RESULTS OF MULTISTAGE SURGICAL TREATMENT OF SCOLIOSIS IN THE FIRST DECADE OF LIFE USING VEPTR INSTRUMENTATION

M.V. Mikhaylovskiy[1], V.A. Suzdalov[1], D.N. Dolotin[1], T.N. Sadovaya[2]
[1]Novosibirsk Research Institute of Traumatology and Orthopaedics n.a. Ya.L. Tsivyan, Novosibirsk, Russia
[2]ANO «Klinika NIITO», Novosibirsk, Russia

Objective. To analyze results of final surgical treatment for scoliosis in the first decade of life.
Material and Methods. In 2008—2016, a total of 95 patients with infantile and juvenile scoliosis were operated on using VEPTR instrumentation. The final stage of surgical treatment was performed in 14 patients (9 girls, 5 boys). The average age at the start of treatment was 5.4 ± 2.1 years, average follow-up period — 2 years (6—36 months).
Results. Average value of the primary scoliotic curve before surgery was 83.0° ± 14.8°, thoracic kyphosis 41.1° ± 11.9°, lumbar lordosis 49.5° ± 4.9°. At the last follow-up average value of the primary scoliotic curve was reduced to 56.8° ± 14.1°, thoracic kyphosis to 24.5° ± 8.5°, lumbar lordosis to 38.4° ± 5.1° ($p < 0.05$). Space available for lung before surgery was 84.5 ± 8.7 %, after surgery 94.8 ± 6.7 %, at the last follow-up it increased to 98.6 ± 5.4 %. Complications included 9 cases of instability of implant anchors and 1 case of suppuration. There were no neurological complications.
Conclusion. Stage correction using different instrumentations is a method of choice for surgical treatment of infantile and juvenile scoliosis.
Key Words: infantile scoliosis, VEPTR, stage correction.

Please cite this paper as: *Mikhaylovskiy MV, Suzdalov VA, Dolotin DN, Sadovaya TN. Results of multistage surgical treatment of scoliosis in the first decade of life using VEPTR instrumentation. Hir. Pozvonoc. 2017; 14(3):8—14. In Russian.*
DOI: http://dx.doi.org/10.14531/ss2017.3.8-14.

This paper continues in part the previously published review on the modern surgical methods to treat scoliosis in the first decade of life [1, 2].

The long-term assessment of surgical outcomes and quality of life of patients with scoliotic spinal deformities has traditionally permitted one to choose the most appropriate method of treatment. Optimal correction and stabilization of spinal deformity is the primary goal in adolescent scoliosis. In children who are actively growing it is necessary to prepare the spine for the final stage of treatment and allow growth while controlling the growth process. Spinal stabilization is not an optimal option, as it can limit further spine growth and lead to thoracic insufficiency syndrome [3, 8, 9]. Posterior fusion can cause uncontrollable progression of spinal deformity and make curve correction in adolescence impossible. Several techniques have been recently focused on the solution of these issues. The main techniques include VEPTR, growing rods technique, the Shilla technique, vertebral stapling, and vertebral tethering [10]. The variety of techniques enables one to identify in more detail the indications for surgical treatment, and most importantly, to start the treatment in time as early as at the child's age of 6–12 months. The final stage of treatment involves using posterior segmental instrumentation and removal of the inserted growing implant.

The purpose of the study is to analyze the outcomes of the final surgical treatment of scoliosis in the first decade of life.

Material and Methods

In 2008–2016, a total of 95 patients with infantile and juvenile spinal deformities of various etiologies were operated on using the VEPTR technique at the Clinic of Children and Adolescent Spine Surgery of Novosibirsk Research Institute of Traumatology and Orthopaedics n.a. Ya.L. Tsivyan. The final stage of surgical treatment was performed in 14 patients.

The inclusion criteria for study groups according to generally accepted indications for surgical treatment were age before 10 years, progressive scoliotic curve of various etiologies, and a Cobb magnitude of more than 40°.

