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Idiopathic scoliosis "syndromocomplex"

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Abstract

Introduction Multifactoriality in the etiology of idiopathic scoliosis (IS) requires an integrated approach to diagnosis, while the regular examination of patients is limited to radiography, computed tomography without a detailed analysis of the data obtained on the state of the musculoskeletal system. The problem of complex diagnosis of IS is practically not covered by the literature including the syndromic approach to the rationale for the method of treatment and rehabilitation. **Purpose of the study** To define the concept of "syndromocomplex" of idiopathic scoliosis based on the study of the state of the spine, muscles, proximal femur, bone mineral density (BMD), mineral metabolism and bone metabolism using current diagnostic methods. **Materials and methods** The state of the spine (300 patients), proximal femur (57 patients), paravertebral (40 patients) and gluteal muscles (60 patients of the main group and 40 of the control group) were studied using the method of multislice computed tomography (MSCT) and magnetic resonance imaging (MRI), densitometry − BMD (40 patients of the main and 40 of control one), mineral metabolism and bone metabolism were studied by biochemical methods in 55 patients with IS. **Results and discussion** The study of patients with idiopathic scoliosis at different ages and with different grades of deformities in various parts of the musculoskeletal system revealed pronounced disorders in the shape of the vertebrae, including an increase in the frontal diameter, wedge shape with a significant difference in density along the convex and concave sides, structural changes in the vertebrae, manifested in a decrease in density, the presence of rarefaction zones, areas of maximum density at the top of the deformity, malnutrition and fatty degeneration of the paravertebral and gluteal muscles, a decrease in BMD, a decrease in the density of the femoral head, impaired mineral metabolism and bone metabolism. **Conclusion** Severe disorders in the shape, X-ray morphological changes in the vertebrae, malnutrition and fatty degeneration of the paravertebral and gluteal muscles, concomitant changes in BMD, hip joint, mineral metabolism and bone metabolism, are included in the concept of "syndromocomplex" of idiopathic scoliosis, underlie the tactical concept for diagnosis, treatment and further rehabilitation measures for patients with severe forms of scoliosis.

Keywords: idiopathic scoliosis, vertebrae, muscles, mineral metabolism, densitometry, computed tomography, biochemical studies

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INTRODUCTION

Many works on the study of the etiology, pathogenesis, and clinical manifestations of idiopathic scoliosis (IS) state the multifactorial nature of this disease [1-5]. In a number of works, it is emphasized that such causes as defects in bone and muscle tissues, pathology of the central nervous system, impaired biomechanics, hormonal and biochemical abnormalities can be of great importance in the development of IS [2, 6-8]. There are many separate studies that have studied the state of muscles, vertebrae, BMD, and other deviations of the musculoskeletal system, where various changes in muscle and bone tissue, violation of biomechanical and biochemical parameters in patients with idiopathic scoliosis have been identified [5, 9-15]. However, a comprehensive study of changes in various components of the musculoskeletal system, mineral metabolism and bone tissue metabolism in one group of patients with idiopathic scoliosis in order to emphasize that pathological manifestations of IS occur in all patients with varying degrees of severity in regard to age and the magnitude of the spine deformity.

MATERIAL AND METHODS

The results of spinal deformity correction with internal transpedicular fixation using the Medtronic (75 %) (USA) and Orion (25 %) (England) systems in 2018-2021 were studied in 300 patients with idiopathic scoliosis of varying severity, aged 10 to 50 years. Inclusion criteria: idiopathic scoliosis with deformity from 25° to 130°, complete radiological archive. Exclusion criteria: presence of congenital pathology of the spine and spinal cord, scoliosis of another etiology, incomplete radiological archive. Multicenter retrospective study. The study is general in nature, based on previous studies.

