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ORIGINAL ARTICLE

Evaluation of orofacial function in temporomandibular disorder patients after low-level laser therapy

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Abstract

Objective. To evaluate the effect of low-level laser therapy on occlusal contact area, occlusal pressure and bite force in temporomandibular disorder patients. ***Patients and method.*** Twenty patients (14 women, six men, mean age 33.1 ± 3.8 years) diagnosed with myofascial pain according to the Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD) participated in the study. Twenty healthy individuals, matched in age and gender, served as a control group. Low-level laser was applied to the mastication muscles three times per week, for a total of 10 sessions. The mandibular mobility range was evaluated. The maximum bite force, occlusal contact area and occlusal pressure were measured bilaterally with a dental pre-scale before and after treatment. All variables were analyzed descriptively. Changes in the masticatory muscle tenderness, mandibular movements, maximum bite force, occlusal contact area and occlusal pressure were compared by paired-sample Student's *t*-tests. ***Results.*** There was a significant increase in the pressure pain threshold of the examined muscles. Mandibular movements were significantly improved in all patients. There was also a significant decrease in pain by palpation after laser exposure. However, no significant change was found in the maximum bite force, occlusal contact area or occlusal pressure after the treatment and also the values after the treatment were still significantly lower than those of the healthy individuals. ***Conclusion.*** This particular type of LLLT is effective at relieving pain but does not provide physical improvement.

Key Words: *maximum bite-force, temporomandibular disorder, low-level laser*

Introduction

The maximum bite force (MBF) is the effort exerted between the upper and lower jaw teeth when the mandible is elevated by the masticatory muscles [1]. The MBF is regulated by the nervous, muscular and skeletal systems [2]. Exertion of a sufficient bite force is an indicator of normal masticatory function [3]. Therefore, many clinicians suggest MBF measurement as a useful method for understanding masticatory function in patients with stomatognatic system disorders [4–10]. Subjects with craniomandibular disorders are expected to have lower bite forces than healthy patients. Lower MBFs are found among patients with temporomandibular disorders (TMDs) [4,6,9,11–13], with MBF increasing as the symptoms decrease. Helkimo et al. [7] evaluated bite force changes before and after conservative treatment in a group of patients with muscle pain. Initially, patients displayed lower MBF values than healthy controls, but after treatment the average MBF in the study group increased to levels similar to those of healthy controls. These results are supported by other studies and masticatory muscle weakness has been considered a predisposing factor for TMD [4,14,15].

Use of low-level laser therapy (LLLT) in TMDs has been extensively investigated and found to have analgesic, myorelaxant, tissue healing and biostimulation effects. Some treatment modalities, such as occlusal splints, TENS and surgical therapy, can improve the bite forces of patients with muscle disorders, but no clinical study has examined the effect of LLLT on the MBF values in patients with MP. Therefore, the aim of this study was to evaluate the effect of LLLT on the

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MBF, occlusal contact area (OCA) and occlusal pressure (OP) in subjects with signs and symptoms of myofascial pain. The null hypothesis is that the MF, OCA and OP are unchanged when patients are exposed to LLLT.

Materials and methods

Subjects

This study was performed at Istanbul University, Faculty of Dentistry, Department of Prosthodontics, and the protocol was approved by the local ethics committee. Written informed consent was obtained from each subject after a full explanation of the study.

A total of 20 subjects (14 women, six men; mean age 33.1 ± 3.8 years) were selected consecutively from 423 TMD (265 MPD) patients between March 2010 and October 2010. Only 45 patients fulfilled the inclusion criteria and 24 of these individuals chose to participate in the study. Four of the patients could not attend their appointments regularly and were therefore excluded. Patients were instructed not to take any analgesics or have any pain treatments for 2 weeks before and throughout the study course. Twenty healthy volunteers were included in the study as a control group. These subjects were age- and gender-matched with the patients and were free from TMD signs and symptoms: no joint noises or pain in TMJ or masticatory muscles, no limitation of mandibular mobility and no actual dental treatment.

