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Original Article

Short-term Effectiveness of High-intensity Laser Therapy in De Quervain Tenosynovitis: A Prospective, Randomized, Controlled Study

De Quervain Tenosinovitinde Yüksek Yoğunluklu Lazer Tedavisinin Kısa Dönem Etkinliği: Prospektif, Randomize, Kontrollü Bir Çalışma

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ABSTRACT

Objective: The effectiveness of high-intensity laser therapy (HILT) has been demonstrated in some musculoskeletal repetitive strain injury disorders. This study aimed to determine the short-term effectiveness of HILT in de Quervain tenosynovitis (DQT).

Methods: Sixty-four patients with DQT diagnosis (32 males, 32 females; 18-65 years) were randomly divided into two groups. A short opponens splint was applied to both groups and HILT to the treatment group and sham HILT to the control group once a day, on alternate days, 3 days a week, for 5 weeks. Pre- and post-treatment evaluations were made using a visual analog scale (VAS); Quick Disabilities of the Arm, Shoulder, and Hand questionnaire; Short Form-36 Health Survey; and hand grip strength test.

Results: The demographic results (age, gender, duration of complaint, body mass index, occupational group) of both groups were similar (p>0.05). The pre-treatment measured values were similar in both groups (p>0.05). After a 5-week treatment, a significant improvement was observed in all parameters in both groups. Post-treatment, hand grip strength levels were statistically higher in the HILT group than in the sham therapy group, and VAS levels were significantly lower (p<0.001).

Conclusions: HILT is a non-invasive and reliable method that increases grip strength and decreases pain in DQT.

Keywords: De Quervain tenosynovitis, hand grip strength, high-intensity laser therapy, pain

ÖZ

Amaç: Yüksek yoğunluklu lazer tedavisinin (HILT) etkinliği, kas-iskelet sistemindeki bazı tekrarlayan zorlanma yaralanmalarında gösterilmiştir. Bu çalışmanın amacı de Quervain tenosinovitinde (DQT) HILT'nin kısa vadeli etkinliğini belirlemektir.

Yöntemler: DQT tanılı 64 hasta (32 erkek, 32 kadın; 18-65 yaş) rastgele 2 gruba ayrıldı. Beş hafta boyunca her iki gruba da kısa opponens ateli, tedavi grubuna HILT, kontrol grubuna sham HILT haftada 3 gün, günaşırı, günde bir kez uygulandı. Tedavi öncesi ve tedavi sonrası değerlendirmeler görsel analog skala (VAS), Kol, Omuz ve El Sorunları Hızlı Anketi, Kısa Form-36 Sağlık Anketi ve el kavrama kuvveti testi kullanılarak yapıldı.

Bulgular: Her iki grubun demografik verileri (yaş, cinsiyet, şikayet süresi, vücut kitle indeksi, meslek grubu) benzerdi (p>0,05). Tedavi öncesi ölçülen değerler her iki grupta da benzerdi (p>0,05). Beş haftalık tedavi sonrasında her iki grupta da tüm parametrelerde anlamlı düzelme gözlendi. Sham terapi grubu ile karşılaştırıldığında HILT grubunda tedavi öncesine göre tedavi sonrası el kavrama kuvveti düzeylerinde istatistiksel olarak anlamlı artış ve VAS düzeylerinde istatistiksel olarak anlamlı azalma görüldü (p<0,001).

Sonuçlar: HILT, DQT'de kavrama gücünü artıran ve ağrıyı azaltan, non-invaziv ve güvenilir bir yöntemdir.

Anahtar kelimeler: De Quervain tenosinoviti, el kavrama kuvveti, yüksek yoğunluklu lazer tedavisi, ağrı

INTRODUCTION

De Quervain's tenosynovitis (DQT) is stenosing tenosynovitis under the dorsal carpal ligament and radial tunnel of the M. abductor pollicis longus and M. extensor pollicis brevis tendons located in the first dorsal compartment of the wrist. Further, the terms Quervain's disease, radial styloid tenosynovitis, stenosing tendinitis, peritendinitis, and styloid tenovaginitis are used[1]. Prevalence has been reported as 0.5% in males and 1.3% in females and those aged 30-55 years[2].

