# EXPERIENCE OF USING UNIPLANAR SCREWS IN COMBINATION WITH DIRECT VERTEBRAL ROTATION FOR CORRECTION OF LENKE TYPE 5 AND 6 SCOLIOTIC DEFORMITIES

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**Objective.** To evaluate the effectiveness of uniplanar pedicle screws in combination with direct vertebral rotation (DVR) and their impact on the choice of the lower instrumented vertebra in the correction of idiopathic scoliosis with a primary lumbar curve.

**Material and Methods.** A retrospective cohort study of 33 patients divided into two groups was conducted. Patients in Group 1 ($n = 17$) underwent correction using uniplanar screws and DVR, and those in Group 2 ($n = 16$) underwent correction using multiaxial pedicle screws according to the standard technique. Radiographic parameters (Cobb angle) and CT data (translation, axial rotation of the spine) and the SRS-22 questionnaire were used for the analysis.

**Results.** A clinically significant threshold for the initial Cobb angle of 60° was identified. For deformities ≤60°, the use of uniplanar pedicle screws with DVR provided statistically significantly better correction of the deformity ($p = 0.037$) and axial rotation ($p < 0.001$) with a shorter construct length. For deformities >60°, no significant differences in Cobb angle correction and translation between the groups were found, with the exception of better derotation achieved in Group 1. According to the SRS-22 questionnaire results, there were no significant differences in the patients' subjective assessment of their condition, except for the "self-image" domain, where the score was higher in Group 1.

**Conclusion.** The use of uniplanar screws in combination with direct vertebral rotation (DVR) technique is effective for the correction of moderate lumbar scoliotic deformities (≤60° Cobb angle). This approach allows for three-dimensional correction and preserves motion segments due to a shorter construct (fixation up to L3). The 60° threshold serves as a practical guide for choosing the fixation type: for smaller angles, uniplanar pedicle screws with DVR are preferable, while for larger angles, the screw type does not have a decisive influence on the correction.

**Key Words:** idiopathic scoliosis; uniplanar screws; direct vertebral rotation.

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The main goal of surgical treatment of idiopathic scoliosis is the correction of the deformity and the achievement of a balanced position of the spine. For this, triplanar correction in the sagittal, frontal and axial planes is necessary. Also, during correction, it is important to consider the possibility of a shorter metal fixation to preserve movements in the unfixed segments of the spine. The main attention is often paid to correction in the frontal plane, while the significance of the rotational component is taken into account to a lesser extent. A number of studies indicate that torsion of the vertebrae serves as an important predictor of the progression of scoliotic deformity [1–3].

A key aspect of surgical planning for idiopathic scoliosis is the choice of the lowest instrumented vertebra (LIV). Despite the presence of a number of classifications and algorithms that help in making this decision [4–6], currently there are no strict clinical guidelines regulating the level of fixation. In particular, the question of the level of fixation of a structural lumbar curve to L3 or L4 remains debatable, and a final consensus in this regard has not been reached [5–8].

In scoliosis of Lenke types 5C and 6C [9], the choice of the L3 vertebra as the lowest instrumented vertebra allows preserving more mobile segments in the lumbar region, but this approach is associated with the risk of deformity progression, especially in its severe forms. On the other hand, fixation down to the L4 potentially ensures better correction in the frontal plane, but this is achieved at the cost of a decrease in the volume of mobility of the lumbar region.

Modern techniques and instrumentation allow surgeons to achieve maximum correction while fixing the minimum number of vertebrae. One of such techniques is direct vertebral rotation (DVR), which provides adequate correction in all three planes [10, 11]. This technique is more effective with the use of uniplanar pedicle screws or monoaxial pedicle screws, however, taking into account the limitations of the latter, preference is given to uniplanar pedicle screws (UPS) [12, 13].

Despite the prevalence of the technique using uniplanar pedicle screws and DVR, unequivocal indications for its application are currently absent. Further research is acquiring particular relevance

due to existing contradictions in the literature and the need to obtain additional data for an objective assessment of the advantages of this type of fixation [3, 12].

