# EFFICIENCY OF REPEATED CORRECTIVE SURGERY IN PATIENTS WITH SPINAL DEFORMITIES: ANALYSIS OF THE IMMEDIATE RESULTS OF A MONOCENTER COHORT AND A BRIEF REVIEW OF THE LITERATURE

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**Objective.** To analyze the results of repeated corrective surgery in patients with spinal deformities of various etiologies.
**Material and Methods.** The study group included 87 patients (mean age is 22.8 years, m : f = 10 : 77) who underwent repeated deformity correction using third-generation instrumentation (CDI and its analogues), and were selected from 144 patients previously operated on for spinal deformities of various etiologies using different types of spinal instrumentation. The magnitude of scoliotic deformity, thoracic kyphosis, lumbar lordosis, rotation of the apical vertebra, the volume of intraoperative blood loss, and the duration of the operation were assessed. All patients answered the questions of the SRS-24 questionnaire at the stages of treatment and postoperative follow-up, and were also examined by computer optical topography method.
**Results.** Out of 87 reoperated patients, 74 had idiopathic scoliosis. In 31 patients, the results were evaluated within a period of at least 2 years (average 61.8 months). As a result of the intervention, the primary curve was corrected by 29.1° (36.5 %). Loss of correction was 4.6° ($p < 0.001$), derotation of the apical vertebra – from 34.9° to 22.1° ($p < 0.001$) and loss of correction – 0.8°. The average blood loss varied from 810 to 1138 ml, and the operation time – from 187 to 289 min. Computer optical topography data convincingly confirmed the corrective effect achieved during the repeated intervention. According to the questionnaire (SRS-24), satisfaction with the results of the operation was quite high.
**Conclusion.** Repeated corrective interventions in patients with spinal deformities of various etiologies, even in long-term periods, can partially restore the lost primary correction and improve the quality of life of patients, which is confirmed by clinical and radiographic data, the results of computer optical topography and the SRS-24 questionnaire.
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Surgical correction of spinal deformities is a major problem in modern spinal surgery. The more advanced the procedure, the greater the risk of major complications. One of the unwanted consequences of corrective surgery in patients with spinal deformities is the required removal of the endocorrector due to suppuration, or remounting of the system due to fracture or displacement, progression of spinal deformity with decompensation of the global body balance, persistent pain, emergence of surgical hardware with the threat of perforation of the skin, or the development of severe neurological symptoms [1–4]. Many complications arise early after surgery, when the bone block has not yet developed throughout the fusion area, resulting in a considerable loss of the correction achieved during the procedure [5–8]. Such circumstances always confront the issue of repeated corrective treatment, considering medical recommendations and the patient's and his entourage's expectations. Undoubtedly, in this case, all participants in the treatment process (the patient, his relatives, and the surgeon) are concerned about the effectiveness of the repeated surgery and, thus, its appropriateness. We failed to find studies devoted to this issue in foreign literature. When it comes to Russian literature, only S.V. Kolesov et al. [9] have dedicated a study to a series of patients surgically treated with the LSZ two-plate endocorrector. Considering the issue to be topical, we have conducted this study.

The objective is to analyze the results of repeated corrective surgery in patients with spinal deformities of various etiologies.

Design: a retrospective monocentric descriptive study with an analysis of treatment strategies, immediate outcomes, and the structure of complications.

## Material and Methods

*Patients*

A total of 144 patients who had undergone procedures earlier in various surgical centers in Russia for spinal deformities of various etiologies, including 8 in our center, were admitted to the hospital from 1998 to 2020. In each case, the issue of repeated correction was decided based on the findings of a detailed clinical and radiological examination and the requests of the patient and his family members.

Inclusion criteria:

1) repeated surgery for deformity correction using third-generation instrumentation (CDI and its analogues);

2) the follow-up period after repeated corrective surgery should be at least two years.

Exclusion criteria: repeated surgery of removal of the endocorrector and/or resection of the rib hump.

Fifty seven patients with fully developed bone blocks were eliminated from the study based on these criteria. Repeated correction was unpromising and dangerous in these patients, or they refused to repeat corrective surgery and insisted exclusively on removing the endocorrector that caused discomfort.

Therefore, the final group of the study included 87 patients aged 15 to 39 years (average age: 22.8 years), including 10 men and 77 women who underwent repeated correction of deformity using the third-generation instrumentation (CDI and its analogues).