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The etiology of DQT includes several factors. With excessive and repetitive movements of the thumb and wrist, increased friction causes force and microtrauma, inducing DQT[3]. The serum in the synovial sheath decreases and is replaced by fibrin granulation tissue. In this condition, the tendon adheres to the synovial sheath, and the flexor retinaculum overlying the first compartment becomes 3-4 times thicker than normal.

Histologically, mucopolysaccharide accumulation, a sign of myxoid degeneration, was observed in the thickened tissue; however, inflammation was not noted[4].

Pain is a typical finding in the pulse groove on the wrist. Moreover, swelling may occur in the painful area and severe pain is felt when the area is pressed. It is extremely painful to open the thumb outward, and the pain affects daily life[1,5].

Diagnosis is made clinically. Finkelstein test positivity is pathognomonic. In differential diagnosis, radial styloid fracture, intersection syndrome, scaphoid fracture, radioscaphoid arthritis, scapolunate instability, and radial neuritis should be considered, and the diagnosis should be supported by X-ray regarding exclusion. Usually, no further examination is required[1,5]. Ultrasonography (USG) and magnetic resonance imaging are useful tools in evaluating joints and tendons[6]. DQT treatment is started with a short opponens splint, non-steroidal anti-inflammatory drugs, pomades, and coldpack. Local injections are planned for patients with persistent pain, and studies have shown that steroid injection is more efficient when applied under USG guidance. Additionally, conventional physical therapy, and exercise methods can be used. Patients with persistent pain despite these treatments are referred to surgery[1,3,7,8].

Laser therapy (low-intensity, high-intensity) has been used safely for years in musculoskeletal disease treatment, as it is non-invasive, painless, and can be combined with other treatment methods. High-intensity laser therapy (HILT) was approved by the Food and Drug Administration in 2002[9]. HILT contributes to tissue repair and regeneration by increasing the extracellular matrix production of connective tissue cells[10]. HILT efficacy has been demonstrated in some tendinopathies in randomized controlled studies[11-13]. To our knowledge, no study has investigated the effects of HILT on DQT in the literature. Therefore, this study aimed to determine the short-term effectiveness of HILT on DQT.

MATERIALS and METHODS

To assess statistical significance at 90% power and 5% error level, it was determined in the power analysis conducted before to the investigation that each group required at least 32 cases.

The Istinye University Clinical Research Ethics Committee (decision no: 2/2020.K-061, date: 11.09.2020) approved the project. The research was listed on ClinicalTrials.gov (ID: NCT05141799). The Declaration of Helsinki was followed in all study methods.

In total, 64 patients (32 females, 32 males) who presented at the Outpatients Clinic of Private Medar Hospital Physical Medicine and Rehabilitation Department between September 2020 and March 2022 with the complaint of unilateral wrist pain were diagnosed with DQT and volunteered to participate in the study and were included. Cases with previous wrist steroid injection or surgery, cervical radiculopathy/myelopathy, neurological disease that may affect the upper extremity, perception problems, recent fractures, or a history of systemic or rheumatic disease that may involve the joints were excluded. All the patients provided written informed consent. Two patients could not complete the treatment process; hence, they were excluded from the study.

Study Design

The doctor who made the diagnosis was blinded to the patient groups as were the patients themselves. The study design is shown in Figure 1. The patients were randomized into the two groups using a computer-based method by the same physiotherapist who attended to the patients. Each patient was given a short opponens splint which was recommended to be removed only 3-4 times a day for hygiene purposes. Fifteen HILT sessions were applied to the treatment group (one session: 3 days a week for 5 weeks). The control group underwent 15 sham HILT sessions.

HILT

Laser therapy was applied using a BTL-6000 high-intensity laser device (12 W; BTL Industries, Inc., Greeneville, TN, USA) at 1,064 nm (neodymium-doped yttrium aluminum garnet laser source). In the HILT group, 100 seconds, 10 w, 10 J/cm^2, and a total of 250 joules of energy was applied to the pulse groove and along the painful course in analgesia mode in the first seven sessions. In the next eight sessions, 30 sec, 6 W, and 120-150 J/cm^2 energy was applied in the biostimulation phase. Similar applications were applied to the sham HILT group with the device turned off.

