Comparison of the Efficiency of High-Intensity Laser Therapy and Transcutaneous Electrical Nerve Stimulation Therapy in Patients With Symptomatic Temporomandibular Joint Disc Displacement With Reduction

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Purpose: Many different treatment modalities have been tried in the treatment of temporomandibular joint (TMJ) disorders and different results have been reported. The aim of the study was to investigate and compare the effects of high-intensity laser therapy (HILT) and transcutaneous electrical nerve stimulation (TENS) therapy on the treatment of patients with TMJ disc displacement with reduction(DDWR).

Methods: Researchers conducted a prospective, single-blind, controlled clinical trial on patients with TMJ disc disease at a university's oral and maxillofacial surgery clinic. One hundred two patients were randomized into 3 groups (HILT, TENS and control group). The patients were evaluated in terms of maximum mouth opening (MMO), assisted MMO, Visual Analog Scale (VAS) (pain), and VAS (function). In addition, the disability status of the patients with the Jaw Functional Limitation Scale-20 (JFLS-20) and the quality-of-life with the Oral Health Impact Profile (OHIP-14) was evaluated.

Results: At the start of the trial, in terms of socio-demographic characteristics, no significant differences existed between the groups. Significant improvements were seen in pain (VAS), MMO, total JFLS-20 and total OHIP-14 scores in the HILT and TENS groups compared to the control group. At week 4, the VAS pain score decreased significantly in the HILT group compared to the TENS group (48 and 25%, respectively), while the MMO was significantly increased (24 and 10%, respectively). In addition, there was a significant improvement in both the total JFLS-20 score and the total OHIP-14 score at weeks 4 and 12 in the HILT group compared to the TENS group ($P < .05$).

Conclusion: It was observed that the healing effect of pulsed Nd: YAG laser therapy was significantly higher than TENS in patients with DDWR. Therefore, HILT should be a priority option over TENS therapy in patients with disc displacement.

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Temporomandibular joint (TMJ) disc displacement is 1 of the most frequent temporomandibular disorders (TMDs) and is classified as either disc displacement with reduction (DDWR) or disc displacement without reduction (DDWoR).[1] DDWR is 1 of the most prevalent internal disorders of TMJ, accounting for 41% of intra-articular disorders.[2] DDWR can also be found in 33% of asymptomatic people.[3] Depending on the degree and term of the locking, DDWR might be painful or not. Symptoms of disc displacement include joint pain, clicking, limited range of mouth opening, masticatory difficulties, and mandibular dysfunction, all of which can be quite disruptive to a person's life.[4]

There are various forms of treatment available for TMDs. The different physiotherapy approaches used are moist heat, laser, ultrasound, exercise, transcutaneous electrical nerve stimulation (TENS), microwave, and manual therapy.[5] TENS is widely used in medicine as a pain reliever outside the orofacial area.[6] TENS is a medical system that consists of self-adhesive electrodes connected to a control box, also known as a neurostimulator, by a cord.[7] The system causes hyperactive muscle relaxation and decreases or eliminates pain by applying an electrical current through electrodes connected to the skin. Many hypotheses for their success have been established. Direct motor nerve stimulation can trigger muscle rhythmic contractions that increase blood flow and decrease muscle edema and hypoxia, resulting in pain reduction. The second hypothesis is based on the gate control theory, which reduces or stops impulse transmission from smaller afferent nerve fibers by closing pain gates in the spinal cord using electric current or pressure applied to larger afferent nerve fibers.[8] TENS is commonly used to alleviate acute and chronic pain in a number of myofascial pains such as back pain, neck pain, and extremity pain, but few studies have been conducted to relieve orofacial pain and TMD pain.[9] Some studies have shown no proof of TENS efficacy in range opening of the jaw or muscle activity in TMD patients.[10,11] However, TENS has been reported to be effective in decreasing pain and enhancing mastication functions in patients with chronic TMD in the short-term.[12-14]

Laser treatment, which has a bio-modulative impact on tissues, was first presented in the early 1960s as a way to decrease inflammation and pain while also speeding up healing in target tissues. Different mechanisms for the effects of lasers have been shown. These include a wide range of therapeutic effects such as stimülating the release of endogenous opioids, increasing vasodilation, increasing cell respiration and tissue healing, reducing inflammation by decreasing prostaglandin E2 and cyclooxygenase 2 levels, increasing the pain threshold by impacting the cellular membrane potential.[15-17] The low-level laser beam of 600 to 800 nm wavelength is widely used in TMD treatment. While the laser produces analgesic and vasodilation effects by stimulating cutaneous nerve endings, it also causes stimulation in various cells and tissues.[18] By stimulating protein synthesis in synovial fluid, it enhances the release of beta-endorphin, resulting in analgesic and anti-inflammatory effects.[19] Recently, neodymium-doped yttrium aluminum garnet (Nd: YAG) laser, which is a kind of intense laser with high peak power (3 kW) and a wavelength of 1.064 nm, has been introduced as a new treatment method. HILT has the ability to penetrate and stimulate larger and/or deeper areas, delivering significantly more energy to the tissue than LLLT. HILT type, pulsed Nd:YAG laser therapy has been used successfully in a wide variety of musculoskeletal diseases.