The objective of the study is the analysis of the effectiveness of applying uniplanar pedicle screws in combination with DVR and the influence of the type of implants on the choice of the lowest instrumented vertebra during the correction of idiopathic scoliosis with a primary lumbar curve.

## Material and Methods

*Study design*

A retrospective cohort study with an analysis of the medical data of patients with scoliotic deformity of the lumbar spine of Lenke types 5 and 6 was conducted. Under our observation were 33 patients (9 males and 24 females), who were enrolled into 2 groups depending on the type of implants used. Group 1 included 17 patients (3 males, 14 females, average age – 20.6 ± 6.8 years), who underwent correction of idiopathic scoliosis of the lumbar spine using UPS in combination with DVR and Group 2 – 16 patients (4 males, 12 females, average age – 19.5 ± 5.4 years; $p = 0.63$), who underwent correction using polyplanar pedicle screws (PPS) according to the standard technique.

The average Cobb angle of deformity before surgery in Group 1 was 54.6° ± 9.4°, in Group 2 – 59.2° ± 10.5° ($p = 0.22$), the deformity mobility index – 0.40 ± 0.17 and 0.46 ± 0.12 respectively ($p = 0.28$). It can be concluded that there were statistically no significant differences between the two groups in terms of age, Cobb angle before surgery, and mobility index.

*Setting*

The study was conducted on the basis of the department of pediatric bone pathology and adolescent orthopedics, all surgical interventions were performed by one surgical team of doctors.

*Study duration*

The data of patients who underwent treatment in 2022–2025 were analyzed.

*Ethical review*

The study protocol was approved by the ethics committee of the N.N. Priorov National Medical Research Center of Traumatology and Orthopedics, Moscow (protocol No. 6/25 dated October 30, 2025). The patients or their legal representatives signed informed consent for the publication of data.

*Eligibility criteria*

Enroll criteria for the study:

- idiopathic scoliosis with a primary lumbar curve (Lenke 5C, 6C);
- Cobb angle of deformity in the range from 40° to 79°; and
- deformity mobility index not more than 0.7.

Exclusion criteria:

- scoliotic deformity of non-idiopathic etiology;
- structural curve of the thoracic spine (Lenke 1, 2, 3, 4);
- Cobb angle of deformity less than 39° or more than 80°; and
- mobility index more than 0.7.

*Description of the medical intervention*

For the purpose of preoperative preparation, the patients underwent CT study of the lumbar spine, postural radiography of the spine and functional tests (bending test – radiography of the lumbar spine with bending to the left and to the right and subsequent calculation of the mobility index).

The mobility index was calculated according to the following formula: mobility index = Cobb angle in the bending position to the side of the deformity / Cobb angle in the standing position [14].

Rotational test – radiography of the lumbar spine in the patient's sitting position with rotation of the torso to the left and to the right. This study allows determining the rotational mobility of the vertebrae, as well as evaluating the possible rotational movements acceptable with potential DVR. The rotation of the vertebrae was calculated according to the Raimondi method (Fig. 1) [15].

To determine the presumed LIV before surgery, the following criteria were used (1): on the functional radiograph in the bending position towards the concave side of the lumbar curve, the L3 reaches the central sacral vertical line (2); on the functional radiograph in the bending position towards the concave side, the wedge-shaped deformity of the L3 to L4 becomes neutral; (3) on the radiographs in the bending position to the convex side, the rotation of the L3 decreased by more than 25% (according to Raimondi) from the initial level on the postural radiograph in the anteroposterior projection (4); the L4 on the postural radiograph in the anteroposterior projection has a frontal tilt of less than 25 ° [16].

The treatment results were evaluated based on the data of postural radiography and CT of the spine. We considered such indicators as the Cobb angle of deformity of the thoracic and lumbar regions of the spine, the translation of the vertebra, the rotation of the vertebrae at the apex of the deformity. The axial rotation of the vertebrae was calculated relative to the neutral vertebra according to the CT results, in our study the calculation was carried out relative to the S1. The use of postural radiography for this purpose has significant limitations, especially in the postoperative period. This is due to the fact that the majority of known radiographic methods for assessing rotation are based on determining the position of the pedicles on the convex side of the curvature [15]. After the installation of metal constructs, the accurate determination of this landmark is often impossible.

