Trigeminal neuropathy following orthognathic surgery

Tanashyan M.M.[1], Maksimova M.Yu.[1], Ivanov S.Yu.[2, 3], Musaeva E.M.[2], Fedin P.A.[1]

[1]Research Center of Neurology, Moscow; [2]Peoples' Friendship University of Russia (RUDN University), Moscow;
[3]I.M. Sechenov First Moscow State Medical University (Sechenov University), Ministry of Health of Russia, Moscow
[1]80, Volokolamskoe Shosse, Moscow 125367, Russia; [2]6, Miklukho-Maklai St., Moscow 117198, Russia;
[3]8, Trubetskaya St., Build. 2, Moscow 119991, Russia

Traumatic trigeminal neuropathy occupies a special place in the pain continuum. The clarification of genesis and clinical and neurophysiological findings makes it possible to perform differentiation treatment.

Objective: *to evaluate the clinical and neurophysiological efficiency of repetitive magnetic stimulation (RMS) and vitamin B complex therapy for traumatic trigeminal neuropathy.*

Patients and methods. *The investigation enrolled 36 patients (26 women and 10 men) aged 25 to 35 years with inferior alveolar neuropathy following bilateral sagittal split osteotomy. The DN4 questionnaire was used to identify a neurogenic pain component. The intensity of pain syndrome was assessed using a visual analogue scale. A neurophysiological examination involving the recording of brainstem auditory evoked potentials (BAEPs) and trigeminal evoked potentials (TEPs) was made using a Neuro-MEP device (Neurosoft, Russia). Therapy including vitamin B complex was performed in 12 patients. Twenty-four patients received low-frequency pulsed magnetic field therapy using a Neuro-MS magnetic stimulator.*

Results and discussion. *The clinical picture in patients with traumatic inferior alveolar neuropathy after corrective mandible surgery is characterized by the polymorphism of pain sensations and sensory disorders. The development of pain syndrome is due to a neuropathic component. The 10-day vitamin group B therapy cycle had no substantial impact on the time course of clinical and neurophysiological changes. After the 10-day RMS cycle, there were reductions in swelling and the intensity of pain syndrome and the severity of sensory disorders in the lower lip, chin, and mandible. The data on BAEPs showed shortening in the interpeak intervals III–V; those on TEPs demonstrated a decrease in the P1–N1 amplitude.*

Conclusion. *Unlike vitamin B complex therapy, the RMS cycle in patients with traumatic trigeminal neuropathy makes it possible to reduce the intensity of pain syndrome and the severity of sensory disorders, as well as excitability of the nonspecific structures of the brainstem and the central structures of the trigeminal system.*

Keywords: *traumatic trigeminal neuropathy; orthognathic surgery; repetitive magnetic stimulation.*
Contact: *Marina Yuryevna Maksimova;* ***ncnmaximova@mail.ru***
For reference: *Tanashyan MM, Maksimova MYu, Ivanov SYu, et al. Trigeminal neuropathy following orthognathic surgery. Nevrologiya, neiropsikhiatriya, psikhosomatika = Neurology, Neuropsychiatry, Psychosomatics. 2020;12(4):37–42.* ***DOI:*** *10.14412/2074-2711-2020-4-37-42*

Inherited (asymmetric development) and acquired deformations of the jaws, dentition or individual teeth, as well as their combinations, are one of the most common pathologies of the maxillofacial area underlying cosmetic and functional (dental malocclusion) defects. Surgical treatment of development anomalies and jaw deformations consists in the dissection (osteotomy) of the body and ramus of the mandible with extraoral approach [1, 2].

Surgery of the mandibular angle or ramus that creates considerable surfaces of contacting bone fragments is performed most often. In bilateral sagittal osteotomy correct correlation of the elements of the temporomandibular joint is preserved, which shortens the duration of rehabilitation [1, 2]. A key feature of this surgical intervention is direct contact of the osteotomized bone fragments with the mandibular canal containing the inferior alveolar nerve [3, 4].

The main causes of traumatic neuropathy of the inferior alveolar nerve are its compression and stretching caused by sagittal, transverse and vertical displacement of the jaws, alongside with postoperative edema causing nerve ischemia [4–6].