*Techniques*

An orthopedist, a neurologist, and other highly specialized physicians examined all patients (according to indications). The X-ray examination included plain-film X-rays of the thoracic and lumbar spine in the patient's standing position and functional X-rays in the lateral tilt position (if the patient was admitted to the hospital after the removal of the first endocorrector). The magnitude of scoliotic deformity (primary and secondary scoliotic curves, thoracic kyphosis, and lumbar lordosis) was defined by the Cobb technique, and the apical vertebral rotation (AVR) of the primary curve was determined by the formula of Sullivan et al. [10]:

AVR = 0.26 × (thoracic kyphosis in Cobb degrees) + 0.34 × (primary curve in Cobb degrees) - 5.38.

In all cases, the intraoperative blood loss volume (ml) and the surgery duration (min) were assessed for each type of surgical intervention (deformity correction, removal of the endocorrector + deformity correction, interbody fusion + deformity correction). The patients answered the questions of the SRS-24 questionnaire [11] at the stages of treatment and postoperative follow-up and were examined by computer optical topography (COMOT) for the evaluation of the back surface topography of the trunk in the pre- and postoperative periods [12].

*Statistical analysis*

Continuous indicators of the surgery duration, blood loss, and magnitude of the curvature were checked for the normality of distributions by the Shapiro – Wilk test. The homogeneity of the deviations of the indicators in the compared groups was examined by Fisher's F-test. Due to the lack of indicators in groups satisfying the condition of validity of the parametric Student's t-test, continuous indicators were compared using nonparametric rank criteria. The Mann – Whitney U test was applied to compare the surgery duration and blood loss between the groups, and the Wilcoxon signed-rank test was used to compare the dynamics of Cobb angles of primary curvatures.

Descriptive statistics for continuous data are shown in the form of the median [first quartile; third quartile] (MED [Q1; Q3]) and minimum or maximum values. The magnitude of the effect (in the table, in the «difference» column) was assessed by calculating the pseudomedian of pairwise differences and the standardized mean between the groups with the construction of 95 % confidence intervals (95 % CI). The correction of multiple comparisons was conducted by the Benjamini-Hochberg procedure.

Statistical hypotheses were verified at a critical significance value of 0.05, which means that the difference was considered statistically significant at the achieved value of $p < 0.05$.

All statistical calculations were performed in the RStudio software (version 1.3.959 – © 2009–2022 RStudio, Inc., USA, URL: https://www.rstudio.com) in R (version 4.0.2; URL: https://www.R-project.org).

## Results

All of 87 patients underwent deformity correction with third-generation instrumentation (CDI and its analogues). The average age of patients was 22.8 (7.6–45.8); there were 10 men and 77 women. According to the etiology of spinal deformities, they were divided as follows: idiopathic scoliosis – 76 patients; congenital deformities – 8 patients; scoliosis due to neurofibromatosis type 1 – 2 patients; and Ehlers-Danlos syndrome – 1 patient. Initially, patients were surgically treated using various types of spinal instrumentation: the Harrington distractor (31), Medilar, LZS (27), Rodnyansky – Gupalov endocorrector (11), the external transpedicular fixation device of the Russian Ilizarov Scientific Center for Restorative Traumatology and Orthopaedics (4), CDI and its analogues (3), and the Drummond and BelCD instrumentation (1 for each). Two patients underwent posterior fusion; it was not possible to determine the type of instrumentation used in 7 cases; 15 patients underwent multiple surgeries (a maximum of 12 procedures).

In 29 patients, the endocorrector was removed before admission to our clinic due to inefficiency or complications; in eight cases, it was associated with infectious complications.

The date of the first procedure was established in 69 cases, and the average period between it and the final stage was 9.5 (1; 34) years.

Examination by a neurologist has revealed the following pathological conditions developed after previously performed surgeries: pyramidal insufficiency in five cases (one of them only during the traction test); spinal cord myelopathy in the thoracic spine with lower paraparesis – 2 cases; L5 root compression, thoracalgia and lumbodynia – 1 case for each. Indications for repeated deformity correction in our hospital were the failure of the surgical hardware (35), postoperative progression of deformity (27), residual deformity (16), and pain syndrome (9).

The outcomes of the repeated corrective procedure (immediate and long-term) are given in Table 1.

