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3D-CT ANALYSIS OF ANATOMICAL AND ANTHROPOMETRIC PARAMETERS OF VERTEBRAE IN CHILDREN WITH LENKE TYPE V IDIOPATHIC SCOLIOSIS

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Objective. To analyze anatomical and anthropometric parameters of vertebrae in children with Lenke type V idiopathic scoliosis using 3D-CT navigation.
Material and Methods. The study included 15 patients aged 14–18 with thoracolumbar/lumbar idiopathic scoliosis of grades III and IV according to VD Chaklin. Anatomic and anthropometric features of the thoracic and lumbar vertebrae were assessed based on CT data in the navigation system. The total Cobb angle of the scoliotic curve, rotation of the apical and periapical vertebrae, external transverse and longitudinal diameters of the pedicles at the T2–L5 levels, and the coefficients of asymmetry of vertebral bone structures were determined.
Results. The angle of scoliosis ranged from 39.8° to 84.3° (average – 59.5°), the angle of rotation of the apical vertebra – from 17.7° to 50.5° (average – 34.6°). Anatomical dimensions of the transverse and longitudinal diameters of the pedicles on the concave and convex sides at the apex of a primary curve exceeded 4.0 mm. A strong correlation between the apical vertebral rotation, the Cobb angle, and the coefficient of asymmetry of longitudinal diameters of the pedicles of the apical vertebra was revealed. The coefficient of asymmetry of pedicle areas is an integral indicator of the severity of asymmetry in scoliosis.
Conclusion. A different degree of asymmetry of the bone structures of the main arch apical vertebrae was revealed in the thoracic and thoracolumbar/lumber scoliosis.
Key Words: idiopathic scoliosis, Lenke type V, anatomic and anthropometric parameters, rotation of the apical vertebra, transpedicular fixation, children.

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Over the past decade the use of transpedicular fixation in surgical treatment of spine deformities in children with idiopathic scoliosis has been holding a prominent position in toolbox of spinal surgeons dealing with this problem. According to research, these spinal systems have a number of advantages over laminar dorsal systems when used for spine deformity correction in patients with idiopathic scoliosis [1, 3, 6, 8, 11, 13].

It was shown in some studies [2, 9] that surgical correction of spine deformity (in particular, of thoracolumbar and lumbar localization) was performed using both anterior and posterior transpedicular systems. Similar results were obtained in these studies. They demonstrated that these systems are efficient in correcting the deformity and the achieved outcome of intervention is stable in the long-term postoperative period. However, the application of anterior systems for correction of thoracolumbar/lumbar spine deformities in patients with idiopathic scoliosis is limited by a number of factors: the magnitude and length of the primary spinal deformity.

At the same time, there are also some studies devoted to comparative analysis of surgical management of patients with idiopathic thoracolumbar and lumbar scoliosis that support the advantages of using posterior transpedicular spinal systems over the anterior ones. These advantages include the possibility to achieve greater correction of scoliotic deformity and reduce the postoperative length of stay [10, 12]. The greater the magnitude of scoliosis curve, the more significant the severity of anatomical and spatial changes in bone structure of the vertebrae in the primary deformity curve [4]. Anatomical and anthropometric features of the vertebrae in the primary deformity curve potentially impose technical challenges for proper placement of transpedicular support elements of spinal instrumentation during the surgery. Due to these factors, it is important to know the regularities of spatial relationships between the vertebral bone structures and the ratios between their anatomical and anthropometric features in terms of their correlation relationships during scoliotic process.

No studies analyzing the anatomical and anthropometric parameters of vertebrae on the basis of 3D-CT navigation data in patients with Lenke type V idiopathic scoliosis and evaluating the regularities of these features depending on the magnitude of scoliosis curve are currently available.

This study continues our earlier publication focused on investigation and analysis of the anatomical and anthropometric features of vertebrae in children with thoracic idiopathic scoliosis [4].

The aim of this work was to determine the features of anatomical and anthropometric parameters of vertebrae in children with Lenke type V idiopathic scoliosis using 3D-CT navigation.

Material and Methods

Fifteen patients aged 14–18 years with idiopathic thoracolumbar/lumbar scoliosis of grade III and IV according to Chaklin's classification were examined. The sex distribution was typical of spine deformities in patients with idiopathic scoliosis: 1 male and 14 female patients. In all cases, they had thoracolumbar/lumbar left-sided scoliotic deformity. Twenty patients with idiopathic thoracic right-sided scoliotic deformity reported in our earlier publication [4] constituted the reference group in order to reveal the severity of structural changes at the level of the apical vertebra.

The diagnosis of idiopathic scoliosis was made according to the routine examination which included clinical and neurological, instrumental, and radiological methods (X-ray and CT), MRI of the craniovertebral area, thoracic and lumbar spine.

The anatomical and anthropometric features of thoracic and lumbar vertebrae were assessed using the CT data. Examination was carried out on a Brilliance CT64 computed tomography scanner (USA), with patients in the prone position in order to achieve maximum similarity to patient's position on an operating table. CT images (1 mm thick) were imported into the navigation system with "SpineMap 3D" software using a data storage device; all the required measurements were performed using this software. We find the terms "longitudinal diameter of the pedicle" and "transverse diameter of the pedicle" most appropriate for the measured parameters. These terms emphasize the elliptical model of the pedicle that we chose to use. Under this model, they correlate with the concepts of the principal diameters of ellipse used in geometry and mechanics to denote the sections connecting the opposite points on an ellipse or their lengths [5, 7].

