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Original paper

Kinesio Taping as an alternative therapy for limited mandibular mobility with pain in female patients with temporomandibular disorders: A randomized controlled trial

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Abstract

Background. Kinesio Taping (KT) is a non-invasive therapy commonly used in physiotherapy (PT). However, the available data on its effectiveness in patients with symptomatic temporomandibular disorders (TMD) remains scarce and contradictory.

Objectives. The aim of the study was to evaluate the analgesic and myorelaxant effects of KT in TMD patients with limited mandibular mobility.

Material and methods. A single-blind randomized controlled trial was conducted among female patients aged 20–45 years with Diagnostic Criteria for Temporomandibular Disorders (DC/TMD) group Ib, using a parallel group design and equal randomization (1:1). All patients underwent surface electromyography (sEMG) of the masseter muscle (MAS), pain intensity was assessed using a Numeric Rating Scale (NRS), and temporomandibular joint mobility was measured before and after 6 and 12 days of treatment. The Perceived Stress Scale (PSS-10) questionnaire was administered on the first and last days of treatment. Statistical analysis was performed using analysis of variance (ANOVA). Mauchly's sphericity test determined changes over time and between groups for variables with a normal distribution. Bonferroni's correction was used for post hoc multiple comparisons. Variables with a non-normal distribution were analyzed using the nparLD package and multiple comparison post hoc test, while correlations were assessed using Spearman's coefficient.

Results. Each treatment had a significant effect on the bioelectrical sEMG parameters ($p = 0.05$). Kinesio Taping had a superior analgesic effect compared to the controls ($p < 0.001$). The combination of KT with therapeutic exercise (TE) proved to be a more effective therapy for improving the maximal mouth opening (MMO) and reducing perceived stress than monotherapy ($p < 0.001$). Minimally significant clinical differences were observed for sEMG, MMO and PSS-10 parameters after both therapies.

Conclusions. Kinesio Taping combined with TE may be considered an effective complementary non-invasive treatment modality for TMD, either as a stand-alone or as part of the therapeutic process in patients experiencing pain and limited mandibular ROM. Additionally, the use of KT and TE was found to have a beneficial effect on perceived stress levels.

Keywords: physiotherapy, Kinesio Taping, electromyography, temporomandibular joint, orofacial pain

Introduction

The etiology of temporomandibular disorders (TMD) is considered multifactorial and continues to be under increased scrutiny by researchers and orofacial pain clinicians. Various factors, including stress, genetic determinants, occlusal factors, and environmental factors (especially psychoemotional and psychosocial factors), have been identified as common causes of TMD.[1–3] The clinical manifestations of TMD can be both subjective and objective. The most common symptoms include decreased mandibular range of motion (ROM), pain in the masticatory muscles and/or temporomandibular joints (TMJs), joint clicking, tinnitus, pre-auricular pain, headaches and/or cervical spine pain, and increased head and neck muscle tension.[4,5] According to contemporary scientific findings, chronic myofascial pain accounts for more than 50% of all TMD diagnoses,[6] and the prevalence of TMD is estimated to be greater than 5% of the population.[6] Lipton et al. showed that approx. 6–12% of evaluated patients had 1 or more TMD symptoms.[7] Wieckiewicz et al. conducted research on the Polish population and found that 48.8% of patients were diagnosed with TMJ disorders, with displacement of the intervertebral disc with reduction being the most common (47.9%).[8] The prevalence of TMD patients is highest among those aged between 20 and 40,[9] and women are affected 1.5–2.5 times more often than men.[10]

The latest TMD standards of care highlight the importance of an individualized and multidisciplinary approach to establish a diagnosis and implement treatment as early as possible. This involves the prevention of chronic pain via local sensitization.[11] The patient should be referred early to a therapeutic team, consisting of a dentist with a background in restorative, prosthetics, or orofacial pain, a psychologist and/or psychiatrist if necessary (therapy of psychoemotional disorders of multiple etiology), a physiotherapist (pain reduction, restoration of normal TMJs and cervical spine biomechanics and ROM, and retraining of muscle engrams), and other specialists, based on the reported symptoms, e.g., neurologist, rheumatologist, or ear, nose and throat (ENT) specialist.[12,13]

Numerous studies emphasize the important role of physiotherapy (PT) in the recovery of patients with TMD.[14] Therapeutic modalities that enhance the effects of treatment are increasingly well documented and include physical therapies such as transcutaneous electrical nerve stimulation (TENS) and lasers, manual therapy (manipulation and mobilization, and soft tissue treatments), and therapeutic exercise (TE).[15] A prevalent method in musculoskeletal rehabilitation that has recently been implemented in dentistry is Kinesio Taping (KT).