The state of the spine (300 patients), the proximal femur (57 patients), paravertebral (40 patients) and gluteal muscles (60 of the main group and 40 of the control group) were studied by MSCT and MRI, BMD was studied by densitometry (40 patients of the main group and 40 of the control one), mineral metabolism and bone metabolism were studied with biochemical methods in 55 patients with IS.

Radiography

Radiography of the spine was taken in AP and lateral views in all the patients, along with bending test and after traction.

Multislice computer tomography (MSCT)

GEOPTIMACT660 (USA) was used for investigation.

Spine

Computed tomography was performed in all patients. MSCT images, including those with 3D reconstruction, were studied to reveal pathological changes in the vertebrae, including their density, dimensions, deformation of the spinal canal, and dimensions of the pedicles of the vertebral arches. MSCT data were used for degree of correction of the rotational component of scoliotic deformity.

Proximal femur

The condition of the proximal femur (total density of the femoral head, its central part, density in the region of the greater trochanter on the convex and concave sides of the deformity) was studied using a workstation and additional software programs using data of the MSCT radiological archive.

Muscles

Paravertebral muscles The density, thickness (length for m. Iliopsoas (ilio-lumbar), the main muscles of the body that involved in the function of the spine: m. erector spinae; m. longissimus thoracis) were studied. The thickness and density of muscles were determined according to the Hounsfield scale (HU) from the convex and concave sides of the deformity, at its apex. The quantitative and qualitative characteristics of the paravertebral muscles were studied at different levels, taking into account the apex of the deformity. Measurement of the area, thickness and density of uscles on axial sections and MPR was performed on sections perpendicular to its length. The muscle density was determined over the entire cross-sectional area, and the local muscle density in its sections was also studied.

Gluteal muscles To analyze the density and thickness of the gluteal muscles, the patients were divided into groups by age (under 18 and over 18 years old – 2.1 and 2.2) and by the degree of deformity (up to 60º and more than 60º – 1.1 and 1.2). The thickness and density of muscles were determined in Hounsfield units (HU) on the convex and concave sides of the deformity. Muscle density was determined over the entire cross-sectional area of the muscle. Moreover, the thickness and local density of the muscles were studied. To study the degree of change in the gluteal muscles, a “Method for quantitative assessment of the change in the gluteal muscles in patients with idiopathic scoliosis” was proposed [17].

Magnetic resonance imaging

The studies were carried out on a Signa HDXT magnetic resonance system (General Electronics) with a magnetic field power of 3.0 Tesla. T1-weighted (T1WI), T2-weighted (T2WI) images were used. The selected slice thickness was 3-4 mm with a cut interval of 0.5-1.0 mm. We also used the IDEAL algorithm for signal processing in tissues containing water and fat.

Densitometry

Studies were conducted on the GE Lunar Prodigy Primo Densitometer, the first digital densitometer for bone mineral density (BMD) and body composition assessment, using a Cadmium Zinc Telluride (CZT) detector array and narrow angle fan beam technology to minimize distortion with obtaining a "seamless" solid image of high quality; quick acquisition of scans (from 10 seconds); ultra-low doses of radiation.

Biochemical tests

Indicators of calcium metabolism (total and ionized calcium, parathormone, daily urine calcium), phosphorus, bone formation markers (alkaline phosphatase, osteocalcin, P1NP in the blood), morning urine DPD, blood 25(OH)D levels were studied before surgery in 55 patients. Biochemical studies were performed on an automatic biochemical analyzer VITROS 5.1FS (Orto-Clinical Diagnostics Johnson-Johnson), hormones were studied on automatic analyzers VITROS® ECIQ, mini Vidas, automated system Cobas E411.

The studies was carried out in accordance with the ethical standards of the Declaration of Helsinki of the World Medical Association "Ethical principles for conducting scientific medical research involving humans" as amended in 2013. All patients or their legal representatives signed an informed consent to the publication of data without their identification.

