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The Use of Therapeutic Ultrasound in the Management of Patients with Temporomandibular Disorder: A Clinical, Cross-Sectional and Quantitative Study

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Background: To manage the temporomandibular disorders (TMD), one of the resources used is therapeutic ultrasound (UST).
Objective: To evaluate the use of therapeutic ultrasound in individuals with temporomandibular disorders (TMD).
Methods: This is a clinical study, which 42 individuals,aged 18-73 years, diagnosed with TMD were recruited. Participants then bit into a wooden spacer until they felt fatigue in the masseter muscle, with time assessed on both sides(right and left), followed by chewing gum. Subsequently,USD was applied to the masseter (at a frequency of 2.0 W=0.52W/cm² for 4 minutes) and the wooden spacer test was repeated to assess the time of fatigue in this muscle.
Results: The most affected age group was up to 28 years old (52.4%), and females (73.8%) ($p<0.05$). Regarding the amount of fatigue, there was a decrease on the left side in the control group and on both sides in the TMD group, with a significant difference (P=0.0049) for the left side when evaluating before and after the treatment.When comparing times, the TMD group also showed the greatest reduction, (P=0.0012) for the left side.
Conclusion: It is concluded that ultrasound therapy promoted immediate improvement in the tightening of the wooden spacer,causing muscle relaxation through the heat applied,reducing fatigue in the masseter muscle.

Keywords: Temporomandibular joint disorders; ultrasound therapy; facial muscles; signs and symptoms; orofacial pain.

1. INTRODUCTION

Chronic pain is a highly prevalent condition, being a pain that has more then three months, with a great impact on the health of individuals, on health services and on society as a whole, in addition to presenting significant difficulties during treatment (Treede et al., 2019; Fehrenbach et al., 2018; Grossman et al., 2012).

One of the anatomical sites most affected by chronic pain is the Temporomandibular Joint (TMJ) Fehrenbach et al. (2018). Temporomandibular Disorder (TMD) is a term that describes a group of disorders involving the TMJ and associated structures (Grossman et al., 2012). It is characterized by a variety of clinical symptoms that involve changes in the muscles of mastication and in the TMJ, as jaw pain, otalgia, headaches and limitation of function (Silva et al., 2023).

This condition is a significant public health problem (Niszezak et al., 2019) and has the third highest prevalence among chronic pain, being more frequent among young people and adults and predominantly affects women (Battistella et al., 2016).

TMD is often associated with other chronic pain such as headache, neck pain and joint pain, causing significant physical and psychological disability of the patient, in addition to the high cost of health care (Battistella et al., 2016). Patients have joint noises, limitations in range of motion or deviations during mandibular function, preauricular pain, pain in the TMJ or masticatory muscles (Chaves, Oliveira, & Grossi, 2008). There is some evidence of a relationship between intense muscle activity and motor behavior during mastication where patients with TMD present greater activation of the masticatory muscles due to their lower functional efficiency, showing a predisposition to muscle fatigue (Ries et al., 2016).

Within the physiotherapy practice, one of the resources used is therapeutic ultrasound (UST). It is used to treat various skeletal muscle pathologies, both acute and chronic, acting on fibroblast activation, increasing collagen extensibility and healing. It also decreases inflammatory cells, in osteogenesis, angiogenesis, reduction of muscle spasms, joint stiffness and analgesia (Oliveira et al., 2015).

Used for tissue repair of muscle injuries, therapeutic ultrasound has a frequency between 1 and 3 MHz. The mechanism is because the increase in muscle temperature, promoting increased blood flow and reduced pain and muscle repair. The higher frequencies (3MHZ) are absorbed more intensely, being used in superficial tissues. The lower frequencies, (1MHZ), penetrate more deeply, being used in

deep tissues (Matheus et al., 2008). Thus, it has been used in the management of TMD.

The study sought to evaluate the use of therapeutic ultrasound in the management of patients with temporomandibular disorders, verifying muscle fatigue in the masseter before and after the use of therapeutic ultrasound.

2. MATERIALS AND METHODS

2.1 Study Population and Sampling Plan

This is a clinical, cross-sectional and quantitative study. The sample consisted of individuals of both sexes, aged over 18 years, who attended for treatment at the TMD clinic of the Escola Cearense de Odontologia - Faculdade São Leopoldo Mandic (Fortaleza-Ceará-Brazil).

Since this is a paired study, based on a flow of 84 individuals assisted until August 2021, and considering the four-month period of assistance, the need to assist a population of 20 individuals was estimated, thus obtaining a sample that represented the studied population with 95% confidence.