The disease was diagnosed before 3 years of age. The VEPTR device when choosing the posterior segmental instrumentation is indicated for: 1 – above 6 months of age; 2 – the prevention of thoracic insufficiency syndrome; 3 – congenital constrictive deformity of the thorax; 4 – massive concave rib fusions with progressive thoracic scoliosis without vertebral abnormality; 5 – progressive thoracogenic, neurogenic, and idiopathic scoliosis; 6 – hypoplastic thorax syndromes (Jeune syndrome, Jarcho–Levin syndrome); 7 – progressive spinal deformities without rib abnormality in chil-

dren. The distribution according to etiologies was as follows: 5 – idiopathic juvenile scoliosis, 2 – congenital scoliosis, 3 – Jarcho–Levin syndromes, 4 – syndromic scoliosis (1 – type 1 neurofibromatosis, 1 – Larsen syndrome, 1 – Kartagener's syndrome, 1 – Russell–Silver syndrome). There were 9 girls and 5 boys among the patients. Thoracic scoliotic deformities mostly dominated. The average age at the start of treatment was 5.4 ± 2.1 years.

Staged surgical correction was performed with intervals of 8–12 months. The average number of stages for a child was 6. The final stage was performed using segmental instrumentation with hybrid fixation. After surgery, vertical postural adaptation was started approximately on the 3–5th day. External immobilization was not performed. The patients were discharged from the hospital on the 10–11th day. The average postoperative follow-up period was 2 years (6–36 months). Statistical processing of the results was performed using the Microsoft Excel and Statistica 6.0 software. A preliminary assessment shows that the original data follow the normal distribution. A p value <0.05 was considered statistically significant.

Results and Discussion

According to the Scoliosis Research Society (SRS) Consensus Statement published in 2015, Early Onset Scolioses (EOS) include deformities revealed before the age of 10. This group includes both infantile and juvenile scoliosis of different etiologies (idiopathic, congenital, neuromuscular, and syndromic). The choice of surgical treatment method depends on more than a dozen of factors; the most significant factors are age, gender, etiology and severity of deformity, the rate of curve progression, bone tissue maturity, and the severity of comorbid pathology [4, 5, 6, 7, 11]. The total number of performed surgeries in 14 patients using the VEPTR instrumentation was 78, including the primary and staged corrections. The following configurations were used: rib – spine, rib – rib, and rib – pelvis. The time of the primary correction was 96.0 ± 8.1 min, blood loss was 15.4 ± 2.5 ml, and the magnitude of distraction was within 3–4 cm. The time of a staged correction was 15.2 ± 3.4 min, the mean blood loss per a stage was 7.2 ± 2.2 ml, and the magnitude of distraction was within 1.5–2 cm.

At the final stage, two patients underwent an anterior surgical stage (discectomy, interbody fusion), intraoperative skeletal skull-leg traction was additionally used in all patients. The length of an anterior surgical stage was approximately 54.3 ± 12.1 min, blood loss was no more than 67.4 ± 9.8 ml, and the length of spinal fusion included 3–4 segments. The operative time at posterior surgical stage was approximately 112.4 ± 16.1 min, blood loss was no more than 195.4 ± 14.2 ml, and the length of the fusion included 10–13 segments.

The dynamics of the main magnitudes characterizing the deformity is presented in Table.

The changes in the trunk balance (the reduction of pelvis obliquity and frontal imbalance) are favorable prognostic criteria in curve progression associated with malignant tumors. The magnitudes of kyphosis and lordosis retain within the physiological norm (their changes are associated with the adaptation of the instrumented spine to vertical loads). At the last follow-up, a noticeable correction of the primary scoliotic curve and its stabilization were achieved (Figs. 1–4).

As known, malignant progression of spinal deformity and the thorax in children can aggravate impaired lung function and lead to thoracic insufficiency syndrome. When using VEPTR technique, the space available for lung was 84.5 ± 8.7 preoperatively, it increased to 94.8 ± 6.7 postoperatively, and it was 98.6 ± 5.4 at the last follow-up.