Sample selection was based on a standardized clinical examination. The first examination evaluated if the subjects fulfilled the following inclusion criteria: (1) myofascial pain diagnosis according to the Research Diagnostic Criteria for Temporomandibular Disorder (RDC/TMD) [16], (2) age of 18–40 years and (3) natural posterior occlusion. Exclusion criteria included: (1) disk displacements with or without reduction (without reduction was with or without limited opening), arthralgia, arthritis or arthrosis; (2) general inflammatory connective tissue diseases (e.g. rheumatoid arthritis); (3) psychiatric disorders; (4) tumours; (5) heart disease or pacemaker use; (7) pregnancy; (8) symptoms potentially attributable to other orofacial region diseases (e.g. toothache, neuralgia, migraine); (9) history of or treatment for headache or bruxism in the last 2 years; (10) local skin infections over the masseter muscle; and (11) edentulous posterior arches, fixed partial dentures or removable partial dentures in the lower or upper jaw.

Study protocol

The functional examination was based on the translation of RDC/TMD suggested by the International RDC-TMD Consortium. The clinician was an experienced prosthodontist and was calibrated prior to the study using RDC/TMD as the gold standard. Masticator muscle tenderness was assessed on both sides by bilateral palpation. The muscle pressure pain threshold (PPT) was obtained with a dial algometer (Wagner Pain Test™ Model FPK Algometer, Wagner Instruments, Greenwich, CT). The PPT (in kg/cm^2) was obtained by applying pressure to the same points described previously [17]. The mandibular mobility was measured with a plastic millimetre ruler on the mandibular excursion [17]. Patients were asked to report any pain during muscle palpations and mandibular movements and the answers were recorded according to a verbal scale. The degree of pain under palpation was rated as 0 (no pain), 1 (mild pain), 2 (moderate pain) or 3 (severe pain).

A continuous low-intensity semiconductor laser (Doris Diode Laser, CTL 1106 MX, Warsaw, Poland) was used for exposure. This device generates continuous radiation with regulated power. The single-probe laser device applies a laser diode generating infrared radiation (820 nm wavelength, 6-mm diameter beam). The energy intensity given to each muscle point was adjusted to 3 J/cm^2 by applying 300 mW output power for 10 s. Low-level laser therapy was applied precisely and continuously on trigger points. Patients were exposed to laser application from a 2-mm distance three times per week, for a total of 10 sessions.

Vertical inter-occlusal bite forces were measured bilaterally with pressure measurement film (Dental Prescale 50 H, Fuji Photo Film Corporation, Tokyo, Japan). The patients were asked to bite in the intercuspal position several times before the measurements were performed, with the goal of maintaining the correct position. The sheets were placed carefully in the mouth such that all teeth contacted it. Patients were encouraged to bite as hard as possible on the bite-force films for 5 s. The first and second measurements were made just prior to and at the end of LLLT, respectively.

Statistical analysis

All variables were analysed descriptively. Changes in masticatory muscle tenderness, mandibular movements, MBF, OCA and OP before and after treatment were evaluated with paired sample t-tests, with the significance level set at $p < 0.05$. ındependent sample t-tests were used to compare the results of the group of patients and group of control. For all statistical tests, the standard SPSS program 3.0 for Windows (SPSS, Chicago, IL) was used.

Results

The demographic characteristics of the patients and the healthy individuals are given in Table I. There was a statistically significant increase in the PPT values of

Table I. Demographics and pain-related descriptive statistics of the patients and the healthy individuals.

		Patients	Healthy
Age (years)		31.25 ± 8.23	33.67 ± 7.11
Education (High school graduate)		55%	53%
Gender	Female	14 (70.0%)	14 (70.0%)
	Male	6 (30.0%)	6 (30.0%)
Marital status	Married	6 (30.0%)	8 (40 %)
	Single	8 (40.0%)	5 (25 %)
	Divorced/ separeted	6 (30 %)	7 (35 %)
Duration of pain (years)		2.8 ± 0.9	
Constant pain	Yes	40%	
	No	60%	
Pain onset	Gradual	50%	
	Abrupt	50%	
Location of pain	Right	5%	
	Left	5%	
	Both	90%	

the examined muscles (Table II). Mandibular movements were significantly improved in all patients (Table III). There was a significant decrease in pain by palpation after laser exposure (Table IV). Only one patient (5%) demonstrated moderate pain in the masseter middle and one patient (5%) reported moderate pain in the lateral pole of the TMJ after treatment.

Student's *t*-test revealed no significant change in the MBF (Table V). Also the values after treatment were still significantly lower than those of the healthy individuals. These calculations demonstrated that LLLT had no statistically significant effect on MBF, OCA or OP.

