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Evaluation of the efficiency of different treatment modalities in individuals with painful temporomandibular joint disc displacement with reduction: a randomised controlled clinical trial

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This article dedicated to Prof. Yuanwen Ouyangi.

Abstract

The aim of the study was to investigate and compare short and long-term effects of occlusal splints (OS), ultrasound (US), and high-intensity laser therapy (HILT) in patients with painful temporomandibular joint (TMJ) disc displacement with reduction (DDWR). This prospective, randomised, single-blinded, controlled clinical study was conducted on patients with DDWR at a university oral and maxillofacial surgery clinic. A total of 140 patients were allocated randomly to four groups (OS, US, HILT, and control), with 35 patients in each. Patients were evaluated for pain, range of motion of the jaw, disability, and quality of life. A total of 132 patients completed the study. In all treatment groups (OS, US, and HILT), a significant improvement was observed in terms of pain, function, disability, and quality of life, at both weeks four and 12 compared with the control group ($p < 0.001$). Improvements in VAS pain and maximum mouth opening were not significantly different between the treatment groups. However, compared with the OS group, there was a significant improvement in the HILT and US groups in terms of total Oral Health Impact Profile (OHIP-14) and Jaw Functional Limitation Scale-20 (JFLS-20) scores at week four, but no difference between the groups at week 12. The results of this study show that OS, US, and HILT are effective treatments for pain and functional jaw movements in patients with DDWR. HILT, a new method, can be an alternative treatment in cases of TMD.

Keywords: Temporomandibular disorder; Occlusal splint; Ultrasound therapy; High-intensity laser therapy

Introduction

Temporomandibular disorder (TMD) refers to a group of clinical conditions that include temporomandibular joint (TMJ) and/or masticatory muscle disorders.[1] The most common signs and symptoms are pain, joint noise, and restricted mandibular motion.[2] The aetiology of TMD is multifactorial, including physical, psychological, and psychosocial factors alone or in combination.[3] Disorders that may be clinically diagnosed by the Research Diagnostic Criteria for Temporomandibular Disorders (RDC/ TMD) are divided into three groups: muscle disorders (group 1), disc displacement (group 2), and arthralgia, osteoarthritis, and osteoarthrosis (group 3).[4] Disc displacement without reduction (DDWoR) is one of the most common internal derangements of the TMJ.[5]

Various therapies, such as drugs, occlusal splint, and physical therapy, have been proposed for management of the symptoms of TMD.[6] Stabilisation splint therapy, one of the main conservative treatments, is highly effective in myofascial pain and disc displacements with or without

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reduction.[7,8] Ultrasound (US) therapy, in which sound waves with a density of 1.25 w/cm^2 cause tissue vibration and heat to increase blood flow to tissues, has been the treatment of choice to alleviate TMD-related pain and inflammation.[9] It provides important nutrients to the tissue by increasing blood circulation, and also causes changes in cell membrane permeability, resulting in the diffusion of cellular metabolites, a reduction in oedema, modulation of pain, and increased local blood circulation.[10]

Recently, the pulsed neodymium-doped yttrium aluminum garnet (Nd: YAG) laser, a type of high-intensity laser therapy (HILT), has been introduced in the field of physiotherapy. It works with high peak power (3 kW) and 1.064 nm wavelength, and is considered to be a non-painful and non-invasive therapeutic method that can stimulate areas such as the wide and/or deep joints that are difficult to reach with a low power laser.[11]

The aim of this randomised controlled study was to evaluate and compare the effects of three treatment methods (OS, US, and HILT) on TMJ pain and range of jaw motion in patients with DDWR. The null hypothesis to be tested was that there is no difference between these three modalities in the treatment of patients with painful DDWR.

Materıal and methods

Study design

To address the research purpose, the investigators designed and implemented a prospective, single-blind, controlled clinical trial. The study population was composed of patients presenting with TMJ sounds and pain between June 2019 and December 2019 at the oral and maxillofacial surgery clinic, Faculty of Dentistry, Afyonkarahisar Health Sciences University. The study was approved by the Human Research Ethics Committee of the Faculty of Medicine, Afyonkarahisar Health Sciences University (Decision no: 2019/184).