RESULTS

Anatomical and structural changes in the vertebrae, proximal femur, paravertebral and gluteal muscles, the state of mineral metabolism and bone metabolism in patients with idiopathic scoliosis of different ages and magnitude of deformities varied in both qualitative and quantitative indices. The pronounced alterations in the shape, including an increase in the frontal diameter, wedge shape with a significant difference in density along the convex and concave sides, structural changes in the vertebrae, the presence of rarefaction zones in the vertebral body and areas of maximum density at the apex of the deformity, hypotrophy and fatty degeneration of the paravertebral and gluteal muscles, concomitant changes in BMD, hip joint, mineral metabolism and bone metabolism, were united in the concept of "idiopathic scoliosis syndromocomplex", which presents a different approach to the choice of tactics of preoperative preparation, details of surgical intervention and postoperative rehabilitation program.

The syndromacomplex of idiopathic scoliosis includes:

1. Radiographic morphological changes in vertebrae

1.1. An increase in the ratio of the frontal diameter of the apical vertebra to the sagittal one depended on the magnitude of the deformity and indicated a change in the shape of the vertebrae and their displacement in the axial plane, what must be assessed due to the three-dimensional nature of the deformity [18].

1.2. The height of the vertebra along the convex side in deformity of 60–80° is by 22.3 ± 1.7 % greater than that along the concave side, the difference increased to 28.9 ± 2.1 % in a deformity of more than 90° [18].

1.3. In any magnitude of deformity, the maximum density of the vertebrae was higher along the concave side of the deformity, the minimum density was higher along the concave side only in the thoracic region, and the average density differed significantly only at a deformity of 60-90° in the thoracic region. In patients with a deformity greater than 90°, the maximum total density of the vertebral bodies on the concave side differed from the density on the convex side by a greater amount than in those with smaller deformities ($p < 0.01$). The density of the compact layer along the concave side at a eformation of 70-90° was 2-2.5 times greater than that along the convex side. In the center of the compact layer of the vertebra the maximum values reached 752 ± 19.4 HU by measuring the density along the concave side in the sagittal plane, [19].

1.4. In S-shaped scoliosis with a deformity of 90° in the thoracic region and 110° in the thoracolumbar region, the density of the apical vertebra along the convex and concave sides in the lumbar region differed significantly ($p < 0.01$), while in the thoracic region the differences were insignificant ($p > 0.05$). By a Th-L deformity of 55-75°, the density of the apical vertebra differed significantly in the region of the lumbar curve ($p < 0.01$) and vertebrae in the thoracic region ($p < 0.05$). In patients with Lenke type 2 scoliosis, the density of the compact layer of the apical vertebra on the concave side with a deformity of Th 90-110° was 42.1 % higher than on the convex side. In deformity of Th 55-75°, it was only by 15 %, in Th 35-40° curve by 29 %.

A direct relationship was found between the density of the compact bone along the convex and concave sides and the magnitude of the deformity in both Lenke type 3 scoliosis and Lenke type 2 scoliosis, but in the second type, the differences in density were smaller [18].

1.5. The overall density of the apical vertebra had a direct dependence on the magnitude of the deformity with significant differences in the convex and concave surfaces ($p < 001$; $p < 0.01$ for different degrees of curvature), except for the deformity of 90-110° in the thoracic region ($p > 0.05$). Spongy bone density in the middle part of the vertebra, when measured on the axial section in the thoracic region, increased from the minimum (on the convex side) to the maximum (on the concave surface) by an amount depending on the magnitude of the deformity, and had a maximum difference of 76 % at a deformity of 90-110°. In scoliosis (Lenke type 3) in the lumbar spine, the density decreased depending on the magnitude of the deformity from its maximum value on the concave side to its minimum value on the convex side (maximum by 72 % at a deformity of 90–110°) [18].

2. Radiographic morphological changes in the proximal femur and their relation with the magnitude of spinal deformity

2.1. In patients with Lenke type 2 scoliosis, when the agnitude of the deformity is not more than 40°, the total density of the femoral head on both sides did not have significant differences. In a deformity of 70-90°, the total density of the femoral head on the side of the convex deformity was greater than on the concave side ($p < 0.01$). In S-shaped scoliosis, the density of the femoral head is approximately the same on both sides [13].

