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Comparison of Low-Level Laser Therapy and Pulsed Electromagnetic Field Treatment for Temporomandibular Joint Dysfunction Following Maxillofacial Surgery

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ABSTRACT

Aim: To assess the impact of Low-Level Laser Therapy (LLLT) compared to Pulsed Electromagnetic Field (PEMF) on intensity of pain and on increasing maximum mouth opening on temporomandibular joint after maxillofacial surgeries on the temporomandibular joint following maxillofacial surgeries.

Design: Prospective single blinded pretest-post test controlled randomized trial

Patients and Methods: This study involved sixty patients (20 males and 40 females) who reduced maximum mouth opening and decrease quality of life six weeks after maxillofacial surgeries. The participants, aged between 18 and 42 years, were selected from the Outpatient Oro and Maxillofacial Surgery department at Shebin Elkom Hospital for Specialized Surgeries. They were randomly assigned to two equal groups, each comprising thirty patients. Group (A): (Low-Level Laser group), Patients received treatment with an infrared diode laser, featuring a wavelength of 810 nm to 940 nm and a power output of 25 mW. The laser was administered to both sides of the face at points ST6 and ST7 for 40 seconds at each point, three times a week over four weeks. Furthermore, patients received Non-Steroidal Anti Inflammatory Drugs NSAIDs twice daily for the same four-week period.Group (B): (Pulsed Electromagnetic Field group) Patients underwent pulsed electromagnetic field treatment, with parameters set at 60 gauss power and a frequency of 50 Hz. The treatment was applied to both sides of the face for 15 minutes, three times a week, over a four-week period. Additionally, they were prescribed NSAIDs to be taken twice daily for the same duration the maximum mouth opening measured by Digital Vernier Caliper before and after 4 weeks of treatment and the impairment of quality of life measured by University of Washington Quality of Life Questionnaire before and after 1 month of treatment.

Results. this study provide support for the significant effectiveness of the pulsed electromagnetic field in decrease of maximal mouth opening and impairment of quality of life after maxillofacial surgeries as there was a significant increase in MMO of (PEMF group) compared with (LLLT group) post treatment ($p = 0.001$) with the percentage of 136.98 % for (PEMF group) compare to 121.17 % for (LLLT group) , and there was a significant improvement of qualiy of life of (PEMF group) compared with (LLLT group) post treatment ($p = 0.001$) with the percentage of 82.81%, for (PEMF group) compare to 58.53%. for (LLLT group) . Furthermore, there was significant difference observed between the two groups after the treatment. ($p<0.001$) in a favor of (PEMF group).

Conclusion. Both low-level laser and pulsed electromagnetic field play a significant role in increasing of maximal mouth opening and improvement of qualiy of life after maxillofacial surgeries. However, pulsed electromagnetic field is more efficacious than low-level laser treatment for increasing of maximal mouth opening and improvement of qualiy of life after maxillofacial surgeries.

Keywords: *Low Level Laser, , Pulsed Electromagnetic Field, Temporomandibular Joint, Maxillofacial Surgeries, NSAID . University of Washington Quality of Life Questionnaire*

1. INTRODUCTION

There was a lack of knowledge about the role of Low-Level Laser Therapy (LLLT) and Pulsed Electromagnetic Field Therapy (PEMF) in increasing maximum mouth opening and improvement of qualiy on temporomandibular joint dysfunction after maxilofacial surgeries.

Whether for medicinal or cosmetic reasons, or a combination of the two, oral and maxillofacial surgeons use a wide range of surgical methods to alter the appearance of the mouth and surrounding facial and jaw structures (1).

One of the most common sources of orofacial discomfort that is not associated with teeth is temporomandibular disorders (TMD). Ten to fifteen percent of individuals have TMD, according to population-based research, yet only five percent actually seek therapy (1).

