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OSTEOPENIC SYNDROME IN CHILDHOOD AS PART OF A TRAUMATOLOGIST - ORTHOPEDIST PRACTICE IN POLYCLINIC

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Abstract

The authors of the article noted a trend associated with bone tissue physiological remodeling violation in a certain group of children during their scientific and practical activities. These are patients with a previously diagnosed hereditary connective tissue disorder. Monitoring of patients with osteopenic syndrome against the connective tissue developmenthereditary disorders background was organized. The authors have developed some algorithms and approaches to improve treatment and rehabilitation, preventive measures in children with this condition. The research process was based on the observations of 30 patients with osteopenic syndrome against the background of connective tissue development hereditary disorders. The work was carried out in the period from 2015 to 2020. It should be noted that hereditary disorders of connective tissue development in childhood have the form of a systemic disease, including bone structures, which is based on incorrect, perverse development of connective tissue. All the patients we examined had a history of limbs and spine fractures. During dynamic observation, the main clinical symptoms of the pathological process were characterized by the presence of curved limbs due to multiple fractures in each patient's anamnesis,

muscle hypotension, incorrect posture (scoliotic, kyphotic, kyphoscoliotic, flat back). Additional examination methods conclusions (laboratory, x-ray, stabilometric, electroneuromiographic, densitometric) confirmed the diagnosis. The treatment and rehabilitation activities carried out allowed achieving desired dynamics and improve the child's life quality. Analysis of pathological process and treatment approaches basic manifestations is necessary not only for traumatologists - orthopedists, working at children's clinics, but also, especially, for pediatricians at polyclinic districts. Early detection of connective tissue pathology, bone structure density allows minimizing a number of further, likely complications, such as osteochondropathy, kyphoscoliosis, juvenile osteochondrosis, and other manifestations.

Keywords

Osteopenic syndrome – *Osteoporosis* – Connective tissue – Bone structure density

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Introduction

In the contemporary context, children's doctors , children's traumatologists - orthopedists, pediatricians focus on bone density and dysplastic background issues[1]. This is relevant, due to an increase in the frequency of abnormalities in bone structures development, changes in pathological processes course in skeleton, connective tissue[2].. Currently, the analysis of body's bone and cartilage system congenital and acquired diseases has become more thorough, including its connection with the development and implementation of modern additional research methods, technical equipment, and computerization. We observe a «different» contingent of patients with bone and joint system diseases. Considerable attention is paid to the hereditary dysplastic processes, bone and joint system malformations study, occuring during periods of child's intensive linear growth. It should be noted that the main part of hereditary dysplastic disorders are congenital abnormalities in bone structures. The growth of pathological changes associated with the dysplastic background state in a child is observed[3]. Increasingly, hereditary disorders of connective tissue development in childhood are often manifested by changes in the bone and joint apparatus. *«Dysplastic process»* concept refers to an incorrect, perverse development. Their main mass consists of congenital malformations in skeletal formations. Bone dysplasia is diverse and variable[4]. *«Osteopenic syndrome»* term is presented in a collective concept. It indicates a slight decrease in bone density without detailing the causes and nature of structural changes[5]. However, more often, osteopenic syndrome is represented as the result of bone tissue metabolism, synthesis and resorption violation[6]. A number of authors suggest considering osteopenic syndrome as a preclinical stage of osteoporosis. The osteoporosis is called a disease characterized by reduced bone mass, impaired bone microarchitecture,leading further to bone strength decrease, propensity to fractures[7]. All these basic aspects, according to the authors, served as a scientific springboard to writing the presented article. The following special terminology was used in the article. *Pediatrics (pediatria)* is a field of clinical medicine, studying children's health in the process of their development, childhood physiology and pathology, as well as developing methods for childhood diseases diagnosis, prevention and treatment. *Hereditary disorders of connective tissue development* are systemic diseases of the skeletal structure with certain disorders, including in the supporting tissues and their progression during child's intensive linear growth periods, skeleton formation. *Remedial gymnastics* is a medical discipline that uses and includes means of physical culture for patients' treatment and rehabilitation

