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Effect of Dry Needling on Morphofunctional Capacity of Masticatory Muscles, and Bite Force in Patients with Temporomandibular Disorders of Muscular Origin

Efeito do Agulhamento a Seco na Capacidade Morfofuncional dos Músculos Mastigatórios e na Força de Mordida em Pacientes com Disfunções Temporomandibulares de Origem Muscular

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Abstract

The presence of myofascial trigger points in the masticatory muscles can lead to pain and may be related to temporomandibular dysfunction. The dry needling technique (DN) is employed for mechanical disruption and deactivation of trigger points in skeletal muscles. The purpose of this observational longitudinal clinical study was to determine the morphofunctional capacity of the masseter and temporalis muscles, and bite force in patients with temporomandibular disorders of muscular origin after DN of the masseter muscle. Twenty-one patients with the presence of trigger points in the masseter muscle were selected. Electromyographic activity of the masseter and temporalis muscles was assessed during the mandibular tasks of rest, protrusion, right and left laterality, and maximal voluntary contraction (MVC). Muscle thickness at rest and dental clenching at MVC was measured with ultrasound. Molar bite force (right and left) was analyzed with a digital dynamometer. Patients were evaluated before and seven days after intervention with DN. Data were subject to the paired t test for dependent samples ($p<0.05$). There was significant difference in the left masseter muscle in right laterality ($p=0.01$), right temporalis muscle thickness in MVC ($p=0.05$), and right ($p=0.01$) and left ($p=0.008$) molar bite force, after DN. The authors suggest that DN was efficient in the positive changes in the morphofunctional performance of the stomatognathic system.

Keywords: Dry Needling. Masticatory Muscles. EMG. Muscle Thickness. Bite Force.

Resumo

A presença de pontos gatilhos miofasciais nos músculos mastigatórios pode gerar dor e estar relacionada à disfunção temporomandibular. A técnica de agulhamento a seco (AS) é utilizada para rompimento mecânico e desativação do ponto gatilho nos músculos esqueléticos. O objetivo deste estudo clínico longitudinal observacional foi determinar a capacidade morfofuncional dos músculos masseter e temporal, bem como a força de mordida, em pacientes com distúrbios temporomandibulares de origem muscular após AS no músculo masseter. Foram selecionados vinte e um pacientes com presença de pontos de gatilho no músculo masseter. A atividade eletromiográfica dos músculos masseter e temporal foi avaliada durante tarefas mandibulares de repouso, protrusão, lateralidade direita e esquerda, e contração voluntária máxima (CVM). A espessura muscular em repouso e a contração dental na CVM foram medidas por ultrassom. A força de mordida molar (direita e esquerda) foi analisada com um dinamômetro digital. Os pacientes foram avaliados antes e sete dias após a intervenção com DN. Os dados foram submetidos ao teste t pareado para amostras dependentes ($p<0,05$). Houve diferença significante no músculo masseter esquerdo na lateralidade direita ($p=0,01$), espessura do músculo temporal direito na CVM ($p=0,05$) e força de mordida molar direita ($p=0,01$) e esquerda ($p=0,008$), após AS. Os autores sugerem que o AS foi eficaz nas alterações positivas no desempenho morfofuncional do sistema estomatognático.

Palavras-chave: *Agulhamento a Seco. Músculos Mastigatórios. EMG. Espessura Muscular. Força de Mordida.*

1 Introduction

Temporomandibular disorder (TMD) is associated with several musculoskeletal conditions that affect the temporomandibular joint, masticatory muscles, and other structures of the stomatognathic system, resulting in myofascial pain with functional limitations.[1]

Myofascial pain can occur as a result of a trigger point, which is characterized by the hypersensitivity of a palpable nodule in a tense muscle band that causes localized pain or referred pain due to sarcomere contraction, reduced capillary blood circulation, and increased anaerobic metabolism.[2,3] It is one of the main causes of functional disability, with a greater predominance for females, and affects more than 85% of the world population at some stage of life, likely reducing the quality of life.[4,5]