Between the ages of 20 and 40, total mass disorder (TMD) is most frequent; it affects women at double the rate of males and causes substantial economic hardship due to missed employment. Tempromandibular disorders (TMD) are a collection of musculoskeletal illnesses indicated by pain and/or dysfunction in the masticatory muscles (2).

Symptoms may vary from moderate discomfort to crippling agony, and they can also include restrictions of jaw function (2).In the US and other countries like Canada and Australia, this was considered a dental specialty, but it came with a lot of problems like pain and restricted mobility, which were treated with physical therapy techniques like pulsed electromagnetic fields (PEMF) and low level laser therapy (LLLT) (3).Over the last two years, the incidence of maxillofacial fractures has risen significantly compared to earlier years. The peak incidence occurs between the ages of 20 and 40, and there is a male preponderance. The frequency of mandibular fractures is higher than that of midface fractures, and road traffic accidents are the leading cause of these injuries, followed by violent incidents. The dramatic rise in the number of maxillofacial fractures caused by violent incidents and vehicle accidents over the last two years is indicative of a shift in societal norms (4).

A non-invasive therapeutic option, low-level laser therapy (LLLT) or photo biomodulation therapy makes use of low-power lasers or light-emitting diodes (LEDs) to encourage tissue healing by stimulating cellular activity. It is worth noting that the specific details and effectiveness of LLLT may differ depending on the particular complication and individual patient factors (5). Despite extensive research and use of LLLT in various medical fields, including dentistry and maxillofacial surgery, its effectiveness in managing complications specifically related to these procedures is still an area of ongoing investigation.

A illness that affects the jaw joint and the muscles around it, temporomandibular joint dysfunction (TMD) has been the subject of research into the possible advantages of pulsed electromagnetic field (PEMF) treatment. Although there is a dearth of literature on this particular subject (6).

University of Washington Quality of Life Questionnaire (UW-QOL Questionnaire) In the original description, the advantages of the UW-QOL questionnaire are that 1) it is brief and self-administered, 2) it is multi-factorial, allowing sufficient detail to identify subtle change, 3) it provides questions specific to head and neck cancer, and 4) it allows no input from the health provider, thus reflecting the QOL as indicated by the patient'. According to our research, there is no universally accepted questionnaire for measuring quality of life. The one that is most commonly used by clinicians in the United Kingdom is the UW-QOL, primarily due to its simplicity and reliability. The fourth version of the UW-QOL questionnaire includes 12 distinct question domains: pain, appearance, activity, recreation, swallowing, chewing, speech, shoulder function, taste, saliva, mood, and anxiety. Each of these domains has between 3 and 6 response options, all scored uniformly from 0 (indicating the worst quality of life) to 100 (indicating the best quality of life) based on the grading of responses." (7).

Digital vernier caliper with the exception of the very good results for intrasession and intersession dependability, all intraclass correlation coefficients (ICCs) are at least somewhat accurate. The only variable that exhibits more variation is the interrater dependability. While the opening, protrusion, and locations of the teeth are always accurate, the side motions were not. There was a lot of variation in the lateral movement measures. Some movements were exempt from this. Encouraging patients to open their mouths at varied angles is crucial, but so is their cooperation. Making a variable laterotrusion on either side is within the realm of possibility. An easy-to-use, low-cost, and quick caliper was the object of the investigation (8).

Patients who have undergone maxillofacial surgeries often experience reduction in their maximum mouth opening and impairment of quality of life after the procedures. These complications can have a significant impact on patients. Therefore, this study set out to fill this information gap by investigating the efficacy of Low-Level Laser Therapy and Pulsed Electromagnetic Field in addressing temporomandibular joint dysfunction following maxillofacial surgeries.

