

SUMMARY

Introduction

Temporomandibular disorder (TMD) involves abnormal functioning of the masticatory muscles, temporomandibular joints and surrounding structures. It is a condition with a challenging and multifactorial aetiology. In recent years, the number of patients presenting for prosthetic treatment for the painful form of TMD has been increasing. Primary treatment involves the use of appliances called occlusal splints, while the goal of physiotherapeutic adjunctive treatment of the dysfunction is to eliminate or alleviate pain in the masticatory muscles and/or temporomandibular joints, as well as to restore the functional efficiency of the stomatognathic system (SS).

The use of radiofrequency waves is currently being used more and more widely in relaxation and pain relief therapy for skeletal muscles in orthopedics or traumatology, and may become an important additional method used in the rehabilitation of the musculoskeletal system of the masticatory organ. The main principle of their operation is the use of thermal energy, which has a beneficial effect on the body's tissues. The heat generated during the radiation is conducive to alleviating perceived pain and lowering excessive muscle tension, stimulating the blood and lymphatic circulatory system and increasing oxygen transport and better tissue metabolism. The method is also responsible for the transdermal transport of active compounds, achieving anti-inflammatory, analgesic, as well as anti-edema effects. Radiofrequency treatments are safe, and the therapeutic effect depends on the biological resistance of the tissues.

Currently, radiofrequency currents are used in the treatment of back pain, especially lumbar pain, joint pain and trigeminal neuralgia due to their proven effectiveness and lack of side effects. Literature data also indicate the possibility of using radiofrequency waves as an alternative procedure in the treatment of chronic cluster headaches. Among the growing number of publications on the beneficial effects of radiofrequency on damaged tissues of the musculoskeletal system, only a few data can be found on its beneficial therapeutic effects in patients with pain in the head and neck region.

Contraindications to the use of these treatments include; pregnancy, the presence of metal implants in the body, electronic implants, pacemakers and open wounds. General diseases such as cancer, epilepsy, tuberculosis are also contraindicated, psychosis, skin diseases, acute thyroid disease, hyperthyroidism, Sudeck's disease, macular atrophy, thrombophlebitis, cataracts and sensory disorders.

Sonophoresis, on the other hand, is a treatment using ultrasound, which is a mechanical vibration that exceeds the audible frequency range of sound, that is, above 20 kHz. Using a special head that emits ultrasound, active ingredients with analgesic and anti-inflammatory effects are introduced to a depth of 30 mm. It is a method often used in physiotherapeutic rehabilitation of the musculoskeletal system. Sonophoresis causes the sealing of blood vessels, which results in an increase in the activity of these drugs at the level of ionic rearrangements in pathologically altered tissues. In addition, it improves blood flow, increases cell membrane permeability, activates cell metabolism and increases cellular respiration. Lymph flow

is also improved, the pH level of acidified tissues is raised and collagen and elastin production is increased. Consequently, the regeneration of pathologically affected muscle and joint areas occurs. In addition, the thermal effect has a beneficial effect on relaxing excessively tense muscles. Sonophoresis treatments are painless. Indications for their use are painful forms of TMD, painful chewing muscles and temporomandibular joints.

Contraindications for sonophoresis treatments include pregnancy and breastfeeding, the presence of a pacemaker, cardiovascular disease, cancer, and high fever.

Only isolated reports on the use of radiofrequency currents in the rehabilitation of masticatory dysfunction have been found in the literature, and comparative studies of the effectiveness of radiofrequency and sonophoresis treatments in the adjunctive treatment of the painful form of TMD have not been conducted yet. This became the inspiration for the present research project.

Assumptions and aim of the study

The primary objective of the study was to obtain data, supported by research results, on the effectiveness of using a new radiofrequency method, not yet used in the supportive physiotherapeutic treatment of painful forms of TMD, as an alternative to one of the frequently used methods of supportive treatment, which is sonophoresis with analgesics.

The concept of the study was that one of the main criteria for the comparative analysis of various methods of supportive physiotherapeutic treatment was to evaluate the dynamics of pain reduction in the area of the masticatory muscles and temporomandibular joints and the decrease of excessive muscle tension and return to functional efficiency of the temporomandibular joints as well.

