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TREATMENT OF SPASTICITY AND DEGENERATIVE-DYSTROPHIC CHANGES IN MUSCLES IN CHILDREN WITH CEREBRAL PALSY

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Summary

One of the most urgent problems of rehabilitation of children with cerebral palsy (CP) is overcoming spasticity and pathological structural changes in muscles, which leads to impaired statics and locomotion of gait, and reduced social adaptation. A central focus of multidisciplinary rehabilitation of patients with CP is the reduction muscle spasticity. One of the most effective methods for achieving this is the administration of botulinum toxin type A. However, existing data on combination therapy involving neurotoxin and agents that stimulate tissue regeneration remain fragmented, predominantly advisory in nature, and require further investigation.

Objective: *To evaluate the efficacy of combined treatment for muscle tone disorders in children with cerebral palsy through the use of neurotoxin therapy alongside agents that stimulate muscle tissue regeneration.*

Materials and methods. *The study analyzed data from 40 pediatric patients with CP presenting with muscle tone disorders such as reflex tonic hypertonia, spasticity, and rigidity. Clinical and instrumental diagnostic methods were employed to assess the condition of the patients.*

Quantitative data were statistically processed using the mean ± standard error (M±m), and statistical significance was determined using Student's t-test. The significance was set at the level of $p < 0.5$-0.05. The study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was approved by the local ethics committee of the All-Ukrainian Centre for Motherhood and Childhood of the National Academy of Medical Sciences of Ukraine. Informed consent was obtained from all participants.

Results. *The comparative analysis demonstrated a more pronounced positive clinical response in patients receiving botulinum toxin as part of a comprehensive rehabilitation program. The combined therapy, targeting the entire myofascial chain of the lower limb and paraspinal muscles, resulted in statistically significant improvements ($p<0.05$) in subgroups A and B of the main cohort, compared to the control group. Patients in subgroup C received therapy aimed at preventing the progression of joint contractures and delaying the need for surgical intervention.*

Conclusions.

1. The proposed multimodal treatment for children with cerebral palsy and muscle tone abnormalities – specifically reflex tonic hypertonia and spasticity – effectively reduces pain and spasticity, restores tropocollagen levels in soft tissues and ligamentous structures, which significantly improves gait biomechanics.

2. Timely conservative treatment aimed at reducing spasticity and stimulating muscle tissue regeneration contributes to marked clinical improvement and facilitates the development of a physiological motor pattern.

3. In patients with muscle rigidity, the implemented treatment approach helps delay surgical intervention and reduces the risk of recurrent contractures requiring reoperation.

Key words: *Children, Cerebral Palsy, Myofascial Chain. Conservative Teatment.*

Introduction

One of the most pressing challenges in the rehabilitation of children with cerebral palsy (CP) is the management of spasticity and pathological structural changes in muscles, which lead to impaired postural control, gait disturbances, and reduced social adaptation [1]. According to published data, the prevalence of cerebral palsy in the global pediatric population ranges from 2 to 5 cases per 1,000 live births, with an average of 2.5 per 1,000 [2]. A central component of multidisciplinary rehabilitation in patients with CP is the mitigation of muscle spasticity [3]. It has been demonstrated that persistent spasticity results in microcirculatory disturbances and alterations in subfascial pressure, which contribute to pain syndromes, structural changes in muscle tissue, and functional impairment [4]. Traditionally, both central and peripheral muscle relaxants are used to address spasticity. One of the most effective approaches is the administration of botulinum toxin type A [5]. However, data on the combined use of neurotoxin with agents that promote tissue regeneration remain fragmented and largely advisory in nature [6].

Currently, the methodology for administering botulinum toxin remains a subject of debate. Some authors advocate for minimizing dosages to reduce potential toxic effects in pediatric patients [7]. However, when low doses are used, the clinical reduction in muscle spasticity is often minimal and transient.

In addition, most techniques are focused on the injection of botulinum toxin into phasic muscles [8,9,10,11 This approach is insufficient without simultaneously targeting postural muscles.

According to some researchers, the muscles of the lower limbs, pelvic girdle, and back form interconnected myofascial chains [12 and therapeutic effects limited to only one pathological segment fail to produce the desired clinical outcomes..