The sequence of procedures in analyzing the anatomical and anthropometric parameters of the vertebrae was as follows. The total Cobb angle, rotation of the apical vertebra (RAV), as well as proximal (RPPV) and distal (RDPV) periapical vertebrae, the external transverse (trd) and longitudinal (lngd) diameters of the right (R) and left (L) pedicles at the T2–L5 levels inclusive were determined.

The areas of the right (SR) and left (SR) pedicles were calculated as the product of the trd and lngd of a pedicle. In order to reveal regularities in the scoliotic process characterized by asymmetric development of the vertebral bone structures, we used the coefficients KAtrd – the asymmetry coefficient of the transverse diameters of pedicles determined as the trdR/trdL ratio; KAlng – the asymmetry coefficient of the longitudinal diameters of pedicles determined as the lngdR/lngdL ratio; and KAS is the asymmetry coefficient of the pedicle areas determined as the SR/SL ratio.

The descriptive statistics were calculated in order to compare all the anatomical and anthropometric parameters of the vertebrae and different asymmetry coefficients under study. The Kolmogorov–Smirnov test was used to verify the normality of distribution.

The box plots were built; the histogram analysis (window closing) and correlation analysis (the method of correlation pleiades modified by VP Terentjev) were used to reveal the regularities and relationship between the parameters. Student's t-test and Fischer's F-test were used to identify the differences between the parameters in groups of patients.

Results

According to the data obtained in this study, the Cobb angle determined using the aforedescribed procedure ranged from 39.8 to 84.3° (mean, 59.5°). The angle of RAV ranged from 17.7 to 50.5° (mean, 34.6°); the angle of RPPV, from 15.3 to 42.8° (mean, 28.3°); the angle of RDPV, from 16.2 to 35.7 (mean, 25.2°).

Tables 1–3 list the absolute values of the transverse and longitudinal diameters of vertebral pedicles, areas of pedicles and their asymmetry coefficients.

The data on the transverse and longitudinal diameters of pedicles and their areas are present in tables as M ± m; for asymmetry coefficients, the data are present as Me (min–max).

Visual analysis of box plots was used for more meticulous consideration of the differences between the diameters of the right and left pedicles and for determining the regularities in changes of their dimensions, as well as the asymmetry coefficients, depending on spine section.

Hence, the trdR values in the upper thoracic spine decreased, starting from the T2 level (5.8 ± 0.7 mm) and reached the minimum at the T4 level (3.7 ± 0.9 mm). The size then increased in the craniocaudal direction to reach its maximum at the T11 level (6.4 ± 1.5 mm). Next, a small decrease in the parameter until the L1 level (4.7 ± 1.7 mm) was observed. In the caudal segments of the lumbar spine, the trdR value increased starting from the L2 level (5.7 ± 1.0 mm) to the L5 level (13.3 ± 1.6 mm).

The following regularity of changes in the trdL values on the box plot was observed. The size of vertebrae changed gradually starting from the T2 level (5.8 ± 0.7 mm) with the minimum values achieved at the T7 level (3.5 ± 0.5 mm). The trdL values then increased towards the T11 vertebra to reach the value 7.1 ± 1.6 mm. Next, the value decreased to the L1 level (5.6 ± 1.2

mm). Starting from the L2 level (6.0 ± 1.1 mm), the direction of changes in trdL dimension was characterized by rising size of transverse diameters of pedicles in the craniocaudal direction, with the maximum values reached at the L5 level (15.1 ± 2.7 mm; Fig. 1).

Visual analysis of the pattern of changes in lngd of pedicles showed similar regularities for the lngdR and lngdL values for the thoracic and lumbar spine. Hence, the lngdR value slightly increased from the T2 level (11.3 ± 1.3 mm) to the T3 level (11.8 ± 1.6 mm), followed by a decrease to 10.6 ± 1.3 mm at the T4 level. Starting from the T5 level (11.0 ± 1.1 mm), the lngdR value smoothly increased to reach its maximum at the T11 level (15.0 ± 1.5 mm) and subsequently decreased at the L1 level (13.3± 1.3 mm). Next, the lngdR value increased again to reach its maximum at the L3 level (14.2 ± 1.1 mm). It subsequently decreased in the craniocaudal direction; the minimal values were observed at the L5 level (12.8 ± 1.9 mm).

An analysis of the distribution of the parameter lngdL in the thoracic spine showed a slight increase starting from the T2 level (11.3 ± 1.8 mm) to the T3 level (11.5 ± 2.3 mm), followed by a decrease to 10.9 ± 1.5 mm at the T5 level. Next, starting from the T6 vertebra level, lngdL increased from 11.1 ± 1.5 mm to reach its maximum at the T11 level (18.8 ± 2.3 mm). The lngdL value then decreased again in the craniocaudal direction, starting from the T12 level (16.3 ± 1.8 mm) and reaching the minimal values (11.7 ± 2.0 mm) at the L5 level (Fig. 2).

