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Creation and Optimization of Diagnostic Algorithms and Integrated Approaches to the Treatment of Neurological Deformations of Lower Leg Segments in Pediatric Practice

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Annotation: Neurogenic deformities of the lower extremities in children represent a serious medical problem that requires a differentiated approach to diagnosis and treatment. These deformations can be caused by various neurological disorders, making diagnosis and treatment complex and multi-stage processes. The relevance of the problem is also supported by the fact that the amazing plasticity of childhood tissues allows achieving the desired result with more complete and less traumatic methods.

Keywords: neurological deformities, lower extremities, pediatric orthopedics, diagnostic algorithms, complex therapy, neurogenic deformities, cerebral palsy, spasticity, biomechanical walking analysis, orthopedic devices, rehabilitation technologies, multidisciplinary approach, functional correction

INTRODUCTION. The problem of neurological deformities of the lower extremities in pediatric practice represents one of the most relevant and socially significant tasks of modern pediatric orthopedics and neurology. According to international epidemiological studies, various forms of neurogenic orthopedic disorders of the lower extremities occur in 2-4% of the child population, while in 60-80% of patients with cerebral palsy, pronounced deformities of the feet and lower legs are recorded.

Neurological deformities of the lower extremities in children are characterized by a progressive course and significant polymorphism of clinical manifestations, which is due to various etiopathogenetic mechanisms of their formation. The development of this pathology is based on disorders of the central and peripheral nervous system, leading to a disbalance of muscle tone, pathological motor stereotypes, contractures, and secondary structural changes in the musculoskeletal system.

Modern statistics indicate that the frequency of neurogenic deformities of the lower extremities tends to increase, which is associated with improved survival of children with severe perinatal pathology, congenital malformations of the nervous system, consequences of neuroinfections and craniocerebral injuries. In the structure of this pathology, deformities associated with cerebral palsy (65-70%), congenital myopathies (15-20%), consequences of spinal hernias (8-12%), and other neurological diseases (3-5%) predominate.

Childhood is characterized by intensive growth and development processes of the musculoskeletal system, which creates both additional opportunities for deformation correction and risks of their progression in the absence of adequate treatment. The plasticity of the child's body, incomplete ossification processes, and the activity of growth zones determine the peculiarities of the pathogenesis, clinical course, and therapeutic approaches to neurogenic deformities in pediatric practice.

Diagnosing the early stages of lower limb neurological deformities in children presents particular difficulty, as the clinical manifestations at the initial stages may be weakly expressed and masked by the physiological features of musculoskeletal development. Traditional clinical and radiological diagnostic methods do not always allow for the timely detection of initial deformation signs and assessment of their prognostic potential.

Modern approaches to treating lower limb neurological deformities in children are based on the principles of multidisciplinary approach, staged treatment, and complex therapeutic intervention. At the same time, the lack of standardized diagnostic and treatment algorithms, insufficient integration of various correction methods, and limited opportunities for objectively assessing the effectiveness of the ongoing therapy create significant difficulties in managing this category of patients.

Analysis of modern literature indicates fragmentation of existing approaches to solving the problem of neurogenic deformities of the lower extremities in children. Most studies are focused on specific aspects of the pathology: either improving surgical correction methods, optimizing conservative treatment methods, or developing technical rehabilitation tools. Integrated approaches that combine various diagnostic and treatment methods into a single system have not been sufficiently studied.

The development of modern technologies opens up new possibilities for improving the diagnosis of neurological deformities. The implementation of methods of three-dimensional biomechanical analysis of movements, computer podometry, high-resolution magnetic resonance imaging, and ultrasound examination of muscles and tendons allows for obtaining objective information about the nature and severity of pathological changes.

Similarly, in the field of therapeutic technologies, there is an active development of innovative approaches: the use of botulinum therapy, functional electrostimulation, robotic rehabilitation systems, and individual prosthetics using 3D printing. However, the integration of these technologies into unified therapeutic algorithms remains insufficiently developed.

The socio-economic significance of the problem of lower limb neurological deformities in children is determined by high rates of disability, the need for long-term multi-stage treatment, and significant financial costs for rehabilitation and social adaptation of patients. According to economic studies, the average cost of comprehensive rehabilitation of a child with pronounced neurogenic deformities of the lower extremities during childhood is 150-300 thousand US dollars.