Kinesio Taping (or elastic therapeutic taping) was developed by Dr. Kenzo Kase in the 1970s as a therapeutic method.[16] The process involves attaching cotton elastic bands to the skin's surface using a hypoallergenic acrylic adhesive.[16] The patches are applied with an initial tension (paper-off tension) of 10–25% and a maximum elasticity of 130–140% of the original length.[17] The tape parameters were designed to mimic human skin and achieve stretchability, greater mobility and adhesion. However, there is limited evidence from peer-reviewed studies on KT. The majority of knowledge on this topic is based on case studies, which may not be sufficient to support its use in contemporary evidence-based medicine. In theory, KT has high therapeutic potential and is thought to facilitate or inhibit muscle function, enable pain-free ROM, improve proprioception, relieve pain, optimize joint alignment, and reduce swelling. Moreover, KT speeds up the healing process and reduces recovery time by decreasing inflammation and pain, increasing blood flow and facilitating neurological rehabilitation.[18–21]

Although KT is widely used in clinical practice, its mechanism of action has not been fully understood.[22] The muscle-fascia chain tension segregation theory, in particular, is the most widely accepted principle.[22] When applied to the skin, KT causes microcoils that increase the subcutaneous space, improve lymphatic fluid and blood flow in the affected area, and stimulate the healing process in the damaged tissues over time.[23] This lays the foundation for the healing process established by KT. The process involves several modalities, such as relieving pressure on the underlying painful or sensitized tissue, creating space for lymphatic fluid movement, improving blood flow, and reducing pain by decreasing pressure on nociceptors.[23] In addition, by modulating muscle tone and stimulating cutaneous receptors, it is possible to restore the complex myofascial function, leading to improved proprioception and increased recruitment of muscle motor units.[24–26] The pain-alleviating effect of KT is believed to be due to the microscopic lifting effect of the skin, which improves lymphatic and blood circulation through stimulation of sensory pathways. Consequently, this process may increase afferent feedback and relieve sensory receptor irritation.[27,28] The effect of dynamic patching also improves self-esteem, as evidenced by numerous studies that highlighted the impact of KT on the patient's psychoemotional state.[29]

Kinesio Taping can be used alone or in combination with other methods to enhance the therapeutic efficacy. Although it was initially used in the field of sports medicine with surprisingly good outcomes, KT is often insufficient to obtain the expected result and is therefore rarely used as a monotherapy in TMD.[30] Currently, its use is more widespread, with KT being employed in various fields of medicine, including orthopedics, traumatology, surgery, neurology, oncology, gynecology, and pediatrics.[17,31]

The annual increase in the number of TMD patients is pushing clinicians to seek new, faster, alternative, and more efficient approaches to managing pain, elevated muscle tension and reduced TMJ mobility. Scientific reports in the field of dentistry indicate that KT is a method used to eliminate pain, particularly within the musculoskeletal system.[32,33] Currently, KT is increasingly used in dental and maxillofacial surgery as a method to assist in postoperative treatment.[34,35] However, a few randomized trials on the efficacy of KT in TMD patients indicate a need to expand this knowledge.[36] Therefore, our goal was to evaluate additional effects, if any, of KT compared to the standard treatment regimen of counseling and self-therapy in TMD patients. We hypothesized that KT will provide additional improvements in pain intensity, changes in bioelectric muscle function, and improved functional mobility in TMD. The use of KT may affect the emotional state of TMD patients, leading to an improvement in well-being by reducing stress levels.

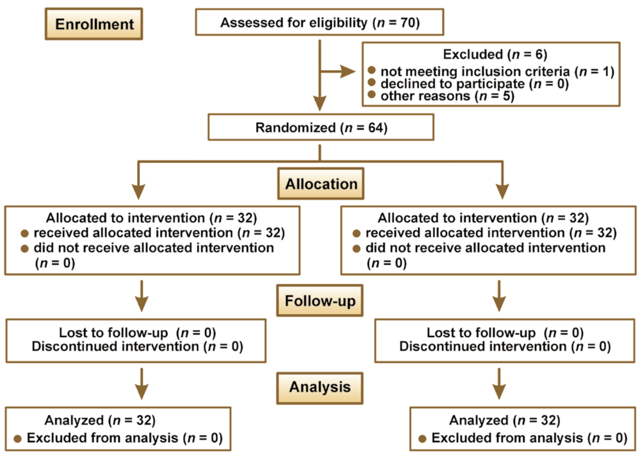

Fig. 1. Consolidated Standards of Reporting Trials (CONSORT)[37] flowchart of the participants' progress through the trial phases

Material and methods

Trial design

This parallel, two-arm, randomized controlled trial with an equal allocation ratio (1:1) followed the Consolidated Standards of Reporting Trials (CONSORT).[37] The study was conducted at the University Dental Clinic of the Pomeranian Medical University in Szczecin, Poland. Participants who met the inclusion criteria were recruited between October 2022 and January 2023. Individuals attended clinic appointments at the time of randomization (baseline), as well as at 6- and 12-day intervals from baseline. Patients were divided into 2 groups in which PT was carried out for 12 weeks (excluding Saturdays and Sundays). All interventions in both study groups were performed free of charge, under the same conditions and by the same physiotherapist. Figure 1 depicts a flowchart of the participants' progress through the trial phases, in accordance with the CONSORT criteria.

The study was approved by the Bioethics Committee of the Pomeranian Medical University in Szczecin (approval No. KB - 0012/102/13). The trial was registered in the ClinicalTrials.gov database (registration No. NCT05021874).

Participants

The study included 64 women (N = 64) between the ages of 20 and 45 years who were diagnosed with myofascial pain with mouth opening restriction for more than 3 months according to the Diagnostic Criteria for TMD (DC/TMD) group Ib. Patients were randomly assigned (simple randomization) to the experimental group (KTG, n = 32, standard deviation (SD) = 9.34) or the control group (CG, n = 32, SD = 8.2).

Study exclusion criteria were inflammation in the oral cavity manifested as myospasm or preventive muscle contraction, previous splint therapy, pharmacotherapy (e.g., oral contraception, hormone replacement therapy and antidepressants), systemic diseases (e.g., rheumatic and metabolic diseases), mental illness, lack of orthopedic stability of the mandible, masticatory organ or whiplash injury, pregnancy, patients undergoing orthodontic treatment, other types of inflammation in the oral cavity (e.g., pulpitis or impacted molars), and fibromyalgia or dermatologic disease.