To assess the rotational mobility of the deformity prior to surgery, functional radiographs were performed and the difference in rotation indicators was calculated according to the radiographs in the patient's supine position (CT scout view) and standing, calculation according to the Raimondi method. As expected, a direct correlation was revealed between this difference and the deformity mobility index: with more mobile curvatures, the difference in rotation in the supine and standing positions was greater. The subjective condition of the patients before and after the surgical intervention was evaluated using the Russian-language version of the Scoliosis Research Society-22 (SRS-22) questionnaire [17].

All surgical interventions were performed under general anesthesia in the patient's prone position. After preoperative marking, a standard approach to the posterior elements of the spine was carried out. In all cases, surgical intervention was performed using implants and instrumentation from a Russian manufacturing company.

In Group 1, UPSs were installed, in Group 2 – PPSs. At the next stage (prior to the installation of rods) under the control of an intraoperative image intensifier, a test rotation of the deformity was performed using L-shaped handles to assess the mobility of the spinal segments after skeletonization of the posterior elements. Upon achieving adequate correction with instrumentation length down to the L3 vertebra, the installation of screws into the L4 vertebra was not performed.

If during the control intraoperative radiography, a test correction revealed a persisted wedge-shaped deformity at the level of the L3-L4 disc and Nash-Moe grade II rotation or greater of the L3 vertebra, then the instrumentation was extended to the level of the L4 vertebra.

Then, pre-bent rods were installed. Initially, the rod was installed from the convex side of the curvature curve and rotated 90°. After this, a rod was installed from the concave side. In Group 1, direct vertebral rotation was additionally performed using specialized instrumentation.

In both groups, the next stage was the frontal correction of the tilt of each vertebra in accordance with the spinal deformity. The final stage of the operation was the definitive fixation of the construct with tightening of the locking nuts and layer-by-layer suturing of the surgical wound (Fig. 2).

*Statistical methods*

A search for the threshold of the Cobb angle "before" was conducted, below which the choice of the type of pedicle screws (uniplanar/polyplanar) has a significant influence on the result of the correction (Cobb angle "after"), and above which the influence of the screw type on this parameter is considered insignificant. To search for the threshold, all integer values of N in the range of observed Cobb angles "before" were selected and for each N the data were divided into two zones: $\leqslant$N and >N. In the $\leqslant$N zone, the Cobb angle "after" was compared between polyplanar and uniplanar screws using a two-sided Welch's *t*-test and the effect size Cohen's *d* was evaluated for the clinical interpretation of the magnitude of the differences. In the >N zone, a one-sided non-inferiority test for the mean difference according to Welch was applied: testing the hypothesis H0: (mean uniplanar – mean polyplanar) $\geqslant\Delta$ vs. H1: $<\Delta$ with a clinical tolerance $\Delta = 5$ ° and $\alpha = 0.05$. The optimal threshold N* was selected among those N where in the >N zone the absence of a difference between the types of screws is confirmed, and below the threshold a significant difference of the Cobb angles "after" between the two screw variants is observed and this difference is maximal ($|d|$).

To identify the specific features of the influence of the type of pedicle screws on the scoliosis correction parameters, the patients were divided into two subgroups depending on the initial Cobb angle: $\leqslant$60° (panel A) and >60° (panel B) according to the determined threshold. For each subgroup, the following parameters were analyzed: residual Cobb angle, change in Cobb angle, change in translation and change in axial rotation. To compare the groups, a two-sample Welch's *t*-test was used.