Subjects

It was calculated that a total of 96 individuals should be taken, with at least 24 subjects from each group when $\alpha = 0.05$ and $1\text{-}\beta = 0.80$ were taken in the power analysis (Heinrich-Heine-Universität Düsseldorf, Germany). Considering the possibility of patients leaving before completing the treatment, 160 patients were included.

The study group comprised 160 patients with unilateral TMD who fell into Axis I, group II (disc displacement) of the DC/TMD.[12] The inclusion criteria for the study were unilateral DDWR in the last 30 days, any TMJ noise(s) present with jaw movement or function, or patients' reports of any noise present during the examination. The magnetic resonance images (MRI) were examined to determine disc displacement. Those with signs of degenerative joint disease and DDWoR on MRI were excluded from the study. The specific inclusion criterion was that the participants had TMJ pain at the time or had had it within the last six months, so patients with asymptomatic DDWR were excluded. Subjects with inflammatory disorders, other rheumatic diseases, neurological and psychiatric disorders, other problems related to the masticatory system, or a history of trauma or physiotherapy, were excluded. Pregnant women and patients under 18 years of age were also excluded.

Interventions

A total of 140 patients were allocated randomly to four groups using randomisation software (QuickCalcs, GraphPad Software Inc): group 1 (occlusal splints), group 2 (ultrasound therapy), group 3 (HILT), and group 4 (control).

Group 1 (OS) patients received a resilient bite splint, 4 mm thick BIOPLAST® (Scheu Dental GmbH) produced in a BIOSTAR® heat and vacuum press (Scheu Dental GmbH). A stabilisation splint was applied to the upper jaw of all patients by the same researcher in line with the recommendations by Okeson.[13] They were instructed to use stabilisation splints at night only. Patients' compliance with the device was followed up, and they were encouraged to continue using it.

Group 2 (US) patients received US treatment (Chattanooga Group Intelect® Mobile 2776, Chattanooga Group Inc) with a 1 MHz ultrasound head at 0.87–1 MHz frequency and 1.5 W/cm^2 dosages to the TMJ area and masticatory muscles in five sessions of 10 minutes duration each week for four weeks. It was applied to the trigger points on the masseter and temporal muscles, drawing concentric circles on and around the trigger point for one or two seconds.

Group 3 patients (HILT) received pulsed Nd: YAG laser treatment produced with the HIRO 3 device (ASA Laser) five times a week for four weeks, 15 minutes/session. In each session, a three-phase treatment programme for the TMD region was applied (Table 1). The first phase involved rapid manual scanning of the TMJ area both transversely and longitudinally (100 cm^2/30 seconds). The second involved applying the 90° handpiece to the trigger points on the masseter and temporal muscles with vertically fixed spacers. The third stage involved slow manual scanning of the TMJ region (100 cm^2 in 60 seconds). The processing time for one session was about 15 minutes, and the total energy supplied to the patient during one session was 1.029.1 J.

The control group had no active treatment, only counselling, education, a home exercise programme, and other self-management therapies, as in other groups. Patients were instructed not to take analgesic/anti-inflammatory and muscle relaxant drugs before and during treatment. All treatments were performed by the same physiotherapist in a standard manner.

Measurements

Patients were evaluated by an independent investigator who was blinded to the study at the start of treatment and at four and 12 weeks after the initiation of treatment. Pain intensity

Table 1
High-intensity laser therapy (HILT) phases.

	Frequency (Hz)	Fluency (mJ/cm^2)	HILT energy dose (J)
Phase 1—fast manual scanning (100 cm^2/30 seconds)	20	360	166
	18	410	166
	15	510	166
Phase 2—trigger point inactivation phase	15	360	6.3
	15	510	9
	14	610	10
	16	360	7.8
Phase 3—slow manual scanning	20	360	166
	18	410	166
	15	510	166

and degree of reduction in jaw function were evaluated with a VAS.[14] Maximum mouth opening (MMO) was measured as the distance between the incisal edge of the upper and lower central incisors using an electronic caliper. The Jaw Functional Limitation Scale-20 (JFLS-20) was used to measure changes in functional disability.[15] Quality of life was evaluated with the Oral Health Impact Profile (OHIP-14) questionnaire.[16]

Statistical analysis

IBM SPSS Statistics for Windows version 20.0 (IBM Corp) was used to evaluate the data. The normal distribution of data was evaluated using the Kolmogorov-Smirnov test. Within-group comparisons were made using dependent two-sample *t* tests and the Wilcoxon test. The chi squared test was used to compare categorical variables. In a comparison of the groups, one-way ANOVA and Kruskal Wallis tests were used for quantitative variables. A p value of less than 0.05 was considered statistically significant.

