Short-term Effects of a First-Line Treatment Including Counseling and Self-Management Strategies on Chronic TMD Muscle Pain and Awake Bruxism in Women

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Aims: To evaluate the short-term effects of a standardized first-line noninvasive approach (FL-A) including counseling and self-management strategies on pain, masticatory muscle tenderness, and awake bruxism in women with chronic temporomandibular disorder myalgia (mTMD) and to test whether patients' trait anxiety predicted their response to treatment. **Methods:** FL-A was administered to 14 women with chronic mTMD (mean age ± SD = 33.8 ± 11.1 years; 8 with Graded Chronic Pain Scale [GCPS] grade I and 6 with grade II). Its effects on facial pain, masticatory muscle tenderness, and spontaneous awake bruxism episodes were evaluated using questionnaires, surface electromyography, and quantitative sensory testing. General linear models were used to test FL-A efficacy after 1 (T1) and 2 (T2) months. **Results:** FL-A reduced pain (from baseline [T0] to T2, $P = .010$), the frequency of awake bruxism episodes (T0 to T1, $P = .024$), and their intensity by about 30% (T0 to T1, $P < .001$). Pressure pain thresholds at the masticatory muscle locations increased significantly from T0 to T2 ($P < .001$). Patients' trait anxiety decreased significantly from T0 to T2 ($P = .030$). Trait anxiety measured at baseline was not correlated with relative changes in pain (T0 to T2, $P = .248$). **Conclusion:** In the short term, FL-A reduces facial pain, masticatory muscle tenderness, and awake bruxism in women with chronic mTMD with low disability. A conservative management strategy should be prioritized for the initial management of these patients. *J Oral Facial Pain Headache 2022;36:36–48. doi: 10.11607/ofph.3037*

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Temporomandibular disorders (TMD) include several pathologic conditions involving the masticatory muscles and/or temporomandibular joints (TMJs).[1,2] TMD-related chronic facial pain affects approximately 15% of people with TMD[3] and is the main cause leading patients to seek treatment, as it significantly affects quality of life.[4,5]

The etiology of TMD is multifactorial. Awake bruxism, an oral behavior characterized by repetitive or sustained tooth clenching,[6] has been shown to be strongly associated with TMD, as it contributes to overloading the muscles of mastication and the TMJs, thereby leading to the onset or exacerbation of TMD symptoms.[7–9] In fact, experimental sustained tooth clenching causes fatigue and pain in the masticatory muscles of healthy subjects[10] and exacerbates facial pain in individuals with TMD of muscular origin (ie, chronic TMD myalgia [mTMD]).[11,12] Awake bruxism may also contribute to maintaining mTMD, as individuals with chronic mTMD have more frequent and intense spontaneous awake bruxism episodes than healthy controls.[8,13]

It is well known that oral behaviors and awake bruxism are affected by mood states or traits, such as state or trait anxiety,[8,14] and that awake bruxism may be an adaptive stress-coping behavior.[15] Anxiety is a state characterized by feelings of unease, worry, tension, and stress in the face of events (state anxiety) or a general personality predisposition to react anxiously to events (trait anxiety).[16] Notably, the intensity of masseter contractions during spontaneous awake bruxism is greater in individuals with high compared to low trait anxiety[17]; the incidence and intensity of spontaneous awake bruxism episodes are positively

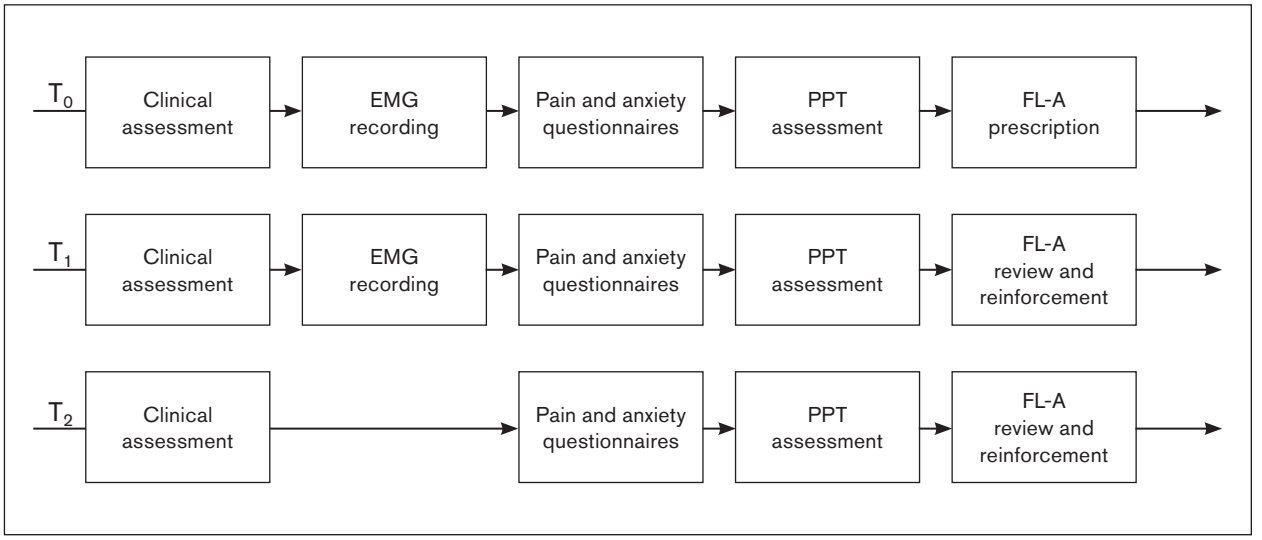

Fig 1 Experimental design. T0 = baseline, T1 = 1 month from initial consultation; T2 = 2 months from initial consultation; PPT = pressure pain threshold; FL-A = first-line treatment approach; EMG: electromyographic recording.

associated with trait anxiety in individuals with chronic TMD[8]; and TMD pain has been shown to augment the relationship between trait anxiety and oral behaviors.[18] Based on these findings, it is plausible that the use of self-relaxation techniques to manage anxiety could contribute to reducing the incidence and intensity of spontaneous awake bruxism episodes and to improving myogenous pain in patients with mTMD. It is also conceivable that individuals with high levels of trait anxiety may respond better to treatment approaches aimed at reducing their anxiety and controlling their oral behaviors.