Evaluation of the asymmetry coefficients for trd and lngd of the pedicles in the thoracic and lumbar spine revealed the following regularities.

KAtrd in the upper thoracic spine until the T5 level inclusive was close to unity. Significant deviation of KAtrd from 1.15 (0.72–1.46) to 1.24 (0.58–1.50) was observed at the T6–T9 level. These changes demonstrated that the trdR parameter of pedicles predominated over trdL at this level. At the T10 and T11 level, KAtrd was close to unity again. In the area of apical vertebrae at the T12–L1 level, the maximum deviation of KAtrd from unity was 0.81 (0.59–1.29), which showed that the trdL parameter predominated over the trdR parameter. Then, KAtrd was close to unity in the lumbar spine, starting from the L2 vertebra to the L5 vertebra inclusive.

The revealed regularities in asymmetry were different for KAlngd. Hence, starting from the T2 to T10 level, KAlngd was close to unity. The zone of maximum deviation of the KAlngd values from unity lied at the T11–T12 level (0.82 and 0.87, respectively). In the lumbar spine, the KAlngd were close to unity, thus characterizing the absence of pronounced structural changes (Fig. 3).

Evaluation of the parameters of the pedicle areas identified the following regularities. The SR value decreased from the T2 level (66.0 ± 12.1 mm2) and reached its minimum at the T4 level (39.3 ± 11.6 mm2). Then it increased in the craniocaudal direction, with the maximum at the T11 level (96.4 ± 28.3 mm2). The SR value then decreased up to the L1 level (63.3 ± 24.8 mm2), followed by an increase in craniocaudal direction, with the maximum values (174.5 ± 31.1 mm2) observed at the L5 level (Fig. 4).

An analysis of the asymmetry coefficient of the areas of pedicles showed that

Table 1

Transverse diameters of the pedicles (M ± m) and their asymmetry coefficients Me (min—max)

Vertebrae	trdR, mm	trdL, mm	KAtrd
T2	5.8 ± 0.7	5.8 ± 0.7	1.00 (0.89—1.23)
T3	4.4 ± 0.8	4.3 ± 0.7	1.02 (0.80—1.50)
T4	3.7 ± 0.9	4.0 ± 0.7	0.93 (0.53—1.56)
T5	3.8 ± 1.0	3.8 ± 0.8	1.03 (0.61—1.34)
T6	4.1 ± 1.0	3.6 ± 0.7	1.20 (0.62—1.66)
T7	4.0 ± 1.2	3.5 ± 0.5	1.24 (0.58—1.50)
T8	4.2 ± 1.0	3.6 ± 0.6	1.15 (0.72—1.46)
T9	4.7 ± 0.9	4.0 ± 0.7	1.23 (0.84—1.38)
T10	5.3 ± 1.1	5.3 ± 1.1	1.02 (0.82—1.30)
T11	6.4 ± 1.5	7.1 ± 1.6	0.93 (0.64—1.37)
T12	5.6 ± 2.0	6.8 ± 1.7	0.82 (0.52—1.11)
L1	4.7 ± 1.7	5.6 ± 1.2	0.81 (0.59—1.29)
L2	5.7 ± 1.0	6.0 ± 1.1	0.92 (0.59—1.33)
L3	7.3 ± 1.9	7.6 ± 1.4	0.97 (0.78—1.09)
L4	9.0 ± 1.2	10.2 ± 1.9	0.90 (0.73—1.05)
L5	13.3 ± 1.6	15.1 ± 2.7	0.90 (0.77—1.05)

trdR — the transverse diameter of the right pedicle; trdL — the transverse diameter of the left pedicle; KAtrd — the asymmetry coefficient of the transverse diameters of a vertebral pedicle, which is determined as the trdR/trdL ratio.

Table 2

Longitudinal diameters of the vertebral pedicles (M ± m) and their asymmetry coefficients Me (min—max)

Vertebrae	lngdR, mm	lngdL, mm	KAlngd
T2	11.3 ± 1.3	11.3 ± 1.8	0.99 (0.88–1.21)
T3	11.8 ± 1.6	11.5 ± 2.3	1.04 (0.82–1.22)
T4	10.6 ± 1.3	11.1 ± 1.6	0.95 (0.80–1.08)
T5	11.0 ± 1.1	10.9 ± 1.5	0.99 (0.85–1.20)
T6	11.4 ± 1.2	11.1 ± 1.5	1.03 (0.88–1.23)
T7	11.9 ± 1.2	11.5 ± 1.5	1.02 (0.89–1.19)
T8	11.5 ± 1.2	12.0 ± 1.6	0.96 (0.75–1.11)
T9	12.6 ± 1.2	13.3 ± 1.9	0.94 (0.85–1.18)
T10	14.2 ± 1.3	16.1 ± 1.6	0.91 (0.75–0.99)
T11	15.0 ± 1.5	18.8 ± 2.3	0.82 (0.69–0.90)
T12	14.1 ± 1.8	16.3 ± 1.8	0.87 (0.73–0.96)
L1	13.3 ± 1.3	15.1 ± 1.4	0.92 (0.72–1.00)
L2	13.4 ± 1.5	14.8 ± 1.6	0.94 (0.74–1.02)
L3	14.2 ± 1.1	13.8 ± 1.5	1.02 (0.92–1.19)
L4	13.5 ± 1.9	12.0 ± 1.2	1.08 (0.98–1.42)
L5	12.8 ± 1.9	11.7 ± 2.0	1.05 (0.89–1.57)

lngdR — the longitudinal diameter of the right vertebral pedicle; lngdL — the longitudinal diameter of the left vertebral pedicle; KAlngd — the asymmetry coefficient of the longitudinal diameters of the vertebral pedicles, which is determined as the lngdR/lngdL ratio.