Ankle pain,[20] low back pain,[21,22] subacromial impingement syndrome,[23] and knee osteoarthritis[24,25] have all been shown to benefit from pulsed Nd: YAG laser therapy for pain management. To the best of our knowledge, no research has studied the efficacy of HILT in patients with TMD. The aim of this randomized controlled study is to assess the effects of HILT and TENS treatment on TMJ pain and jaw range of motion in patients with DDWR. The null hypothesis to be tested is that there is no difference between HILT and TENS methods in the treatment of patients with symptomatic DDWR. The specific aims of the study were:*1)* To investigate the healing effects of treatments on DDWR both in the short-term (week 4) and in the long-term (week 12). *2)* To use psychosocial parameters as well as clinical physiological parameters while evaluating the recovery of patients.

Methods

STUDY DESIGN/SAMPLE

To address the research aim, the researchers planned and implemented a prospective, single-blind, controlled clinical trial. The study population consisted of patients presenting for complaints of TMJ sounds and pain between January 2019 and April 2019 in the Afyonkarahisar Health Sciences University, Faculty of Dentistry, Oral and Maxillofacial Surgery Clinic.

A total of 102 individuals with unilateral TMD who fell under Axis I, group II (disc displacement) of the DC/TMD were included in the research.[26] The inclusion criteria for the study were unilateral DDWR (patient report of any noise present during the exam or in the last 30 days, any TMJ noise(s) present with jaw movement or function). Disc displacement was determined by MRI images, and patients with anterior DDWR and biconcave disc shape were included. In addition, the psycho-social status of the patients was examined in line with axis-2. Patients with DDWR who complained of TMJ pain and dysfunction were

involved in the study, and patients with asymptomatic DDWR were excluded. Patients were excluded as study subjects if the history of trauma and previous TMJ surgery, inflammatory rheumatic disease, neuromuscular diseases, continuing or previous malignancy history, a history of arthrocentesis, or physical therapy for the TMJ region was within the last 6 months. In addition, patients with cardiac dysrhythmias or using pacemakers, patients with disc displacement without reduction and age less than18 years were excluded. The local ethics committee of the university approved the study (Decision no: 2019/183), and the study was conducted in accordance with the principles of the Declaration of Helsinki. The methodology of the study was explained to all participants and their written consents were obtained.

INTERVENTIONS

Using a numbered envelope approach, patients were randomly assigned to 1 of 3 groups (HILT group, TENS group, and control group). HILT group received pulsed Nd: YAG laser+exercise, TENS group received TENS+exercise and control group only received exercise).

HILT (pulsed Nd:YAG Laser Therapy)

Patients were given pulsed Nd: YAG laser therapy produced by the HIRO 3 device (ASA Laser, Arcugnano, Italy) 5 times a week for a period of 3 weeks. A 3-phase treatment program for the TMD area was performed in each session. The first phase involved rapid manual scanning of the TMJ area both transversely and longitudinally (100 cm^2 per 30 second). The second phase involved applying the 90˚ handpiece to the trigger points on the masseter and temporal muscle with vertically fixed spacers. The third stage involved slow manual scanning of the TMJ region (100 cm^2 in 60 seconds). During a 20-minute session, a total of 1060 J of energy was given to the patient (500j in the first stage, 60j in the second stage and 500j in the third stage).

TENS Therapy

Patients were given 20 minutes conventional Intelect TENS (The Intellect, ChattanoogaGroup, Hixson, TN) with 50 Hz frequency and 20e60ms transition period at the tingling current level. A positive electrode was placed on the TMJ region and an inert electrode was placed on the back of the neck, and the sensitive muscles in the TMJ region were treated for 20 minutes at a frequency of 75 Hz and a pulse width of 0.75 milliseconds. In order for the procedure not to be painful, the power of the device was adjusted according to the sensitivity and tolerance of the patient.[27] This treatment was applied as 15 sessions for 3 weeks.

Exercise Program

All patients in 3 groups (HILT, TENS, control) performed mobilization exercises, isometric strengthening exercises (resistance training), active ROM exercises, coordination exercises, and postural exercises for 10 minutes once a day, for a period of 3 weeks. While the control group received only the exercise program, the HILT and TENS groups applied the same exercise program, similar to the control group, except for the treatment. Patients were asked not to take any analgesic and/or anti-inflammatory drugs until the study was completed. All treatments were performed in a standard manner by the same physiotherapist.

DATA COLLECTION METHODS AND OUTCOMES

The patient's socio-demographic characteristics, the presence of jaw deviation, joint sounds, locking, jaw pain, and maximum mouth opening (MMO) were recorded. TMJ clicking was recorded as present or absent while joint and muscle tenderness and pain were recorded on a scale from 0 (no pain) to 3 (intorelable pain). Pain intensity and degree of decrease in jaw functions were evaluated with the Visual Analog Scale (VAS). Patients were asked to mark the severity of their TMJ pain on a 10 cm long line between points 0 and 10 (point 0 is painless, point 10 is the worst pain). The distance between the marked point and point 0 was measured in mm with a ruler.[28] Similarly, jaw function was assessed using a 10 cm VAS (0, no function; 10, no decreased function). Using an electronic caliper, MMO was calculated as the distance between the incisal edges of the upper and lower central incisors.[29] The changes in functional impairment were measured using the Jaw Functional Limitation Scale-20 (JFLS-20) which has 3 subcomponents.[30] The Oral Health Impact Profile (OHIP-14) questionnaire was used to measure the quality-of-life. The OHIP-short form questionnaire consists of 14 questions and 7 subcomponents that aim to measure the perception of patients of the effect their oral conditions have on their quality-of-life.[31] Before and after therapy (weeks 4 and 12), patients were assessed by a blinded researcher, however, patients were aware of the treatment they were receiving (single-blind method).

