Acta Scientific Dental Sciences (ISSN: 2581-4893)

Volume 7 Issue 9 September 2023

Research Article

Dry Needling for Treatment of Temporomandibular Disorder of Muscular Origin: A Functional Approach to the Stomatognathic System

Veridiana Wanshi Arnoni, Mariah Acioli Righetti, Nayara Soares da Silva, Karina F Bombonato-Prado, Isabela Hallak Regalo, Paulo Batista de Vasconcelos, Marcelo Palinkas*, Ligia Maria N Gonçalves, Simone Cecilio H Regalo and Selma Siéssere

Department of Basic and Oral Biology, Faculty of Dentistry of Ribeirão Preto, University of São Paulo, Brazil

***Corresponding Author:** Marcelo Palinkas, Department of Basic and Oral Biology, Faculty of Dentistry of Ribeirão Preto, University of São Paulo, Brazil.

Received: August 07, 2023

Published: August 24, 2023

Abstract

Background: The aim of this longitudinal study was to evaluate the function of the stomatognathic system in subjects with muscle temporomandibular disorder before and after seven days of dry needling in the masseter muscles.

Materials and Methods: Twenty-one patients with temporomandibular disorders participated in this study. Dry needling was performed at trigger points of the masseter muscle. The following variables were evaluated: numerical visual scale, mandibular mobility, masticatory efficiency by electromyography of the masseter and temporal muscles, and occlusal force. Paired t-test and t-test were performed for the independent samples ($p < 0.05$).

Results: Pain decreased ($p < 0.001$) and mobility increased in right ($p = 0.028$) and left ($p = 0.022$) laterality. There was no statistically significant difference in masticatory efficiency. The analysis of occlusal force distribution showed an increase in force on the left side ($p = 0.001$).

Conclusion: Dry needling effectively improved the pain and function of the stomatognathic system in subjects with muscular temporomandibular disorders.

Keywords: Dry Needling; Pain; Temporomandibular Disorder; Mandibular Mobility; Masticatory Efficiency; Occlusion

Introduction

Temporomandibular dysfunction is characterized by modifications and damage to the structures associated with the stomatognathic system, such as muscles and articulations [1,2]. Myofascial pain is a major symptom, with trigger points in the masticatory muscles, primarily the masseter muscles [3]. Temporomandibular dysfunction are common and can have a significant impact on an individual's quality of life. These disorders cause symptoms like jaw pain, difficulty chewing, and headaches, leading to discomfort and limitations in daily activities. Emotional distress, sleep issues, and reduced self-esteem are also common, affecting overall well-being. Social interactions and participation in activities may be limited due to pain and functional difficulties. Effective management is important for improving the lives of those with temporomandibular dysfunction [3].

The therapeutic approach for disconnection of the muscle pain trigger point has been broadly discussed in literature [4-6]. Thus, among existing techniques, such as acupuncture and laser terapy, dry needling is a promising therapy [7]. This technique is called dry needling, because no substance is inoculated into the body. It has its origin in acupuncture, which is an ancient technique from Chinese traditional medicine, involving the insertion and manipulation of needles in acupoints, promoting an energetic flow in all the body systems [8].

Dry needling technique also involves the utilization of sterilized acupuncture needles with thin monofilaments to perform a mechanical stimulation at the site of pain (that is at the myofascial trigger points). This promotes a response of local spasm with systemic anti-inflammatory action [9,10] and changes in the biomechanical makeup of the trigger point, leading to reduction in tissue irritability and pressure pain, along with increased articular mobility, and muscular function, and culminates in local release and individual wellbeing [11].

This investigation aims to assess how the dry needling technique impacts the stomatognathic system's functionality in individuals with muscle-related temporomandibular dysfunction. The study not only focuses on pain relief and functional improvement

but also aims to understand its effects on changing beliefs related to chronic pain. By examining these aspects, the research seeks to offer a comprehensive understanding of dry needling's potential benefits in managing temporomandibular dysfunction and chronic pain.