All women underwent intraoral and extraoral dental examination by a dentist specialized in orofacial pain. The aim was to rule out odontogenic, periodontal and intracapsular origins of TMD pain.

A dentist determined whether the patient met the inclusion criteria based on the patient's history and physical examination. Another dentist was involved in the randomization of the patients.

The individuals qualified for the study underwent instrumental diagnostics, including surface electromyography (sEMG) of the masseter muscle (MAS) at rest and during exercise, and linear measurement of the range of maximal mouth opening (MMO). The intensity of pain was assessed on the Numeric Rating Scale (NRS). These measurements were then performed after the 6th and 12th days of treatment. The Perceived Stress Scale (PSS-10) questionnaire was used to assess the perceived stress levels of all subjects before and after the 12th day of therapy.[38]

Interventions

The KTG received MAS KT, counseling and TE. The CG received counseling and TE. After the 6th and 12th days of treatment, all patients were assessed for MAS sEMG, mandibular ROM and NRS.

During the entire treatment process, most attention was paid to patient cooperation. Therefore, lifestyle counseling and instructions for TE were initially implemented in all subjects (Table 1). Patients were informed about the causes of their dysfunction and how they could self-control their occlusal and non-occlusal oral habits, especially teeth clenching, grinding, gum chewing, and nail biting. The participants were also informed about parafunctional self-management, the pathophysiology of the potential dysfunction, and the influence of their therapeutic interaction on the effectiveness of treatment. A standardized exercise regimen was presented to all subjects, with the application of KT also implemented in the KTG.

Therapeutic exercises (self-therapy)

Each participant was given a paper TE program by the physiotherapist. The program included a description of each exercise and instructions for performing them daily (frequency: 6 times a day, 10 repetitions each) throughout the study period (Table 1).[39]

Application of Kinesio Taping in the experimental group

Certified hypoallergenic 5-cm-wide tapes (K-Active; Nitto Denko Corporation, Osaka, Japan) were used for the study. Before the application of the tape, the patient's skin was cleaned twice with an alcohol-based solution and dried with a paper towel. The KT application was performed by a qualified physiotherapist. The tape was applied over the MAS while the patient was seated with their back stabilized against the back of a chair. The taping technique followed that of Benlidayi et al. for TMJs.[40]

The length of the tape was measured for each patient individually, from the preauricular region to the corner of the nose. The patient was instructed not to clench their teeth or make tooth contact and to relax their facial and neck muscles during the application process. To apply the tape, a Y-shaped patch was used. The therapist warmed the patch by rubbing it 3 times in the palm of their hands to activate the adhesive. Subsequently, the therapist asked the patient to open and close their mouth twice to palpate the TMJs. The bottom (base) of the tape was adhered to the TMJ area with no tension (0%). Then, the upper and lower branches of the patch were attached with approx. 10–15% tension.[40] The application was carried out on the right and left sides of the face (Fig. 2).

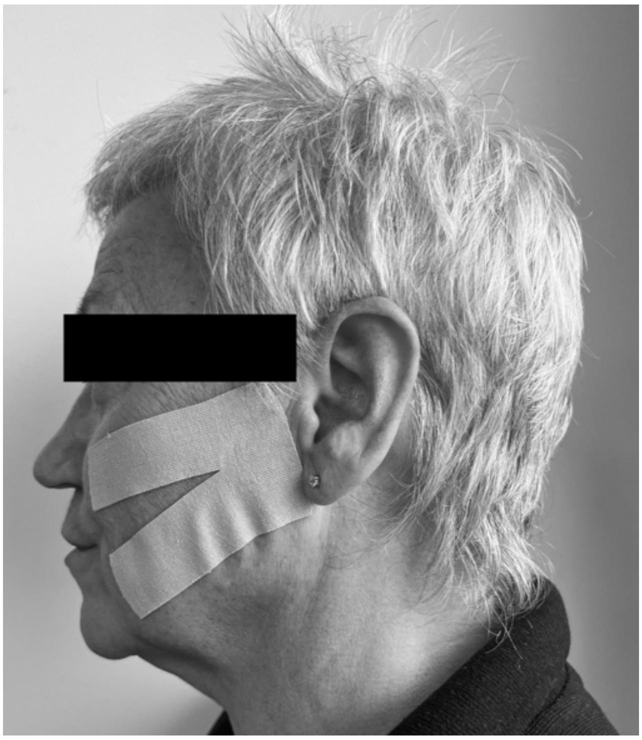

Fig. 2. Application of Kinesio Taping (KT) (own source)

Primary outcome measures

Pain severity scale

The severity of pain was assessed using the NRS in both the KTG and CG after each therapy session. The NRS is a tool used to measure pain intensity on a scale from 0 to 10, with 0 indicating no pain and 10 indicating the worst possible pain. Additionally, mandibular ROM was assessed. Pain intensity was measured during the preliminary examination, as well as after the 6th and 12th days of treatment.