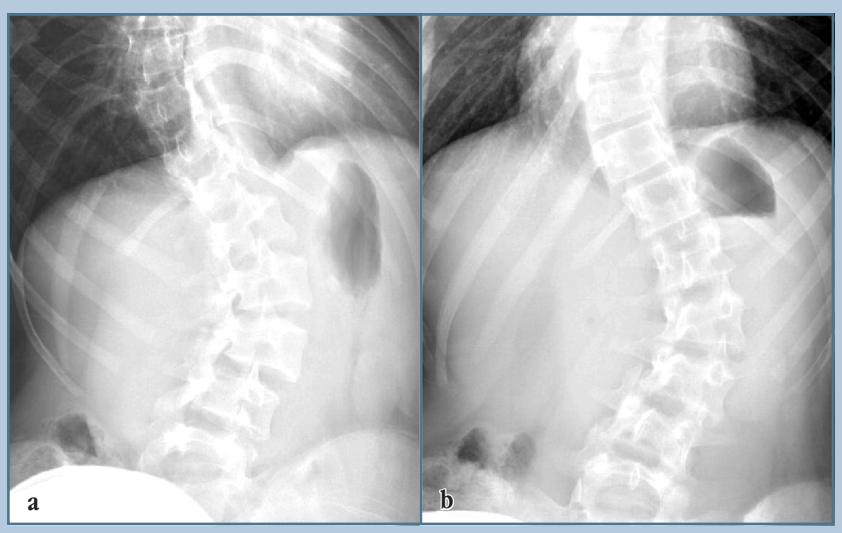


**Fig. 1**
Rotational test: radiography of the lumbar spine in the patient's sitting position (to fix the pelvis in a neutral position) with torso rotation to the left **(a)** and to the right **(b)**

## Results

We tested the hypothesis of the presence of a threshold of the initial Cobb angle, below which the choice of the type of pedicle screws influences the length of the metal construct and the result of the correction, and above which the type of screws can be considered insignificant. Based on the results of the analysis, a threshold N* from 58° to 62° was identified (due to the absence of data in this range, N* gave the same result), rounded to 60° (Fig. 3). This means that in patients with an initial Cobb >60°, the type of screws does not affect the expected Cobb angle "after" and the length of the metal construct: according to the one-sided test of non-inferiority, which in clinical practice allows making a choice based on other factors, such as the complexity of the anatomy, mobility

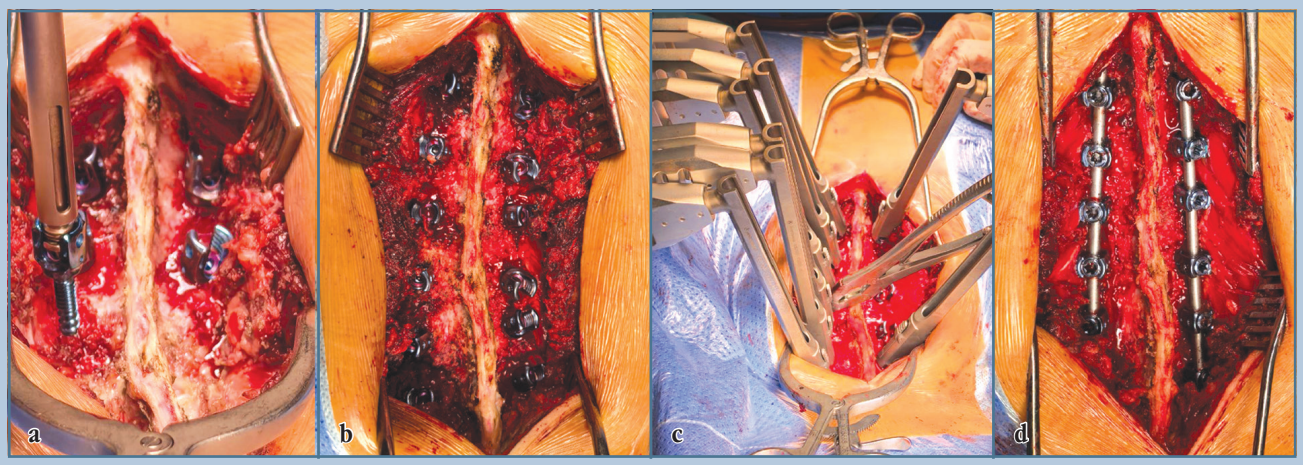


**Fig. 2**
Stages of surgery: installation of pedicle screws **(a)**, view prior to correction **(b)**, during execution of correction **(c)** and after correction **(d)**