It was hypothesized that patients with muscular temporomandibular dysfunction who underwent dry needling had pain relief and consequently changed their beliefs associated with chronic pain, which lead to better functioning of the stomatognathic system. This study will proceed to investigate the effects of dry needling on individuals with temporomandibular dysfunction, elaborating on the methodology and results in subsequent sections.

Materials and Methods

Section snippets

Study design and ethics

search study and selection procedures

This interventional and self-controlled longitudinal study was approved by the University of São Paulo Ethics Committee (process # 81176417.8.0000.5419). Informed consent was obtained from all the participants.

Sample

The sample size was formerly determined (software G* Power 3.1.9.2; Franz Faul, Kiel University, Kiel, Germany) utilizing the pain threshold for palpation as a primary variable as described by Blasco-Bonora and Martín-Pintado-Zugasti [12]. To perform the calculation operation, the average values and standard deviation of the masseter muscle were used, before and after intervention, which was 1.54 (0.27) and 2.10 (0.4), respectively. Thus, the effect size was 1.58 and the minimal sample size was 6 subjects.

To perform this investigation, 21 patients of both genders ranging from 21 to 60 years old (average age of 35.81 ± 13.16 years; weight 72.13 ± 15.90 kg; height 1.67 ± 0.10 m; body mass index 25.46 ± 3.55) and with temporomandibular muscle disorders, in agreement with The Diagnostic Criteria for Temporomandibular Disorders (DC/TMD), pain and trigger point in masseter muscle for more than 3 months, as reported by the subjects and a score higher than 3 out of 10 points in the visual scale of pain, participated in this study.

The exclusion criteria were as follows: absence of integrity of the cognitive system, utilization of removable or total prosthesis, the presence of mandibular or palatal torus, clinical history of systemic diseases such as neurological and psychiatric disturbances requiring chronic medication, subjects using drugs that interfere with muscular activity, absence of teeth (except for third molars), and patients undergoing treatment in orthodontics, speech therapy, physiotherapy, or otolaryngology (before or during the study).

The study's methodological choices described below were carefully tailored to provide a thorough analysis of the impact of dry needling on temporomandibular dysfunction. To address muscle--related issues, dry needling was employed, targeting trigger points in the masseter muscles to alleviate pain and enhance functionality. Electromyography was utilized to comprehensively gauge masticatory efficiency, delving into muscle activity during chewing different foods. Additionally, occlusal analysis, facilitated by the T-Scan® III system, enabled the assessment of dental occlusion and the distribution of biting forces, revealing changes in overall occlusal function.

Muscle pain analysis

The visual numerical scale was presented to the subjects to estimate the level of pain in the masseter muscles region. This scale is numbered from 0 to 10, with 0 representing "absence of pain" and 10 representing "maximal pain"[13].

To perform dry needling treatment of the trigger points of the masseter muscles, systemic filiform acupuncture needles (Dong Bang, South Korea) with a diameter of 0.25 x 30 Mm C was used; each package contained 10 needles and 1 guide tube [14,15].

The subject was in a supine position, with the head on a pillow and the feet supported by a cushion, followed by palpation of the trigger points in the masseters. Digital compression is generally painful for the patient. Skin asepsis was performed with alcohol, and the trigger point was delimited using a fine tip pen. Subsequently, a visual numerical scale was used.

The package of needles was opened in front of the subject and the examiner was equipped with gloves. With the help of the chuck, the needle was inserted at a 90° angle to the skin at all trigger points that were selected, which promoted a local spasm. The needle was removed only after the subject reported that pain was less than 3 points on the visual numerical scale. The needle was discarded into an adequate medical waste container.

During the application of dry needling, the individual felt mild discomfort because of the penetration of the skin, which was monitored using the visual numerical scale to avoid acute pain. The participants were instructed to relax to avoid nausea or fainting. Eventual bleeding after the removal of the needle was minimized with cotton compression. The subjects did not receive any other type of pain treatment such as physical therapy.