The value of a first-line noninvasive approach (FL-A) for the management of TMD including counseling and self-management strategies (self-relaxation, self-monitoring of adverse oral behaviors, massage, and jaw exercise) has been widely recognized.[19–25] Yet, it is unclear to what extent it could impact awake bruxism and whether the response to FL-A may depend on an individual's trait anxiety levels.

This study aimed *(1)* to measure the short-term effects of a standardized FL-A including counseling and self-management strategies on spontaneous pain, masticatory muscle tenderness, and awake bruxism in women with chronic mTMD and *(2)* to determine whether patients' anxiety levels predict the therapeutic response to FL-A. It was hypothesized that FL-A would contribute to reducing TMD pain intensity, increasing pressure pain thresholds (PPTs) at masticatory muscle locations, and reducing the electromyographic (EMG) amplitude and frequency of spontaneous wake-time tooth-clenching episodes, and that patients' trait anxiety levels would predict response to treatment.

Materials and Methods

Study Participants

Women aged > 18 years with a complaint of facial pain who presented for a TMD consultation to the Department of Neurosciences, Section of Temporomandibular Disorders, at the University of Naples Federico II were subjected to a preliminary screening. They were invited to answer the TMD Pain Screener questionnaire,[26] which investigates the presence of pain in the jaw or temple area in the last 30 days, pain or stiffness in the jaw on awakening, and whether oral activities affect any pain in the jaw or temple area. A score ranging from 0 to 2 points is attributed to each answer. The TMD Pain Screener has a sensitivity of 0.99 and a specificity of 0.97 for correct classification of the presence or absence of TMD for scores ≥ 3.[26]

Women with a TMD Pain Screener score ≥ 3 underwent a full clinical examination according to the Diagnostic Criteria for Temporomandibular Disorders (DC/TMD)[1] by an operator expert in TMD (A.M.). Subjects with chronic facial pain (> 6 months) and a diagnosis of mTMD who agreed to participate in the study were recruited. The exclusion criteria included wearing extended dental fixed or removable prostheses (≥ 3 teeth); ongoing orthodontic and/or dental treatment; neurologic disorders; habitual intake of drugs affecting the central nervous system and/or muscle relaxants; and/or migraine diagnosis at the moment of screening. All participants signed an informed consent, and they were informed that the treatment options for their condition were conservative. The procedures were approved by the Research

Ethics Board at the University of Naples Federico II (Protocol 15/16).

Experimental Design

A schematic representation of the experimental design is depicted in Fig 1. The effects of FL-A on spontaneous TMD pain, masticatory muscle tenderness, and awake bruxism on research participants were evaluated over 2 months.

To evaluate the effect of FL-A on masticatory muscle activity, the EMG activity in the right masseter was measured for 20 minutes at two time points: immediately after the first TMD consultation (baseline [T0], before FL-A was discussed and prescribed to patients), and after 1 month (T1, before the follow-up TMD assessment).

To evaluate the effect of FL-A on TMD pain and masticatory muscle tenderness, facial pain intensity and pressure pain thresholds (PPTs) were measured at T0, T1, and 2 months after the first TMD consultation (T2). Trait anxiety was also measured at all time points. Participants were informed to use over-the-counter medications as needed (eg, nonsteroidal anti-inflammatory drugs [NSAIDs]) if they could not tolerate their pain. TMD assessments were performed by the same operator (A.M.) at all time points.

FL-A Protocol

After the first TMD consultation, an operator (A.M.) administered FL-A for the initial management of chronic TMD myalgia. The operator followed a standardized checklist to ensure that all components of the FL-A were thoroughly discussed with the patient. The treatment was discussed chairside in a private consultation room in the clinic. FL-A included patient education, self-monitoring, avoidance of oral behaviors, and self-administered physical therapy.[25] The main aim of FL-A was to allow healing and prevention of further injury to the musculoskeletal system and to directly involve patients in their TMD management.

Patient education.

Education, also defined as behavioral therapy or counseling, is recommended as the first conservative approach for the treatment of patients with TMD.[19,25] First, all patients received extensive information on normal jaw muscle function, the suspected etiology of their pain, and reassurance of its benign character and its limited consequences. Then, they were provided with specific information on the role of oral behaviors in TMD and were instructed to monitor and avoid oral behaviors. Specifically, patients were told to avoid excessive mandibular movements and oral habits such as clenching/grinding teeth; biting/chewing/playing with the tongue, cheeks, or lips; holding objects between the teeth; or biting the fingernails. They were invited to keep their masticatory muscles relaxed by holding the mandible in a postural position with teeth apart rather than in occlusion (as this jaw position determines "unintentional" muscle contraction) throughout the day. Other strategies to relax jaw musculature were further discussed, such as pronouncing the letter "N" several times to reduce jaw muscle activation or placing the tongue behind the maxillary incisor teeth with the lips in slight contact. Furthermore, patients were recommended to use sticky notes at home or at their workplace as a visual feedback to remind them to control the position of their jaws and teeth throughout the day and to avoid sustained tooth-to-tooth contact. Patients were informed that oral habits do not improve spontaneously and that the patient's role in controlling them is fundamental to reducing TMD pain. Finally, patients were asked to avoid hard food, cut hard food into small pieces, chew with the back teeth on both sides, and avoid chewing gum.

Home-exercise regimen.