The risk of inferior alveolar nerve damage after orthognathic operations on the mandible is so high that it is advised to warn the patients about possible complications [1, 4, 7]. Postoperative inferior alveolar traumatic neuropathy caused by orthognathic operations occurs in 70–86% of all surgeries [1–3] and manifests in permanent nagging pain in the innervation zone of the damaged nerve branches, mandible teeth, lower lip and chin skin numbness, and sometimes paresthesia in the form of tingling or «creepy» sensation in the skin. Pain may arise spontaneously and is sometimes intensified by emotional tension. The absence of paroxysms and allogenic (trigger) areas is common. During the examination, sensory deficits in the form hyperesthesia, hypoesthesia or anesthesia of the facial skin, oral mucous membrane and teeth can be detected [4–7].

Chin and lower lip sensitivity is impaired in 16.2% of patients post-surgery. [8–11]. Paresthesia, dysesthesia, hyperesthesia and neuropathic pain occur in 50% of patients with damage to the branches of the alveolar nerve [9].

Currently, there are no universally recognized algorithms for the treatment of posttraumatic alveolar neuropathies. Pharmacotherapy is not always effective. Previously, we have noted the efficiency of repetitive magnetic stimulation (RMS) [12].

The purpose of this study is to evaluate clinical and neurophysiological effects of pharmacotherapy with group B vitamins and RMS in treatment of inferior alveolar traumatic neuropathy.

Patients and methods. This study enrolled 36 patients (26 women, 10 men) aged 25 to 35 years, with inferior alveolar neuropathy following bilateral sagittal split osteotomy. There were 15 cases of lower microgenia of the skeletal type with distal occlusion, Angle class II; and 21 patients with lower microgenia, upper retromicrognathia of the skeletal type with mesial occlusion, Angle class III.

One month after surgery, clinical and neurological examination was performed. In order to objectivize the patients' subjective feelings and neuropathic symptoms, sensitivity impairments (numbness, paresthesia) were graded in points: from 0 (no symptoms) to 3 (high intensity). The DN4 questionnaire was used to identify a neurogenic pain component. Intensity of pain syndrome was evaluated using a visual analogue scale (VAS).

Neurophysiological examination – recording of evoked potentials (EP) – brainstem auditory evoked potentials (BAEPs) and trigeminal evoked potentials (TEPs) – was made using a Neuro-MEP device (Neurosoft, Russia).

BAEP was used to evaluate the functional state of the brainstem acoustic structures. BAEP registration was made during consecutive stimulation of each ear individually with short acoustic clicks. The duration of stimulation was 0.1 ms, intensity – 70 decibels above the audibility threshold, frequency – 10 Hz, averaged number – 4000. The active electrode was placed on the vertex (Cz), the reference electrode – on the mastoid, the grounding electrode was placed on the forehead (Fpz). In the 2-channel system of registration we used the ipsilateral lead A2-Cz (with the right-side stimulation) and the contralateral lead A1-Cz. Normally, BAEP consists of 7 spikes, 5 of which are sustainable and reproducible. Spike I is generated by the distal part of the auditory nerve, spike II – by the proximal part of the auditory nerve and cochlear nuclei, spike III – by the superior olivary complex, spike IV – by the ascending auditory fibers at the level of the upper pons and lateral lemniscus, spike V – by the inferior colliculi, spike VI – by the medial geniculate nucleus, and spike VII – by the distal part of the acoustic radiations. The latency periods and amplitudes of spikes I, III, V; inter-peak intervals I–III, III–V, I–V were analyzed both on the ipsilateral (on the side of neuropathy) and contralateral sides.

Table 1. *Parameters of brainstem auditory evoked potentials before and after treatment (median)*

Parameter	Norm	Vitamin B group therapy (n=12)		Repetitive magnetic stimulation (RMS) (n=24)	
		before treatment	after treatment	before RMS	after RMS
Stimulation of the left ear					
Peak I:					
range, μV	0.3	0.3	0.3	0.3	0.4
latent period, msec	1.7	1.7	1.6	1.7	1.5
Peak III:					
range, μV	0.2	0.3	0.3	0.3	0.3
latent period, msec	3.9	3.6	3.5	3.7	3.5
Peak V:					
range, μV	0.4	0.5	0.5	0.6	0.5
latent period, msec	5.7	5.6	5.5	5.6	5.4
Interpeak interval:					
I–III, msec	2.1	1.9	1.9	2.0	1.9
III–V, msec	1.9	2.0	2.0	2.0	1.8*
I–V, msec	4.0	3.9	3.9	3.9	3.8
Stimulation of the right ear					
Peak I:					
range, μV	0.3	0.4	0.3	0.4	0.3
latent period, msec	1.7	1.6	1.5	1.5	1.4
Peak III:					
range, μV	0.2	0.4	0.3	0.3	0.2
latent period, msec	3.9	3.5	3.5	3.4	3.4
Peak V:					
range, μV	0.4	0.5	0.4	0.6	0.5
latent period, msec	5.7	5.3	5.3	5.2	5.3
Interpeak interval:					
I–III, msec	2.1	1.9	2.0	1.9	1.9
III–V, msec	1.9	2.0	2.0	2.0	1.8*
I–V, msec	4.0	3.7	3.8	3.8	3.8

