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ORIGINAL ARTICLE

Karpal tünel sendromunda düşük yoğunluklu lazer tedavisi ile çoklu dalga kilitli sistem lazer tedavisinin karşılaştırmalı değerlendirilmesi: retrospektif bir çalışma

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Amaç: Bu çalışmada, Karpal Tünel Sendromunun tedavisinde kullanılan Düşük Yoğunluklu Lazer terapisi (DYLT) ve Çoklu Dalga Kilitli Sistem *(ÇDKS) Lazer terapisi* uygulamalarının klinik ve fonksiyonel parametreler üzerine olan etkilerinin değerlendirilmesi amaçlandı.
Yöntem: Çalışmada, hafif-orta dereceli karpal tünel sendromlu 60 hasta, 3 grupta retrospektif olarak değerlendirildi. Grup I; DYLT, Grup II; ÇDKS Lazer terapisi, Grup III; herhangi bir lazer uygulaması yapılmayan splint, ev egzersiz programı ve hasta eğitimi verilen hastalardan oluşuyordu. Hastaların dosyalarından başlangıçta, 4. Haftada ve 12. Haftada Vizüel Analog Skala (VAS), El Kavrama Gücü ölçümü ve Boston Karpal Tünel Sorgulama Anketi ölçümleri değerlendirildi.
Bulgular: Grup I ve Grup II'de 4. ve 12. haftada başlangıca göre tüm parametrelerde istatistiksel olarak anlamlı düzeyde iyileşme görüldü. Grup III'te ise el kavrama gücü ölçümlerinde ve Boston-Fonksiyonel Durum ölçeğinde 4. haftada başlangıca göre istatistiksel olarak anlamlı fark bulunamadı. Başlangıç ile 4. hafta arasındaki değişimler tüm parametreler açısından Grup I ve Grup II'de Grup III'e göre istatistiksel olarak anlamlı düzeyde daha iyi bulundu. Grup I ve II arasında ise VAS ve el kavrama gücü iyileşmeleri açısından istatistiksel olarak anlamlı fark bulunamadı ama Boston-Semptom Şiddet Skalasındaki iyileşme Grup II'de Grup I'e göre istatistiksel olarak anlamlı düzeyde daha belirgin bulundu.
Sonuç: Hem DYLT hem de ÇDKS Lazer terapisi karpal tünel sendromunun semptomlarını kontrol altına almak için splintleme ve egzersizle birlikte konservatif tedavi seçeneği olabilir. ÇDKS lazer terapisi semptom şiddetini azaltmada DYLT'e üstün olabilir.
Anahtar kelimeler: Karpal tünel sendromu, Lazer terapi, Konservatif tedavi, Fizik tedavi yöntemleri.

Comparative evaluation of low-level laser therapy and multi-wave locked system laser therapy for carpal tunnel syndrome: a retrospective study

Purpose: This study aimed to evaluate the effects of Low-Level Laser Therapy (LLLT) and Multi-Wave Locked System (MLS) Laser Therapy on clinical and functional parameters in Carpal Tunnel Syndrome.
Methods: In the study, 60 patients with mild-moderate carpal tunnel syndrome were evaluated retrospectively in 3 groups. Group I; LLLT, Group II; MLS Laser therapy, Group III; It consisted of patients who did not receive any laser application and were given splints, a home exercise program and patient education. Visual Analogue Scale (VAS), Hand Grip Strength measurement and BOSTON Carpal Tunnel Questionnaire measurements were evaluated from the patients' files at baseline, 4th week and 12th week.
Results: Statistically significant improvements were observed in all parameters in Group I and Group II at 4 weeks and 12 weeks compared to baseline. Group III showed no significant differences in grip strength measurements and the BOSTON Functional Status Scale at 4 weeks compared to baseline. The changes between baseline and 4 weeks were statistically significantly better in Group I and Group II compared to Group III for all parameters. No significant difference was found between Group I and Group II in VAS and grip strength improvements, but the improvement in Boston Symptom Severity Scale was significantly more prominent in Group II than in Group I.
Conclusion: Both LLLT and MLS Laser Therapy can be considered as conservative treatment options along with splinting and exercise to control the symptoms of Carpal Tunnel Syndrome. MLS Laser Therapy may be superior to LLLT in reducing symptom severity.
Keywords: Carpal tunnel syndrome, Lasers, Conservative treatment, Physical therapy modalities.