There is evidence that physical therapy is effective for the rehabilitation of patients affected by TMD pain and restricted motion[19–24] via reducing inflammation, improving muscle activity and jaw range of motion, and promoting the repair and regeneration of tissue. Patients were invited to perform relaxation exercises with diaphragmatic breathing, self-massage of the masticatory muscles, stretching and coordination exercises, and application of moist heat pads on the painful muscles during the day.

Diaphragmatic breathing was prescribed for at least three times/day. Patients were instructed to place one hand on their upper chest and the other on their belly, below the ribcage, and to inhale slowly and deeply through their nose. They were instructed to tighten their abdominal muscles as they exhaled with pursed lips.

Self-massage of painful masseter and/or temporalis muscles was prescribed for at least three times/day. Patients were informed that the more frequently they massaged their muscles of mastication, the better the effect on their muscles would be. Detailed instructions were given to patients. The masseter had to be massaged for at least 1 minute by slight rolling movements performed with the index, middle, and ring fingers positioned extraorally on the cheek above the masseter muscle and the thumb positioned intraorally, exerting a counterpressure during massage. The masseter also had to be strained by pulling the thumb laterally starting from its origin on the zygomatic arch up to the insertion on the mandibular angle. Each masseter had to be massaged by the contralateral hand. The temporal muscles were massaged by slight circular movements made with the ipsilateral index, middle, and ring fingers or by pressing with one fingertip on the painful area.

Stretching exercises for the masseter and temporalis were administered to patients with myofascial pain with limited mouth opening. Patients were invited to open their mouth until they experienced an initial pain sensation (painful unassisted maximal mouth opening) and to position their thumbs on the maxillary arch and their index fingers on the mandibular arch. Then, they had to exert pressure with their fingers on both dental arches and stretch the musculature. This exercise had to be performed each day, every 2 hours, holding the mandible stretched for 1 minute (six repetitions). If they wanted to avoid contact between their fingers and mouth, patients could also perform this stretching exercise by using tongue depressors piled together between the maxilla and mandible. In this case, patients had to open their mouth wide, insert the pile in their mouth, and actively open their mouth in order not to touch the piled tongue depressors with their teeth. They were further instructed to add one tongue depressor (about 1 mm thick) each following day. The initial height of the pile was determined by the clinician (A.M.) and corresponded to the patient's painful unassisted maximal mouth opening.

Coordination exercises were performed by patients three times/day. They were asked to slowly open and close their mouth 20 times with their index finger placed on the lateral pole of the TMJs. They had to control the mandibular excursion while opening and maintain the mandibular dental midline parallel to a vertical line traced on a mirror.

Thermal modalities, including the use of moist heat and/or cold pads on the painful areas, depending on the diagnosis, were also prescribed. For instance, cold packs and massage were prescribed to reduce swelling and to improve mandibular range of motion. Patients could obtain a cold pack by wrapping some ice in a cloth and positioning it on the painful area for 10 minutes once a day. Application of heat (40°C to 50°C) pads for 20 minutes once per day was recommended to improve blood flow to fatigued muscles. Patients were suggested to use a wet towel, microwave it for a few seconds until warm, and then to wrap it around a bottle with hot water.

FL-A was reviewed through verbal reinforcement given during the successive face-to-face follow-up visits to ensure comprehension and adherence. Patient compliance with the FL-A was measured at both T1 and T2 using a 100-mm visual analog scale (VAS: Were you compliant with the self-management strategies discussed with your health care provider at your first appointment?, with anchors "not compliant at all" and "extremely compliant"). The operator (A.M.) reviewed and verbally reinforced the therapy based on the FL-A at each follow-up visit.

Questionnaires

To evaluate pain intensity at each time point, patients were asked to complete the Graded Chronic Pain Scale (GCPS),[1,27] which includes 8 questions assessing the current, worst, and average pain intensity in the previous 30 days and measures the interference of pain on usual, daily recreational, social, and family activities on 0–10 numeric rating scales (anchors, respectively: "no pain" and "pain as bad as could be"; "no interference" and "unable to carry on any activities)." These scores are used to compute the Characteristic Pain Intensity (CPI) and the GCPS grade, which is a categorical measure including 4 levels. The CPI can range between 0 and 100 and is the average of the current facial pain, the worst pain intensity in the last 30 days, and the average pain in the last 30 days, multiplied by 10. GCPS categories are grade I = low-intensity pain without disability; grade II = high-intensity pain without disability; grade III = moderately limiting; and grade IV = severely limiting.

The frequency of self-reported oral behaviors at baseline was measured using the Oral Behaviors Checklist (OBC),[28] which includes 21 items assessing awareness and the self-reported frequency of oral behaviors. The reliability and validity of the OBC in detecting waking-state oral parafunctions has been previously demonstrated.[29,30] This instrument asks the patient to report the daily frequency for each oral behavior listed in the questionnaire by choosing from among the following response options: none of the time; a little of the time; some of the time; most of the time; or all of the time. A score from 0 to 4 is assigned to each answer.

Other than computing the total OBC score for each subject, a partial score (OBC6)[18,29] was calculated by summing the OBC items 3, 4, 5, 10, 12, and 13 (item 3: grinding teeth together during waking hours; item 4: clenching teeth together during waking hours; item 5: pressing, touching, or holding teeth together other than eating; item 10: biting, chewing, or playing with tongue, cheeks, or lips; item 12: holding objects between teeth or biting objects such as hair, pipe, pencils, pens, and/or fingers; item 13: use of chewing gum). The rationale for using these items was that these oral activities are characterized by pressing attitudes against soft tissues, objects, or teeth, and may account for oral behaviors involving repetitive tooth-to-tooth contact and clenching.