Postural abnormalities occur in at least 95-98% of children with cerebral palsy. In patients with hemiparetic

CP, spinal pathology is observed in 100% of cases, with one-third being progressive [13,14]. The majority of specialists in pediatric CP treatment tend to focus on limb pathology [15]. However, the lack of an integrated therapeutic approach addressing both limb and trunk muscle tone disorders limits the potential for sustained clinical improvement in terms of reducing myofascial, neurogenic, and arthrogenic pain, enhancing microcirculation in muscle tissue, and preventing degenerative-dystrophic changes. Thus, questions remain regarding the optimal sites for neurotoxin injection, its impact on postural muscle tone, and the clinical effectiveness of its combination with agents that stimulate muscle tissue regeneration.

Objective: to evaluate the effectiveness of comprehensive treatment of muscle tone disorders in children with cerebral palsy through the combined use of neurotoxin therapy and agents that stimulate muscle tissue regeneration.

Methods and materials

The analyzed parameters were obtained during the treatment of 40 patients (each limb was assessed as a separate clinical case – 80 cases) with cerebral palsy who presented with muscle tone disorders in the form of reflex tonic tension, spasticity, and stiffness [16].]. In all cases, contractures of the hip and knee joints of grade I-II, foot deformities, and postural abnormalities were observed.

Depending on the treatment approach, patients were divided into two groups: the main group – 42 cases; the control group – 38 cases. Each group was further subdivided into three subgroups based on the type of muscle tone disorder.

Main group: Subgroup A – 14 cases (reflex tonic tension); Subgroup B – 14 cases (spasticity); Subgroup C – 14 cases (stiffness). All patients received neurotoxin therapy combined with agents that stimulate soft tissue regeneration. Injections were administered into the muscles of the back and lower extremities, followed by staged casting.

Control group: Subgroup A – 14 cases (reflex tonic tension); Subgroup B – 12 cases (spasticity); Subgroup C – 12 cases (stiffness). All patients received neurotoxin therapy exclusively in the muscles of the lower extremities using the conventional technique, without the use of tissue-regenerative agents.

Botulinum toxin type A was used to reduce spasticity. This neurotoxin acts by irreversibly blocking the release of acetylcholine at the presynaptic level. In skeletal muscle, its effect is manifested through inhibition of neuromuscular transmission. The method of treating cerebral palsy with localized botulinum toxin injections allows for targeting different muscle groups depending on their involvement in pathological synergies, and permits individual dose selection based on muscle volume. The drug does not induce significant pain and can be used in combination with agents that stimulate tissue regeneration (MD-Collagen products).

Collagen is the primary structural protein of connective tissue, responsible for the key biomechanical properties of muscles, fasciae, and ligaments – namely, firmness, elasticity, and tensile strength. Approximately 80% of all collagen in the human body is type I collagen, the principal structural component of tissues subjected to constant mechanical stress. If untreated, long-standing muscle tone disorders lead to chronic inflammation in the musculoskeletal segment, reduced synthesis of physiologically functional collagen, and degradation of collagen structures in the affected areas. This is one of the causes of degenerative and dystrophic changes in muscle tissue. Therefore, the use of MD-Collagen products, whose primary active ingredient is naturally derived collagen, promotes tissue regeneration by restoring the synthesis of endogenous collagen. In addition to collagen, MD-Collagen (MD-Muscle) contains adjunct substances that enhance the effects of the main component. For example, Hypericum perforatum exhibits tropism toward the neuromuscular spindle and enhances reparative processes. Two components (Colchicum and Lithium benzoicum), which act through the pituitary-adrenal axis, reduce muscle inflammation and provide analgesic effects in cases of chronic myalgia. Interferon-gamma modulates T-lymphocyte activity, suppressing cytokine formation and thereby attenuating inflammatory processes within muscle tissues. Muscle tisse suis is an organic compound that helps prevent the development of muscle fibrosis. Two other components target the spastic etiology of muscle pain: Colocynthis modulates the neurogenic component of pain, while Cuprum sulphuricum exerts its effects directly on muscle tissue [17,18].

In both groups, physiotherapeutic treatment was applied according to standardized protocols, followed by the use of orthopedic footwear and orthoses.

Pain intensity was evaluated dynamically using the Numeric Rating Scale (NRS):

- 0-3 points – no pain or mild pain with minimal impact on well-being;
- 4-6 points – moderate pain of noticeable intensity;
- 7-10 points – severe pain [4].

Spasticity was assessed using the Modified Ashworth Scale, which is designed to evaluate the resistance of muscles to passive movement at varying speeds.