2.2. When the deformity is less than 40°, the difference in the density of the central part of the head from the concave and convex sides in patients is not significant. If deformity ranged 70–90°, the density of the central part of the head on the convex side was higher than on the concave side [13].

2.3. In the area of the greater trochanter, the density of the femur in patients with IS, as in the norm, was lower than the formations surrounding this area. In deformity of 30-40°, the density in the area of the greater trochanter on the convex and concave sides did not differ significantly. A significant difference between the bone density in the region of the trochanter with convex and concave sides was found in deformities of 60° or more [13].

2.4. The density of the ischial bone in C-shaped scoliosis with a spinal deformity of 30-40 degrees differed slightly. As the deformity increased to 70-90° (scoliosis Lenke type 2), the differences increased to statistically significant values. In patients with Lenke type 3 scoliosis, statistically significant differences were not recorded [13].

2.5. ***Changes in bone mineral density*** As the magnitude of spinal deformity increased in children with idiopathic scoliosis aged 11 to 18 years, a trend towards an increase in the number of patients with reduced BMD of the spine and proximal femur was revealed. Pathological changes in the bone tissue were revealed, characterized by low values of mineral density according to the Z-criterion by 2.3 times. In adult patients with increasing severity of scoliosis, especially with deformities greater than 90°, T-score ranged from (-2) to (-2.5). This indicates the need to control the state of bone mineral density, given the importance of this indicator for preventing implant displacement.

3. Radiographic morphological and MRI changes in the paravertebral and gluteal muscles in patients with different deformity magnitudes

*3.1. **Paravertebral muscles***

3.1.1. The density of the paravertebral muscles in patients with IS did not depend on the age of the patient, as in the norm, but was determined by the magnitude of the deformity. The maximum differences in the average density of the paravertebral muscles along the convex and concave sides were noted at a deformity of 90-120°. The most complex dependence on the level and degree of deformation is typical for m. iliopsoas. Even in deformity of 40-45º, the length of the muscle increased by 25-30 %, and the thickness decreased [20].

3.1.2. A significant decrease in density associated with fatty degeneration, a decrease in the length and thickness of muscles, especially along the inner surface of the curvature, was noted for S-shaped deformity of 90º or more. At the level of the apical vertebrae, changes in the paravertebral muscles were most pronounced [20].

3.1.3. In patients with spinal deformity within 40º, changes in the paravertebral muscles were characterized by moderate hypotrophy, and differences in their density from the convex and concave sides were not significant. In deformity of more than 100º, the length and thickness of the muscles along the concave side of the deformity were 75-120 % less. In addition, there was significant fatty degeneration of the paraspinal muscles, especially in the lumbar region. Pronounced anatomical changes are characteristic of m. iliopsoas, located in the zone of maximum curvature [20].

3.1.4. MRI of the paraspinal muscles made could identify the degree of fatty degeneration as accurately as possible by assessing the intensity of the signal. Analysis of T2-weighted MRI of the paravertebral muscles of the spine in patients with idiopathic scoliosis showed significant fatty infiltration, especially on the concave side. In addition, the more caudally the paravertebral muscles were located in the lumbar region, the higher the signal was recorded in areas with fatty degeneration. The data obtained are a useful tool for measuring the degree of paravertebral muscle degeneration. The signal intensity (295.9 ± 57.1) and the area of fatty infiltration (41.3 ± 8.2 %) of the spine muscles in patients with idiopathic scoliosis were significantly higher on the concave side than on the convex side (179.1 ± 26.5 % and 15.9 ± 3.2 %, respectively). These differences were more significant at the L3 to L4 level, where the intensity of the signal from adipose tissue was 1038.5 ± 97.5, for muscles – 419.8 ± 21.4. The total area of high signal (fatty degeneration) ranged from 33 to 42 %, which refers to "minor" fatty infiltration [21, 22].

