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Original research

The effects of Biofreeze and superficial heat on masticatory myofascial pain syndrome

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Purpose
This study aims to assess the influence of superficial heat and Biofreeze on pain, mouth opening (mm), and quality of life in patients with masticatory myofascial pain syndrome (MPS).

Materials and Methods
52 patients with MPS were included in the study. They were randomly divided into two groups. Patients in the Biofreeze group (n = 26) applied 3.5% menthol gel to the masseter and temporal muscles twice a day for seven days, while the other group applied superficial heat. Baseline, 7th, and 21st days of VAS, mouth opening (mm), and Oral Health Impact Profile-14 (OHIP-14) scores of the patients were evaluated statistically.

Results
The mouth opening increased by 4.27 ± 3.80 mm in the Biofreeze group and 2.58 ± 2.16 mm in the superficial heat group. In each group, a significant decrease in VAS and OHIP-14 scores was observed on the 7th day compared to the baseline values ($p<0.001$). There was no statistically significant difference between the two applications on myofascial pain, mouth opening (mm), and OHIP-14 total score variables. The favorable effects of both applications on these parameters were limited to the duration of use.

Conclusion
Biofreeze and superficial heat in MPS were found to increase the quality of life, but the limited effectiveness of these applications underlines the importance of the underlying factors.

Keywords: *Myofascial pain, myofascial pain syndromes, myofascial trigger point pain, menthol, referred pain*

Introduction

Masticatory myofascial pain syndrome (MPS) is characterized by the presence of trigger points that cause local and referred pain in associated structures, such as the teeth and temporomandibular joint (TMJ) (1). Previously, myofascial trigger points were detected in 55.4% of patients who presented to dental clinics for the treatment of chronic head and neck pain, highlighting the wide distribution of MPS (2). Clinically, the restriction of mandibular movements secondary to pain, facial asymmetry, difficulty speaking, vertigo, and tinnitus are common symptoms (3). Several factors, such as sudden muscle loading or chronic injury due to recurrent microtraumas, genetic factors, and stress, contribute to MPS development (4). Treatment strategies aim to relieve pain by inactivating trigger points, relieving local muscle spasms, normalizing the muscle length, and improving functional capacity (5). Local anesthetic/botulinum toxin injections, acupuncture, transcutaneous electrical nerve stimulation (TENS),

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ultrasound, superficial heat, massage, cold compression applied to the trigger point, and pharmacological agents are frequently preferred treatment methods (5).

Superficial heat is widely used to increase blood pressure and tissue perfusion as well as to reduce neuropathic pain and joint stiffness (6). It can be applied at home using a variety of methods. This is one of the advantages of superficial heat, which makes it a commonly preferred treatment approach for MPS (6,7). However, the use of alternative agents to relieve pain has become increasingly popular (8,9). Menthol, one of the primary active ingredients in Biofreeze, has been shown to control pain through the stimulation of cold receptors within the opioid or glutamate systems (10). Unlike traditional cold applications, Biofreeze exerts cryotherapeutic effects by blocking sodium channels, which creates a cooling sensation without actively decreasing overall skin temperature, increasing the topical analgesic effects of menthol (11,12). Menthol reduces blood flow and causes vasoconstriction, similar to the outcome observed with ice application (13). However, the isopropyl alcohol and glycerin contained in Biofreeze have also been shown to exert vasodilation effects (14,15). Due to the contradictory nature of these substances, we aimed to investigate the effects of Biofreeze on MPS. To our best knowledge, no previous studies have explored the effects of superficial heat and Biofreeze on the outcomes of pain, mouth opening (measured in mm), and quality of life among patients with MPS. Therefore, we have tested the null hypothesis that no statistically significant difference would be found between Biofreeze and superficial heat in terms of inhibiting the pain associated with MPS by preventing the formation of trigger points. This study also aimed to determine the short and long-term effects of these two applications when used in patients with MPS.

Materials and Methods

Ethical statement

The research was approved by the Local Ethics Committee (No:2015/118), and all participants signed a consent form before the start of the study. The study was carried out compatible with the Declaration of Helsinki.

Sample size estimation

A priori power analysis was performed based on the repeated measures ANOVA with three-time points using the software G*power version 3.1.9.4 (18). A sample size of 52 was found to be adequate to detect a difference in terms of the effect size of f= 0.25 with 80% statistical power at $\alpha = 0.05$.