Table 3

The transverse diameters of the vertebral pedicles multiplied by the longitudinal diameters (M ± m) and the corresponding asymmetry coefficients Me (min—max)

Vertebrae	SR, mm^2	SL, mm^2	KAS
T2	66.0 ± 12.1	65.8 ± 14.2	0.98 (0.83–1.21)
T3	51.6 ± 12.8	49.7 ± 17.3	1.02 (0.66–1.82)
T4	39.3 ± 11.6	44.7 ± 11.5	0.88 (0.43–1.59)
T5	41.3 ± 11.1	41.0 ± 10.9	1.02 (0.52–1.58)
T6	47.1 ± 12.3	40.6 ± 11.5	1.28 (0.54–1.88)
T7	46.9 ± 14.8	40.4 ± 6.3	1.41 (0.56–1.75)
T8	48.5 ± 14.8	43.2 ± 10.2	1.06 (0.75–1.61)
T9	59.6 ± 12.8	53.5 ± 10.4	1.17 (0.78–1.29)
T10	76.7 ± 21.4	85.6 ± 22.2	0.97 (0.67–1.15)
T11	96.4 ± 28.3	134.5 ± 37.4	0.76 (0.48–1.19)
T12	78.3 ± 28.3	111.6 ± 31.0	0.68 (0.48–1.06)
L1	63.3 ± 24.8	85.1 ± 20.9	0.67 (0.45–1.19)
L2	76.8 ± 18.4	89.0 ± 20.9	0.90 (0.52–1.25)
L3	104.2 ± 32.3	104.7 ± 24.6	1.00 (0.72–1.24)
L4	120.8 ± 27.0	122.0 ± 25.7	0.99 (0.79–1.24)
L5	170.4 ± 36.0	174.5 ± 31.1	0.96 (0.75–1.39)

SR — area of the right vertebral pedicle; SL — area of the left vertebral pedicle; KAS — the asymmetry coefficient of areas of the vertebral pedicles determined as the SR/SL ratio.

it deviated from unity at several levels of thoracic vertebrae in different directions. Hence, the KAS values were characterized by maximum deviation from unity at the T4 level – 0.88 (0.43–1.59), T6 level – 1.28 (0.54–1.88), and T7 level – 1.41 (0.56–1.75). Next, at the T8–T10 level inclusive, the KAS values were close to unity. Then a pronounced asymmetry in the areas of pedicles was observed again, starting from the T11 level – 0.76 (0.48–1.19), with the maximum deviation of KAS from unity observed at the L1 level – 0.67 (0.45–1.19). In the lumbar spine, the KAS values were close to unity starting from the L2 level, thus demonstrating that there were no pronounced structural changes (Fig. 5).

An analysis using the method of correlation pleiades modified by V.P. Terentjev was carried out for 10 parameters: the

Cobb angle and nine other anatomical and anthropometric parameters of the apical vertebra (Fig. 6).

Fig. 6 shows the two pleiades of parameters.

The first pleiade at the |r| > 0.8 level combines the RAV, Cobb angle, and KAlnd parameters. It illustrates the clinical significance of the relationship between RAV as a local parameter of spatial position of the vertebra, the Cobb angle as a global parameter, and the ratio between the longitudinal diameters of pedicles of the apical vertebra that is representative of structural deformation of the apical vertebra. The position of the apical vertebra joins it at the level of pleiade |r| > 0.6. TrdR, KAtrd and KAS form another pleiade at the |r| > 0.6 level.

Comparative analysis of the asymmetry coefficients of the apical vertebra in patients with Lenke type I and V idiopathic scoliosis showed statistically significant differences. They indicate that the degree of asymmetry of the bone structures of apical vertebrae is fundamentally different when the primary scoliosis curve localizes in the thoracic and thoracolumbar/lumbar spine (Table 4).

The data is present as the geometric mean (95 % confidence interval). The values of three coefficients were characterized by lognormal distribution (the Kolmogorov–Smirnov test). No significant difference was observed in variance of the log of coefficients (Fischer F-test). Student's t-test was used for logarithms of the asymmetry coefficients. The differences were statistically significant in all three cases.

When performing visual analysis of the histograms of asymmetry coefficients, the difference in asymmetry coefficients in the patient groups being compared can be seen well according to the shift in the enveloping peaks (Fig. 7).

Greater degree of asymmetry of apical vertebrae in patients with Lenke type I scoliosis was observed for all the coefficients compared to that of apical vertebrae in patients with Lenke type V scoliosis.