Range of mandibular movements analysis

The range of mandibular movements was evaluated using the average value obtained from three measurements performed with a digital pachymeter (Mitutoyo®, Suzano, São Paulo, SP, Brazil) from movements of mouth opening, protrusion, and right and left

laterality. The measurement of the range of mandibular movements was performed with the middle dental line as a reference in addition to the deviations that were presente [16]. The pachymeter was positioned in the middle incisal region of the superior and inferior central incisors [17,18].

Masticatory efficiency analysis

The masticatory cycles of the masseter and temporal muscles were evaluated using portable electromyography MyoSystem Br-1-P84 and active simple silver electrodes (DataHominis, Uberlândia, Minas Gerais, Brazil).

After cleaning the skin with alcohol, the electrodes were placed on the superficial portion of the masseter and temporal muscles, according to the norms determined by Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM) [19]. The subjects were seated on a chair, in a straight position, with feet on the ground and hands on the thighs. The head was maintained straight ahead, with the occlusal plane parallel to the ground [20].

The evaluation of the efficiency of masticatory cycles was performed through the integrated linear envelope electromyography (EMG) of the masseter and temporalis muscles in a clinical setting with habitual chewing of peanuts as a hard food (5g), seedless raisins as a soft food (5 g), and non-habitual chewing of a paraffin paper that was folded 12 times (Parafilm M®; Pechiney Plastic Packaging, Batavia, IL, USA) [21].

In non-habitual chewing, a movement of short opening was performed to reduce the effects of changes in length × muscle tension, which is typical in dynamics registers [22]. To obtain the values of the linear envelope integral of masticatory cycles, intervals of 5 to 10 sec of habitual and non-habitual chewing were used, discarding the initial masticatory cycles because of the variation in the pattern of mandibular mobility [21]. Data were normalized by the linear envelope integral obtained during dental clenching in maximal voluntary contraction (5 s).

Distribution of occlusal contacts analysis

T-Scan® III Occlusal Analysis System (Tekscan, Inc. South Boston, MA. USA) was used for the analysis of dental occlusion using Windows-based computer software and sensors of 100 µm. This system allows the identification of early contacts and visualization of the bite force in 2D and 3D images, with a legend for strength intensity [23,24].

To perform the examination, a sensor was inserted into the oral cavity of each patient such that the position of the support guide is centralized and placed between the superior central incisors. Each participant was instructed to bite the sensor thrice naturally. The distribution of the initial and final occlusal forces for the superior and inferior hemiarcades from both sides was analyzed using the software.

Statistical method

Data obtained from the study were submitted to the Kolmogorov-Smirnov test for distribution analysis. Parametric statistical analysis (paired t-test and t-test for independent samples) was performed using GraphPad Prism (GraphPad Software Inc., California, USA), version 6.0, with significance set at 5%.

Results

A decreased symptomatology of pain ($p < 0.001$) was observed in the masseter muscles when compared to the period before (4.23 ± 1.89) and after seven days (0.47 ± 0.87) of dry needling.

The range of mandibular movement data before and after the application of dry needling technique is shown in Table 1. After dry needling, a significant increase in the amplitude of the right and left laterality was observed ($p < 0.05$) (Table 1). In the clinical conditions of opening and protrusion, there was no significant increase in values; however, after the application of dry needling technique, a better execution of these movements was observed.

Mandibular Mobility	Before	After	p-value
Mouth opening	37.93 ± 8.99	38.41 ± 8.83	0.78
Right laterality	8.72 ± 2.30	11.00 ± 3.58	0.02
Left laterality	9.64 ± 2.61	12.03 ± 3.22	0.02
Protrusion	5.16 ± 1.95	5.42 ± 1.98	0.63

Table 1. Mouth opening, right laterality, left laterality, and protrusion (mm) before and after the application of dry needling technique; mean ± standard deviation and p-values.

