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The effect and dosage of low level laser therapy in carpal tunnel syndrome: A literature review

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ABSTRACT

Background

Carpal tunnel syndrome (CTS) is an entrapment mononeuropathy seen very frequently in clinical practice, and is caused due to compression of the median nerve at the wrist. It is one of the commonest peripheral nerve disorders seen in general population. Low level laser therapy has become progressively more popular in the management of a wide variety of medical conditions, such as soft tissue injuries, low back pain, arthritis and skin traumas.

Aim

This review aims at gathering information about the dosage parameters of Low level laser therapy and their respective effects on persons with mild to moderate carpal tunnel syndrome.

Methods

An extensive literature review was done on various electronic handprint databases which included Pedro, pub med, science direct and Google scholar. Total 8 articles were reviewed and reported based on eligibility criteria, which included 7 randomized controlled trials and 1 meta analysis.

Results

Low level laser therapy brings about an improvement in pain, clinical signs, nerve conduction velocity and functional status in patients with carpal tunnel syndrome. However, dosage specific effects of Low level laser therapy are not yet clear, and need further research.

Conclusion

In addition to the clinical benefits, low level laser therapy also reduces the treatment time and expense in each session as compared to other electrotherapeutic modalities.

Keywords: Carpal tunnel syndrome, Median nerve entrapment, Low level laser therapy, Low energy laser therapy.

INTRODUCTION

The American Academy of Orthopaedic Surgeons (AAOS) Clinical Guidelines on the Diagnosis of Carpal tunnel syndrome defines Carpal tunnel syndrome as a symptomatic compression neuropathy of the median nerve at the level of the wrist [1]. It accounts for 90% of all entrapment neuropathies. It is found to be present in 3.8% of general population with a prevalence of 9.2% in female and 6% in male [1]. Carpal tunnel syndrome is commonly seen bilaterally with signs and symptoms which include: pain in the hand, unpleasant tingling, pain or numbness in the distribution of the median nerve distal to the wrist (thumb, index, middle finger and the radial side of the ring finger), a reduction of grip strength and a reduction in function of the affected hand [1]. Symptoms tend to become worse at night, and clumsiness is reported during the day with activities that require wrist flexion. Shaking or flicking of wrists relieves symptoms, also known as 'flick sign' [1].

The risk factors of Carpal tunnel syndrome can be divided as environmental factors and medical factors: (1) Environmental factors: Prolonged postures of the wrist in extremes of extension or flexion, exposure to vibration and repetitive use of the flexor muscles. (2) Medical risk factors: (a) extrinsic factors that increase the volume within the tunnel (outside or inside the nerve) include pregnancy, menopause, obesity, renal failure, hypothyroidism, the use of oral contraceptives and congestive heart failure; (b) intrinsic factors within the nerve that increase the volume within the tunnel include, tumours and tumour-like lesions; (c) extrinsic factors that alter the contour of the tunnel may include fractures of the distal radius, directly or via posttraumatic arthritis; and (d) neuropathic factors, such as diabetes, alcoholism, vitamin toxicity or deficiency, and exposure to toxins. Diabetic patients have a higher chance of developing CTS [1].

On the basis of signs and symptoms carpal tunnel syndrome can be classified into 3 stages: Stage 1: Patients frequently wake up during the night with a swollen and numb hand. Pain moves upward from the wrist to the shoulder, accompanied with tingling in the hand and fingers (brachialgia paraesthetica nocturna). Hand shaking (the flick sign) relives the symptoms and hand stiffness usually persists until morning. Stage 2: The symptoms continue to be present also during the day, especially when the patient remains in the same position for a long time, or performs repeated movements with their hand and wrist. Stage 3: Atrophy (wasting) of the thenar eminence is seen, poor results are seen on surgical decompression, sensory symptoms diminish with aching in the thenar eminence. With severe compression, weakness and atrophy of the abductor pollicis brevis and opponens pollicis is seen [1].

Diagnosis is mainly by patient history and provocative test i.e. Tinel's sign and Phalen's test. However, Nerve conduction studies, Ultrasound and Magnetic resonance imaging can also be made use of [1]. The treatment of CTS can be divided into two categories: conservative and surgical. Conservative treatment is the first line of action in patients suffering from mild to moderate CTS which include oral and transvenous steroids, vitamins B6 and B12, corticosteroids, non steroidal anti-inflammatory drug, yoga, ultrasound, carpal bone mobilisation and hand splints. Surgical treatment is Carpal tunnel release (CTR) [1]. Low Level Laser Therapy (LLLT) is known to benefit in providing pain relief and thus show improvement in signs of Carpal tunnel syndrome [2]. Various theories exist that hypothesize the physiology behind the action of LLLT. One hypothesis states that LLLT can modulate inflammatory processes, however, a second hypothesis says that LLLT acts by altering the excitation and nerve conduction in the peripheral nerves. A third hypothesis states that LLLT stimulates the release of endogenous endorphins [2]. However, the dosage used in the treatment is still not precisely known. The current study is aimed to review the current state of evidence on the dosage specific effects of low level laser therapy on carpal tunnel syndrome.