2. SUBJECTS AND METHODS

Subjects:

Sixty patients participated in this study their age from eighteen to forty-two, with twenty men and forty females. Patients who fulfilled inclusion criteria were chosen from the Outpatient Clinics at Shebeen-Alkawm Hospital for Specialized Surgeries in the Monofyia Government. There was a 6-week reduction in the maximal mouth opening for all patients who had discomfort after their maxillofacial operations. The patient was excluded from the trial if they fulfilled any of the following conditions:(1) Patients with psychological or mental health issues. (2) Patients with systemic disorders that might compromise the study's aims might not participate. Women who were expecting a child. 4. Individuals who have a cardiac pacemaker implanted. Five, patients who are wearing braces or other fasteners. Six weeks after maxillofacial surgery, if any patient experienced discomfort and a reduction in maximum mouth opening,

Sample size determination

The necessary number of patiens for this research was determined to be 60 using the G*POWER statistical program (version 3.1.9.2; Franz Faul, Universitat Kiel, Germany) in conjunction with VAS data obtained from Fouda (2014). The values used for the calculations were $\alpha = 0.05$, power = 90%, and effect size = 0.74.

Design:

The Cairo University Ethical Committee for the Physical Therapy Faculty (No: P.T.REC/012/002717) approved this study. The research used an allocation ratio of 1:1 in its single-blind randomized controlled trial design. After careful disclosure, patients gave their informed permission to participate in the research. Authors used envelope method to randomly divide the patients into two equal groups. Following the patients' consent, the physical therapist, who was blind to the study, was asked to choose an envelope based on the card's label: "LLLT" or "pulsed electromagnetic field." Then, the patients were assigned to the corresponding group. Separately, 30 patients had low-level laser therapy (Group A) and 30 patients underwent pulsed electromagnetic field (Group B) treatment. The examiner physical therapist had no knowledge of the treatment allocation and was not involved in the randomization process. During the assessment, patients were requested not to reveal to the physical therapist the treatment they were allocated. All patients were instructed to report any adverse effects that occurred throughout the course of therapy.

Assessment:

After 4 weeks, decreased maximum mouth opening and impairment quality of life using digital vernier caliper and University of Washington Quality of Life Questionnaire, done two time.

Digital Vernier Caliper: When the maxillofacial opening (MMO) is less than 40 mm, the typical range of motion for the total maxillofacial opening (TMD) is 40-60 mm (9).

Patients should be in a relaxed position while they sit comfortably; the physiotherapist showed them how to use a digital vernier caliper, instructed them to open their mouths actively while they passively open them to their full range of motion, inserted the caliper into their mouths, and then displayed the results on a digital screen.

University of Washington Quality of Life Questionnaire : The patients should be in a relaxed state of mind and sit comfortably while the physiotherapist explained the UW-QOL questionnaire The therapist then instructed` the patient to record his or her results after each domain Version 4 of the UW-QOL questionnaire consists of 12 single question domains, these having between 3 and 6 response options that are scaled evenly from 0 (worst) to 100 (best) according to the hierarchy of response. The domains are pain, appearance, activity, recreation, swallowing, chewing, speech, shoulder, taste, saliva, mood and anxiety. Another question asks patients to choose up to three of these domains that have been the most important to them. There are also three global questions, one about how patients feel relative to before they developed their illness (7).

Treatment:

Low level laser therapy: the procedures had been explained for every patient, patient signed on the consent form and took full data of the patient, patient and therapist wore goggles, patient sit in most relaxed comfortable position in sitting position, laser device should be well earthed and connected to electricity source, put the elecnhhtricity cable in the plague, open the device and hear the sound indicator that it is opened, hold the probe and start application, patient sit in most relaxed comfortable position in sitting position, laser device must be well earthed and connected to electricity source, patient and therapist must wear goggles, open the device and sterilized the probe, choose the program and determined the wavelength and duration for treatment, the parameters of Low-level laser device used were as follow (wavelength 830nm, power output of 25 MW, and energy dose of 1 J, laser probe applied perpendicular on patient skin and session applied in three sessions per week for 4 weeks with exposure time 90 sec delivered on both side on check on st6 and st7 the total time about 3 min .