[1] L. S. Evert; S. V. Borozdun; E. I. Bobrova et al., “Diagnostics of connective tissue dysplasia using biomarkers”, Journal of the Siberian Federal University. Series: Chemistry num 4 (2009): 385-390.
[2] A. V. Aksenov, “Blood serum microelement composition features in children with juvenile arthritis living in the city of Chelyabinsk”, Modern problems of science and education num 6 (2012): 200-215
[3] Z. S. Gulieva, “Undifferentiated connective tissue dysplasia as a risk factor for miscarriage in early pregnancy”, Bulletin of the Ivanovo Medical Academy num 2 (2013): 39-41.
[4] V. F. Demin, “Significance of connective tissue dysplasia in childhood pathology”, Modern Pediatrics Issues Vol:4 num1 (2005): 45-55
[5] E. V. Zemtsovsky, “Diagnostics and treatment of connective tissue dysplasia”, Medical Bulletin Vol:354 num 11 (2006): 12-13
[6] T. I. Kadurina y L. N. Abbakumova, “Undifferentiated connective tissue dysplasia severity assessment in children”, Medical Bulletin of the North Caucasus num 2 (2008): 15-20; T. I. Kadurina, “Connective tissue dysplasia: path to diagnosis”, Bulletin of the Ivanovo Medical Academy num 3 (2014): 5-11.
[7] A. V. Kazanbayeva, “Connective tissue dysplasia”, International Student Scientific Bulletin num 4 (2018): 3-6

purpose, as well as pathological conditions prevention. *Prophylactic medical examination* is represented by a system of therapeutic and preventive measures carried out in order to preserve and strengthen people's health, ensuring high performance of the population. *Osteopenic syndrome* is a concept used to denote a decrease in x-ray shadow density, when performing hands radiography, a decrease in bone mass, which is determined by densitometry[8]. *Osteoporosis* is a systemic skeletondisease in which there is a decrease in bone mass per unit volume, impaired microarchitecture of the bone, further leading to increased bone fragility, risk of fracture from minimal trauma or spontaneously, without injury[9].

Methods

Research aim. The aim of our work was to identify the probability of osteopenic syndrome in children, including against the background of connective tissue development hereditary disorders, with patients' monitoring creation, increase treatment and rehabilitation measures effectiveness in this group of patients.

Our research is represented by the observation of 30 patients with osteopenic syndrome against hereditary connective tissue disorders background (the main group) and 30 patients without background pathology (the control group). The emphasis was placed on the bone tissue structural and functional state. All patients were treated at the city children's trauma center on the basis of the city children's polyclinic in the period from 2015 to 2020.

Among the children in the groups there were 16 boys and 14 girls. Hereditary connective tissue development disorder was detected from birth in all children in the main group. The patients' age was from 6 to 14 years. The control group included 30 children who went to the trauma center after some minor injury to the soft tissue component without background pathology.

Clinical and x-ray research methods, biochemical, densitometric, magnetic resonance imaging, electroneuromyographic method, and stabilographic methods were used in our research. Work with patients was based on their orthopedic status analysis, complaints analysis, life history, anthropometry, physical and mental development assessment, phenotypic signs of hereditary connective tissue disorders on the part of the musculoskeletal system and dysplastic processes' visceral manifestations identification. X-ray examinations of various parts of the skeleton, including the spine, were performed in all patients. All x-ray examinations were performed on the Prestige 1S device. During x-ray examinations, the patient was placed with the device centered on the damaged spine - lying on his stomach and on his left side.

Quantitative bone densitometry method allowed to identify the bone mass loss, evaluate the pathological process dynamics, and the therapeutic measures effectiveness. Two-energy x-ray absorption (DEXA) was used in our work.

[8] N. R. Kech; O. Z. Hnatejko; H. V. Makukh, et al., “Role of the genetic component in osteopenic syndrome pathogenesis in children from regions with a polluted environment”, Cytology and Genetics Vol: 52 num 1 (2018): 46-53

[9] M. Li; F. Wan; J. Liu et al., “Analysis of Clinical Risk Factors for Refracture in Osteoporosis”, Journal of Medical Imaging and Health Informatics Vol: 10 num (2020): 2337-2341.

