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THE EFFECTIVENESS OF BOTULINUM TOXIN TYPE A IN THE TREATMENT OF NEUROPATHY OF THE INFERIOR ALVEOLAR NERVE AFTER DENTAL SURGERY

Kocharyan A.M. [1*], Amkhadova M.A.[1], Soiher M.I.[2], Yessayan L.K. [3], Azatyan V.Yu. [3]

[1]Department of Surgical Dentistry and Implantology, Moscow Regional Research Clinical Institute named after. M.F. Vladimirsky, Moscow, Russia

[2] Department of Pediatric, Preventive Dentistry and Orthodontics, I.M. Sechenov First Moscow State Medical University, Moscow, Russia

[3]Departament of Therapeutic Stomatology, Yerevan State Medical University after M. Heratsi, Yerevan, Armenia

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Abstract

Neuropathy of the inferior alveolar nerve in recent years is one of the most common complications after dental interventions, accompanied by severe pain and sensitivity disorders. Clinically, iatrogenic neuropathy of the trigeminal nerve is represented, as a rule, by the presence of constant aching, burning or dull pain in the area of innervation of the affected nerve, against which neuralgic paroxysms occur with irradiation of pain, respectively, to the segmental areas of the face. The autonomic nervous system is often involved in the process. Unfortunately, at present there is no uniform treatment protocol for this pathology. As is known, botulinum toxin type A has a direct effect on pain afferents and an analgesic effect when administered locally into areas of sensitivity disorder.

The aim of study to analyze the effectiveness of treatment methods for patients with iatrogenic neuropathy of the inferior alveolar nerve after surgical intervention using botulinum toxin type A.

70 patients took part in the study. For a comparative assessment of the effectiveness of treatment, they were divided into two groups: group 1 – patients who received conservative drug treatment; group 2 - conservative drug treatment in combination with botulinum therapy. Dynamic observation and evaluation of the effectiveness of treatment were carried out before the start of treatment, after 3 and 6 months.

A comparative analysis of the effectiveness showed that the method of complex therapy using injections of botulinum toxin type A in group 2 demonstrated more pronounced positive dynamics than in patients of group 1.

The results of our studies confirmed that botulinum therapy is a modern clinically proven method for relieving pain and sensory disorders in neuropathy.

Keywords: *neuropathy of the inferior alveolar nerve, dental pain, electroneuromyography, botulinum toxin type A, facial pain, complication.*

Introduction

Neuropathy of the inferior alveolar nerve (IAN) often occurs as a result of dental surgery, most often due to extraction of impacted and dystopic teeth and implantation in the lower jaw [*Akopyan G.V., Mat-*

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Address for Correspondence:
Ani M. Kocharyan,
Moscow Regional Research Clinical Institute named after. M.F. Vladimirsky
61/2 Shchepkina street, Moscow 129110, Russia
Tel.:+7-(919)-878-34-75
E-mail: Ani.kocharyan.91@mail.ru,

evosyan D.V., 2019; *Olimov A. et al., 2020]*. Such neuropathy is called iatrogenic and can be associated with the anatomical location of the nerve, incorrect assessment of the available volume of bone tissue bordering the mandibular canal, as well as incorrect choice of implant sizes [*Manjul Tripathi et al., 2020; Ibragimova P.C. et al., 2021*]. Such factors make IAN damage easily accessible through dental surgery. Seddon (1943) noted that nerve damage can have three forms: neurapraxia, axonotmesis, and neurotmesis. Neuropraxia is the mildest form of nerve injury and is caused by mechanical pressure leading to segmental demyelination. Axonotmesis is a more severe lesion in which the structural elements of the nerve fiber are destroyed, but the endo- and perineurium are preserved. Neurotmesis is the most severe form. In this form, a complete rupture of the nerve occurs. The first two forms are most common after a dental appointment [*Rayanova, G.Sh., 2020*]. Lesions of the peripheral nerves of the trigeminal system lead to disruption of their function,and, as a result, along with the pain symptom, sensitivity disorders are also detected in the form of perversion (paresthesia), persistent increase (hyperesthesia), decrease (hypesthesia), loss (anesthesia) [*Tanashyan M.M. et al., 2020; Mohammad M.H. et al., 2021*].

According to the International Association for the Study of Pain (IASP), "pain is an unpleasant sensation or emotional experience associated with actual or potential tissue damage or described in terms of such damage." Patients often describe pain as "excruciating and debilitating", "unbearable sensations", "fear of touching the face when washing, applying cream and other manipulations" [*Timofeev A.A. et al., 2019, Wen C. et al., 2018*]. Sometimes patients go in a "vicious circle" from a dentist to a neurologist, from a neurologist to a psychotherapist or to a psychologist, and then return to the dentist again [*Scholz J. et al., 2019*]. All the above can affect the emotional state and behavior of the patient in society, as well as worsen his quality of life [*Pawan Bista, Wendy L. Imlach, 2019*]. Unfortunately, at present there is no uniform protocol for the treatment of patients with this pathology [*Tanashyan M.M. et al., 2018; Vesova E.P., 2019*].