Surface electromyography of the masseter muscle

All patients were assessed for MAS sEMG during the preliminary examination and after the 6th and 12th days

Table 1. Therapeutic exercises in the control (CG) and experimental (KTG) groups

Therapeutic exercise	Starting position	Movement
Gerry's exercise	tongue positioned on the palate	slow movements of opening and closing the mouth
Active exercises for lateral movements of the mandible	maxillary and mandibular teeth separated by about 5 mm	a slow motion of the mandible to the left, back to the midline, to the right, and again back to the midline
Side-to-side exercise	holding the front of the pen or pencil between upper and lower teeth	a slow motion of the lower jaw from side to side
Protrusion and mouth opening	teeth separated	lowering the lower jaw forward, opening the mouth, closing the mouth, retracting the lower jaw
Self-massage of the masseter muscle	teeth separated, hands clenched into a fist, placed around the mandibular branch (right hand on the right side, left hand on the left side)	circular rubbing movements of the masseter muscle with a pressure of approx. 0.5 kg
Cervical spine exercise (active flexion and extension movements of the spine)	standing or sitting with the head in a neutral position (gazing straight ahead)	bending the head forward and returning to the starting position, straightening the head and returning to the starting position

of treatment. The sEMG recordings were obtained in the morning hours, and the patients were instructed to refrain from drinking coffee, tea, or other stimulants before signal acquisition.

The study utilized a two-channel electromyograph (NeuroTrac® MyoPlus 2; Verity Medical Ltd., Tagoat, Ireland) with NeuroTrac® software (Verity Medical Ltd.) in clinical mode to record MAS sEMG activity. To ensure precise sEMG measurements, a band-stop filter was employed to eliminate interference from frequencies of 50 Hz and 60 Hz (mains) during recording (measured in microvolts [μV]). The application of specialized filtering enables the acquisition of sEMG measurements with a precision of 0.1 μV.

To prevent magnetic interference during sEMG measurements, the device was positioned at a distance of at least 4 m from cell phones or other potential sources of interference. The test was conducted using 2 unipolar electrodes, which were placed 10 mm apart. The electrodes were positioned over the center of the muscle body, parallel to the path of its fibers. The lower electrode was approx. 5 mm above the mandibular angle, while the upper electrode was 10 mm above it. The placement of the electrodes was preceded by careful palpation of each muscle by an experienced clinician to identify the thickest part of the muscle body. The bioelectrical signals of the MAS were acquired while the subject was seated upright with the head in a natural position, hands resting on the knees, and feet on the ground. Before the application of the electrodes, the skin was cleaned with rubbing alcohol, following the manufacturer's recommendations and Surface ElectroMyoGraphy for the Non-Invasive Assessment of Muscles (SENIAM) guidelines (www.seniam.org). The ground electrode was placed on top of the C7 styloid process in the cervical section. This area is usually devoid of vastly active muscle fibers and is considered the optimal location for ground electrode placement in the orofacial region. This placement prevents cross-talk from muscles and electrodes that are not relevant to the examiner.

Electrical activity of the masseter muscle at rest

A rest test (RLX) was conducted on patients, with their dental arches slightly open and their tongues in a resting position.[41] Patients were instructed not to swallow saliva during the examination. Three measurements were taken 3 times, and the mean value was calculated.

Bioelectrical activity of the masseter muscle during maximal voluntary contraction

The sEMG signal was recorded in a sitting position with the teeth clenched with the greatest possible force for 5 s. The computer program connected to the device registered the minimum and maximum values and calculated the mean electric potentials, which, in conjunction with signal standardization, are considered essential for providing repeatable and unbiased electric signal acquisition.[41] Three measurements were taken, each recorded 3 times, and the mean value was calculated. The sEMG values were normalized by calculating the ratio of RLX to maximal voluntary contraction (MVC) using the following formula (Equation 1[42]):

$$\%MVC\ [\%] = RLX\ [\mu V]/MVC\ [\mu V] \times 100\%. \qquad (1)$$

Secondary outcome measures

Perceived Stress Scale

Perceived stress levels were assessed in the KTG and CG during the preliminary examination and after the 12th day of therapy. The examination used the standard paper-and-pencil method, with the patient seated at a table and no individuals in their immediate vicinity to avoid any influence on the responses. The study was conducted in a moderately dampened room with a pre-set air temperature of 22°C and without any time constraints.

The PSS-10 contains 10 questions about different subjective feelings related to personal problems and events, behaviors, and coping mechanisms. Respondents provide answers by selecting a number from 0 to 4 (0 – never, 1 – almost never, 2 – sometimes, 3 – quite often, 4 – very often). The overall score is the sum of all points, ranging from 0 to 40. The higher the score, the greater the perceived stress severity. The sten score properties determine the interpretation of the general indicator after conversion to standardized units. Scores ranging from 1 to 4 are considered low, while those ranging from 7 to 10 are considered high. Scores between 5 and 6 are considered average.[38]

Sample size

The sample size of 44 was determined for repeated measures analysis of variance (RM-ANOVA) with within-between interactions using the effect size of 0.25, α of 0.05, and power of 0.95.[43]

Randomization and blinding

Patients were assigned to the study group using simple randomization with the opaque closed envelope method. Allocation (1:1) concealment was achieved through consecutively numbered sealed envelopes, which were carefully checked to ensure they were undamaged and not see-through when held against a light source. Randomization was carried out by an investigator who was not involved in the determination of patient eligibility, intervention delivery or data collection.

The outcome assessors were blinded to the group allocation and were not involved in providing the interventions (single-blind). The statisticians who conducted the statistical analyses were also blinded to the group allocation until after the analyses were completed. There was no need to unblind any of the participants at any point during the study.

