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Review Article

Effect of Laser Therapy, Neurodynamic Stabilization and Strengthening Exercises on Hand Function in Patients of Carpal Tunnel Syndrome with Rheumatoid Arthritis- A Narrative Review

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Abstract:

Background: Carpal tunnel syndrome (CTS) is an entrapment neuropathy in which median nerve is compressed or squeezed at the wrist level in the carpal tunnel. Carpal tunnel syndrome is the most prevalent neurological complication in the rheumatoid arthritis patients. The prevalence of CTS in RA ranged from 3.5% to 22.8 %. Tenosynovitis, inflammation of the synovial tissue of the flexor tendons, can cause increased pressure in the carpal tunnel and result in CTS. Hand function is usually affected in carpel tunnel syndrome which affects the daily living performance by affecting both gross motor activities like grasping, carrying, holding and fine motor activities like writing, gripping and buttoning the shirts. Laser therapy, also called as photo biomodulation, can reduce pain, inflammation, swelling and synovitis. The dexterity and functionality of the hands improved through hand and wrist stretching and strengthening exercises.

Objective: To find out the effect of laser therapy, neurodynamic mobilization exercises and strengthening exercises on hand function in patients of carpal tunnel syndrome with rheumatoid arthritis.

Study selection: This narrative review is conducted on databases from Pubmed, Google scholar, scopus, web of knowledge, Virtual Health Library, Research Gate and Cochrane library in Nov 2023.

Introduction

Carpal tunnel syndrome (CTS) is an entrapment neuropathy in which median nerve is compressed or squeezed at the wrist level in the carpal tunnel.[1] The carpal tunnel is formed by a U-shaped trough which have carpal bones and the flexor retinaculum as roof of the canal. The median nerve enters the carpal tunnel at

the middle or slightly radially to it, along with the nine flexor tendons.[2]

Among all neurological complications in rheumatoid arthritis (RA), Carpal tunnel syndrome is the most prevalent.[1] Women are affected more than men.[3] The prevalence of CTS in RA ranged from 3.5% to 22.8 % .[4]

Early signs of CTS are paraesthesias, pain, numbness of the hand especially at night or during wrist flexion activities. In progression clumsiness of hand, difficulty in grasping objects, opening jars and later on atrophy of thenar eminence and reduced thumb abduction and opposition may occur.[5] CTS symptoms are felt in the 3 radial digits and the radial half fourth digit, supplied by sensory branches from the median nerve. Palm is usually not affected in CTS as it is supplied by palmar sensory cutaneous branch of the median nerve which arises, about 6 cm proximal to the transverse carpal ligament.[2] To perform hand function both hand and wrist joint work simultaneously in each side without any restriction. Hand function is usually affected in carpel tunnel syndrome which affects the daily living performance by affecting both gross motor activities like grasping, carrying, holding and fine motor activities like writing, gripping and buttoning the shirts.[6]

Despite the fact that idiopathic causes are the most frequent, trapping may result from any ailment that increases the volume of the tunnel's content or decreases its size, resulting in reduction of median nerve function at that level.[1] Carpal tunnel syndrome has been related to professions that require repeated and vigorous hand activity.[3] Obesity, repetitive wrist motion, diabetes mellitus, hypothyroidism, pregnancy, hereditary factors, osteoarthritis, acromegaly, chronic renal insufficiency, acute trauma and rheumatoid inflammation are among the risk factors for CTS.[5]

RA is an autoimmune disease of unknown cause[7] commonly manifests between the age of 30- 50 years, is a chronic, systemic, inflammatory, and autoimmune condition that causes Symmetrical polyarthritis of both large and small joints.[8] In rheumatoid wrists synovial thickening, joint erosions, and ligamentous laxity cause a decrease of carpal tunnel height and an increase in carpal tunnel pressure. This results in impeded axonal transport, compression of the median nerve, and ischemia of the median nerve due to arteries in the perineurium.[4] Tenosynovitis, inflammation of the synovial tissue of the flexor tendons, can cause increased pressure in the carpal tunnel and result in CTS. Physiological evidence suggests that increased pressure within the carpal tunnel reduce the function of the median nerve at that level.[2]

Clinical assessments includes phalen and tinel signs, numeric pain rating scale, symptom Severity scale, functional status score, nerve conduction studies cross-sectional area measurement. Conservatively CTS is managed using rest, splints, non-steroidal anti-Inflammatory drugs, steroid injection, control of any underlying disease, physical therapy, ultrasound therapy, iontophoresis and laser therapy.[9] Surgery can be advised if conservative treatmet failed to show any improvement, atrophy of thenar eminence, or severe sensory impairment .[10]

Several methods are employed in conservative treatments for CTS like splints, functional massage, carpal bone mobilisation, laser therapy, ultrasound therapy, electrophysical modalities, kinesiotaping, tendon gliding and neurodynamic mobilisation techniques (NMTs) of the median nerve.