Patients of both sex aged between 18 and 73 years were included. Patients with any inability to fill out the forms and answer questions asked during the consultation and patients who already use therapeutic ultrasound or another type of therapy for muscle fatigue were excluded. Asymptomatic participants for TMD, who did not complain of muscle fatigue in the masticatory muscles, formed the control group of this research.

2.2 Instrument for Data Collection

Participants were using the Diagnostic Criteria for Temporomandibular Disorders instrument (DC/TMD Axis I) to diagnose the presence of TMD pain. Muscle fatigue was assessed with wooden spacers, Trident gum and a stopwatch. The results obtained were tabulated and submitted to a descriptive statistical analysis where the effectiveness of therapeutic ultrasound in patients with muscle fatigue in the masseter was evaluated.

2.3 Data Collect

The examiner evaluated the patient according to the DC/TMD (axis 1); assessed the location of the pain in the last 30 days, and diagnosed the present TMD subtype(s).

After completing the questionnaire, each participant sat comfortably in a chair, the masseter palpation examination was performed (origin, body and insertion), thus completing item 9 of the DC/TMD. The researcher placed the wooden spacer in the participant's mouth, in the region corresponding to the first molars (upper and lower) and asked the patient to bite down hard on the wooden spacer until he felt fatigue in the masseter. The time was recorded on a spreadsheet.

First, the wooden spacer was placed on the right side, the time that the patient was able to keep the wooden spacer on the right side was noted, and the same thing was done on the left side. Subsequently, the researcher asked the participant to chew the gum in the usual way and discreetly counted 20 chewing cycles.

After counting, the participant removed the chewing gum from his mouth, the researcher laid down the dental chair and passed the therapeutic ultrasound of the brand Quark and model Proseven 977 1 Mhz Full, using program 36, in the masseter muscle (origin, body and insertion) for 4 minutes at a frequency of 2.0 W=0.52 W/cm².

The application of UST was performed with circular, continuous and slow movements. The researcher repeated the wooden spacer test with the participants, placing it in the patient's mouth, more precisely in the region of the posterior teeth, and asked the patient to tighten the wooden spacer until he felt fatigue in the masseter. The same was done on the opposite side.

2.4 Statistical Analysis

The data was tabulated in Microsoft Office Excel® software and exported to GraphPad Prism 8.4 for statistical analysis. The data was expressed as simple frequency and percentage. The normality of the data was tested through the tests of *Kolmogrov-Smirnov* and *Shapiro-wilk*. For the comparative analysis of the data, the tests of *Kruskal Wallis*, binomial, *Wilcoxon* and *Mann-Whitney*. Outliers were detected using the ROUT method (*Robust regression and Outlier removal*) and the confidence interval adopted was 95% and $P<0.05$ (5%) was considered statistically significant.

3. RESULTS

The 42 participants were aged between 18 and 73 years, with an average of 34.5 ± 14.7. The normality of data distribution was verified, revealing an abnormal distribution for the variables evaluated in this study. The sample had 73.8% (n=31) of female participants and 26.2% (n=11) of male participants, showing a significant difference for this variable (P=0.0014, binomial test). The age group with the highest number of individuals was up to 28 years old (52.4%). A significant difference was found between groups (p=0.0001, Kruskal-Wallis test), when analyzing age by age group (Table 1).

Of the DC/TMD questionnaire questions that were applied, the highest occurrence of pain reported for both sides was in the masseter, representing 81.0% of the sample for the right side and 90.5% for the left side.Reports of pain in the temporal and TMJ areas were identical for both sides, with 23.8% of participants claiming to feel pain on the right side and 28.6% on the left side.Headache was also reported for laterality, affecting 47.6% of participants in the temporal region (Table 2).

Table 3 shows comparisons between paired and unpaired groups with their respective significance and tests used.

There was an average increase of 8% in the tightening time of the wooden spacer when the right side was evaluated, while for the left side this increase was 44% (Table 4).

After treatment, it was possible to observe a total decrease in the number of severe fatigue on the left side in the control group, while in the TMD group there was a decrease of 33.3% on the right side and 42.8% on the left side (Table 5).

Table 1. Demographic profile of the sample

Variables	**n**	**%**	**P**
Sex			
Female	31	73.8	=0.0014
Male	11	26.2	(Binomial test)
Age range	**n**	**%**	**P**
Up to 28 years old	22	52.4**,***	<0,0001
29 to 43 years old	8	19.0*	(Kruskal-Wallis)
44 to 58 years old	8	19.0*	
59 to 73 years old	4	9.5*	

*Legend: *Significant difference when compared to the group "Up to 28 years old"; **Significant difference when compared to the "29 to 43 years old" group; ***Significant difference when compared to the "44 to 58 years old" group*