Myofascial trigger points can be deactivated through the destruction of motor endplates that promote distal axon denervation and induction of physiological regeneration because of manual intervention techniques, such as dry needling, thus reducing pain.[6,7] However, the functional and morphological behavior of the stomatognathic system before the TMD and manual interventions in the trigger points has been the subject of many studies to understand the impact of this treatment on quality of life.[8]

According to the study by Macedo et al.[9], the dry needling technique improved oxygen saturation in the masseter muscle of women with TMD, suggesting its potential benefit in the treatment of this condition. Another study showed that the application of the dry needling technique to the masseter muscle in patients with TMD reduced tinnitus discomfort.[10]

Dry needling stands out in the treatment of orofacial pain due to its precise ability to target muscular trigger points. Compared to other manual approaches such as manual therapy and therapeutic massage, dry needling uses fine needles to reach trigger points, triggering a relaxation response in the affected muscles. This results in pain relief and improved muscular function.[11]

Therefore, this study aimed to analyze myofascial pain, morphofunctional capacity of the masseter and temporalis muscles, and molar bite force of patients with TMD of muscular origin after application of dry needling to the masseter muscle. The null hypothesis of this study was that after seven days of dry needling intervention, patients with TMD of muscular origin would not show alteration in the maximum molar bite force, and the functional performance of the stomatognathic system, especially in electromyographic activity and thickness of the masseter and temporalis muscles.

2 Material and Methods

2.1 Subjects and study design

This longitudinal study received approval from the Ethics Committee of the Faculty of Dentistry at Ribeirão Preto, University of São Paulo, Brazil (protocol # 81176417.8.0000.5419). Informed consent was obtained from all the participating patients. To ensure that the convenience sample was representative, the sample calculation (pos hoc power analysis), was performed using G* Power 3.1.9.2 software (Franz Faul, Kiel University, Kiel, Germany). To perform this calculation, the values obtained at the thickness of the right temporal muscle in maximum voluntary contraction (mean and standard deviation) for before and after dry needling were considered, which were respectively: 0.56 (± 0.18) and 0.46 (± 0.07) considering the error of 5%. After the calculation, an effect size of 0.63 and a test power of 87% were obtained.

Twenty-one patients, aged between 21 and 60 years old (mean age 35.8± 13.1 years), without limitation of mouth opening were confirmed with muscle TMD by digital palpation. The mean values of body mass index, weight, and height of the patients were as follows: 25.46 ± 3.55kg/m^2; 72.13 ± 15.90kg and 1.67 ± 0.10cm, respectively.

The inclusion criteria were as follows: presence of trigger points in the masseter muscles for more than three months (type of muscular TMD). The exclusion criteria were as follows: lack of integrity of the cognitive system; partial edentulism (except for missing third molars); physical or mental illness during examination and treatment with dry needling; concurrent orthodontic therapy, speech therapy, physical therapy, or otorhinolaryngological treatment; systemic diseases that require chronic medication, such as neurological and psychiatric disorders, as well as users of drugs that may interfere with muscle and circulatory activity; needle phobia or reluctance to technique; history of abnormal reaction to needle or injection; needle metal allergy; current areas of lymphedema on the face; anticoagulant use and abnormal bleeding, cerebrovascular disease, uncompensated diabetes mellitus, and epilepsy.

The control group comprised healthy subjects with a normal occlusion and no TMD from the studies of Palinkas et. al.[12] (bite force and masticatory muscles thickness) and Cecilio et.al.[13] (electromyographic activity). The subjects at group III (adults) of the two cited studies were matched to this study group by age, sex, height, and weight.