Trait anxiety was measured using the State-Trait Anxiety Inventory (STAI), which includes 20 items for assessing state anxiety and 20 for assessing trait anxiety.[16] State anxiety includes constructs such as "I feel calm," "I feel secure," "I feel comfortable," and "I feel nervous." Participants reported how they felt at the moment of assessment by choosing from among the following options: not at all; somewhat;

moderately so; or very much so. Each answer is ranked as a score from 1 to 4. Trait anxiety includes constructs such as "I feel pleasant," "I feel nervous and restless," and "I feel like a failure." For the assessment of trait anxiety, participants report how they generally feel by choosing from among the following options: almost never; sometimes; often; or almost always. Each answer is ranked as a score from 1 to 4. For the purposes of this study, only trait anxiety scores were collected.

EMG Recording and Signal Processing

Before the first consultation (T0) and after 1 month (T1), before the follow-up visit, an operator (V.D.) recorded the EMG activity in the right masseter for 20 minutes using a portable EMG device (Bruxoff, Spes Medica). Although this device is commonly used to measure and score sleep bruxism via specialized software,[31] it also allows for recording standard EMG signals in the masticatory muscles during daytime, as done in a previous study by the same authors.[8] Notably, the use of a portable system allows for the reduction of participants' discomfort during recordings.

All participants were asked to sit on a chair, with their head unsupported. Chewing gum, food, and drinks were not allowed. Participants were asked to abstain from energy drinks or caffeinated drinks within 12 hours preceding the EMG recording and not to talk during the actual recording. The participant's right cheek was cleaned and slightly abraded with an abrasive gel (Everi, Spes Medica, Genova, Italy) to diminish impedance, allowing the conductive paste to adequately moisten the skin's surface. Then, a disposable bipolar self-adhesive concentric electrode (CoDe 2.0, Spes Medica) with a radius of 2 cm and a silver/silver chloride surface was applied to the right masseter. The electrode was placed along a line going from the mandibular angle to the cantus, about 20 mm above the mandibular angle,[32] and recording was performed 5 to 6 minutes later. The concentric ring systems of the electrodes have more spatial selectivity than the traditional systems and reduce the problem of electrode location because they are insensitive to rotations. Facial photographs of participants with the EMG electrode in place and templates were collected at baseline to ensure that the position of the electrode could be replicated at each time point. The reference electrode was placed on the middle point of the clavicle. The EMG signals were sampled at 800 Hz, bandpass filtered between 10 and 400 Hz, and stored in the device. The EMG device was tested while the participants were invited to perform some activities, such as swallowing, touching electrodes, and shaking their head.

Once the EMG equipment was set up, participants were asked to clench at their maximum voluntary contraction (MVC) in maximum intercuspal position, about three times, each lasting 3 seconds, separated by two 5-second intervals, during which they were invited to relax their jaw muscles as much as possible. Verbal encouragement was provided during the MVC task. The determination of the average EMG amplitude of the three MVC tests served to transform and standardize the EMG signals. During the MVC task, participants were asked to keep their head still. Thereafter, the EMG activity in the right masseter was recorded for 20 minutes while the participant waited to be seen by the clinician (A.M). for the TMD assessment. During the EMG recording sessions, participants were monitored by a single operator (V.D.) who recorded activities that could have led to movement artifacts (eg, touching electrodes, coughing, and head movements).

The EMG signals of each participant were processed using the OT BioLab software (OT Bioelettronica) to identify spontaneous wake-time tooth-clenching episodes during the experiment and to determine whether their amplitude and duration were different between time points. EMG data were processed as described in previous reports.[8,13,17,33] First, to ensure that the EMG signals were not affected by the transition to the experimental task, the first minute of the EMG recording was removed. Root mean square (RMS) values were computed via software. For each participant, an offset was computed using the average EMG activity during the two 5-second breaks (maximum relaxation) of the MVC task. This value was subtracted from the entire EMG signal. Thereafter, the average RMS (expressed in μV) of the three clenching tests during the MVC task was calculated and set to 100% MVC. A scaling factor was computed to convert the entire EMG signal from μV into % MVC. This procedure served to standardize the EMG signals recorded during the reading task and to reduce the effect of noise on the EMG recording. Therefore, each transformed EMG signal (% MVC) expressed the level of motor effort of the right masseter relative to each participant's MVC during the experimental EMG recording. The EMG signals were examined by two operators (V.D. and I.C.). EMG artifacts were identified and manually removed.

The primary outcome measures of the EMG analysis were as follows:

- EMGtotal (% MVC): the motor effort of the right masseter during the experiment relative to each participant's MVC
- EMGbruxism (% MVC): the motor effort of the right masseter during spontaneous

tooth-clenching episodes relative to each participant's MVC
- Frequency and duration of spontaneous tooth-clenching episodes

EMGtotal was measured by including the entire transformed EMG signal (% MVC) of the right masseter in the statistical model. EMGbruxism included the transformed EMG signals of those muscle contractions (ie, tooth-clenching episodes), with EMG amplitude ≥ 10% MVC lasting at least 0.5 seconds, as done previously.[8,13,17,33] These episodes were identified and counted. Their duration and their cumulative duration (seconds) were measured in each participant using BioLab software.

Pressure Pain Thresholds

PPTs were measured with a real-time feedback electronic pressure algometer (Somedic), with a rubber tip measuring 1 cm^2, at the superficial masseter and anterior temporalis muscles, bilaterally. For the masseter, PPTs were measured halfway between the origin and the insertion of the muscle and 1 cm posterior to its anterior boundary. For the temporalis, PPTs were measured on the line from the top edge of the eyebrow to the highest point of the pinna of the ear and 2 cm behind the anterior margin of the muscle. A single trained operator (V.D.) placed the algometer tip on the respective site and applied pressure at a rate of approximately 30 kPa/second using visual feedback. The participant indicated the PPT—the minimum pressure exerting pain—by pressing a button, which froze the current pressure value on the digital display. The procedure was explained to the subject, who was invited to keep the muscles relaxed during the recordings. The measurements were repeated for a total of four trials at each muscle, with a 1-minute interval between trials, as done previously.[13,29,34] The order of measurements was randomized across subjects. While assessing the PPT at masticatory muscle locations, the subject's head was supported by counterpressure from the opposite hand of the operator. PPTs were measured by the same operator (V.D.) at all time points.