MATERIALS AND METHODS

Design- Literature review. An extensive literature review was done on various electronic handprint databases which included Pedro, pub med, Science direct and Google scholar. Total 8 articles were reviewed and reported based on eligibility criteria, which included 7 randomized controlled trials and 1 meta analysis. Inclusion criteria: articles published in English language, articles of low level laser in carpal tunnel syndrome, articles focused on low level laser as the

intervention, articles from 2008 onwards. Exclusion criteria: Non-English language articles, animal studies articles and articles without full text accessibility. Literature search was conducted using the above mentioned databases using search strategies and key words. A total of 2,311 articles were retrieved. The three step process- title, abstract, full text was used to select articles: Based on the title 666 articles were obtained. Based on abstract 18 articles were obtained and using eligibility criteria and free full text availability 8 articles were selected for review.

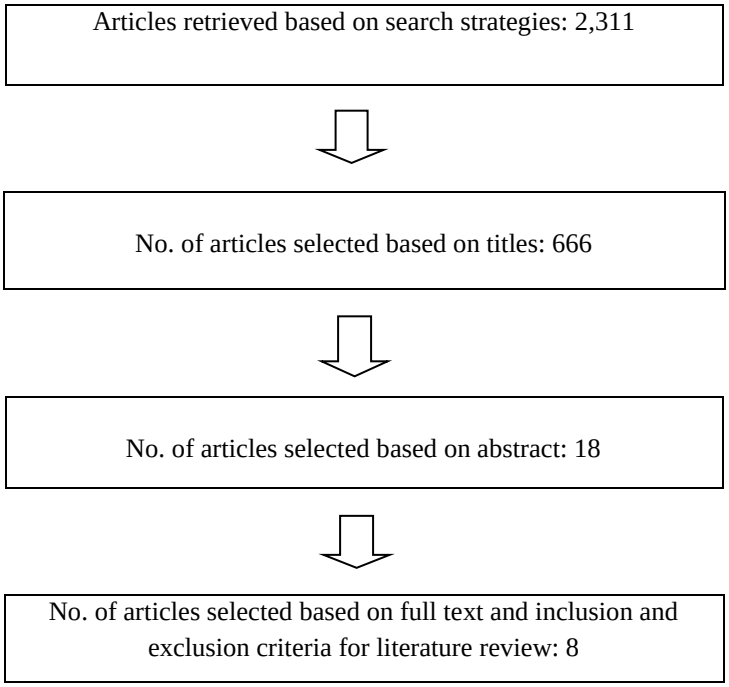

Figure 1- Flow chart of data extraction.

RESULTS AND DISCUSSION

Results

Low level laser therapy leads to an improvement in pain, clinical signs, nerve conduction velocity and functional status in patients with mild to moderate carpal tunnel syndrome. The results of a particular treatment depends on parameters such as wavelength, power output and pulse frequency. The type of laser used, either scan type or spot type, also play an important role in deciding the appropriate dosage parameters.

Table 1: Summary of the articles reviewed.

Sr.no	Title/ author/year of study	Type of study	Sample size	Outcome measures	Result	PEDro score
1.	Effectivness of Low Level Laser in Carpal tunnel syndrome Li Z J et al. [3] 2015	Meta analysis Level of evidence: Ia	7 Randomized controlled trials	Visual analog scale Nerve conduction velocity	Improvement seen in the nerve conduction, grip strength ($p=0.04$) and pain ($p<0.01$) after the application of laser in persons with carpal tunnel syndrome.	--
2.	Placebo-controlled investigation of low-level laser therapy to	Randomized controlled trial.	N=79 Active laser	Nerve conduction velocity	Improvements seen in pain ($p<0.001$) and median sensory	5/10