Discussion

Hence, the anatomical parameters trd and lngd of pedicles on the concave and convex sides at the apex of the primary deformity curve in patients with Lenke type V idiopathic scoliosis were greater than 4.0 mm. This indicates that bilateral total transpedicular fixation can be performed along the scoliosis curve. This feature was the fundamental difference from the scoliotic deformity in patients with Lenke type I scoliosis, in whom the average trd parameter of pedicles of the apical vertebrae on the concave side of the primary scoliosis curve was 3.6 mm.

An analysis of the KAtrd and KAlngd parameters of pedicles of the apical vertebrae showed that the KAtrd and KAlngd were 0.81–0.82 and 0.87–0.92, respectively. However, the greatest degree of asymmetry of bone structures of the vertebrae detected at the level of the apical vertebra in the thoracolumbar/lumbar scoliotic curve was characterized by the asymmetry coefficient of their areas (KAS, 0.67–0.68). It should be mentioned that the changes in KAS also significantly deviated from unity at the T4 (0.88), T6 (1.41), and T7 level (1.28), i.e., outside the primary scoliotic curve. No similar changes in KAS for the upper thoracic spine and the caudal segments of the lumbar spine were revealed by statistical analysis. The sensitivity of this coefficient to asymmetry of pedicles and the visualization of its structural changes in a diagram give grounds for considering it as an integral parameter that represents

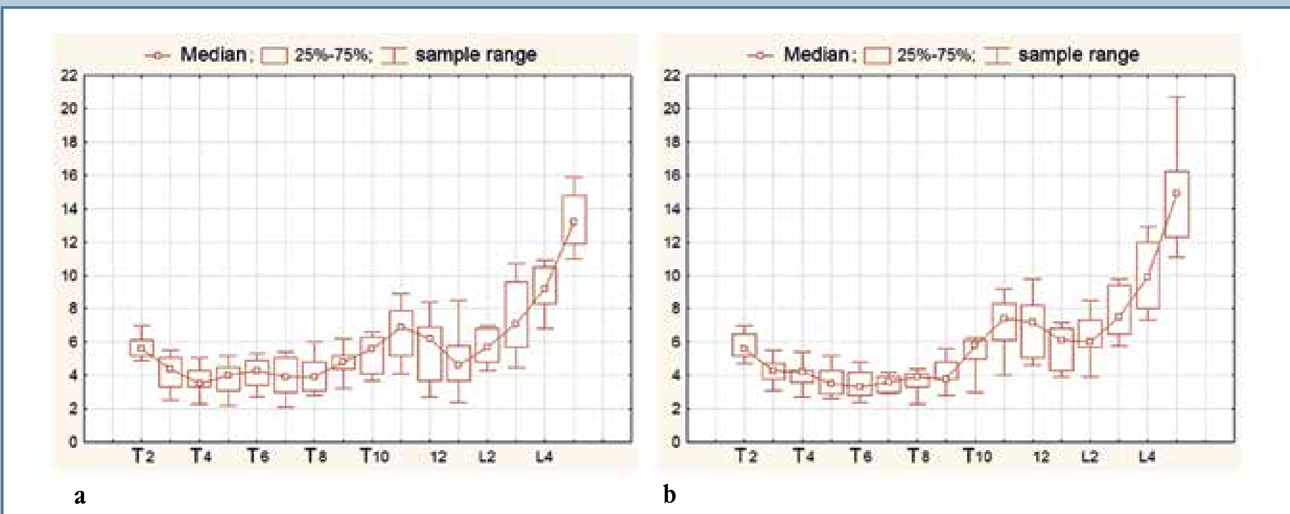


Fig. 1
Joint box plot for the transverse diameters of the right **(a)** and left **(b)** vertebral pedicles in the thoracic spine