Demographic data and complaint periods of the diagnosed patients were recorded. Before starting the

treatments, evaluations of the patients were made with visual analog scale (VAS), Quick Disabilities of the Arm, Shoulder, and Hand (QDASH), and Short Form-36 (SF-36).

Outcome Measures

The intensity of pain felt by the patient was evaluated by them marking a VAS score of 10 (0, no pain; 10, very severe pain).

The QDASH is a questionnaire used to assess activity and participation limitations in upper extremity disorders. The total score is obtained as the total of the sub-parameters, ranging from 0 (no difficulty or symptoms) to 100 (no activity or very severe symptoms)[14]. The Turkish version of the scale's validity and reliability studies have been performed[15].

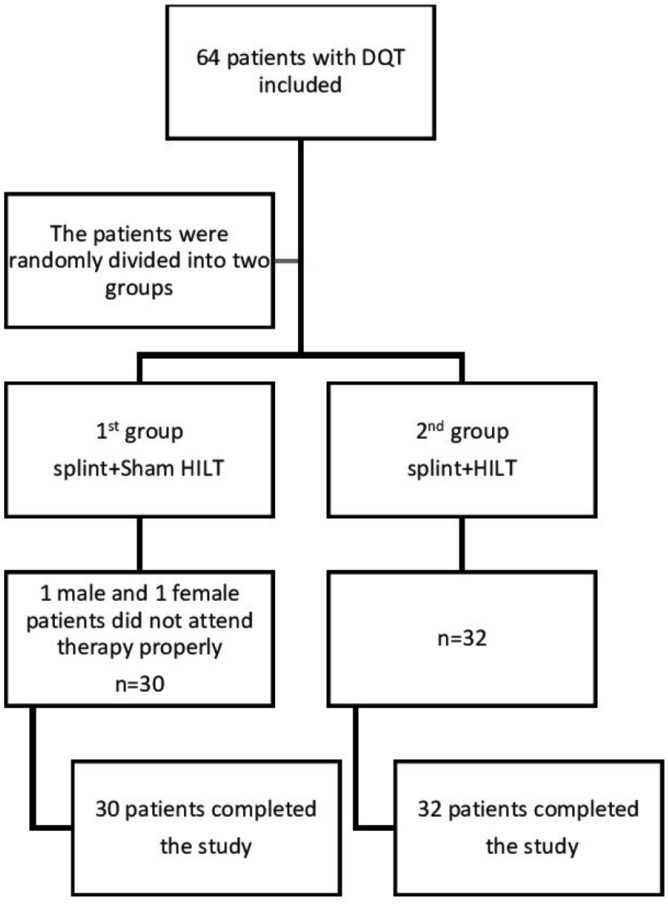

Figure 1. Flow diagram of the study.

VAS: Visual analog scale, HILT: High-intensity laser therapy, SF-36: Short Form-36, QDASH: Quick Disabilities of Arm, Shoulder, and Hand, DQT: de Quervain tenosynovitis

SF-36 is a common quality-of-life scale used in healthcare and is not specific to any age, disease, or treatment type. Higher scores indicate a good quality of life, and lower scores, a poor quality of life. Validity and reliability studies of the Turkish version were performed by Koçyiğit et al.[16].

Hand grip strength was assessed using a Jamar brand dynamometer (Saehan Hydraulic Hand Dynamometer, Korea) as recommended by the American Association of Hand Therapists. Three measurements were taken with the patient seated, with the shoulder in adduction and neutral rotation, the elbow in 90° flexion, the forearm in neutral position, and the wrist in 30° extension. In each measurement, the patients were asked to grasp as strongly as possible and hold for 3 seconds. After each measurement, a 30-second rest was given. All patients underwent this evaluation before and after treatment. The measurement values were recorded in kilograms[17,18].