Results

A total of 140 patients were evaluated for eligibility and 132 completed the study. Their study data were evaluated (Fig. 1). No side effects relating to the treatment were

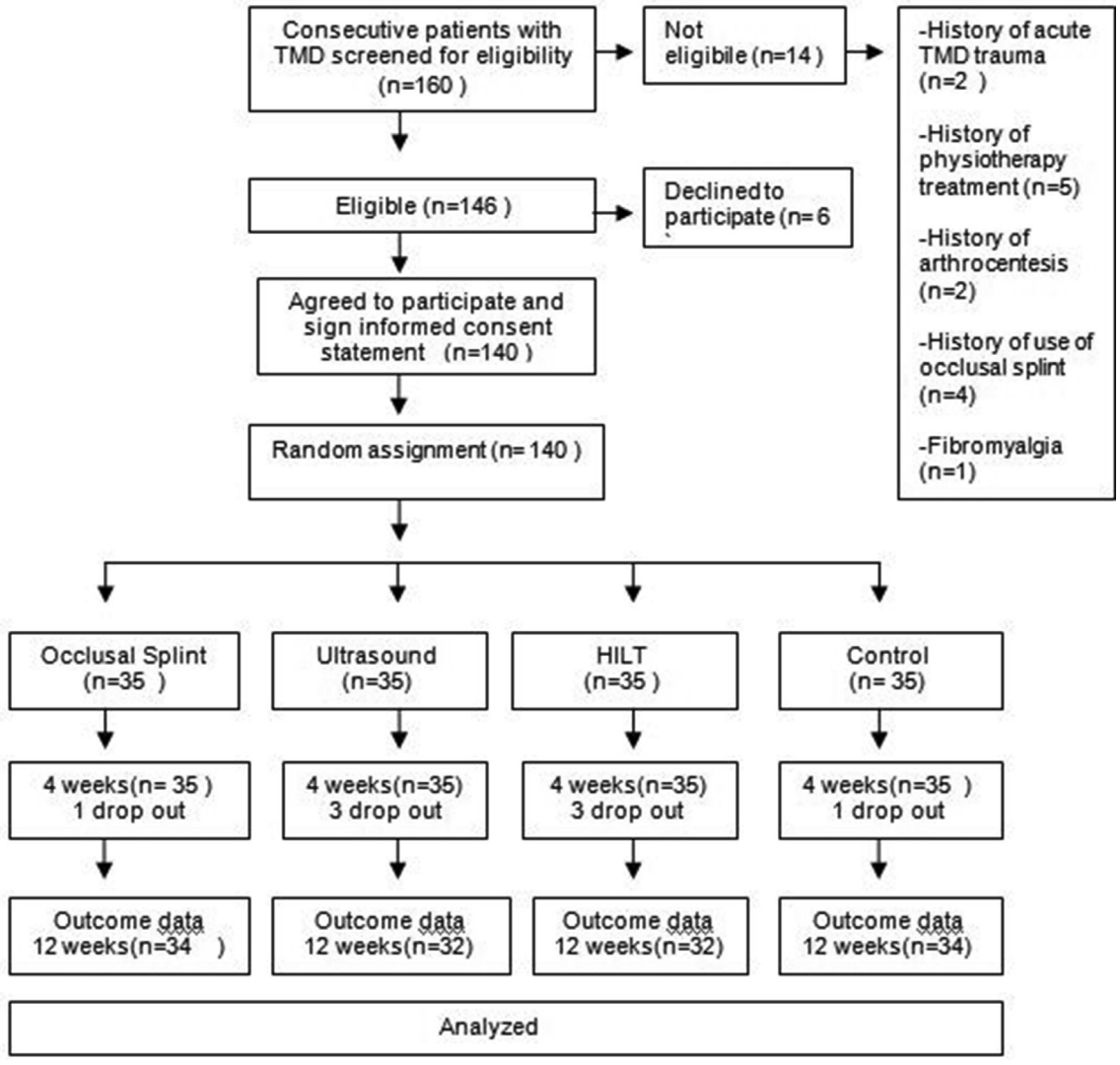

Fig. 1. Patients' details. Flow diagram of recruitment and retention of patients with disc displacement with reduction (DDWR).

