

## Pneumosimulator-Mouth Expander Usage in Patients with Spastic Cerebral Palsy

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### Abstract

One of the main clinical symptom in children with cerebral palsy (CP) is muscle spasticity. It is extremely difficult to treat such children; dental care must be provided very carefully. Preventive measures of oral disease are extremely important in comparison with their healthy contemporaries, since the outcomes or treatment can be life-threatening. Children with CP have insufficient oral hygiene, a high prevalence of caries and its complications, gingival hypertrophy, periodontal disease, tongue thrust and trauma, as well as trauma of the anterior group of teeth. Muscle hypertonia is one of the reasons for the dental pathologies mentioned above. The masticatory muscle hypertension therapy is better to be performed in a complex - myogymnastic exercises and our patented pneumosimulator-mouth expander. This paper describes the prospects for pneumosimulator-mouth expander usage in patients with CP as an uncoupling and muscle relaxant device. Preventive and rehabilitative measures are very important in dental treatment management.

**Review (J Int Dent Med Res 2021; 14(3): 1154-1159)**

**Keywords:** Cerebral palsy, children, pneumosimulator-mouth expander, rehabilitation, treatment, prevention.

**Received date:** 05 June 2021

**Accept date:** 17 July 2021

### Introduction

One of the most common neuropathologies is cerebral palsy<sup>1</sup>. There are 2 to 7 people with CP for every 1000 healthy children<sup>2</sup>. There is 4.5% of children with CP in the Volgograd oblast. The total number is 8560 people<sup>3</sup>. The brain suffers at the earliest stage of its development with this pathology and affects all future body functions. Brain damages can occur either before, during, or immediately after birth. The child is forced to grow up and develop, adapting to the available capabilities of the nervous system<sup>3</sup>. Children do not have the experience of performing correct movements, the main advantage of the newborn is the fact that

the nervous system is very plastic and easily rebuilt, while compensating for the lost functions<sup>4</sup>. According to the International Classification of Diseases, Tenth Revision (ICD-10), there are 5 main forms of cerebral palsy: spastic diplegia, hemiplegic form, double hemiplegia, hyperkinetic and atonic-spastic forms. All patients are characterized by common clinical signs along with the variety of forms<sup>5</sup>:

1. Increased tone-spasticity (in 80% of cases).
2. Decreased muscle strength and endurance.
3. Coordination dysfunction and body feeling.
4. Neuromuscular disease, poor control of precise movements.
5. Preservation of primitive instinctive (innate) reflex that stop the development of conscious complex movements.

It should be noted that the nervous system damage in CP is stable, it never progresses again, however, the outcomes of this pathology progress<sup>6</sup>. It is necessary to start treatment timely and in comprehensive manner, we should compensate the consequences of trauma to the nervous system but not the

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elimination of brain damage, since this is impossible<sup>7</sup>.

Children with cerebral palsy develop severe and aggressive diseases, including the teeth and gums pathologies in combination with disorders of the entire dentition. Our retrospective analysis of the dental diseases in patients with CP in Volgograd revealed that 5488 people with CP and autism have oral diseases: – "gingivitis" – in 100%; – caries and its complications – in 76%; – enamel hypoplasia – 44%<sup>8</sup>.

There are many reasons for the dental diseases development mentioned above<sup>9</sup>. First of all, it is difficult to provide dental care for dentists, due to: children hyperactivity, their behavior variability. <sup>1</sup>This category of patients has the gag reflex, joint contracture, inability to stabilize the head and trunk, upper and lower extremities during dental treatment, professional oral hygiene<sup>10</sup>. <sup>1</sup>Nowadays, the issue of providing dental care to this category of patients is relevant<sup>11</sup>. It was revealed that there is not a unified clinical dental protocol for treatment management of patients with CP<sup>12</sup>. The most common way of treatment children with CP is the general anesthesia usage<sup>13</sup>. This procedure is unsafe, since, due to the presence of general somatic pathology, there is a high risk of complications<sup>14</sup>. In addition, repeated anesthesia is required. Because of this, psychoemotional stress is present in both: parents and children, and it can lead to worse the course of the underlying disease. There is also a possible risk of allergic reactions development and a general deterioration in well-being. At the same time, under general anesthesia, the dentist treats the teeth and lets the patient go. Professional hygiene is extremely rare, preventive examinations are not carried out, which leads to the high percentage of inflammatory periodontal diseases<sup>15</sup>.