There is insufficient information in the scientific literature about the pathophysiological mechanisms of damage to the IAN [*Geun W. Lee et al., 2019*], which determine the clinical picture and condition of the patient. Also, the lack of timely diagnosis and single diagnostic criteria can lead to incorrect diagnosis and, as a result, to further incorrect treatment of patients [*Khabadze Z.S. et al., 2019*]. Patients are usually prescribed conservative drug treatment (analgesics, glucocorticosteroids, antidepressants, anticonvulsants) [*Akhmedova Ch.Z, 2022*]. Unfortunately, the analgesic effect of such drugs is often limited or hindered due to significant side effects and/or contraindications. Additional drug therapy is also prescribed (B vitamins [*Ang C.D. et al., 2008*], anticholinesterase drugs) [*Inoyatova S.N. et al., 2020*]. In addition to the main therapy, a course of physiotherapy is prescribed.

Surgical methods are used when conservative methods are completely ineffective, since there is a high risk of relapse with worsening of the clinical picture, and they are also quite traumatic [*Benoliel R. et al., 2012*]. The question of using the modern surgical method of minimally invasive surgery and microsurgery in the treatment of neuropathy remains open, since it is difficult to access, complex and poorly studied.

One of the innovative treatment methods is the use of botulinum toxin type A, the advantage of which is the local administration of the drug and its effect, dose dependence, reversibility, safety, good tolerability in patients, clinical and economic effectiveness [*Muñoz Lora V.R.M. et al., 2019; Wei-Jia Chen et al., 2021; Capon C. et al., 2022*]. The scientific literature describes cases where, with a single course of administration of botulinum toxin type A, the result of relief of pain and sensory disorders was achieved [*Capon C. et al., 2021*]. Also, such treatment can provide significant improvement in the patient's condition and overall quality of life without any significant side effects [*Moreno-Hay I. et al., 2019*]. Further studies will be required to fully evaluate the effectiveness and safety of this method.

The aim of study to analyze the effectiveness of treatment methods for patients with iatrogenic neuropathy of the inferior alveolar nerve due to surgical intervention using botulinum toxin type A (BTA).

MATERIALS AND METHODS

70 patients took part in the study, of which 52 were women (74.2%) and 18 men (25.8%).

For a comparative assessment of the effectiveness of treatment, they were divided into two groups: group 1 - patients who received conservative drug treatment, group 2 - conservative drug treatment in combination with botulinum therapy. Dynamic observation and evaluation of the effectiveness of treatment were carried out before the start of treatment, after 3 and 6 months.

Inclusion criteria:
- surgical intervention (wisdom tooth removal and implantation);
- patients aged 18 to 55;
- complaints of sensitivity disorder and pain;
- negative pregnancy test;
- availability of informed voluntary consent.

Non-inclusion criteria:
- pregnancy;
- breastfeeding;
- burdened allergy anamnesis;
- severe somatic diseases.

Exclusion criteria:
- refusal to sign informed voluntary consent;
- patient non-compliance with recommendations.

A clinical randomized controlled trial was conducted. Permission from the Interuniversity Independent Ethics Committee (№11 dated October 1, 2020) was obtained to conduct clinical studies.

The patients under study were divided into two groups: group 1 - 35 people, patients who were prescribed conservative treatment (Neuromidin 20 *mg* - 3 times a day, Berlition 600 *mg* - 1 time a day, Milgamma - 2 IM - 1 time a day for 10 days), group 2 - patients who were prescribed conservative treatment in combination with injections of botulinum toxin type A - Relatox (MICROGEN, Russia, Registration Certificate No. LP-001593 dated March 19, 2012). The area of impaired sensitivity was determined by touching the skin in the face area with impaired sensitivity and the side symmetrical to it with a gauze (cotton) ball. The patient under study had to register all touches that were applied sequentially to different areas in the area of impaired sensitivity, and answer "yes (he feels)" or "no (he does not feel)."