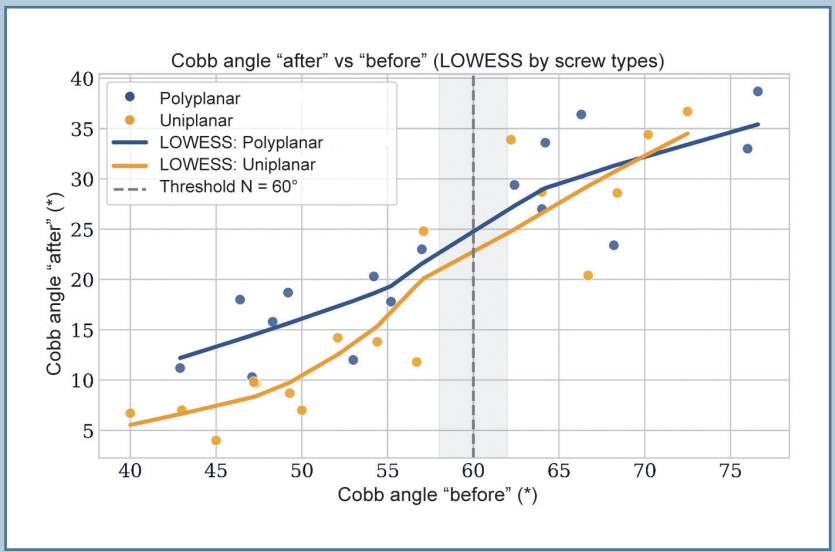


**Fig. 3**
The dependence of the resulting Cobb angle on the initial value in scoliotic correction: dynamics by the type of pedicle screws and determination of the clinically significant threshold value N. The relationship of the Cobb angle «after» and «before» surgical correction by the type of pedicle screws (uniplanar pedicle screw – orange, polyplanar pedicle screw – blue). For each type of screws, Locally Weighted Scatterplot Smoothing curves are plotted, reflecting the general trend of the correlation of the resulting Cobb angle after correction from the initial Cobb angle value. The vertical dashed line marks the identified clinical threshold N* = 60°: at an initial Cobb ⩽60°, uniplanar pedicle screws are associated with statistically significantly lower Cobb angle values after surgery compared to polyplanar screws; at values above the identified threshold – the differences are minimal.

index, availability of implants. In contrast, at an initial Cobb angle of ⩽60°, treatment using uniplanar pedicle screws demonstrates better correction with a smaller construct length (the advantage is confirmed both statistically and by the magnitude of the effect).

For further evaluation of the differences between the types of screws, each group was divided into two subgroups in accordance with the identified threshold of the initial Cobb angle (⩽60° and >60°), after which a comparative analysis of key correction parameters was conducted in each subgroup: Cobb angle "after", translation of the spine, axial rotation of the vertebrae at the apex of the deformity. In the subgroup of patients with an initial Cobb angle of ⩽60° (Fig. 4), correction using uniplanar pedicle screws in combination with DVR was associated with a statistically significantly smaller residual Cobb angle and a greater magnitude of correction than in the group with correction on polyplanar pedicle screws ($p = 0.037$ and $p = 0.016$, respectively). At the same time, to achieve this result, a smaller length of the metal construct was required – the lowest instrumented vertebra in this group was located at the level of L3, whereas in Group 2 – at the L3 (Fig. 5).