Most patients with CP do not receive dental care, as a result the risk of complications threatening the patient's life increases many times over<sup>16</sup>. In addition, the quality of life decreases and social disorientation appears due to difficulties to carry out the rehabilitation of the patient for the underlying disease<sup>17</sup>. Neglected dental diseases complicate the course of the underlying pathology, being foci of chronic infection in the body, hidden foci. It should be noted that children clench their teeth very

strongly that they injure the oral mucosa, even bit off part of the tongue. Therapy should be aimed at correcting and compensating for the consequences of brain damage – speech disturbance, swallowing, chewing<sup>18</sup>.

The masticatory muscle hypertension is one of the leading causes of unsatisfactory oral state. First of all in children with CP we should pay attention to the masticatory muscles to prevent the development of dental complications<sup>19</sup>. The concept of myostomatology, introduced by us, implies a complex effect on the masticatory muscles in order to eliminate the dental problems that arise in this case. The myostomatology is to relieve hypertonicity in the early stages, which will prevent the development of such dental diseases as pathological abrasion of hard dental tissues, gum recession, noncarious lesions (wedge-shaped defects), joint clicking, multiple caries, the oral mucosa trauma.<sup>21,22 23,24</sup> Also, to reduce the masticatory muscles tone will prevent the onset of symptoms in patients due to muscle spasm: headache, dizziness, glossalgia and stomatodynia, allodynia, myalgia.<sup>23,24</sup> The masticatory muscle hypertension treatment should be carried out in compliance with the basic principles of medicine - complex, individual and consistent.

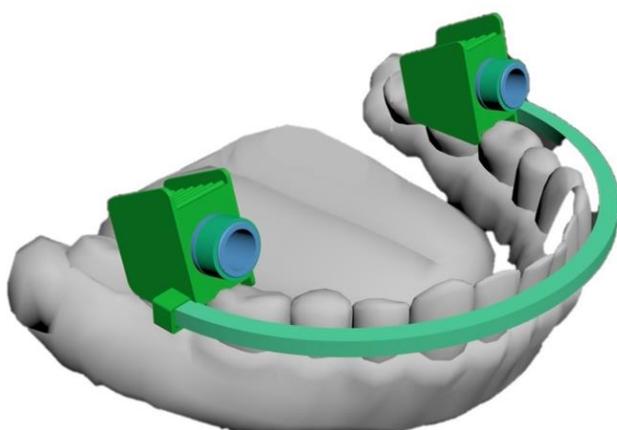
The developed pneumosimulator-mouth expander is one of the ways to influence on the masticatory muscles<sup>25</sup>. The invention proposed by us relates to medicine, namely to dentistry, and is intended for use in gnathic dentistry, as well as for separating the dentition during medical procedures in the oral cavity.

The purpose of the study: to prove the pneumosimulator-mouth expander usage in children with CP