Statistical Analysis

Values were reported as mean ± SD for normally distributed data, and as medians and interquartile ranges for not normally distributed data. A mixed-effects model was used to test differences in EMGtotal and EMGbruxism between T0 and T1. Differences in frequency, duration, and cumulative duration of spontaneous wake-time tooth-clenching episodes were tested using Wilcoxon signed-rank test. General linear models were used to test differences in current pain (CGPS questionnaire, question 2), compliance self-reports, and PPTs between time points (T0, T1, T2). For PPTs, natural logarithmically transformed data were included in the model, as residuals were not normally distributed. Time point, muscle site, and the interaction time point*muscle site were included as fixed factors. Correlations between variables were tested using Pearson or Spearman method, based on whether the data were normally or not normally distributed. Post hoc comparisons were adjusted using Bonferroni method.

A minimum sample size of 12 participants was required to obtain 80% power with a medium to large effect size (d = 0.8, α = .05). SPSS software (version 24, IBM) was used for all statistical analyses. Statistical significance was set at $P < .05$. The statistical analysis was conducted with the operator (I.C.) blinded (dataset masking) to the time point.

Results

A total of 118 women > 18 years of age with a complaint of facial pain were screened between January and July 2018. Of these patients, 72 underwent a full clinical examination, as they had a TMD Pain Screener score ≥ 3, and 45 of these patients had TMD myalgia for more than 6 months. Eighteen refused to participate in the study, and 11 among those who agreed to participate in the research did not attend the follow-up appointments for personal reasons (dropouts). Therefore, 16 women participated in the longitudinal evaluation and were recruited for the study. Two subjects were excluded from the analysis for technical reasons. The final sample included 14 women (mean age ± SD = 33.8 ± 11.1 years; range: 22 to 55 years) with chronic mTMD. All participants completed each component of the study.

Patient Characteristics at Baseline

Baseline characteristics of the research participants are reported in Table 1. Participants had pain for 3.0 ± 1.8 years (range: 8 months to 6 years). According to the GCPS, participants reported to have had facial pain for 63 ± 51 days (range: 15 to 180 days) in the last 6 months, and their current facial pain on a numeric rating scale (NRS; 0 = no pain, 10 = pain as bad as could be) was 4.6 ± 2.1 (range: 1 to 7). Their average pain in the last 30 days was 5.9 ± 1.8 (range: 3 to 8). CPI was 48.7 ± 19.4 (range: 20 to 70). Eight individuals had GCPS grade I (low-intensity pain without disability), and six had GCPS grade II (high-intensity pain without disability).

Mean ± SD OBC and OBC6 scores were 36.3 ± 10.1 (range: 22 to 58) and 11.2 ± 3.8 (range: 6 to 18), respectively. Trait anxiety according to the STAI

Table 1 Clinical Characteristics of the Study Participants at Baseline

Patient no.	Sex	Age, y	Pain duration	NRS pain intensity (0–10)	GCPS grade (I–IV)	Diagnosis (DC/TMD)	Pain sites	Pain comorbidities	Medications
1	F	26	4 y	4	I	Myalgia; headache attributed to TMD	RM, LM, LT	–	NSAIDs (patches)
2	F	55	1 y	7	II	Myalgia	LM	–	–
3	F	23	NR	4	I	Myalgia; headache attributed to TMD	RT, LT	–	–
4	F	40	4 y	3	II	Myalgia; arthralgia; headache attributed to TMD	RM, LM, RT, LT, RTMJ, LTMJ	Shoulder, neck, knee	NSAIDs (oral tablets), cortisone
5	F	36	6 y	7	II	Myalgia; headache attributed to TMD	RT, LT	–	NSAIDs (oral tablets)
6	F	22	1 y	2	I	Myalgia	RM	–	–
7	F	29	3 y	4	I	Myalgia; arthralgia; headache attributed to TMD	RM, LM, RT, LT, RTMJ, LTMJ	–	–
8	F	30	4 y	5	I	Myalgia; headache attributed to TMD	RM, LM, RT, LT	Neck	NSAIDs (oral tablets)
9	F	23	2 y	2	I	Myalgia	RM, LM	–	–
10	F	29	6 y	7	II	Myalgia; headache attributed to TMD	RM, LM, RT, RTMJ, LTMJ	Neck	NSAIDs (oral tablets)
11	F	25	1 y	1	I	Myalgia; arthralgia	RM, LM, LTMJ	–	–
12	F	45	2 y	4	I	Myalgia; headache attributed to TMD	RM, LM, RT, LT	–	–
13	F	27	8 mo	7	II	Myalgia; headache attributed to TMD	RM, LM, RT, LT	–	–
14	F	53	5 y	7	II	Myalgia	RM, RT	Neck, shoulder	NSAIDs (oral tablets)

LM = left masseter; LT = left anterior temporalis; LTMJ = left temporomandibular joint; RM = right masseter; RT = right anterior temporalis; RTMJ = right temporomandibular joint; GCPS = Graded Chronic Pain Scale; NR = not reported. Information about medications was collected during the first clinical examination and refers to the period before the study.

was 46.6 ± 7.3 (range: 37 to 60). Patients' pain at T0 was significantly correlated with the OBC6 measured at the same time point (r = 0.573, P = .016), but not with the OBC (r = 0.055, P = .445) or trait anxiety (r = −0.159, P = .294).

The FL-A contributed to a reduction in TMD pain and masticatory muscle activity, as well as an increase in PPTs.