Bone mineral density was measured using a GE Lunar Corp bone densitometer (USA). The method allowed to determine the bone mineral content in any part of the skeleton[10].

Magnetic resonance imaging (MRI) made it possible to visualize intervertebral discs, ligaments, and the spinal cord. The study was performed in direct and lateral projections on a 0.5 Tl MP tomograph «GyroscanT5-II».

The electroneuromyographic method determined the muscles', straightening the spine, bioelectric activity. The study was performed on the device «Neuro-EMG-Micro» (Neurosoft, Russia, 2001). Electroneuromyography refers to methods for recording muscles' electrical activity, using electrodes inserted into muscle fibers. The received data in the form of a curve is recorded on an oscilloscope. A more modern method of neuromuscular system studying by registering spontaneous potentials is classified as classical, based on simultaneous stimulation of nerves and registration of muscles' stimulating electrical activity. The neuromuscular system is a single complex that includes skeletal muscles and segmental - peripheral formations in the nervous system. A functional (motor) unit of the neuromuscular system is called a formation consisting of a single motor neuron, its axon, and innervated muscle fibers. At rest, muscles' electrical activity does not occur, but with volitional or reflex action, their contractile force increases, their intensity can be determined using skin or needle electrodes. In our patients, an atraumatic subcutaneous method of fixing electrodes was used. In various pathological conditions, including postural disorders, electroneuromyographic studies allowed carrying out differential diagnostic analysis[11].

Stabilographic examination allowed us to determine the gravity center projection relative to the support area. Stabilographic examination method is based on the load distribution on the feet registration, allowing to estimate its value on the front and back of each foot. Gravity center projection on the support area was recorded as graphic images. The obtained indicators of stabilographic examinations were used for objective evaluation of the treatment and rehabilitation measures effectiveness. Before the stabilographic examination, anthropological measurements of height and body weight were performed in the groups. the distance between the antero - upper pelvic bones in the frontal plane was measured, which was closest to the distance between the centers of the hip joints and the true base between the loads axes on the lower extremities. To assess the patient's vertical posture, a stabilography method was used based on recording the projection of the general gravity center of the body on the support plane. The study used a computer diagnostic system «Stabilan-01» (Regional Krai Hospital «Rhythm», Taganrog).

Ultrasound examinations have become widespread in diseasesdiagnosis and musculoskeletal system injuries in childhood. In this case, the ultrasonic vibrations beam of 1.6-7.5 MHz, directed deep into the child's tissues, is reflected from structures of different densities in various ways. Thus, gaseous substances slow down the ultrasound propagation, and solids conduct and reflect it.

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[10] A. I. Strukov, Systemic diseases of connective tissue. In book: Pathological anatomy. Eit by A. I. Strukov, V. V. Serov. Moscow: Lana. 1993: 300-310; Torshin, I. Yu. “Connective tissue dysplasia, cell biology and molecular mechanisms of magnesium exposure”. Rus. med. zhurn.: selected lectures for family doctors Vol: 16 num 4 (2008): 7-8.

[11] T. D. Tyabut y O. M. Karatysh, “Undifferentiated connective tissue dysplasia”. Modern rheumatology num 2 (2009): 19-23; E. V. Zemtsovsky, “Diagnostics and treatment of connective tissue dysplasia”. Medical Bulletin Vol:354 num 11 (2006): 12-13.

Ultrasound diagnostics methods have been introduced into clinical practice in order to study the diagnostic capabilities of ultrasound examinations for posture violations in the frontal plane, scoliotic deformities, spinal osteochondropathies in children and to assess the soft tissue structures severity. Patients of the main group and the control group were examined.

In case of spinal injury, the examination was performed on a LogiqBook ultrasound scanner (General Electric, USA, 2004) using a multi-frequency linear sensor (6.0-10.0 MHz) with a base frequency of 8.0 MHz with dorsal access. Access was performed in the position of the patient lying on his stomach with his arms bent at the elbow joints and his head resting on the forehead.