All the protocols of this study that evaluated the morphofunctionality of the stomatognathic system were performed before and seven after the dry needling intervention by the same trained professional. Evaluating patients after a 7-day period, rather than immediately after needling, can provide more accurate results regarding the effects of the treatment. Immediately after needling, the occurrence of muscle spasms and an inflammatory process is common, as part of the body's natural response to the stimulus. By waiting for this 7-day period, it allows the initial inflammatory process to decrease, and muscle responses to stabilize, thus providing a clearer and more stable view of short-term treatment results. The analysis procedures were performed by a single researcher who was calibrated and trained.

2.2 Electromyographic activity analysis

The electromyographic signals from the masseter and temporalis muscles were analyzed using the Myosystem BrI P84 electromyograph (Myosystem-Br1, Data Hominis Tec. Ltda, Brazil) with a reference electrode that reduced the risk of interference According to the recommendations of the Surface EMG for Non-Invasive Assessment of Muscles (SENIAM) project, the use of digital palpation associated with tooth clenching in maximum voluntary contraction (MVC) determined the correct position of the electrodes that were positioned perpendicularly to the muscle fibers and on the belly of the masticatory muscle.[14]

The protocol for analyzing the electromyographic activity (EMG) of the masseter and temporalis muscles during mandibular tasks was as follows: rest (4 seconds), protrusion (10 s), right laterality (10 s), left laterality (10 s), and dental clenching in CVM with and without inert material (4 s).The inert material consisted of a paraffin sheet (Parafilm M, Pechinery Plastic Packaging, Batavia, IL, USA) that was folded (18x17x4mm, weight 245 mg) and placed between the occlusal surfaces of the maxillary and mandibular first molars, on the right and left sides of the dental arch.[15]

2.3 Muscle thickness analysis

A portable ultrasound device with a 13 MHz linear transducer (NanoMaxx; SonoSite Inc, Bothell, WA, USA) was used to measure the masseter and temporalis muscles thickness in mandibular tasks at rest and MVC. In order to locate the bellies of the masticatory muscles, digital palpation and movement of the linear transducer were performed.[12] The linear transducer was coated with a water-based conductive gel and positioned perpendicularly to the muscle fibers, noting that the belly of the masseter muscle was located approximately 1.5 cm to 2.00 cm above the angle of the mandible towards the eyelid, and the superior and anterior portion of the temporalis muscle was approximately 1.00 to 1.5 cm behind and above the external angle of the eye.

Three ultrasound images were obtained for each masticatory muscle during the mandibular tasks, with an interval of two minutes between the images.[16] The averages of the three measurements obtained in centimeters were used for data analysis.

2.4 Bite force analysis

A digital dynamometer (IDDK, Kratos - Equipamentos Industriais Ltda., Cotia, São Paulo, Brazil) adapted for oral conditions and with a maximum recording capacity of up to 980.66 Newtons (N) was used to record the maximum right and left molar bite force. The dynamometer rods were sanitized with 70% alcohol and protected with disposable latex fingers (Wariper, São Paulo, Brazil) for biosafety reasons.

The molar bite force was obtained in the region of the right and left first permanent molar. The patient squeezed the rods with maximum effort three times, with a two minute break between each recording, alternating the right and left sides.[17,18] The maximum molar bite force, on both sides, obtained from the three records was used for data analysis.

2.5 Dry needling intervention at trigger points

The dry needling intervention was performed at trigger points located in the right and left masseter muscles of patients with muscular TMD. Sterile monofilament disposable acupuncture needles (Dong Bang, South Korea) with a diameter of 0.25x30 Mm C/ made of stainless steel were used because of their flexibility, thus preventing breakage after insertion. The procedure was performed using a mandrel, without the introduction of medications or other substances.[19] The presence of myofascial trigger points was detected by means of digital palpation in the patient lying in the supine position on a stretcher, with the feet supported on a wedge and the head on a pillow.[20]

After palpating the masseter muscle and confirming the presence of trigger points, the patient was asked about the location of the pain (local or referred) and the hypersensitive point so that the needle could be inserted exactly into this location. Prior to needle insertion, the skin was sanitized with 70% alcohol.

