Effects of Piroxicam Phonophoresis in the Treatment of Temporomandibular Joint Disorders in Patients Undergoing Orthodontic Treatment: A Prospective Clinical Study

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ABSTRACT

Objective: To evaluate the effect of phonophoresis of piroxicam, versus ultrasound alone, in the treatment of temporomandibular joint disorders of orthodontic patients

Materials and methods: A prospective comparative clinical study was conducted on 40 patients with temporomandibular joint disorders. The age range of patients was 20-40 years with a mean of 26.4± 4.9 years, 14 were males and 26 were females. Groups I of 20 patients received seven days of daily application of piroxicam gel over the joint and activated by ultrasound for 5 minutes. Group II only received ultrasound therapy. Visual analogue pain score and degree of mouth opening were measured before starting treatment and after the seven days of therapy.

Results: Both piroxicam phonophoresis and ultrasound alone application resulted in a significant reduction of pain score and improvement of mouth opening. Piroxicam phonophoresis reduced VAS score by 3.74 (±1.61) as compared to 1.45 (±1.09) in the ultrasound group. The improvement in mouth opening in piroxicam group was 9.05 mm(±4.49mm) as compared to 3.24 mm (±3.70 mm) However, the change of these two clinical parameters was significantly more in the phonophoresis group than in the ultrasound group.
Conclusion: Phonophoresis of piroxicam significantly influences the pain relieve and improvement of mouth opening in patients with temporomandibular disorders.

Keywords: Phonophoresis, Piroxicam, Temporomandibular joint disorders, Ultrasound

INTRODUCTION

The temporomandibular joint (TMJ) is the most complex joint in the body which is formed by the articulation of the mandibular condyle with the squamous temporal bone of the cranium. The articulating surfaces are covered by fibrocartilage and separated from each other by a disc. The two joint compartments formed by the intervening articulating disc are lined by a synovial membrane. This articulating surface along with the disc and joint cavities is enveloped by a joint capsule[1].

Temporomandibular disorders (TMD) are defined by the American Academy of orofacial pain as an umbrella term, which covers a set of musculoskeletal and neuromuscular conditions involving the masticatory musculature, the temporomandibular joint (TMJ), and/or their associated structures[2]. These disorders are characterized by pain in the region of the TMJs and muscles of mastication, limitation or deviation in mandibular movements, clicking sounds during jaw function, ear symptoms, and sensation of variable bite disturbances[3].

The first report of TMD was by a British surgeon in 1887, who published an article describing surgical management of disc displacements in the TMJ[4]. An early and influential publication in 1934 by James Bray Costen emphasized that dental malocclusions caused pain around the ear and the TMJs, but also related to other ear symptoms such as headache, tinnitus, impaired hearing, dizziness, and vertigo[5].

TMD is a major cause of nondental pain in the orofacial region. Population-based studies showed that TMD affects 0-15% for adults and 4-7% for adolescents[6], but in 3% - 7% of the population, pain and dysfunction, lead the patient to seek treatment[7]. The incidence of TMD peaks from 20 to 40 years of age; it is twice as common in women than in men and carries a significant financial burden from loss of work[8].

Although the aetiology remains controversial, multiple factors have an impact on the evolution of TMD, with many overlapping predisposing, precipitating, or maintaining risk factors. Predisposing factors increase the risk of TMDs (structural, metabolic, genetic, and psychological conditions). Precipitating factors are microtrauma, or microtrauma such as recurrent unfavourable loading. Stress might also be a predisposing factor owing to the disruption of sleep and the increase of nocturnal bruxism. Perpetuating (aggravating) factors that sustain a TMD are stress, poor coping skills, chronic detrimental habits such as clenching and grinding, and poor posture[9].

The main goals of treatment for temporomandibular disorders are to alleviate pain, reduce or eliminate joint noises, and restore normal mandibular and lifestyle function. The non-invasive treatment is still the most effective remedy for managing over 90% of patients with temporomandibular disorders[10]. Explanation and reassurance, education and self-care, pharmacotherapy, jaw physiotherapy, occlusal splint therapy, behavioural therapy, psychotherapy, acupuncture, Botox injections, and chiropractic manipulation are the most commonly used conservative treatments. Invasive and surgical treatments include arthrocentesis, arthrography, and open joint surgery like arthrotomy/arthroplasty and joint replacement[11].