The analysis of the table data reveals that the primary curve was corrected by 29.1° (by 36.5 % of its initial value) as a result of repeated corrective interventions. The postoperative loss of correction, in turn, amounted to 4.6° (15.8 % of the corrective effect achieved during the procedure). Both changes are significant ($p < 0.001$). The dynamics of apical vertebral rotation is slightly different from the one described above: if its correction is highly significant (from 34.9° to 22.1°; $p < 0.001$), then the loss of correction is minimal (0.8°; $p = 0.043$).

Quite similar outcomes were obtained with respect to counter-curvature: correction by 15° (30.2 % of the initial value), loss of correction of 2° (13.3 % of the achieved effect). The indicators of the vertebral column in the sagittal plane showed trends typical for scoliosis surgery: smoothing of thoracic kyphosis and lumbar lordosis in the immediate postoperative period and strengthening in the long-term postoperative period. Meanwhile, the average indicators of thoracic kyphosis and lumbar lordosis practically did not extend beyond the anatomical standard.

Considering the inevitable problems arising during repeated surgeries (cicatrical tissue overgrowth, spontaneous bone block formation, peculiarities of the implants being removed), we found it crucial to analyze the blood loss volume and the surgery duration depending on the volume of the required procedures (Table 2). In cases where the primarily implanted endocorrector was removed prior to admission to our hospital, either a one-stage correction (type I) or a two-stage procedure – anterior release plus deformity correction (type II) – was performed. Type III included removal of the implant and repeated corrective surgery. Calculations have shown that a significant difference in the blood loss volume ($p = 0.005$) exists only between surgery types I and III. In other cases, it is absent: types I and II ($p = 0.143$), types II and III ($p = 0.426$). As for the surgery duration, significant differences were found only between surgery types I and II ($p = 0.001$); no significant differences were found between types I and III ($p = 0.283$) or types II and III ($p = 0.105$).

*Complications.* There were 20 complications that developed after revision surgery. The most frequent (11) were complications associated with implants: 5 cases of hook displacement, 5 rod fractures, and 1 screw disconnection. Neurological complications are on the second place: pyramidal insufficiency (with complete recovery), S1 root irritation, brachialgia, and an intraoperative liquorrhea. All complications were stopped without consequences. Speaking of other complications, there were 2 cases of late suppuration, post-injection infiltration, subcutaneous hematoma, and the tube tear-off during removal of thoracic drainage. In terms of implant-related complications, the metal structure had to be remounted in four cases. In both cases of late suppuration (23 and 37 months), the endocorrector was removed, and the presence of a bone block in the area of fusion was determined. In the case of tear-off of the drainage tube, a minithoracotomy was performed as well as the removal of a fragment of the drainage.

The study of the quality of life of patients after surgery, conducted using the SRS-24 questionnaire, gave the results shown in Table 3. In almost all domains, the outcome remained at the preoperative level or slightly improved (statistically unreliable). The overall outcome was reliably the best. It is worth noting that this result tended to increase in the postoperative period (from 79.57 ± 8.50 points to 82.32 ± 11.63 points).

The back topography of the trunk was examined using the COMOT technique. Not having the number of studies sufficient for statistical processing, we consider it advisable to present one of the clinical cases demonstrating the possibilities of repeated corrective surgery (Fig. 1).

*Clinical case.* Patient B., female, born in 1977, suffered from idiopathic right-sided thoracic kyphoscoliosis in 1989–1994. She underwent multi-stage surgical treatment using a Harrington-type distractor in a hospital in one of the Siberian cities. In 2002, at the age of 25, the patient applied to our hospital with complaints of a gross deformity of the spine. The Harrington-type distractor was removed on November 18, 2002. The patient underwent a three-stage surgical intervention (discectomy and interbody fusion, skeletal traction through the bones of the cranial vault, and spinal deformity correction using CDI) on October 23, 2003. The Cobb angle of the thoracic curve before surgery was 93°, immediately after surgery – 56°, 3 years after – 63°.

The main topographic parameters measured before the surgery, after it, and 3 years after the procedure are given in Table 4.