DATA ANALYSES

The sample size was calculated as 45 subject using the G*Power version 3.1.9.2 program(Heinrich-Heine-Universität Dusseldorf, Germany; power 0.95, a = 0.05, b = 0.05)., based on the data of the previous study.[32] Considering the possibility of patients leaving before completing the treatment, 110 patients were involved in the study. Patients were enrolled in accordance with the CONSORT (Consolidated Standards of Reporting Trials) criteria (Fig 1). Data were analyzed

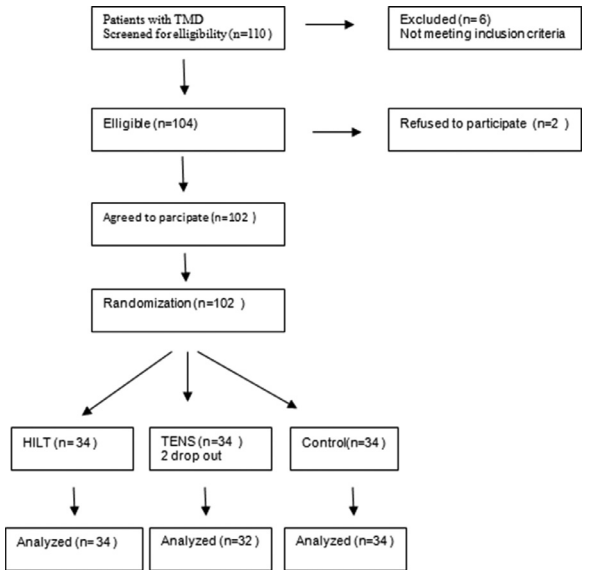

FIGURE 1. Flowchart diagram for the participants who were randomized into 3 groups as receiving high-intensity laser therapy (HILT), transcutaneous electrical nerve stimulation (TENS), and control.

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with the Statistical Package for the Social Sciences (SPSS 20.0, Chicago, IL, United States). The normal distribution of data was evaluated using the Kolmogorov-Smirnov test. Pre- and post-treatment values within the group were compared with the paired *t*-test or Wilcoxon test. When comparing categorical variables, the Chi-square test was employed. In comparison between groups, a 1-way ANOVA test or Kruskal Wallis test was employed. The level of significance was set at $P < .05$.

Results

One hundred two patients were divided into 3 groups (HILT, TENS and control group), involving 34 patients in each group. A total of 100 patients completed the study, as 2 patients left the TENS group before completing the study (Fig 1). There were no treatment-related adverse effects identified in the participants in the trial.

Some sociodemographic and clinical characteristics of the patients were given in Table 1. The patients were between the ages of 18 to 60 (mean age 32.22). The female to male ratio was approximately 9:1. There was no significant difference in demographic characteristics of the groups at the start of the study (Table 1).

Statistically, significant difference was observed for all variables in the HILT group after treatment (4th and 12th weeks) compared to before treatment (Table 2). While the average VAS pain level of the patients was 68.23 before treatment, it decreased to 35.29 after the treatment, and the average VAS function level increased from 49.41 to 68.23. The mean maximum mouth opening of the patients increased from 32.58 to 41.11 mm, and the assisted maximum mouth opening increased from 35.70 to 43.23 mm. In the same period, the JFLS-20 total score decreased from 86.88 to 60.40, while the OHIP-14 total score decreased from 21.17 to 17.03.

Similar to the HILT group, statistically significant differences were observed in all variables in the TENS group after treatment (4th and 12th weeks) compared to before treatment (Table 3). VAS pain level decreased from 63.12 before treatment to 48.12 after treatment (4th week), and VAS function level increased from 38.75 to 54.37. Similarly, the maximum mouth opening increased from 33.18 to 37.18 mm, while the assisted maximum opening increased from 36.12 to 39.62 mm. During the same period, the total JFLS-20 score of the patients decreased from 56.43 to 45.40 and the total OHIP-14 score from 24.31 to 21.38. In the control group, in contrast to the HILT and TENS groups, no significant difference was seen for all variables after treatment (4th and 12th weeks) according to the beginning of the treatment (Table 4).

After treatment (weeks 4 and 12), all groups' percentage changes were compared according to pre-treatment values and are given in Table 5 and Table 6, respectively. Significant improvements were observed in pain, mouth opening, total JFLS-20, and total OHIP-14 scores in the HILT and TENS groups compared to the control group. While there was a significant reduction in VAS pain scores at 4 weeks in the HILT group compared to the TENS group (48 and 25%, respectively), there was no significant difference between the groups at 12 weeks (Fig 2). The increase in VAS function values was similar in both groups at week 4 and 12. In the HILT group, the increase in MMO was significantly higher than in the TENS group at the 4th week (respectively, 24 and 10%), while both groups showed a similar increase at the 12th week (Fig 3). At 4 and 12 weeks, both total JFLS-20 and total OHIP-14 scores improved more in the HILT group than in the TENS group ($P < .05$). While these healings were observed in almost all of the JFLS-20 sub-dimensions, they were seen in some of the OHIP-14 sub-dimensions (physical pain and functional disability).

