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ORIGINAL ARTICLE

DESIGNING OF A CUSTOM DEVICE FOR INVESTIGATING THE MASTICATORY AND TEMPORAL MUSCLES IN PATIENTS EXPERIENCING TMJ DYSFUNCTION

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Abstract

Relevance: At present, electromyography (EMG) serves as the standard method for diagnosing the condition of masticatory muscles.

This technique enables the evaluation of bioelectric potentials, including bioelectric rest, average biopotential amplitude, the duration of chewing cycle and the number of chewing movements performed.

In dental practice, EMG is conducted using electromyographs with electrodes attached to the skin using adhesive or electrically conductive gel. However, this installation process is often time-consuming, and the mobility of the sensors can compromise result reliability. Furthermore, when performing multiple EMG studies on a patient during different stages of treatment, there is no guarantee that the motor point will be consistently selected, leading to inaccurate data and comparisons.

The aim is to develop and implement a personalized device design for performing EMG on masticatory muscles, ensuring consistent repetition of the study in clinical practice.

Materials and methods: Through a comprehensive analysis of scientific literature, information sources were utilized to develop and manufacture an EMG device.

Results: The technical outcome achieved includes a simplified methodology, improved sensor fixation, reduced EMG duration, and the ability to replicate the study consistently at various stages of a patient's treatment.

Conclusion: The developed device and EMG methodology offer a simplified approach to obtaining accurate study results with reduced time requirements. Additionally, if repetition of the study is necessary, the obtained data would be representative.

Keywords*: electromyography, bruxism, masticatory muscle hypertension, dental CAD/CAM technologies, 3D printing*

Introduction

Diseases of the temporomandibular joint are quite common in the practice of a dentist. According to the World Health Organization (WHO) in 2008, the prevalence of this pathology among people aged 35-45 was more than 75%. In most cases, patients also have concomitant hypertension of the masticatory muscles. However, several authors speak about the reverse mechanism of the development of TMJ dysfunctions and claim that hypertension of the masticatory muscles is the original cause and leads to disturbances in the work of the TMJ.[8]

Among the factors affecting changes in the function of the masticatory muscles attribute chronic stress. One of its examples affecting the work of the masticatory muscles is bruxism – due to the tension of the central nervous system (CNS), there is an increase in the activity of the masticatory muscles, which is manifested by day or night clenching of teeth (clenching and bruxism), is the cause of spasm and disruption of normal work.[9,21]

In the same way, the activity of the masticatory muscles is affected by functional overload, occlusion disorders associated with the presence of premature contacts, pathological teeth abrasion and non-physiological movements of the mandible; dental anomalies; deformities of the facial skeleton; fractures and injuries of the mandible.[6,14,23]

Due to the polyetiological nature of these pathologies, the unspecified etiology, the difficulty in choosing the right stages of complex treatment, an important role is given to diagnosis.[7,10,11,13] Modern additional methods of assessing the condition of the masticatory muscles include surface electromyography (EMG).[12,17,18,19,20,22]

This method allows us to evaluate the bioelectric potentials of the muscles selected for diagnosis, bioelectric rest, the average amplitude of biopotentials, the time of one chewing cycle and the number of chewing movements performed.[5]

In dental practice, electromyographs with 4 or 8 sensors are used, which are attached to the skin in various ways: with glue, electrically conductive gel or with special solid-gel electrodes. Installation often takes a long time; due to the mobility of the sensors the reliability of the result is reduced. In addition, when conducting several studies of EMG in a patient at various stages of treatment, there is no certainty that the motor point will be selected in a similar place, which implies that the data obtained, and their comparison are inaccurate. The aim of the study is to develop with the help of software, produce with the help of digital technologies and apply in clinical practice the design of a personalized device for performing EMG of masticatory muscles.[1,2,3]

Materials and methods

When developing a personalized device for EMG, we analyzed various information sources. The databases of international and domestic electronic libraries were selected as sources.