Discussion

Obtaining objective and consistent data is important in understanding muscle disorders. Several methods are available to measure the bite force, including gynadynamometers and bite force transducers [16,18,19]. In the last two decades, pressure-sensitive measurement films and occlusal evaluation systems have been introduced to quantitatively analyse the MBF and OCA. The Dental Prescale is one such computerized image analysis system that provides quantitative data on the OCA, bite force and OP. Its several reported advantages include the following: (1) measurements can be made near the intercuspal position, since the pressure film is very thin and induces little change in the occlusal vertical dimension; (2) special measurement equipment is not required; (3) it is fast; (4) records can be stored for a long period; and (5) it is intuitive to explain the treatment to patients using dental images [20]. In the present study, Dental Prescale was used as the measuring device, providing an easy and comfortable measuring process both for the clinician and patient. The thin measurement film did not disturb the patient during the measurement process. Furthermore, the film could be placed in the same position within the dental arch, allowing measurements at the same position before and after laser application.

The purpose of this research was to establish whether the mylorexant effect of LLLT increases bite forces in myofascial pain patients. Low-level laser therapy is frequently used to treat various pain-associated conditions, including musculoskeletal pain disorders, because of its analgesic, myorelaxant, tissue-healing and biostimulation effects [21]. Many randomized and non-randomized, double-blind clinical studies have been designed to investigate the effect of LLLT in TMD [21–25]. In these previous studies, objective and subjective parameters were used as testing criteria and the PPTs, mandibular movements and muscle pain on palpation were evaluated. In none of these studies were bite force changes or related factors tested.

Table II. Comparison of PPT values (in kg/cm^2).

	Mean difference	SD	*p*
TA	1.200 00	4.777 69	0.027 532*
TM	2.400 00	4.235 19	0.020 22*
TP	3.300 00	4.290 14	0.002 74*
MS	3.100 00	4.811 17	0.009 56*
MP	3.325 00	4.377 80	0.003 03*
MI	4.425 00	4.837 56	0.000 62*
SCM	4.450 00	4.850 12	0.000 61*

* Statistically significant.
Each line demonstrates the statistical analysis of a muscle before and after laser exposure.
TA, temporalis anterior; TM, temporalis middle; TP, temporalis posterior; MS, masseter superior; MP, masseter posterior; MI, masseter inferior; SCM, sternocleidomasteideous.

Table III. Mandibular movements.

	Mean difference (mm)	SD	*p*
UOP	3.72	4.599 30	0.003 17*
MUO	2.056	2.940 03	0.008 65*
MAO	2.50	5.090 36	0.052 59*
LLE	1.17	1.200 49	0.000 71*
RLE	0.44	1.503 81	0.022 65*
P	1.44	1.381 48	0.000 36*

*Statistically significant.
Each line demonstrates the statistical analysis of a mandibular movement before and after LLLT.
UOP, unassisted jaw opening without pain; MUO, maximum unassisted jaw opening; MAO, maximum assisted opening; LLE, left lateral excursion; RLE, right lateral excursion; P, protrusion.

Table IV. The results of the masticatory muscles palpations.

	Before treatment				After treatment			
	0	1	2	3	0	1	2	3
Right side								
Temporalis (ant.)	40%	25%	20%	15%	65%	35%	—	—
Temporalis (middle)	60%	25%	10%	5%	90%	10%	—	—
Temporalis (post.)	75%	5%	15%	5%	95%	5%	—	—
Masseter (superior)	5%	35%	30%	30%	45%	55%	—	—
Masseter (middle)	10%	45%	20%	25%	20%	80%	—	—
Masseter (inferior)	35%	35%	25%	5%	50%	50%	—	—
Posterior mandibula	40%	35%	10%	15%	80%	20%	—	—
Submandibul.region	60%	15%	20%	5%	90%	10%	—	—
TMJ–Lateral pole	40%	35%	20%	5%	60%	35%	5%	—
TMJ–post. attach.	85%	10%	—	5%	85%	15%	—	—
Lateral pterygoid	15%	20%	45%	20%	55%	45%	—	—
Tendonof temporalis	40%	30%	20%	10%	95%	5%	—	—
Left side								
Temporalis (ant.)	45%	20%	20%	15%	65%	35%	—	—
Temporalis (middle)	60%	15%	20%	5%	95%	5%	—	—
Temporalis (post.)	70%	20%	10%	—	90%	10%	—	—
Masseter (superior)	20%	25%	25%	30%	50%	50%	—	—
Masseter (middle)	5%	45%	10%	40%	20%	75%	5%	—
Masseter (inferior)	35%	35%	15%	15%	45%	55%	—	—
Posterior mandibula	45%	35%	10%	10%	80%	20%	—	—
Submandibul.region	70%	15%	15%	—	85%	15%	—	—
TMJ–Lateral pole	45%	35%	20%	—	75%	25%	—	—
TMJ–post. attach	75%	15%	10%	—	90%	10%	—	—
Lateral pterygoid	30%	30%	25%	15%	35%	65%	—	—
Tendonof temporalis	40%	30%	25%	5%	85%	15%	—	—