Relatox was administered using the intradermal injection technique into the area of loss of sensitivity in a checkerboard pattern, the distance between injections was 1–1.5 *cm*, the injection depth was 2–4 *mm*, while 1–2 units were injected at the injection point, and the total dose of the injected solution was 9 – 15 units (Fig. 1) [*Hong S, 2023*]. Dynamic observation and evaluation of the effectiveness of treatment were carried out before the start of treatment, after 3 and 6 months. To subjectively assess the severity of the pain syndrome, a visual analogue scale (VAS) was used, and separately the "Severe pain" indicator, which was

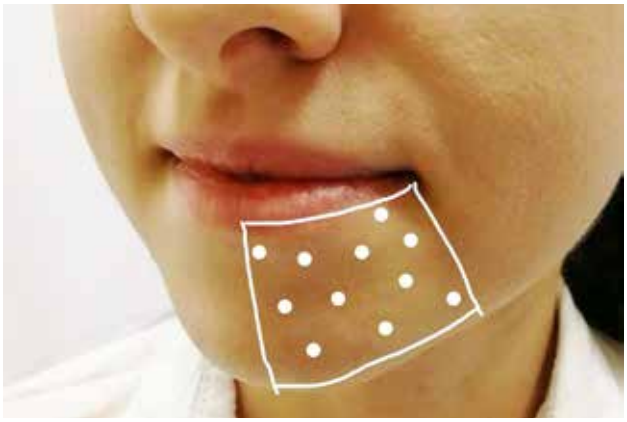

Figure 1. *Scheme of administration of botulinum toxin type A. Relatox was administered using the intradermal injection technique into the area of loss of sensitivity in a checkerboard pattern.*

equal to 7 points on the scale, the area of neuropathy (S) was calculated with outlining the boundaries of Sensitivity disorders on the surface of the skin and on the oral mucosa (Fig. 5; 6). [*Aicher B. et al., 2012*] At the same time, the area of neuropathy in each patient was individual in localization and rotation (Fig. 2).

Determining the boundaries for calculating the area of neuropathy (where the white line is the initial level of sensitivity disorder that appeared at the onset of the disease; red - after a year of conservative therapy, it also corresponds to the moment of BTA administration (primary injection); yellow - 3 months after the initial administration of BTA; green – six months after the administration of BTA (secondary injection was made 3 months after the primary)).

The VAS is a pain intensity scale that is determined by a linearly increasing value. Its extreme values for the patient correspond to the absence of pain (0 points), followed by mild pain (from 1 to 4 points), moderate (from 4 to 7 points) and the presence of the most "Severe pain" that he can imagine (from 7 to 10 points). When contacted, patients often described the

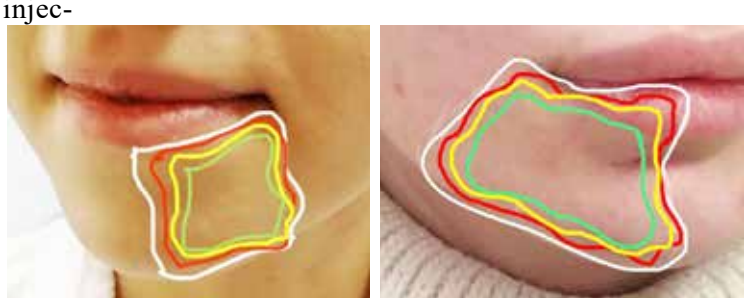

Figure 2. *The area of neuropathy in each patient was individual both in localization and rotation*

nature of the pain as: "debilitating", "very strong", "impossible to endure", "painful to touch". Therefore, we calculated the "Severe pain" score (based on the VAS score of 7, which is its lower limit) 3 and 6 months after treatment in the 2 groups in order to compare the results of the therapy.

Electroneuromyography (ENMG) was used as a functional diagnostic method [*Zavaliy L.B. et al., 2022*]. ENMG is a research method that is based on recording and assessing electrical potentials arising during the work of skeletal muscles, conducting impulses along peripheral nerve fibers. Electroneuromyography is used for the differential diagnosis of movement disorders arising from damage to peripheral nerves. Neurophysiological research was carried out using the Neuro-MVP device (Neurosoft, Russia, registration certificate RZN 2021/13988).

The stimulating electrode was installed at the exit site of the IAN (III branch of the trigeminal nerve). The lead electrodes were located on the mentalis muscle so that the active electrode was more proximal and the reference electrode more distal. The distance between the output electrodes is at least 2–3 cm. (Fig. 3). The amperage used to stimulate the sensory nerve fiber is much lower than that used to elicit an M-response from the motor nerves (about 7–15 mA). When recording a sensory response (SR), its amplitude, latency and distance from the middle of the cathode of the stimulating electrode to the middle of the active electrode are measured, and then the nerve conduction velocity (NCV) is calculated.