Taking into account the above considerations, the research carried out under the present assumptions sought answers to the following questions:

1. Whether the use of radiofrequency currents, as a method of adjunctive physiotherapeutic treatment for painful forms of TMD, can result in the most rapid reduction or resolution of pain and excessive masticatory muscle tension, as well as improvement in the function of the temporomandibular joints?
2. Which of the tested methods will show greater effectiveness in eliminating pain caused by excessive tension of the masseter muscles and disorders of the temporomandibular joints?
3. How does the effectiveness of the two methods studied in the elimination of pain in the masticatory muscles and temporomandibular joints according to gender?
4. In view of the above, can radiofrequency, as a new method of adjunctive physiotherapeutic treatment of the painful form of TMD, which has not been used in dentistry so far, be an effective alternative to previously used therapeutic methods?

Material and methodology of the study

The study included 100 patients of both sexes from the Małopolska province of Poland (69 females and 31 males) aged 20 - 42 years (average age of patients - 32 years), who reported

for prosthetic treatment due to painful form of TMD to the Prosthodontics Clinic of the Institute of Dentistry of the Collegium Medicum of the Jagiellonian University in Krakow in the period from May 2019 to December 2020. Part of this research project was carried out during the COVID-19 pandemic. The qualification of patients for the project was based on the results of medical history and preliminary clinical examination, taking into account the DC/TMD diagnostic criteria, preceded by a questionnaire subject examination and analysis of the results of additional tests.

Patients were divided into 2 groups, 50 patients each. Assignment of patients to the two groups was done alternately, according to the order of reporting for treatment and according to the exclusion of contraindications to both treatments. Ultimately, this did not result in major gender differences in the assigned patients.

Inclusion criteria for the study were the following: painful form of TMD, progressing with a pathological increase in masticatory muscle tone and/or symptoms from the temporomandibular joints within the appropriate age range, good general health, exclusion of contraindications to radiofrequency and sonophoresis treatments, patients' consent to participate in the research project.

The criteria for exclusion from the study were: the willingness to forgo continuation of the study, the progression of TMD into a more advanced form (e.g., displacement of an articular disc without reduction), the occurrence of pregnancy, the need to insert metal implants within the body, the occurrence of general medical conditions that make it impossible to continue participation in the study.

In study group I (N-50), 10 physiotherapy treatments using radiofrequency currents with a bipolar head were carried out on the area of the masticatory muscles (masseter muscles and the anterior part of the temporal muscles) and the temporomandibular joints. Comparative group II included 50 patients, with 10 treatments using sonophoresis and analgesic gel.

The study was conducted in accordance with the guidelines of the Bioethics Committee of the Jagiellonian University, issued in Opinion No. 1072.6120.116.2018, dated June 22, 2018.

The predominant symptoms of masticatory dysfunction reported by patients classified in both groups were pain in the muscles and/or temporomandibular joints, abnormalities in the range and symmetry of jaw movements, acoustic symptoms in the temporomandibular joints, and difficulty chewing food, accompanied by prolonged excessive levels of tension in the masticatory muscles.

All subjects underwent an examination: a subjective examination, a basic dental examination, a specialized functional examination of the masticatory organ, and additional examinations (assessment of the intensity of pain in the muscles and/or temporomandibular joints and ultrasound examinations of the joints). Patients assessed the severity of pain in the masticatory muscles and temporomandibular joints using the combined VAS+ VNRS scales, where 0 means no pain and 10 means unbearable pain.

Specialized functional examination included: evaluation of the range and symmetry of mandibular movements, analysis of the mandibular inversion track, palpation of the masticatory muscles and temporomandibular joints, verification of the intensity of muscle and/or joint pain complaints using the VAS+VNRS scale during mandibular movements, as well as evoked by palpation, assessment of acoustic symptoms in the joints, evaluation of the occlusal conditions of the patients' dentition in central and extra-central

occlusion, and analysis of the results of additional tests (ultrasound of the temporomandibular joints and muscles).

The above clinical examinations were carried out twice (except for the ultrasound examination), i.e. at the start of treatment and one week after the last supportive physiotherapeutic treatment.

Radiofrequency current treatments were performed using a bipolar head, with a frequency of 3-5 MHz and a power of 3W/cm². The duration of each treatment was 20 minutes, (10 minutes for the temporomandibular joint and 10 minutes for the masticatory muscles). The head was guided mutually in a dynamic manner.

Sonophoresis treatments were carried out using a head with a frequency of 1 MHz and a power of 1.25 W/cm² with the active substance Diclofenac in the form of 2.5% gel (Voltaren). Treatment time is 10 minutes for each area (masticatory muscles and temporomandibular joints). The head was guided mutually in a dynamic manner, the filling factor was 80%.