Neurodynamic mobilisation techniques are a part of manual therapy that focus on diagnosing and treating specific disorders, including the peripheral nervous system. These techniques are widely used in CTS management. A recent clinical trial showed the long-term effectiveness of NMTs in improving pain intensity, grip strength and functional

status. Wolny et al. (2017) showed that manual therapy, including neurodynamic techniques, positively affected pain reduction and functional status in people with CTS.[11]

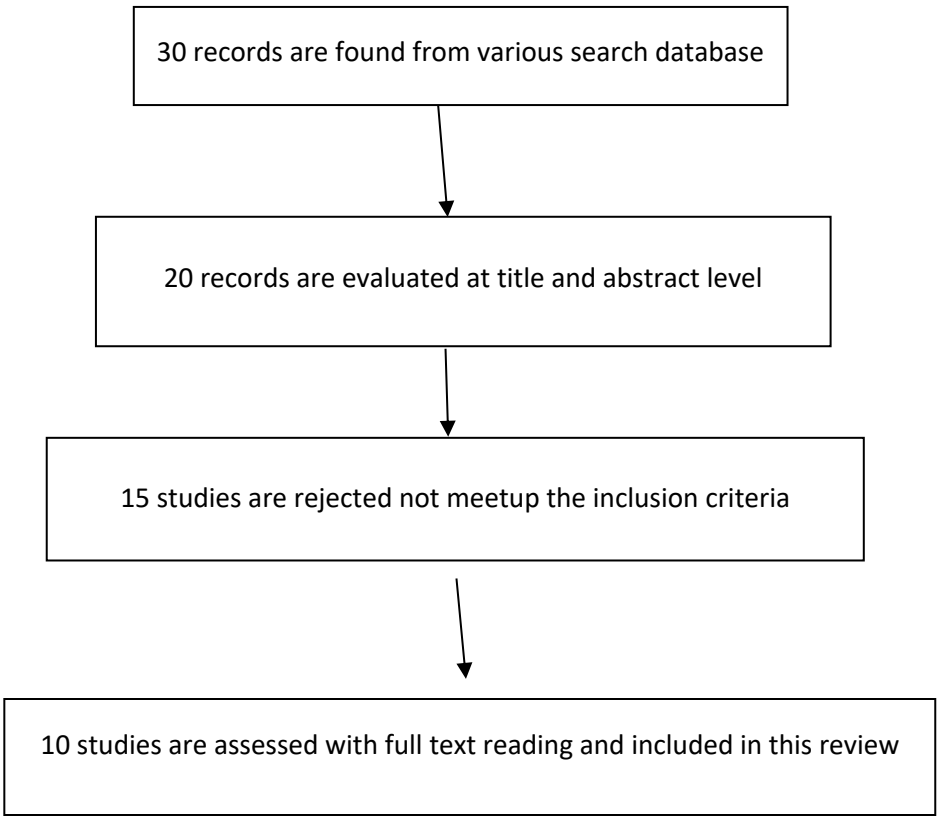
Exercises may have a positive effect on CTS by facilitating venous return or edema in the median nerve. By stretching and lengthening the restrictive flexor muscles that "close" the hands and strengthening and shortening the extensor muscles that "open" the hands, the carpal tunnel can return to its normal size. In addition, decreasing impingement of the tendons and median nerve eliminates friction and carpal tunnel symptoms.[12]

Recently, trials of laser therapy without any side effects have demonstrated benefits on clinical and electrophysiological parameters. Laser therapy, also called as photobiomodulation, can reduce pain, inflammation, swelling and synovitis. Studies also indicated tissue remodeling and regeneration effects of laser therapy. Photons produced by laser therapy are absorbed in the cells which increased ATP production, induce cellular events such as DNA synthesis and replication, cell proliferation, cell differentiation and protein synthesis. Low-intensity lasers has non-thermal and non-invasive effect on biological systems.[7] The dexterity and functionality of the hands improved through hand and wrist stretching and strengthening exercises.[1]

Method:

Studies are searched from the following search engine Pubmed, Google scholar, scopus, web of knowledge, Virtual Health Library, Research Gate and Cochrane library to review the literature. Studies include that investigate parameters symptom severity and functional severity symptom scales, hand strengthening measurements, nerve conduction studies and pain measurements.