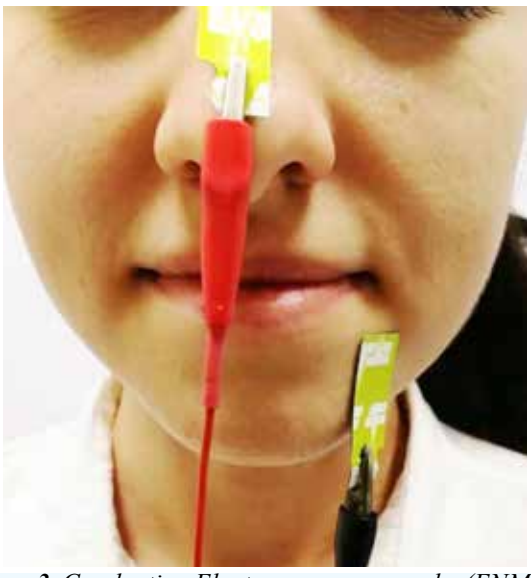

FIGURE 3. *Conducting Electroneuromyography (ENMG). Neurophysiological research was carried out using the Neuro-MVP apparatus, the stimulating electrode of which was installed at the exit site of the third branch of the trigeminal nerve. The lead electrodes were placed on the mentalis muscle such that the active electrode was proximal and the reference electrode was distal.*

Statistical data processing was carried out using application packages Statistica 10 and SAS JMP 11. Statistical significance was fixed at 0.05.

Analysis of data completeness was carried out on the base of the number of non-missing data and their share in full in the "N (%)" format (Table 1). The average value and standard deviation in the format "M ± S" were used to indicate the central position and absolute variability in measurements, and the variation coefficient V

TABLE 1.

Descriptive statistics of quantitative indicators for two comparison groups. In all grroups N=70 (100%)

Indicator	M ± S	V (%)	Me [LQ; UQ]	(Min; Max)
Variables at the beginning of the study "Debut"				
VAS	7.50± .46	19	8.00 [6.25;8.75]	(4.00; 10.00)
S	7.88±2.22	28	7.80 [6.43;9.80]	(3.40; 12.00)
SR (*mV*),	6.63±1.87	28	6.70 [5.40;8.05]	(2.20; 10.20)
NCV (*m/s*)	41.47±6.09	15	42.35 [36.98;46.38]	(28.70; 52.40)
Variables during the period of "3 months"				
VAS	6.89±1.48	21	7.00 [6.00;8.00]	(3.00; 10.00)
S	7.12±2.03	29	7.10 [5.82;8.78]	(3.00; 10.80)
SR (*mV*)	6.16±1.63	26	6.20 [5.12;6.90]	(2.20; 10.00)
NCV (*m/s*)	40.10±5.52	14	40.20 [36.25;44.10]	(28.70; 51.10)
Variables over a period of "6 months"				
VAS	5.40±1.63	30	5.00 [4.00;7.00]	(1.00; 8.00)
S	5.09±1.78	35	5.55 [3.40;6.20]	(2.00; 8.90)
SR (*mV*)	9.01±2.23	25	9.50 [7.90;10.30]	(2.40; 12.60)
NCV (*m/s*)	46.70±5.45	12	47.75 [44.32;51.05]	(30.60; 54.20)

NOTES: *VAS - visual analogue scale, S - area of neuropathy, NCV - nerve conduction velocity, SR - Sensory response,*

was used to estimate the relative variability in measurements (if the level of variation is less than 10%, then the degree of data scattering is insignificant, from 10% to 20 % - average, more than 20% and less than or equal to 33% - significant; if the value of the coefficient of variation does not exceed 33%, then the population is considered homogeneous, if more than 33%, then it is heterogeneous), which describes the homogeneity of the indicator and allows one to compare the homogeneity of different variables , regardless of their scale and units of measurement. To study the data structure for each indicator, the median and quartiles were used in the format "Me [LQ; UQ]", and minimum and maximum to assess the range of dispersion of indicator values in the format "(Min; Max)".

Correlation analysis was carried out using nonparametric Spearman's rank correlation coefficient Table 2.

Based on the obtained data presented in the Table 1, we can conclude that during the "Debut" period, the indicator "NCV, m/s" is strongly positively correlated with the indicator "Sensory response, mV" (Rs = 0.83, p≤0.01). An increase in one indicator leads to an increase in the other. And vice versa: a decrease in one of the indicators leads to a decrease in the other. A similar picture can be seen between these indicators in the period of "3 months" (Rs = 0.79, p≤0.01) and in the period of "6 months" (Rs = 0.82, p≤0.01), which indicates a strong correlations of the indicators "NCV" and "Sensory response" throughout the observation of patients. These two indicators correlate with each other, as when the nerve is restored, both capacity along the nerve trunk and the speed of nerve conduction velocity improves.

If the obtained coefficient values correlations are statistically significant, this means that they are typical not only for the subjects being studied, but also for the general population, that is, for any other patients that can be studied.