The closest to the device being developed were:

A method of EMG of lateral pterygoid muscles, including the introduction of electrodes into the oral cavity, the imposition of surface electrodes on the skin of the face in the projection of the zygomatic bone on the right and left, determining the frequency and amplitude of the potentials of the action of muscle fibers at rest and with physical effort. The first stage is bimanually performed palpation of the lateral pterygoid muscle on both sides, an individual impression tray is made according to the impression, where anatomical formations of the area of palpation of the lateral pterygoid muscle are visualized. After fitting the spoon, correction is performed using articulation paper to determine the location of the electrodes. A device is inserted into the oral cavity, which contains an individual impression tray, on the surfaces of which, pressing tangentially to the site of the lateral pterygoid muscle, in the palpation area, semi-lunar cutouts are made, in which 2 round electrodes are located, wires from which run along the outer sides of the spoon, on each of which there are two fixators in the form of hooks, after which the device is pressed against the hard palate.[15]

A method of EMG using surface electrodes is known. Such electrodes are applied to the skin above the area of the motor point of the muscle. The skin is wiped with alcohol before applying the electrode and moistened with an isotonic sodium chloride solution. The electrode is fixed over the muscle with rubber bands, cuffs, or a band aid. If a long-term study is

necessary, a special electrode paste used in electroencephalography is applied to the area of skin-electrode contact.[4]

Of the many technical devices known a device for fixing electrodes is known, which is an elastic tape, characterized in that the device additionally contains a second elastic tape for fixing it on the back of the head, rigidly fastened to the first tape at an angle of 40-45 ° for fixing under its chin, the ends of the tapes are equipped with Velcro fasteners.[16]

The objective that the invention aims to solve is representative EMG of the masticatory and temporal muscles.

Results

The technical result of the invention is achieved since the method of conducting EMG of the masticatory and temporal muscles is carried out as follows: sensors (Figure 1) for conducting EMG studies are fixed on a patient's head using a locking device that includes elastic bands (Figure 2) connected to each other.

Figure 1. *Sensors for electromyography "Kolibri" (LLC «Neurotech», Russia) and clamping screws*

Figure 2. *Elasticband with transverse tape*

The study is carried out at rest and under functional loads, characterized in that the sensors are fixed in the center of the masticatory and temporal muscles, determined by palpation.

The fixing device is a band that fastens around the patient's head, made of an elastic band, transversely connected along the parietal part of the head with another elastic band. On the elastic band, a plastic sleeve is placed on both sides in the projection of the temporal part, which can move horizontally along the band. A polymer plate with a rectangular slot (Figure 3) is attached to this sleeve with a clamping screw, while the plate is made with the possibility of individual adjustment and movement along the slot in vertical direction. Wireless EMG sensor is fixed to this plate with a fixing screw in the projection of the temporal muscle, tightly pressed by the sensing electrodes to the skin or the hair part of the patient's head. A smaller plate is fixed to the plate with a clamping screw, in which a wireless EMG sensor is fixed with a clamping screw, tightly pressed by the sensing electrodes to the patient's skin in the projection of the chewing muscles. Polymer plates are made with the ability to move in vertical and horizontal directions relative to each other, with individual adjustment and fixation, with a graduated centimeter scale along the length of the plates on their outer surface.

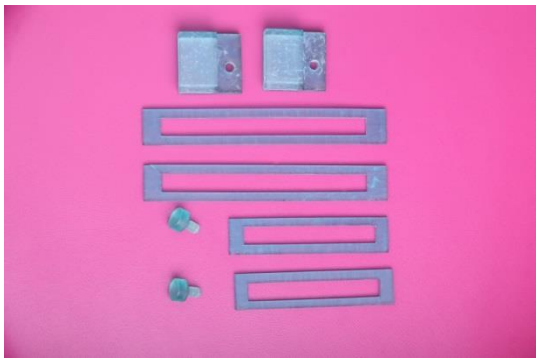

Figure 3. *Polymer plugs made by 3D printing, horizontal plates with rectangular holes and fixing screws*

Pressing the electrodes of the wireless sensors of the myograph to the patient's skin using the proposed method makes it possible to conduct research in conditions of poor fixation with adhesive compounds,

for example, in patients with a beard or hair in the area of the temporal muscles.

Moving the sensors along the polymer plates in vertical and horizontal directions, with the possibility of fixing them with clamping screws, allows the method to be used in different patients.