Statistical analysis

The normality of the variables was assessed using the Shapiro–Wilk test and Q–Q plots. For variables with a normal distribution, ANOVA and Mauchly's sphericity test were used to determine changes over time and between groups. The Greenhouse–Geisser correction was applied if the assumption was not met, and Bonferroni's correction was used for post hoc multiple comparisons. Variables with a non-normal distribution were analyzed using the nparLD package and a multiple comparison post hoc test. The minimal important difference (*MID*) value was calculated as 1/2 of the *SD* of each parameter's initial value. The differences between the parameters were calculated by subtracting the final value from the initial value and then correlating these values using Spearman's coefficient. The level of significance set for the study was set at $p < 0.05$. The analysis was conducted using the R Studio software (Posit, Boston, USA; https://posit.co).[44] Wilcoxon test was performed to assess differences between the study and control participants.

Results

Baseline data

Table 2 presents the results of the preliminary study for the KTG and CG. In the preliminary examination, no significant differences were found between the groups regarding age, sEMG MVC, sEMG %MVC, MMO, left lateral movement (LLM), and the PSS-10.

Primary analysis

The primary analysis was conducted based on an intention-to-treat principle and included 64 patients who were randomly assigned. The patients were analyzed according to the protocol.

Table 2. Statistical analysis for age, surface electromyography (sEMG) values, temporomandibular joint (TMJ) range of motion (ROM), and pain intensity in the control group (CG) and the experimental group (KTG) at baseline

Variable	Group	Min	Max	*Me*	*SD*	*CI*	Q1	Q3	*p*-value
Age [years]	CG	20	45	29	8.2	2.82	25.5	39.5	0.994
	KTG	20	45	30	9.34	3.49	23.5	42	
sEMG RLX [µV]	CG	4.38	17.8	9.19	3.31	1.14	7.54	12.9	0.020*
	KTG	4.78	20	10.5	3.24	1.21	8.74	12.3	
sEMG MVC [µV]	CG	161	484	284	92.2	31.7	221	344	0.738
	KTG	137	438	275	68.8	25.7	238	331	
sEMG %MVC [%]	CG	19.6	31.8	25.6	3.21	1.1	23	28	0.192
	KTG	18.3	33.3	28.3	4.2	1.57	25.2	30.7	
NRS	CG	5	8	6	0.891	0.306	5	6.5	0.003*
	KTG	5	8	7	0.884	0.33	6	7	
MMO [mm]	CG	33	40	37	1.4	0.481	36	37.5	0.082
	KTG	31	38	36	1.53	0.572	35	37	
LLM [mm]	CG	5	7	6	0.657	0.226	5	6	0.077
	KTG	5	8	6	0.986	0.368	5	7	
RLM [mm]	CG	5	7	6	0.684	0.235	5.5	6	0.001*
	KTG	5	9	6	0.952	0.356	6	7	
PSS-10 [stens]	CG	5	10	8	1.36	0.466	7	9	0.288
	KTG	5	10	8	1.56	0.583	7	9	
PSS-10 [points]	CG	15	31	23	4.5	1.55	20	27	0.227
	KTG	14	35	25.5	5.83	2.18	20.2	28.8	

RLX – rest test; MVC – maximum voluntary contraction; %MVC – ratio of RLX to MVC; NRS – Numeric Rating Scale; MMO – maximal mouth opening; LLM – left lateral movement; RLM – right lateral movement; PSS-10 – Perceived Stress Scale; Min – minimum; Max – maximum; *Me* – median; *SD* – standard deviation; *CI* – confidence interval; Q1 – first quartile; Q3 – third quartile; * statistically significant ($p < 0.05$, Wilcoxon test).

Outcomes and estimations

The results of the statistical analysis of MAS bioelectrical activity before treatment (1), after 6 days of treatment (2) and after 12 days of treatment (3) in the KTG and CG are presented in Fig. 3.

Both the KTG and CG showed differences in the sEMG parameters (RLX, MVC, %MVC) of the MAS over time, indicating that each treatment affected the bioelectrical signal of the muscle ($p < 0.05$) (Fig. 3). No significant differences were observed between the groups when comparing the applied treatments after 6 days (RLX: $p = 0.192$; MVC: $p = 0.555$; %MVC: $p = 0.246$) and 12 days of treatment (RLX: $p = 0.430$; MVC: $p = 0.334$; %MVC: $p = 0.318$).

Table 3 shows the 95% confidence intervals (*CI*s) for sEMG after 6 and 12 days of treatment in the KTG and CG.

Figure 4 presents the results of the mandibular mobility analysis (LLM, right lateral movement (RLM), MMO) before treatment (1), after 6 days of treatment (2) and after 12 days of treatment (3) in the KTG and CG.

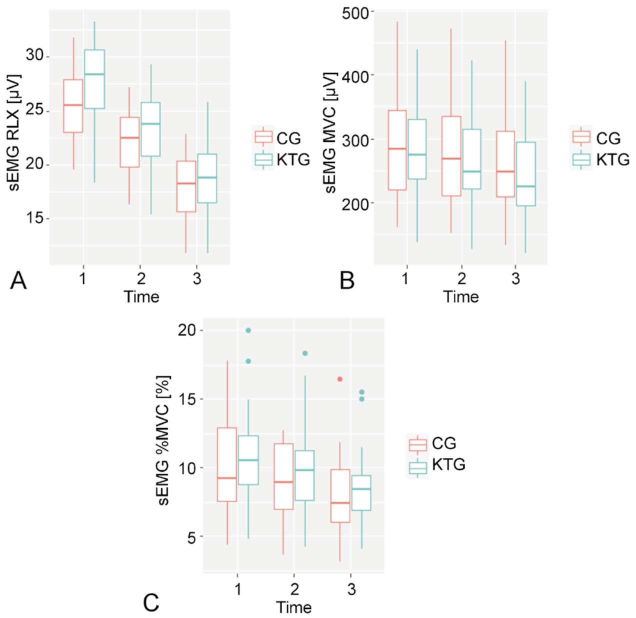

Fig. 3. Statistical analysis of the surface electromyography (sEMG) of the masseter muscle (MAS) in the control (CG) and experimental (KTG) groups before treatment (1), after 6 days of treatment (2) and after 12 days of treatment (3)