Therapeutic ultrasound (US) is a common therapeutic modality often

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used in conjunction with exercise or manual therapy to treat various musculoskeletal conditions. Ultrasound converts electrical energy to an acoustic waveform that is transformed to heat as it passes through tissues. The objective is to warm the tissues to improve blood flow, eliminate inflammatory mediators, and accelerate healing. Furthermore, cell proliferation, protein synthesis, and cytokine production by human fibroblasts, osteoblasts, and monocytes are enhanced[12]. It is identified as a stimulator if used at low-intensity level, and would promote neovascularization, differentiation of mesenchymal stem cells and provoke the local release of angiogenic factors that act on ischemic tissues to enhance blood flow[13,14].

Phonophoresis is a therapeutic modality that uses US to enhance the trans-dermal absorption of drugs. It promotes the diffusion of topically applied drugs via the mechanical effects which simplify drug diffusion through diminishing membrane potential, shifting the lipid structure, increasing cell permeability, increasing ion conductance, or disrupting the cell membrane[15]. Phonophoresis with NSAIDs has been reported to treat pain and inflammation in many musculoskeletal conditions. Advantages of this approach encompass noninvasiveness, minimal risk of adverse effects associated with systemic administration of NSAIDs, and the combined therapeutic effects of both US and NSAIDs[16].

This study was conducted to evaluate the short- term effect of piroxicam phonophoresis and ultrasound in the treatment of temporomandibular joint disorders.

MATERIALS AND METHODS

Sample: This study followed the ethical principles of the declaration of the Helsinki guideline and all patients were given a thorough explanation regarding the procedures and signed a written consent form. The protocol was approved by the ethical committee of our institute. This prospective randomized-controlled clinical study was conducted on orthodontic patients with temporomandibular joint disorders, during a period from June 2020 to October 2021. Forty patients of both sexes (26 female and 14 male) with an average age of 20-40 years were considered for the study.

Exclusion Criteria: Exclusion criteria were systemic or mental illness, pregnancy, pacemakers, local infection, radiation in the joint area, history of TMJ surgery with placement of prosthetic material. The Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were used in this study. Patients were diagnosed with TMD when three of the following six symptoms were identified: articular sounds, deviation of the jaw during the opening, restricted mouth opening, articular pain, cervical or facial muscle pain, and tenderness of the masticator muscle on palpation[17].

Treatment: The participants were randomly allocated into two equal groups of 20 patients. Group (I) received Phonophoresis with piroxicam gel, group (II) received only ultrasound therapy.

Group (I) was treated with 5 ml 0.5% piroxicam gel, (Figure 1), over the joint area and sonographically activated for 5 minutes in a circular motion using home care medical grade portable therapeutic ultrasound (Figure 2). The procedure was conducted daily by the patient at home for seven consequent days. The ultrasound was delivered at an intensity of 1.0 w/cm² and a frequency of 1.0 MHz with pulsed mode. Group (II) received ultrasound therapy alone with the coupling gel at the same above parameters.

Baseline measures of pain and maximum mouth opening was made before commencing treatment, and after the course of treatment. Pain was assessed subjectively by the patient using Visual Analogue Scale (VAS) VAS is a ten centimeters line with of 11 scores (0-10), where '0' was marked as 'No Pain' and '10' as 'Most Severe Pain'. Maximum mouth opening was measured by the operator using digital vernier placed between the incisor edges of the upper and lower central incisors.

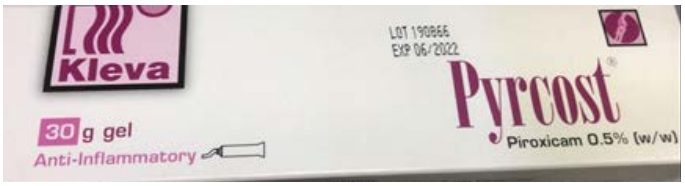

Figure 1: Piroxicam gel 0.5% w/w (Kleva Pharmaceutical S.A., Greece)