The solitary filamentary needle was inserted into the belly of the masseter muscle, and then the inserted needle was kept fixed at the trigger points and could be stimulated with rotational movements. The penetration time varied according to the individual response capacity, which was considered when the referred pain was lower than a score of three. Needle removal was performed when the patient demonstrated a reduction in painful symptoms, which was inactivation of the trigger points. After removing the needle, light pressure was applied with cotton at the site to minimize bleeding in the area.

2.6 Data analysis

The raw electromyographic signal was used to derive values of electromyographic amplitudes, which were obtained by calculating the square root of the mean (RMS). The RMS of dental clenching in CVM with Parafilm M was used for data normalization. EMG, muscle thickness, and maximum molar bite force data were subject to statistical analysis using the GraphPad Prism 6.0 software. The results were obtained through descriptive analysis (mean and standard deviation) for each variable. After verifying the normal distribution of the sample, the paired t test was used for dependent samples, with a significance level of 5% and a confidence interval of 95%.

3 Results and Discussion

Table 1 shows the results of normalized EMG of the masseter and temporalis muscles in mandibular tasks before and seven days after intervention with dry needling of the masseter muscle. There was a significant difference in right laterality for the left masseter muscle (p=0.01) with a decrease in EMG after dry needling.

Table 1 - Normalized EMG before and after dry needling; mean (±) standard error of the mean and p values in comparison to the control group.

Mandibular Tasks/ Muscles	Period		p values	Comparison CG
	Before	After		
Rest				
RM	0.03 ± 0.02	0.04 ± 0.04	0.77	0.07 ± 0.0009
LM	0.04 ± 0.03	0.03 ± 0.03	0.29	0.08 ± 0.0008
RT	0.09 ± 0.04	0.10 ± 0.06	0.84	0.10 ± 0.01
LT	0.09 ± 0.05	0.08 ± 0.03	0.12	0.11 ± 0.01
Protrusion				
RM	0.17 ± 0.22	0.19 ± 0.24	0.79	0.16 ± 0.02
LM	0.16 ± 0.17	0.13 ± 0.11	0.18	0.18 ± 0.02
RT	0.14 ± 0.09	0.12 ± 0.07	0.25	0.11 ± 0.01
LT	0.13 ± 0.09	0.10 ± 0.05	0.06	0.11 ± 0.01
Right laterality				
RM	0.06 ± 0.06	0.08 ± 0.09	0.44	0.09 ± 0.01
LM	0.16 ± 0.18	0.09 ± 0.09	0.01	0.12 ± 0.01
RT	0.16 ± 0.10	0.15 ± 0.11	0.72	0.13 ± 0.06
LT	0.11 ± 0.08	0.09 ± 0.04	0.07	0.11 ± 0.01

Mandibular Tasks/ Muscles	Period		p values	Comparison CG
	Before	After		
Left laterality				
RM	0.14 ± 0.17	0.11 ± 0.12	0.61	0.11 ± 0.01
LM	0.08 ± 0.07	0.06 ± 0.06	0.24	0.10 ± 0.01
RT	0.12 ± 0.08	0.10 ± 0.05	0.29	0.11 ± 0.01
LT	0.12 ± 0.07	0.10 ± 0.06	0.28	0.14 ± 0.01
MVC				
RM	0.71 ± 0.68	0.85 ± 0.46	0.47	0.74 ± 0.04
LM	0.62 ± 0.37	0.76 ± 0.40	0.15	0.84 ± 0.07
RT	0.85 ± 0.44	0.94 ± 0.51	0.48	1.03 ± 0.08
LT	0.78 ± 0.27	0.85 ± 0.35	0.32	0.95 ± 0.06

RM, right masseter; LM, left masseter; RT, right temporal; LT, left temporal; MVC, maximum voluntary contraction; CG, control group; significant difference, t test for paired samples (i.e., $p<0.05$).
Source: research data.