Pulsed electromagnetic field: the procedures had been explained for patient, patient sit in most relaxed comfortable position in sitting position, PEMF device should be well earthed, connected the device to electricity source, open the device, hold the PEMF rings, put the rings on both side of the cheek of the patient, choose the program and determined the intensity, frequency and duration for treatment, the parameters of pulsed electromagnetic field device used as follow (power 60 gauss and frequency from 50 HZ can be used for 15 minutes delivered on both side on the face on masseter muscle on both side for 4 weeks.

3. RESULTS

Subject characteristics:

Sixty patients (20 males and 0 females) with pain and decrease maximum mouth opening after maxillofacial surgery participated in this study. Table (1) showed the patients characteristics of group A and B. There was no significant difference between groups in age, weight, height, BMI and sex distribution ($p > 0.05$).

Table 1. Comparison of subject characteristics between group A and B:

	Group A	Group B	p-value	sign
	Mean ± SD	**Mean ± SD**		
Age (years)	27.96 ± 5.77	29.43 ± 6.96	0.37	NS
Weight (kg)	70.90 ± 8.42	72.39 ± 9.33	0.51	NS
Height (cm)	162.13 ± 5.29	161.01 ± 6.57	0.46	NS
BMI (kg/m²)	27.01 ± 3.25	27.95 ± 3.47	0.27	NS
Sex				
Females	23 (77%)	21 (70%)	0.55	
Males	7 (23%)	9 (30%)		NS

SD, standard deviation; p-value, probability value BMI: Body Mass Index NS:non signifance

Effect of treatment on MMO and UW-QOL:

Within group comparison

Both groups showed statistically significant improvements in UW-QOL and MMO after therapy compared to before (p > 0.001). Group A had a percentage change of 58.53% for UW-QOL and 121.17% for MMO, while group B saw a percentage change of 82.81% and 134.98%, respectively. (Table 2)

Between group comparison

Before treatment, there was no statistically significant difference between the groups (p > 0.05). Group B's post-treatment 82.81%, was significantly higher than group A's, while group A's MMO was much higher (p > 0.001). In Table 2.

Table 2. Mean UW-QOL and MMO pre and post treatment of group A and B:

	Group A	Group B				
	Mean ± SD	**Mean ± SD**	**MD**	**t- value**	**p value**	**sign**
UW-QOL						
Pre treatment	48.57 ± 9.64	50.27 ± 8.71	1.7	0.72	0.47	NS
Post treatment	77.00 ± 3.91	91.90 ± 5.16	14.9	12.60	0.001	S
MD	-28.43	-41.63				
% of change	58.53	82.81				
t- value	-13.39	-24.84				
	p = 0.001	***p = 0.001***				
MMO (mm)						
Pre treatment	24.42 ± 4.55	25.12 ± 5.11	-0.7	-0.56	0.57	NS
Post treatment	54.01 ± 3.95	59.53 ± 3.08	-5.52	-6.04	0.001	S
MD	-29.59	-34.41				
% of change	121.17	136.98				
t- value	-27.59	-30.91				
	p = 0.001	***p = 0.001***				

SD, standard deviation; p-value, t-value probability value MMO&VAS: Maximum Mouth Opening, NS:non signifance,S: significance

4. DISCUSSION

Results showed that this is the first research to compare the effects of low-level laser and pulsed electromagnetic fields on temporomandibular joint dysfunction after maxillofacial surgery.

Evidence from a large body of epidemiological research indicates that between five and twelve percent of the population has TMD symptoms. Several studies of the general population have found higher percentages, up to 40% (10).

Because of all the stresses that college students endure, TMD is a major problem. Research shows that people who are emotionally distressed are more likely to suffer from TMD and oral parafunctions. Postgraduate university students in Egypt are more at risk for TMD symptoms, although there is a lack of data on this topic overall (11) and (12).

This research compared the effects of low-level laser therapy and pulsed electromagnetic fields on temporomandibular joint dysfunction (TMD) following maxillofacial surgery. TMD affects 5-12% of the general population, with higher rates up to 40% in some studies, particularly among stressed college students. The study involved two groups: one receiving pulsed electromagnetic field therapy (Group B) and the other low-level laser therapy (Group A). After one month, Group B showed a significantly greater improvement in quality of life (UW-QOL) and mouth opening measurements (MMO)(13).