Key words used to search studies are laser therapy, carpal tunnel syndrome, rheumatoid arthritis, entrapment mononeuropathy,



Authors, Journal, Year	Objectives	Design	Characteristics of participants sample size	Material and Methods	Outcomes Measures	Results
Ekim A et al. 2007 [9]	the aim of the study was to evaluate the efficacy of low level laser therapy (LLLT) in patients with rheumatoid arthritis (RA) with carpal tunnel syndrome (CTS).	A placebo controlled randomized controlled trial.	A total of 19 patients with clinical and electro-physiologic evidence of CTS with RA were studied	The patients were randomly divided into two groups. Ten patients in group 1 underwent LLLT and 9 patients in group 2 underwent placebo LLLT for 10 days. Gallium-Aluminum Arsenid (Ga-Al-As) laser device (Endolaser 476-Enraf Nonius, Netherlands) was used with a power out-put of 50 mW and wavelength of 780 nm.	FSS, SSS, VAS, grip-strength, NCV, Tinel and Phalens test	Group mean differences at 3 months adjusted at baseline were found to be statistically significant for pain score and functional status scale score. There were no statistically significant differences in other clinical and electrophysiological parameters between groups at 3 months
Fusakul Y et al. 2014 [17]	This study aimed to conduct a comprehensive study to demonstrate the clinical and electroneurophysiological benefits of LLLT when combined with a wrist splint for patients with mild to moderate CTS.	double-blinded randomized controlled trial	66 patients with mild to moderate carpal tunnel syndrome	The patients were randomly assigned into two groups. Group I received 15 sessions of a galliumaluminum-arsenide laser treatment at a dosage of 18 J per session over the carpal tunnel area with neutral wrist splint. Group II received placebo laser therapy with neutral wrist splint	VAS, SSS, FSC, and pinch strength and grip strength before the treatment and at 5- and 12-week follow-ups and nerve conduction (NCV) study which were evaluated before the treatment and at 12-week follow-up	Improvements were significantly more pronounced in the LLLT-treated group than the placebo group especially for grip strength at 5- and 12-week follow-ups. At 12-week follow-up, distal motor latency of the median nerve was significantly improved in the LLLT group than the placebo group ($p<0.05$).
Saffan A et al. 2017 [3]	This study aimed to compare the effect of low level laser therapy (LLLT) plus tendons and nerve gliding exercise versus phonophoresis plus tendons and nerve gliding exercises on median nerve conduction studies, pain intensity, symptoms severity, function status, hand grip strength, and key pinch strength in patients with mild and moderate CTS.	Experimental study	40 patients aged between 25-50 years referred from a neurologist and diagnosed as mild and moderate CTS were included	Patients were assigned in 2 different groups: Group 1: LLLT plus tendons and nerve gliding exercise (n=20) and Group 2: phonophoresis plus tendons and nerve gliding exercises (n=20).	Pre-treatment (W0) and post-treatment follow-ups at four weeks (W4) were carried out using Electromyography (EMG) devise, Visual Analogue Scale (VAS), Boston Carpal Tunnel Questionnaire (BCTQ), Hydraulic hand dynamometer, and pinch dynamometer	There was a significant ($p =0.0001$) improvement in all the tested parameters between pre-and post-treatment within each group. There was no significant difference ($p > 0.05$) between two groups concerning median nerve conduction studies, and grip strength. While, there was significant difference ($p < 0.05$) for phonophoresis plus tendons and nerve gliding exercises group in post Vas, SSS, FSS, and key pinch values between the two groups

Ahmed OF et al. 2017 [13]	The aim of the study was to investigate and compare between Low Level Laser Therapy (LLLT) and Ultrasound (US) in treatment of Carpal Tunnel Syndrome (CTS) using the advantage of application of treatment directly over the transverse carpal ligament, as well as over the course of the median nerve in the forearm simultaneously y.	Controlled comparative study	Fifty patients (25–55 years) with diabetic neuropathy, diagnosed as unilateral carpal tunnel syndrome participated in the study They were equally divided and randomly assigned into two groups; each group consisted of 25 patients.	Patients in group (A) received a program of IR Gallium Arsenide LLLT (wavelength 904 nm, average power 20 mW, laser probe 7 mm diameter), with a total application of 4.8 J, while patients in group (B) received a program of US (frequency 1 MHz, power 1.0 W/cm2, pulsed mode 1:5).	Hand dynamometer, NCV, VAS	It was concluded that both low level laser (20 mW power, 904 nm Wavelength) and ultrasound (1.0 w/cm2 power, 1 MHz frequency) are effective in the treatment of mild and moderate CTS patients.
Ünver S et al. 2018 [12]	To determine the effects of hand exercise performed with a ball on symptoms and to evaluate the results in hemodialysis (HD) patients with CTS	One-group pre-test post-test designed quasi-experimental study	19 patients (28 hands) with a diagnosis of mild and moderate stage CTS were included in the study	patients were instructed to perform exercise with a ball for 2 times/day for 3 months at home	Phalen and Tinel tests, Carpal tunnel questionnaire, Jamar Handheld Dynamometer, Electrophysiologic test (MNCV)	Recovery was performed from physical examination results, grip strength, and Boston questionnaire scores. About 21.4% of patients' electrophysiological results were negative at the end of the 1st month and 32.1% of them at the end of the 3rd month.