A. Rest test (RLX); B. Maximal voluntary contraction (MVC); C. The ratio of RLX to MVC (%MVC).

Table 3. 95% confidence intervals (*CI*s) for sEMG after 6 and 12 days of treatment in the CG and KTG

Variable		After day 6		After day 12	
		CG	KTG	CG	KTG
sEMG	RLX [µV]	23.0–28.8	21.62–24.58	16.86–18.94	17.27–19.93
	MVC [µV]	244.8–305.2	237.5–288.5	228.5–287.5	215.8–264.2
	%MVC [%]	7.916–9.884	8.62–10.92	8.86–8.80	7.546–9.474

Data presented as 95% *CI*.

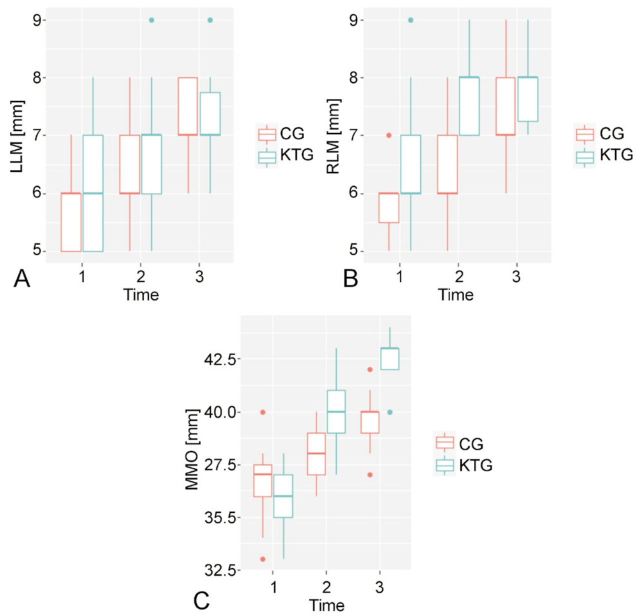

Fig. 4. Statistical analysis of the mandibular mobility range in the KTG and CG before treatment (1), after 6 days of treatment (2) and after 12 days of treatment (3)

A. Left lateral movement (LLM); B. Right lateral movement (RLM); C. Maximal mouth opening (MMO).

The parameter that showed the largest statistically significant changes was MMO, with a significant difference ($p < 0.001$) between the groups after 6 and 12 days of treatment (Fig. 4). After 6 days of treatment, the 95% *CI*s were as follows: 37.707–38.492 (CG MMO) vs. 39.161–40.439 (KTG MMO); 6.28–6.7 (CG LLM) vs. 6.449–7.091 (KTG LLM); 6.148–6.592 (CG RLM) vs. 7.491–7.969 (KTG RLM). After 12 days of treatment, the 95% *CI*s were as follows: 39.227–39.973 (CG MMO) vs. 42.479–43.121 (KTG MMO); 7.061–7.519 (CG LLM) vs. 6.817–7.383 (KTG LLM); 6.888–7.392 (CG RLM) vs. 7.653–8.147 (KTG RLM).

Figure 5 shows the results of the NRS pain intensity analysis in the KTG and CG before treatment (1), after 6 days of treatment (2) and after 12 days of treatment (3).

A significant difference was observed between the groups in the analysis of the pain intensity parameter ($p < 0.001$). The patients who received KT in combination with TE experienced better pain relief than the CG (Fig. 5).

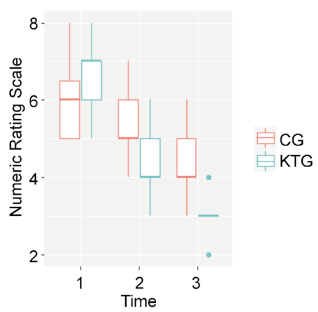

Fig. 5. Statistical analysis of the pain intensity in the KTG and CG before treatment (1), after 6 days of treatment (2) and after 12 days of treatment (3)

The 95% *CI*s after 6 days of therapy were 4.888–5.392 (CG NRS) vs. 3.973–4.627 (KTG NRS). The 95% *CI*s after 12 days of therapy were 4.164–4.576 (CG NRS) vs. 2.762–3.178 (KTG NRS).

Figure 6 shows the statistical analysis results for the PSS-10 (in stens and points) before treatment (1) and after 12 days of treatment (3) in the KTG and CG. The analysis of the PSS-10 results indicates that therapy using KT and TE significantly reduced perceived stress intensity compared to the CG ($p < 0.05$) (Fig. 6).