VAS scores do not correlate with any of the other scores. So, for example, we can conclude that while reducing the pain of the patients, there is no effect on the change in the area of sensitivity disorder, the same can be said vice versa. Also, changes in nerve conduction, for example, it's strengthening, do not affect the change in pain of the patients, that is, VAS may not change in any way when the sensory response changes, in other words, the feeling of pain in patients may not change when nerve conduction increases. However, the NCV indicators and sensory response are interrelated with each other, as in the "Debut" stage.

The same pattern can be traced between these indicators in the period of "3 months" (Rs=0.79, p≤0.01) and in the period of "6 months" (Rs=0.82, p≤0.01), which indicates a strong correlations of indicators "NCV" and "Sensory response" throughout the observation of patients. It means that at the treatment stage of 6 months, conduction along the nerve trunk and the speed of nerve conduction velocity, as well as at previous stages of treatment, are interconnected. With increased conductivity, the speed of nerve conduction velocity also increases, which is reasonable during the process of regeneration of the

Table 2.

Indicators of the relationship of variables (Spearman correlation coefficients) during the periods ("Debut", "3 months", "6 months")

Indicator	VAS	S	SR (*mV*)	NCV, (*m/s*)
Variables at the beginning of the study "Debut"				
VAS	1	0.12	0.12	0.09
S	0.12	1	0.04	0.09
SR(*mV*)	0.12	0.04	1	0.83**
NCV (*m/s*)	0.09	0.09	0.83**	1
Variables during the period of "3 months"				
VAS	1	0.02	0.13	0.08
S	0.02	1	0.01	0.09
SR (*mV*)	0.13	0.01	1	0.79**
NCV (*m/s*)	0.08	0.09	0.79**	1
Variables over a period of "6 months"				
VAS	1	0.15	-0.02	-0.04
S	0.15	1	-0.09	-0.03
SR (*mV*)	-0.02	-0.09	1	0.82**
NCV (*m/s*)	-0.04	-0.03	0.82**	1

Notes: *VAS - visual analogue scale, S - area of neuropathy, NCV - nerve conduction velocity, SR - Sensory response,*
** - statistical significance at the level of p≤0.05.*
*** - statistical significance at the level of p≤0.01.*

peripheral nervous system. At the same time, pain in patients and Area of sensitivity disorder may not change or change insignificantly, which means that these indicators are subjective, patients may not always accurately assess changes and give an exact assessment of sensitivity disorder.

Based on the obtained data presented in the Table 3, we can conclude that all indicators do not differ statistically significantly between the two compared groups during the "Debut" period, which means that they are comparable. That is, the indicators we studied in both the first and second groups at the start of treatment did not have much difference in values. We believe that it is important to conduct the study and summarize the results, since with a large difference between the study groups, it is impossible to draw a reliable conclusion.

Based on the obtained data presented in the Table 3, we can conclude that in the "Indicators" category, all indicators do not differ statistically significantly between the two compared groups in the "3 months" period. This means that they are also comparable. Also, it means that after 3 months of treatment there were no significant changes between the indicators of the first and the second group, it means that the treatment in both groups had almost the same result.

TABLE 3.

Comparison of the two groups according to quantitative indicators during the "Debut", "3 months" and "6 month" periods (mean ± standard deviations (Mann-Whitney test))

Indicator	Conservative Groups		P Level
	Without BT (N=35)	With BT (N=35)	
variables at the beginning of the study "Debut"			
VAS	7.7±4 1.36	7.26±1.54	0.1718
S	7.91±2.17	7.85±2.30	0.9766
SR, (*mV*)	6.47±1.79	6.79±1.95	0.4771
NCV (*m/s*)	42.22±5.63	40.71±6.51	0.2877
variables during the period of "3 months"			
VAS	7.20±1.35	6.57±1.56	0.0633
S	7.23±2.04	7.01±2.05	0.5728
SR, (*mV*)"	5.87±1.46	6.45±1.75	0.2469
NCV (*m/s*)	40.86±5.23	39.35±5.78	0.2045
variables during the period of "63 months"			
VAS	6.17±1.38	4.63±1.50	<0.0001
S"	5.67±1.74	4.50±1.64	0.0065
SR, (*mV*)	8.33±1.96	9.68±2.32	0.0021
NCV (*m/s*)"	45.55±5.17	47.84±5.56	0.0311

NOTES: *VAS - visual analogue scale, S - area of neuropathy, NCV - nerve conduction velocity, SR - Sensory response,*

Based on the obtained data presented in the Table 3, we can conclude that all indicators differ statistically significantly between the two compared groups. The most significant differences were found for the "S" indicator in the "Conservative" group in relation to the "Conservative + BT" group (on average by 1.2; P = 0.0065); indicator "Sensory response, mV" in the "Conservative + BT" group in relation to the "Conservative" group (on average by 1.4 mV; P = 0.0021); "VAS" indicator in the "Conservative" group in relation to the "Conservative + BT" group (on average by 1.5; P < 0.0001). It means that the treatment outcome at 6 months was noticeably different between the two groups. One can also note the positive dynamics in the "Conservative with botulinum therapy" group compared to the "Conservative" group.