Gross motor function was assessed using the Gross Motor Function Classification System for Cerebral Palsy (GMFCS) [19, 20].

The extent of structural changes in muscles and joints was assessed via ultrasonography using an ALOKA diagnostic system with a 5 MHz linear transducer. Peripheral blood flow in the lower limbs was evaluated through Doppler ultrasound examination.

Spinal radiography was performed in both sagittal and frontal projections.

The study population consisted of children with cerebral palsy and altered muscle tone. Children with post-traumatic or congenital contractures, or without neurological pathology, were excluded from the study.

Statistical analysis. Quantitative data were statistically processed using the mean ± standard error (M±m), and statistical significance was determined using Student's t-test. The significance was set at the level of $p < 0.5$-0.05.

The study was conducted in accordance with the principles of the Declaration of Helsinki. The study protocol was approved by the local ethics committee of the All-Ukrainian Centre for Motherhood and Childhood

of the National Academy of Medical Sciences of Ukraine. Informed consent was obtained from all participants.

Results

Based on clinical observations, the authors confirmed that muscle tone disorders are a consequence of lesions in the pyramidal and extrapyramidal pathways of the central nervous system [8]. These lesions weaken the inhibitory influence of alpha motor neurons on the antigravity musculature, leading to the emergence of postural antigravity phenomena, such as plantar flexion or pronation of the foot, knee flexion, flexion and adduction of the hip joints, and overall postural misalignment. J. Little was the first to describe this clinical manifestation, which presents as syndromes characterized by predominant spasticity in specific muscle groups (e.g., adductor syndrome, hamstring syndrome, triceps surae syndrome).

We took into account that all skeletal muscles are functionally divided into two groups: postural and phasic. The postural muscles primarily support the body against gravity, whereas phasic muscles are responsible for initiating and controlling voluntary movement. Postural muscles, capable of sustained contraction, play a leading role in the development of postural antigravity patterns. These muscles are interconnected through unified myofascial chains [12]. In the presence of predominant labyrinthine tonic reflexes, flexion synergies of the lower limbs become pronounced. Ambulation on flexed hips and knees causes the origin and insertion points of the gastrocnemius muscle to approximate, leading to muscle shortening and increased contractility [16]. This results in impaired stabilization of the ankle and knee joints. The muscles are recruited into complex chains of pathological synergies, triggered and maintained by primitive tonic reflexes that propagate along the superficial posterior myofascial line (Fig. 1).

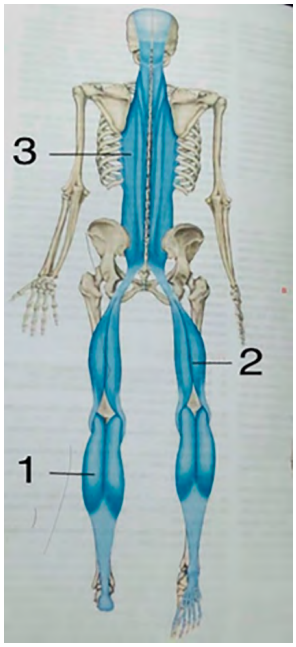


Figure 1. Myofascial chain of the superficial posterior line:
1 – m. gastrocnemius; 2 – m. biceps femoris; 3 – m. erector spina

Disruption of the antigravity process leads to a decrease in tone and functional activity of the extensor muscles. Their extensor and stabilizing functions become impaired. Weakness of the extensors (gluteus maximus and the quadriceps femoris muscle group) and the predominance of flexion synergies in the lower limbs contribute to the development of contractures in the hip and knee joints, as well as to foot deformities. These pathological synergies also extend to the paraspinal musculature, resulting in a cascade of biomechanical reactions that reinforce abnormal motor patterns and ultimately lead to the development of spastic scoliosis.

Therefore, in our view, when diagnosing and treating children with cerebral palsy, in addition to the principal clinical syndromes, attention should also be given to the syndrome associated with spastic spinal deformities – **vertebralis syndrome**.

Method of botulinum toxin administration. Intramuscular injections of botulinum toxin were utilized to manage muscle tone abnormalities and alleviate pain in patients from the main group. The approximate dosage did not exceed 30 units per kilogram of body weight, with a maximum total dose of 1500 units for adolescent patients. This approach facilitates the so-called 'white paper effect' – a state of maximal approximation to normotonia, creating favorable conditions for further therapeutic interventions. Intramuscular injections were administered using a needle measuring 40-60 mm in length and 21 mm in diameter. The needle was inserted perpendicularly at a 90^0 angle. In anatomically complex regions, ultrasound guidance was employed to ensure accurate needle placement (Fig. 2).