The electromyographic data (habitual and non-habitual chewing) of the masseter and temporalis muscles before and after the application of dry needling technique are shown in Table 2. There was no significant difference in usual and non-habitual chewing after the application of dry needling technique for all muscles analyzed in this study (Table 2).

Chewing and muscle	Before	After	p-value
Raisins			
RM	0.64 ± 0.32	0.66 ± 0.39	0.90
LM	0.67 ± 0.26	0.67 ± 0.40	0.96
RT	0.68 ± 0.22	0.64 ± 0.33	0.64
LT	0.73 ± 0.28	0.68 ± 0.28	0.28
Peanuts			
RM	1.04 ± 0.56	1.12 ± 0.47	0.63
LM	1.22 ± 0.93	1.10 ± 0.55	0.43
RT	0.89 ± 0.26	0.89 ± 0.41	0.94
LT	1.00 ± 0.46	0.92 ± 0.35	0.37
Parafilm M			
RM	0.89 ± 0.61	0.94 ± 0.61	0.79
LM	0.83 ± 0.46	0.90 ± 0.50	0.47

RT	0.91 ± 0.34	0.93 ± 0.56	0.81
LT	0.96 ± 0.47	0.98 ± 0.51	0.73

Table 2: Electromyographic data (habitual and non-habitual chewing) for the right masseter (RM), left masseter (LM), right temporal (RT), and left temporal (LT) muscles before and after the application of dry needling technique; mean ± standard deviation and p-values.

The analysis of the distribution of occlusal force contact showed that there was a decrease in force on the right side and a significant increase in force on the left side ($p < 0.05$), when the same side was compared before and after dry needling (Table 3).

Occlusal force (hemiarcade)	Before	After	p-value
Right	54.09 ± 8.80	51.74 ± 8.90	0.20
Left	45.91 ± 8.87	48.41 ± 8.85	0.001

Table 3: Values of occlusal force distribution (%), comparing the same side before and after the application of dry needling technique; mean ± standard deviation and *p*-values.

The occlusal force was analyzed on the right and left sides before dry needling was applied, with decreased force to the left side ($p < 0.05$). Seven days after dry needling, there were no differences between the sides (Table 4).

	Occlusal force (hemiarcade)		
Period	Right	Left	p-value
Before	54.09 ± 8.80	45.91 ± 8.87	0.01
After	51.74 ± 8.90	48.41 ± 8.85	0.29

Table 4: Values of occlusal force distribution (%), comparing the right and left side before and after the application of dry needling technique; mean ± standard deviation and p-values.

Discussion

In the present study, the effect of dry needling technique on the stomatognathic system in individuals with temporomandibular dysfunction, after bilateral masseter needling was analyzed. Temporomandibular dysfunction can affect all masticatory muscles; however, the individuals in this study did not present trigger points in the temporal muscles, and did not require needling.

The complexity of pain evaluation in individuals with temporomandibular dysfunction is associated with the multidimensionality of this clinical pathology, and the correct evaluation of pain may aid in diagnosis and treatment [25]. Although there is no gold standard measure for subjective symptoms, several authors [26-28] have utilized scales to verify the response before and after treatment.

The study by Campagna., *et al*. [29] utilized a visual analog scale of pain during the application of dry needling technique (for four sessions) in individuals that presented with chronic buzzing promoted by myofascial trigger points. They observed statistically significant differences between the evaluations obtained before and after treatment. A similar result was observed in the present study, where dry needling technique decreased pain symptoms in the masseter muscles; this was verified using a scale to quantify the pain before and after the application of the technique. The efficacy of dry needling may involve mechanical blockage of the integrity of dysfunctional terminal plates [4].

In this study, dry needling technique was effective not only in the reduction of pain but also in the improvement of mandibular mobility, as evidenced by the greater amplitude in movement with right and left laterality. The results of this study are in agreement with those of Fernández-Carnero., *et al.* [30] who also verified an increase in mandibular mobility and a significant increase in the threshold level of pain after applying dry needling to trigger points of masseter muscles in individuals with temporomandibular dysfunction.