Patient selection

A total of 52 patients (45 females and 7 males) who were diagnosed with MPS and have no history of occlusal splint usage were included in the study. The patients were divided into 2 groups: the first group received Biofreeze (n=26) while the second one superficial heat treatment (n=26). The inclusion criteria were chronic unilateral pain longer than 3 months and referred pain distributed from myofascial trigger points in the masseter and temporalis muscles to the face, mouth, or TMJ. These inclusion criteria for MPS are consistent with the guidelines of the American Academy of Orofacial Pain and the Research Diagnostic Criteria for TMD (RDC/ TMD) (7). In clinical examination, any tooth or maxillofacial lesions that could be the source of the pain were excluded. Radiographic imaging of the temporomandibular joint was performed to rule out disc displacement, effusion, degenerative disorders. Patients with trigeminal neuralgia, head and neck inflammation, endocrine diseases, and those using oral contraceptive drugs, and those with skin lesions (scar tissue, skin graft) on the treatment area were excluded from the study. The presence of hard, palpable nodules in the masseter and temporalis muscles, indicating the active myofascial trigger points, was the common feature of all patients in this study. By bilateral manual palpation, pain in the muscles was recorded using the visual analog scale (VAS).

Administration of Biofreeze and superficial heat

The patients were divided into two groups randomly. In the Biofreeze group, the patients applied 3.5% menthol gel to the masseter and temporal muscles twice a day for seven days. Patients were informed about the correct application of Biofreeze gel and a marked applicator strip was given to each patient to apply with a standard dose. Patients were told to massage the area with circular movements for about 30 seconds to 1 minute to allow the Biofreeze gel to penetrate under the skin. The remaining half of the patients applied superficial heat to the painful muscle areas twice a day for seven days. In this study, superficial moist heat application was done with a towel soaked in hot water (212^0 F). In this group, each cycle was repeated for 10 minutes and paused for 5 minutes. After three 10-minute heat cycles, with two 5-minute pauses, the superficial heat application took 40 minutes. Since the adipose tissue on the face is not as dense as the other tissues of the body, 5-minute pauses were given to ensure tissue safety against the rapidly rising heat. No application was applied to all patients after the 7^{th} day.

Recording of the clinical data

VAS, mouth opening (mm), and Oral Health Impact Profile-14 (OHIP-14) scores of the patients were compared at baseline, 7^{th}, and 21^{st} days. The unassisted (mandibular) opening without pain and maximum assisted (mandibular) opening of the patients were measured using a millimeter ruler between the edges of the upper and lower middle incisors. The current study assessed the patients' functional limitation, physical pain, psychological discomfort, physical/psychological/social incapacity, and social disadvantage with the OHIP-14 and compare the effects of these two applications at baseline, 7^{th}, and 21^{st} days. The OHIP, originally consisting of 49 questions, uses the World Health Organization (WHO) International Classification of Impairments, Disabilities and Handicaps framework (16). However, OHIP-14 is a shorter, patient-friendly version and consists of 14 questions. The previously validated Turkish translation of the OHIP-14 scale was used in this study. This scale scored between "0" and "4". An increase in the OHIP-14 score indicates the severity of the current problem and a decline in quality of life (17).

Statistical analysis

Data was evaluated by using Statistical Package for Social Science (SPSS Statistics for Windows, Version 25.0 Armonk, NY: IBM Corp, USA). The effects of the two different applications on the unassisted (mandibular) opening without pain and maximum assisted (mandibular) opening, VAS, and OHIP-14 score over time were compared with two-way repeated-measures ANOVA. The differences between the time points for each treatment group were further evaluated using the one-way repeated measures ANOVA followed by Bonferroni post-hoc multiple comparison tests. The confidence interval was set to 95% and p values less than 0.05 were considered statistically significant.

Results

A total of 52 patients with MPS (86.5 % females, 13.5 % males; age range: 18–50 years; mean age: 36.75±10.47) were included in this study. There were no differences between treatment groups in terms of age and gender (Table 1). There were no statistically significant differences between Biofreeze and superficial heat group for all of the four parameters (VAS, OHIP-14, the unassisted (mandibular) opening without pain, and maximum assisted (mandibular) opening) (Table 2). However, the favorable effects of both applications on these four parameters continued only during the usage periods (p<0.001, observed power=1.000).

For each treatment group, a significant difference between the unassisted (mandibular) opening without pain, maximum assisted (mandibular) opening, VAS, and OHIP-14 scores, and usage periods was observed (Table 3).