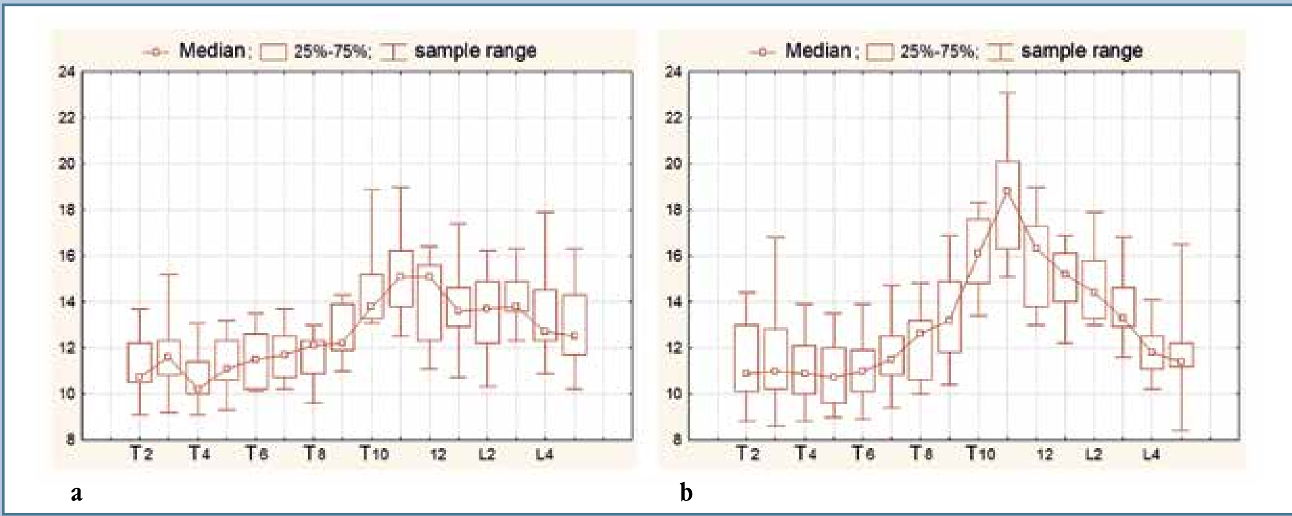


Fig. 2
Joint box plot for the longitudinal diameters of the right **(a)** and left **(b)** vertebral pedicles in the thoracic and lumbar spine

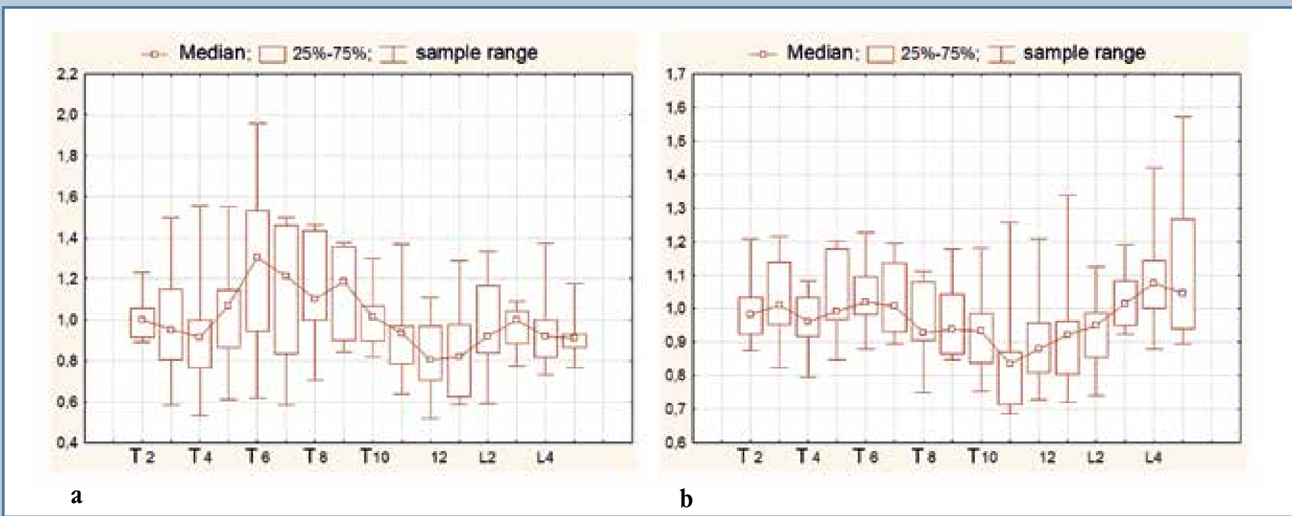


Fig. 3
Joint box plot for the asymmetry coefficients of the transverse **(a)** and longitudinal **(b)** diameters of vertebral pedicles in the thoracic and lumbar spine

the severity of scoliotic process in different types of scoliosis.

The correlation analysis using the method of correlation pleiades modified by V.P. Terentjev revealed the pleiade (RAV, Cobb angle, and KAlngd) that was previously identified in patients with idiopathic thoracic scoliosis. The regularities of the scoliotic process for Lenke type I and V scoliosis were similar as there was no correlation relationship between the Cobb angle and RAV and the trdR and KAtrd parameters of the apical vertebra. Correlation relationships between the AVtrdR, KAtrd, and KAS parameters were revealed in patients with Lenke type V scoliosis, indicating that the transverse diameter of pedicles of the apical vertebrae has a greater effect on KAS, the integral parameter of the degree of asymmetry in scoliosis.

The statistical analysis showed a statistically significant ($p < 0.05$) difference consisting in greater degree of asymmetry of the transverse and longitudinal diameters of pedicles of apical vertebrae in Lenke type I scoliosis compared to