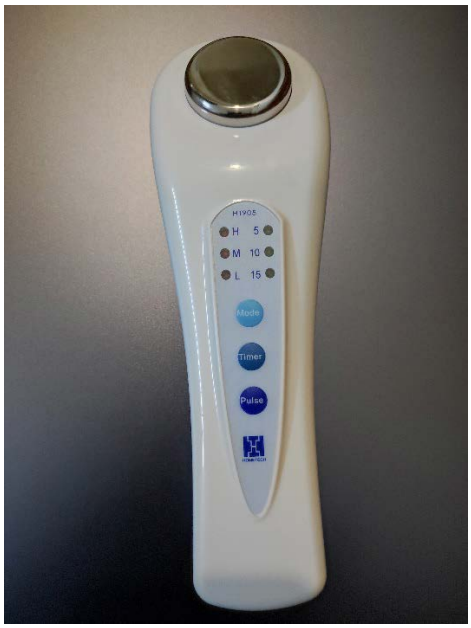

Figure 2: Portable therapeutic ultrasound machine (Home Care Technology Co, Ltd, Taiwan)

Statistical Analysis: The statistical package for social science (SPSS) was utilized for data analysis. Quantitative variables were presented as means and standard deviations, while qualitative variables were presented as percentages and frequencies. Fischer exact test was used for comparison of differences in sex and unpaired t-test for comparison of age between the groups. A paired sample t-test was used to compare maximum mouth opening within the group and unpaired t-test was used for intergroup comparison. Wilcoxon signed-rank test was used for intragroup comparison of VAS and Mann -Whitney U test was used for comparisons of VAS between the two groups. A probability value of less than 0.05 was considered statistically significant.

RESULTS

All the patients in both groups completed the treatment course. There were 26 (65%) females and 14 (35%) males, with a female: male ratio of 1.8:1. The mean age of piroxicam phonophoresis was 26.3±7.6 years and it was 24.5±6.3 in the ultrasound group (Table 1). No significant difference was noted in the age and sex distribution of patients between the two groups.

The VAS pain score of the two groups in the pre- and post- treatment periods is presented in table 2. Both groups showed a significant

reduction in pain scores. Piroxicam phonophoresis reduced VAS score by 3.74 (±1.61) as compared to 1.45 (±1.09) in the ultrasound group. The difference was highly significant (p=0.000).

The maximum inter-incisor mouth opening of the two groups in the pre- and post- treatment periods is presented in table 3. Significant improvement in mouth opening was achieved in the two groups. The improvement in mouth opening in the piroxicam group was 9.05 mm(±4.49mm) as compared to 3.24 mm (±3.70 mm). This difference was significant (p=0.000).

Table 1: Mean age and sex distribution of the two groups

	Piroxicam Phonophoresis (n=20)	Ultrasound (n=20)	p-value
Age (years)	26.3±7.6	24.5±6.3	0.4199*
Sex Males	5	9	0.3203†
Females	15	11	

*Independent t test for between-groups analysis; P value is not significant.
† Fisher exact test for between-groups analysis; P value is not significant.

Table 2: Pre-and post- treatment of visual analogue scale of pain of the two groups

	Visual analogue scale		
	Piroxicam phonophoresis (Mean ±SD)	Ultrasound (Mean ±SD)	Intergroup difference P-value
Pre-treatment	5.84±2.33	6.35 ±2.00	0.4101†
Post-treatment	2.10 ±1.48	4.90 ±2.12	
Intragroup difference P-value	0.000*	0.026*	
Difference in improvement	3.74 ±1.61	1.45 ±1.09	0.000††

*Wilcoxon signed-rank test, P value is significant, † Mann-Whitney U test, P value is significant.
†† Mann-Whitney U test, P value is significant.

Table 3: Pre-and post- treatment maximum inter-incisor opening of the two groups

	Maximum inter-incisor opening (mm)		
	Piroxicam phonophoresis (Mean ±SD)	Ultrasound (Mean ±SD)	Intergroup difference P-value
Pre-treatment	30.62 ±4.58	32.44±3.2	0.1487†
Post-treatment	39.67 ±6.12	35.68 ±5.0	
Intragroup difference P-value	0.0001*	0.0194*	
Difference in improvement	9.05 ±4.49	3.24 ±3.70	0.0001††

† Unpaired t-test, p value is not significant,
†† unpaired t-test, p value is significant,
*Paired t-test, p value is significant.

DISCUSSION

To the best of our knowledge, this is the first study of piroxicam gel phonophoresis in the management of pain and limited mouth opening associated with TMD. No previous article had already defined the effectiveness of piroxicam phonophoresis on pain management and functional recovery of TMD.