Pain Intensity

Compliance with FL-A was reported to be good at both T1 (76.8 ± 11.5 mm) and T2 (63.6 ± 21.7 mm) by research participants and did not differ significantly between time points (P = .502). Pain trajectories before and after FL-A are reported in Fig 2. Current pain intensity decreased significantly from T0 to T2 (contrast estimate 2.31; 95% CI: 0.46 to 4.11; P = .010). There was no statistically significant difference between T0 and T1 (P = .129), or between T1 and T2 (P = 1.0).

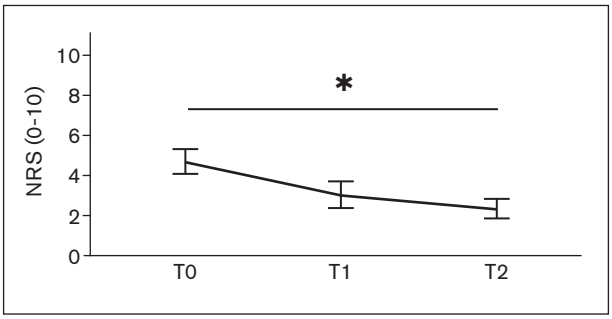

Fig 2 Mean ± SEM pain trajectories from baseline (T0) to the follow-up visits after 1 month (T1) and 2 months (T2). NRS = numeric rating scale (answer to question #2 of the Graded Chronic Pain Scale, version 2.0: How would you rate your facial pain RIGHT NOW?, with response options 0 = no pain to 10 = pain as bad as could be). *Statistically significant (P < .05).

Pressure Pain Thresholds

PPT trajectories over time are reported in Fig 3. Results of the general linear model are reported in Table 2. PPTs changed significantly over time (F = 9.311, P < .001) and were different across muscle sites (F = 26.850, P < .001). There was no significant effect of the interaction for site*time point on PPT outcomes (F = 0.393, P = .923). PPTs

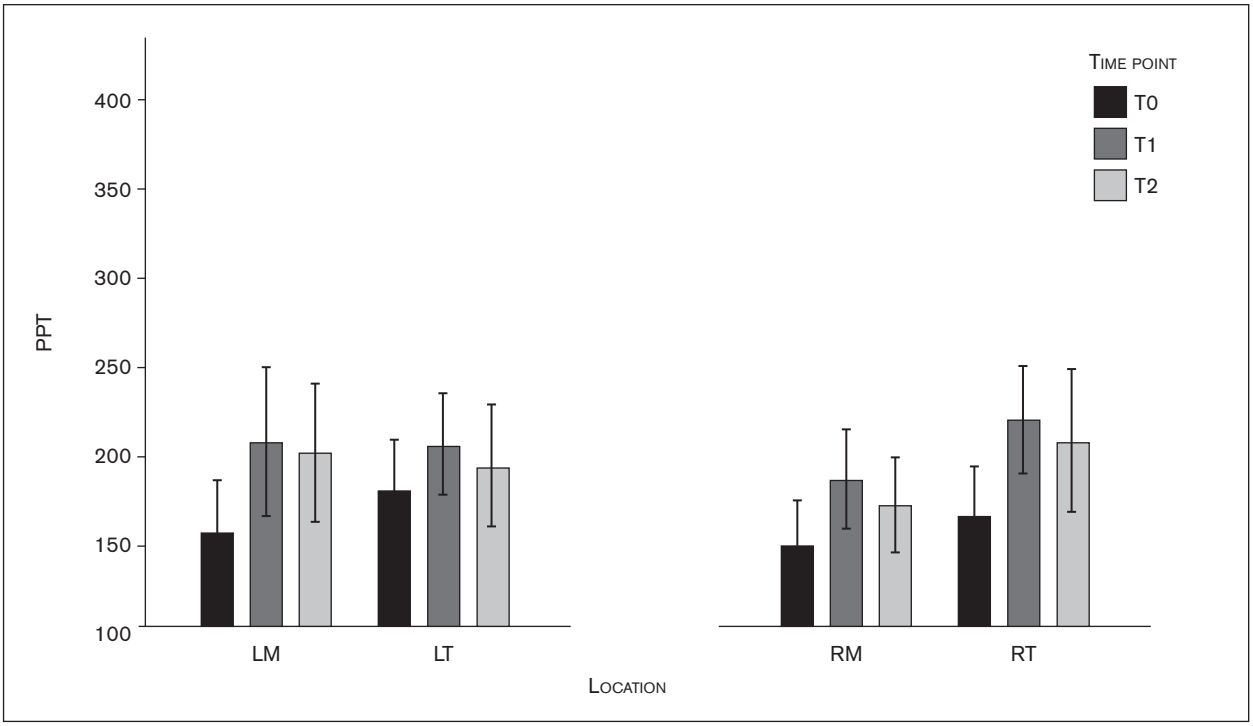

Fig 3 Mean ± SEM pressure pain threshold (PPT; kPa) trajectories from baseline (T0) to the follow-up visits after 1 month (T1) and 2 months (T2). LM = left superficial masseter; LT = left anterior temporalis; RM = right superficial masseter; RT = right anterior temporalis.

Table 2 Effect of FL-A on Pressure Pain Thresholds Trajectories

	DF	F value	*P* value	Partial η2	Observed power
Time point	2	9.311	< .001	0.096	0.976
Muscle site	4	26.850	< .001	0.380	1.000
Time point*muscle site	8	0.393	.923	0.018	0.183

Results from the general linear model. Dependent variable: pressure pain threshold (logarithmically transformed data). Fixed factors: Time point (T0, T1, T2), muscle site, and interaction time point*muscle site.

increased significantly from T0 to T1 (contrast estimate/log-transformed data: 0.229, 95% CI: 0.092 to 0.365, $P < .001$), and from T0 to T2 (contrast estimate: 0.163, 95% CI: 0.038 to 0.288, $P < .001$). No differences were found between T1 and T2 (contrast estimate: 0.066, 95% CI: −0.071 to 0.202, $P > .001$).