Discussion

In this randomized controlled study, the effects of HILT and TENS treatment on TMJ pain, range of

Table 1. DEMOGRAPHIC AND CLINICAL FEATURES OF HILT GROUP, TENS GROUP, AND CONTROL GROUP

	HILT group (n=34)	TENS group (n=34)	Control group (n=32)	*P* value
Age	33.23 ± 11.66	32.25 ± 10.60	31.17± 11.28	0.751
Sex (n, %)				
Female	30 (88.24)	30 (93.75)	31(91.17)	0.736
Male	4 (11.76)	2 (6.25)	3 (8.82)	
BMI (kg/cm^2)	26.31 ± 5.03	24.41 ± 4.09	24.66 ± 5.01	0.213
Marrital status (n, %)				
Married	22 (64.71)	20 (62.50)	23 (67.34)	
Single	8 (23.53)	10 (31.25)	10 (29.41)	0.111
Divorced	4 (11.76)	2 (6.25)	1 (2.94)	
Duration of illness(years)	3.53 ± 4.23	2.37 ± 2.15	2.17 ± 1.80	0.422
Unilateral disc displacement (R/L) (n)	14/20	16/16	16/18	0.502
TMJ sounds(clicking etc.) (n,%)	23 (67.64)	22 (65.62)	24 (70.58)	0.643
Deviation (n, %)	20 (58.82)	18 (56.25)	19 (55.88)	0.841
Pain/tenderness on TMJ palpation (n, %)				
Mild	5 (14.70)	5 (15.62)	6 (17.64)	
Moderate	17 (50)	16 (50)	16 (47.05)	0.542
Severe	12 (35.29)	11(34.37)	12 (35.29)	
Pain during jaw movements(n,%)	25 (73.52)	24 (75)	26 (76.47)	0.244
Pain on muscles palpation (n,%)				
Masseter muscle	20 (58.82)	19(59.37)	22 (64.70)	
Temporal muscle	9 (26.47)	8(25)	9 (26.47)	0.338
Temporal muscle tendon	14 (41.11)	13(40.62)	15(44.11)	
Sleep bruxism (n,%)	24 (70.57)	22 (68.75)	24 (70.57)	0.118
Additional symptoms(n,%)				
Headache	22 (64.70)	20 (62.50)	23 (67.64)	
Earache	10 (29.41)	10 (31.25)	11 (32.35)	
Neck pain	14 (44.1)	13 (40.62)	15 (44.11)	0.244
Tinnitus	12 (35.29)	10 (31.25)	11 (32.35)	
Maximum mouth opening (mm)	32.58	33.18	32.55	0.382
Assisted maximun mouth opening(mm)	35.70	36.12	37.50	0.256

Abbreviations: BMI,Body Mass Index; HILT, High intensity laser therapy; L,Left; n, Number R, Right; TMJ, Temporomandibular joint; TENS, Transcutanous electrical nerve stimulation.

Data were presented as mean ± SD or n (%)

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motion, disability, and quality-of-life in patients with DDWR were evaluated and compared. Patients in the HILT and TENS groups had significant improvements in pain, function, disability, and quality-of-life after treatment compared to the control group. But the HILT group showed a higher recovery rate in all parameters than the TENS group, supporting the rejection of the null hypothesis. There was no significant difference between pre-treatment and post-treatment recovery parameters in the control group.

Because HILT has the ability to stimulate deeper and/or broader regions than LLLT, its use has recently increased in many musculoskeletal disorders.[33] The benefits of Nd:YAG laser therapy in individuals with pain have been demonstrated in recent studies.[21,34] In the present study, pain intensity was measured with VAS, and a significant decrease was observed in the pain scores of TMD patients treated with HILT at the 4th and 12th week after the treatment (48 and 49%, respectively). The MMO enhanced by 24% at the 4th week and by 37% at the 12th week after the treatment. Similarly, there was an increase of 15% in the 4th week and 53% in the 12th week in VAS function values. These findings show that the effect of HILT treatment on jaw functions is better in the long-term.

TENS is a safe, non-invasive, effective, and rapid method of providing analgesia, and is widely used as a physical therapy method.[9] Although some studies have shown that TENS has no effect in increasing the jaw opening,[10,35] other studies have reported that

Table 2. COMPARISONS OF THE PRETREATMENT (WEEK 0), AND POST-TREATMENT (WEEKS 4 AND 12) EVALUATION PARAMETERS IN HILT GROUP