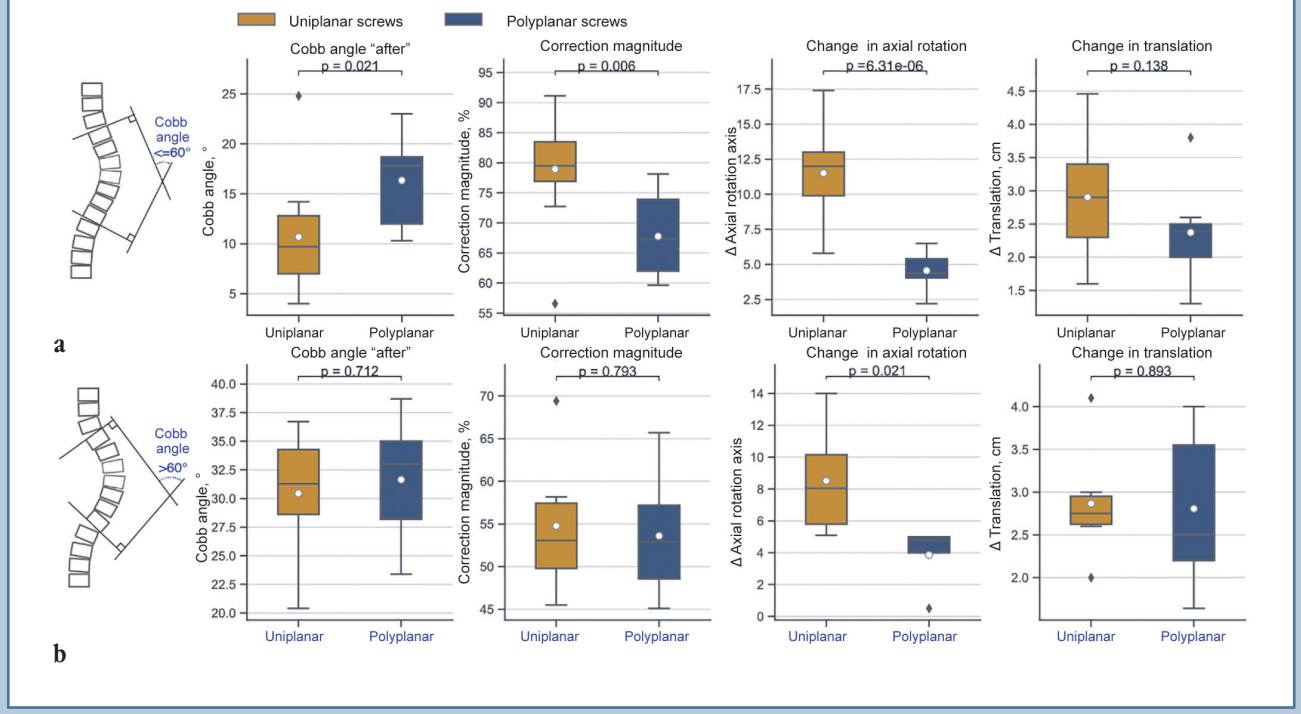


**Fig. 4**
The influence of the pedicle screw type on the correction parameters in patients with an initial Cobb angle ⩽60° **(a)** and >60°**(b)**

The most pronounced advantage of uniplanar pedicle screws was noted in the indicator of change in axial rotation ($p$ <0.001). This value was greater compared to PPS regardless of the deformity angle. However, in the subgroup with a deformity of ⩽60°, the correction was more pronounced. It is also worth noting that the result of the preoperative rotational test correlated with the indicator of rotation; in patients with more pronounced rotational mobility, the result of axial rotation according to CT data was more pronounced.

When comparing the change in the magnitude of translation, statistically significant differences between the groups were not revealed ($p$ = 0.173), however, a trend in favor of the use of uniplanar pedicle screws was observed.

In the subgroup of patients with an initial Cobb >60° (Fig. 4), a significant difference between the types of screws was only in the indicator of axial rotation. Statistically significant differences in the residual Cobb angle and translation between the groups were not revealed. Thus, at a Cobb >60°, the type of screws does not distinctly affect the achieved correction and the length of the metal construct.