Most complications in children who undergo an early surgical treatment of spinal deformities are mechanical complications (instrumentation fractures, instability of implant anchors). These complications were observed in 9 patients (a total of 16 cases) when using VEPTR instrumentation and required a

Table
Dynamics of main parameters of spinal deformity

Parameter	Preoperative	Postoperative	Before the final stage	After the final stage	In 24 months postoperative
Pelvic obliquity, degrees	8.67 ± 5.20	4.30 ± 2.20	4.20 ± 1.90	3.30 ± 2.20	4.40 ± 2.70
Frontal imbalance, mm	38.20 ± 12.50	24.00 ± 18.40	32.30 ± 17.40	32.00 ± 9.60	18.00 ± 4.70
Primary curve, degrees	83.00 ± 14.80	59.90 ± 10.00 (Correction 27.9 %)	73.80 ± 11.60 (Progression 11.1 %)	54.80 ± 11.10 (Correction 25.8 %)	56.80 ± 14.10 (Progression 2.7 %)
Kyphosis, degrees	41.10 ± 11.90	35.60 ± 10.40 (Correction 13.4 %)	60.5 ± 10.6 (прогрессирование 32.0 %)	34.00 ± 9.30 (Correction 43.8 %)	24.50 ± 8.50 (Correction 59.5 %)
Lordosis, degrees	49.50 ± 4.90	48.60 ± 9.00 (Correction 1.9 %)	41.30 ± 13.40 (Correction 16.6 %)	45.50 ± 8.50 (Correction 9.9 %)	38.40 ± 5.10 (Correction 6.6 %)