	Baseline (Wk 0)	Wk 4	Wk12	*P* (baseline −wk 4)	*P* (baseline −wk 12)
Pain (VAS) (cm)	68.23 ± 18.16	35.29 ± 22.59	34.54 ± 27.03	0.000†	0.000†
Function (VAS) (cm)	49.41 ± 20.44	68.23 ± 19.45	68.18 ± 17.89	0.002*	0.000†
Max. mouth open(mm)	32.58 ± 7.63	41.11±7.37	42.40 ± 5.73	0.000†	0.000†
Assisted max. mouth open	35.70 ± 8.47	43.23 ± 6.49	43.60 ± 5.96	0.000†	0.001*
JFLS-20, mastication	29.58 ± 15.79	20.47 ± 10.15	22.94 ± 12.30	0.000†	0.000†
JFLS-20, mobilization	21.76 ± 10.68	14.52±6.57	16.94 ± 8.01	0.000†	0.000†
JFLS-20, communication	35.52 ± 27.62	25.41 ± 17.75	23.88 ± 17.34	0.000†	0.000†
JFLS-20 Total	86.88 ± 44.26	60.40 ± 39.54	63.76 ± 41.08	0.000†	0.000†
OHIP-14, functional limitation	2.00 ± 1.77	1.70 ± 1.62	1.47 ± 1.26	0.006*	0.000†
OHIP-14, physical pain	5.41 ± 1.51	4.00 ± 1.43	4.64 ± 1.39	0.000†	0.000†
OHIP-14, psychological discomfort	3.17 ± 1.64	2.76 ± 1.41	2.52 ± 1.16	0.000†	0.000†
OHIP-14, physical disability	3.05 ± 2.32	2.17 ± 1.74	2.11 ± 1.70	0.000†	0.000†
OHIP-14, psychological disability	3.23 ± 2.29	2.70 ± 1.69	2.58 ± 1.67	0.000†	0.000†
OHIP-14, social disability	2.70 ± 2.43	2.41 ± 2.11	2.23 ± 1.95	0.001*	0.000†
OHIP-14, handicap	1.58 ± 2.00	1.29 ± 1.58	1.23 ± 1.45	0.001*	0.002*
OHIP-14 total	21.17 ± 9.24	17.03 ± 8.37	16.78 ± 8.01	0.000†	0.000*

Abbreviations: JFLS-20, Jaw Functional Limitation Scale-20; OHIP-14, Oral health impact profile-14; VAS, Visual analogue scale.
* $P < .05$
† $P < .001$

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Table 3. COMPARISONS OF THE PRETREATMENT (WEEK 0), AND POST-TREATMENT (WEEKS 4 AND 12) EVALUATION PARAMETERS IN TENS THERAPY GROUP

	Baseline (Wk 0)	Wk 4	Wk 12	*P* (Baseline −wk 4)	*P* (Baseline −wk 12)
Pain (VAS) (cm)	63.12 ± 18.56	48.12 ± 23.34	37.69 ± 27.46	0.000†	0.000†
Function (VAS) (cm)	38.75 ± 21.81	54.37 ± 23.54	63.07 ± 24.78	0.007*	0.008*
Max. mouth open(mm)	33.18 ± 6.00	37.18 ± 5.47	41.81 ± 5.67	0.000†	0.000†
Assisted max. mouth open	36.12 ± 5.97	39.62 ± 6.07	43.18 ± 5.06	0.000†	0.000†
JFLS-20, mastication	21.56 ± 13.10	17.53 ± 10.46	18.09 ± 10.89	0.000†	0.000†
JFLS-20, mobilization	14.00 ± 9.83	11.25 ± 7.83	11.71 ± 8.14	0.000†	0.000†
JFLS-20, communication	20.87 ± 21.01	16.62 ± 15.72	15.56 ± 14.96	0.000†	0.000†
JFLS-20 Total	56.43 ± 40.05	45.40 ± 31.02	45,36 ± 31.05	0.000†	0.000†
OHIP-14, functional limitation	2.75 ± 2.25	2.31 ± 1.61	2.28 ± 1.85	0.002*	0.000†
OHIP-14, physical pain	4.31 ± 2.45	3.65 ± 1.91	3.56 ± 1.93	0.000†	0.000†
OHIP-14, psychological discomfort	5.00 ± 1.75	4.59 ± 1.52	4.43 ± 1.36	0.000†	0.000†
OHIP-14, physical disability	2.87±2.09	2.31±1.53	2.53 ± 1.77	0.000†	0.000†
OHIP-14, psychological disability	3.43 ± 2.24	3.03 ± 1.85	2.90 ± 1.76	0.000†	0.000†
OHIP-14, social disability	4.00 ± 2.59	3.68 ± 2.29	3.53 ± 2.07	0.001*	0.002*
OHIP-14, handicap	2.06 ± 2.07	1.81 ± 1.73	1.75 ± 1.62	0.003*	0.005*
OHIP-14 Total	24.31 ± 10.17	21.38 ± 9.86	20.98 ± 9.27	0.000†	0.000†

Abbreviations: JFLS-20, Jaw Functional Limitation Scale-20; OHIP-14, Oral health impact profile-14; VAS, Visual analogue scale.
* $P < .05$
† $P < .001$

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Table 4. COMPARISONS OF THE PRETREATMENT (WEEK 0), AND POST-TREATMENT (WEEKS 4 AND 12) EVALUATION PARAMETERS IN CONTROL GROUP