When analyzing the SRS-22 questionnaires, significant differences in the subjective assessment of their condition by the patients were not revealed, with the

**Table**
Result of the subjective assessment of the patients' condition according to the SRS-22 questionnaire, points

| Group | Function | Pain | Self-image | Mental health | Treatment |
|---|---|---|---|---|---|
| *Average value* | | | | | |
| 1 | 4.42 | 4.49 | 4.63 | 4.43 | 4.89 |
| 2 | 4.37 | 4.45 | 4.07 | 4.37 | 4.87 |
| *Standard deviation* | | | | | |
| 1 | 0.40 | 0.33 | 0.30 | 0.24 | 0.24 |
| 2 | 0.45 | 0.28 | 0.38 | 0.28 | 0.27 |
| *p-value. Welch's t-test* | | | | | |
| $p$ -value | 0.78 | 0.70 | 0.00058 | 0.54 | 0.80 |
| Significant difference | No | No | Yes | No | No |

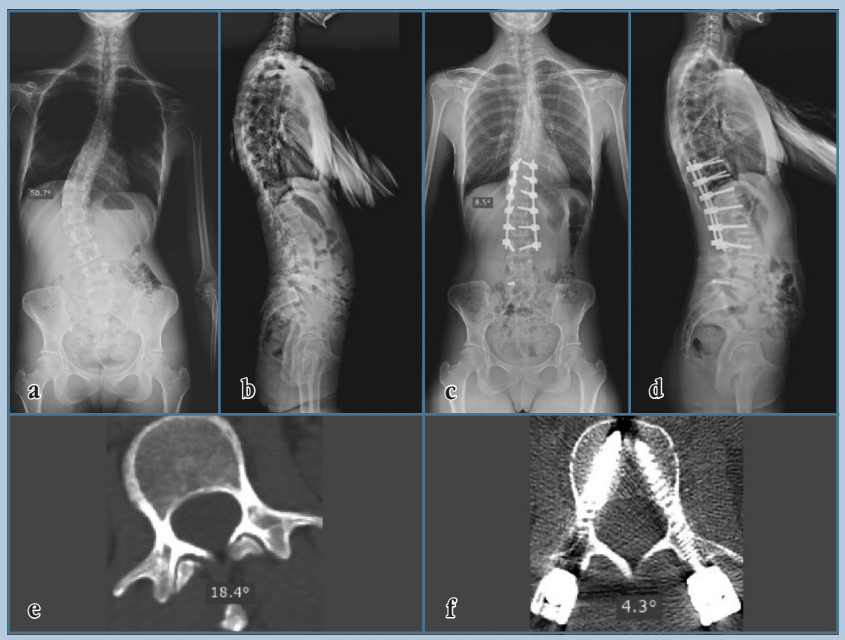


**Fig. 5**
The result of deformity correction in a patient with right-sided thoracolumbar scoliosis of the fourth degree: **a, d** – postural radiographs in the anteroposterior projection before and 2 years after surgery; **b, e** – postural radiographs in the lateral projection before and 2 years after surgery; **c, f** – axial rotation according to CT data before and 2 years after surgery

exception of the "self-image" domain (see Table). Probably, this is associated with the more pronounced correction of the deformity achieved in patients of Group 1 with a deformity of ⩽60°.

## Discussion

The conducted study is aimed at evaluating the clinical effectiveness of using UPS in combination with DVR for the correction of idiopathic scoliosis with a primary lumbar curve. At the moment, there is a limited number of studies over the past 5 years devoted to this problem.

Uniplanar pedicle screws, providing a more rigid lever for manipulations, fully reveal the potential of the DVR technique, allowing more effective action in the axial plane compared to PPS [1, 3, 12, 13]. The biomechanical study by Liu et al [13]. demonstrated that the DVR technique is technically more feasible with the use of mono- and uniplanar pedicle screws, since the structure of the "head-threaded shaft" node limits mobility in the horizontal plane, thereby providing the most effective lever for rotation. At the same time, the authors note that monoaxial pedicle screws possess a number of disadvantages, in particular, the difficulty of installing the rod and the lack of mobility of the screw head in the sagittal plane, which can lead to increased stress in the "bone-screw" contact zone.