*p<0,05 – compared to pre-treatment parameters

For TEPs registration a 2-channel recording system was used with the placement of active electrodes in C3 and C4 spots of «10–20%» pattern. The reference electrode was placed on Fpz spot, the grounding electrode – on the bridge of the nose. Stimulation intensity was 1.5–2 times higher than the sensitive threshold, but not over 12 mA. Rectangular impulses with the length of 100 ms in the transmission band of the amplifier 5–2000 Hz were used. The averaging number was 300; the analysis period – 100 ms; impedance – not more than 5 kљ. The latency periods of P1, N1, P2 spikes and P1–N1, N1–P2 amplitudes were evaluated.

Subsequently, all patients were divided into 2 groups: 12 patients received group B vitamin therapy for 10 days, and 24 patients with trigeminal traumatic neuropathy were treated using therapeutic RMS with low-intensity impulse magnetic field generated by Neuro-MS magnetic stimulator with a round coil (Neurosoft, Russia, Ivanovo). The external edge of the coil was placed on the mandible area according to the sensory defects. The duration of the procedure was 20 minutes, stimulation force – 1.5 Tesla, impulse frequency – 1 Hz. The procedures occurred daily, the course of treatment was 10 days. The patients did not take any drugs enhancing reparative

processes or improving the functional state of the nervous system. The comparative evaluation of group B vitamins and RMS therapy effectiveness was made on 10th day of the treatment in the hospital.

The statistical analysis was made with MS Excel (Microsoft, USA) and Statistica 8.0 software (Statsoft Inc., USA). The data was introduced in the form of a mean value ± standard deviation. Differences were considered statistically significant at $p<0.05$.

Results. Facial edema, trismus, difficulties with lip stretching and closing, limitations in mandible motor function, articulatory motor skills deficits, paresthesias, pain and sensory defects in the mandibular gingiva, oral mucous membrane, lower lip area, chin and mandible were noted in all patients in the early postoperative period. The pain syndrome was characterized by one-sided constant stabbing, nagging or dull pain in the innervation area of the inferior alveolar nerve, prevalence of such sensations as «creeping» or «tingling», agitation, rubbing of the affected area with a hand, sense of pressure on the affected zone. Food intake and oral cavity hygiene usually intensified pain. Neurological evaluation revealed paresthesia zones, hypoesthesia, hyperalgesia, dysesthesia of the lower lip and chin, slight tenderness on vertical percussion of the teeth and mandible palpation. Trigger areas on the face or in the mouth were not detected.

In accordance with results of neuropathic pain screening test using DN4 questionnaire, in all cases DN score >4 before treatment indicated a neuropathic pain component. According to VAS, pain intensity was 6.8±1.7 cm.

BAEP investigation before the treatment revealed alterations on the medulla-pons level (in the areas of generation of spikes III, V), predominantly on the right, in both groups (Table 1). Latency period shortening and spike amplitude elevation represent higher excitability of non-specific brainstem structures.

TEP analysis before the treatment revealed shortening of the latency of N1 and P2 components and elevation of P1–N1 amplitude on both sides, which is characteristic of hypersynchronal TEP type (Table 2). These changes represent impaired function of the trigeminal system on both sides.

Pain syndrome intensity on the VAS (6,6±1,4 cm), sensory impairment in the operation zone, BAEP and TEP parameters did not significantly change after the 10-day course of vitamin B pharmacotherapy (Tables 1 and 2). Reduction of the postoperative facial soft tissue edema, severity of pain syndrome and sensory defects were noted after the 10-day course of RMS. Sensory impairments regressed in 20 (83,3%) patients. After evaluation with the VAS, subjective intensity of the pain syndrome after treatment was 4,5±1,6 cm (p=0,01).