There was a statistically significant difference between groups A and B when comparing QOL and MMO values four weeks following LLLT therapy. Group B fared better.

The findings align with the LLLT research published by Bjordal et al. (2006), Ramezani et al (2022) Wang et al. (2011), Xu et al. (2018), Zecha et al (2016) and others.

All patients reported improvement in TMD symptoms after maxillofacial operations, according to Bjordal et al., 2006. When it came to treating TMD, Low-Level Laser Therapy (LLLT) worked wonders. Several things have contributed to this progress.LLLT may enter deeper, which increases its efficacy. It also has an anti-inflammatory impact, which means that lymphatic channels become thicker and more numerous, and phagocytes work better. This normalizes the permeability of the vascular walls, which in turn reduces edema, by restoring micro-capillary circulation and decreasing blood vessel permeability. An increase in mucosal membrane thickness is a result of these actions. There is some evidence that localized low-level laser therapy (LLLT) may reduce inflammation and alter biochemical markers of inflammation in both cells and soft tissues (14).

In the 2022 study, Ramezani et al. found that LLLT is considered an important innovation in improving pain and therefore has great potential for therapeutic applications in neuropathic pain, this meta-analysis found that LLLT (SMD: -0.87, 95% CI: -1.29 to -0.45) was more effective than sham LLLT or clonazepam in reducing burning pain without serious side effects. LLLT also had a positive effect on quality of life (SMD: 0.01, 95%CI: -0.58 to 0.60) and negative emotions (SMD: -0.12, 95% CI: -0.54 to 0.30), but these effects were not statistically significant. (15).

In 2016 the study done by Zecha et al, showed remarkable improvement of patients' trismus and pain after the various therapy modalities. LLLT had a more impressive positive effect on trismus after third molar operation as compared to its placebo application which used He-Ne laser with a wavelength of 633 nm, a power of 0.3 W/cm2 , and a dose of 10 J/cm2 at different six points around the operation site with a spot of 1.5 mm. and it has a great effect in managing the side effects following chemoradiation therapy of Head and Neck Cancer (HNC) including trismus, dysgeusia, dysphagia, lymphedema, and speech problems. So, it is highly impact on quality of life (16).

In contrast, other research have confirmed the findings of the PEMF studies published by Ouanounou et al. (2017), Elerian et al. (2021), Fouda et al. (2014), Mohajerani et al. (2019), Richards et al 1997 , Jiang et al. (2016), Wang et al (2019) and others .

In 2017, Ouanounou et al. Patients in the active LLLT group reported less discomfort on day 0 (P = 0.000), at the eighth session (P = 0.000), and one month (P = 0.001), the last treatment point that was within-group. At day 0, (8 sessions), 1 month, and there is no significant difference between the groups (P = 0.230, P = 0.806, and P = 0.214, respectively). After treatment, there was a significant increase in mouth opening in both Group 1 (P = 0.006) and Group 2 (P = 0.021). But there was no statistically significant difference (P = 0.330) between the two sets of data. Clicking also improved significantly before and after therapy in Group 2 (P = 0.001) and Group 1 (P = 0.000). Results show that LLLT is just as effective as a placebo in relieving function-related TMJ discomfort. The illness is likely multifactorial; therefore, it stands to reason that a more specific LLLT application is required (17).

In 2019 Wang et al found that biophysical stimulus employing physical therapy modalities, such as pulsed electromagnetic fields (PEMFs), light amplification by stimulated emission of radiation (LASER), and physical exercise, has been offered as alternative treatments that are less expensive, non-invasive, effective, safe, and causes fewer side effects, and is highly recommended for clinical use (PEMFs are electromagnetic fields capable of producing biological currents in tissue and have unique biological effects. PEMFs also help patients with osteoporosis feel better by reducing pain, improving functional results and improving quality of life (QoL) (18).