Statistical Analysis

Data analysis was performed using IBM SPSS Statistics vn. 25.0 software (IBM Corporation, Armonk, NY, US). The Shapiro-Wilk test was used to determine normal distribution of continuous numerical variables. For continuous numerical variables, descriptive statistics were expressed as mean standard deviation, median (minimum-maximum), or median (25^{th} percentile-75^{th} percentile) values, and for categorical variables, as number (n) and percentage (%). The significance of the differences between the groups regarding mean values was evaluated with the Student's t-test, in terms of continuous numerical variables not showing normal distribution with the Mann-Whitney U test. Categorical variables were evaluated with continuity corrected χ^2 or the Fisher Freeman Halton test. Dependent t-test determined any significant change in QDASH levels within the groups according to the follow-up times. The significance of the differences between pre-treatment and post-treatment values of VAS, hand grip strength, and SF-36 was evaluated with the Wilcoxon signed-rank test. The Bonferroni correction was used to reduce the type I error in all possible multiple comparisons. Accepted <0.05 was considered statistically significant. Bonferroni correction was applied to eliminate type I error in all conceivable multiple comparisons.

RESULTS

Table 1 shows the comparisons made regarding the clinical and demographic characteristics of the patients according to the groups.

The mean body mass index, mean age, gender distribution, median duration of complaints, and employment status of the HILT group and the control group did not statistically differ from each other (p>0.05).

Table 2 compares the cases' QDASH, hand grip strength, and VAS scores according to the groups and follow-up intervals.

No significant difference was noted between the groups regarding pre-treatment QDASH levels (p=0.788). In both groups, a significant decrease was observed in QDASH levels following treatment compared to pre-treatment (p<0.001). Regarding QDASH levels following therapy, between the groups, no significant difference was found (p=0.084). Although the QDASH score in the HILT group decreased more from pre- to post-treatment, the difference between the groups was not statistically significant (p=0.072).

When comparing the pre-treatment hand grip strength levels between the groups, no significant difference was observed (p=0.871). Compared to previous therapy, a significant improvement was noted in hand grip strength levels in both groups (p<0.001). The Bonferroni correction showed no significant difference between the groups regarding post-treatment hand grip strength levels (p=0.043). Compared to pre-treatment,

Table 1. Group-specific clinical and demographic characteristics of the cases.

	Sham therapy group (n=30)	HILT group (n=32)	p-value
Age (years)*	37.9±8.4	40.4±8.9	0.254†
Gender			0.799‡
Female	16 (53.3%)	15 (46.9%)	
Male	14 (46.7%)	17 (53.1%)	
Duration of complaints (months)**	6 (3-24)	6 (3-18)	0.286¶
Body mass index (kg/m^2)*	26.1±4.4	25.6±3.9	0.655†
Occupation			0.927¥
Housewife	10 (33.3%)	9 (28.1%)	
Manual worker	11 (36.7%)	14 (43.8%)	
Clerical worker	2 (6.7%)	3 (9.4%)	
Other	7 (23.3%)	6 (18.7%)	

Descriptive statistics; expressed as *mean ± standard deviation or **median (minimum-maximum). †Student's t-test, ‡Continuity corrected χ^2 test, ¶Mann-Whitney U test, ¥Fisher Freeman Halton test. HILT: High-intensity laser therapy

Table 2. According to the groups and follow-up intervals, the cases' QDASH, hand grip strength, and VAS levels.

	Baseline	After treatment	p-value†	Change
QDASH*				
Sham therapy group	50.8±15.3	23.8±15.8	<0.001¶	-27.0±17.0
HILT group	51.9±16.2	17.3±13.4	<0.001¶	-34.6±15.6
p-value‡	0.788§	0.084§		0.072§
Hand grip**				
Sham therapy group	17.4 (14.3-22.5)	22.6 (19.5-28.7)	<0.001¥	5.0 (3.3-8.0)
HILT group	18.6 (14.2-25.0)	29.8 (20.0-35.0)	<0.001¥	9.8 (5.0-13.0)
p-value‡	0.871#	0.043#		<0.001#
VAS**				
Sham therapy group	5.0 [5.0–7.0]	4.0 [1.0–5.0]	<0.001¥	−3.0 [−4.0–−2.0]
HILT group	6.0 [5.0–8.0]	2.0 [0.0–3.0]	<0.001¥	−4.5 [−6.0–−3.0]
p-value‡	0.484#	<0.001#		<0.001#

