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CONSERVATIVE TREATMENT OF PRONATIONAL CONTRACTURE OF THE FOREARM IN CHILDREN WITH CEREBRAL PALSY

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Aim. We aimed to evaluate the effectiveness of conservative treatment for pronational contracture of the forearm, depending on the contracture severity.

Materials and methods. This study was based on the results of the examination and treatment of children experiencing cerebral palsy with upper limb involvement. The main criterion for patient selection was the presence of pronational contracture of the forearm, both isolated and in combination with other contractures in the upper limb joints. Three patient groups were formed based on the pronounced pronation contracture of the forearm.

Results and conclusions. Previous research has established that with the increase in the degree of severity of pronation contracture, the effectiveness of conservative treatment decreases in general. Conservative treatment of patients with a deficiency of active supination of the forearm of >90° is ineffective. The use of botulinum toxins type A and RFD in groups II and III is ineffective. Conservative treatment with botulinum toxins type A achieved good results only in patients of group I.

The RFD method had a longer lasting; however, there were significantly more complications. The use of botulinum toxins type A (*m. pronator teres*) among patients with pronational contracture of the forearm with the possibility of active supination of the forearm > 90° significantly improved the result of basic conservative treatment.

Keywords: cerebral palsy; upper limb; spastic hand; pronation contracture; surgical treatment.

КОНСЕРВАТИВНОЕ ЛЕЧЕНИЕ ПРОНАЦИОННОЙ КОНТРАКТУРЫ ПРЕДПЛЕЧЬЯ У ДЕТЕЙ С ДЕТСКИМ ЦЕРЕБРАЛЬНЫМ ПАРАЛИЧОМ

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Целью работы являлась оценка эффективности консервативного лечения пронационной контрактуры предплечья в зависимости от степени выраженности контрактуры.

Материалы и методы. Настоящее исследование основано на результатах обследования и лечения детей, страдающих ДЦП с поражением верхней конечности. Основным критерием отбора пациентов было наличие пронационной контрактуры предплечья, как изолированной, так и в сочетании с другими контрактурами в суставах верхней конечности. Сформированы три группы пациентов на основании выраженности пронационной контрактуры предплечья.

Результаты и выводы. На основании проведенных исследований установлено, что по мере увеличения степени выраженности пронационной контрактуры снижается эффективность консервативного лечения в целом. Консервативное лечение пациентов с дефицитом активной супинации предплечья более 90° неэффективно. Применение ботулотоксинов типа А и РЧД во II и III группах малоэффективно. На хороший результат консервативного лечения с применением ботулотоксинов типа А можно рассчитывать только у пациентов I группы.

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Метод РЧД обладает более долговременным эффектом, но имеет значительно большее количество осложнений. Применение ботулотоксинов типа А (*m. pronator teres*) среди пациентов с пронационной контрактурой предплечья с возможностью активной супинации предплечья более 90° достоверно улучшает результат базового консервативного лечения.

Ключевые слова: ДЦП; верхняя конечность; спастическая рука; пронационная контрактура; хирургическое лечение.

The term "spastic hand" characterizes the impaired functionality of the upper limb in children with infantile cerebral palsy (cerebral palsy) [1–6]. Typical contractures for this condition are flexion contracture in the elbow joint, pronational contracture of the forearm, flexion contracture in the wrist joint and finger joints, and the adduction–flexion contracture of the first finger [4–9]. Pronational contracture of the forearm is detected in 48%–50% of patients with upper limb lesion [1, 10–12]. In addition, supination–pronation is known to play a crucial role in the implementation of all functional capabilities of the hand [10–13]. Thus, the emergence of patients with cerebral palsy experiencing progressive pronational contracture at an early age results in a sharp restriction of the function of the entire upper limb.

The musculus pronator teres (*m. pronator teres*) exerts the main impact on the formation of pronational contracture of the forearm [4, 10, 14–16]. Apparently, a long-term contracture can shorten the forearm pronators, as well as form the torsion deformity of the elbow and radial bones. In addition, the use of sophisticated surgical interventions is imperative to eliminate such deformities [6, 15, 17, 18], and is critical to start preventive conservative treatment promptly to prevent the formation of secondary contractures and deformities [1, 5, 15].

Thus, this study **aims** to assess the efficiency of conservative treatment of pronational contracture of the forearm, depending on the degree of its severity.

Materials and methods

This study protocol based on the analysis of the results of the examination and treatment of 64 patients with cerebral palsy, who were treated at the Turner Scientific and Research Institute for Children's Orthopedics of the Ministry of Health of Russia between 2010 and 2016. In this study, we enrolled 64 pediatric patients (34 males [53%] and 30 females [47%]; age: 3–17 years; average age: 8.04 ± 4.15 years). We obtained signed informed consent from all patients or their representatives.