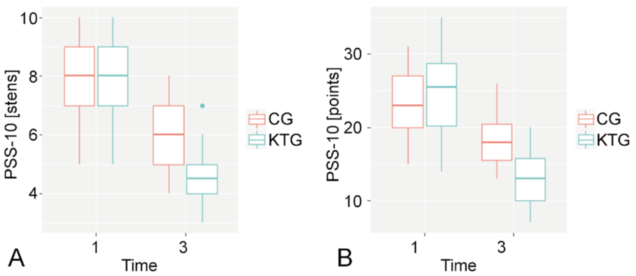

Fig. 6. Statistical analysis of the Perceived Stress Scale (PSS-10) in the KTG and CG expressed in stems (A) and points (B) before treatment (1) and after 12 days of treatment (3)

Ancillary analyses

Table 4 presents the results of the *MID* analysis. The analysis focuses on changes in the patient's reported results (beneficial or harmful) that are significant enough to justify a change in the patient's management.[43] Minimally important significant differences were found for the MMO, sEMG and PSS-10 parameters (Table 4).

Table 4. Results of minimal important difference (*MID*) analysis

Variable	*M*	*SD*	*MID*
MMO [mm]	36.2	1.49	0.746*
RLM [mm]	6.29	0.897	0.448
LLM [mm]	5.94	0.846	0.423
NRS	6.29	0.947	0.474
sEMG RLX [µV]	26.5	3.82	1.91*
sEMG MVC [µV]	286	81.6	40.8*
sEMG %MVC [%]	10.4	3.29	1.65*
PSS-10 [points]	23.8	5.17	2.58*
PSS-10 [stens]	7.72	1.45	0.726*

M – mean; * statistically significant.

Possible harms

No adverse effects were reported by any patient during the study. However, as KT tape is visible on the patient's face, it may cause mild social discomfort for sensitive individuals. Additionally, there have been some minor publications regarding hypersensitivity to KT glue. However, none of our patients reported any complaints.[44]

Discussion

The current study aimed to assess the therapeutic efficacy of KT and TE in female patients with pain, increased masticatory muscle tension and limited MMO. Our clinical observations have shown a significant increase in the number of patients with this profile. Similar observations have been reported by other authors.[45–47]

The study results indicate that both self-treatment and KT combined with TE had a significant effect on the change in MAS sEMG at rest and during exercise ($p < 0.05$). However, it is important to note that the measure of power (partial eta squared (pes); ANOVA) obtained in the study was poor (RLX: pes = 0.007; MVC: pes = 0.074; %MVC: pes = 0.017). There was no statistically significant difference between the effects of the 2 treatments on muscle bioelectric activity ($p > 0.05$). However, the *MID* analysis showed a significant difference in the sEMG parameter due to the applied therapies (RLX: *MID* = 1.91; MVC: *MID* = 40.8; %MVC: *MID* = 1.65). Nevertheless, the difference between the 1st measurement point (after 6 days of therapy) and the 3rd measurement point (after 12 days of treatment) was minimal in both groups. Similarly, Rocha Dutra et al. did not find a significant difference in sEMG between the KTG and the CG ($p = 0.1494$).[36] In a study by Soylu et al. that evaluated the short-term effect of masseteric KT on selected sEMG parameters related to fatigue and muscle strength during MVC, the effect of KT on sEMG parameters was not significant before or after KT application in healthy subjects.[48] In contrast, a study by Rathi et al. evaluating the effect of KT on MAS bioelectric activity and pain in patients with bruxism showed that KT markedly improved MAS activity and reduced pain. Additionally, a significant carry-over effect was observed after tape removal (the effect persisted for 24 h).[49] Therefore, dynamic patching may have an impact on the bioelectric function of the MAS in patients with TMD. However, due to the limited number of scientific reports, conflicting results and small study groups, any conclusions should be made with caution. Further studies using EMG are necessary to accurately determine the effect of KT on MAS bioelectrical function.

The assessment of the effect of the different therapies on improving TMJ ROM revealed a significant improvement in the KTG compared to the CG after 12 days, with a statistically significant difference in

MMO found in subjects who received dynamic patching ($p < 0.001$). Indeed, KT may contribute to improvements in TMJ function that result in increased mouth opening. When analyzing the *MID*, the applied therapies led to a clinically effective difference in the MMO parameter (MMO = 0.746), with the KTG showing improvement compared to the CG. After 6 days of therapy, the KTG demonstrated a more substantial difference in mouth opening, and after 12 days, the KTG had a more than twofold improvement in this parameter. In contrast, no *MID* was demonstrated in the LLM and RLL parameters (LLM: *MID* = 0.423; RLL: *MID* = 0.448). Therefore, the use of KT therapy may prove to be an effective adjunctive method for patients with TMD and limited mouth opening.

A statistically significant difference in pain intensity level on the NRS was observed between the KTG and CG ($p < 0.001$). The application of KT to the MAS showed an analgesic effect in patients with TMD, leading to an improvement in mouth opening. This therapeutic effect was already achieved after 6 days of therapy. Benlidayi et al. found that adding KT was more effective than counseling and training alone in improving several factors in 28 TMD patients, including pain reduction ($p = 0.001$), improvement in ROM ($p = 0.003$), disability ($p = 0.010$), and psychological status ($p = 0.000$).[40] Therefore, the increased TMJ ROM may be related to the pain-relieving effects of KT, which may have facilitated the implementation of TE in subjects.