Centimeter scale applied to the outer surface of polymer plates allows for repeated myography at different treatment periods in the same patient, which is important for the representativeness of the study.

The method of EMG of the masticatory and temporal muscles is carried out as follows:

1. Band made of elastic tape is fixed on the patient's head, transversely connected along the parietal part of the head with another elastic band, plastic plugs are placed on the elastic band on both sides in the projection of the temporal part, the thickness of which corresponds to the thickness of the sensor of the device used for EMG.
2. Polymer plate with a rectangular slot in the central part is attached to the plastic plugs with a clamping screw.
3. Wireless EMG sensor is fixed to this plate with a fixing screw in the projection of the temporal muscle, tightly pressing it with the sensing electrodes to the patient's scalp.
4. Also, a similar plate is fixed to the plate with a clamping screw, to which a wireless EMG sensor is fixed with a clamping screw, tightly pressing the sensing electrodes to the patient's skin in the projection of the chewing muscles.
5. Preliminarily the middle of the examined muscles is determined by palpation.
6. Perform a superficial EMG of the temporal and masticatory muscles.
7. If necessary, repeat the studies at different periods of treatment, installing the sensors of the device on a graduated scale, at the same values.

Clinical example

Patient G, 23 years old (Figures 4, 5, 6), came to the clinic with complaints of pain in the masticatory muscles in the morning and gnashing of teeth at night. Upon examination were revealed signs of hypertension of the masticatory muscles. The patient was referred for surface EMG of the masticatory and temporal muscles.

Figure 4. *Portrait photos of the patient at the initial appointment.*

A – portrait photo 90 degrees to the right

B – full-face portrait photo

C – portrait photo 90 degrees to the left

Figure 5. *Photograph of the patient's smile*

Figure 6. *Intraoral photographs of the patient in occlusion*

Elastic band was fixed on the patient's head (Figure 7), transversely connected along the parietal part of the head with another elastic band. Vertical polymer plates in the projection of the temporal and masticatory muscles were fixed to the plastic plugs with clamping screws. Sensors of the complex of wireless monitoring of electrophysiological signals "Kolibri" (LLC «Neurotech», Russia) were fixed in the slots of vertical and horizontal plates with clamping screws, tightly pressing them to the patient's face with electrodes, having previously installed them in the middle of the temporal and masticatory muscles previously determined by palpation. Superficial EMG of temporal and masticatory muscles was performed. The recording of elecromyograms was carried out in a sitting position without head support.

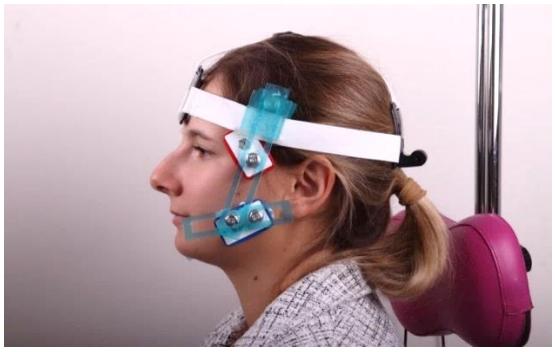

Figure 7. *Fixing the device during electromyography*

The activity of the masticatory muscles was recorded simultaneously from four muscles: the masticatory and anterior bundles of the temporal muscles on the right and left. The parameters of symmetry between the left and right masticatory and left and right temporal muscles were calculated, as well as the average bioelectric activity (μA) of all four muscles. The first measurement of the EMG activity of the masticatory muscles was carried out in a state of relative physiological rest. Then, to assess the effect of the occlusal factor on the bioelectric activity of the masticatory muscles, a study was conducted in the usual occlusion and with maximum volitional compression of the jaws. All studies were conducted within 10 seconds.

The values of the location of the sensors, recorded on a centimeter scale, were recorded in the patient's chart.

Based on the results of the conducted studies, it was decided that it was necessary to manufacture a muscle relaxant night mouthguard for the patient.

Similar EMG studies were carried out at the treatment periods after 3, 6 and 12 months, previously the sensors were installed in accordance with the location values recorded in the medical history.

In both cases, the sensors retained contact with the skin and representative values of EMG were obtained.