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Carpal Tunnel Syndrome (CTS) is a disease caused by compression of the median nerve in the carpal canal, a canal whose walls are composed of bones and ligaments, on the palmar side of the wrist. Factors such as the presence of certain diseases, anatomical features and hand performance may cause the development of CTS. Compression of the median nerve in this canal can characteristically cause hand pain, numbness, tingling, and muscle weakness.

CTS is one of the most diagnosed entrapment neuropathies, and its estimated prevalence in the population varies between 1 and 5 percent. It is seen three times more frequently in women than in men.[1] The diagnosis of CTS is based on history, clinical signs and symptoms, and electrodiagnostic studies. Electrodiagnostic studies are considered to be the gold standard for confirming the diagnosis and planning treatment.[2] Electrodiagnostic tests are also useful for measuring the severity of median nerve injury because the extent of clinical symptoms may not always correlate with the severity of median nerve injury. CTS is divided into 3 stages according to the American Society of Electrodiagnostic Medicine, electrodiagnosticly and depending on the severity of the patient's symptoms.[3-4] In the first stage, symptoms such as pain, numbness, and tingling in the hand and fingers occur primarily at night, leading to frequent waking of the patient. In the second stage, these nighttime symptoms persist throughout the day. Finally, in the third stage, motor deficits emerge, resulting in objects falling from the hand.

Treatment of CTS can be managed in two ways, conservatively and surgically, depending on the severity and stage of the symptoms. Conservative treatment options include non-steroidal anti-inflammatory drugs, wrist splints, kinesiotaping, tendon and median nerve gliding exercises, local steroid injections, acupuncture and physical therapy applications such as paraffin, magnet therapy, ultrasound, and low-intensity laser.[5]

After the discovery of the therapeutic effects of lasers in the late 1960s, low-level laser therapy (LLLT) began to be applied in various diseases.[6] LLLT reduces inflammation, pain and edema, heals deep tissues and nerves, and prevents tissue damage. LLLT has no thermal effect, it acts by causing a chemical change after light is absorbed.[7] Laser biostimulation causes changes in cellular metabolism by increasing ATP synthesis, protein synthesis, cell proliferation, enzyme activity, number of mitochondria and membrane potential.[8] LLLT is a treatment used in CTS because it increases nerve regeneration, has positive effects on neurotransmission, and increases myelin production by increasing blood supply. Although LLLT is used as a conservative treatment option in CTS, uncertainty about the evidence supporting its efficacy has been mentioned in some CTS treatment guidelines.[5-9]

Multiwave Locked System (MLS) Laser therapy was developed in an effort to overcome the limitations of LLLT and the concerns of high-power laser therapy to produce an effective and simultaneous effect on pain, inflammation and edema. This treatment method targets nerve, muscle and connective tissue using two different wavelengths (808nm and 905nm) of a laser simultaneously.[10] A synergistic energy is created when transmitting these wavelengths that produce more anti-inflammatory and analgesic effects than either could produce on their own, while minimizing the risk of thermal damage. MLS laser therapy can be used to treat acute and chronic pain, tendinitis, rheumatoid arthritis and other inflammatory conditions. MLS laser therapy is also used in CTS and Bell's palsy as it accelerates and improves nerve regeneration.[11-12]

Although there are previous studies evaluating the effect of LLLT and MLS laser treatments on various diseases, there is no study comparing these two treatments in CTS. The aim of this study is to retrospectively reveal the effects of LLLT and MLS laser therapy applications used in the treatment of patients with CTS on clinical and functional parameters, to compare the two treatment methods and to investigate whether they are superior to each other.