RESULTS

During the study, we found that the "VAS" indicator in the period of "3 months" in relation to the "Debut" period decreased for two groups: "Conservative" and "Conservative with botulinum therapy" by 7.0% and 9.5% respectively. "VAS" indicator for the period "6 months" in relation to the "Debut" period decreased for the two groups by 20.3% and 36.2% respectively (Fig. 4).

From Table 3 we see that there were no significant differences at the initial stage of the VAS score between the study groups; patients felt pain equally (p = 0.1718). However, according to the study results from Table 3, clear differences are visible between the study groups after six months of treatment (p <0.0001). It also means that the VAS in the "Conservative with botulinum therapy" group is on average 1.5 points lower, and since the difference is significant, it means that in this group the VAS score after 6 months of treatment is lower, which, in its turn, indicates a better result than in the "Conservative" group.

We should note the "Severe pain" indicator, since the two groups differ significantly in the number of patients 6 months after treatment (Chi-

square, p = 0.0015). We observe a sharp decrease in the number of positive responses that severe pain persisted after treatment in the "Conservative with botulinum therapy" group compared to the "Conservative" group, which is an indicator of good dynamics in complex treatment using injections of botulinum toxin type A. We believe it's important, since by reducing sharp pain, the patient's quality of life and well-being increases.

The "Severe pain" indicator in the "Debut" period did not differ in the two studied groups (Chi-square, p = 0.2740), while after 6 months they were significantly different (p = 0.0015). It means that in the "Conservative" group there are more patients with the "Severe pain" indicator than in the "Conservative with botulinum therapy" group.

Against the background of the therapy, at the 3-month follow-up stage, there were no positive dynamics noted in the "Severe pain" indicator, which may be relative due to a delayed effect on the stimulating processes of one's own regeneration of nervous tissue.

Indicator "Area of sensitivity disorder" during the period "3 months" in relation to the "Debut" period decreased for two groups: "Conservative" and "Conservative with botulinum therapy" by 8.5% and 10.8% respectively. Indicator "Area of sensitivity disorder" during the period "6 months" in relation to the "Debut" period decreased for the two groups by 28.3% and 42.7% respectively. (Fig. 7)

The indicator "Sensory response, mV" in the period "3 months" in relation to the period "Debut" decreased for two groups: "Conservative" and "Conservative with botulinum therapy" by 9.2% and 4.9% respectively. Increase in the indicator "Sensory response, mV" during the period of "6 months" in relation to the "Debut" period was registered for the two groups by 28.8% and 42.6% respectively (Fig. 8).

Indicator "NCV, m/s" during the period "3 months" in relation to the "Debut" period decreased for two groups: "Conservative" and "Conservative with botulinum therapy" by 3.2% and 3.3% respectively. Increase in the indicator "NCV, m/s" in the period "6 months" in relation to the "Debut" period, 7.9% and 17.5% were registered for the two groups. (Fig. 9)

The data obtained during the study allows us to conclude the following:

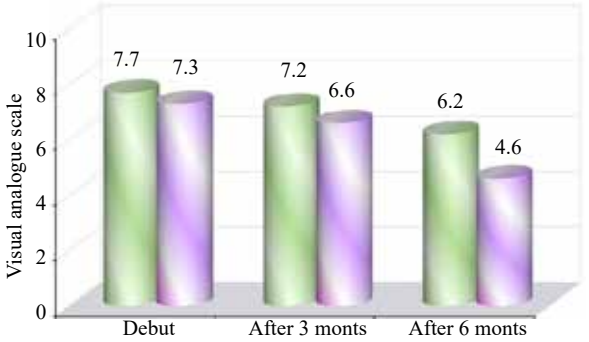

Figure 4. *Dynamics of the visual analogue scale (VAS) indicator. On the left are the indicators of the group with "Conservative" treatment, on the right is the group with "Conservative with botulinum therapy".*

Figure 5. *Percentage of occurrence of indicators "Severe pain after 6 months" in the "Conservative" group.*