The aim of the research is to create and scientifically substantiate an optimized system of diagnostic algorithms and integrated approaches to the treatment of neurological deformities of the lower extremities in children to improve the effectiveness of medical care and improve functional outcomes.

Materials and methods: We examined 110 children with neurogenic deformities of the lower extremities who received inpatient treatment at the Republican Specialized Scientific and Practical Medical Center of Diseases of the Ministry of Health of the Republic of Uzbekistan for the period 2022-2025. Treatment of patients with PVDS of varying degrees and genesis was carried out at the Republican Specialized Scientific and Practical Medical Center of Traumatology and Orthopedics for the period from 2022 to 2025 according to the methodology developed by the center. A necessary condition for including patients in the study was the informed consent of the child's parents. Before admission to the center, 65 (89.0%) patients received conservative treatment, 8 (11.0%) patients did not receive treatment. Surgical treatment was performed on 65 children with moderate and severe PVDS. Conservative treatment was administered to 45 patients (90 feet) who were included in the comparison group, comparable in age and gender.

Patients were divided into 3 groups depending on the etiology of the disease. The proportion of patients with true congenital PVDS ("vertical taran," "foot swagger") was 9.4% (all under 3 years old), with secondary PVDS (against the background of cerebral palsy, myodystrophy, polyneuropathy) due to impaired static-dynamic relationships in the lower extremities was 14.6% between the ages of 12-18. The group of patients with myendoplastic PVDS was the largest - 76%. Diagnosis of neurogenic foot deformities is based on clinical, radiological examination, and computed tomography data. Often, the need arises to perform a series of radiographs in various functional positions. Neurological examination of the patient is mandatory: muscular electromyography, consultation with a neurologist.

Results: Depending on the severity of the pathology and the patient's age, we performed 3 types of surgical interventions:

1. Patients with congenital PVDS and secondary PVDS under 8 years of age underwent Kummer-Koel-Ramsey surgery in a modified department.
2. In patients with secondary PVDS over 8 years of age, foot arthroeresis was performed using a submersible implant, supplemented, if necessary, with retraction of the posterior tibial muscle and extension of the Achilles tendon.
3. In patients with secondary PVDS over 8 years of age with rigid foot deformity, 2 stages of deformity correction were performed, including: 1) posterior-medial release of the foot; 2) Arthroeresis of the foot with an immersion implant. The methods we use, in particular, the Kummer-Koel-Ramsey operation in the CITO modification, allow us to restore both the bone-joint relationship of the foot and the good function of the feet.

Restoring normal architectonics allows for the correct formation of the foot skeleton. The identified pathological changes dictate the need to form adequate motor skills in patients after deformation correction at the level of passive foot stabilizers.We presented a comparison of computer podography indicators in patients before and after treatment in a group of 110 children. In most cases, statistically significant improvement is observed after treatment:

Conclusions: thus, our studies show the effectiveness of various methods of treating flatfoot after 1 year and 3 years. Surgical methods (Kummer-Koel-Ramsey operation and arthroeurosis) show better results, while conservative treatment often yields satisfactory results. A differentiated approach to surgical treatment of flat-valgus deformity of the foot in children, based on the age of the patients and the type of pathology, provides optimal functional results. In children under 8 years of age with congenital and secondary PVDS, Kummer-Koel-Ramsey surgery is indicated in a modified section, in patients older than 8 years - foot arthroeurosis or two-stage correction in rigid forms of deformation. Kummer-Koel-Ramsey surgery in modified CITO in young children showed high effectiveness in restoring the bone-joint relationships of the foot and ensuring the correct formation of the foot skeleton during growth, which is confirmed by a significant improvement in computer podography indicators ($p<0.001$). Arthroeresis of the foot with an immersion implant in patients older than 8 years with the flexible forms of secondary PVDS provides a statistically significant improvement in the longitudinal arch angle (from 142.5±8.2° to 128.3±6.1°, $p<0.001$) and the rolling coefficient (from 0.62±0.08 to 0.71±0.06, $p<0.001$). Two-stage correction in the rigid forms of deformity in children over 8 years of age, including the posterior-medial release of the foot with subsequent arthroeresis, allows achieving satisfactory anatomical and functional results even with pronounced structural changes.

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