METHODS

This retrospective study includes 60 patients with CTS who applied to the Medipol Mega University Hospital Physical Medicine and Rehabilitation clinic and received treatment between January 2022 and March 2023. The study encompassed patients aged 20-60 years

who were diagnosed with unilateral, mild, or moderate CTS in the dominant extremity based on the recommendations of the American Association of Electrodiagnostic Medicine.[3] These patients presented with symptoms of paresthesia and/or pain in areas corresponding to the distribution of the median nerve in their hands. The duration of symptoms was at least one month, and during physical examination, at least one of the Tinel, Phalen, or Reverse Phalen tests was positive. Patients with systemic diseases such as diabetes mellitus and rheumatoid arthritis, neurological conditions like radiculopathy, polyneuropathy, and brachial plexopathy, pregnant patients, those with a history of wrist surgery or steroid injections, and patients diagnosed with severe CTS according to ENMG were excluded from the study. The study protocol was approved by the Istanbul Medipol University Ethics Committee on May 15, 2023 (E-10840098-772.02-3000).

In our outpatient clinic, patients diagnosed with mild and moderate CTS are provided with patient education regarding the mechanism of the disease, potential symptoms, and activities that could contribute to the progression of the condition. All patients are prescribed a resting splint, recommended for nighttime use, to immobilize the wrist in a neutral position.

In addition, in one session, physiotherapists show patients median nerve gliding exercises in detail and provide information on how to do them. Visual materials are provided so that they can practice their exercises at home more easily.[13] These exercises are based on a specialized approach, as suggested by Totten and Hunter, focusing on reducing nerve tension rather than elongating the median nerve bed. In the initial exercise, wrist extension and finger flexion positions are alternated, while in the second exercise, elbow flexion and wrist extension positions are alternated. Each exercise session consists of ten repetitions, and completing one session takes approximately 2 minutes. This method helps enhance the mobility of the median nerve while minimizing nerve tension. Patients are encouraged to engage in regular home exercises following this guidance and exercise program.

In our study, we reviewed the documents of patients diagnosed with CTS in our outpatient clinic who underwent regular follow-ups. Patients meeting our study criteria were divided into three different groups: Group I received education, a splint, and additional LLLT; Group II received education, a splint, and additional MLS Laser therapy, while Group III consisted of patients who could not participate in the physical therapy program and received only education, a splint, and a home exercise program. Patients were categorized in this manner to evaluate the effectiveness of different treatment methods.

In our physical therapy unit, LLLT is applied to CTS patients on the volar surface of the wrist at the carpal tunnel area at five different points. Using a wavelength of 830 nm, a power of 30 mW, a dose of 1.5 J/cm², continuous, and 100% output parameters with the Chattanooga® Intelect Mobile Laser device, each point is treated for 5 minutes, five days a week for three weeks. The MLS laser (ASALASER MLS® Mphi) is applied to the distal wrist crease and the thenar eminence for three weeks, five days a week. The given dose is 15.01 J/cm², with a frequency of 700 Hz, a duration of 10 minutes for 2 points, and the total treatment dose per session is 600.36 Joules.

The patients' pain levels were assessed at the beginning, and in the 4th and 12th weeks using a 10 cm Visual Analog Scale (VAS). Hand grip strength (HGS) was measured by Jamar hand dynamometer (Baseline hydraulic hand dynamometer, Irvington, NY, USA) in all patients at baseline, week 4, and week 12. HGS measurements were taken from the dominant extremity with the patient in a seated position, shoulder adducted, elbow flexed at 90 degrees, and forearm in a neutral position. Three measurements were taken, with a 1-minute break between each measurement, after instructing the patients to perform maximal voluntary gripping. The average of the three measurements was recorded in kilograms.[14] Symptom severity and functional assessments of the patients were evaluated with the Boston questionnaire at baseline, week 4, and week 12. This questionnaire consists of 19 questions divided into two parts, assessing symptom severity (SSS) (11 questions) and functional status (FSS) (8 questions). Responses are rated on a scale of 1 to 5, with 1 representing the mildest symptom or the best functional status, and 5 representing the worst symptom or worst functional status. To calculate the average scores, the total score is divided by the number

of questions.[15] The Turkish version of the Boston questionnaire has been validated for reliability.[16] All clinical evaluations were conducted by the same physiatrist (AU).