	Baseline (Wk 0)	Wk 4	Wk 12	*P* (Baseline −wk 4)	*P* (Baseline −wk 12)
Pain (VAS) (cm)	58.23 ± 20.37	58.08 ± 18.35	57.00 ± 18.96	0.792	0.052
Function (VAS) (cm)	47.05 ± 23.03	47.82 ± 21.74	47.91 ± 21.49	0.205	0.081
Max. mouth open(mm)	32.55 ± 7.52	32.70 ± 7.17	32.97 ± 6.79	0.361	0.070
Assisted max. mouth open	37.50 ± 6.07	37.64 ± 5.52	37.85 ± 5.46	0.598	0.067
JFLS-20, mastication	19.88 ± 13.75	19.00 ± 13.59	18.88 ± 0.83	0.062	0.083
JFLS-20, mobilization	16.91 ± 10.01	15.79 ± 9.86	15.88 ± 9.62	0.086	0.242
JFLS-20, communication	18.88 ± 19.37	17.94 ± 19.47	18.08 ± 19.27	0.609	0.825
JFLS-20 Total	55.67 ± 33.78	52.73 ± 31.70	52.84 ± 31.72	0.061	0.083
OHIP-14, functional limitation	1.88±2.25	1.85±2.10	1.79 ± 2.07	0.571	0.263
OHIP-14, physical pain	3.88 ± 2.04	3.64 ± 1.84	3.64 ± 1.82	0.535	0.422
OHIP-14, psychological discomfort	2.58 ± 1.72	2.44 ± 1.72	2.35 ± 1.45	0.160	0.096
OHIP-14, physical disability	1.67 ± 1.75	1.44 ± 1.58	1.47 ± 1.50	0.134	0.160
OHIP-14, psychological disability	2.05 ± 2.01	1.73 ± 1.62	1.70 ± 1.54	0.103	0.096
OHIP-14, social disability	2.17 ± 1.80	2.00 ± 1.63	1.91 ± 1.48	0.325	0.134
OHIP-14, handicap	1.64 ± 1.73	1.55 ± 1.56	1.55 ± 1.58	0.184	0.083
OHIP-14 Total	15.94 ± 9.01	14.65 ± 8.89	14.41 ± 8.72	0.152	0.086

Abbreviations: JFLS-20, Jaw Functional Limitation Scale-20; OHIP-14, Oral health impact profile-14; VAS, Visual analogue scale.

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TENS is effective in relaxing the masticatory muscles, reducing facial pain, and increasing the jaw opening.[12,13,36] The TENS is a safe, non-invasive, effective and rapid method of providing analgesia, and it widely used as physical therapy methods.[9] Although some studies have shown that TENS has no effect in increasing the jaw opening,[10,35] other studies have reported that TENS is effective in relaxing the masticatory muscles, reducing facial pain and increasing the jaw opening.[12,13,36] In present study, pain scores of patients with TMJ disc displacement decreased by 25% at the 4th week and by 44% at the 12th week. In the majority of previous studies, patients with myogenic TMDs reported an estimated 57% reduction in pain following TENS therapy.[9] Wessberg et al [37] reported that TENS reduced patients' myofascial pain by 95%. Patil et al [38] reported that a decrease in 74.19% VAS scores following TENS treatment in patients with myositis and myofascial pain. These findings in the literature show that TENS treatment has a higher pain reduction effect in myogenic TMDs.

Studies reported an increase in the range of mandibular movements, including inter-incisal distance, in patients with TMD after the TENS therapy. Patil et al [38] reported a 19.46% increase in mouth opening in TMD patients after TENS treatment. Some studies reported an increase in mouth opening of 5.3 to 13% in TMD patients after TENS treatment.[9] In the present study, similar to the literature, there was a 10% increase in the maximum mouth opening at the 4th week and 23% in the 12th week in TENS group. Similar increases were seen in assisted maximum mouth opening (8 and 15%, respectively).

There have been some studies comparing the efficiency of TENS and LLLT on patients with TMD. Keto et al [39] reported that both treatments were effective in reducing the symptoms of patients with TMD. Mansourian et al [40] reported that HILT and TENS treatment resulted in similar improvements in reduction of pain and improvement of limitation of jaw movement in patients with TMD. Nunez et al [13] reported that LLLT provided greater improvement in patients' mouth opening. In present study, it was observed that HILT treatment was more effective than TENS in the short-term (4th week) in both decreasing pain and increasing mouth opening in patients with TMD. VAS pain scale values decreased by 25% in the 4th week in the TENS group and 48% in the HILT group. In the same period, the MMO increased by 10% in the TENS group and 24% in the HILT group. Similar results were seen between TENS and HILT at assisted MMO (8 and 17%, respectively). There was no significant difference between the HILT and TENS groups in terms of long-term (12th week) effect in terms of pain, MMO and assisted MMO. The findings of this study revealed that the short-term effects of HILT are better than that of TENS therapy.