Table 1. *Comparison of the two groups in terms of age and gender. t-test and Fisher's exact text; sd: standard deviation; p: population correlation coefficient; n: sample size.*

	Total (n=52)	Biofreeze (n=26)	Superficial heat (n=26)	p
Age, mean (±sd)	36.75±10.47	37.35±10.64	36.15±10.47	0.686
Gender, n (%)				
Male	7 (13.5)	24 (92.3)	21 (80.8)	0.419
Female	45 (86.5)	2 (7.7)	5 (19.2)	

On the 7th day, the unassisted (mandibular) opening without pain and maximum assisted (mandibular) opening were statistically significant compared to baseline (p<0.001). On the 21st day, the unassisted (mandibular) opening without pain, and maximum assisted (mandibular) opening significantly reduced compared to the 7th day after treatment, but they were not statistically significant from the baseline

Table 2. *Results of the two-way repeated-measures ANOVA for the unassisted (mandibular) opening without pain, maximum assisted (mandibular) opening, VAS, and OHIP-14 scores. VAS: visual analog scale; df: degrees of freedom; F: F value (the ratio of the model mean square to the error mean square); OHIP-14: The Oral Health Impact Profile-14; [a]Greenhouse-Geisser corrected p-values were used due to the violation of sphericity assumption; Bold p-value indicates statistically significant effect at α=0.05.*

	Type III Sum of Squares	df	Mean Square	F	p[a]	Observed Power
The unassisted (mandibular) opening without pain						
Treatment	1.853	1.000	1.853	0.025	0.875	0.053
Time	380.667	1.363	279.265	63.024	**<0.001**	1.000
Time× Treatment interaction	21.128	1.299	16.262	2.937	0.087	0.320
Maximum assisted (mandibular) opening						
Treatment	3.692	1.000	3.692	0.037	0.849	0.054
Time	251.551	1.496	168.181	34.219	**<0.001**	1.000
Time× Treatment interaction	35.808	1.443	24.821	4.206	0.054	0.563
VAS						
Treatment	20.103	1.000	20.103	1.578	0.221	0.227
Time	328.551	1.186	276.910	238.435	**<0.001**	1.000
Time× Treatment interaction	0.782	1.332	0.587	0.907	0.376	0.244
OHIP-14 Score						
Treatment	1.641	1.000	1.641	0.013	0.912	0.051
Time	9520.192	1.209	7874.080	51.146	**<0.001**	1.000
Time× Treatment interaction	222.936	1.514	147.282	5.024	**0.018**	0.812

Table 3*. Comparison of the long and short-term effects of Biofreeze and Superficial heat groups. VAS: visual analog scale; OHIP-14: The Oral Health Impact Profile-14; n: sample size; mean±SD[a,b]: Same superscript letters indicate a statistically significant difference between the periods based on the Bonferroni post-hoc tests.*

	Biofreeze (n=26)			Superficial heat (n=26)		
	Baseline	**7th day**	**21st day**	**Baseline**	**7th day**	**21st day**
The unassisted (mandibular) opening without pain	31.27±5.59a	35.54±5.49ab	31.65±4.95b	32.15±4.98a	34.73±4.99ab	32.23±4.95b
Maximum assisted (mandibular) opening	35.65±6.73a	39.65±6.61ab	36.35±6.06b	36.31±5.70a	38.04±5.52ab	36.38±5.68b
VAS	6.58±2.04a	3.65±1.65ab	6.62±2.04b	7.31±1.78a	4.19±1.36ab	7.50±1.86b
OHIP-14 Score	39.23±7.80a	30.35±7.40ab	51.50±9.17ab	41.88±9.53a	31.35±8.91ab	48.46±13.32ab

values for each treatment group. After 7 days, the mouth opening increased by 4.27 ± 3.80 mm in the Biofreeze group and 2.58 ± 2.16 mm in the superficial heat group. In each group, a significant reduction in VAS and OHIP-14 scores was observed on the 7th day compared to the baseline values ($p<0.001$). Additionally, the 21st day of VAS and OHIP-14 scores increased significantly compared to the 7th day ($p<0.001$).