Before surgery and 3 years after it, the PTI (Posterior Trunk Index) has the same value (2.9), which is caused by multidirectional changes: deterioration in the frontal (2.1 and 2.6) and sagittal (1.2 and 1.4) planes, and improvement in the horizontal (4.4 and 3.9). The change in the trunk balance in three planes (frontal, sagittal, and horizontal) shows a typical picture of postoperative course: the maximum change (usually in the direction of improvement) immediately after surgery and a certain loss of correction towards the preoperative condition.

## Discussion

Repeated surgeries in patients with spinal deformities of various etiologies are not uncommon. According to numerous studies [2, 4, 8, 13–20], the frequency of repeated surgeries (removal or replacement of the endocorrector) varies from 4.8 to 25.8 %. In one of these papers [19], it was remarked that with the increment of the post-op period, the number of repeated surgeries increases – from 13 to 20 %. Generally, the average time of removal or replacement of the endocorrector varies within comparatively restricted limits – from 2.4 to 5.7 years [4, 6–8, 15, 16, 18]. The loss of the correction achieved during the primary surgery is almost unavoidable and can be complete or partial, ranging from 7–9° to 20° or more [4, 6–8]. One of

**Table 1**

Dynamics of the main parameters of spinal deformity before and after reimplantation of the endocorrector

| Parameters | Before the repeated surgery | Immediately after the repeated surgery | Remote postoperative period |
|---|---|---|---|
| Primary curve, degree | 79.7 (43–133) | 50.6 (15–112) | 55.2 (11–125) |
| Secondary curve, degree | 49.7 (20–89) | 34.7 (19–96) | 36.7 (9–96) |
| Thoracic kyphosis, degree | 63.5 (15–149) | 41.1 (9–122) | 50.3 (10–148) |
| Lumbar lordosis, degree | 65.0 (30–97) | 50.5 (28–104) | 52.2 (23–89) |
| Rotation of the apical vertebra, degree | 34.9 (11.2–75.9) | 22.1 (2.1–61.9) | 22.9 (2.8–69.6) |

The table contains the data on 31 patients with postoperative follow-up of at least 2 years, averaging 61.8 (24–139) months.

**Table 2**

Blood loss and duration of surgery for various types of intervention

| Parameters | Deformity correction Type I | Anterior release + deformity correction Type II | Impant removing + deformity correction Type III |
|---|---|---|---|
| Blood loss, ml | 810 (250–1950) | 1120 (300–3000) | 1138 (400–2000) |
| Surgery duration, min | 187.6 (75–400) | 289.4 (120–725) | 205.0 (110–345) |

the authors [21] stated a 50° correction loss in a patient with congenital scoliosis. The reasons for repeated surgical interventions are diverse, according to all the listed authors. However, among the most frequent reasons are suppuration, implant-associated problems (fracture, emergence under the skin), false joints, and junctional kyphosis [22–26]. Less often, the reasons of repeated surgeries are neurological and pulmonary [20] complications, decompensation of the trunk, and progression of deformity [5]. The above data combines two circumstances. Firstly, all patients are surgically treated in hospitals in highly developed countries with the use of modern, effective instrumentation developed by specialized companies and manufactured on a commercial scale. Secondly, there is a complete lack of information concerning the effectiveness of repeated corrective surgeries and their characteristics (surgery duration and blood loss volume).

The situation that has been developing in our country for decades has a significant feature. A large number of patients suffering from spinal deformities (many hundreds and possibly thousands) underwent surgeries with use of various types of spinal instrumentation wildly different than the global standards. This should include the Rodnyansky–Gupalov instrumentation and the Medilar endocorrectors designed on its basis [27] (Fig. 2), LZS, the extrafocal endocorrector of the Kurgan Center [28] (Fig. 3), the Gavrilov instrumentation [29] (Fig. 4), analogues of the Harrington distractor (Fig. 5), and some others.

All this metal implants are well known to domestic specialists. We have never made a point of critically evaluating their design features and the outcomes achieved with their help.