Table 2
Demographic characteristics of the patients. Data are number (%) unless otherwise stated.

Variables	Occlusal splint (n = 34)	Ultrasound therapy (n = 32)	HILT therapy (n = 32)	Control (n = 34)	p value
Mean (SD) age (years)	28.58 (14.46)	28.81 (12.68)	31.50 (12.67)	29.47 (10.49)	0.786
Gender:					
Male	10 (29.4)	8 (25)	10 (31.3)	3 (8.8)	0.119
Female	24 (70.6)	24 (75)	22 (68.8)	31 (91.2)	
Mean (SD) body mass index (kg/cm^2)	22.92 (4.81)	23.18 (4.47)	24.42 (3.66)	24.02 (4.19)	0.459
Marital status:					
Married	12 (35.3)	12 (37.5)	14 (43.8)	19 (55.9)	0.435
Single	20 (58.8)	20 (62.5)	16 (50)	14 (41.2)	
Divorced	2 (5.9)	–	2 (6.3)	1 (2.9)	
Educational status:					
Primary school	10 (29.4)	8 (25)	4 (12.5)	8 (23.5)	0.001*
Secondary school	8 (23.5)	16 (50)	16 (50)	7 (20.6)	
High school	16 (47.1)	8 (25)	10 (31.3)	11 (32.4)	
Faculty and above	–	–	2 (6.3)	8 (23.5)	
Working status:					
Student	4 (11.8)	–	6 (18.8)	5 (14.7)	0.004*
Housewife	4 (11.8)	8 (25)	4 (12.5)	8 (23.5)	
Working	6 (17.7)	8 (25)	8 (25.1)	8 (23.5)	
Unemployed	12 (35.3)	14 (43.8)	14 (43.8)	12 (35.3)	
Retired	8 (23.5)	2 (6.3)	–	1 (2.9)	
Mean (SD) symptom duration (years)	2.47 (2.23)	1.80 (1.58)	2.37 (2.15)	2.58 (1.97)	0.422

HILT: High-intensity laser therapy, VAS: visual analogue scale; *p < 0.05.

observed. At the beginning of the study, there was no significant difference in the demographic characteristics of the groups, except for education and working status (Table 2).

In all treatment methods, there were statistically significant improvements in pain and MMO measurements at weeks four and 12 compared with the beginning of the treatment. (Table 3). In week four, the VAS pain score was significantly lower in the OS (41%), US (42%), and HILT (44%) groups compared with the control group (3%) (p < 0.001). Similarly, in week 12, the VAS pain score

Table 3
Comparison of mean (SD) maximum mouth opening (MMO) and visual analogue scale (VAS) values of groups at baseline, and at 4 and 12 weeks.