Masseter EMG Activity

FL-A contributed to reducing masseter EMG activity by about 30% (all $P < .001$). EMGtotal decreased significantly from T0 (mean ± SEM = 1.51% ± 0.29% MVC) to T1 (0.98% ± 0.29% MVC; contrast estimate: 0.50% ± 0.05% MVC; 95% CI: 0.44 to 0.62; $P < .001$). EMGbruxism decreased significantly from T0 (mean ± SEM = 28.26% ± 2.43% MVC) to T1 (20.32% ± 2.60% MVC; contrast estimate: 8.04% ± 1.42% MVC; 95% CI: 5.25 to 10.84; $P < .001$). The frequency of spontaneous tooth-clenching episodes decreased significantly from T0 (median [IQR]: 23 [31.25]) to T1 (9 [17.50]; $P = .024$). The duration of spontaneous tooth-clenching episodes was not affected by FL-A (T0: 0.5 [0.5] seconds, T1: 0.5 [0.5] seconds; $P = .333$). Similarly, the cumulative duration of tooth-clenching episodes (total time spent while clenching) was not statistically different between T0 (26.2 [46] seconds) and T1 (10 [29] seconds; $P = .434$). Only four subjects (#ID 4, 5, 10, 14; Table 1) reported to have taken NSAIDs (oral tablets/once a week) during the first month of observation.

Trait Anxiety

Participants' trait anxiety decreased significantly from T0 (49.64 ± 7.3) to T2 (42.64 ± 5.6; contrast esti-

mate 7.00; 95% CI: 0.52 to 13.48; P = .030). No differences were found between T0 and T1 (45.64 ± 7.5; P = .391) or between T1 and T2 (P = .761). Trait anxiety measured at baseline (T0) was not correlated with relative changes in pain (T2–T0; r = 1.00, P = .248).

Discussion

This study measured the short-term effects of a standardized FL-A including counseling and self-management strategies on spontaneous pain, masticatory muscle tenderness, and awake bruxism in patients with chronic mTMD. It was hypothesized that FL-A would contribute to reducing TMD pain intensity, increasing PPTs at masticatory muscle locations, and reducing the EMG amplitude and frequency of spontaneous wake-time tooth-clenching episodes. It was further hypothesized that patients' trait anxiety levels would predict response to treatment. To the best of the authors' knowledge, this is the first study testing the effects of a standardized and structured FL-A on both facial TMD pain and spontaneous awake bruxism episodes in a sample of individuals with chronic TMD myalgia using a multimodal approach including behavioral and electrophysiologic measurements and quantitative sensory testing (ie, PPT). All outcomes were consistent and clearly indicated that FL-A was effective in improving clinically relevant outcomes in the short term in patients with chronic mTMD and low disability.

It was found that FL-A contributed to reducing masticatory muscle activity and pain and increasing PPTs in the short term (ie, within 2 months). The reduction of pain after FL-A is consistent with a clinical trial conducted in a sample of 26 women that proved the effectiveness of counseling on TMD symptoms and pain after 7 and 60 days.[35] Moreover, the results of the present study confirm those of a previous randomized controlled trial that evaluated the effect of an 8-week protocol of local endurance exercises of masticatory muscles on perceived pain and muscular fatigue assessed through visual analog scales (VAS), PPTs, and surface EMG. In agreement with the findings of the present study, the therapy administered to 23 women with chronic TMD pain determined a reduction of VAS scores and an increase in PPT values over time. Moreover, it improved muscle fatigue and efficiency, as shown by EMG recordings.[36] However, differently from the present study, EMG characteristics of spontaneous awake bruxism episodes were not evaluated, and the sample was recruited by public invitation and not from among subjects seeking treatment.

The second main outcome of the present investigation was that FL-A contributed to reducing both the intensity and frequency of spontaneous awake bruxism episodes, and that participants' trait anxiety decreased significantly after FL-A. Therefore, strategies that aim to induce relaxation and reduce anxiety, such as FL-A, can modulate muscular effort and clenching episodes in subjects with chronic painful TMD. As all participants responded well to FL-A and were compliant with the instructions provided by the operator, it is likely that they were successful in controlling their jaw posture and musculature, thereby significantly reducing the intensity and frequency of spontaneous awake bruxism episodes. However, it is also possible that modulation of trait anxiety with self-relaxation techniques included in the FL-A protocol contributed to reducing pain and the intensity and frequency of awake bruxism episodes, similar to a recent study where relaxing music decreased the intensity of awake bruxism episodes in individuals with chronic mTMD.[13] Yet, the neural mechanisms responsible for such effects are difficult to pinpoint. It is known that anxiety is associated with a state of arousal and increased activation of the sympathetic system, which in turn can affect motor responses. Of note, trait anxiety is positively correlated with somatosensory amplification,[18] the tendency to amplify somatic sensations,[37,38] which increases pain sensitivity at masticatory muscle locations.[34,39] Recently, it was demonstrated that the central amygdala—a nucleus of the amygdala, a brain region that plays a central role in responses to stressful situations and is involved in pain processing[40,41]—is functionally connected with the trigeminal motor nuclei in the brainstem in rodents.[42] Of note, trait anxiety predicts individual differences in the structural integrity of the amygdala in humans.[43] Therefore, it is possible that the amygdala may play a major role in the modulation of jaw motor activity and oral behaviors in individuals with TMD pain. However, future studies are needed to test this hypothesis. Of interest, baseline trait anxiety scores were not correlated with relative changes in pain after 2 months, which suggests that patients' trait anxiety levels before treatment may not help predict patient response to FL-A.