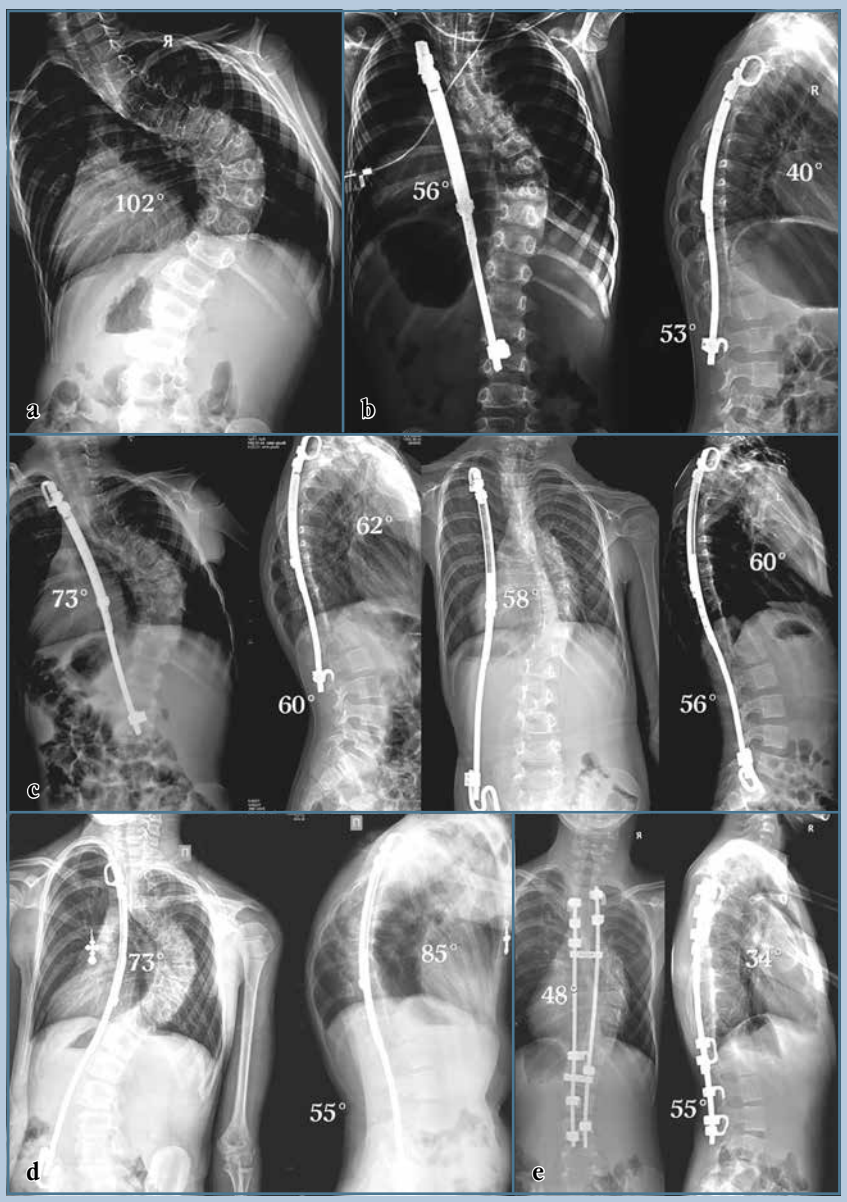

Fig. 1
The outcomes of surgical treatment of a patient aged 8 with spinal deformity associated with the Russell – Silver syndrome: **a** – before surgery; **b** – after correction using the VEPTR instrumentation; **c** – stages of treatment; **d** – before the final stage of treatment; **e** – after the final stage of treatment using segmental instrumentation

routine instrumentation re-implantation simultaneously with a staged distraction without the loss of the achieved correction. Intraoperative liquorrhea occurred in 3 patients with syndromic scoliosis at the final stage. Complications appeared because of a rapid bone thinning at posterior portions of instrumented vertebrae. Lumbar drainage was performed to treat liquorrhea. Suppuration was noted twice in the same case. This patient after the 4th stage of correction with VEPTR instrumentation, which was removed, underwent the final stage of surgical treatment in 1 year using segmental instrumentation. After another 12 months, deep suppuration was observed requiring the removal of instrumentation. There were no neurological complications.

Conclusion

Treatment of early onset scoliosis in children is one of the main challenges of modern vertebrology. Currently, there is no gold standard in conservative or surgical treatment. Conservative treatment is commonly ineffective, but surgical interventions on the anterior and posterior spine departments can cause restriction of growth of the spine, can lead to uncontrolled curve progression and reduction of spaces available for lungs. Since 2000, new methods of surgical treatment have been actively implemented using various multi-point endocorrectors with the possibility of staged distractions. The diversity of techniques gives the chance to identify in more detail the indications for surgical treatment and to conduct early effective surgical treatment. The VEPTR instrumentation for staged surgical treatment of children with scoliosis in the first decade of life allows conducting effective final surgical correction in adolescence.