Variables	Occlusal splint (n = 34)	Ultrasound therapy (n = 32)	HILT (n = 32)	Control (n = 34)	p value
Max. mouth opening (mm):					
Baseline	35.75 (7.48)	35.75 (7.33)	30.50 (8.20)	33.41 (7.18)	
At 4th week	39.50 (7.27)	40.87 (7.54)	35.53 (5.87)	33.82 (6.61)	
Mean differences$^{\alpha}$	0.15 (0.10)^a	0.15 (0.14)^a	0.16 (0.22)^a	0.02 (0.04)^b	0.000**
At 12 th week	41.00 (8.74)	42.91 (7.16)	39.70 (4.37)	34.29 (6.32)	
Mean differences$^{\beta}$	0.22 (0.11)^a	0.25 (0.23)^a	0.19 (0.10)^a	0.03 (0.06)^b	0.000**
Assisted max. mouth opening(mm):					
Baseline	39.14 (7.24)	38.68 ± (7.69)	34.62 (8.19)	38.20 (5.97)	
At 4th week	41.10 (7.26)	43.18 (7.78)	38.00 (6.10)	38.82 (5.52)	
Mean differences$^{\alpha}$	0.08 (0.07)^a	0.11 (0.11)^a	0.09 (0.09)^a	0.02 (0.02)^b	0.000**
At 12 th week	44.28 (7.97)	44.91 (7.05)	41.22 (5.17)	39.29 (5.14)	
Mean differences$^{\beta}$	0.13 (0.08)^a	0.16 (0.23)^a	0.19 (0.06)^a	0.03 (0.03)^b	0.000**
VAS -pain (cm):					
Baseline	39.44 (26.39)	46.87 (23.47)	53.12 (22.92)	58.82 (21.42)	
At 4th week	22.50 (17.34)	24.37 (17.94)	26.42 (18.30)	56.61 (20.87)	0.000**
Mean differences$^{\alpha}$	0.41 (0.20)^a	0.42 (0.27)^a	0.44 (0.34)^a	0.03 (0.06)^b	
At 12 th week	19.50 (19.32)	9.16 (11.38)	18.18 (17.89)	55.14 (20.05)	0.000**
Mean differences$^{\beta}$	0.44 (0.40)^a	0.66 (0.18)^a	0.64 (0.32)^a	0.05 (0.13)^b	
VAS-Function (cm):					
Baseline	64.72 (24.19)	55.62 (26.38)	60.00 (20.94)	47.05 (22.09)	
At 4th week	78.21 (19.44)	83.75 (10.08)	67.85 (20.79)	50.00 (21.06)	
Mean differences$^{\alpha}$	0.18 (0.31)^a	0.32 (0.26)^a	0.17 (0.14)^a	0.03 (0.06)^b	0.000**
At 12 th week	77.36 (20.23)	89.16 (11.38)	79.09 (19.25)	52.20 (21.74)	
Mean differences$^{\beta}$	0.20 (0.33)^a	0.32 (0.24)^a	0.30 (0.26)^a	0.05 (0.13)^b	0.000**

HILT: High-intensity laser therapy,
α: percentage change from baseline (week 0) to week 4; β: percentage change from baseline (week 0) to week 12.
In each line, different superscripts indicate statistically significant difference between groups. * p < 0.05; ** p < 0.001.

Table 4
Comparison of mean Jaw Functional Limitation Scale-20 (JFLS-20) values of groups at baseline, and at 4 and 12 weeks. Data are mean (SD).