Statistical Analysis

The statistical analyses were performed using the IBM SPSS software package (Statistics Package for Social Sciences, Version 21.0, IBM Corp., Armonk, NY). Graphical representations were created using MS Office Excel 2022 (Microsoft Corporation, Redmond, WA, USA). The behaviors of the quantitative variables were described using measures of central tendency and variance, specifically the mean±SD. When assumptions of normality and homoscedasticity were not met, the Kruskal-Wallis H-Test method was utilized to identify differences in behavior among group means. For multiple comparisons between groups, the Bonferroni post hoc correction method was applied. The Wilcoxon Signed-Rank Test was employed to assess whether the changes between measurement values for the same individuals at different time points differed significantly from zero. For all analyses, a significance level of p=0.05 was determined.

RESULTS

Sixty patients diagnosed with unilateral mild or moderate CTS in the dominant hand were included in the study. Group I mean age 45.37±6.52 years, mean symptom duration 12.64±5.44 months, Group II mean age 46.26±5.88 years, mean symptom duration 13.73±4.83 months, Group III mean age 44.51±6.17 years, mean symptom duration 13.24±5.91 months was. Demographic data are presented in Table I, and no significant difference was found between the groups in age, dominant hand, symptom duration, body mass index and CTS severity levels.

In Table II, the mean values and standard deviations of clinical and functional parameters baseline, 4 weeks and 12 weeks after treatment for all three groups are given, and the data baseline and 4 weeks after treatment and the data baseline and 12 weeks after treatment are compared. In Group I and Group II, statistically significant improvement was observed in all parameters after 4 and 12 weeks compared to baseline. In Group III, statistically significant improvement was observed in the VAS and SSS after 4 and 12 weeks compared to baseline (p<0.001). In group III, no statistically significant difference was found in HGS measurements after 4 and 12 weeks compared to baseline (p=0.68 and p=0.875, respectively). In Group III, on the FSS, there was no statistically significant difference after 4 weeks compared to baseline (p=0.059) but a significant improvement was observed after 12 weeks compared to baseline (p=0.024).

Table III presents the mean and standard deviations of the changes in clinical and functional scores between baseline and 4 weeks, as well as between baseline and 12 weeks, for each group. The intergroup comparison of these changes is also presented for both periods.

There were no statistically significant differences between Group I and Group II in the changes in VAS values in both periods. However, statistically significant less improvement was found in group III compared to group I and group II in both periods (p=0.005, p<0.001, p=0.007, p=0.013, respectively).

Changes in HGS measurements between baseline and 4 weeks did not show statistically significant differences between Group I and Group II (p=0.792). However, statistically significantly less improvement was found in Group III compared to Group I and Group II (p=0.007 and p=0.001, respectively). Changes in hand grip strength measurements between baseline and 12 weeks did not show statistically significant differences between Group I and Group II (p=0.611) and between Group I and Group III (p=0.13). However, a statistically significant improvement was found in Group II compared to Group III (p=0.014).

Changes in symptom SSS scores showed statistically significantly more improvement in Group II compared to Group I and Group III in both periods (p<0.001). There was also a statistically significant improvement in Group I compared to Group III in both periods (p<0.001).

Changes in FSS scores were statistically significantly more improved in Groups I and II compared to Group III in both periods (p<0.001). The changes in FSS scores between baseline and 4 weeks did not demonstrate statistically significant differences between Group I and Group II (p=0.22). However, the changes in FSS scores between baseline and 12 weeks were significantly more improved in Group II compared to Group I (p=0.034).

Table 1. The demographic characteristics of the patients.

		Group I	Group II	Group III
		Mean±SD	Mean±SD	Mean±SD
Age		45.37±6.52	46.26±5.88	44.51±6.17
Duration of Symptoms (months)		12.64±5.44	13.73±4.83	13.24±5.91
Body Mass Index (kg/m^2)		25.61±2.75	24.15±3.12	25.93±2.94
		n	n	n
Gender	Female / Male	16 / 4	17 / 3	14 / 6
Dominant Hand	Right / Left	19 / 1	18 / 2	19 / 2
Severity of Carpal Tunnel Syndrome	Mild / Moderate	6 / 14	5 / 15	7 / 13

Table 2. Clinical and functional parameter values and measurements: baseline, 4 weeks, and 12 weeks comparisons.