Descriptive statistics; expressed as *mean ± standard deviation or **median [25th percentile-75th percentile]. †Comparisons made between groups before and after treatment were considered statistically significant for p<0.025 according to the Bonferroni correction. ¶Dependent t-test, ¥Wilcoxon signed-rank test, §Student's t-test, #Mann-Whitney U test. ‡According to the Bonferroni correction, the results were considered statistically significant for p<0.025 in comparisons made between groups before and after treatment, but for p<0.05 in comparisons made regarding changes after treatment compared to before treatment. VAS: Visual analog scale, QDASH: Quick Disabilities of Arm, Shoulder, and Hand

post-treatment hand grip strength levels increased significantly more in the HILT group than in the control group (p<0.001). Further, no side effects were reported by patients during or after HILT.

In terms of pre-treatment VAS scores, no significant difference was found between the groups (p=0.484). Both groups experienced a statistically significant decrease in VAS following treatment compared to before treatment (p=0.001). VAS score decrease from pre- to post-treatment was significantly greater in the HILT group than in the control group (p<0.001).

Table 3 compares the SF-36 quality-of-life subscale scores between groups and follow-up intervals.

When comparing the groups' scores on any of the SF-36 subscales prior to therapy, the Bonferroni correction revealed no significant difference between them (p>0.025). Pain, role limitations due to physical health, general health, and energy/fatigue levels significantly increased in the HILT group from pre-treatment to post-treatment (p<0.01). The Bonferroni correction showed no significant difference in the scores of the other components (p>0.025). Energy/fatigue, role limitations due to physical health, emotional well-being, pain, social functioning, and general health levels in the control group increased significantly from pre-treatment to post-treatment (p<0.025), and the Bonferroni correction revealed no statistically significant change in the scores of the remaining components (p>0.025). Further, the Bonferroni correction identified no significant difference between the groups in any of the SF-36 subscale scores following therapy (p>0.025). In terms of changes in SF-36 subscales between before and after therapy, no significant difference was noted (p>0.05).

DISCUSSION

DQT is a repetitive strain injury (RSI) disease, and various treatment options can be applied. Cases that do not benefit from conservative and pharmacological treatment are referred to surgery. This study aimed to investigate the effectiveness of HILT in DQT. The results showed a significant increase in hand grip strength levels and a decrease in pain levels in the HILT group compared to the control group. Our study result was similar with those in studies showing the analgesic effect of HILT in several musculoskeletal pains such as shoulder, knee, low back, neck, and elbow pain[19].

A literature scan showed several recent studies that have investigated the effectiveness of HILT in patients with tenosynovitis. This indicates the increased use of HILT in physiotherapy in recent years. While those studies showed the benefit and multifaceted effect of HILT in the treatment of various musculoskeletal diseases, it was emphasized that it achieved these effects due to anti-inflammatory, anti-edemic, and analgesic mechanisms[20]. Both modalities were shown to be beneficial in a study by Kaydok et al.[12], which compared the short-term efficacy of HILT with low-intensity laser treatment (LILT). However, HILT had more significant impacts on QDASH, hand grip strength, and SF-36 physical component summary scores than LILT[12].

The pain scores, grip strength, disability scores, and various sub-dimensions of the SF-36 health survey values in both groups varied significantly in another study comparing the efficacy of splint and HILT in treating lateral epicondylitis; however, no significant difference was seen between the groups[21]. In the current study, while VAS scores decreased significantly in both groups, grip strength increased significantly. When the difference between the groups was examined, it was found that the HILT group was statistically significantly better. This effect of the high-intensity laser beam could be because it reorganizes the cellular cytoskeleton network, contributes to tissue repair and regeneration by increasing the extracellular matrix production of connective tissue cells, and strongly affects endothelial cell functions by regulating fibronectin production-distribution and fibril regulation[9].