## Materials and methods

A gnathic device is made of medical silicone with an occlusal splint along the outer surface and with edges bent outward of the body to rest on the dental arch. This device is characterized by detachable, consisting of two occlusal bite blocks connected by a vestibular arch, opposite sides which is made with a fixing relief, and its ends are installed in loops rigidly fixed to the bodies of the blocks. The body of each block is made in the form of a truncated prism with a cavity inside and a through hole in the larger base of the prism for installing an air

valve. The air valve is made in the form of a cylinder with a through axial hole, where one end of the air valve is made with flanges along the outer surface for fixing relative to the hole of the block, and the other end is equipped with an adjusting ring fixed on the outer surface and an internal thread for connecting to an air supply source and / or installing a lock of the device. Inside the air valve, perpendicular to its axis, there are fixed blades made in the form of mirrored sectors, rigidly connected by an arc to the valve body, and movable blades made in the form of mirrored, interconnected sectors connected to fixed blades with the possibility of rotation, while the movable blades are additionally connected to the adjusting ring by means of a rod installed in a through groove made in the air valve, and providing the ability to rotate the movable blades at an angle of 90 degrees. The air valve body is made of SBS plastic. The arch of the fixed blades is made with a larger arc of the movable blades. The block body and the adjusting ring of the air valve are made with an indicator for visual observation of the position of the movable blades, made in the form of aligned colored stripes (Fig. 1).



**Figure 1.** 3D visualization of the pneumosimulator-mouth expander prototype.

## Results

The pneumosimulator-mouth expander has several effects, and that is why our device has clinical success. The pneumosimulator-mouth expander allows opening the mouth as

wide as it is necessary during various medical manipulations in the oral cavity by making a certain increased internal pressure in the bite block. Making pressure in the device cavity helps to determine the degree of mouth opening and the degree of the masticatory muscles stretching, which is necessary in masticatory muscles hypertension treatment. At the same time, the device elasticity allows it to be used as a simulator for muscle tissue atrophy. During the patients' treatment and rehabilitation, it is possible to use the device in a complex of myogymnastics to increase its effectiveness and reduce the rehabilitation period. The clinical effects of the pneumosimulator-mouth expander can be achieved due to the masticatory muscles stabilization by redistributing the occlusal load on the joint and restoring the masticatory muscles functions, which is one of the solutions to problems in myostomatology.

There is no requirements for the pneumosimulator-mouth expanders in the available literature, so we tried to formulate them based on their structure and function under normal conditions.

From our point of view, it should:

- provide therapeutic and prophylactic effects
- transfer action to the masticatory muscles
- have a range of motion close to that of a healthy person;
- have a lightweight and durable design, adaptable to the anatomical parameters of the oral cavity;
- bioinert and safe for the patient;
- expand the mouth by 40-50 mm
- be elastic and durable, to maintain high intracavitary pressure
- be able to cyclically dosed air injection to the required values and its release as needed, depending on the disease and the impact on it;
- provide adequate access to the dentition for therapeutic and prophylactic treatment by a doctor,
- simple and available to activate for both, doctor and patient or his parents
- do not slip from the dentition,
- no aspiration during manipulations,
- easy to be disinfected, cleaned and sterilized;
- be available for an individual anatomical parameterization
- do not injure the oral mucosa and gums
- do not effect on the oral hygiene
- be able to remove the device in case of the

mucous membrane inflammation and injury to the gingival papillae

- be mobile and independent of power sources.
- affordable for the mass consumer.

This device should only be used and prescribed for compliant patients, and they have to visit their dentists regularly.

The pneumosimulator-mouth expander usage is also indicated for the following diseases classified according to the ICD-10 code.

1. Dysfunctional conditions of the TMJ:

- K07.6 - Temporomandibular joint disorders (neuromuscular dysfunctional syndrome, occlusive articulation syndrome, pain dysfunction syndrome)
- K07.62 - Jaw claudication and subluxation
- K07.64 - Temporomandibular joint stiffness
- S03.0 - Dislocation of jaw (intra-articular meniscus)
- S03.4 - Sprain and strain of jaw (Temporomandibular joint ligament)

2. Arthritis:

- M00.VX - Pyogenic arthritis of the TMJ
- M12.5X - Traumatic arthropathy (acute traumatic arthritis)
- M05.VX - Rheumatoid, rheumatic, infectious-allergic arthritis

3. Arthrosis:

- M19.0X - Primary arthrosis of other joints (TMJ)
- M24.6VX - Ankylosis of joint