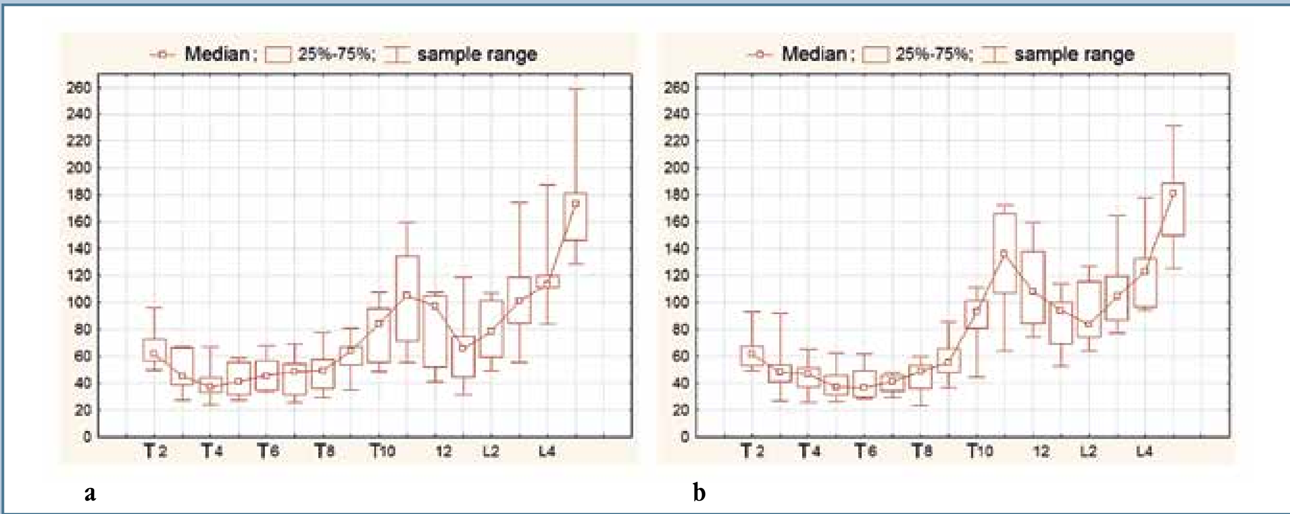


Fig. 4
Joint box plot for the areas of the diameters of the right **(a)** and left **(b)** vertebral pedicles in the thoracic and lumbar spine

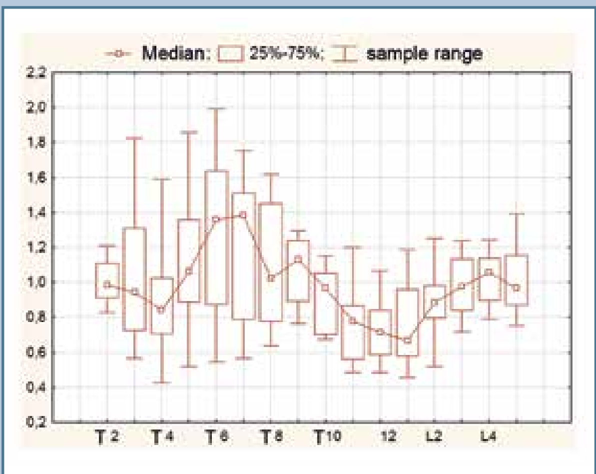


Fig. 5
Joint box plot for the asymmetry coefficients of the areas of vertebral pedicles in the thoracic and lumbar spine

those of the vertebrae in Lenke type V scoliosis. We believe that the features of the KAtrd, KAlngd, and KAS parameters identified by comparative analysis can be attributed to the fact that the character and course of scoliosis undoubtedly affects the anatomical and anthropometric parameters and spatial relationships between bone structures of the vertebrae in the primary scoliosis curve. In their turn, the differences between parameters of bone structures of vertebrae in the scoliosis curve being analyzed in patients with Lenke types I and V idiopathic scoliosis are caused by different localization of the primary scoliosis curve and the features of the anatomical structure of thoracic and lumbar vertebrae.

Conclusions

The analysis of the features of anatomical and anthropometric parameters of vertebrae in children with idiopathic thoracolumbar/lumbar left-sided scoliotic deformity using 3D-CT navigation revealed certain regularities and identified the correlation relationships between the absolute and relative values of vertebral parameters in patients with Lenke type V idiopathic scoliosis. Different degrees of asymmetry of bone structures of apical vertebrae were observed for the primary scoliotic curve localized in the thoracic and thoracolumbar/lumbar spine.

The anatomical dimensions of the transverse and longitudinal diameters of the vertebral pedicles on the concave and convex sides at the apex of the primary scoliosis curve were >4.0 mm, enabling bilateral total transpedicular fixation within the entire length of the scoliosis curve in this group of patients.