	Baseline	4 weeks	12 weeks		
	Mean±SD	Mean±SD	Mean±SD	p*	p**
Pain (Visual Analog Scale, VAS)					
Group I	6.85±1.27	4.45±1.1	4.5±0.76	<0.001	<0.001
Group II	6.8±1.36	4.15±0.81	4.65±0.75	<0.001	<0.001
Group III	6.75±1.07	5.45±0.89	5.55±0.94	<0.001	0.001*
Power of Hand Grip (kg)					
Group I	22.1±2.25	24.25±2.12	23.7±2.05	<0.001	0.003*
Group II	22.0±2.81	24.55±2.06	24.3±1.56	0.001*	0.003*
Group III	23.15±2.87	23.35±2.37	23.3±2.27	0.68	0.875
Symptom Severity Scale					
Group I	3.27±0.18	2.34±0.42	2.42±0.41	<0.001	<0.001
Group II	3.24±0.15	2.0±0.19	2.04±0.14	<0.001	<0.001
Group III	3.18±0.19	2.98±0.24	2.91±0.19	<0.001	<0.001
Functional Status Scale					
Group I	2.9±0.11	2.3±0.21	2.31±0.23	<0.001	<0.001
Group II	2.88±0.16	2.2±0.18	2.14±0.18	<0.001	<0.001
Group III	2.86±0.13	2.78±0.17	2.77±0.18	0.059	0.024*

* p<0.05. p*: Baseline-4 weeks. p**: Baseline-12 weeks.

Table 3. Inter-group comparison of changes in clinical and functional parameters baseline-4 weeks and baseline-12 weeks.

	Group I	Group II	Group III			
	Mean±SD	Mean±SD	Mean±SD	p1	p2	p3
VAS (Baseline-4 weeks)	-2.4±1.05	-2.65±1.18	-1.3±0.8	0.005*	1	<0.001
VAS (Baseline-12 weeks)	-2.35±1.09	-2.15±1.18	-1.2±0.89	0.007*	1	0.013*
HGS (Baseline-4 weeks)	2.15±1.73	2.55±2.48	0.2±1.47	0.007*	0.792	0.001*
HGS (Baseline-12 weeks)	1.6±1.88	2.3±2.68	0.15±2.37	0.13	0.611	0.014*
SSS (Baseline-4 weeks)	-0.93±0.35	-1.25±0.2	-0.2±0.19	<0.001	0.001*	<0.001
SSS (Baseline-12 weeks)	-0.85±0.36	-1.21±0.17	-0.27±0.21	<0.001	<0.001	<0.001
FSS (Baseline-4 weeks)	-0.6±0.17	-0.68±0.14	-0.08±0.16	<0.001	0.22	<0.001
FSS (Baseline-12 weeks)	-0.59±0.2	-0.74±0.17	-0.09±0.16	<0.001	0.034*	<0.001

* p<0.05. p1: Group I-III. p2: Group I-II. p3: Group II-III. Visual Analog Scale (VAS). HGS: Handgrip Strength. SSS: Symptom Severity Score. FSS: Functional Status Score.

DISCUSSION

In this study, the effects of two different laser applications and splinting, exercise and patient education on clinical and functional parameters before and after treatment were evaluated in patients with mild and moderate CTS. Results revealed that LLLT and MLS laser were more effective than splinting, exercise and training alone in terms of pain, HGS, SSS, and FSS.

The most common conservative treatments in CTS are primarily patient education, splinting and exercises. Splinting is the first-line treatment for mild to moderate CTS because of its easy availability, patient compliance, and low cost.[17] A 2012 Cochrane review concluded that a hand-wrist rest splint was more effective than placebo.[18] And one study reported that a hand-wrist splint fixed in the neutral position provided twice the relief than a splint fixed in extension.[19] Nerve gliding exercises are simple hand and finger movements that theoretically restore normal movement of the median nerve, which may become "attached" due to nerve compression. In the review of Ballestero et al. on the effectiveness of nerve gliding exercises in CTS, it was reported that nerve gliding exercises had similar effects and better results than standard care when compared with other conservative methods for the treatment of CTS.[20] In our study, we provided all groups with a hand-wrist resting splint in neutral position and home exercise program, education what CTS is, in which movements and positions the compression can increase, and they should limit activities that require repetitive movements, heavy gripping and vibration in the hand.