In a trial conducted by Richards et al., the efficacy of PEMF therapy using an Enermed pulsing magnetic device in MS

patients was evaluated using the Multiple Sclerosis Performance Scales (MSPS). After 8 weeks of treatment, patients in the active group showed a higher overall performance scale compared to the placebo group, although there was no difference in the fatigue subscale (19).

Dextrose phonophoresis and pulsed electromagnetic field (PEMF) both have positive effects on pain, range of motion (ROM), and function in patients with temporomandibular dysfunction (TMD), according to an investigation and comparison by Elerian et al. in 2021. Pulsed electromagnetic field (PEMF) research has shown that it may influence ion transport across cell membranes, leading to claims that it can enhance tissue blood supply, boost energy use and turnover, and ultimately lead to an increase in ATP (20).

Finding the best therapy for myofascial pain dysfunction patients' discomfort and increasing their mouth range of motion was the goal of a 2014 research by Fouda et al., which targeted painful trigger points (TrPs) in an effort to ablate muscular spasms and restore normal muscle length. According to the findings, the gold standard for pain alleviation treatments is pulsed electromagnetic field (PEMF) therapy. During every follow-up period, both the anesthetic and PEMF groups demonstrated a decrease in mean pain scores and a statistically significant rise in mean MMO. The results indicate that pulsed electromagnetic fields (PEMF) are the best option for treating myofascial pain which improve quality of life and increasing oral mobility (21).

When treating mandibular fractures, Mohajerani et al., 2019 found that pulsed electromagnetic fields (PEMF), low-intensity laser irradiation (LILI), and low-intensity ultrasound (LIPUS) all had an effect on bone density. From the end of the second week to the fourth week after a mandibular fracture, three studies with 12 to 32 patients found that PEMF significantly increased bone density in the fracture zone compared to the control group. However, at the 2nd week after the fracture, both the PEMF and control groups showed a decrease in bone density, but this decrease was not statistically significant ($P>0.05$) (22).

The researchers found that when 28 patients underwent LIPUS therapy at the fracture zone, their bone density increased at the 3rd and 5th week compared to the control group. This suggests that 1) using PEMF, LILI, and LIPUS therapy at the mandibular fracture zone increases bone density and speeds up the formation of new bone. 2) The therapies had the greatest impact from the 2nd to the 5th week of treating the mandibular fracture (22).

Jiang et al. (2016) concluded that low-level laser therapy and pulsed electromagnetic field therapy both have a dual effect on pain and maximum mouth opening after maxillofacial surgeries. However, the electromagnetic field therapy leads to an acute improvement in pain and increases MMO. Results suggest that a specific low-frequency PEMF appears to have some beneficial analgesic effects, especially in patients with TMJD, and should be used in conjunction with other therapies. The patient reported less post-treatment discomfort and an improvement in their range of motion while expanding their mouths thanks to laser therapy. This research demonstrated that PEMF treatment was more effective than laser therapy in reducing muscular discomfort between the first and final session. In order to treat TMJD effectively and alleviate pain symptoms without addressing the disorder's underlying cause, laser treatment is an effective supportive therapy. This allows for long-term success with treatment. Based on our research, PEMF seems to be the gold standard for treating myofascial pain dysfunction, both in terms of pain relief and increased oral mobility. Despite its pain-relieving and range-of-motion-improving effects, the biggest problem is choosing a patient and starting treatment, especially for those from low-income backgrounds. This is because patients often receive poor-quality advice, which in turn affects their healing and prognosis.

5. CONCLUSION

Pulsed electromagnetic fields and low-level lasers are effective in reducing post-maxillofacial surgery discomfort and restoring full mouth opening. Nevertheless, when it comes to impair quality of life and reducing the maximum mouth opening after maxillofacial procedures, pulsed electromagnetic fields are much more effective than low-level laser therapy.

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