HILT increases blood flow, vascular permeability, and cell metabolism, which together with its photochemical and photothermic actions have analgesic effects on nerve endings. The primary factor causing HILT's rapid analgesic impact is its photomechanical effect. Some evidence support the theory that the pain-relieving effects of laser therapy may be caused by raising levels of neurotransmitters that influence pain modulation, such as serotonin, releasing endorphins that bind to nociceptors, bradykinin, and substance P from peripheral nociceptors, as well as bradykinin release from damaged tissues. A crucial mechanism in the effect of HILT on pain are gate control system and nerve fiber regeneration[19]. Our findings show that HILT significantly reduced pain compared to exercise and splint therapy alone. That is, a faster, and more significant pain decrease was noted in the HILT group than in the other group.

Splinting is a significant conservative therapy option for DQT. The use of orthoses in the acute period has proven to be very effective and has been found to reduce pain and inflammation. The main purposes of using a splint in DQT are to rest the involved wrist and minimize inflammation and to reduce sliding of the abductor pollicis longus and extensor pollicis brevis

tendons. Rest leads to a decrease in the forces exerted by these muscles, which helps to heal the syndrome[22,23]. In our study, although the grip strength of the patients increased in both groups, it increased more in the HILT group than in the sham therapy group. Moreover, the use of splints is less effective than other therapies for pain, grip, and pinch strength according to earlier studies[22,24,25].

A considerable decrease in QDASH scores was determined in both groups in a 2017 study comparing the effectiveness of therapeutic ultrasound (US) and splint in DQT; however, no significant difference was determined between the groups[26]. Similar to the previous trial, no significant difference was observed between the groups, and both groups' QDASH scores significantly decreased in our study.

Table 3. SF-36 quality of life subscale scores of patients according to the groups and follow-up intervals.

	Baseline	After treatment	p-value†	Change
Physical functioning				
Sham therapy group	80.0 (62.5-91.2)	82.5 (65.0-95.0)	0.053	0.0 (-1.2-20.0)
HILT group	82.5 (61.2-90.0)	85.0 (75.0-95.0)	0.135	7.5 (-10.0-25.0)
p‡	0.777	0.623		0.899
Role limitations due to physical health				
Sham therapy group	50.0 (43.7-75.0)	75.0 (50.0-100.0)	0.002	0.0 (0.0-25.0)
HILT group	50.0 (50.0-75.0)	75.0 (75.0-100.0)	0.012	25.0 (0.0-50.0)
p‡	0.913	0.645		0.666
Role limitations due to emotional problems				
Sham therapy group	66.7 (33.3-75.0)	66.7 (45.8-100.0)	0.221	0.0 (0.0-33.3)
HILT group	66.7 (33.3-100.0)	66.7 (41.6-100.0)	0.176	0.0 (-33.3-33.4)
p‡	0.959	0.833		0.829
Energy/fatigue				
Sham therapy group	45.0 (33.7-55.0)	55.0 (43.7-61.2)	<0.001	6.6 (0.0-20.0)
HILT group	40.0 (30.0-55.0)	55.0 (45.0-65.0)	<0.001	12.5 (5.0-23.8)
p‡	0.569	0.809		0.360
Emotional well-being				
Sham therapy group	60.0 (55.0-68.0)	64.0 (55.0-81.0)	0.054	0.0 (0.0-12.0)
HILT group	64.0 (48.0-72.0)	66.0 (56.0-76.0)	0.008	0.0 (0.0-7.0)
p‡	0.955	0.739		0.726
Social functioning				
Sham therapy group	62.5 (50.0-75.0)	68.8 (62.5-75.2)	0.065	1.2 (0.0-15.6)
HILT group	62.5 (50.0-87.5)	68.7 (50.0-87.5)	0.008	0.0 (0.0-12.5)
p‡	0.732	0.897		0.786
Pain				
Sham therapy group	45.0 (35.0-55.0)	77.5 (67.5-80.0)	<0.001	32.5 (20.0-42.5)
HILT group	45.0 (25.0-57.5)	80.0 (67.5-90.0)	<0.001	33.8 (22.5-55.0)
p‡	0.803	0.034		0.219
General health				
Sham therapy group	57.5 (45.0-70.0)	70.0 (53.7-81.2)	0.007	0.0 (0.0-21.2)
HILT group	52.5 (45.0-73.7)	70.0 (60.0-78.7)	0.005	15.0 (-5.0-25.0)
p‡	0.717	0.815		0.452