We found it reasonable to compare the outcomes of repeated surgeries with those obtained during the initial correction at our hospital. In this case, a unified approach to the indications and contraindications of the surgery as well as a unified surgical technique and postoperative follow-up were guaranteed. Paper by M.A. Chernyadyeva et al. [30] which analyses in detail surgical correction of idiopathic scoliosis in 352 patients at the age of active skeletal growth and progression of spinal deformity, was chosen as a material for comparison. The analysis of the data given in Table 5 shows that the comparison of primary and secondary surgeries by the main parameters gives largely the expected outcomes. The correction of the primary curve and the apical vertebral derotation volume during original surgeries are significantly higher, which seems quite logical, given the inevitable changes in vertebral and paravertebral tissues that the surgeon who performs the repeated corrective surgery faces. For the same reasons, the blood loss volume following the primary correction is also significantly lower. The loss of the achieved correction of the primary curve (which, in our opinion, is more logical to define as postoperative progression) and the derotation of the apical vertebra differ between groups slightly and unreliably. This circumstance also seems logical, since the actual technique of instrument implantation and correction in both groups is almost equal. The surgery duration in both the group of primary and that of secondary surgery varies slightly (an average of 23 minutes); these differences are unreliable.

Table 3

The results of self-assessment of the quality of life of patients according to SRS-24, points

| Domain | Before the repeated correction | After the repeated correction |
|---|---|---|
| Pain | 3.41 ± 0.62 | 3.40 ± 0.70 |
| General appearance | 3.17 ± 0.58 | 3.26 ± 0.60 |
| Appearance after surgery | 3.98 ± 0.63 | 4.12 ± 0.79 |
| Function after surgery | 2.57 ± 1.57 | 2.63 ± 1.48 |
| General activity | 2.68 ± 0.71 | 2.92 ± 0.85 |
| Professional activity | 3.41 ± 1.10 | 3.42 ± 1.06 |
| Satisfaction with the surgery results | 4.12 ± 0.66 | 4.13 ± 0.75 |
| Result | 79.57 ± 8.50 | 82.32 ± 11.63 |

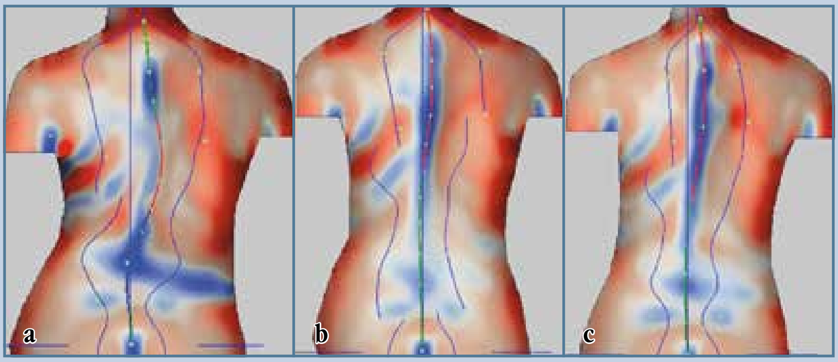


**Fig. 1**
Topography of the back surface of the trunk using the COMOT method, demonstrating the possibility of repeated correction of spinal deformity in patient B., female, born in 1977, with idiopathic right-sided thoracic kyphoscoliosis: **a** – before surgery; **b** – immediately after surgery; **c** – 3 years after surgery

The quality of life of patients after removal of endocorrectors practically does not change, and there is a distinct tendency to improve after repeated corrective surgery, although not in all parameters.

The study of the correction outcomes of spinal deformities of any etiology should, by definition, be comprehensive. We consider the scope of the study to be optimal and exhaustive, including the following 3 components:

• clinical and radiological examination data contained in an updated electronic database;

• self-assessment of the quality of life of patients using a questionnaire (in our case – SRS-24);

• quantitative evaluation of the topography of the back surface of the trunk (the COMOT in our case).

The examination is performed immediately before surgery, immediately after it (within no more than two weeks), and in the long-term postoperative period – at least two years after the treatment.

The obtained outcomes, studied in accordance with the above standard, enable us to draw the following conclusion: repeated corrective surgeries for scoliosis are quite effective, even after multistage treatment and in the long-term after the primary surgery. This gives us the right to recommend repeated surgery to patients in the event of an unsuccessful primary correction. Undoubtedly, the approach should be strictly individualized, considering all the objective and subjective circumstances.

*Limitations.* The limitation of the presented study should be considered the heterogeneity of the cohort on an etiological principle. Nevertheless, in relation to the chosen research topic, we consider this circumstance to be irrelevant, since it does not fundamentally affect the technique of surgery or the evaluation of the immediate outcomes.