*3.2. **Changes in gluteal muscles. MSCT findings***

3.2.1. Densitometric density of the gluteal muscles in patients with IS had a direct dependence on the magnitude of the deformity, but the density and cross section of the muscles were more often changed on both sides and depended more on the duration of the disease (age of the patients), in contrast to the paraspinal muscles. In patients with IS over the age of 18, muscle density decreased in any magnitude of the deformity, but the differences were not equivalent for different muscles. In patients under the age of 18 with spinal deformities of 40-45º, the density of the gluteus medius muscle was increased on both sides, and the gluteus minimus muscle was 44-49 % more dense on the convex side of the deformity. In patients older than 18 years, the density of the gluteal muscles increased by a larger amount in comparison with normal age indices [17, 23].

3.2.2. In right-sided scoliosis, there was a difference in the length and thickness of the gluteal muscles with slight differences in signal intensity on the right (MRI). The length of the muscles in patients with a curve in the thoracic region and an anti-arc in the lumbar region was almost the same. The thickness on the right was somewhat bigger. In idiopathic scoliosis (type 3 according to Lenke) and small value of scoliotic curves, the thickness and area of the gluteal muscles on the right and left almost did not differ. Determining the area and intensity of the signal with the construction of histograms, a small difference in the height of the signal in the gluteal muscle was revealed (higher on the left than on the right – 161.7 ± 8.2) [23].

3.2.3. The complex of anatomical and structural changes in the gluteal muscles in patients with IS included changes in the shape, muscle density, architectonics, hypotrophy of varying degrees and atrophic changes, and fatty degeneration. The minimus and medius gluteal muscles were more prone to hypotrophy (atrophy) with an increase in densitometric density, the gluteus maximus muscle was more susceptible to moderately pronounced hypotrophy with a violation of the structure of the muscle belly and fatty degeneration. MRI revealed a difference in the length of the gluteal muscles in patients with right-sided idiopathic scoliosis against the background of a slight increase in signal intensity [23].

4. Calcium metabolism and markers of bone formation in relation to patients' age and deformity magnitude

4.1. ***Indicators of calcium metabolism and markers of bone formation in patients with idiopathic scoliosis in relation to age*** Changes in calcium metabolism (decrease in calcium excretion with daily urine at normal levels of calcium in the blood) were found in 30 % of patients. The resorption markers, deoxypyridinoline and osteocalcin, were within the reference values in all patients, but alkaline phosphatase, P1NP in the blood were significantly higher than normal in all patients under the age of 18 years; in patients older than 18 years, alkaline phosphatase had normal values. The level of vitamin D (25(OH)D) in patients under the age of 18 did not exceed 8-13 ng/ml, which is regarded as a deficit, in adult patients it was reduced to 15-19 ng/ml, which corresponds to deficiency. In summary, it can be noted that markers of bone metabolism in patients with idiopathic scoliosis in childhood differ from those in adult patients [24].

4.2. ***Changes in calcium metabolism and bone formation markers in patients with idiopathic scoliosis in relation to the grade of the deformity***

Patients were divided into three groups: deformity of 25-40° (Group 1), 40-60° (Group 2) and more than 60° (Group 3) (n = 30).

In spinal deformity up to 40 degrees, the level of alkaline phosphatase and P1NP were higher than normal ($p < 0.05$), in the second and third groups they did not differ from the normal level. This characterizes the high-turnover type of bone remodeling in patients of the first group, which consisted mainly of patients under the age of 18 years, which is an indication for studying vertebral BMD in these patients. As for vitamin D, in the first group there was a deficit, and in the second and third, its level could be regarded as a deficiency. A higher excretion of deoxypyridinoline (DPD) was noted in the group of patients with a deformity of more than 60°, which is an indicator of a high rate of bone resorption. A similar relationship was found for blood phosphorus levels, which confirms the change in the processes of synthesis and resorption in the bone in patients of the third group, which included older patients [25].