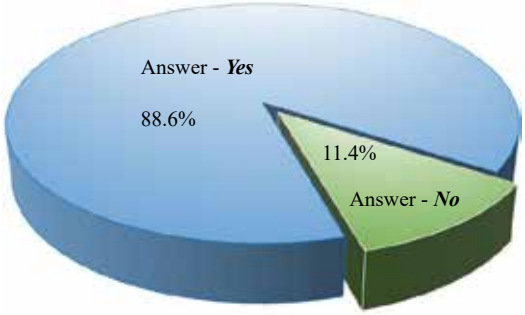

Figure 6. *Percentage of occurrence of indicators "Severe pain after 6 months" in the "Conservative with botulinum therapy" group.*

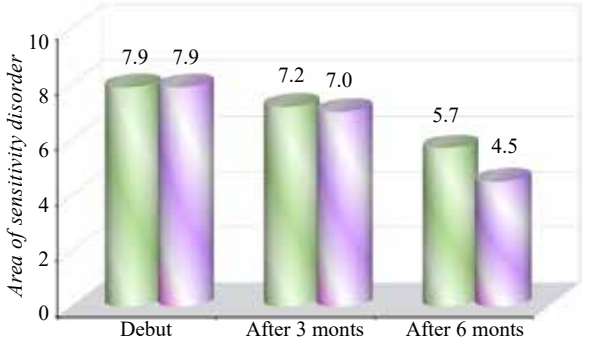

Figure 7. *Dynamics of the "Area of sensitivity disorder" indicator. On the left are the indicators of the group with "Conservative" treatment, on the right is the group with "Conservative with botulinum therapy".*

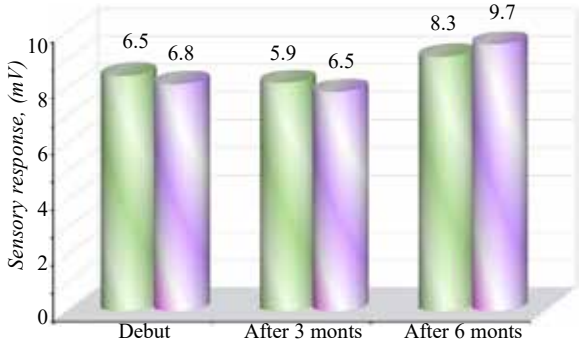

FIGURE 8. *Dynamics of the indicator "Sensory response, mV". On the left are the indicators of the group with "Conservative" treatment, on the right is the group with "Conservative with botulinum therapy".*

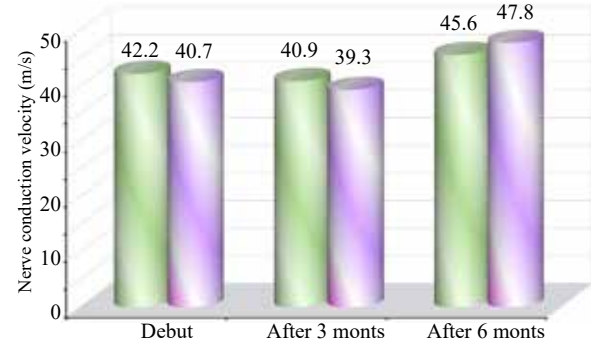

FIGURE 9. *Dynamics of the indicator "NCV, m/s". On the left are the indicators of the group with "Conservative" treatment, on the right is the group with "Conservative with botulinum therapy".*

1. The indicator "Severe pain after 6 months" in patients in the "Conservative" group - the decrease in the average value was 47.5%, while in the "Conservative with botulinum therapy" group it was 11.4%, which is 4 times less than in the first group.

2. In the second group, the area of sensitivity disorder was significantly smaller after 6 months. Thus, in respect that the lower this indicator, the better the result, we can say that complex conservative treatment with "Conservative with botulinum therapy" has better results after 6 months.

3. The increase in the indicator "NCV, m/s" during the period "6 months" in the second group "Conservative with botulinum therapy" was 17.5% compared to the "Debut" period, while in the "Conservative" group it was 7.9%, which indicates that the conduction of impulses along peripheral nerve fibers is better in patients who were treated with botulinum toxin therapy.

4. The increase in the indicator "Sensory response, mV" in the period "6 months" in relation to the period "Debut" was 28.8% for the "Conservative" group and 42.6% for the "Conservative with botulinum therapy" group. The data of "NCV, m/s" we obtained allow us to assert that against the background of complex therapy in the second group "Conservative with botulinum therapy", the conductivity of the IAN is noticeably improved in the period of "6 months", compared to the first group "Conservative", due to the stimulatory effect on one's own regenerative functions.

5. Against the background of the therapy, at the stage of 3 months there is no pronounced positive dynamics in all indicators, this is due to some lag of the ENMG picture from the clinical one (normally 2-3 weeks), as well as with the delayed effect of botulinum toxin type A, due to its stimulating effect on the processes of tissues' own regeneration.