According to the results of the study of the average bioelectric activity of the masticatory muscles (μA), the average value at rest before the start of treatment was 68. After the start of treatment with an occlusive splint, a decrease at rest was recorded by 7% after 3 months; by 11% after 6 months; by 14% after 12 months.

The average value of the symmetry of the masticatory muscles was 91%, at 3 months after the start of the treatment the indicator increased slightly by 3%, after 6 months by 4%. At the end of treatment, there was a significant increase in the symmetry of the masticatory muscles by 4%.

The average value of the symmetry index of the temporal muscles was also 90%, however, 3 months after the start of the treatment the work of the temporal

muscles became 3% more symmetrical, and after 6 months the indicator increased by 4%, and after 12 months the increase in the symmetry index increased by 6% (Figures 8, 9).

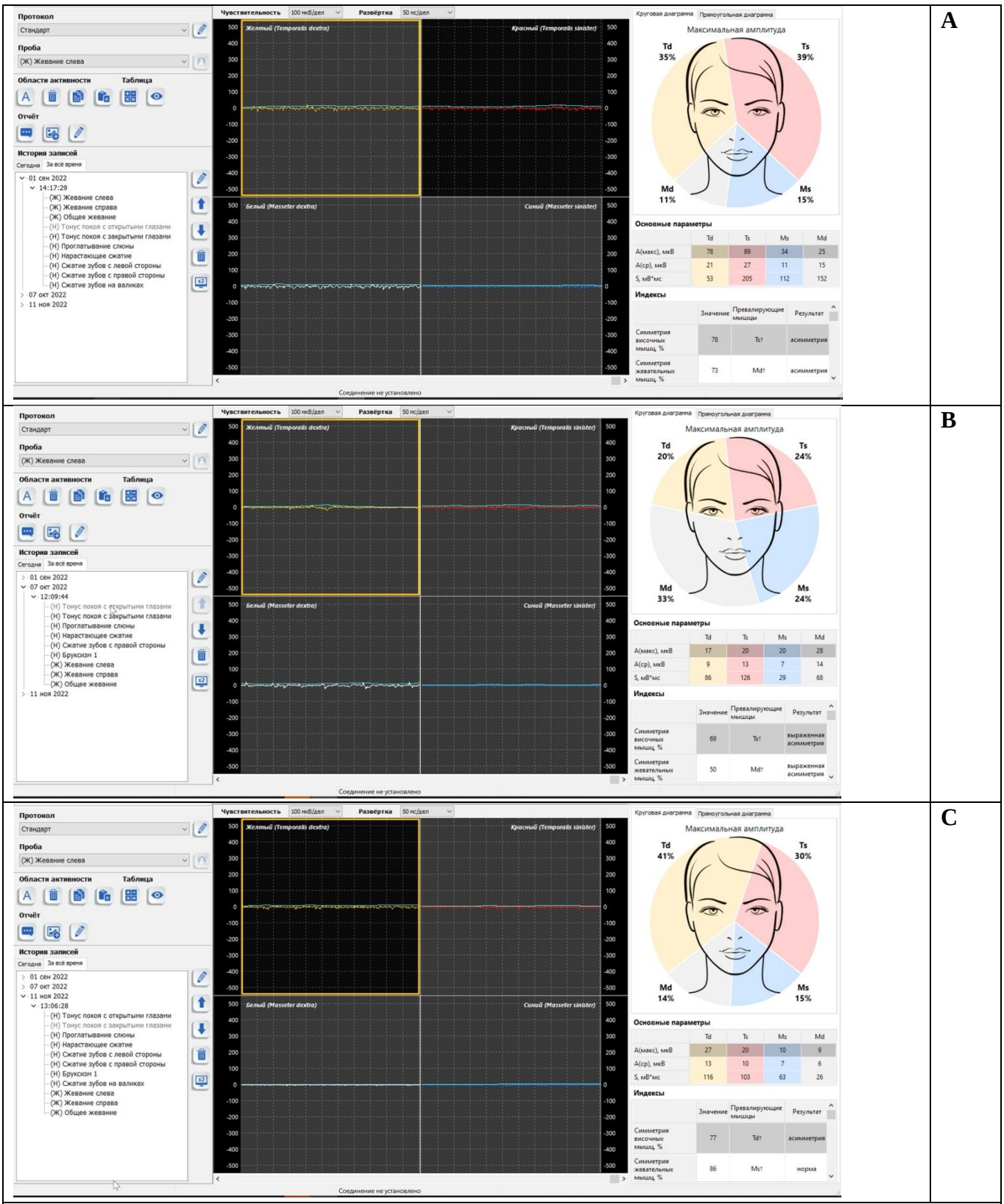

Figure 8. *Results of electromyography of the patient G. The Rest tests.*

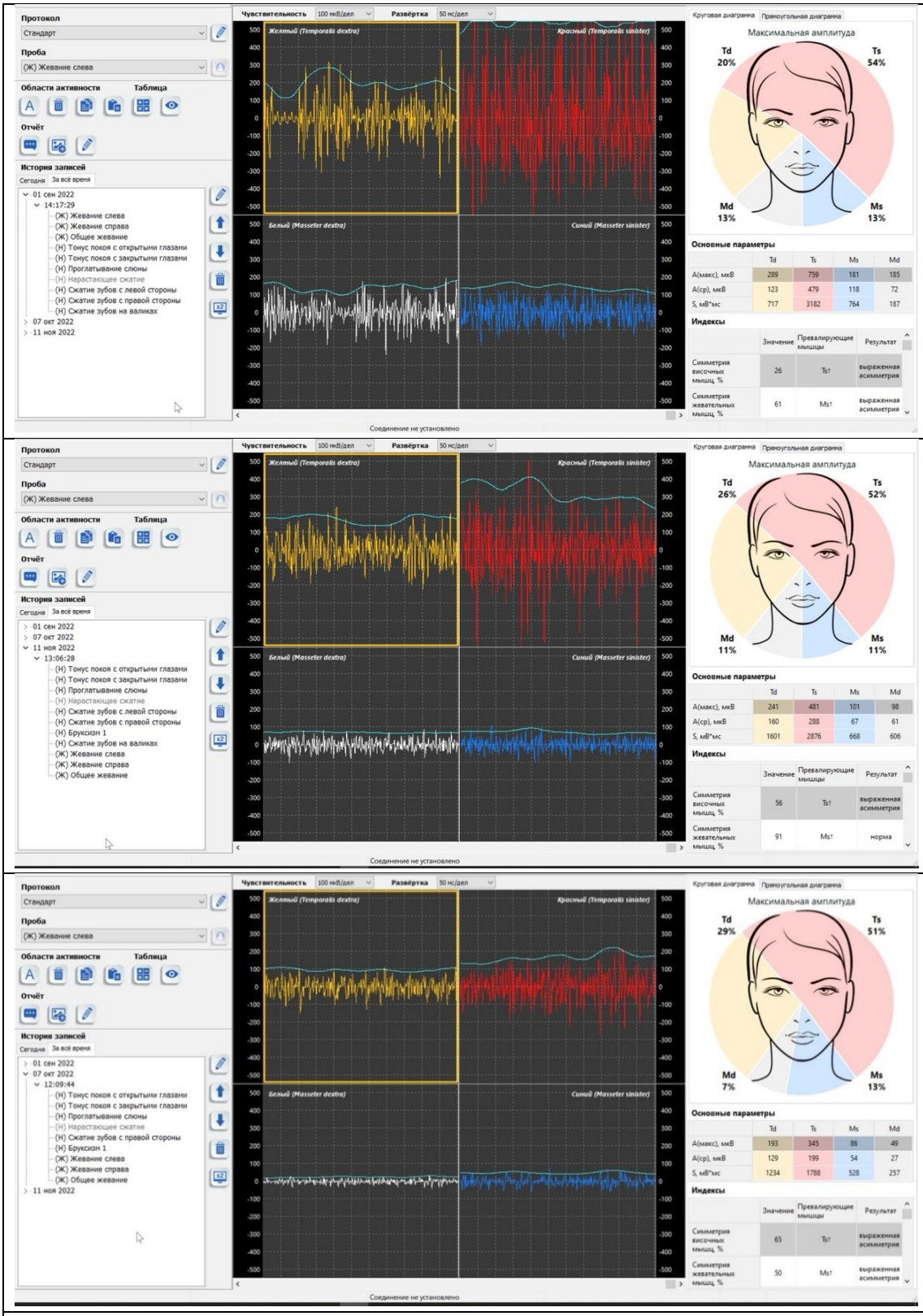

Figure 9. *The results of electromyography of the patient G. The Increasing compression tests.*