During laboratory studies, the levels of calcium, phosphorus, alkaline phosphatase in the blood serum, oxyprolines, calcium and phosphorus in the urine are reflected. For blood and urine biochemical tests, an automatic biochemical analyzer HITACHI-911E, a semi-automatic photometer Epo11 - 20 from ECO-MED-POLL and a spectrophotometer SF - 46 were used. The following list of methods was used: total calcium determination in blood serum and urine, inorganic phosphorus in blood and urine, alkaline phosphatase in blood, oxyproline in blood and urine.

Results and discussion

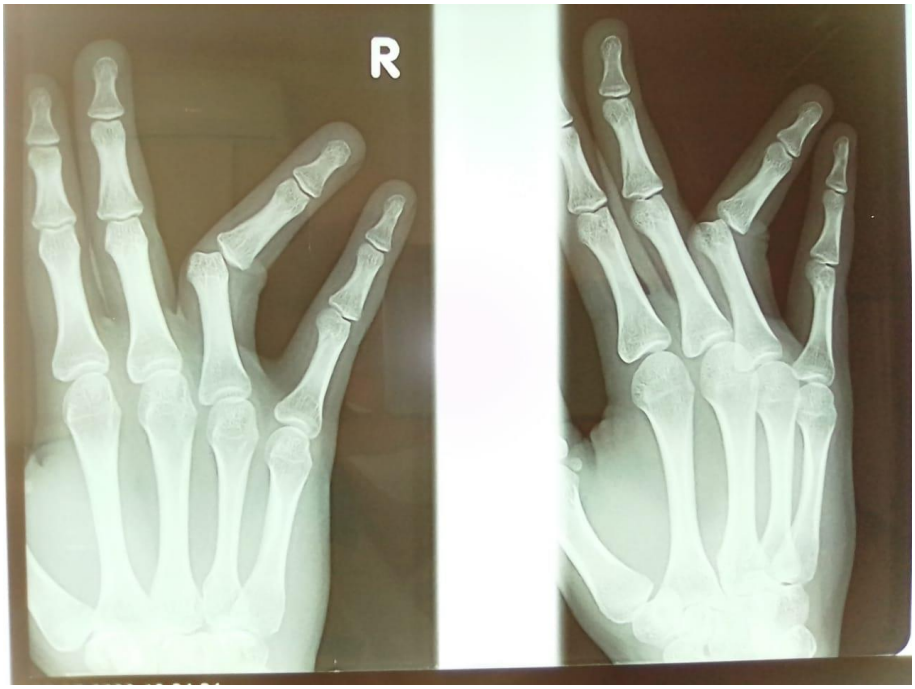
When examining children in the main group using generally accepted methodological approaches in medicine, patients complained of rapid fatigue, pain in the lower legs and spine. In 100% of cases, there was a history of extremities and spine fractures, muscle hypotension, impaired posture, more often by kyphoscoliotic type (Table 1).

Indicators	Main group (n=30), abs. (%)	Control group (n=30), abs. (%)	P_{1-2}
	1	2	
Pathological symptoms 1	30 (100,0)	3 (10,0)	**<0,001**
Pathological symptoms 2	30 (100,0)	0 (0,0)	**<0,001**
Postural disorders	30 (100,0)	0 (0,0)	**<0,001**

Note: Pathological symptoms 1 – pre-existing upper and lower extremitiews bones, spinal fractures. Pathological symptoms 2 – hypomyotonia, impaired posture by kyphoscoliotic type.

Table 1
Pathological symptomatology in groups

All 30 participants from the main group had pre-existing fractures in «critical regions», 20 patients had distal radius bone fractures, 6 patients had diacondylar fractures in upper arm bones, 4 patients had pre-existing finger bones dislocation (Fig.1).
Figure 1. Transcondylar fracture of the humerus (upper arm bone). Boy. 10 years. 4th finger of the hand middle phalanx dislocation. Girl. 12 years.