Rashad U M et al. 2020 [14]	Objective of the study was aimed at determining the effect of extracorporeal shock wave therapy (ESWT) on different severities of carpal tunnel syndrome	case–control experimental study	60 patients with unilateral CTS aged between 20-40 years	60 patients were divided into 3 equal groups according to severity (mild, moderate, and severe). All patients received shock wave therapy one session per week, for 6 weeks	NCV, Pinch Dynamometer, VAS, Ultrasonography. Measurements were done at the beginning and at the end of the study	There was significant improvement ($P < 0.05$) in sensory conduction parameters, CSA, lateral pinch power, and VAS after shock wave therapy in all groups. Also, there was significant improvement in motor latency, motor, and sensory amplitudes after shock wave therapy in mild and moderate groups only ($P < 0.05$).

Hamzeh H et al. 2020 [15]	This study aimed to examine the long-term effect of neurodynamic techniques vs exercise therapy in managing patients with CTS	randomized parallel-group clinical trial.	Participants who met the inclusion criteria (age >18 years and a confirmed CTS diagnosis both clinically by a physician and using nerve conduction test) were recruited	Of 57 patients screened, 51 were randomly assigned to either receiving four sessions of neurodynamics and exercise or home exercise therapy alone as a control.	Boston Carpal Tunnel Syndrome Questionnaire, Wrist ROM,NPRS, Hand grip strength, Quick DASH (Arabic)	The neurodynamics group demonstrated significant improvement in all outcome measures at 1 and 6 months ($P < .05$). Significant between-group differences were found in pain score at 1 month (-1.93) and in FSS (-0.5) and Shortened version of DASH (-12.6) at 6 months ($P < .05$)

Hojjati F et al. 2020 [16]	The purpose of this study was to compare the efficacy of low-power and HPL therapies on pain, function, and electrodiagnostic parameters in patients with mild or moderate CTS.	A Prospective Randomized Single-Blind Clinical Trial	The study population included 45 patients aged 30-50 years with mild or moderate CTS	The patients were randomly assigned to one of the treatment groups: wrist splint (control group), wrist splint + LPL, and wrist splint + HPL. Pain, function, pinch strength, and nerve conduction study findings were recorded in all groups before, immediately and 12 weeks after the treatment.	VAS, Hydraulic pinch gauge, FSS, SSS, NCV, EMG	All groups showed improvement regarding pain, function, and pinch strength. Laser therapy showed significantly better results compared to a wrist splint, but no significant difference was seen between high-power and LPL therapy groups
Bedda H et al. 2022 [11]	This study aimed to investigate the effectiveness of NMTs of the median nerve compared to joint mobilization of the elbow not directed at the median nerve on pain intensity, grip strength and functional status in women with mild or moderate CTS	Randomised single-blind clinical trial	62 female patients with mild or moderate bilateral CTS	62 female patients were assigned one wrist to the treatment group (TG) and the other to the control group (CG). Both groups underwent carpal bone mobilization. The TG underwent NMTs while the CG received a placebo elbow mobilization not targeting the median nerve	NPRS, 33JAMAR Plus+ Digital Hand dynamometer and the FSS of the BCTQ Outcome measures were performed at baseline, after 5 weeks and immediately after the treatment cycle at 10 weeks	Comparison of groups showed that NMTs at 5 weeks decreased pain intensity by 1.15 and by 2 at 10 weeks. Difference in functional status was 0.45 at 5 weeks and 0.84 at 10 weeks. The CG's grip strength improved by 0.59 after 5 weeks and 0.61 at 10 weeks