Table 2. DC/TMD questionnaire variables

Questions from the DC/TMD questionnaire		
1st. Location of pain: in the last 30 days		
	Right side	**Left side**
None	1(4.8%)	0(0.0%)
Temporal	5(23.8%)	6(28.6%)
Other muscles of mastication	1(4.8%)	0(0.0%)
Non-masticatory structures	1(4.8%)	1(4.8%)
Masseter	17(81.0%)	19(90.5%)
ATM	5(23.8%)	6(28.6%)
1b. Location of headache: in the last 30 days		
None	10(47.6%)	10(47.6%)
Temporal	10(47.6%)	10(47.6%)
Other	2(9.5%)	2(9.5%)

Legend: DC/TMD – Diagnostic criteria for temporomandibular disorders; TMJ - Temporomandibular joint

Table 3. Paired and unpaired tests performed.

Comparison	P	Test Used
Before/After LD Ctrl	0.7680	*Wilcoxon*
Before/After LD DTM	0.4038	
Before/After LE Ctrl	0.2774	
Before/After LE DTM	0.0012	
Ctrl/DTM LD Before	0.6191	*Mann-Whitney*
Ctrl/DTM LD After	0.9539	
Ctrl/DTM LE Before	0.1215	
Ctrl/DTM LE After	0.7614	

LD – Right side; Ctrl – Control; DTM – Temporomandibular disorder; LE – Left side. P significant when less than 0.05

Table 4. Mean time and standard deviation of tightening with maximum force of the wooden spacer before and after ultrasound treatment

	Mean time ± Standard deviation of test time with wooden spacer				
		Right side before	**Right side after**	**Left side before**	**Left side after**
Control	Average time (seconds)	73.63	100.37	57.22	76.19
	Standard deviation	70.53	151.23	73.32	123.51
DTM	Average time (seconds)	55.29	59.76	31.70	45.70
	Standard deviation	33.14	29.89	16.36	25.72

Table 5. Classification of fatigue in the studied groups

Fatigue classification				
CONTROL				
Fatigue	**Right side before**	**Right side after**	**Left side before**	**Left side after**
Absent	10 (47.6%)	8 (38.1%)	5 (23.8%)	6 (28.6%)
Light	4 (19.0%)	8 (38.1%)	4 (19.0%)	6 (28.6%)
Moderate	6 (28.6%)	4 (19.0%)	9 (42.9%)	9 (42.9%)
Severe	1 (4.8%)	1 (4.8%)	3 (14.3%)	0 (0.0%)
DTM				
Fatigue	**Right side before**	**Right side after**	**Left side before**	**Left side after**
Absent	10 (47.6%)	9 (42.9%)	2 (9.5%)	6 (28.6%)
Light	2 (9.5%)	5 (23.8%)	3 (14.3%)	3 (14.3%)
Moderate	6 (28.6%)	5 (23.8%)	9 (42.9%)	9 (42.9%)
Severe	3 (14.3%)	2 (9.5%)	7 (33.3%)	3 (14.3%)

4. DISCUSSION

Currently, among the complementary treatments used, the following stand out: thermotherapy, dry needling, joint mobilization, stretching, laser therapy, transcutaneous electrical nerve stimulation (TENS) and therapeutic ultrasound, providing improved blood flow, analgesia and improved muscle function (Batista et al., 2022).

This study sought to compare the use of UST in individuals with TMD to a control group, evaluating its effectiveness in the masseter muscle, improving muscle fatigue. Individuals of both sexes, with complaints of pain and fatigue in the masticatory muscles, participated in this study. Likewise, asymptomatic individuals for TMD were also evaluated, included in the control group of the present study. The sample consisted of 42 individuals, in which 21 individuals formed the study group and 21 the

control group. In the sample of the present study, the most affected age group was up to 28 years old (52.4%) with a predilection for females (73.8%). The findings are in line with the literature, as in the study by Batista et al. (2022) reported that 50 to 75% of the population has some TMD symptom, with prevalence between 20 and 40 years old, being mainly frequent in females.

In the sample of the present study, the highest occurrence of pain on both sides, before the therapeutic ultrasound, was in the masseter muscle, representing 81.0% of the sample for the right side and 90.5% for the left side. Similar to such information, in the study by Hussain et al. (2018) masseter muscle pain has been reported on both sides. The pain score, according to the verbal measurement scale for pain intensity, ranged from 4 to 9 in the masseter muscle on the right side and for the left side it ranged from 4 to 8. The authors tested different types of ultrasound and pointed out that both have therapeutic effects, with no differences between the types used.