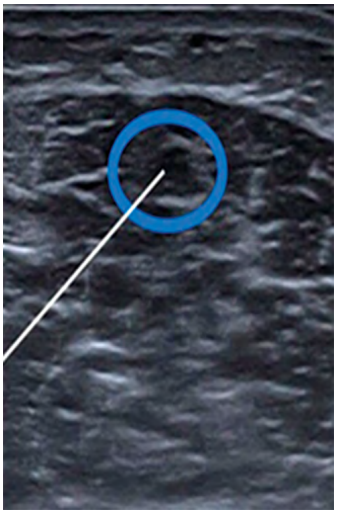


Fig. 2 Injection of the drug into the area of m. popliteus.

In addition to the phasic muscles, postural muscles and muscles involved in the development of tunnel syndromes of the lower extremities were selected as target muscles (Fig. 3). In cases where postural abnormalities were diagnosed, the drug was also administered into the paravertebral muscles of patients in the main group (Table 1).

One week following the combined therapy for spasticity, patients in the main group underwent deep fascial release (according to the I. Rolf method), physiotherapy, and injectable collagen-based treatments.

Table 1

Localisation of injections into muscle groups with Dysport

Clinical syndromes	Muscles.	Dose of 'Dysport' Total number of units ОД	Number of points injections
Vertebralis-syndrome			
Thoracolumbar scoliosis	m.spinalis thoracis m.psoas major m.erector spinae	100	3
Hamstring-syndrome			
Gluteal area	m.iliopsoas	100	1
Back surface of the thigh	m.biceps femoris caput longum m.biceps femoris caput brevis	100	2
Hamstring area	m.popliteus	100	1
Adductor syndrome			
Inner surface of the thigh	m. adductor brevis, longus et magnus	200	2
Triceps – syndrome			
Back surface of the lower leg (middle third)	m.soleus	100	1

Methods of tropocollagen application. MD-Collagen (MD-Muscle) was administered in combination with a 2% lidocaine solution, at a dosage of 0.5 ml per 10 kg of body weight. To minimize pharmaceutical burden, the drug was injected every other day into the anatomical loci of affected muscles and periarticular tissues bilaterally (Table 2). Intramuscular injections were performed using a 40-60 mm long, 21-mm needle inserted perpendicularly at a 90^0 angle. The volume per procedure ranged from 2 to 4 ml. The full treatment course included 6 to 8 procedures. The number of injection sites was twice that used for neurotoxin administration (Fig. 3).

Table 2

Scheme of MD-Collagen injection into pathologically significant areas in patients of the main group

Clinical syndromes	Muscles.	Dose of MD-Collagen (MD-Muscle) (ml)	Number of points injections
Vertebralis-syndrome			
Thoracolumbar scoliosis	m.spinalis thoracis m.psoas major m.erector spinae m trapezius	0,5	8
Hamstring-syndrome			
Gluteal area	m.iliopsoas	0,5	2
Back surface of the thigh	m.biceps femoris caput longum m.biceps femoris caput brevis	0,5	4
Hamstring area	m.popliteus	0,5	2
Adductor syndrome			
Inner surface of the thigh	m. adductor brevis, longus et magnus	0,5	4
Triceps – syndrome			
Back surface of the lower leg (middle third)	m.soleus	0,5	2

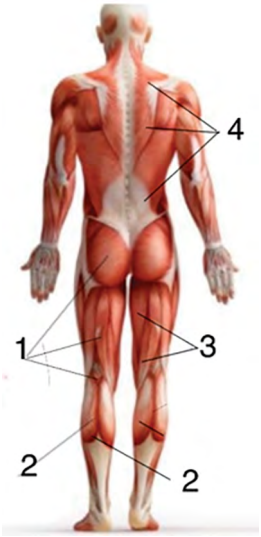


Figure 3. Areas of neurotoxin and MD-collagen injection depending on the clinical syndrome: 1 – hamstring syndrome; 2 – triceps syndrome; 3 – adductor syndrome; 4 – vertebralis syndrome.