Thus, we see that by the 6th month of treatment, the "Conservative with botulinum therapy" method has a significantly better value for all indicators we measured. It means that this type of therapy can be recommended, as it showed good results after 6 months.

DISCUSSION

If the inferior alveolar nerve is damaged, timely diagnosis and proper treatment are necessary. There are various neurometabolic drugs aimed at treating traumatic neuropathy, but B vitamins are most often used for this purpose. Experimental clinical data show that they are quite effective, although this has not yet been conclusively proven [*Ang C.D. et al., 2008*]. There is a method of treating the inferior alveolar nerve using electrical stimulation with the Myovolna apparatus with a voltage amplitude of 20-30 *V*, a current frequency of 4-7 *Hz*, a duration of 10 minutes, a course of 10 daily procedures. Additionally, daily projection irradiation of the operated area of the lower jaw is carried out for 10 minutes with a scanning laser emitter from the Intradont apparatus for 12 days. The authors indicate that this method provides relief of pain and numbness of the relevant areas of the facial skin. However, the disadvantage of this treatment is the lack of choice of direct local impact on the post-traumatic area, which affects the effectiveness and the result of such treatment [*Sirak S.V. et al., 2015*]. A study was also conducted in which patients with traumatic neuropathy received magnetic stimulation (MS) with high-

intensity pulses, in particular transcranial one. As a result, data were obtained that the therapeutic effect of high-intensity rhythmic MS pulses is due to the maximum threshold sensitivity of the nervous structures to this effect and helps to reduce inflammation, edema, and has a trophic effect. However, the authors of the article indicate that MS therapy does not provide complete clinical recovery without complex drug treatment of neuropathies, which was not carried out in the presented patients [*Tanashyan M.M. et al., 2018*]. The traditional drug approach is not the optimal solution to the problem of treating traumatic trigeminal neuropathy [*Pawan Bista, Wendy L. Imlach, 2019*]. Some colleagues recommend prescribing corticosteroids, a commonly used anti-inflammatory drugs for patients with paresthesia after nerve injury. The study suggests these medications may help to prevent neuroma formation, that's why higher doses were recommended in the first week after nerve injury [*Misch C.E., Resnik R.*, *2010*; *Agbaje J.O. et al., 2016*]. However, taking corticosteroids does not solve the underlying problem of patients. There is also a study conducted on a patient with paresthesia - a 56-year-old woman who underwent implantation in the area of teeth 3.6, 3.7 two years ago. The patient received weekly acupuncture sessions for four months. Six sites were used: colon (LI4), colon (LI11), stomach (ST36), liver (LR3), head and neck (EHN-18), and stomach (ST5). As the authors of the study stated, these points were selected according to patient characteristics and observed clinical features (paresthesia and muscle pain). [*Yamamura Y., 2001*]. A visual analogue scale was used before and after each session to analyze paresthesia and pain, and to evaluate paresthesia by delimiting the desensitized area of skin and experienced discomfort. After the first session, a decrease in pain intensity was observed. After three sessions, acute pain became less frequent and disappeared after the fourth session. After 10 sessions, paresthesia remained in only one point, and after one year of follow-up it remained in the same point. However, this treatment method has little evidence base, so we cannot conclude about its effectiveness. Therefore, the search for alternative approaches to the treatment of IAN neuropathy seems relevant.

Conclusion

The injection technique of botulinum toxin type A in combination with drug therapy can be used as an alternative treatment method. According to the study, the clinical picture in patients with traumatic neuropathy of the inferior alveolar nerve after complex treatment together with injection of botulinum toxin type A was characterized by a noticeable decrease in pain and sensory disturbances in the area of the lower lip, chin, and lower jaw. During the functional research method, a clear relationship was established between the severity of ENMG indicators ("NCV, m/s" and "Sensory response, mV"), and the duration of IAN neuropathy. We also observed a decrease in the time required to achieve positive dynamics in comparison with previous surveys. The increase in the above indicators was directly proportional to the decrease in clinical manifestations of neuropathy. Assessing our results, an analgesic effect has been identified and proven, as well as a reduction in the area of sensory impairment during complex therapy using botulinum therapy injections, which can contribute to a better therapeutic effect in the treatment of this pathology. In this regard, it can be claimed that drug treatment in combination with injections of botulinum toxin type A is more effective than conservative treatment. We believe that if the evidence base is strengthened, this method of therapy can become a standardized method of treating patients.

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Address for correspondence:

Yerevan State Medical University
2 Koryun Street, Yerevan 0025,
Republic of Armenia

Phones:

(+37410) 582532 YSMU
(+37493 588697 Editor-in-Chief
Fax: (+37410) 582532
E-mail:namj.ysmu@gmail.com, ysmiu@mail.ru
URL:http//www.ysmu.am

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