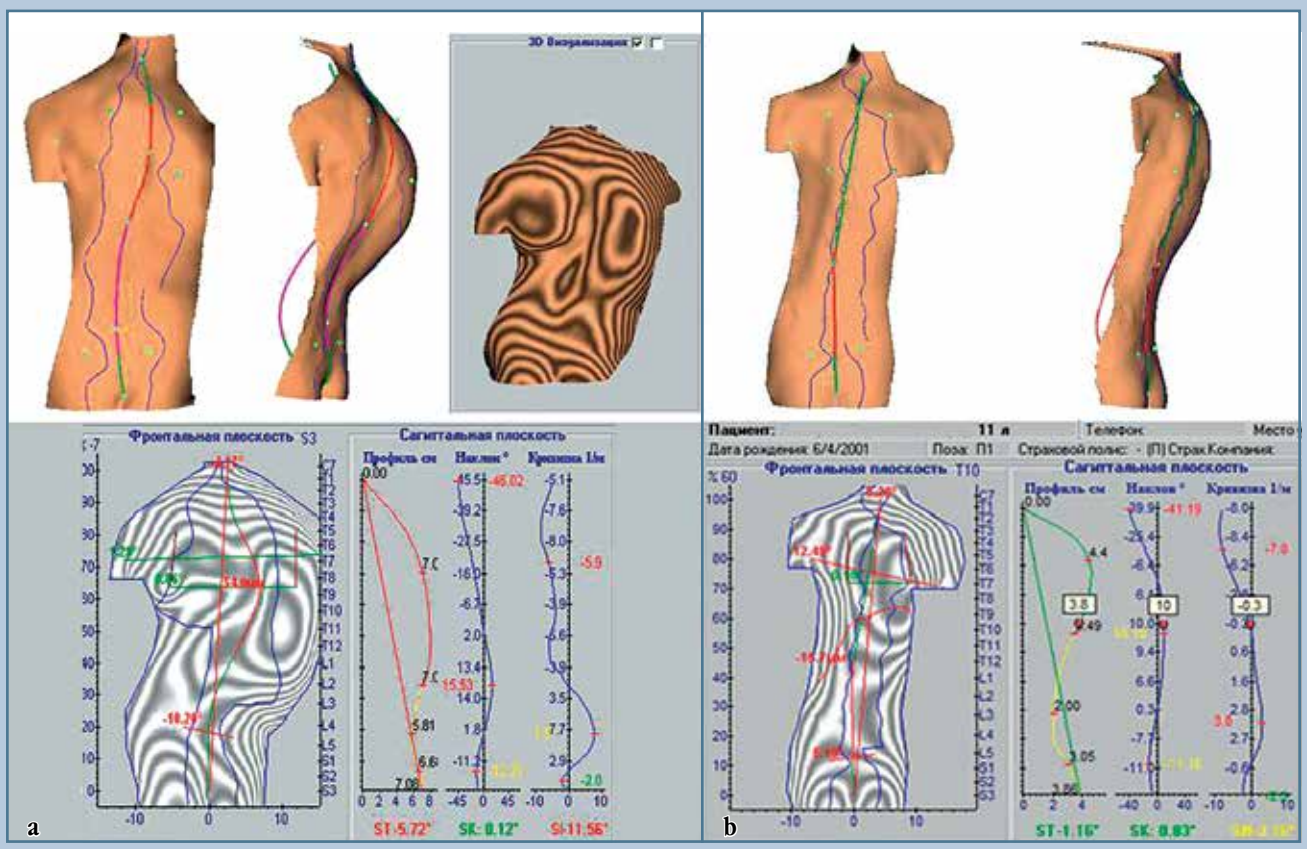

Fig. 2
The outcomes of surgical treatment of a patient aged 4 with spinal deformity associated with the Russell – Silver syndrome according to computed optical tomography data: **a** – before surgical treatment; **b** – after surgical treatment