## Conclusion

Repeated corrective surgeries in patients suffering from spinal deformities of various etiologies is one of the most complicated issues of our speciality, especially in cases where non-standard instrumentation is used for primary correction. Repeated interventions performed even in the long-term period, can partially restore the lost primary correction and improve the quality of life of patients. The outcomes of such procedures are quite stable, which is confirmed by the data of a three-component postoperative examination.

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*All authors contributed significantly to the research and preparation of the article, read and approved the final version before publication.*

**Table 4**

The main topographic parameters of female patient B., measured before and after surgery and 3 years after

| Period | PTI | PTI_F | PTI_G | PTI_S | FT, degree | ST, degree | GT, degree |
|---|---|---|---|---|---|---|---|
| Before surgery | 4.1 | 4.6 | 4.9 | 2.4 | -2.3 | 2.6 | 6.55 |
| After surgery | 2.9 (-29.3 %) | 2.1 (-54.3 %) | 4.4 (-10.2 %) | 1.2 (50.0 %) | -0.7 | -2.3 | 1.87 |
| 3 years after surgery | 2.9 (-29.3 %) | 2.6 (-43.5 %) | 3.9 (-20.4 %) | 1.4 (41.7 %) | -2.1 | -1.2 | 2.6 |

PTI is the general integral index of violations of the shape of the back surface of the trunk (dimensionless, for «after surgery» and «3 years after» the percentage of change relative to the preoperative value is given in parentheses); PTI_F is the integral index of violations of the shape of the back surface of the trunk for the frontal plane (dimensionless, for «after surgery» and «3 years after» the percentage of change relative to the preoperative value is given in parentheses); PTI_G is the integral index of violations of the shape of the back surface of the trunk for the horizontal plane (dimensionless, for «after surgery» and «3 years after» the percentage of change relative to the preoperative value is given in parentheses); PTI_S is the integral index of violations of the shape of the back surface of the trunk for the sagittal plane (dimensionless, for «after surgery» and «3 years after» the percentage of change relative to the preoperative value is given in parentheses); FT — inclination of the trunk in the frontal plane (balance in the frontal plane, "+" sign — counterclockwise inclination, "-" sign — clockwise inclination); ST — inclination of the trunk in the sagittal plane (balance in the sagittal plane, "+" sign — posterior inclination, "-" sign — anterior inclination); GT - twisting of the trunk in the horizontal plane (turning the shoulder girdle relative to the pelvis, balance in the horizontal plane, the sign «+» — twisting clockwise, the sign «-» — twisting counterclockwise).