Discussion

This study represents the influence of superficial heat and Biofreeze on myofascial pain, mouth opening (measured in mm), and oral health-related quality of life among patients with MPS. The prevalence of myofascial pain was predominantly identified in young women in the present study. Consistent with this result, myofascial pain has been most commonly reported among individuals aged 30–49 years and occurs twice as frequently in women as in men (19,20). Ligament laxity, subluxation, posture disorders, and psychic factors are considered to serve as predisposing factors for the development of MPS (2). However, Brennum *et al.* (21) have postulated that women are more sensitive to pain than men, although no correlation has been found between age and pain perception. Treatment recommendations for MPS range from rest, nonsteroidal anti-inflammatory drugs (NSAIDs), and oral splints to more aggressive and irreversible treatments (22-24). Occlusal splints can change the muscle activity patterns and the positioning of the temporomandibular joint by increasing the vertical dimension of the mouth (25). Hot-cold packs and jaw exercises are considered self-care therapy, and these approaches can reduce parafunctional jaw activities, relieve pain, and improve the range of motion by relaxing the muscles (26-28). Truelove *et al.* (29) stated that oral splint therapy did not provide any advantage over self-care therapy, such as thermal packs, stress reduction, NSAIDs, and jaw relaxation techniques. Therefore, in the present study, we aimed to evaluate the long-term occlusal splint needs of patients who used two basic treatment approaches. Therefore, only patients with MPS who did not use occlusal splints were included in this study.

Heat application, which is preferred for the treatment of myofascial pain, increases metabolism and facilitates circulation by dilating the blood vessels, resulting in increased catabolism, the excretion of lactic acid, and the removal of uric acid and other acidic waste products from muscle cells (30,31). Due to these mechanisms, heat application is thought to reduce fatigue and the signs of aging and produce an analgesic effect on the musculoskeletal system (31). The effects of heat application are not limited to the treatment of neck and back pain, with beneficial effects described for reducing knee pain, temporomandibular joint pain, and delaying exercise-related muscle pain (6,32,33). Chabal *et al.* (34) reported that the analgesic effects of a single one 30-minute thermal application lasted for 2 hours after the application was completed. The principles of thermodynamics suggest that moist heat is more effective than dry heat due to the interactions between molecules (34,35). For this reason, moist heat using a towel soaked in hot water was the preferred method used in our study, with the goal of reducing muscle tension and increasing the size of the mouth opening by providing flexibility to collagen structures, such as tendons, ligaments, joint capsules (6,36,37). A previous study reported that trigger points are inactivated for up to 72 hours by the application of only moist heat, without the need for additional treatment (38). In addition, heat wraps have been found to have more effective analgesic properties than ibuprofen or acetaminophen (39). In patients with acute temporomandibular disorder, the mouth opening was increased by 3.5 to 9 mm following the application of superficial moist heat (6). In our study, an increase of 2.58 ± 2.16 mm was found following superficial heat application.

The use of thermotherapy for the treatment of temporomandibular disorders and neuromuscular disorders has been described in previous studies, but few studies have addressed the amount and or changes in temperature used in the methodology (6,40-43). In these studies, the daily application dose and duration of the heat applications often vary (6,40-43). Previous studies have indicated that pain relief was achieved with a minimum of 20 minutes of heat application (6,40-43). Based on these results, a total of 30 minutes of superficial moist heat, applied once per day, was the preferred approach used in our study, and we found significant improvements in the size of the mouth opening among patients with myofascial pain. However, the patients' acceptance of heat- or cold-based treatments for pain relief may vary. Brandt reported that 60% of participants diagnosed with rheumatoid arthritis (RA) and osteoarthritis (OA) expressed a preference for heat-based treatments for their aching joints, whereas 20% expressed a preference for cold-based applications (44). Cold-based applications exert analgesic effects by increasing the pain threshold and suppressing inflammation (45).

The primary component of the Biofreeze application used in this study is menthol. When menthol is applied to the skin, a cooling effect is mediated through TRPM8 (transient receptor potential cation channel subfamily M [melastatin] member 8), which can prevent inflammatory pain (46,47). TRPM8, also referred to as the menthol receptor, has also been detected in gingiva and incisive papilla (46-48). The wide distribution of menthol receptors throughout oral and craniofacial structures can also result in the topical analgesic effect being mediated through interactions with the dense neural network that is embedded in the dermal-epidermal junction of the skin and mucosa (49,50). It acts as a dose-dependent skin vasodilator, acting through nitric oxide, RhoA/Rho-kinase, and endothelium-derived hyperpolarizing factor (EDHF)-based mechanisms, which can increase cutaneous blood flow (51,52). Increasing attention has been paid to the therapeutic efficacy of menthol for the treatment of neuropathic pain syndromes, which is accompanied by hyperalgesia and allodynia (53). The current study showed an increase in the mouth opening size among patients during the Biofreeze application.