In 80% of cases the nature and mechanism of the damage did not correspond to the classic ones. According to our observations, the complicated fractures frequency, as well as those that are not typical for children – pinned or splintered, has increased to 20%. Radial bones fractures and compression fractures of the vertebrae were 1.5 times more common in boys aged 8 to 12 years (Fig. 2).

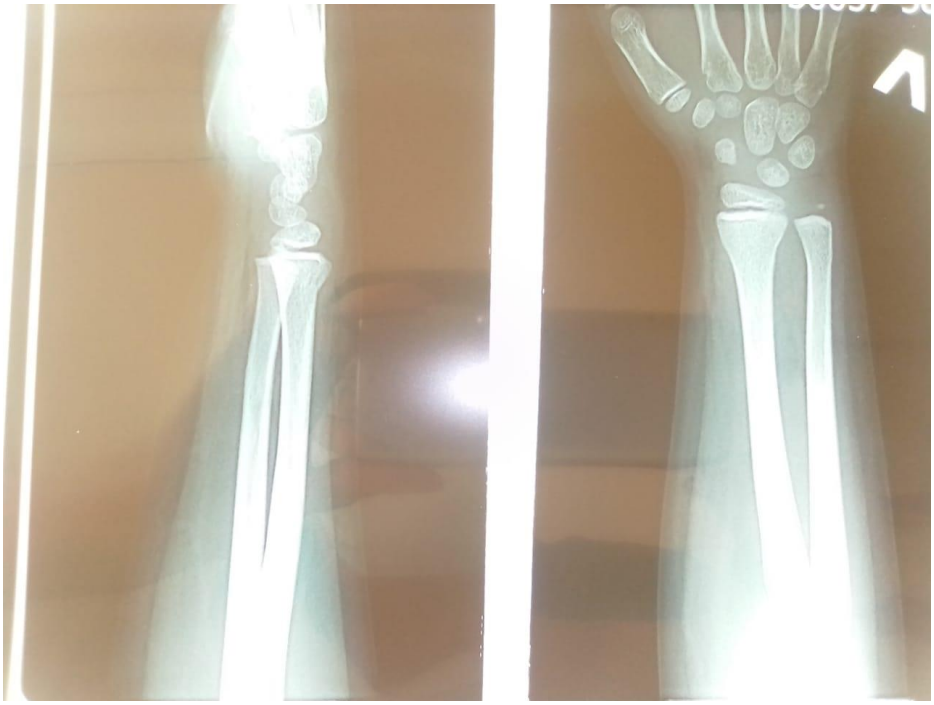


Figure 2
Compression fracture of the 4-5-6 thoracic vertebrae (1-2 degrees of compression). Boy. 10 years. Fracture of the radius in the lower third. Girl. 12 years

It is in this age period of time, during intensive linear growth period, bone structures remodeling is accompanied by a decrease in strength properties. Pre-existing fractures were diagnosed at least 3 episodes. According to the literature, this is a pathognomonic sign of the dysplastic process in a child. There was no fragments displacement in patients, which fact, in our opinion is due to the muscles weakness and a slight mechanism of injury. The deformity on the hip in 5 boys was a curvature with an angle open inside and behind. The lower leg bones in 10 patients curved in the sagittal plane, taking a «saber-shaped» (bandy leg) shape. The sternum of all the children protruded forward, and the ribs sank in from the sides.

Attention was drawn to the skull deformity. The skull vault was disproportionately large and spherical. In the anamnesis, the closure of the fontanelles was delayed.

The musculoskeletal system weakness was manifested by the joints «looseness» and muscles hypotension of. A number of authors consider muscle weakness to be a primary lesion manifesting itself simultaneously with changes in the skeleton.

All patients had a weak muscular corset, combined with posture violation in the frontal plane. Patients underwent x-ray examination. The main feature was osteoporosis of the examined segment in the skeleton, which was confirmed by a radiologist. At the site of previously suffered fractures, periosteal bone calluses were determined, which, in some cases, reached large sizes. There was a cortical layer thinning, a decrease in the bones diameter. For the spine was characterized by platyspondyly, the vertebrae bodies had acquired a biconcave shape.