The position of the full pronation of the forearm (up to 90°) was consider 0° in this study to conveniently compare indicators and facilitating the statistical analysis. Thus, the total amplitude of the forearm rotation was 0°–180°.

We created three patient groups in this study based on the amplitude of rotational movements of the forearm as follows: group I, active supination of the forearm is >90° and passive supination of the forearm is not limited (22 pediatric patients); group II, active supination of the forearm is possible only up to the position of 90°; a fixed pronational contracture of the forearm is present in the clinical picture (22 pediatric patients); and group III, active supination of the forearm is impossible until the position of 90°, and there is a fixed pronational contracture of the forearm (20 pediatric patients).

This study comprised the following three phases. First, evaluation of the anatomical and functional state of the upper limb before conservative treatment. Second, evaluation of the efficacy of conservative treatment, depending on the degree of manifestation of pronational contracture of the forearm. In this study, conservative treatment comprised the physical therapy exercises, a course of the massage, laying on the upper limbs with retraction in the shoulder joint, maximum extension in the elbow joint, maximum supination of the forearm, extension in the wrist joint and finger joints, and orthotics. The results were evaluated 2 weeks to 3 months after conservative treatment. The minimum period for evaluating the result was selected on the basis of the observation of positive results primarily in the first 2 weeks after its onset. Children who, in our opinion, did not exhaust all the possibilities of the therapy continued conservative treatment. Third, A comparative analysis of the efficiency of botulinum therapy and radiofrequency destruction (RFD; motor

branches of the peripheral nerves or motor points of muscles), depending on the degree of manifestation of pronational contracture of the forearm.

Thus, we randomly divided patients of each group into two equal subgroups after the completion of conservative treatment. While patients in subgroup 1 were treated with botulinum toxins, those in subgroup 2 were treated with RFD. In addition, we compared the effectiveness of isolated conservative treatment with conservative treatment along the reduced spasticity because of botulin toxins or RFD. For botulinum therapy, we used Dysport (Ipsen Pharma, France), the active substance of which is *Clostridium botulinum* toxin, type A that blocks the release of acetylcholine in the neuromuscular junction, facilitating the removal of muscle spasm at the site of drug administration.

In addition, we used the RFD technique for the spasticity reduction using the radiofrequency generator RFG-1A (Cosman Medical, Inc.; Fig. 1), and the spinal muscles were denervated by thermal destruction of motor branches of the peripheral nerves or nerve fibers in the zone of motor points of *m. pronator teres*.

Perhaps, referring the RFD method as only a conservative or surgical treatment would be unambiguous because the RFD procedure is minimally invasive and is performed through a skin puncture with a needle. However, as the procedure is painful and time-consuming, it is performed under anesthesia.

In addition, the RFD method of treating spasticity refers to the reduction of tone in its effect. Thus, we considered the technique and its results in parallel with botulinum therapy and, then, compared their efficiency. Furthermore, the results of tone-reducing methods were compared 2 months after the treatment.

In this study, methods primarily comprised clinical (evaluation of the amplitude of active and passive supination of the forearm) and functional aspects. In addition, the overall functionalities of the upper limb were assessed using the 2002 MACS classification system (Manual Ability Classification System for Children with Cerebral Palsy 4–18 years). In addition, from the existing functional tests for the upper limb, we selected and adapted the following

Fig. 1. Radiofrequency generator RFG-1A (Cosman Medical, Inc.)

tests that enabled to consider the active rotational amplitude of forearm movements, the degree of arbitrary limb control, and bimanual skills.

1. The "Hand–knee" test: Patients were asked to put their hand on their head and, then, move it to the knee opposite the arm (Leclercq, 2003). This test was assessed on a five-point scale.
2. The grasp test: Patients had to take the object offered to them in the hand (Memberg, 1997). The test was assessed on a five-point scale.
3. The cube displacement test. We calculated how many cubes patients could displace from one box to another in 1 min (Mathiowetz, 1985).
4. The Enjalbert test, It assesses the quality of the grasp of a pen placed at a distance of 40 cm from patients, and shifting it from one hand to the other (Enjalbert, 1988). It was assessed on a five-point scale.
5. Test for the speed of grasping: We counted how many times patients could make a fist and unclench a fist in 1 min.

Results and discussion

We observed a decline in the efficiency of conservative treatment as the degree of manifestation of pronational contracture of the forearm increased. However, a significant effect of the baseline conservative treatment was observed only in group I ($p < 0.05$). Furthermore. the indicators of functional tests increased significantly only in patients of group I and remained completely unchanged in groups II and III.