According to Miernik et al. (2012) myofascial pain in masticatory muscles is strongly associated with parafunctions, fatigue, stiffness and tension. In the sample of the present study, pain in the area of the temporal muscle and TMJ was reported, being identical for both sides. 23.8% of the participants felt pain on the right side of the temporal muscle and TMJ and 28.6% of the participants felt pain on the left side of the temporal muscle and TMJ. This is in line with the literature (Özden et al., 2020), where muscle TMD is more related to the masticatory muscles, with the masseter and temporalis being the most common muscles associated with muscle TMD.

In the sample of the present study, headache was also reported in terms of laterality, affecting 47.6% of participants in the temporal region. Said findings are similar to the study by Calixtre et al. (2019) who pointed out that headache was significant among 29 patients who reported that headache influenced their vitality, cognitive function and psychological distress. This also goes against the fact that typically 70% of the population suffering from headaches also have TMD symptoms (Calixtre et al., 2019).

In this context, ultrasound therapy has been one of the treatments chosen to reduce pain and inflammation related to TMD, improving blood supply to the muscle and reducing muscle spasms (Lima et al., 2017; Khaimar et al., 2019). In that study, the tightening times of the wooden spacer on the left side, before and after the therapeutic ultrasound, showed a significant difference. An increase of 8% was observed in the tightening time of the wooden spacer on the right side; meanwhile, this increase was 44% for the left side.

Similar to these findings, Rai et al. (2016) compared the use of TENS in the masseter muscle. In this study, pain, quality of life, perception of improvement with massage, and appearance of the masseter muscle were evaluated. All results showed a significant difference between ultrasound and TENS, indicating that patients who received therapy with therapeutic ultrasound showed improvement in pain in the masseter muscle, better mandibular movement, and improved quality of life. Pihut et al. (2020) also reinforced these findings, pointing to a rapid improvement in symptoms and clinical parameters. In addition, therapeutic ultrasound has been associated with other modalities, such as photobiomodulation therapy, showing promising results after 30 days (Panhóca et al., 2019).

Unlike Boufleur et al. (2014) in the present study, the highest occurrence of pain was in the masseter before the physiotherapeutic intervention with UST. The studied group reported the presence of more pain on the left side. The sample also showed a prevalence of pain in the temporal region and joint on the left side. In this study, therapeutic ultrasound was effective in patients with muscle fatigue in the masseter. This can be justified by the fact that the deep heat that is applied to the muscle causes an immediate improvement in pain.

In the present study, a decrease in the number of fatigues, especially the severe ones, was observed in both groups.The TMD group showed a greater reduction, which was significant, however this was already expected, since it is the group with this condition, which justifies the tendency to present better results. In addition, patients in the TMD group had a shorter time to tighten the wooden spacer compared to the control group. Wofniak et al. (2015) reinforce these findings, performing a maximum effort test for muscle fatigue in their study. They found that the increase in fatigue in the tested muscles was proportional to the severity of the TMD. The TMD group showed greater depletion of the masseter muscle compared to the control group.

In addition, it was noticed that patients, after using ultrasound, felt an immediate improvement in muscle fatigue in the masseter muscle. The study stands out for its use of the main diagnostic criteria for TMD (DC/TMD), compared to a control group, and the application of a standardized therapeutic ultrasound protocol, which provides greater reliability to the immediate results observed. Furthermore, it contributes to the literature by exploring a low-cost physiotherapeutic approach applicable in clinical practice for the management of muscle fatigue in patients diagnosed with TMD.

Some limitations can be pointed out, such as the cross-sectional design, the sample size and longer-term follow-up, which limits the external validity of the findings. Thus, dentists must be attentive in the search for complementary and effective therapies to control orofacial pain symptoms in their patients.

5. CONCLUSION

After analysis of the results and discussion, it was found that muscle TMD has a predilection for females. The statistical evaluation of the data showed that therapeutic ultrasound can be used to treat muscle fatigue in the masseter. Ultrasound therapy promotes immediate improvement in the flatness of the wooden spacer, causing muscle relaxation through the applied heat, reducing fatigue in the masseter muscle.

6. CLINICAL RELEVANCE

Complementary therapies have been increasingly validated in the management of temporomandibular disorders. When it comes to the muscular type, ultrasound has been gaining prominence with dentists, doctors and physiotherapists, thus alleviating the symptoms of this condition. The present study pointed out that after the session with this therapeutic modality, the individuals showed encouraging results in the improvement of symptoms. Thus, it is important that more and more evidence and protocols of complementary therapies are shared to validate their use in the clinic.

ETHICAL APPROVAL AND CONSENT

The project was accepted by the Ethical Committee and approved by the number 5.132.133. Initially, the Free and Informed Consent (IC) was delivered to the patients treated at the TMD-Clinic of São Leopoldo Mandic College (Fortaleza, Brazil) aged over 18 years, of both sexs, who agreed to participate in the research

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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