Variables	Occlusal splint (n = 34)	Ultrasound therapy (n = 32	HILT (n = 32)	Control (n = 34)	p value
Mastication:					
Baseline	10.88 (8.31)	15.50 (9.20)	19.06 (15.12)	17.67 (12.20)	
At week 4	9.85 (7.41)	12.25 (6.96)	13.33 (9.63)	17.32 (11.73)	
Mean differences$^{\alpha}$	0.06 (0.08)^{b}	0.16 (0.12)^{a}	0.20 (0.15)^{a}	0.01 (0.02)^{b}	0.000**
At week 12	8.94 (6.61)	12.00 (6.93)	14.40 (11.00)	17.05 (11.32)	
Mean differences$^{\beta}$	0.12 0.16)^{a}	0.18 (0.13)^{a}	0.18 (0.12)^{a}	0.01 (0.04)^{b}	0.000**
Vertical jaw mobility:					
Baseline	9.17 (11.83)	13.62 (9.22)	13.00 (9.62)	16.08 (9.80)	
At week 4	8.20 (10.45)	10.78 (7.06)	8.33 (5.03)	15.64 (9.22)	
Mean differences$^{\alpha}$	0.04 (0.06)^{b}	0.15 (0.20)^{a}	0.20 (0.21)^{a}	0.01 (0.03)^{b}	0.000**
At week 12	6.67 (8.22)	10.56 (6.66)	9.46 (6.24)	15.52 (9.09)	
Mean differences$^{\beta}$	0.10 (0.15)^{a}	0.16 (0.14)^{a}	0.16 (0.15)^{a}	0.02 (0.03)^{b}	0.000**
Emotional and verbal expression:					
Baseline	10.00 (11.82)	11.43 (11.07)	24.06 (27.56)	21.58 (21.18)	
At week 4	8.79 (10.11)	10.00 (9.42)	17.13 (16.94)	20.91 (20.01)	
Mean differences$^{\alpha}$	0.05 (0.07)^{b}	0.07 (0.08)^{b}	0.13 (0.15)^{a}	0.01 (0.02)^{b}	0.000**
At week 12	6.91 (7.72)	9.06 (7.24)	15.73 (14.65)	20.76 (19.97)	
Mean differences$^{\beta}$	0.15 (0.17)^{a}	0.11 (0.13)^{a}	0.17 (0.18)^{a}	0.01 (0.03)^{b}	0.000**
JFLS-20 total:					
Baseline	30.05 (22.71)	40.55 (32.83)	56.12 (48.80)	55.33 (47.30)	
At week 4	26.84 (22.03)	33.03 (26.62)	38.79 (31.00)	53.87 (44.06)	
Mean differences$^{\alpha}$	0.10 (0.15)^{c}	0.18 (0.20)^{b}	0.30 (0.32)^{a}	0.02 (0.03)^{d}	0.000**
At week 12	22.52 (17.53)	31.62 (25.02)	39.59 (32.03)	53.33 (42.09)	
Mean differences$^{\beta}$	0.25 (0.22)^{a}	0.22 (0.20)^{a}	0.29 (0.27)^{a}	0.03 (0.04)^{b}	0.000**

HILT: High-intensity laser therapy.
α: percentage change from baseline (week 0) to week 4; β: percentage change from baseline (week 0) to week 12.
In each line, different superscripts indicate statistically significant difference between groups. * $p < 0.05$; ** $p < 0.001$.

was significantly lower in the OS (44%), US (66%), and HILT (64%) groups compared with the control group (5%) ($p < 0.001$). MMO increased similarly in the three treatment groups at weeks four and 12, and the increase in all treatment groups was significantly higher than in the control group ($p < 0.001$).

In all treatment methods, there were significant improvements in both the total JFLS-20 and OHIP-14 scores at four and 12 weeks compared with the beginning of treatment. At four weeks, most improvement in JFLS-20 scores was in the HILT group (30%), followed by the US group (18%) (Table 4). There was a significant improvement in the total OHIP-14 score in the HILT (23%) and US (21%) groups at week four compared with the OS group (7%) (Table 5). However, at 12 weeks there was no significant difference between the three treatment groups in terms of improvement in total JFLS-20 and OHIP-14 scores.

Discussion

In this prospective, randomised, clinical study, the effects of three different conservative treatments on pain, function, disability, and quality of life of patients with DDWR were investigated. In all treatment groups (OS, US, and HILT), there were significant improvements in pain, function, disability, and quality of life at both weeks four and 12 compared with the control group ($p < 0.001$). There was no significant difference in terms of improvement in VAS pain and MMO between treatment groups.

However, significant improvements were observed in the JFLS-20 and OHIP-14 scores at week four in the US and HILT groups compared with the OS group. These results led to the partial acceptance of the null hypothesis.

Occlusal splints are frequently used in the treatment of TMD, although the mechanism of action is still controversial. The splint reduces overload within the TMJ by providing a stable position for the mandible and preventing parafunctional habits.[17] In this study OS therapy showed significant improvements in all parameters studied at four and 12 weeks of treatment compared with the control group. However, its effectiveness in reducing the symptoms was higher in week 12.

There is conflicting information in the literature regarding the effectiveness of US therapy in TMD. Some studies have reported that US alone has no effect on TMJ dysfunction.[18,19] On the other hand, another study[20] demonstrated that US combined with a home exercise programme can better improve the symptoms of patients with TMD. Gray et al[21] compared the effects of shortwave diathermy, US, and low-intensity laser therapy (LILT) in patients with TMJ dysfunction, and found no difference among them in terms of treatment outcomes. In this study, compared with OS and HILT, US had a similar effect on pain reduction at weeks four and 12. However, US was more effective in improving the quality of life and decreasing the disability of TMD patients than OS therapy at four weeks.