Exercise programs are simple, safe, and useful treatments that can be applied in TMD patients as well as

Table 5. COMPARISON OF THE PERCENTAGE CHANGES OF THE GROUPS AFTER THE TREATMENT (4TH WEEK) ACCORDING TO THE PRETREATMENT VALUES

	HILT Group Wk 4	TENS Group Wk 4	Control Group Wk 4	*P* value
Pain (VAS) (cm)	0.48 ± 0.31^{a}	0.25 ± 0.28^{b}	0.00 ± 0.01^{c}	0.000†
Function (VAS) (cm)	0.15 ± 0.58^{a}	0.10 ± 0.98^{a}	0.02 ± 0.03^{b}	0.000†
Max. Mouth open(mm)	0.24 ± 0.14^{a}	0.10 ± 0.10^{b}	0.00 ± 0.01^{c}	0.000†
Assisted max. mouth open	0.17 ± 0.16^{a}	0.08 ± 0.08^{b}	0.00 ± 0.01^{c}	0.000†
JFLS-20, mastication	0.25 ± 0.14^{a}	0.14 ± 0.09^{b}	0.04 ± 0.07^{c}	0.000†
JFLS-20, mobilization	0.26 ± 0.19^{a}	0.13 ± 0.11^{b}	0.07 ± 0.11^{c}	0.000†
JFLS-20, communication	0.19 ± 0.14^{a}	0.11 ± 0.11^{b}	0.05 ± 0.08^{c}	0.000†
JFLS-20 Total	0.30 ± 0.36^{a}	0.19 ± 0.14^{b}	0.05 ± 0.08^{c}	0.001*
OHIP-14, functional limitation	0.12 ± 0.27^{a}	0.10 ± 0.12^{a}	0.02 ± 0.03^{b}	0.000†
OHIP-14, physical pain	0.26 ± 0.18^{a}	0.10 ± 0.10^{b}	0.06 ± 0.10^{c}	0.000†
OHIP-14, psychological discomfort	0.11 ± 0.15^{a}	0.06 ± 0.09^{a}	0.05 ± 0.08^{a}	0.187
OHIP-14, physical disability	0.24 ± 0.27^{a}	0.12 ± 0.14^{b}	0.14 ± 0.09^{b}	0.022*
OHIP-14, psychological disability	0.09 ± 0.12^{a}	0.07 ± 0.09^{a}	0.16 ± 0.15^{a}	0.440
OHIP-14, social disability	0.06 ± 0.10^{a}	0.05 ± 0.08^{a}	0.08 ± 0.11^{a}	0.637
OHIP-14, handicap	0.07 ± 0.11^{a}	0.06 ± 0.12^{a}	0.05 ± 0.08^{a}	0.922
OHIP-14 Total	0.19 ± 0.14^{a}	0.12 ± 0.14^{b}	0.08 ± 0.11^{c}	0.018*

Abbreviations: HILT: High intensity laser therapy; JFLS-20: Jaw Functional Limitation Scale-20, OHIP-14: Oral health impact profile-14; TENS: Transcutanous electrical nerve stimulation; VAS: Visual analogue scale.

In each line, different superscripts indicate statistically significant difference between groups.

* $P < .05$

† $P < .001$

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other musculoskeletal disorders.[41] In this study, it was observed that exercise alone was not sufficiently effective on TMJ pain and jaw dysfunction in patients with DDWR. In some studies comparing jaw exercise with education, it has been reported that exercise in TMD patients does not have any additional advantages in the short and long-term compared to those who received only education.[42,43] Contrary to these results in the literature, in a recent study,[44] the counseling program and jaw exercise protocol improved the quality-of-life of patients with DDWR more than the counseling program alone. A meta-analysis study[45] investigating the effect of exercise on TMD revealed great uncertainty about exercise efficacy for TMD and did not find high-quality evidence. Because most exercise programs were part of the overall conservative treatment regimen that included other treatments and did not supply clear information on frequency, dosage, or compliance. The standalone impact of exercise in treating TMD and the optimal regimen is currently unclear.[45] There is no consensus on how long and how often exercise should be applied in these patients. In this study, exercise was applied for 3 weeks, 10 minutes a day. Perhaps the exercise would have been more effective if the exercise had been applied for longer periods of time, such as for 1 hour a day and for 6 weeks, or if additional home exercises had been done. Therefore, although exercise did not produce effective results in this study, exercise can be effective if it is done at the appropriate dose and frequency.

TMD-associated pain and stress have a detrimental effect on systemic health and quality-of-life, which cause negative consequences in daily social activities, social functions, emotional and cognitive balance, sleep, and physical activities at school or work.[46] It can be suggested that TMD is likely to affect people's quality-of-life, especially when chronic.[47] In this study, improvement in patients with TMJ disc displacement after HILT and TENS treatment was evaluated not only by clinical variables such as pain and mouth opening but also by disability and quality-of-life index. After HILT and TENS treatment, significant improvements were observed in both jaw functions and quality of life compared to the control group. The HILT group had greater improvement in total JFLS-20 and total OHIP-14 scores at both the 4th week and the 12th week compared to the TENS group. In addition, in some OHIP-14 sub-dimensions (physical pain and physical

Table 6. COMPARISON OF THE PERCENTAGE CHANGES OF THE GROUPS AFTER THE TREATMENT (12TH WEEK) ACCORDING TO THE PRETREATMENT VALUES