While performing magnetic resonance imaging (MRI), deformity, decrease in the damaged vertebrae illumination intensity in the thoracic - lumbar region, and change in the shape of the intervertebral discs underlying divisions were found. These signs were detected in the main group of patients in 100% of cases.

The stabilographic examination method was used in groups of patients as a criterion for the children's with scoliosis, impaired posture in the frontal plane, and spinal osteochondropathies treatment effectiveness. It was found that the greater the spine deformation degree and the weaker the muscular corset, the more the center of gravity deviated from the norm. In patients of the main group, stabilographic changes were detected in 70% of cases. In the control group, the parameters were normal. The load was distributed more physiologically to the front and heel parts of the feet after conservative treatment for scoliotic deformities, as well as as the muscle corset formation.

Densitometric examination made it possible to diagnose low bone mineral density in all cases in patients of the main group. The relationship between the increase in the anatomical size of the body and the skeleton mineralization is traced.

Laboratory testing of blood and urine in patients was a mandatory part of our examination, allowing us to be wary of a pathological condition presence in the child. In 2 patients of the main group, who underwent blood tests on the next day after going to the trauma center, along with the changes listed below, there was a slightly accelerated rate of erythrocyte sedimentation - 17 mm/hour and 21 mm/hour. In all 30 patients of the main group, an increase in oxyproline concentration in the blood serum, urinary excretion of oxyproline and calcium was determined. There were no changes in the control group.

The main laboratory indicators were different in the two groups at the time of the regular medical check-up start. The basic indicator of collagen metabolism state in the body is the amount of oxyproline in the blood serum and urine. This examination determines the depth and extent of connective tissue damage. In all patients of the main group, an increase in the concentration of oxyproline in the blood serum, urinary excretion of oxyproline and calcium was determined. This is testified to collagen metabolism violation in patients. Changes in oxyproline level in the blood serum and during renal excretion can confirm the fact of collagen fibers formation violation, these being one of the main components of the connective tissue matrix, including growth zones. No changes were detected in the group of healthy children (control group) (Table 2).

Indicators	Main group (n=30) M±m	Control group (n=30) M±m	P_{1-2}
	1	2	
Blood calcium (mmol/l)	2,38±0,02	2,38±0,02	0,981
Blood phosphorus (mmol/l)	1,54±0,02	1,57±0,02	0,677
Urine calcium (mmol/l)	3,69±0,07	2,33±0,09	<0,001
Urine phosphorus (mmol/l)	24,89±0,39	25,32±0,64	0,922
Blood oxyproline (μmol/l)	27,20±0,46	15,09±0,07	<0,001
Urine oxyproline (μmol/ CRNN mg)	26,21±0,37	19,48±0,04	<0,001

Note: P – the significance level when testing hypotheses was assumed to be the corresponding p less than 0.05. Indicators were compared between groups: 1-2.

Table 2

Basic laboratory indicators at the time of regular medical check-up beginning

In all patients of the main and control groups, the circulating immune complexes (CIC) level, immunoglobulins of A, M, and G classes levels were detected. Immunoglobulin G and CIC content was higher in the main group than in the control one (children without hereditary connective tissue disorders) ($p<0.05$). Immunoglobulin M level in the main group is lower than in children without hereditary connective tissue disorders ($p<0.05$).

In all the examined patients with hereditary connective tissue development disorders after injury, ultrasound signs of edema and muscles hypertonus of the injured segment were determined. Their intermuscular connective tissue structures had a large number of big vascular hyperechogenic inclusions. In patients without hereditary connective tissue disorders, hyperechoic inclusions were visualized in small amounts (Table 3).

Ultrasound characteristics	Main group (n=30)	Control group (n=30)	P
Large number of big stranding hyperechogenic inclusions (%)	100	0	<0,001
Singular hyperechogenic inclusions (%)	0	100	<0,001

Table 3
Ultrasound differences between groups

According to electroneuromyography data for the damaged segment (muscles straightening the spine, after spinal injury), changes in parameters were observed in 15 children of the main group with hereditary connective tissue development disorders. In all children of the control group, without hereditary connective tissue disorders, no pathological changes were detected. The pathological process was tracked in dynamics, one year after the injury ($p<0.001$) (Table 4).

