebral body bone tissue. Genii Ortopedii. 2007;(1): 30–34. In Russian.
3. **Vetrile ST, Kuleshov AA.** Surgical treatment for thoracic and lumbar spine fractures with modern technologies. Hir Pozvonoc. 2004;(3):33–39. In Russian.
4. **Vissarionov SV, Kokushin DN, Rerikh VV, Belyanchikov SM, Efremov AM.** Mistakes in diagnosis and surgical treatment of children with injuries of the spine and spinal cord. Hir Pozvonoc. 2014;(4):8–14. In Russian.
5. **Lavrukov AM, Tomilov AB.** Osteosynthesis by the System of External Fixation in Patients with Spinal Injuries and Diseases. Ekaterinburg, 2002. In Russian.
6. **Makarevich SV.** Spinal Fusion with Universal Fixation System for Thoracic and Lumbar Spine. Manual for Physicians. Minsk, 2001. In Russian.
7. **Rerikh VV, Borzykh KO.** Post-traumatic deformities of the thoracic and lumbar spine in patients in the late period of the spinal trauma after previously performed surgical interventions. Proceedings of the 6th Congress of Association of Spine Surgeons "Vertebrology in Russia: Prospects, Problems and Ways of Solution". Krasnodar, 2015. Vol. 1. P. 207–212. In Russian.
8. **Tyulkin ON, Davydov EA, Bersnev VP, Nazarov AS.** Analysis of the causes of repeated surgical procedures for diseases and injuries of the spine. Proceedings of the 6th Congress of Association of Spine Surgeons "Vertebrology in Russia: Prospects, Problems and Ways of Solution". Krasnodar, 2015. Vol. 1. P. 105–108. In Russian.
9. **Ulrikh EV, Mushkin AYu.** Vertebrology in Terms, Figures, and Drawings. St. Petersburg, 2005. In Russian.
10. **Usikov VV, Usikov VD.** Errors and complications of internal transpedicular osteosynthesis in the treatment of patients with unstable injuries of spinal column, their prevention and treatment. Traumatology and Orthopedics of Russia, 2006;(1):51–57. In Russian.

Address correspondence to:
Afaunov Asker Alievich
Zakharova str., 29, ap. 10, Krasnodar, 350007, Russia,
afaunovkr@mail.ru

Asker Alievich Afaunov, MD, DMSc; Igor Vadimovich Basankin, MD, PhD; Aleksandr Veniaminovich Kuzmenko, MD; Karapet Karapetovich Takhmazyan, MD, Kuban State Medical University, Regional Clinical Hospital No. 1 n.a. Prof. S.V. Ochapovsky, Krasnodar; Aleksey Viktorovich Mishagin, MD, Regional Clinical Hospital No. 1 n.a. Prof. S.V. Ochapovsky, Krasnodar, Russia.