Ashour AA et al. 2023 [18]	To test the effectiveness of HILT combined with a conventional physical therapy program to reduce pain intensity, sensory and motor nerve distal latency, and increase grip strength in pregnant women with CTS compared with the physical therapy alone.	Single-blind randomized controlled trial.	54 pregnant women with mild to moderate CTS	Subjects were allocated into two groups. The HILT group (n = 27) received both HILT and conventional physical therapy, and the control group (n = 27) received only physical therapy, including nerve and tendon gliding exercises and the use of an orthotic device.	Numerical pain rating scale, electromyography, and a handheld dynamometer	Participants from both groups presented significant improvement in the median nerve motor nerve distal latency (MNDL), sensory nerve distal latency, numerical pain rating scale, and handgrip strength after the intervention. The between-group difference showed more improvements in participants of the HILT group on reducing pain intensity, and sensory nerve distal latency, compared with the control group.

Yiğit F et al. 2023 [19]	The aim of this study was to evaluate the effects of high intensity laser therapy (HILT) on pain, functional status, hand grip strength, and median nerve cross-sectional area by ultrasonography in patients with carpal tunnel syndrome	Randomized Controlled Trial	60 patients who were diagnosed with carpal tunnel syndrome were included in the study	Subjects were randomly divided into two groups with 30 patients in each group. Splint+ exercise and HILT (pulsed mode with a power of 8.0 W and energy density of 8 J/cm^2 for 1.40 minutes for every 25 cm^2, continuous mode with a power of 3.0 W and energy density of 80 J/cm^2 for 11 minutes for each 25 cm^2; total 10 sessions 5 days a week) were applied for 2 weeks for the first group, and splint+exercise and sham laser treatment were applied for 2 weeks for the second group	Hydraulic hand dynamometer, visual analog scale (VAS), Boston CTS Questionnaire, and ultrasonography	The results of the research presented here have confirmed that hand grip strength may increase and the median nerve's cross-sectional area may decrease upon the application of high-intensity laser for individuals experiencing CTS

Discussion:

CTS is known as most common neurological findings of RA. Studies on CTS in RA are mostly based on electrophysiological methods. A compensatory intervention programme such as assistive devices and joint protection splints are needed to improve ADLs in rheumatoid arthritis disease. Despite the pharmaceutical intervention physical therapy was also play remarkable role in management of chronic RA patients. Large joints respond well but small joints need more attention of physical therapist for functional status.[25] The main objective of the review is to figure out the effect of laser therapy, neurodynamic mobilization and strengthening exercise of hand of patients of CTS with RA. Laser therapy is used for symptomatic treatment: for pain and paresthesia. The use of laser therapy in the treatment of CTS is one of the first method approved by the FDA. The use of both low and high intensity laser beams using the corresponding dose regimen is appropriate.[24]

Rayegani et al showed that low level therapy resulted in a pain decrement and functional improvement in 50 patients with mild to moderate CTS. They also mentioned an improvement in electrodiagnostic parameters, although with no significance.[20] Brorsson S et al. had introduced therapeutic putty as hand strengthening exercise tool. Therapeutic putty is composed of borosiloxane chain compounds. It exhibits resistance to deforming force which is proportional to the force applied to them. This resistance properties makes it useful as therapeutic putty.[21] Fleckenstein JL et al. proved that exercise performance with progressive resisted technique causes more protein synthesis in muscle thus increased the muscle volume.[22] Choudhry D et al. showed that the use of hand strengthening exercise as an adjunct to routine physiotherapy treatment in the rehabilitation of chronic RA patients.[23]

NMTs combined with carpal bone mobilisation have better effects on pain intensity, functional status and, to a lesser degree, grip strength than the placebo joint mobilisation technique not directed at the median nerve. These findings could be explained by NMTs' desensitisation effects in decreasing pain levels and improving functional status.[17]

Through above studies, it is found that laser therapy, neurodynamic stabilization and hand strengthening exercises are effective techniques in terms of pain, inflammation, grip strength, disability and progression of disease.

Conclusion:

Laser therapy, neurodynamic mobilization and hand strengthening exercises are effective methods for patients of CTS with RA. All above mention studies have multiple limitations such as only females were included with wide age range, small sample size, none of the studies consulted made reference to the race of the patients, design and the restricted number of patients owing in part to the extremely labour intensive treatment protocol.

Few studies have done on effect of laser therapy with hand strengthening exercise and no study explained the exact protocol for patients of CTS with RA.

Hence, in order to establish a definitive protocol and to overcome all limitations, there is a need to study the effect of laser therapy with hand strengthening exercises in patients of CTS with RA.

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