After the 10-day course of RMS, shortening of interpeak interval III–V on both sides was noted in BAEP investigation (Fig. 1, Table 1). TEP analysis showed P1–N1 amplitude reduction – 2,1 μV with left-sided stimulation; 2,0 μV with right-sided stimulation, whereas the normal value is 1,9 μV (Fig 2, Table 2).

Discussion. In the early postoperative period pain may be caused by damage to the inferior alveolar nerve due to ischemia, compression, or stretching during surgery. Neuropathic syndrome in the late postoperative period is often related to reinnervation processes, development of ectopic stimulation sites in regenerating fibers, and formation of neuromas, which could explain the appearance of pain in the postoperative scars [5, 13, 14].

According to our study, clinical presentation of patients with inferior alveolar traumatic neuropathy after orthognathic operations on the mandible may be quite diverse with regard to pain perception and sensory impairment in the lower lip area, chin and mandible. Trigger areas were not detected. The development of pain syndrome resulted from neuropathic component, which was confirmed by the screening test (DN>4).

Prior to the initiation of treatment, neurophysiological alterations of BAEP and TEP parameters were demonstrated in the form of shortened spike latency and amplitude elevation of several components on both sides, which represent both peripheral and central structures involvement in the pathological process. The elevation of P1–N1 amplitude on both sides characterizes hypersynchronal TEP type. BAEP changes in the form of spike III latency shortening and elevation of primary spikes amplitude indicate enhanced excitability of non-

Table 2. *Parameters of trigeminal evoked potentials before and after a 10-day course of treatment (median)*

Parameter	Norm	Vitamin B group therapy (n=12)		RMS (n=24)	
		before treatment	after treatment	before RMS	after RMS
Left-sided stimulation					
Threshold, mA	5.7	5.1	5.1	5.2	5.1
Components of potentials, msec					
P1	19.2	19.9	19.2	19.8	18.3
N1	33.0	30.2	29.5	30.3	27.5
P2	49.0	40.4	39.5	40.0	37.5
Range, mV					
P1–N1	1.9	2.5	2.3	2.6	2.1*
N1–P2	1.9	2.8	2.5	2.8	1.6
Right-sided stimulation					
Threshold, mA	5.7	5.1	5.0	5.0	5.0
Components of potentials, msec					
P1	19.2	20.5	20.3	20.7	20.2
N1	33	30.4	30.4	30.5	30.3
P2	49.0	42.2	42.0	42.0	42.5
Range, mV					
P1–N1	1.9	2.3	2.2	2.4	2.0*
N1–P2	1.9	1.8	1.7	1.8	1.9

*p<0,05 – compared to pre-treatment parameters

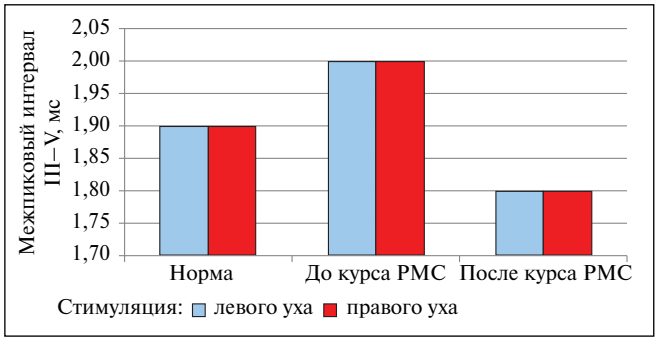

Fig 1. *Dynamics of the interpeak intervals III-V according to acoustic stem-evoked potentials during RMS*

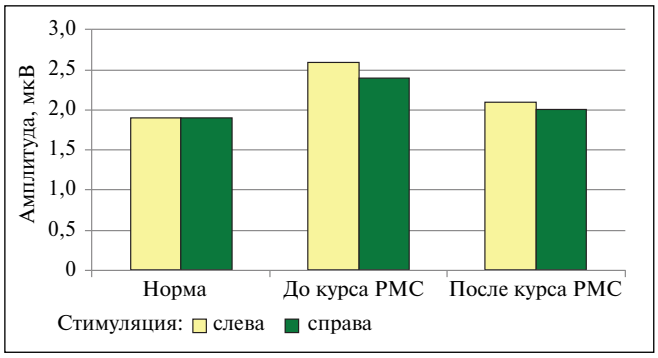

Fig 2. *Dynamics of the interpeak intervals III-V according to acoustic stem-evoked potentials during RMS*

specific brainstem structures. Our results demonstrate that trigeminal neuropathy is caused by structural peripheral impairment and functional changes of the central trigeminal structures.