The analysis of the effect of botulinum therapy and RFD on the amplitude of active supination

Table 1

The dynamics of the amplitude of rotational movements of the forearm after conservative treatment (n = 64)

Group	Average value of active supination of the forearm (before treatment/after treatment/dynamics) (°)			Average value of passive supination of the forearm (before treatment/after treatment/dynamics) (°)		
I	103.9 ± 2.2	136 ± 2.1	+32.1*	–	–	
II	90	103.8 ± 2.9	+13.8	150.6 ± 3.8	157.7 ± 2.9	+7.1
III	49.5 ± 4.5	52 ± 5.1	+2.5	89 ± 4.2	92.3 ± 4.2	+3.3

Note. *p < 0.05.

Table 2

The Dynamics of the amplitude of rotational movements of the forearm after botulinum therapy and RFD (n = 64)

Group	Botulinum therapy. Average value of active supination of the forearm (before treatment/after treatment/dynamics) (°)			Radiofrequency destruction. Average value of active supination of the forearm (before treatment/after treatment/dynamics) (°)		
I	134.1 ± 3.0	173.6 ± 2.1	+39.5*	137.7 ± 2.9	172.3 ± 2.3	+34.6*
II	105.9 ± 3.0	110.9 ± 4.5	+5	101.8 ± 5.1	107.2 ± 5.4	+5.4
III	63.1 ± 5.6	65.9 ± 5.9	+2.8	48.6 ± 8.8	51.3 ± 10.0	+2.7

Note. *p < 0.05.

Table 3

The effect of tonus-reducing procedures on the results of functional tests (number of patients with positive dynamics)

Тесты	Group I (n = 11)		Group II (n = 10)		Group III (n = 10)	
	Botulinum therapy	RFD	Botulinum therapy	RFD	Botulinum therapy	RFD
Enjalbert test	3	4	0	1	0	0
“Hand–knee”	11	11	2	2	1	0
Grasp test	2	4	1	0	0	1
Cube displacement test	1	0	0	0	0	1
Test for the speed of grasping	3	2	0	0	1	0

Note. RFD — radiofrequency destruction.

of the forearm (by 39.5 at 34.6°, respectively) exhibited a significant increase in active supination of the forearm only in group I (p < 0.05; Table 2). In addition. groups II and III exhibited no effect of both botulinum therapy and RFD. Accordingly, patients in groups II and III exhibited no positive changes in the state of the upper limb based on the MACS system. In group I, however, we observed a significant positive dynamics, as the average index was 3.04 ± 0.07 before treatment and 2.09 ± 0.09 after treatment (p < 0.05). Table 3 shows the data of functional tests that both methods are comparable in effectiveness among patients groups.

The functional analysis tests confirmed the conclusions drawn earlier that groups II and III were unpromising for conservative treatment. necessitating surgical treatment. In this study, however, complications of botulinum therapy were not noted.

After RDS, 13 (40.6%) patients (different groups) complained of neuropathy of the median nerve in the form of a vicious extensor position of the hand with a sharp decrease in the strength of the flexors of the fingers II and III; decreased sensitivity (on the palmar surface) of the same fingers. The time limits of the effect of the tone-reducing procedures were evaluated only among patients in group I, as only they exhibited a noticeable effect of reducing spasticity. The duration of RFD of the motor points of the *m. pronator teres* was 4 months to 1 year (average, 8.4 months). Meanwhile, we observed the elimination of neuropathy of the median nerve. In addition, the duration of action of botulinum toxins was 2–6 months (average, 3.8 months).

Thus, this study determined that as the degree of manifestation of pronational contracture increases, the efficiency of conservative treatment, in general, decreases. In addition, conservative treatment of patients. in whom the forearm was not brought to the middle position, was ineffective. Besides, the use of botulinum toxins type A and RFD in groups II and III exhibited low efficacy. Thus, a good result of conservative treatment with the use of botulinum toxins type A could be expected only in group I patients.

Although the RFD method provides a more stable effect, it present a considerably higher number of complications. The use of type A botulin toxins (*m. pronator teres*) among patients with pronational contracture of the forearm with the possibility of active supination of the forearm >90° improves the result of the basic conservative treatment substantially.

Conclusions

This study deduces that conservative treatment of patients with a deficiency of active supination of the forearm >90° is not effective. The use of tonus-reducing techniques increases the efficiency of conservative treatment of pronational contracture of the forearm significantly, but only in patients who could actively supine the forearm to the middle position and more. Furthermore, to reduce focal spasticity of *m. pronator teres*, it is preferable to use type A botulin toxins than RFD because of the higher safety of the first technique.

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