Fibromyalgia (FM) and MPS are the most common types of chronic musculoskeletal pain, reported to affect 80% of the general population (54). Whereas MPS is a regional pain condition that can be managed using conservative interventions, FM is a more complex pain condition, often requiring a multidisciplinary treatment approach, in addition to conservative measures (55,56). The etiology of FB is unknown, whereas MPS has been linked to local injuries and repetitive microtraumas (54). FB is classified as a chronic form of myal-

gia and bilateral, generalized muscle tenderness that lasts at least 3 months (54). In MPS, pain can also persist for more than three months, originating from the trigger point and excessively irritable nodules that respond to palpation (54).

MPS affects the social functioning and physical/psychological health of the affected individual person and results in loss of workdays and the increased need for healthcare (57). Acute MPS is likely to be localized and can heal spontaneously or through the use of simple therapeutic strategies (heat or cold application, physical therapy, dry needling, or injection with a local anesthetic). However, MPS can also occur intermittently due to an underlying structural and environmental stimulus that cannot be corrected (58).

Conclusion

Biofreeze and superficial heat were both found to increase the quality of life, but the limited effectiveness of these applications emphasizes the importance of the underlying structural, postural, and ergonomic factors which should be treated appropriately to control myofascial pain and to prevent recurrence.

Türkçe Özet: *Biofreeze ve yüzeyel ısının mastikatör miyofasiyal ağrı sendromuna (MAS) etkisi. Amaç: Bu çalışma, MAS'lı hastalarda yüzeysel ısı ve Biofreeze'in ağrı, ağız açıklığı (mm) ve yaşam kalitesi üzerindeki etkisini değerlendirmeyi amaçlamaktadır. Gereç ve Yöntem: Çalışmaya dahil edilen MAS'ı olan 52 hasta, yüzeysel ısı ve Biofreeze uygulaması yapılmak üzere rastgele iki gruba ayrıldı. Biofreeze grubundaki hastalar (n=26) günde iki kez olmak üzere yedi gün boyunca masseter ve temporal kaslarına % 3.5 mentol jeli uygularken, diğer grup yüzeyel ısı uyguladı. Hastaların başlangıç, 7. ve 21. gün VAS, ağız açıklığı (mm) ve Ağız Sağlığı Etki Profili-14 (OHIP-14) skorları SPSS ile değerlendirildi. Bulgular: Ağız açıklığı, Biofreeze uygulanan grupta 4,27 ± 3,80 mm, yüzeysel ısı uygulanan grupta 2,58 ± 2,16 mm artmıştır. Her grupta başlangıç değerlerine göre 7. günde VAS ve OHIP-14 skorlarında anlamlı azalma gözlenmiştir (p <0.001). Miyofasiyal ağrı, ağız açıklığı (mm) ve OHIP-14 skorlarında iki uygulama arasında istatistiksel olarak anlamlı fark yoktur (p> 0.05). Her iki uygulamanın bu parametreler üzerindeki olumlu etkileri sadece kullanım süreleri ile sınırlı kalmıştır. Sonuç: Bu çalışmada, Biofreeze ve yüzeysel ısının MPS'deki etkileri analiz edilmiştir. Her iki uygulamanın da yaşam kalitesini artırdığı bulunmuştur, ancak bu uygulamaların sınırlı etkinliği altta yatan faktörlerin düzeltilmesinin önemine dikkat çekmektedir. Anahtar Kelimeler: Miyofasiyal ağrı, miyofasiyal ağrı sendromları, miyofasiyal ağrı tetik noktası, mentol, yansıyan ağrı*

Ethics Committee Approval: Research was approved by the Ethics Committee of the Gazi University (No:2015/118).

Informed Consent: Participants provided informed constent.

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Author contributions: DY and CA participated in designing the study. DY and CA participated in generating the data for the study. DY and CA participated in gathering the data for the study. OK participated in the analysis of the data. DY wrote the majority of the original draft of the paper. DY and CA participated in writing the paper. DY and CA have had access to all of the raw data of the study. DY and CA have reviewed the pertinent raw data on which the results and conclusions of this study are based. have DY, CA, OK approved the final version of this paper. DY guarantees that all individuals who meet the Journal's authorship criteria are included as authors of this paper.

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