In the comprehensive treatment of patients in the main group, staged plaster casting was employed to lengthen the spastic muscles of the lower extremities. This was alternated weekly with physiotherapy, deep fascial rhylosis, and administration of MD-Collagen. Such an approach allows for the maximal preservation of weakened muscle function, suppression of tonic activity, and the creation of favorable conditions for the restoration of locomotor function. Plaster cast therapy for flexion synergies of the lower extremities was directed at stretching the most spastic muscles involved in forming flexion contractures at the hip and knee joints. The technique entailed a gradual extension of the knee flexors and calf muscles. Only after achieving knee joint extension to 170º was a stepwise correction of the foot performed (depending on the type of deformity), to an angle of 85º–90º relative to the tibia.

The initial plaster cast was applied without muscle or tendon traction, with minimal correction of contractures and deformities, to reduce stretch reflex activity and pathological afferent input. Silicone pads were used to prevent microcirculatory disturbances in areas of highest soft

tissue compression under the plaster cast. The cast extended from the distal third of the lower leg to the proximal third of the thigh, followed by shaping around the foot, taking into account the specific deformity. At each subsequent stage, the pathological position of the limb was progressively corrected. The duration of the full complex treatment course following neurotoxin therapy was 1 to 1.5 months.

Pain syndrome is of multifactorial origin [4]. Indicators of pain intensity, knee joint contracture, spinal deformity, and spasticity assessment are presented in the table (Table 3).

Table 3

Indicators of clinical examination methods before treatment

Indicators (points)	The main group n=42 M ± m			Control group n=38 M ± m		
	Subgroup A n=14	Subgroup B n=14	Subgroup C n=14	Subgroup A n=14	Subgroup B n=12	Subgroup C n=12
Pain syndrome	3,3±0,1	6,1±0,2	3,0±0,4	3,4±0,2	6,3±0,4	2,8±0,1
Ashworth Scale.	1,8±0,1	2,8±0,3	3,5±0,2	2,0±0,1	2,5±0,3	3,8±0,4
Passive knee extension angle	155º	145º	141º	157º	146º	142º
Deformation angle of the spine (according to V. Chaklin)	8º ± 1,0	16º±2,0	22º±4,0	7º±2,0	18º±4,0	25º±3,0

Ultrasound examination of the postural muscles of the lower extremities in both groups of patients with reflex tonic tension revealed isolated structural changes in muscle fibres, reduced echogenicity, and elongation or obliquity of fibre orientation. Moderate synovitis of the knee and ankle joints was also diagnosed.

In patients with muscle tone disorders characterised by spasticity, ultrasound revealed muscles with a heterogeneous structure due to areas of reduced echogenicity and well-defined striations. There was a marked increase in the volume of muscle fibres. Examination of the knee joint showed increased echogenicity of the posterior horns of the medial and lateral menisci, shortening and thickening of the posterior cruciate ligament, and signs of pronounced synovitis.

In patients with muscle stiffness caused by slow transformation and degenerative-dystrophic changes, ultrasound demonstrated a reduction in the cross-sectional area of the muscles. The muscles exhibited a heterogeneous architecture with alternating zones of hypoechogenicity and hyperechogenicity, typical of fibrotic tissue. Acoustic shadow enhancement within the muscle indicated the presence of scar tissue containing multiple calcifications. Pronounced degenerative-dystrophic changes were also found in the joints, including fragmentation of the posterior horns of the medial and lateral menisci, and structural heterogeneity of the collateral and cruciate ligaments.

Duplex scanning of the arteries of the lower extremities (femoral, popliteal, anterior and posterior tibial arteries) in both groups showed moderate alterations in blood flow velocity and spectral characteristics at standard arterial reference points. Triplex scanning of the deep veins (popliteal vein, posterior tibial vein) demonstrated a reduction in the venous lumen diameter, which correlated with the severity of muscle tone disorders.

Functional assessment of muscle status, including contractile adequacy and structural changes before and after treatment, was performed using comprehensive electromyography (Table 4).