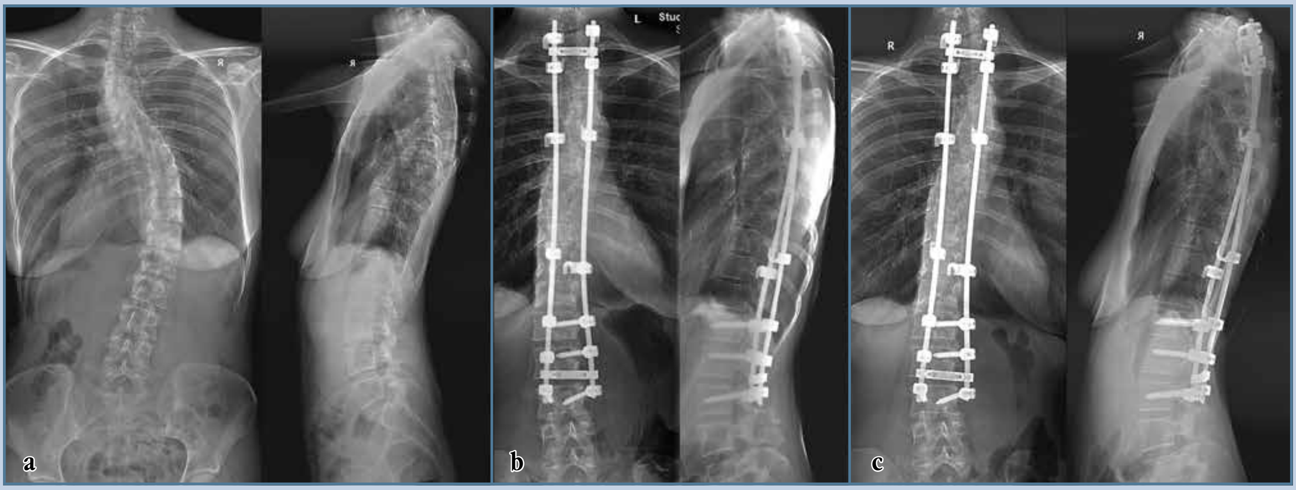


**Fig. 2**

X-ray images of patient N., female, 20 years old, with idiopathic right-sided grade IV thoracic scoliosis with lumbar countercurvature, at the age of 13 years, underwent a surgery at the place of residence using Medilar instrumentations, in 2010 the implant was removed due to failure of the support points: **a** – on admission (May 6, 2011): thoracic curve – 70°, lumbar curve – 43°, thoracic kyphosis – 65°, lumbar lordosis – 78°; **b** – after a three-stage intervention – anterior release, interbody fusion with autologous bone, skeletal traction through the bones of the cranial vault, correction with segmental instrumentation (May 28, 2011): thoracic curve – 45°, lumbar curve – 20°, thoracic kyphosis – 44°, lumbar lordosis – 72°; **c** – 8 years after the revision intervention (January 28, 2019): thoracic curve – 56°, lumbar curve – 11°, thoracic kyphosis – 52°, lumbar lordosis – 67°

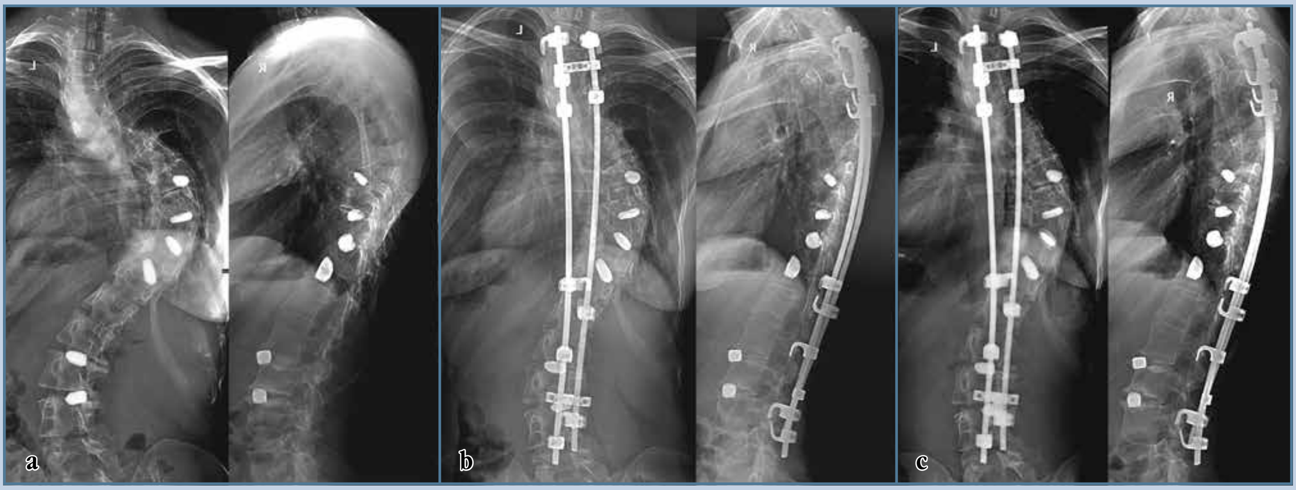


**Fig. 3**
X-ray images of patient K., female, 24 years old, with idiopathic right-sided grade IV thoracic scoliosis with upper thoracic and lumbar countercurves, at the age of 17 years, underwent the surgery using the method of extrafocal correction of spinal deformity, followed by interbody fusion with porous titanium nickelide implants: **a** – on admission (February 19, 2011): thoracic curve – 95°, lumbar curve – 48°, upper thoracic curve – 61°, thoracic kyphosis – 64°, lumbar lordosis – 70°; **b** – after correction with segmental instrumentations (March 2, 2011): thoracic curve – 60°, lumbar curve – 38°, upper thoracic curve – 45°, thoracic kyphosis – 45°, lumbar lordosis – 61°; **c** – 2 years after the revision intervention (March 2, 2013): thoracic curve – 61°, lumbar curve – 40°, upper thoracic curve – 507°, thoracic kyphosis – 55°, lumbar lordosis – 65°