Different neurometabolic drugs are proposed to treat traumatic neuropathy, although the most commonly prescribed drugs in clinical practice are group B vitamins. Despite the fact that their medical effect is not thoroughly proven, experimental and clinical data suggested their effectiveness. Group B vitamins use is regarded by many authors as an element of pathogenetic therapy of neuropathy that can contribute to reduction of pain syndrome and sensory impairment, and regression of autonomic defects [15].

Clinical and neurophysiological parameters did not improve in the group of patients who underwent a 10-day course of pharmacotherapy with group B vitamins. Traditional pharmacological approach does not appear to be an optimal approach to the problem of treating traumatic trigeminal neuropathy. Thus, the search for an alternative is necessary.

The most important neurophysiological effects of RMS include stimulation of inhibition processes in the cortical representation of the sensory analyzer, elevation of the pain sensitivity threshold, enhancing the activity of the descending pain control systems and increasing the impulse stream along thick myelinated fibers of the trigeminal nerve.

Considering pathophysiological mechanisms of RMS, positive clinical effect is noted in different types of neuropathies (including cranial) of traumatic, compressive, ischemic and toxic etiology [12].

Therapeutic impact of RMS with impulses of low intensity results from threshold sensitivity of neuronal fibers to this type of impact that blocks afferent impulses from the damaged area, increases local blood flow, decreases inflammation and edema, and has trophic influence.

Improvement was noted in pain intensity and sensory deficits after the very first procedure and up to the end of the RMS course.

After the 10-day RMS course inter-peak intervals III–V shortened on both sides according to BAEP data, while the amplitude of spikes P1–N1 lowered. This could indicate lower excitability of non-specific brainstem structures and central structures of the trigeminal system.

Clinical and neurophysiological dissociation in 4 patients after the RMS course (the «delay» of clinical improvement) could be explained by a short course of stimulation during hospitalization and incomplete restoration of functions of the structures involved in impulse conduction.

In this study we have shown that including RMS in the program of treating postoperative trigeminal neuropathy is effective and reasonable, unlike therapy with group B vitamins.

Similar studies at the borderline of neurology and maxillofacial surgery are scarce. Thus, it is important to enhance our understanding of the pathogenetic mechanisms of trigeminal traumatic neuropathy in the setting of increased number of maxillofacial and cosmetology interventions.

Conclusion: RMS course in patients with traumatic trigeminal neuropathy can reduce the intensity of pain syndrome and severity of sensory disorders, as well as excitability of the nonspecific structures of the brainstem and the central structures of the trigeminal system.

REFERENCES

1. Agbaje JO, Salem AS, Jacobs R, Politis C. Systematic review of the incidence of inferior alveolar nerve injury in bilateral sagittal split osteotomy and the assessment of neurosensory disturbances. *Int J Oral Maxillofac Surg.* 2015;44:447-51. doi: 10.1016/j.ijom.2014.11.010

2. Танашян ММ, Максимова МЮ, Федин ПА и др. Невропатия тройничного нерва после оперативных вмешательств в челюстно-лицевой области. Нервные болезни. 2018;(3):22-7. doi: 10.24411/2071-5315-2018-12029
[Tanashyan MM, Maksimova MYu, Fedin PA, et al. Trigeminal neuropathy after surgery in the maxillofacial region. *Nervnye bolezni*. 2018;(3):22-7. doi: 10.24411/2071-5315-2018-12029 (In Russ.)].