The decrease in pain symptomatology and improvement of mandibular mobility found in this study might have occurred because of biochemical effects resulting from the dry needling technique, which promotes excitement of pain receptors [31].

The electromyographic results of the current study did not show a statistically significant difference in the evaluated muscles. Different results might have been observed had this study utilized high-density surface electromyography, which allows the collection of myoelectrical activity from different points of the muscle, identifies the position of the innervation zone, and estimates the speed of conduction of the action potential of motor units [32].

Even though there were no statistical differences in the electromyographic results, it was observed that in the habitual chewing of peanuts, the electromyographic averages of right and left masseter were similar (1.12 and 1.10, respectively), which is a decrease from the initial discrepancy (1.04 and 1.22, respectively) found in the electromyographic activity of these muscles. The same can be said about the left temporal muscle that presented a better balance after treatment, when compared to the right temporal muscle.

During habitual chewing with raisins, there was a subtle increase in the electromyographic activity of the right masseter after dry needling, which decreased the activity of the right and left temporal muscles, allowing normal masticatory pattern with increased activation of the masseter and less activation of the temporal [33].

The recovery of the masticatory pattern may explain the significant results found when analyzing the occlusal force distribution using T-scan. The occlusal force is considered an essential factor for dental stabilization, and several innovative technologies have been created to perform this evaluation [34].

It was observed in this study that after 7 days of dry needling, there were no statistical difference between the sides regarding the distribution of occlusal force, indicating homeostasis in the distribution of this force.

In agreement with Karakis, Bagkur,Toksoy [35], the distribution of occlusal force is associated with the balance of occlusion and masticatory muscles, in this study. This suggests that muscular balance was achieved after the application of dry needling technique with an equivalent occlusal force distribution. The improvement of occlusal distribution can be associated with a decrease in pain, as demonstrated by the numerical scale. In the presence of pain, an individual may have compensatory attitudes toward masticatory biomechanics.

Pain is a multifactorial condition that involves mechanical, physical, psychological, and social factors. Thus, beliefs about the human body and pain play a powerful role in the emotional and behavioral responses to musculoskeletal pain [36]. Therefore, the hypothesis of this study was confirmed because dry needling technique was effective in the functional improvement of individuals with this type of chronic dysfunction.

However, this study has some limitations. Although the eligibility criteria were well established, the use of a pressure algometer could have helped quantify the tolerance and sensibility of the individual associated with pain in the evaluated muscles. Another limitation was that the examinations were performed after 7 days of dry needling, and not along the time, which could demonstrate the long-term effectiveness of this technique. Future investigations should perform a comparison of the variables, for a better comprehension of the utilization of dry needling technique in patients who present with chronic temporomandibular dysfunction muscle type.

The observed improvements in pain reduction, increased mandibular mobility, and balanced occlusal force distribution, resulting from the application of dry needling technique, hold significant clinical implications for individuals with temporomandibular dysfunction. These enhancements collectively translate into a notable enhancement in the quality of life for these patients, offering relief from discomfort, improved functional abilities, and the potential for reduced psychological burden associated with chronic pain.

Conclusions

The data obtained in this investigation suggest that patients with temporomandibular disorder muscle type, presented an improvement in pain, mandibular mobility, and occlusal force distribution when treated with dry needling technique, which demonstrates the effectiveness of this technique in the treatment of temporomandibular dysfunction, and in improving the function of the stomatognathic system. These outcomes hold promising clinical implications, suggesting that dry needling could serve as an effective intervention strategy. However, to comprehensively establish its long-term effectiveness and mechanisms, further longitudinal research is needed. This study underscores the potential for enhancing patients' quality of life by addressing both functional and discomfort aspects of temporomandibular dysfunction.

Conflict of Interest

Declare if any financial interest or any conflict of interest exists.