‡Comparisons between groups, Mann-Whitney U test. In comparisons made pre- and post-treatment, according to the Bonferroni correction, the results were considered statistically significant for $p<0.025$, whereas the results for $p<0.05$ were considered statistically significant in the comparisons made regarding the changes that occurred after the treatment compared to before the treatment. †Comparisons between the groups pre- and post-treatment, Wilcoxon signed-rank test, Bonferroni correction. Comparing the groups' pre- and post-treatment data, using the Wilcoxon signed-rank test, and applying the Bonferroni correction for $p<0.025$ were evaluated statistically significant. HILT: High-intensity laser therapy, SF-36: Short Form-36

According to the literature, DQT is more common in females than in males[2]. In the current study, the number of males, and females were similar in both groups. This may be due to the fact that our hospital is located in an industrial area and a large part of our patient group consists of male factory workers.

The effectiveness of laser in DQT was investigated in two studies, both of which were reported by Sharma et al.[27,28], using a low-intensity laser. In the first study, LILT and sham LILT were applied to 28 patients, and a significant reduction was found in grip strength and combined thickness of the abductor pollicis longus and extensor pollicis brevis tendon sheaths. In the second study comparing LILT and US in DQT, no significant difference was observed between the two groups, whereas US was found to be more effective in the mean values for grip strength and VAS. In that study, which included 30 patients in total, the dose of the laser was 2-3 J/cm^2 for 7 sessions on alternate days. However, it was found that corticosteroid injections were more effective in reducing pain and improving grip strength than the combination of laser and US[23]. It further indicates that a non-invasive and effective method in DQT is required.

In DQT, unlike other RSI diseases, evidence of the effectiveness of steroid injection in the short and medium term is moderate and evidence in the short term is limited and no evidence in the medium term of surgery in cases resistant to physical therapy and injection[29]. The most crucial factor increasing resistance to treatment may be the adhesion and thickening of the flexor retinaculum, which occurs as a result of fibrin granulation tissue and myxoid degeneration rather than inflammation in DQT, whereas inflammation is prominent in other RSI diseases[4]. Currently, a need arises for a new physical modality that can be applied before the patient is sent to surgery, which will target the adhesions caused by fibrin granulation tissue and myxoid degeneration. A study by Spivak et al.[30] has determined that high-intensity laser contributed to the healing process in tendon and ligament lesions and prevented fibrosis development.

In the current study, while improvement was observed in some sub-scores of SF-36 in both groups, the groups did not differ significantly from one another. The significant improvement in pain, energy/fatigue, role limitations due to physical health, and general health levels in both groups may indicate that the splint plays a critical role in the treatment.

The most relevant limitation of this study was that the recovery status of the patients before and after the treatment could not be evaluated with an imaging method such as USG. New studies in which the measurement of common extensor tendon thickness will be measured before and after treatment may be warranted. Another crucial limitation was that only the short-term results at 5 weeks were evaluated.

CONCLUSION

HILT is a non-invasive, safe, and reliable method that increases grip strength and decreases pain in DQT in short-term. Further randomized controlled studies comparing longer-term results are required to provide stronger data.

Ethics

Ethics Committee Approval: The Istinye University Clinical Research Ethics Committee (decision no: 2/2020.K-061, date: 11.09.2020) approved the project. The research was listed on ClinicalTrials.gov (ID: NCT05141799). The Declaration of Helsinki was followed in all study methods.

Informed Consent: All the patients provided written informed consent.

Peer-review: Externally and internally peer-reviewed.

Author Contributions

Surgical and Medical Practices: E.D.A., Consept: E.D.A., H.S., Design: E.D.A., H.S., Data Collection and/or Processing: E.D.A., H.S., Analysis and/or Interpretation: E.D.A., H.S., Literature Search: E.D.A., H.S., Writing: E.D.A., H.S.

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