Time after injury	Main group (n=30)	Control group (n=30)	P
Till 1 month	100%	100%	>0,05
12 months	50%	0%	<0,001

Table 4
Changes in muscles' bioelectric activity at the damaged segment level

In pediatric and orthopedic practice, the need to further improve patients' with osteopenic syndrome against the background of hereditary disorders of connective tissue development prevention, diagnosis, treatment and medical examination effectiveness is clearly seen[12]. Of course, in this regard, scientifically - based, modernly adapted concepts and approaches are needed. Such an imbalance, a developmental anomaly, occurs more and more frequently in our daily activities. In recent years, dysplastic conditions correction methods, based on early activation of patients in combination with drug correction have been actively introduced in practical healthcare[13], However, in our opinion, clearly designed schemes, preventive routes, and rehabilitation approaches are not indicated. There is no single monitoring of children with osteopenic syndrome, including in combination with background pathology - connective tissue development hereditary disorders[14]. Also, it is significant and important to prevent the development of further possible complications - kyphoscoliosis, vicious posture, osteochondropathies of different localization, juvenile osteochondrosis and other pathological changes.

Conclusion

Treatment and dynamic control of patients in the main group was complex. It was conducted, if necessary, in parallel with the geneticist, pediatrician, neurologist. The outpatient stage provided for the patient's medical supervision by an orthopedic traumatologist in the city children's polyclinic was carried out once in 4 months, if necessary, on an individual basis, once in 3 months.

[12] V. K. Serkova, “Extracardial manifestations of connective tissue dysplasia in patients with mitral valve prolapse”, Ukrainian Journal of Cardiology num 4 (2007): 72.
[13] M. S. Starodubtseva, “Cardiodynamics state in children with small heart development abnormalities”, RSMU Bulletin Vol: 42 num 3 (2005): 130-135.
[14] D. O. Akhmetzhanova; R. L. Ivanova y Y. F. Lobanov, “Complex Treatment of Children Affected by Undifferentiated Connective Tissue Dysplasia Combined with Bone Mineral Density Reduction”, Asian Journal of Pharmaceutics Vol: 11 num 4 (2017): S950-S954

The tasks included forming a muscular corset, creating favorable conditions for functional recovery of the damaged segment with activation, patients' social and psychological adaptation, possible further complications (thoracic spine scoliotic deformity, spinal osteochondropathies, early juvenile osteochondrosis) prevention and bone mineral density correction.

During the entire period of medical observation, the patient was recommended to sleep on a hard bed, depending on the spinal deformity nature (flat back, kyphotic deformity, scoliotic deformity, back muscles hypotension). If a patient had a flat back, it was recommended to sleep on back using a feather bed or a soft mattress. If a patient had kyphotic deformity it was recommended to sleep on stomach using a feather bed or a soft mattress. For scoliotic deformity it was recommended to sleep on a standard orthopedic mattress. Corsets were not used at initial diagnosis stages of a vicious posture. It was recommended to correct the muscular corset with gymnastic exercises and swimming.

Complex programs for children of the main group included a combined drug containing calcium and phosphorus with vitamins and trace substances - Calcium-D3 Nicomed. It was used and recommended as an additional source of calcium and vitamin D. For children of the main group, Calcium-D3 Nicomed was administered orally, chewing or resorbing during meals. Children, aged from 3 to 12 were recommended to take 1 tablet once a day for 1 month, older children took 1 tablet twice a day for 1 month. During the year, 4 courses of this drug were prescribed.

In patients with bone fractures in the upper and lower extremities, the immobilization period remained relatively age-related. In the future, in the process of dynamic observation, a sparing regime organization, fractures and deformities prevention and general strengthening measures were of particular importance.

The effectiveness of osteopenic syndrome prevention was evaluated clinically. The positive aspect was considered to be the absence of fractures and bone deformities during a year. The basic indicator was considered to be a densitometric study of bone resorption markers.

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