Bibliography

1. Zotelli VL G., *et al.* "Acupuncture effect on pain, mouth opening limitation and on the energy meridians in patients with temporomandibular dysfunction: a randomized controlled trial". *Journal of Acupuncture and Meridian Studies* 10.5 (2017): 351-359.

2. Thirunavukarasu AJ., *et al.* "Temporomandibular joint anatomy: ultrasonographic appearances and sexual dimorphism". *Clinical Anatomy* 34.7 (2021): 1043-1049.

3. Tesch RS., *et al.* "Effectiveness of dry needling on the local pressure pain threshold in patients with masticatory myofascial pain. Systematic review and preliminary clinical trial". *Cranio* 39. 2 (2021): 171-179.

4. Unverzagt C., *et al.* "Dry needling for myofascial trigger point pain: a clinical commentary". *International Journal of Sports Physical Therapy* 10.3 (2015): 402-408.

5. Ziaeifar M., *et al.* "The effect of dry needling on pain, pressure pain threshold and disability in patients with a myofascial trigger point in the upper trapezius muscle". *Journal of Bodywork and Movement Therapies* 18.2 (2014): 298-305.

6. López-Royo MP., *et al.* "Effects of ischemic compression on trigger points in the first dorsal interosseous muscle in patients with thumb carpometacarpal osteoarthritis". *International Journal of Environmental Research and Public Health* 18.6 (2021): 2961.

7. Nuhmani S., *et al.* "Dry needling in the management of tendinopathy: A systematic review of randomized control trials". *Journal of Bodywork and Movement Therapies* 33 (2023): 128-135.

8. Fernández-Jané C., *et al.* "Acupucture techniques for COPD: a systematic review". *BMC Complementary Medicine and Therapies* 20 (2020): 138.

9. Navarro-Santana MJ., *et al.* "Effectiveness of dry needling for myofascial trigger points associated with neck pain symptoms: an updated systematic review and meta-analysis". *Journal of Clinical Medicine* 9.10 (2020): 3300.

10. Fernández-De-Las-Peñas C., *et al.* "Is dry needling effective when combined with other therapies for myofascial trigger points associated with neck pain symptoms? A systematic review and meta-analysis". *Pain Research and Management* 2021 (2021): 8836427.

11. Vier C., *et al.* "The effectiveness of dry needling for patients with orofacial pain associated with temporomandibular dysfunction: a systematic review and meta-analysis". *Brazilian Journal of Physical Therapy* 23.1 (2019): 3-11.

12. Blasco-Bonora PM., *et al.* "Effects of myofascial trigger point dry needling in patients with sleep bruxism and temporomandibular disorders: a prospective case series". *Acupuncture in Medicine* 35.1 (2017): 69-74.

13. Shafshak TS., *et al.* "The visual analogue scale versus numerical rating scale in measuring pain severity and predicting disability in low back pain". *Journal of Clinical Rheumatology* 27.7 (2021): 282-285.

14. Velázquez-Saornil J., *et al.* "Efficacy of quadriceps vastus medialis dry needling in a rehabilitation protocol after surgical reconstruction of complete anterior cruciate ligament rupture". *Medicine (Baltimore)* 96.17 (2017): e6726.

15. Hsieh YL., *et al.* "Dry needling to a key myofascial trigger point may reduce the irritability of satellite MTrPs". *American Journal of Physical Medicine and Rehabilitation* 86.5 (2007): 397-403.

16. Spagnol G., *et al.* "Impact of midface and upper face fracture on bite force, mandibular mobility, and electromyographic activity". *International Journal of Oral and Maxillofacial Surgery* 45.11 (2016): 1424-1429.

17. Magnani DM., *et al.* "Evaluation of oral-motor movements and facial mimic in patients with head and neck burns by a public service in Brazil". *Clinics (Sao Paulo)* 70.5 (2015): 339-345.