Clinically, the following results were observed in the mandibular tasks after dry needling application: a slight increase in EMG activity was observed in the masseter and temporalis muscles on the right side and a decrease on the left side at rest. There was also a slight increase in EMG activity in the right masseter muscle and a decrease on the left side during protrusion. Additionally, there was a slight decrease in EMG activity in the right temporal and left masseter muscles during right laterality, as well as a decrease in EMG activity in the left temporal and right masseter muscles during left laterality. Moreover, there was an increase in EMG activity during dental clenching in MVC for all the masticatory muscles.

The maximum molar bite force data and the masseter and temporalis muscles thickness are shown in Table 2. There was a statistically significant difference in the right molar bite force ($p=0.01$), left molar bite force ($p=0.008$), and right temporalis muscle thickness on MVC ($p=0.05$). After dry needling, an increase in molar bite force (right and left) was observed, in addition to the similarity in thickness of the right masseter muscles and decreased thicknesses of the temporalis muscles (clinical observation).

Table 2 - Bite force and muscle thickness before and after dry needling; mean (±) standard error of the mean and p values in comparison to the control group

Variables	Period		p values	Comparison CG
	Before	After		
Bite Force (N)				
Right	363 ± 205	405 ± 206	0.01	280 ± 235
Left	374 ± 202	418 ± 201	0.008	297 ± 245
Muscle thickness (cm)				
Rest				
RM	0.92 ± 0.12	0.94 ± 0.12	0.22	0.92 ± 0.04
LM	0.91 ± 0.13	0.93 ± 0.14	0.30	0.95 ± 0.04
RT	0.34 ± 0.03	0.36 ± 0.06	0.29	0.61 ± 0.03
LT	0.36 ± 0.10	0.33 ± 0.04	0.31	0.63 ± 0.03
MVC				
RM	1.35 ± 0.23	1.35 ± 0.19	0.87	1.24 ± 0.04
LM	1.35 ± 0.20	1.36 ± 0.19	0.71	1.25 ± 0.04
RT	0.56 ± 0.18	0.46 ± 0.07	0.05	0.70 ± 0.03
LT	0.51 ± 0.22	0.45 ± 0.06	0.25	0.71 ± 0.03

RM, right masseter; LM, left masseter; RT, right temporal; LT, left temporal; MVC, maximum voluntary contraction; CG, control group; significant difference, t test for paired samples (i.e., $p<0.05$).
Source: research data.

The null hypothesis of this study was rejected because there were significant differences in the stomatognathic system seven days after the application of dry needling to the masseter muscle, especially in normalized EMG, and temporalis muscle thickness and molar bite force.

Dry needling is an excellent technique used in the treatment of myofascial pain, as its effectiveness is based on the mechanical interruption of the integrity of dysfunctional endplates.[21] There is evidence that when applied to the muscle belly or subcutaneous fascia, it has effects on pain modulation during myofascial syndrome.[22]

In this study, the normalized EMG of the masseter and temporalis muscles were analyzed bilaterally before and after the application of dry needling during the five mandibular tasks. At rest, it was possible to observe a slight increase in the normalized EMG of the muscles on the right side and a decrease in the normalized EMG of the muscles on the left side after seven days of dry needling application.