Of note, there is a small number of publications devoted to the issue of the influence of the implant type on deformity correction and the length of instrumentation. Thus, the work of Alonge et al. [6] analyzed the impact of DVR technique on the level of the LIV during the correction of lumbar scoliosis less than 60°. The obtained data showed that in deformities of Lenke 5C and 6C the use of this technique makes it possible to complete the fixation at the L3. At the same time, statistically significant differences in the degree of correction between the groups with and without the use of DVR were not established, however, Group 1 managed to preserve more distal mobile segments. It is important to note that the authors did not specify the type of used pedicle screws.

At the same time, the studies of Hu et al. [12] and Lin et al. [3] also demonstrate that the use of UPS provides more effective derotation and overall correction in Lenke type 5 idiopathic scoliosis. However. in these works, the main focus was placed on such parameters as apical rotation and correction in the frontal plane, without an analysis of the influence of the implant type on the length of the construct.

A retrospective analysis of our sample of idiopathic scoliosis of the thoracolumbar/lumbar parts of the spine showed that with deformities of ⩽60°, the use of UPSs in combination with direct vertebral rotation ensures statistically significantly better results compared to PPS. Also, a relationship was established between the type of implant and the choice of the LIV. In the ⩽60° subgroup, the application of UPS in combination with DVR made it possible to conduct fixation down to the L3 without loss of correction, whereas when using PPS to achieve the same correction, fixation to the L3 was required. This directly answers one of the main goals of scoliotic spinal deformity treatment: maximum possible correction while preserving a larger number of mobile segments.

On the other hand, our study showed that with deformities of >60°, the type of screws does not affect the correction result. Statistically significant differences in the residual Cobb angle and translation between the groups were not revealed. This can be explained by the fact that with rigid and pronounced deformities, the biomechanical advantages of UPS become insufficient to overcome the stiffness of the deformity; the required correcting effect is achieved due to a longer construct and adjacent segments, regardless of the type of implant used. This conclusion has an important practical significance: when planning surgery in

patients with a Cobb >60°, the choice between UPS and PPS can be based on other factors, such as the anatomical features of the patient. the mobility of the spinal deformity. and the cost of the implants.

*Limitations of the study.* This study has a number of limitations. Firstly, the retrospective nature and relatively small sample size, which does not allow for objective conclusions. Secondly, all operations were performed by a single surgical team using implants from a single manufacturer, which may affect the reproducibility of the results in other clinics. To confirm the obtained data and refine the threshold values, further studies with an evaluation of the results are necessary.

## Conclusion

The study demonstrates that the use of UPS with the DVR technique is a highly effective method for correcting scoliotic deformities with a primary lumbar curve of ⩽60°. Its key advantages are triplanar correction and the possibility of preserving mobile segments due to a shorter construct without compromising the quality of the correction. The identified Cobb angle threshold of 60° provides vertebrologists with a clear clinical guide for choosing the type of fixation, contributing to a personalized approach in the planning of surgical treatment for idiopathic scoliosis.

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## Additional information

***Author contributions.*** A.A. Snetkov – patient treatment, performing operations, collection and processing of material, statistical data processing, writing the text of the article; I.D. Ishkinyaev – patient treatment, performing operations, collection and processing of material, statistical data processing, writing the text of the article, duties of the corresponding author; R.S. Gamayunov – patient treatment, performing operations, collection and processing of material, statistical data processing, writing the text of the article. All authors approved the manuscript (the version for publication), and also agreed to bear responsibility for all aspects of the work, guaranteeing proper consideration and resolution of issues related to the accuracy and integrity of any part of it.

***Ethical review.*** The conduct of the study was approved by the local ethics committee of the N.N. Priorov National Medical Research Center of Traumatology and Orthopedics (protocol No. 6/25 dated October 30. 2025).

***Consent for publication.*** All study participants or their legal representatives voluntarily signed the informed consent form for inclusion in the study.

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