Table 4

Electromyographic characteristics of muscle spasticity before treatment

EMG signs	The main group n=42 M ± m			Control group n=38 M ± m		
	Subgroup A n=14	Subgroup B n=14	Subgroup C n=14	Subgroup A n=14	Subgroup B n=12	Subgroup C n=12
Frequency (Hz)	160 ± 5,2	110 ± 3,1	20 ± 4,3	155 ± 5,6	90 ± 4,2	10 ± 2,6
Amplitude (μV)	150 ± 5,4	170 ± 5,4	48 ± 2,6	145 ± 4,8	165 ± 5,6	42 ± 2,2
Integral indicator (μV/s)	50 ± 5,8	75 ± 5,2	10 ± 2,2	55 ± 3,2	70 ± 4,4	12 ± 3,4

During the dynamic follow-up of children in the main group receiving combined treatment, positive dynamics were observed in muscle spasticity, pain syndrome, joint range of motion, and spinal deformity in subgroups A and B compared to the control group (Table 5). In subgroup C of the main group, improvements were also noted after treatment, although these changes were not statistically significant.

Following treatment in the main group (subgroups A and B), significant improvements in motor function were recorded according to the Gross Motor Function Classification System (GMFCS). Specifically, subgroup A: 2.20 ± 0.25 and 1.60 ± 0.32; $p < 0.05$; subgroup B: 2.60 ± 0.20 and 1.80 ± 0.30; $p < 0.05$. No significant differences were observed in subgroup C of the main group or in the control group (subgroup C of the main group: 3.60 ± 0.22 and 3.10 ± 0.25; control group – subgroup A: 2.10 ± 0.20 and 1.90 ± 0.23; subgroup B: 2.50 ± 0.28 and 2.20 ± 0.24; subgroup C: 3.45 ± 0.24 and 3.20 ± 0.35).

Ultrasound examination of the hamstring and lower leg muscles in patients from the main group (subgroups A and B) revealed positive structural changes in muscles and joints compared to the control group Muscles exhibited a homogeneous structure with pronounced echogenicity. The cross-sectional volume of muscles and areas of tissue hyperechogenicity decreased, alongside reduced echogenicity of the posterior horns of the medial and lateral menisci. In most cases, signs of synovitis in the knee and

ankle joints were absent in the main group, unlike in the control group. Subgroup C of the main group showed less pronounced results, attributable to the advanced degenerative and dystrophic tissue changes.

Table 5

Indicators of clinical and radiological examination methods after treatment

Показники (бали)	The main group n=42 M ± m			Control group n=38 M ± m		
	Subgroup A n=14	Subgroup B n=14	Subgroup C n=14	Subgroup A n=14	Subgroup B n=12	Subgroup C n=12
Pain syndrome	1,5±0,1	2,3±0,2	2,0±0,4	3,0±0,2	5,5±0,4	2,0±0,1
Ashworth Scale.	1,0±0,1	2,1±0,3	2,5±0,2	2,0±0,1	2,5±0,3	3,5±0,4
Knee joint extension angle	162º±3,0	152º±4,0	145º±3,0	158º±4,0	147º±3,0	144º±4,0
Deformation angle of the spine (according to V. Chaklin)	3º ± 1,0	9º±2,0	18º±4,0	6º±2,0	16º±4,0	24º±3,0

Post-treatment, a decrease in the activity of the labyrinthine tonic reflex was observed, evidenced by increased bioelectrical activity in the flexor muscles (Table 6).

Table 6

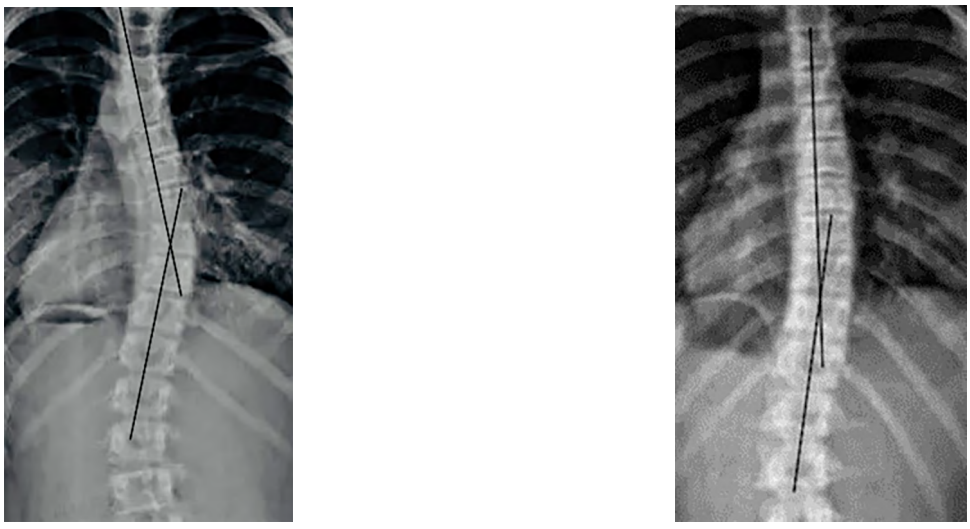
Electromyographic characteristics of muscle spasticity after treatment