Discussion

The device developed and presented in this article for representative EMG of masticatory muscles is presented in the form of an elastic band with a transverse band, to which plates with rectangular slots made by 3D printing are attached with clamping screws on both sides using a plastic sleeve. Horizontal plates are attached to vertically positioned plates with clamping screws. Rectangular slotted plates and plastic bushings were created in Blender 3D modeling software, version 3.4.0 (Blender Foundation) (Figure 10). The plates and plugs were manufactured using additive technologies, using polymer dental material Harz Labs Dental Tray, which has the necessary physical and mechanical properties.

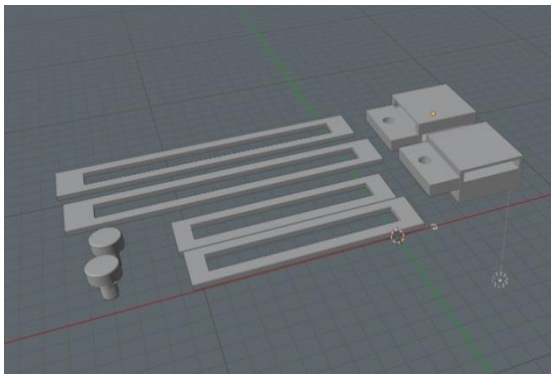

Figure 10. *Modeling of plugs, horizontal plates, and fixing screws in the Blender program (Blender Foundation)*

Conclusions

The use of a personalized device for performing EMG of the masticatory muscles allows for:

1) Simplification of the research methodology with a reduction in the time for the installation of sensors
2) Higher reliability of the results due to the fixation of sensors with the possibility of representative EMG of the masticatory muscles
3) Improving the fixation of sensors under unsatisfactory conditions of fixing the electrodes with an adhesive base
4) Further studies are needed to identify the statistical significance of clinical results.

Declarations

Conflict of interest and financial disclosure

The author declares that he has no conflict of interest and there was no external source of funding for the present study. None of the authors have any relevant financial relationship(s) with a commercial interest.

Ethical approval

Research protocol was approved by the local Ethical Committee (2018/23) and in accordance with those of the World Medical Association and the Helsinki Declaration.

Informed consent

Informed consent was obtained from all individual participants included in the study.

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Availability of Data and Materials

Not applicable.

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Not applicable.

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ԱՆՀԱՏԱԿԱՆ ՍԱՐՔԻ ՄՇԱԿՈՒՄ ՔՍԾ ԴԻՍՖՈՒՆԿՑԻԱՅՈՎ ՀԻՎԱՆԴՆԵՐԻ ՄՈՏ՝ ՔՈՒՆՔԱՄԿԱՆԻ ԵՎ ԾԱՄԻՉ ՄԿԱՆԻ ՀԵՏԱԶՈՏՈՒԹՅԱՆ ՀԱՄԱՐ

Սամվել Ապրեսյան բ.գ.դ.,[1] Ալեքսանդր Ստեպանով բ.գ.դ.,[1] Իրինա Բորոդինա[2]

[1] Ռուսաստանի Ժողովուրդների բարեկամության համալսարանի պրոֆեսոր, Մոսկվա, Ռ Դ

[2] Ռուսաստանի Ժողովուրդների բարեկամության համալսարանի թվային ստոմատոլոգիայի ինստիտուտի ասիստենտ, Մոսկվա, ՌԴ

Ամփոփում

Ներկայումս էլեկտրամիոգրաֆիան (ԷՄԳ) ծառայում է որպես ծամող մկանների վիճակի ախտորոշման ստանդարտ մեթոդ:

Այս տեխնիկան հնարավորություն է տալիս գնահատել բիոէլեկտրական պոտենցիալները, ներառյալ բիոէլեկտրական հանգիստը, միջին կենսապոտենցիալ ամպլիտուդը, ծամելու ցիկլի տևողությունը և կատարվող ծամելու շարժումների քանակը:

Ատամնաբուժական պրակտիկայում ԷՄԳ-ն անցկացվում է էլեկտրամիոգրաֆների միջոցով՝ մաշկին ամրացված էլեկտրոդներով սոսինձի կամ էլեկտրահաղորդիչ գելի միջոցով: Այնուամենայնիվ, տեղադրման այս գործընթացը հաճախ ժամանակատար է, և սենսորների շարժունակությունը կարող է վտանգել արդյունքի հուսալիությունը: Ավելին, բուժման տարբեր փուլերում հիվանդի վրա բազմաթիվ ԷՄԳ հետազոտություններ կատարելիս երաշխիք չկա, որ շարժիչ կետը հետևողականորեն կընտրվի, ինչը կհանգեցնի ոչ ճշգրիտ տվյալների և համեմատությունների:

Նպատակն է մշակել և ներդնել անհատականացված սարքի դիզայն՝ ծամող մկանների վրա ԷՄԳ կատարման համար՝ ապահովելով հետազոտության հետևողական կրկնությունը կլինիկական պրակտիկայում:

Նյութեր և մեթոդներ. Գիտական գրականության համապարփակ վերլուծության միջոցով տեղեկատվական աղբյուրներն օգտագործվել են ԷՄԳ սարքի մշակման և արտադրության համար:

Արդյունքներ. Ձեռք բերված տեխնիկական արդյունքը ներառում է պարզեցված մեթոդաբանություն, բարելավված սենսորային ֆիքսացիա, կրճատված ԷՄԳ տևողություն և հիվանդի բուժման տարբեր փուլերում հետազոտությունը հետևողականորեն կրկնելու հնարավորություն:
Եզրակացություն. Մշակված սարքը և ԷՄԳ մեթոդոլոգիան առաջարկում են պարզեցված մոտեցում՝ ուսումնասիրության ճշգրիտ արդյունքներ ստանալու համար՝ կրճատված ժամանակի պահանջներով: Բացի այդ, եթե ուսումնասիրության կրկնությունն անհրաժեշտ է, ստացված տվյալները կլինեն ներկայացուցչական:

РАЗРАБОТКА ИНДИВИДУАЛЬНОГО ПРИБОРА ДЛЯ ИССЛЕДОВАНИЯ ЖЕВАТЕЛЬНЫХ И ВИСОЧНЫХ МЫШЦ У ПАЦИЕНТОВ С ДИСФУНКЦИЕЙ ВНЧС

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Абстракт

Актуальность: В настоящее время электромиография (ЭМГ) служит стандартным методом диагностики состояния жевательных мышц.
Этот метод позволяет оценить биоэлектрические потенциалы, включая биоэлектрический покой, среднюю амплитуду биопотенциала, продолжительность жевательного цикла и количество выполняемых жевательных движений.
В стоматологической практике ЭМГ проводят с помощью электромиографов с электродами, прикрепленными к коже с помощью клея или электропроводящего геля. Однако этот процесс установки часто занимает много времени, а мобильность датчиков может поставить под угрозу надежность результатов. Кроме того, при проведении нескольких исследований ЭМГ у пациента на разных этапах лечения нет гарантии, что двигательная точка будет последовательно выбрана, что приведет к неточным данным и сравнениям.
Цель состоит в том, чтобы разработать и внедрить индивидуальный дизайн устройства для проведения ЭМГ жевательных мышц, обеспечивающий последовательное повторение исследования в клинической практике.
Материалы и методы: Благодаря всестороннему анализу научной литературы источники информации были использованы для разработки и производства устройства ЭМГ.
Полученные результаты: Достигнутый технический результат включает упрощенную методологию, улучшенную фиксацию датчика, сокращение продолжительности ЭМГ и возможность последовательного повторения исследования на различных этапах лечения пациента.
Заключение: Разработанный прибор и методика ЭМГ предлагают упрощенный подход к получению точных результатов исследования с меньшими временными затратами. Кроме того, если необходимо повторение исследования, полученные данные будут репрезентативными.