Although the present study clearly indicates that FL-A is effective in managing symptoms in chronic mTMD patients with low disability in the short term, over half of general practitioners usually perform occlusal adjustments to treat TMD-related pain, despite their irreversibility and uncertainty of effectiveness, or use occlusal appliances in their clinical routines.[44] As in other musculoskeletal conditions, chronic TMD should be initially managed with conservative strategies[45] aimed at improving jaw mobility, blood perfusion to the muscles of mastication, and

reducing load to the muscles and joints. The lack of confidence concerning TMD diagnostics and therapeutic decisions may explain, at least in part, such a different approach, where less conservative treatments are prioritized.[46] Notably, FL-A can be administered to the majority of TMD patients at a first glance, given its conservative nature and high and immediate impact. Of importance, FL-A can be administered by general practitioners and not necessarily by pain specialists. Nevertheless, more individualized and less conservative treatment approaches (eg, use of muscle relaxants and/or occlusal devices) could be prescribed after FL-A in patients who do not improve significantly, unless the clinical evaluation indicates that those treatments must be prioritized. However, patients presenting with complex conditions including several comorbidities may require more specific pharmacologic treatments targeting the central nervous system and an interprofessional approach. Indeed, chronic TMD may be associated with structural and functional abnormalities in the central and peripheral nervous system, which may indicate maladaptive nociplastic changes and be responsible for generalized disruption in pain processing.[47,48] In fact, many patients affected with chronic TMD pain present with several comorbidities[49] and may require more personalized pharmacologic treatment and an interprofessional approach compared to individuals without comorbidities. Of importance, wide implementation of FL-A in the dental community, also via telehealth, could help reduce unnecessary waitlists and improve access to care for those in need of an orofacial pain specialist consultation. This aspect could be particularly relevant to reduce burden to health care services during the COVID-19 pandemic, which has worsened the incidence of oral behaviors and facial pain.[50,51]

There are some limitations of this study. The study sample included women with TMD and GCPS grade I or II, which may not be representative of patients with more complex conditions, and investigated the effect of FL-A in the short term. Therefore, although it may be hypothesized that this treatment approach might benefit most patients with mTMD, it cannot be determined whether FL-A could resolve the condition in the long term or benefit patients with more complex conditions; ie, those associated with high pain-related disability. Also, only women, who are more frequently affected by TMD than men,[49] were recruited in the present study. Therefore, it is not possible to draw conclusions on the effectiveness of this approach in male individuals, which could be addressed in future studies. Of note, an untreated control group or a group submitted to a different intervention were not included. As the treatment modality tested in this study has been recommended as a first-line/first-step treatment approach for TMD via a Delphi Consensus,[19] and the present study included individuals in pain who were seeking a TMD consultation, the allocation of some of these individuals to an untreated control group would have been ethically questionable. Therefore, it was not pursued in this study. Moreover, as only individuals seeking a TMD consultation were recruited in this study, improvement in pain following FL-A may have also been determined by nonspecific effects of treatment (eg, placebo effect leading to positive expectations) or regression to the mean. Also, four subjects reported having taken NSAIDs (oral tablets/once a week) during the first month of observation. Because of the limited sample of individuals taking NSAIDs and the limited total sample of 14 participants, a statistical analysis to compare whether individuals who used NSAIDs responded better to the FL-A protocol was not performed. However, since current pain intensity had decreased significantly only at the 2-month follow-up, it is unlikely that NSAID intake would have acted as a potential confounder during the study.

Additionally, the EMG recording period was relatively short (20 minutes). Therefore, only a limited number of spontaneous tooth-clenching episodes were identified and recorded. In addition, it may be argued that the analysis of tooth-clenching episodes may have been affected by the frequency of swallowing. Swallowing leads to an activation of the masseter ranging between 3% and 7% MVC,[52] which is below the threshold set to identify spontaneous tooth-clenching episodes ($\geq$ 10% MVC) in this investigation. In addition, participants had their heads unsupported during the EMG recording session and were asked to keep their head still. Any major head movement was noted by the operator in the room to detect potential movement artifacts during EMG signal postprocessing. However, minor head movements could have occurred, as the participants' heads were not restrained using a craniostat. Nevertheless, it is unlikely that these movements had significant effects on the masseter EMG readings. Also, the use of a craniostat could have significantly impacted the occurrence of spontaneous jaw motor activities.

Finally, %MVC was used as a relative measure of muscle contraction, as done in previous investigations,[8,13,33,53] as there is evidence that the EMG activity recorded from the muscles of mastication is dependent on several factors, such as dentofacial morphology,[54] dental malocclusions,[55] and even minor occlusal discrepancies.[56] By computing standardized %MVC for each participant, it is possible to reduce the potential impact of all of these interindividual variations on the overall EMG analysis. However, %MVC is an estimate of the masseter motor activity relative to the participant's MVC and cannot be

interpreted as an absolute measure of the electrical activity of the muscle. Finally, the present study relied on patients' self-reports to measure their compliance with FL-A. The use of ecological momentary assessment via mobile apps may have increased the precision of such measurements.

Conclusions

This study has shown that an FL-A for the management of TMD including counseling and self-management strategies (self-relaxation, self-monitoring of adverse oral behaviors, massage, and jaw exercise) is effective in improving pain and reducing the intensity and frequency of awake bruxism episodes in women with chronic TMD myalgia and limited pain-related disability in the short term. Given its high impact, this conservative approach should be prioritized in individuals with such conditions unless the clinical assessment suggests that less conservative pain management strategies should be prioritized. In general, less conservative procedures should be reserved for individuals who do not respond well to FL-A and/or who present with more complex conditions associated with high pain-related disability.

Highlights

- General practitioners could implement the conservative FL-A protocol described in this study for initial management of patients with mTMD and low pain-related disability, at least in the short term.
- Less conservative procedures for the initial management of chronic mTMD should be reserved for patients who do not respond well to FL-A or present with complex conditions or severe TMD-related disability.

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