Physiotherapeutic adjunctive treatments (radiofrequency and sonophoresis) were performed in both groups daily or every other day, except on days off. Physiotherapeutic treatments were carried out during the performance period of the occlusion devices.

The evaluation of the results was carried out based on a detailed and thorough analysis of the results of the examinations: subjective examination, functional examination of the masticatory organ - assessing the functional efficiency of the various elements of the stomatognathic system (range and symmetry of mandibular movement during inversion and lateral movement, mandibular inversion trajectory, results of palpation of the masticatory muscles and temporomandibular joints, assessment of acoustic symptoms in the temporomandibular joints) and, in particular, assessment of the decrease in the intensity of pain complaints of the masticatory muscles and temporomandibular joints.

Statistical analysis was carried out using the R statistical package (version 4.1.1) on Windows 10 x64 (build 19044), using the effectsize, report, ggstatsplot and psych packages. The significance level of statistical tests was considered to be $\alpha=0.05$.

Nominal scale variables were analyzed by pairwise contingency tables indicating the number of patients with pre- and post-treatment disorders and odds ratios.

The effectiveness of the counts was examined using the ratio test (Wilson, Newcombe).

In order to examine dependent variables with the number of groups more than two, we used a parametric one-way analysis of variance for repeated measures. For this purpose, Fisher's exact test with an effect size calculation of $\hat{w}_p^2$ was used.

Graphical visualization of the differences between groups was presented in the form of a combination of violin plots together with scatter plots of inter-object observation data points along the vertical axis with statistical details included in the plot as a sub-title. For this purpose, the *grouped_withinstats()* method was used for dependent variables grouped from the {ggstatsplot} package (Patil). To visualize the distribution of the intensity of pain in the masticatory muscles and temporomandibular joints before treatment, cumulative column charts were used. A comparison of the effectiveness in eliminating pain in the chewing muscles and temporomandibular joints using both methods is shown on line charts with markers, while the results of subjective and functional studies are presented on clustered column charts.

Results

As a result of the study, it was found that both the method of radiofrequency and sonophoresis, applied to a group of patients with the painful form of TMD, allows to achieve positive treatment results by improving clinical parameters, abolishing pain in the masticatory muscles and temporomandibular joints and excessive muscle tension, as well as relieving pressure and thus returning to functional efficiency of the temporomandibular joints. At the same time, the radiofrequency method gave better therapeutic effect in the case of pain from the temporomandibular joint area and abnormal lateral range of motion of the mandible, while sonophoresis proved more effective in reducing pain in the masticatory muscle area, as well as the cessation of parafunction symptoms.

The use of both methods cited a statistically significant reduction in pain conditions at each measurement point after the start of treatment. A characteristic feature for both methods was greater level of reduction in pain states with higher initial scores on the VAS+VNRS scale.

However, in the case of women, the radiofrequency method has been shown to be more effective in reducing the level of pain. At the same time, the speed of pain reduction for radiofrequency appeared to be greater compared to sonophoresis, both for the entire group and for both gender subgroups. This means that the use of radiofrequency is worth of recommendation in the painful form of TMD.

Conclusions

The analysis of the results of the research, obtained during the course of this project, makes it possible to formulate the following conclusions about the possibility and effectiveness of using radiofrequency currents in the adjunctive physiotherapeutic treatment of TMD:

1. The use of radiofrequency waves as a method of adjunctive physiotherapeutic treatment for painful forms of TMD results in a reduction or cessation of pain in the masticatory muscles and temporomandibular joints, a reduction of excessive masseter muscle tension and an improvement in the function of the temporomandibular joints, which provides grounds for a positive evaluation of this method of adjunctive treatment.
2. A comparison of the two methods used to alleviate pain associated with TMD showed that the radiofrequency method produced a better therapeutic effect for pain localized to the temporomandibular joints, while sonophoresis proved more effective in eliminating pain originating in the masticatory muscle area.
3. The analysis of the results of pain intensity tests of the masticatory muscles and temporomandibular joints showed that in the case of women, the radiofrequency method has been shown to be more effective in reducing the level of pain. At the same time, the speed of pain reduction after the use of radio waves turned out to be greater compared to sonophoresis, both for the entire group and for both gender subgroups.
4. Given the above, it can be concluded that radiofrequency, as a new method of adjunctive physiotherapeutic treatment of the painful form of TMD, which has not been used in dentistry so far, can be an effective alternative to previously used physiotherapeutic methods.