18. Celić R., *et al.* "Measurement of mandibular movements in patients with temporomandibular disorders and in asymptomatic subjects". *Collegium Antropologicum* 27.2 (2003): 43-49.

19. Hermens HJ., *et al.* "Development of recommendations for SEMG sensors and sensor placement procedures". *Journal of Electromyography and Kinesiology* 10.5 (2000): 361-374.

20. Palinkas M., *et al.* "Evaluation of the electromyographic activity of masseter and temporalis muscles of women with rheumatoid arthritis". *Hippokratia* 22.1 (2018): 3-9.

21. Siéssere S., *et al.* "Masticatory process in individuals with maxillary and mandibular osteoporosis: electromyographic analysis". *Osteoporosis International* 20.11 (2009): 1847-1851.

22. da Silva N., *et al.* "Impact of parkinson's disease on the efficiency of masticatory cycles: electromyographic analysis". *Medicina Oral, Patologia Oral y Cirugia Bucal* 24.3 (2019): e314-e318.

23. Di Berardino F., *et al.* "The occlusal imaging and analysis system by T-scan III in tinnitus patients". *Biomedical Journal* 39.2 (2016): 139-144.

24. Cerna M., *et al.* "Validity and reliability of the T-Scan (®) III for measuring force under laboratory conditions". *Journal of Oral Rehabilitation* 42.7 (2015): 544-551.

25. Dos Reis FJ., *et al.* "Measuring the pain area: an intra- and inter-rater reliability study using image analysis software". *Pain Practice* 16.1 (2016): 24-30.

26. Chiarotto A., *et al.* "Measurement properties of visual analogue scale, numeric rating scale, and pain severity subscale of the brief pain inventory in patients with low back pain: a systematic review". *The Journal of Pain* 20.3 (2019): 245-263.

27. Myles PS., *et al.* "Measuring acute postoperative pain using the visual analog scale: the minimal clinically important difference and patient acceptable symptom state". *British Journal of Anaesthesia* 118.3 (2017): 424-429.

28. Ulger O., *et al.* "The effect of manual therapy and exercise in patients with chronic low back pain: Double blind randomized controlled trial". *Journal of Back and Musculoskeletal Rehabilitation* 30.6 (2017): 1303-1309.

29. Campagna CA., *et al.* "Effectiveness of dry needling in bothersome chronic tinnitus in patients with myofascial trigger points". *International Archives of Otorhinolaryngology* 26.2 (2022): e233-e242.

30. Fernández-Carnero J., *et al.* "Short-term effects of dry needling of active myofascial trigger points in the masseter muscle in patients with temporomandibular disorders". *Journal of Orofacial Pain* 24.1 (2010): 106-112.

31. Mahmoudzadeh A., *et al.* "The effect of dry needling on the radiating pain in subjects with discogenic low-back pain: A randomized control trial". *Journal of Research in Medical Sciences* 21 (2016): 86.

32. Felici F., *et al.* "Surface electromyography: what limits its use in exercise and sport physiology?" *Frontiers in Neurology* 11 (2020): 578504.

33. Palinkas M., *et al.* "Aging of masticatory efficiency in healthy subjects: electromyographic analysis--Part 2". *Acta odontológica Latinoamericana* 26.3 (2013): 161-166.

34. Ruttitivapanich N., *et al.* "Correlation of bite force interpretation in maximal intercuspal position among patient, clinician, and T-Scan III system". *European Journal of Dentistry* 13.3 (2019): 330-334.

35. Karakis D., *et al.* "Comparison of simultaneously recorded computerized occlusal analysis and surface electromyographic activity of masticatory muscles between patients with unilateral TMD". *The International Journal of Prosthodontics* 34.5 (2021): 554-559.

36. Ansari M., *et al.* "Effects of dry needling and low-power laser for the treatment of trigger points in the upper trapezius muscle: a randomized clinical trial". *Journal of Chiropractic Medicine* 21.4 (2022): 288-295.