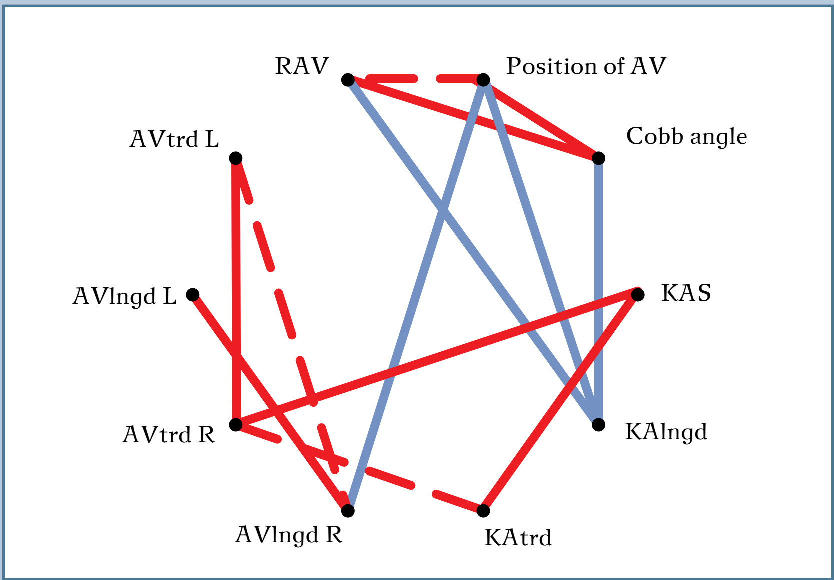
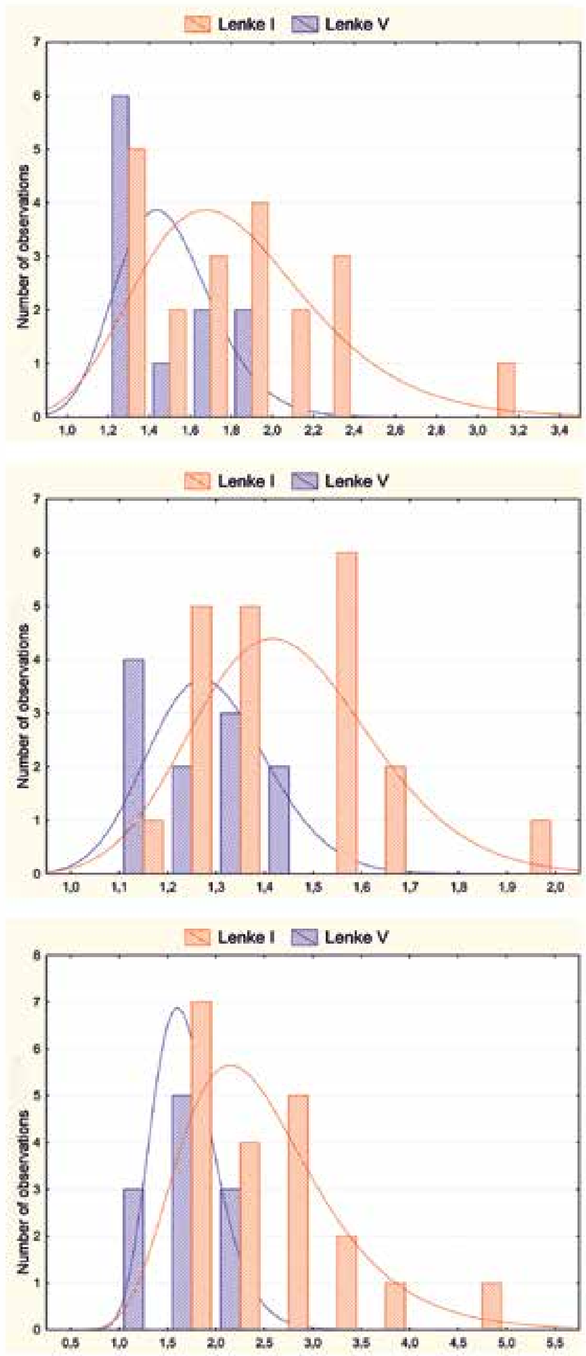


Fig. 6
Correlation relationships between the parameters being analyzed in patients with Lenke type V scoliosis; the relationships between parameters with the nonzero correlation coefficient r at the significance level $P < 0.05$: solid lines – the level $|r| > 0.8$; dashed lines – $|r| > 0.6$; line thickness is proportional to $|r|$; red lines – positive r values; blue lines – negative r values; RAV – rotation of the apical vertebra; AV – apical vertebra; L – left vertebral pedicle; R – right vertebral pedicle; trd – transverse diameter of vertebral pedicles; lngd – longitudinal diameter of vertebral pedicles; KAS – the asymmetry coefficient of the areas of vertebral pedicles; KAlngd – the asymmetry coefficient of the longitudinal diameters of vertebral pedicles; KAtrd – the asymmetry coefficient of the transverse diameters of vertebral pedicles

Table 4
Asymmetry coefficients of the apical vertebrae in patients with Lenke type I and V idiopathic scoliosis

Coefficient	Lenke I	Lenke V	t-test	F-test
KAtrd	1.77 (1.25; 3.11)	1.47 (1.26; 1.93)	p < 0.028	p = 0.168
KAlngd	1.44 (1.19; 1.90)	1.28 (1.12; 1.46)	p < 0.015	p = 0.337
KAS	2.36 (1.50; 4.73)	1.66 (1.16; 2.20)	p < 0.002	p = 0.129

KAtrd — the asymmetry coefficient of the transverse diameters of vertebral pedicles determined as the trdR/trdL ratio; KAlngd — the asymmetry coefficient of the longitudinal diameters of vertebral pedicles determined as the lngdR/lngdL ratio; KAS — the asymmetry coefficient of the areas of vertebral pedicles determined as the SR/SL ratio.



a

b

c

Fig. 7
Joint histogram showing the distribution of values of the asymmetry coefficients of the transverse diameters of vertebral pedicles **(a)**, asymmetry coefficient of the longitudinal diameters of the vertebral pedicles **(b)**, the asymmetry coefficient of the areas of vertebral pedicles **(c)** in groups of patients with Lenke type I and V idiopathic scoliosis : the envelope sampled values correspond to the lognormal distribution (the Kolmogorov–Smirnov test)

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