**Fig. 4**
Elements of instrumentation of V.A. Gavrilov who used a treatment system that included long-term (up to six months) traction preoperative preparation aimed at mobilizing the primary curvature, then anterior release and multi-stage correction with customized instrumentations. The need for numerous repeated surgeries, according to the author, was determined by the desire to achieve maximum correction. The endocorrector worked on the principle of a distractor with lateral pull. The number of complications was significant

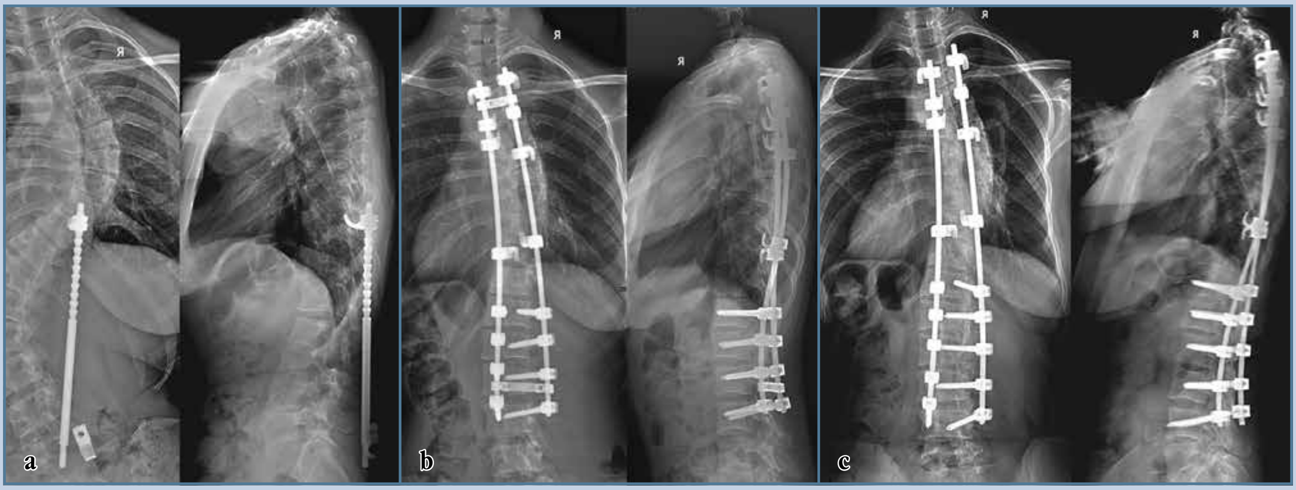


**Fig. 5**
X-ray images of patient K., female, 33 years old, with idiopathic right-sided grade IV thoracic scoliosise with lumbar countercurvature, previously underwent the surgery at the place of residence, 12 staged distractions were performed with a Harrington-type endocorrector within the period from 1993 to 2007: **a** – on admission (April 10, 2012): thoracic curve – 77°, lumbar curve – 78°, thoracic kyphosis – 15°, lumbar lordosis – 54°; **b** – after removal of the Harrington-type distractor, correction with segmental instrumentation (May 2, 2012): thoracic curve – 38°, lumbar curve – 17°, thoracic kyphosis – 16°, lumbar lordosis – 41°, in 2008 due to the disconnection of the pedicle screw and the rod at the level of the L3 vertebra, remounting was carried out; **c** – 8 years after the revision intervention (October 23, 2020): thoracic curve – 38°, lumbar curve – 18°, thoracic kyphosis – 17°, lumbar lordosis – 48°

**Table 5**
Comparative results of repeated and primary corrective interventions in patients with spinal deformities

| Indicators | Repeated surgeries | Primary surgeries | p-value |
|---|---|---|---|
| Primary curve correction, degree | 29.03 (10–61) | 49.40 (19–102) | <0.001 |
| Loss of correction of the main curve, degree | 7.32 (0–29) | 5.47 (0–46) | 0.487 |
| Derotation of the apical vertebra, degree | 12.86 (0.68–29.20) | 18.50 (0.60–51.00) | <0.001 |
| Loss of derotation of the apical vertebra, degree | 1.97 (0.00–14.44) | 0.78 (1.06–16.16) | 0.419 |
| Blood loss, ml | 956 (250–3000) | 670 (185–1950) | <0.001 |
| Surgery duration, min | 212 (75–725) | 189 (90–355) | 0.156 |

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