0, no pain; 1, mild pain; 2, moderate pain; 3, severe pain.

Investigation of the MBF, OP and OCA may be useful in assessing the biomechanical properties of the masticatory system [13,26] or in diagnosing dysfunction [27]. Bonjardim et al. [2] demonstrated that TMD in adolescents affects the bite force magnitude, consistent with clinical studies showing that TMD patients have lower MBFs than healthy subjects [4–29]. However, other studies have reported contradictory results [30,31]. In the present study, the MBF was measured in myofascial pain patients before and after an assigned therapy. This investigation showed that the patients with myofascial

Table V. Mean value and standard deviation of OCA, OP and MBF in study and control group; before and after treatment values were compared with healthy subjects.

	OCA (mm^2)		OP (MPa)		MBF (N)	
	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)	Mean ± SD	Median (IQR)
Before treatment	10.63 ± 8.25	10.10 (11.20–12.16)	31.57 ± 6.89	30.3 (29.87–35.41)	441.89 ± 212.90	423.21 (417.45–461.54)
After treatment	10.64 ± 6.85	17.355 (10.67–13.09)	31.95 ± 7.32	40.8 (28.76–43.89)	436.24 ± 128.29	432.76 (419.98–445.65)
Control group	18.97 ± 7.41	17.35 (14.17–25.97)	42.95 ± 5.21	40.8 (39.28–46.71)	685.24 ± 167.26	640.35 (557.88–865.05)
p	0.001 833*		0.000 196 4*		0.001 38*	

* Statistically significant.
OCA, occlusal contact area; OP, occlusal pressure; MBF, maximum bite force.

disorders demonstrated lower bite forces and the assigned therapy did not alter the bite force, which means that the decreased bite force can not be recovered with LLLT. No association was found between MBF recovery and clinical signs and symptoms. This was an unexpected but interesting result, since many studies have reported that pain is the major limiting factor for reduced bite force in TMD patients [7,9,12,32–34].

The authors of the present study hypothesized that LLLT would reduce pain, thereby increasing bite forces. Although subjects displayed significantly less pain post-treatment, they did not demonstrate higher bite forces or any other significant change. A possible explanation for this may be that the sensory feedback of the subjects limited their willingness to exert the maximum effort [35]. Patients included in the study had long-term pain (mean 2.8 years), leading to reflex adaptation, muscle hypo-activity and an avoidance of chewing or biting hard food. Despite clear and extensive instruction, the patients might have been unable to bite as hard as possible. They had been in the habit of avoiding oral behaviours that could increase pain and the alarm function of the pain receptors protected them from injury [36]. The MBF measurements were performed soon after LLL application. Had the measurements been performed later (e.g. 4 weeks later) and the patients might have had more pain-free time, they could have demonstrated higher bite forces. Another possible explanation for the unchanged MBF, OCA and OP values is the poor laser effectiveness, since LLLT is a conservative and non-invasive treatment modality.

Within the limitations of the present clinical trial, it is possible to conclude that this particular type of LLLT (820 nm, 3 J/cm^2, 300 mW output power) has a positive effect in managing pain and improving mandibular function due to its analgesic and myolorexant effect, but does not influence bite force. In other words, LLLT is effective at relieving pain but does not provide physical improvement. To our knowledge, until now no previous study has examined the effect of LLLT on bite force. Further double-blind, randomized, placebo-controlled clinical research is needed to establish whether these findings have clinical relevance.

Declaration of interest: The authors report no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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