After the discovery of the therapeutic properties of lasers after the 1960s, low-intensity lasers began to be used in various musculoskeletal diseases. Although LLLT is a conservative treatment option for CTS, several guidelines have cited uncertainty regarding the evidence supporting its effectiveness.[5-9] LLLT has been reported to have both anti-inflammatory and anti-edema effects due to its reducing effect on prostaglandin synthesis.[21] In a prospective randomized controlled study on CTS patients with rheumatoid arthritis, LLLT treatment was shown to be effective for pain and hand function in CTS.[22] In the study by Evcik et al., although LLLT was found to be more effective in increasing HGS than the placebo, it was found to be ineffective in terms of pain and EMG results.[23] Irvine et al. also compared a Ga-Al-As diode laser with a wavelength of 860 nm to sham laser therapy and concluded that LLLT was no more effective than a placebo in improving CTS symptoms, median nerve conduction and hand function.[24] In our study, positive effects of LLLT on all evaluated symptoms and functional parameters were shown. This result may be due to the combined effect of splinting, exercise and patient education in all patients and the additional administration of LLLT.

MLS laser therapy is a novel technique that utilizes synchronized emission of two wavelengths, 808 nm (continuous mode) and 905 nm (pulse mode), to enhance the effects of laser irradiation. The two emissions are absorbed by different mitochondrial complexes and can affect cellular energy metabolism by simultaneously acting on multiple sites in the cellular respiratory chain.[25] Lights with a wavelength of 808 nm given in continuous mode cause anti-inflammatory and antiedema effects by supporting the production of ATP, stimulating the microcirculation and affecting the synthesis of inflammatory mediators. Lights with a wavelength of 905 nm given in pulse mode affect nerve conduction and provide analgesic effects over superficial nociceptors and afferent nerve fibers.[26]

The use of MLS laser in musculoskeletal diseases has increased recently. Pattapong et al. conducted a single-blind, randomized, controlled study evaluating the efficacy of MLS Laser therapy in the treatment of patients with CTS. They included 30 patients in the study and applied 12 sessions of MLS laser treatment at a dose of 15.01 J/cm^2 to one group and placebo laser treatment to the other group. The patients were evaluated both clinically, functionally and electrophysiologically before and after the treatment at 4 weeks and 12 weeks. As a result, they found a statistically significant improvement in the compound muscle action potential (CMAP) amplitude values of the median nerve and VAS values in the MLS laser group compared to the placebo group.[11] In a randomized, double-blind, placebo-controlled study investigating the effect of MLS laser in patients with idiopathic Bell's palsy, they

reported that MLS laser is an effective physiotherapy method used in the treatment of patients with idiopathic Bell's palsy compared to placebo laser.[12] In our study, we found that the MLS laser was more effective on the SSS and FSS of CTS patients in a short time compared to splint, exercise and education alone. The anti-inflammatory and analgesic effects provided by the use of two different wavelengths offer an effective conservative method option in controlling CTS symptoms.

Limitations

This study had some limitations. The most important limitation of our study was that it is retrospective. If the study had been a prospective randomized controlled study, the results could have been better interpreted. In our study, we followed the clinical evaluations with VAS, hand dynamometer and Boston questionnaire. If we had followed up with EMG at week 12, the data of the study would have been more objective. However, due to the improvements in the clinics of the patients and the absence of routine EMG control in mild and moderate CTS stages, EMG was only present at the diagnosis stage in our study. Another limitation is that the follow-up period is limited to 12 weeks. This situation resulted from both patient non-compliance and the conditions of our hospital that made long-term follow-up difficult.

Conclusion

The results of this study suggest that both LLLT and MLS laser therapy, in combination with splinting, exercise, and education, are effective in improving symptoms and functional parameters in patients with mild to moderate CTS. However, MLS laser therapy showed superior outcomes compared to LLLT in terms of SSS and FSS. Further studies comparing the efficacy of different laser therapies in CTS are needed to validate these findings and guide clinical decision-making.

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Conflicts of Interest: *None*

Ethical Approval: The protocol of the present study was approved by Ethics Committee of Istanbul Medipol University (issue: E-10840098-772.02-3000 date: 15.05.2023).

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