Some studies have reported that LILT is a suitable and alternative treatment for TMD-related pain and limited

Table 5
Comparison of mean Oral Health Impact Profile-14 (OHIP-14) values of groups at baseline, and at 4 and 12 weeks. Data are mean (SD).

Variables	Occlusal splint (n = 34)	Ultrasound therapy (n = 32)	HILT (n = 32)	Control (n = 34)	p value
Functional limitation					
Baseline	1.52 (1.35)	1.00 (1.61)	1.75 (2.04)	1.82 (2.45)	
At week 4	1.35 (1.15)	0.76 (1.10)	1.37 (1.71)	1.70 (2.24)	
percentage change	0.05 (0.12)[b]	0.05 (0.13)[b]	0.15 (0.27)[a]	0.02 (0.06)[b]	0.010*
At week 12	1.20 (0.94)	0.70 (1.08)	1.25 (1.45)	1.79 (2.34)	
percentage change	0.09 (0.17)[b]	0.07 (0.19)[b]	0.15 (0.21)[a]	0.01 (0.08)[b]	0.014*
Physical pain					
Baseline	3.41 (1.97)	3.26 (2.39)	3.12 (2.32)	4.17 (2.22)	
At week 4	3.05 (1.70)	2.40 (1.47)	2.25 (1.62	4.11 (2.12)	
Mean differences	0.07 (0.12)[b]	0.15 (0.20)[a]	0.20 (0.19)[a]	0.01 (0.18)[c]	0.000**
At week 12	2.38 (1.10)	2.56 (1.67)	2.56 (1.89)	4.08 (2.06)	
Mean differences	0.22 (0.20)[a]	0.12 (0.17)[a]	0.12 (0.15)[a]	0.01 (0.18)[b]	0.000**
Psychological discomfort					
Baseline	2.82 (1.84)	1.80 (1.82)	3.06 (2.16)	2.70(2.13)	
At week 4	2.70 (1.71)	1.53 (1.47)	2.43 (1.79)	2.61 (2.04)	
Mean differences	0.02 (0.06)[b]	0.06 (0.11)[b]	0.17 (0.19)[a]	0.01 (0.06)[b]	0.000**
At week 12	2.47 (1.48)	1.36 (1.27)	2.25 (1.66)	2.50 (1.87)	
Mean differences	0.07 (0.11)[b]	0.10 (0.15)[b]	0.22 (0.20)[a]	0.03 (0.08)[b]	0.000**
Physical disability					
Baseline	2.41 (2.33)	1.73 (2.30)	1.75 (1.74)	1.61 (1.75)	
At week 4	2.26 (2.06)	1.10 (1.39)	1.06 (1.10)	1.55 (1.61)	
Mean differences	0.02 (0.05)[c]	0.12 (0.19)[b]	0.21 (0.26)[a]	0.01 (0.04)[c]	0.000**
At week 12	2.02 (1.66)	1.23 (1.59)	1.18 (1.35)	1.52 (1.52)	
Mean differences	0.05 (0.12)[b]	0.09 (0.15)[b]	0.19 (0.25)[a]	0.01 (0.05)[b]	0.000**
Psychological disability					
Baseline	2.41 (1.81)	0.93 (1.20)	2.12 (2.12)	2.11 (2.19)	
At week 4	2.29 (1.69)	0.83 (1.08)	1.75 (1.88)	2.00 (1.98)	
Mean differences	0.03 (0.10)[b]	0.03 (0.11)[b]	0.12 (0.18)[a]	0.01 (0.05)[b]	0.003*
At week 12	2.08 (1.46)	0.70 (0.91)	1.56 (1.56)	1.94 (1.85)	
Mean differences	0.07 (0.13)[b]	0.11 (0.26)[a]	0.15 (0.20)[a]	0.02 (0.07)[c]	0.047*
Social disability					
Baseline	2.47 (2.32)	1.80(1.58)	2.37 (2.15)	2.58 (1.97)	
At week 4	2.35 (2.02)	1.63 (1.35)	1.93 (1.77)	2.52 (1.84)	
Mean differences	0.01 (0.05)[b]	0.03 (0.08)[b]	0.11 (0.17)[a]	0.00 (0.03)[b]	0.000**
At week 12	2.17 (1.78)	1.53 (1.22)	1.75 (1.45)	2.44 (1.69)	
Mean differences	0.05 (0.10)[b]	0.05 (0.13)[b]	0.14 (0.17)[a]	0.02 (0.07)[b]	0.001*
Handicap					
Baseline	1.05 (1.36)	0.86 (1.10)	1.00 (1.83)	1.91 (1.97)	
At week 4	0.97 (1.24)	0.73 (0.86)	0.87 (1.60)	1.85 (1.81)	
Mean differences	0.02 (0.08)	0.04 (0.13)	0.04 (0.12)	0.00 (0.03)	0.425*
At week 12	0.88 (1.09)	0.73 (0.86)	0.81 (1.57)	1.76 (1.61)	
Mean differences	0.05 (0.11)	0.04 (0.13)	0.07 (0.16)	0.02 (0.07)	0.457*
OHIP-14 total score					
Baseline	16.09 (8.65)	11.38 (6.01)	15.17 (7.43)	16.90 (8.22)	
At week 4	14.97 (6.54)	8.98 (5.98)	11.66 (6.25)	16.34 (8.06)	
Mean differences	0.07 (0.16)[b]	0.21 (0.02)[a]	0.23 (0.02)[a]	0.03 (0.01)[b]	0.000**
At week 12	13.20 (6.98)	8.81 (5.44)	11.36 (6.02)	16.03 (8.00)	
Mean differences	0.18 (0.25)[a]	0.22 (0.02)[a]	0.25 (0.02)[a]	0.05 (0.012)[b]	0.000**