4. Muscle damage:

- F45.8 - Other somatoform disorders (bruxism, teeth grinding)
- M60.0 - Infective myositis of the masticatory muscles
- M62.5 - Muscle wasting and atrophy, not elsewhere classified
- M24.8.0 - Muscle hypertonicity

5. Diseases of the nervous system:

- G43 - Migraine
- G43.2 - Status migrainosus (Tension type headache)
- K14.6 - Glossodynia

Many patients with TMJ pathology do not consult with a doctor, however, they note the following symptoms, which cause the use of a pneumatic expander.

- Muscle pain
- Night grinding teeth (bruxism)
- Pathological abrasion of teeth, split of orthopedic and therapeutic structures
- Fatigue of the masticatory and facial muscles
- Pathological bite

- Headaches, migraines, tinnitus and ringing in the ears caused by the masticatory muscles supertension

- Abnormal fixed postural reflexes
- Mouth opening restriction
- Joint pain while eating, talking
- Face configuration change due to hyper-; masticatory muscle atrophy

Contraindications to use are:

Absolute:

- Intolerance to the components of the pneumosimulator-mouth expander
- Increased gag reflex

Relative:

- Low level of compliance between parents and a child
- Acute respiratory diseases
- Unstable psycho-emotional behavior of the child
- Persistent contracture of the TMJ, with limited mouth opening less than 10 mm
- Periodontal exacerbation and TMJ disorders
- Cheilitis and erosive and ulcerative diseases of the oral mucosa in the acute stage.

Active exercises with the use of relaxing techniques can be effective in the pneumosimulator-mouth expander usage to trigger a biological response of the masticatory muscles, followed by the normalization of the masticatory muscles functional activity. The pneumosimulator-mouth expander usage as a muscle relaxant device to normalize the state of the masticatory muscles, is obviously necessary both for solving practical problems in myostomatology and for increasing the clinical effectiveness in treatment patients with CP in practical health care.

## Discussion

The timely muscle tone correction in CP is the basis for existing rehabilitation methods and a guarantee of the technical means usage in rehabilitation. The masticatory muscles spasticity leads to movements limitation of the lower jaw, muscles shortening, joints deformation, contracture development, existing motor skills loss, impaired breathing, and digestion. It is quite difficult to select identical children with CP based on clinical signs and to conduct a comprehensive analysis of the developed method effectiveness. One and the same method may have a sufficiently high level of effectiveness to achieve

one of the goals and insufficiently justified for the other. Of course, only medical methods (botulinum therapy, antispastic tablet forms) and neurosurgical operations have a direct effect on spasticity. However, it is advisable to include exercises with the pneumosimulator-mouth expander in the treatment regimen, since alternative methods can be used together, and not instead of effective and recommended ones, rehabilitation measures are mandatory for the muscles in order to improve the lost functions. CP treatment is a complex serious problem, and the approach to its solution should also be a complex one. The pneumosimulator-mouth expander usage in combination with isokinetic exercises will contribute to achieve the set goal for a dentist at a dental appointment.

### Conclusions

By influencing the masticatory muscle hypertonicity with the help of the developed pneumosimulator-mouth expander, the dentist solves several problems at once: provides high-quality access to the oral cavity due to its expansion, thereby creating favorable conditions for dental treatment, since dental diseases, their consequences can be dangerous for life, there is a risk of developing infective endocarditis, TMJ disorders, digestive tract diseases. Individual exercising with the help of this device helps to reduce the pathological muscle tone and correct the development of its complications.

### Acknowledgements

The authors express their gratitude to the local authorities (the Volgograd State Medical University) for their support and contribution to this study.

### Declaration of Interest

The authors report no conflicts of interest pertaining to any of the products or companies discussed in this article.

The research performed within the implementation of the grant "sos... — ... cp" of the presidential grants foundation 2021 application 21-2-003314.

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