EMG signs	The main group n=42 M ± m			Control group n=38 M ± m		
	Subgroup A n=14	Subgroup B n=14	Subgroup C n=14	Subgroup A n=14	Subgroup B n=12	Subgroup C n=12
Frequency (Hz)	175 ± 5,1	136 ± 3,2	25 ± 4,2	158 ± 4,5	100 ± 3,2	15 ± 1,4
Amplitude (μV)	135 ± 3,4	150 ± 4,4	50 ± 2,3	148 ± 3,8	160 ± 4,7	45 ± 1,6
Integral indicator (μV/s)	40 ± 4,8	60 ± 3,6	10 ± 2,1	50 ± 2,4	68± 4,3	10 ± 2,1

In the main group (subgroups A and B), more pronounced positive changes in electromyographic parameters were observed compared to the control group ($p < 0.05$). Although subgroup C of the main group also demonstrated improvement following treatment, these changes were not statistically significant.

An example illustrating the outcomes of botulinum toxin injection combined with complex treatment in a patient from subgroup B of the main group is presented based on radiological studies (Fig. 4).

Thus, the results of the comparative analysis confirmed more marked positive clinical dynamics associated with the use of botulinum toxin as part of comprehensive rehabilitation in children with cerebral palsy. The combined therapy, targeting the entire myofascial chain of the lower extremity and back muscles in subgroups A and B, yielded statistically significant improvements ($p < 0.05$) relative to the control group. Patients in subgroup C primarily received treatment aimed at preventing progression of joint contractures and preparing for surgical intervention.



a **b**

Figure 4. Radiographs of the thoracolumbar spine of patient B, 12 years old. Diagnosis: Cerebral palsy, right-sided scoliosis of the II degree.
a – before treatment; b – after treatment.

Discussion

Spastic cerebral palsy is the most prevalent form of cerebral palsy, accounting for 60-65% of all cases. The increase in muscle tone predominantly affects the lower extremities [19]. Most specialists concentrate their efforts on managing lower limb spasticity [20,21]. However, even after correcting contractures and foot deformities, significant motor improvement often remains elusive due to the interconnection of muscle groups within unified myofascial chains [12]. Our observations support this concept; for instance, ultrasound examination of the triceps femoris fascia demonstrated concurrent displacement of the biceps femoris fascia during foot dorsiflexion. Consequently, spastic foot deformity imposes mechanical load along the entire superficial posterior line, transmitted from the toe flexors through the Achilles tendon to the triceps surae, hamstring muscles, psoas, and paravertebral deep back muscles. Most authors recommend neurotoxin administration targeting the muscles of the upper and lower limbs without considering the entire kinematic chain [22, 23]. We propose that optimal clinical outcomes are achieved when neurotoxin therapy addresses the entire myofascial chain, including back muscles. This approach facilitates a longer-lasting clinical effect, thereby reducing the frequency of botulinum toxin injections to once every 8-10 months, which minimizes the drug's toxic impact.

When selecting neurotoxin dosages, patient age and degree of muscle tone disorder are typically considered [24, 25], but the severity of regional postural imbalance and functional muscle characteristics are often overlooked. As previously noted, muscles should be categorized into two functional groups: postural (anti-gravity) and phasic muscles. Postural muscles, capable of sustained contraction, play a central role in the development of joint contractures and deformities of the spine and foot. Increased spasticity leads to chronic postural imbalance manifested by hyperactivity and hypertonicity. Muscle fibers become denser and shortened, with degenerative and dystrophic changes occurring in both muscles and surrounding fascia [26]. As the pathological process advances, muscles lose their elasticity and contractility. Therefore, we advocate using the highest permissible doses of neurotoxin injected into a limited number of priority postural muscles (gastrocnemius, hamstring, psoas, paravertebral) during the initial treatment phase. Conversely, injecting small doses across many phasic muscles by traditional methods results in only short-term and clinically insignificant effects.

The therapeutic effect of tropocollagen in complex treatment promotes tissue regeneration by restoring endogenous collagen synthesis and reduces reparative processes in muscle tissue, as evidenced by ultrasound findings in patients of the main group (subgroups A and B). The lack of significant improvement in subgroup C is attributable to pathological muscle changes characterized by tissue destruction and degeneration.