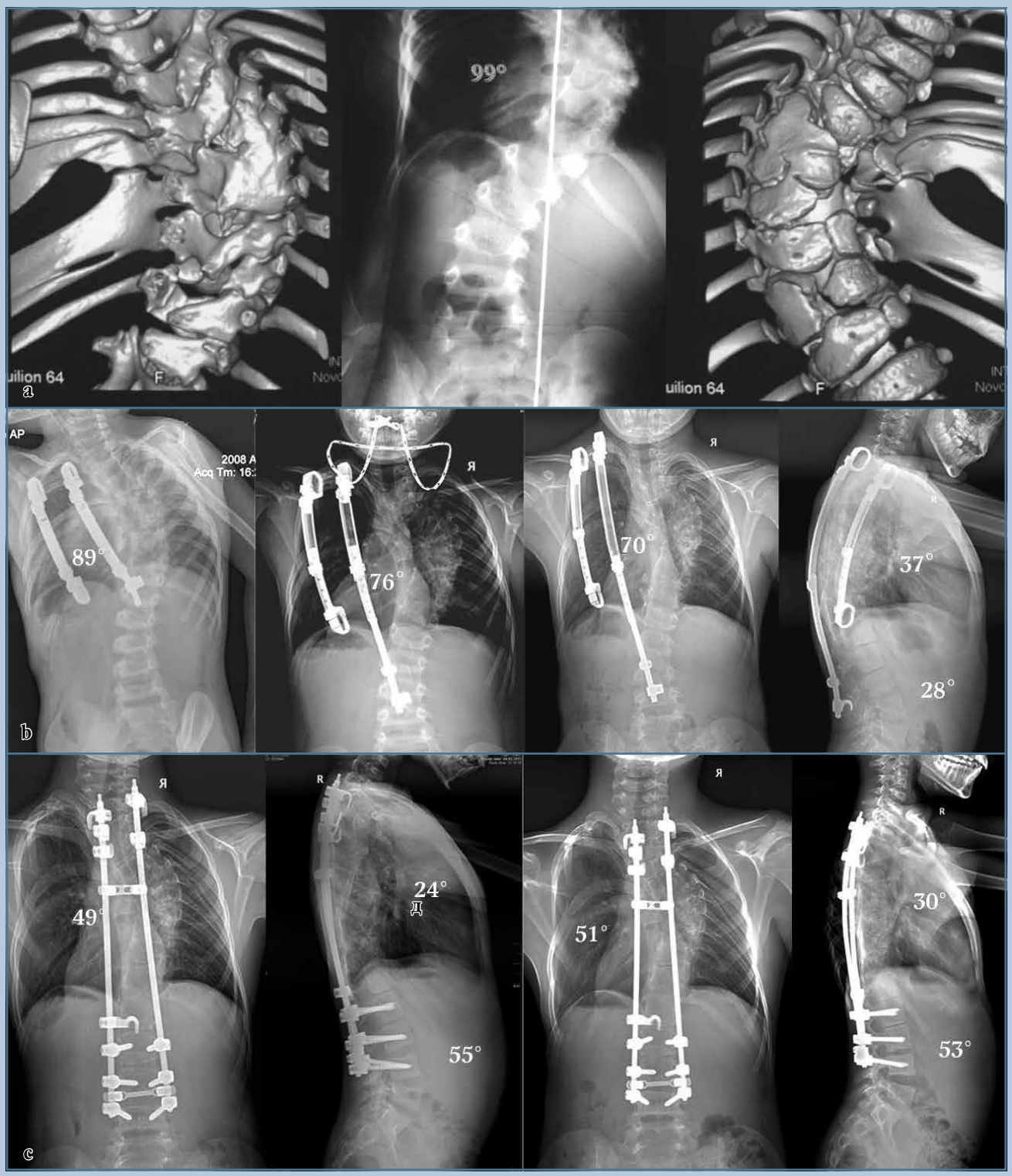

Fig. 3
The outcomes of surgical treatment of a patient with spinal deformity associated with the Jarcho–Levin syndrome: **a** – preoperatively; **b** – after correction with the VEPTR instrumentation; **c** – 3 years after the final stage of treatment using segmental instrumentation

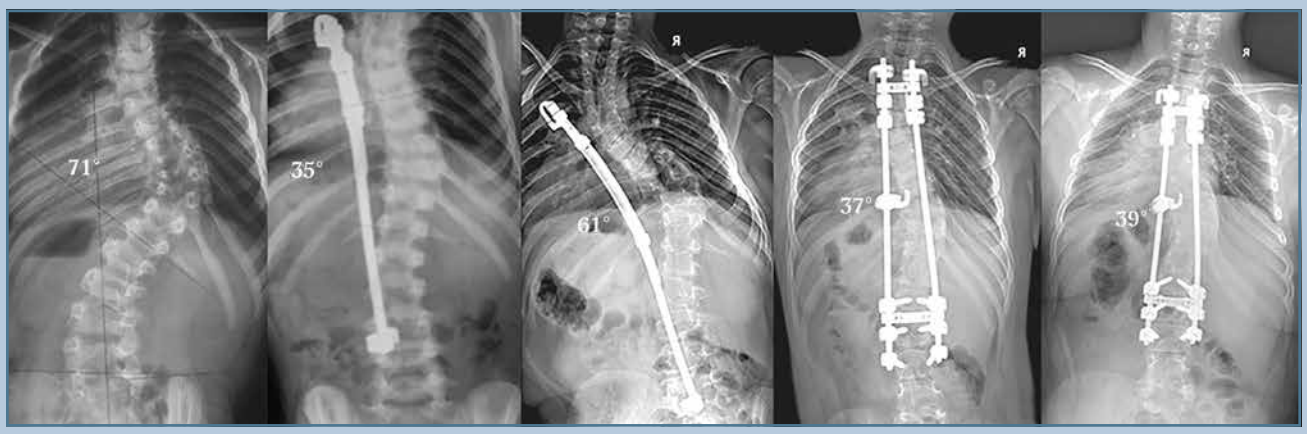

Fig. 4
The outcomes of surgical treatment of a patient aged 7 with idiopathic malignantly progressing scoliosis using the VEPTR and NITEK instrumentation: stages of treatment and 3 years after surgical treatment

This study is not a sponsored project. The authors declare that they have no conflict of interests.