The changes in the spine, separate vertebrae, muscles, in the state of the proximal femur, BMD, calcium metabolism and bone metabolism were included by us into the concept of "syndromocomplex" of idiopathic scoliosis (Fig. 1).

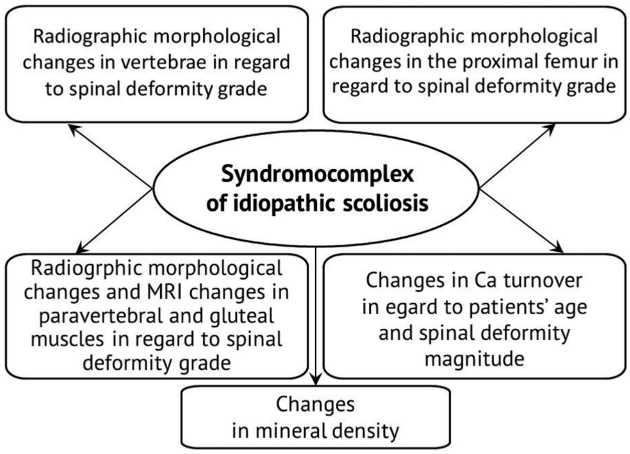

Fig. 1 Sundromocomplex of idiopathic scoliosis

DISCUSSION

These conducted studies have shown how diverse are the changes in the vertebrae in different types of scoliosis and deformity magnitude. In severe spinal deformities, a pronounced distortion of the shape, an increase in the frontal diameter, a change in the density of the spongy part and the cortical layer, torsion of grades 3 and 4 [26] was observed in the apical vertebrae, which was accompanied by a violation of the symmetry of the pedicles of the vertebral arches and a pronounced wedge-shaped deformity of the vertebral body. The introduction of implants was a significant difficulty without a detailed study of the anatomical and radiographic morphological changes in the vertebrae. Proper fixation of the apical vertebrae prevents rotation and fracture of the pins. Knowledge of the mineral density of the vertebrae, their density is essential to determine the fixation points in order to prevent implant displacement, and in particular, to select their diameter [27]. Depending on the level of fixation and if the pedicle of the vertebral arch allows, it is necessary to use an implant with a larger diameter in the zone with a lower density to obtain a more reliable fixation [27]. Information on the shape of the vertebrae and size of the pedicle of the arch is necessary for planning the direction and angle of implant insertion. It is required to consider the torsion of the vertebrae with concomitant changes in the pedicles of the arches through which the implants are inserted into the vertebral body. The data obtained also enable to determine the extent and level of fixation, which in most cases was limited to Th2-L2 (L3, L4), without low stabilization, focusing on accurate data on the extent of the scoliotic curves, the location and condition of the apical vertebra, neutral caudal and cranial vertebrae, their structural characteristics. A detailed preoperative MSCT study of changes in the vertebrae may reveal all the nuances of their anatomy and architectonics and guarantee a good result and prevent postoperative complications. It is also necessary to take into account the change in the hip joint, which, together with the deformity of the spine, affects the supporting function of the limb and the biomechanics of the feet [28].