In the treatment of muscle tone disorders, the use of staged casts is a common practice [26]; however, compression from plaster dressings on soft tissues can significantly impair microcirculation in the lower extremities. The application of siliconized pilots allows for better molding of the plaster cast during correction of foot deformities and prevents excessive compression of soft tissues, thereby avoiding deterioration of blood flow.

Recent studies indicate that pain syndrome is multifactorial, encompassing neurogenic, myofascial, and arthralgic components [4]. The implementation of complex treatment strategies enables the targeting of all aspects of pain syndrome, achieving a positive and sustained clinical effect.

Conclusions

1. The proposed complex treatment for children with cerebral palsy exhibiting muscle tone disorders in the form of reflex tonic tension and spasticity effectively reduces pain and muscle spasticity, restores tropocollagen deficiency in soft tissues and the ligamentous apparatus, and significantly improves gait biomechanics.

2. Timely conservative management aimed at decreasing spasticity and promoting muscle tissue regeneration leads to significant positive clinical outcomes and facilitates the formation of a physiological motor pattern.

3. The applied treatment approach in patients with muscle stiffness helps to postpone surgical intervention and reduces the likelihood of repeated surgeries related to contracture recurrence.

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The authors declare no conflict of interest.

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ЛІКУВАННЯ СПАСТИКИ ТА ДЕГЕНЕРАТИВНО-ДИСТРОФІЧНИХ ЗМІН В М'ЯЗАХ У ДІТЕЙ, ХВОРИХ НА ДИТЯЧИЙ ЦЕРЕБРАЛЬНИЙ ПАРАЛІЧ

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Резюме.

Однією з актуальних проблем реабілітації дітей, хворих на дитячий церебральний параліч (ДЦП), є подолання спастичності та патологічних структурних змін у м'язах, що призводить до порушення статики та локомоції ходи, зниження соціальної адаптації. Одним із центральних напрямків мультидисциплінарної реабілітації хворих на ДЦП є подолання спастичності м'язів. Особливо розповсюдженим є застосування ботулотоксину типу «А». У той же час дані про комбіноване лікування із застосуванням нейротоксину в комплексі із засобами, які стимулюють регенерацію тканин, є розрізненими, носять здебільшого рекомендаційний характер та потребують подальшого вивчення.

Мета роботи: вивчити ефективність комплексного лікування порушень м'язового тонусу в дітей, хворих на ДЦП, на основі комбінованого застосування нейротоксинотерапії та засобів, що стимулюють регенерацію м'язових тканин.

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Матеріали і методи. Проаналізовані показники, що були отримані при лікуванні 40 пацієнтів, хворих на ДЦП, з порушенням м'язового тонусу у вигляді рефлекторних тонічних напружень, спастичності та ригідності. Для діагностики застосовували клінічні та інструментальні методи обстеження.

Результати. Результати порівняльного аналізу показали більш виражену позитивну клінічну динаміку при застосуванні ботулотоксину в комплексній реабілітації дітей з ДЦП. Завдяки впливу комбінованої терапії на весь міофасціальний ланцюг м'язів нижніх кінцівок та спини в підгрупах А і В основної групи були досягнуті позитивні статистично значимі результати ($p< 0,05$) в порівнянні з контрольною групою. Пацієнтам підгрупи С лікування проводили з метою запобігання прогресування контрактур суглобів та відтермінування оперативного втручання.

Висновки: 1**.** Запропоноване комплексне лікування дітей, хворих на ДЦП з порушенням м'язового тонусу у вигляді рефлекторного тонічного напруження та спастичності дозволяє досягти зменшення больового синдрому та спастики м'язів, відновити дефіцит тропоколагену в м'яких тканинах та зв'язковому апараті, що суттєво покращує біомеханіку ходи. 2. Вчасно розпочате консервативне лікування, спрямоване на зниження спастичності та регенерацію м'язових тканин, веде до значної позитивної клінічної динаміки та дає можливість формувати фізіологічний руховий стереотип.

3.Застосована методика в пацієнтів з ригідністю м'язів сприяє відтермінуванню хірургічного лікування та зменшує вірогідність проведення повторних операцій, пов'язаних з рецидивом контрактур.

Ключові слова: діти; церебральний параліч; міофасціальний ланцюг; консервативне лікування.

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