HILT: High-intensity laser therapy.
α: percentage change from baseline (week 0) to week 4; β: percentage change from baseline (week 0) to week 12.
In each line, different superscripts indicate statistically significant difference between groups. * $p < 0.05$; ** $p < 0.001$.

mouth opening,[22] but some studies have reported that it has no effect on the treatment of pain, swelling, and trismus in TMJ dysfunction.[23,24] HILT can stimulate joints more deeply and treat a wider area than LILT, thus HILT for TMD may improve pain and function more than LILT. HILT has been known to reduce heat accumulation in tissues and to have photothermal and photochemical effects on deep tissues for limited periods.[25] This study has demonstrated that in patients with DDWR, the effectiveness of HILT is similar to that of US and OS therapy in reducing pain and increasing mouth opening. However, HILT also has quite positive effects on disability and quality of life compared with other methods.

This study may have some limitations due to its methodology. Different results can be obtained with HILT when it is used with different power and wavelengths and different durations. OS treatment is inherently dependent on patient compliance, and poor compliance may affect its success. In

addition, self-reported VAS pain, disability, and quality of life scales may be subjective in nature. In this study, the long follow-up period was limited to three months, similar to that reported in the literature, but longer follow-up periods are required to evaluate the true effectiveness of the treatments.

The strengths of this study are that it was, to our knowledge, the first study to apply HILT treatment to TMDs, to evaluate healing both in the short and long term, and to use psychosocial parameters in addition to physiological parameters in the evaluation.

Conclusıon

OS, US, and HILT resulted in significant improvements in pain, function, disability, and quality of life in patients with DDWR, both in the short and long term. HILT, a new treatment, has been found to be as effective as OS and US in patients with painful TMD. The short-term effects of US and HILT treatment on disability and quality of life were better than OS in this study. HILT can be an alternative treatment for TMD because it can stimulate deeper and larger tissues than LILT and so transfer more energy to the tissues. A large number of randomised controlled clinical studies are now needed on the therapeutic effects of HILT in TMD patients.

Conflict of interest

We have no conflicts of interest.

Ethics statement/confirmation of patients permission

This study was approved by the Human Research Ethics Committee of the Faculty of Medicine, Afyonkarahisar Health Sciences University (Decision no: 2019/184). Patients were given a full explanation of the treatment protocol and asked to sign written informed consent. The study was carried out according to the Helsinki Declaration.

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