Although these data do not show statistically significant differences, a functional muscle balance is suggested, which agrees with data from previous studies that have shown that at mandibular rest, EMG is minimal or non-existent, suggesting a lack of contraction of the motor units.[23]

The temporalis muscles demonstrated greater activity than the masseter muscles, results that agree with Cecilio et al.[13] It is still very important to point out that the temporalis muscle acts in relation to movement and not specifically in relation to strength, and its purpose is to keep the mandible stable before gravity.[24]

In protrusion, when comparing the situations before and after dry needling, the right masseter muscle showed an increase in normalized EMG, and the left masseter muscle showed a decrease in normalized EMG after the application of dry needling. The right and left masseter muscles demonstrated higher myoelectric activities when compared to the right and left temporalis muscles. This agrees with the neuromuscular pattern that is responsible for this excursive movement, with greater activation of the masseter muscles compared to the temporalis muscles.[25]

In right laterality, a lower normalized EMG was observed for the left masseter muscle, with a statistically significant difference. The right temporalis muscle was found to be more active than the left temporalis muscle after dry needling application. This condition corroborates previous studies that claim greater activation of the muscle contralateral to the activity performed.[10] In addition, with a decrease in the

normalized EMG of the left masseter muscle, a balance in the myoelectric activity in relation to the masseter muscles was noted after dry needling, and this balance is likely related to the decrease in pain symptoms reported by the patient.[8]

In left laterality, there was a decrease in normalized EMG in the masseter and temporalis muscles after the application of dry needling, but no statistically significant difference was observed. When comparing contralateral muscle activity during left laterality, greater activation of the right masseter muscle was observed. These findings agree with studies that demonstrated that the right masseter muscle is more active in relation to the left masseter muscle.[26] Similarly, the left temporalis muscle follows the neuroanatomical pattern.[27]

In MVC, it was observed that the normalized EMG increased in all the masticatory muscles, with no statistically significant difference. However, if we compare the masseter muscles with the temporalis muscles, there was an increase in normalized EMG in the temporalis muscles when compared to the masseter muscles. These data are in agreement with previous studies that report the pattern of myoelectric activity of the masseter minor muscle when compared to the temporalis muscle.[25,27]

Uemoto et al.[28] carried out a study with 21 female patients, aged between 20 and 52 years, who received DN in active trigger points in the masseter muscles and were unable to observe significant changes in the EMG recorded during MVC after the treatment, corroborating our results.

In this study, the muscle thickness examination performed at mandibular rest did not demonstrate a statistically significant difference, but on the other hand, in the MVC, there was a similarity in the thickness of the masseter muscles and lower thickness values for the temporalis muscles, with a statistically significant difference in the right temporalis muscle after the application of dry needling.

The reduced results in the temporalis muscles thickness corroborate the results of the study by Bagheri et al.[22], wherein a reduction in muscle thickness was observed in patients with active trigger points in the upper trapezius muscle after dry needling application.

A hypothesis that could explain the morphological alteration of the skeletal striated musculature after the application of dry needling would be that manual mechanical stimulation promotes changes in muscle fibers, decreasing the degree of stiffness with fascia repair due to collagen fragmentation, thus promoting muscle relaxation.[29]

Analysis of the maximum right and left molar bite force before and after dry needling demonstrated a significant increase in forces on both sides. The results of this study agree with those of Fernández-Carnero et al.[30], who observed that patients diagnosed with myofascial pain in the masseter muscle and treated with dry needling showed a significant improvement in occlusal strength.

Therefore, the use of dry needling is based on sound neurophysiological principles and is a cost-effective, efficient, accessible, and therefore important technique in the inactivation of trigger points in the masticatory muscles. Thus, this technique should be in the arsenal of all healthcare providers managing patients with TMD of muscular origin to improve these patient's quality of life. It is important to emphasize that the execution of dry needling depends directly on the professional's knowledge and that he/she must consider the psychological and clinical aspects of the dysfunction and/or disorders that are present to minimize any negative outcomes.

This study had limitations. The evaluation exams were performed only after seven days of dry needling application in the masseter muscle. A longer follow-up period may aid in determining the long-term effectiveness of this technique. A second limitation was the limited number of patients in this study.

4 Conclusion

The authors suggest that dry needling is effective in the treatment of myofascial trigger points based on the results obtained in this study, which suggested positive changes in the morphofunctional performance of the stomatognathic system.

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