It is known that the paravertebral muscles play an important role in maintaining the physiological shape of the spine and the development of its pathological conditions [29]. Paravertebral muscles feature multifunctionality and organic connection with the spine. These muscles are not only a functional, but also a structural element of the spine, without which its strength would be minimal [30]. MSCT and MRI of the spine revealed anatomical and structural changes in the paravertebral muscles, including asymmetry of longitudinal dimensions and thickness, differences in muscle density on the convex and concave sides, fibrous and fatty degeneration in patients with IS, associated with the magnitude and level of deformity, which coincides with the data of Rybka et al. and Jiang et al. [31, 32]. Morphological studies also confirm changes in the paravertebral muscles and their dependence on the magnitude of the deformity [33]. The changes, in our opinion, are included in the concept of "syndromocomplex of idiopathic scoliosis", should be taken into account when assessing its severity and planning the operation. In particular, the surgical intervention should cause minimal trauma to the paravertebral muscles on the concave side of the deformity, where they are maximally changed [34]. It is possible that additional preparation for the operation (electrical stimulation, exercise therapy) is necessary if massive fibrosis or fatty degeneration of the paravertebral muscles is detected, and long-term rehabilitation or even bracing for a certain period of time after the operation.

Due to the changes revealed and the role of the gluteal muscles in the functioning of the spine and hip joints, not only preoperative preparation of patients with pronounced changes in the gluteal muscles is necessary, but also a long-term rehabilitation in the postoperative period. A balanced state of the gluteal muscles plays a huge role in maintaining the correct stereotype of an upright position, sitting, and movements in the lower extremities [35]. Hypotrophy, fatty degeneration, a decrease or increase in the tone of the gluteal muscles lead to a violation of the physiological lordosis at the lumbosacral level, contribute to hypertone of the iliopsoas muscles, leading to changes in the hip joints and spine. The developed complexes of exercise therapy, kinesitherapy, which must be used in patients with IS before and after surgery, contribute to the normalization of the tone of the gluteal muscles, elimination of imbalance, formation of the physiological biomechanics of the hip joint, and improve the function of the spine.

The analysis of mineral metabolism and bone metabolism in patients with IS revealed disorders associated with both calcium and phosphorus metabolism and changes in alkaline phosphatase, vitamin 25(OH)D, P1NP, deoxypyridinoline (DPD) levels, which coincides with the data of Bakhtina et al. [36].

In this regard, the question arises about the correction of such disorders, in particular of vitamin 25(OH)D, the level of which is reduced especially in children and can be relatively easily compensated to prevent the consequences of its deficiency. The "Draft Federal Clinical Guidelines for the Diagnosis, Treatment and Prevention of Vitamin D Deficiency" states that vitamin D deficiency is a condition characterized by a decrease in serum 25(OH)D concentrations below optimal values, which can potentially lead to suboptimal absorption calcium in the intestine, the development of secondary hyperparathyroidism and an increased risk of fractures, especially in the elderly [37]. According to Heaney and Holick et al., vitamin D deficiency leads to impaired calcium-phosphorus and bone metabolism. Due to a decrease in the absorption of dietary calcium in the intestine, the level of PTH increases and secondary hyperparathyroidism develops, which maintains a normal level of blood serum calcium by mobilizing it from the skeleton [38, 39]. This is extremely dangerous for patients with IS, since a decrease in bone mineral density can lead to displacement of the implants inserted into the vertebrae and slow down the formation of a bone fusion [40]. Moreover, vitamin D deficiency leads to myopathy, which is also highly undesirable in the treatment of patients with IS. Thus, the need to study vitamin D in patients with IS is extremely important for the timely normalization of its level. If vitamin D deficiency (25(OH)D) is detected, it is recommended to evaluate the levels of calcium corrected for albumin, phosphorus, alkaline phosphatase, PTH, creatinine, and magnesium in the blood serum [41]. All these tests were done in the examined groups of patients, except of magnesium.

CONCLUSION

Severe disorders in the shape, including an increase in the frontal diameter, radiological morphological changes in the vertebrae, manifested in a decrease in density, the presence of rarefaction zones in the vertebral body and areas of maximum density at the top of the deformity, hypotrophy and fatty degeneration of the paravertebral and gluteal muscles, concomitant changes in BMD, hip joint, mineral metabolism and bone metabolism, are included in the concept of "syndromocomplex" of idiopathic scoliosis, underlie the tactical concept for the diagnosis, treatment and further rehabilitation measures in patients with severe types of scoliosis.

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