References

1. **Mikhaylovskiy MV, Suzdalov VA.** Surgical treatment of patients with scoliosis in the 1st decade of life: a literature review. Hir. Pozvonoc. 2016;(2):36–44. In Russian. DOI: http://dx.doi.org/10.14531/ss2016.2.36-44.
2. **Mikhaylovskiy MV, Suzdalov VA., Sadovoy MA.** Surgical treatment of patients with scoliosis of the first decade of life: literature review. Hir. Pozvonoc. 2016;(3):32–40. In Russian. DOI: http://dx.doi.org/10.14531/ss2016.3.32-40.
3. **Mikhaylovskiy MV, Ulrikh EV, Suzdalov VA, Dolotin DN, Ryabykh SO, Lebedeva MN.** VEPTR instrumentation in the surgery for infantile and juvenile scoliosis: first experience in Russia. Hir. Pozvonoc. 2010;(3):31–41. In Russian. DOI: http://dx.doi.org/10.14531/ss2010.3.31-41.
4. **Ulrikh EV.** Abnormalities of the Spine in Children. St. Petersburg, 1995. In Russian.
5. **Ulrikh EV, Mushkin AYu**. Surgical Treatment of Malformations of the Spine in Children. St. Petersburg, 2007. In Russian.
6. **Ulrikh EV, Ryabykh SO.** Results of compensating spine fusion in children with spine deformities associated with vertebral segmentation disorder of the thoracic spine. Hir. Pozvonoc. 2009;(4):8–14. In Russian. DOI: http://dx.doi.org/10.14531/ss2009.4.8-14.
7. **Ulrikh EV, Tsvetkova GV.** Corrective surgery for scoliogenic disorders of vertebral segmentation in children. In: Topical Issues of Modern Pediatric Surgery. Novosibirsk, 1988. In Russian.
8. **Berdan EA, Larson AN, Hess DJ, Acton RD, Ledonio CG, Seidel FG, Polly DW, Saltzman DA.** Double crush to the thorax: kyphoscoliosis and pectus excavatum. AAP National Conference and Exhibition, New Orleans 20.10.2012. Section on Surgery – poster session with oral presentations. Electronic resource. URL: https://aap.confex.com/aap/2012/webprogram/Paper16241.html.
9. **Campbell RM Jr, Smith MD, Mayes TC, Mangos JA, Willey-Courand DB, Kose N, Pinero RF, Alder ME, Duong HL, Surber JL.** The characteristics of thoracic insufficiency syndrome associated with fused ribs and congenital scoliosis. J Bone Joint Surg Am. 2003;85:399–408.
10. **Hershman SH, Park JJ, Lonner BS.** Fusionless surgery for scoliosis. Bull Hosp Jt Dis. 2013;71:49-53.
11. **McCalla JD, Williams BA, Matsumoto H, Akbarnia BA, Blakemore LC, Betz RR, Flynn JM, Johnston CE, McCarthy R, Roye DP, Skaggs DL, Smith JT, Snyder BD, Sponseller PD, Sturm PF, Thompson GH, Yazici M, Vitale MG.** Introducing the early onset scoliosis classification system. AAP National Conference and Exhibition, New Orleans, October 20–21, 2012.

Address correspondence to:
Mikhaylovskiy Mikhail Vitalyevich
NNIITO, Frunze str., 17,
Novosibirsk, 630091, Russia,
MMihailovsky@niito.ru

Received 10.04.2017
Review completed 09.06.2017
Passed for printing 14.06.2017

Mikhail Vitalievich Mikhaylovskiy, DMSc, Prof., Head of Department of Children and Adolescent Spine Surgery, Novosibirsk Research Institute of Traumatology and Orthopaedics n.a. Ya.L.Tsivyan, Novosibirsk, Russia, MMihailovsky@niito.ru;
Vasily Aleksandrovich Suzdalov, MD, PhD, traumatologist-orthopaedist in the Department of Children and Adolescent Spine Surgery, Novosibirsk Research Institute of Traumatology and Orthopaedics n.a. Ya.L. Tsivyan, Novosibirsk, Russia, niito@niito.ru;
Denis Nikolayevich Dolotin, MD, traumatologist-orthopaedist, Novosibirsk Research Institute of Traumatology and Orthopaedics n.a. Ya.L. Tsivyan, Novosibirsk, Russia, d.dolotin@mail.ru;
Tatyana Nikiforovna Sadovaya, MD, DMSc, traumatologist-orthopaedist, pediatric orthopedic centre, ANO «Klinika NIITO», Novosibirsk, Russia, niito@niito.ru.