Although the term TMD is not a disease entity, rather a range of presentations of altered structure or function of TMJ and associated periarticular tissues that may arise from a variety of causes. Pain can be present at any stage of TMDs and is a significant part of the symptoms that prompt patients to seek treatment[18]. Painless functional movement is the main purpose of treatment of patients with TMD. Therefore, it was the objective of the present study to assess the effectiveness of phonophoresis using piroxicam gel for this purpose.

The age range of this study was 20-40 years as it is the most commonly affected by temporomandibular joint disorders[19]. The female to male ratio of patients with temporomandibular disorders in this study was 1.8:1. This finding comes in accordance with other previous studies[20,21]. It is suspected that this predisposition is related to female reproductive hormones, especially estrogen[22], which would increase the attention to pain stimuli by limbic activity at the central nervous system[7]. Females also show a more sensitive response to stress-inducing events[23].

Phonophoresis can be described as a non-invasive technique that uses piezoelectric potential by converting electrical energy into high-frequency oscillation sound waves which lead to the formation of cavitation. This action provides a controlled and safe way to potentiate the transdermal absorption of a wide variety of ionizable drugs without causing significant discomfort. The cavitation results in the formation of gaseous microbubbles in the outer layer of the skin that can rupture violently, favoring the penetration of the drug[24]. The parameters of US in this study were set at1 W/cm2 /1 MHz in accordance with the protocol proposed by Rai et al.[21].

Piroxicam gel was shown to be safe and efficacious for the treatment of musculoskeletal pain. In our study, piroxicam was used in the gel formula rather than the cream formula. The gel-formulation is very similar to the US gel used as a coupling agent in diagnostic and therapeutic US and the gel preparation has a higher acoustic transmission ability than the cream preparation[25]. Piroxicam has been used orally in the treatment of TMD[26] and with arthrocentesis in the treatment of non-reducing disk displacement of the TMJ[27].

In our study, even though both groups showed significant improvement, piroxicam phonophoresis group seems to be better than the ultrasound group, which was evident in the alleviation of pain and the increase in mouth opening. In comparison to baseline measurements, the piroxicam phonophoresis reduces VAS pain score by 3.75 as compared to 1.45 in the ultrasound group. The phonophoresis group showed about a 9 mms increase in mouth opening from the baseline measurement as compared to 3 mms in the ultrasound group.

In their study on the effect of piroxicam phonophoresis on knee osteoarthritis, Luksurapan and Boonhong[28] have found a significant change of the VAS and the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) pain scores from baseline by approximately 67% and 64% for piroxicam phonophoresis, respectively, versus 39% and 30%, respectively, for the ultrasound group. Nakhostin-Roohi et al.[29] concluded that phonophoresis with virgin olive oil and piroxicam gel wase effective in lowering WOMAC scores of knee pain in female athletes. Boonhong and Thienkul[30] revealed that US, piroxicam phonophoresis, and dexamethasone phonophoresis (using 1 MHz frequency and 1.0 w/cm2 intensity) were not effective in improving electrodiagnostic parameters in mild to moderate Carpel tunnel syndrome but did improve the clinical symptoms and movement without between- group statistical differences.

This study uses at- home treatment in which the patient or a relative performed the phonophoresis or the ultrasound application. The patient was given instructions on the application of gel and the use of the ultrasound machine. This at home treatment strategy is better than a clinic -based treatment because patients may not attend regularly for treatment or may discontinue treatment. The limitation of the study is that it reveals the short-term effects of both treatment modalities on TMD and further studies with a longer follow period are needed to demonstrate whether the improvements in symptoms are of long term.

CONCLUSION AND RECOMMENDATION

Piroxicam phonophoresis and ultrasound significantly improved the symptoms of temporomandibular joint symptoms after seven days of daily application for 5 minutes. However, the piroxicam phonophoresis was superior to ultrasound in reducing pain and increasing the degree of mouth opening. Further clinical studies with longer follow up periods to see the long- term effects of this treatment.

Authorship Contribution: All authors share equal effort contribution towards (1) substantial contributions to conception and design, acquisition, analysis and interpretation of data; (2) drafting the article and revising it critically for important intellectual content; and (3) final approval of the manuscript version to be published. Yes.

Potential Conflict of Interest: None.

Competing Interest: None.

Acceptance Date: 20 June 2022

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