3. Yamauchi K, Takahashi T, Kaneuji T, et al. Risk factors for neurosensory disturbance after bilateral sagittal split osteotomy based on position of mandibular canal and morphology of mandibular angle. *J Oral Maxillofac Surg.* 2011;70:401-6. doi: 10.1016/j.joms.2011.01.040

4. Politis C, Lambrichts I, Agbaje JO. Neuropathic pain after orthognathic surgery. *Oral Surg Oral Med Oral Pathol Oral Radiol.* 2014;117:e102-e107. doi: 10.1016/j.oooo.2013.08.001

5. Wijbenga JG, Verlinden CR, Jansma J, et al. Long-lasting neurosensory disturbance following advancement of the retrognathic mandible: distraction osteogenesis versus bilateral sagittal split osteotomy. *Int J Oral Maxillofac Surg.* 2009;38:719-25. doi: 10.1016/j.ijom.2009.03.714

6. Пирадов МА, Максимова МЮ, Синева НА, Водопьянов НП. Невропатия тройничного нерва: Учебное пособие. Москва: Медицинское информационное агентство; 2019. 96 с. doi: 10.30629/978-5-907098-23-7-2019-4-100
[Piradov MA, Maksimova MYu, Sineva NA, Vodop'yanov NP. *Nevropatiya troynichnogo nerva: Uchebnoe posobie* [Trigeminal Neuropathy: A Training Manual]. Moscow: Meditsinskoe informatsionnoe agentstvo; 2019. 96 p. doi: 10.30629/978-5-907098-23-7-2019-4-100 (In Russ.)].

7. Yoshioka I, Tanaka T, Khanal A, et al. Relationship between inferior alveolar nerve canal position at mandibular second molar in patients with prognathism and possible occurrence of neurosensory disturbance after sagittal split ramus osteotomy. *J Oral Maxillofac Surg.* 2010;68:3022-7. doi: 10.1016/j.joms.2009.09.046

8. Politis C, Sun Y, Lambrichts I, Agbaje JO. Self-reported hypoesthesia of the lower lip after sagittal split osteotomy. *Int J Oral Maxillofac Surg.* 2013;42:823-9. doi: 10.1016/j.ijom.2013.03.020

9. Bagheri SC, Meyer RA, Khan HA, Steed MB. Microsurgical repair of peripheral trigeminal nerve injuries from maxillofacial trauma. *J Oral Maxillofac Surg.* 2009;67:1791-9. doi: 10.1016/j.joms.2009.04.115

10. Gualdani R, Ceruti S, Magni G. Lipoic-based TRPA1/TRPV1 antagonist to treat orofacial pain. *ACS Chem Neurosci.* 2015;6(3):380-5. doi: 10.1021/cn500248u

11. Sladki E. Trials of the treatment of trigeminal neuralgia with local administration of thioctic acid. *Med Welt.* 1962;52:2783-4.

12. Танашян ММ, Максимова МЮ, Федин ПА и др. Диагностика и лечение травматической невропатии тройничного нерва. Анналы клинической и экспериментальной неврологии. 2018;12(2):22-6. doi: 10.18454/ACEN.2018.2.3
[Tanashyan MM, Maksimova MYu, Fedin PA, et al. Diagnosis and treatment of traumatic trigeminal neuropathy. *Annaly klinicheskoy i eksperimental'noy nevrologii*. 2018;12(2):22-6. doi: 10.18454/ACEN.2018.2.3 (In Russ.)].

13. D'Agostino A, Trevisiol L, Gugole F, et al. Complications of orthognathic surgery: the inferior alveolar nerve. *J Craniofac Surg.* 2010;21:1189-95. doi: 10.1097/SCS.0b013e3181e1b5ff

14. Degala S, Shetty SK, Bhanumathi M. Evaluation of neurosensory disturbance following orthognathic surgery: a prospective study. *J Maxillofac Oral Surg.* 2015;14:24-31. doi: 10.1007/s12663-013-0577-5

15. Ang CD, Alviar MJ, Dans AL, et al. Vitamin B for treating peripheral neuropathy. *Cochrane Database Syst Rev.* 2008 Jul 16;(3):CD004573. doi: 10.1002/14651858.CD004573.pub3

Received/Reviewed/Accepted
23.04.2020/26.05.2020/1.06.2020

Conflict of Interest Statement
The study was performed as a part of the public assignment of the Research Center of Neurology. The investigation has not been sponsored. There are no conflicts of interest. The authors are solely responsible for submitting the final version of the manuscript for publication. All the authors have participated in developing the concept of the article and in writing the manuscript. The final version of the manuscript has been approved by all the authors.

Tanashyan M.M. *https://orcid.org/0000-0002-5883-8119*
Maksimova M.Yu. *https://orcid.org/0000-0002-7682-6672*
Ivanov S.Yu. *https://orcid.org/0000-0001-5458-0192*