	HILT Group Wk 12	TENS Group Wk 12	Control Group Wk 12	*P* value
Pain (VAS) (cm)	0.49 ± 0.34^{a}	0.44 ± 0.45^{a}	0.02 ± 0.03^{b}	0.000†
Function (VAS) (cm)	0.53 ± 0.49^{a}	0.80 ± 1.22^{a}	0.02 ± 0.03^{b}	0.000†
Max. Mouth open(mm)	0.37 ± 0.35^{a}	0.23 ± 0.15^{a}	0.01 ± 0.01^{b}	0.000†
Assisted max. mouth open	0.30 ± 0.36^{a}	0.15 ± 0.12^{a}	0.01 ± 0.01^{b}	0.000†
JFLS-20, mastication	0.21 ± 0.12^{a}	0.12 ± 0.09^{b}	0.05 ± 0.08^{c}	0.000†
JFLS-20, mobilization	0.17 ± 0.14^{a}	0.11 ± 0.09^{a}	0.06 ± 0.10^{b}	0.000†
JFLS-20, communication	0.23 ± 0.17^{a}	0.14 ± 0.16^{b}	0.04 ± 0.07^{c}	0.000†
JFLS-20 Total	0.26 ± 0.18^{a}	0.19 ± 0.14^{b}	0.05 ± 0.08^{c}	0.002†
OHIP-14, functional limitation	0.14 ± 0.20^{a}	0.13 ± 0.16^{a}	0.05 ± 0.08^{b}	0.029*
OHIP-14, physical pain	0.13 ± 0.10^{a}	0.12 ± 0.13^{a}	0.06 ± 0.10^{b}	0.039*
OHIP-14, psychological discomfort	0.16 ± 0.16^{a}	0.09 ± 0.11^{a}	0.09 ± 0.12^{a}	0.150
OHIP-14, physical disability	0.25 ± 0.25^{a}	0.07 ± 0.11^{b}	0.12 ± 0.24^{b}	0.003*
OHIP-14, psychological disability	0.12 ± 0.14^{a}	0.09 ± 0.13^{a}	0.17 ± 0.16^{a}	0.078
OHIP-14, social disability	0.09 ± 0.15^{a}	0.07 ± 0.10^{a}	0.12 ± 0.27^{a}	0.236
OHIP-14, handicap	0.08 ± 0.12^{a}	0.04 ± 0.15^{a}	0.05 ± 0.08^{a}	0.122
OHIP-14 Total	0.20 ± 0.17^{a}	0.13 ± 0.14^{b}	0.09 ± 0.12^{c}	0.022*

Abbreviations: HILT, High intensity laser therapy; JFLS-20, Jaw Functional Limitation Scale-20; OHIP-14, Oral health impact profile-14; VAS, Visual analogue scale; TENS, Transcutanous electrical nerve stimulation.

In each line, different superscripts indicate statistically significant difference between groups.

* $P < .05$

† $P < .001$

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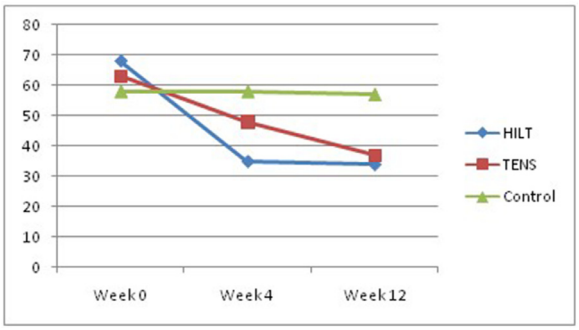

FIGURE 2. Comparison of the change in Visual Analog Scale (VAS) pain levels.

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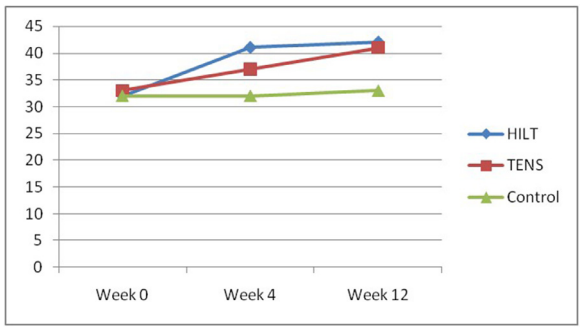

FIGURE 3. Comparison of the change in maximum mouth opening.

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disability), a higher rate of healing was seen in the HILT group compared to the TENS group.

This study may have some limitations due to its methodology. The optimal dose, frequency, and duration of HILT therapy are still unclear. Various power, wavelengths, and durations may provide different outcomes in HILT. The short duration and dose of the exercise program in this study may be the reason for the lack of effect of exercise. In addition, self-reported VAS pain level, disability and quality-of-life scales may be subjective in nature. However, the strengths of this study are that it was the first study to apply HILT treatment to TMDs, the evaluation of healing both in the short and long-term, and the use of psychosocial parameters in addition to physiological parameters in the evaluation.

In conclusion, in this study, after TENS and HILT treatment, patients with DDWR showed significant improvements in mouth opening, pain, disability and

quality-of-life, both in the short and in the long-term. In view of the results and limitations of this study, it can be stated that the efficiency of HILT treatment on relieving symptoms and improving functions in patients was significantly higher than that of the TENS group. The effectiveness of HILT compared to TENS treatment has emerged especially in the short period after treatment. HILT treatment can be an alternative treatment method in the treatment of temporomandibular joint disorders because it can stimulate deeper and larger tissues compared to LILT and thus transfer more energy to the tissues. For this, a large number of randomized controlled clinical studies are needed regarding the therapeutic effects of HILT on TMD patients. These studies may be designed in the form of comparing different treatment methods in different subgroups of TMJ disorders, at different doses and durations.

Data Availability

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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