Tran et al. conducted a meta-analysis of 36 research papers comparing the effectiveness of KT with other methods for the treatment of musculoskeletal disorders.[50] The results showed that KT improved pain and disability in all body areas. Within the first 5 days of use, KT significantly reduced pain in all body regions (SMD = −0.63, 95% *CI*: −0.87−−0.39).[50] Furthermore, after 4–6 weeks of use, KT improved disability in all body areas (SMD = −0.59, 95% *CI*: −0.96−−0.22).[50] Uzma's study compared the effectiveness of KT and conventional therapy with myofascial and traditional treatment in TMD patients. A within-group comparison showed improvement in both groups after 1 week. However, the experimental group demonstrated a significant improvement ($p = 0.05$). Therefore, KT is beneficial for reducing pain or improving ROM in TMD patients.[51]

Volkan-Yazici et al. compared the effects of manual therapy (MT) alone with MT combined with KT in patients with bruxism. The results showed that both methods were effective in treating bruxism, with the combination of MT and KT resulting in further reduction of jaw pain and temporal pain compared to MT alone.[52] In a meta-analysis by Meneses Emérito et al., taping was found to provide significant pain relief (measured using the visual analog scale (VAS)) after 1 week of treatment, compared to other methods analyzed. However, the authors noted that the limited number of studies and their biases limited the results.[53]

Baklaci reached a significant conclusion when comparing the effectiveness of treating TMD through relaxation splinting and KT.[54] Both the KT and splint groups experienced a reduction in pain ($p < 0.01$) and a significant increase in ROM ($p < 0.05$). However, there were no significant differences in VAS and ROM between the 2 groups. Moreover, both groups demonstrated improvements in daily eating activity and sleep quality, although no such improvements were observed in other oral activities.[54] Keskinruzgar et al. compared the therapeutic efficacy of KT and chiropractic therapy in patients with sleep bruxism and found a statistically significant difference between the KT and splint groups in terms of masseter and temporal muscle pressure pain thresholds (MPPT, TPPT), VAS, and mouth opening values before treatment and at weeks 1 and 5, except for TPPT values at week 1, which were higher in the kinesiology group than the splint group ($p < 0.05$).[55] Thus, the study suggests that KT is at least as effective as an occlusal splint in the treatment of sleep bruxism.[55]

In contrast, a literature review of 34 articles by Cheshmi et al. concluded that KT is not a reliable standalone treatment option for craniomaxillofacial disorders. However, it is considered a useful complementary option to improve treatment outcomes in a variety of conditions.[56] The study found a reduction in perceived stress in the KT group compared to the CG ($p < 0.001$). Analysis of the *MID* showed that the therapies used had a clinical effect on the PSS-10 scores and sten scores (*MID* = 2.58 and *MID* = 0.726, respectively). Patients receiving KT and TE exhibited a greater reduction in the PSS-10 score compared to the CG.

He et al. studied the efficacy of KT in patients with TMD by assessing its impact on various parameters, including the Self-Rating Anxiety Scale (SAS) and the Self-Rating Depression Scale (SDS), over a 6-day period. The results demonstrated that KT effectively improved the mood of TMD patients.[57] Our results, along with those of other authors, suggest that KT has a beneficial effect on stress parameters, which is particularly important in the treatment of TMD patients, as the literature reports that patients with these disorders often have high levels of stress, anxiety and depression.[58]

The results of the current study indicate that KT, in combination with TE, is an effective tool for reducing pain and improving mandibular ROM in female TMD patients. The authors of this paper and other researchers suggest that the effect of KT on the psychoemotional state may play a significant role in this process.[40] In addition, the potential risks or complications associated with the use of KT appear to be very low. It is a non-invasive method that is easy to use and can be removed if necessary. However, due to the paucity of scientific studies, the heterogeneity of methods and the small treatment groups, it is recommended that the therapeutic effect described be approached with caution. Arguably, in everyday clinical practice, KT may prove to be an effective adjunct to well-established TMD treatments. Based on current knowledge, KT should be considered a tool to sustain the therapeutic effect of standardized and well-described therapies. Further studies are necessary to evaluate the effectiveness of KT in treating TMD and to determine its therapeutic potential tangibly and unequivocally.

Limitations

The present study initially aimed to assess the therapeutic effects of KT in female patients with pain, increased MAS tension and limited TMJ mobility. There were several limitations to this study. First, the sample size was relatively small, which limited the generalizability of the results. Second, the study had a short intervention period (12 days), which will be extended in future studies to assess whether the evaluated indicators change over the course of treatment, providing a better understanding of the effects of the KT intervention. Additionally, the conducted studies lacked a comparative placebo group. Finally, the duration of treatment effects was not analyzed after the end of treatment. The authors will continue their study on the effectiveness of KT in treating TMD, with a focus on the abovementioned limitations.

Conclusions

The combination of KT, counseling and MAS exercises provides additional therapeutic benefits by increasing TMJ mobility and reducing pain severity compared to exercise alone. Therefore, KT could be an effective form of complementary therapy in TMD management. Additionally, KT combined with TE demonstrated a beneficial effect on perceived stress levels, which is a novel finding. However, further insight and additional studies are required to fully understand this phenomenon, including psychological assessment of TMD patients. Clinicians, physiotherapists and orofacial pain practitioners should consider implementing KT and TE in patients with painful TMD who have elevated pain sensitivity. Patients who catastrophize or have severe symptoms that could be intensified by more intense PT treatment, such as MT, may benefit from alternative treatment modalities.

Ethics approval and consent to participate

The study was approved by the Bioethics Committee of the Pomeranian Medical University in Szczecin (approval No. KB - 0012/102/13). Informed consent was obtained from all study participants.

Data availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Consent for publication

Not applicable.

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