	treat carpal tunnel syndrome. Lazovic M et al. [4] 2014	Level of evidence: Ib	group=40 Placebo group=39	Visual analog scale	nerve conduction velocity ($p<0.01$) by the use of Low Level Laser Therapy.	
3.	Low-level laser therapy with a wrist splint to treat carpal tunnel syndrome: a double-blinded randomized controlled trial. Fusakul Y et al. [5] 2014	Randomized controlled trial. Level of evidence: Ib	N=66 n=28 Laser group=28 Placebo group=28	Visual analog scale Functional status scale Symptom severity scale Jamar dynamometer Pinch gauge	Improvements seen in Pain, symptoms and function at the same time post laser treatment and placebo treatment. However, grip strength improvement seen much earlier in the Laser group as compared to the placebo group.	8/10
4.	Low level laser treatment relieves pain and neurological symptoms in patients with carpal tunnel syndrome. Jiang J A et al. [6] 2011	Randomized controlled trail. Level of evidence: Ib	N=90 Laser group=45 Placebo group= 42	Visual analog scale Boston questionnaire Nerve conduction velocity	Decrease in pain ($p<0.05$) and neurological signs ($p<0.05$) were seen in the laser group. Significant increase in nerve conduction velocity was also seen in the laser group.	7/10
5.	Low-level laser in the treatment of carpal tunnel syndrome: clinical, electrophysiological, and ultrasonographical evaluation. Tascioglu F et al. [7] 2010	Randomized controlled trial. Level of evidence: Ib	N=60 Laser group 1=20 Laser Group 2=20 Non laser Group 3=20	Visual analog scale Functional status scale Symptom severity scale Hydraulic hand Dynamometer Ultrasonography	Improvement in pain, symptoms and functions were seen in all the groups. Sensory nerve velocity improvements were seen only in the two laser groups.	9/10
6.	The effectiveness of conservative treatments of carpal tunnel syndrome: splinting, ultrasound, and low-level laser therapies. Dincer U et al. [8]	Randomized controlled study Level of evidence: Ib	N=50 Splint= 20 Splint and low level laser=20 Splint and ultrasound=20	Visual analog scale Symptom severity scale Functional status scale	The laser plus splinting group showed the highest success rate which accounts to 61.1% (w.r.t pain, function, electromyography results).	6/10

	2009			Elecroneuro-myography		
7.	Carpal Tunnel Syndrome Treated with a Diode Laser: A Controlled Treatment of the Transverse Carpal Ligament Chang W D et al. [9] 2008	Randomized controlled trial. Level of evidence: Ib	N=36 Laser group=20 wrist Placebo group= 20 wrist	Visual analog scale Functional status scale Symptom severity scale Nerve conduction study Jamar Hydraulic Hand Dynamometer Jamar Hydraulic Pinch Gauge	Pain and grip strength ($p<0.05$) showed significant improvements after 2 weeks post treatment in the treatment group as compared to the placebo group.	6/10
8.	The effects of low level laser in clinical outcome and neurophysiological outcomes in carpal tunnel syndrome. Shooshtari1 S. M. J. et al. [10] 2008	Randomized control study Level of evidence: Ib	N=80 Laser group group=40 Sham laser group=40	Visual analog scale Nerve conduction velocity	Significant improvements were seen in pain ($p<0.001$), signs and symptoms ($p<0.001$), grip strength ($p<0.001$) and nerve conduction ($p<0.001$) post treatment in the laser group as compared to the sham laser group.	4/10

DISCUSSION

Conditions which cause Carpal tunnel syndrome could arise congenitally, due to systemic or inflammatory factors or traumatically [11]. Current treatment protocol for carpal tunnel syndrome includes conservative treatment initially, and if relief is not seen by conservative treatments, carpal tunnel release is carried out [12]. This study aims to review literature available to understand the treatment protocols of low level laser therapy and its respective effects in the treatment of mild to moderate carpal tunnel syndrome.

Even though, Low level laser therapy is used extensively in the field of physiotherapy, there still exists a limited evidence of its effectiveness [13]. Various studies conducted on the therapeutic effects include the following findings: (a) At peripheral nerves laser causes inhibition of nociceptive activation, (b) brings about an increase in ATP production, cellular respiration as well as increases secretion of endogenous opioids, (c) increases blood circlulation which brings about clearance of allergic substances [14]. Laser is known to bring about improvement in proximal and distal latencies and NCV by bringing about a balance in cell homeostasis of neurons thus normalising the cell membrane. It also helps in improving nerve blood supply, decreasing oedema

and promoting lymphatic drainage [10]. The healing effect of Low level laser therapy brings about acceleration of collagen synthesis [8].

Inspite of various studies proving the usefulness of Laser, some studies contradict the use of laser in carpal tunnel syndrome. Tascioglu F et al. in a randomized controlled trial using a laser with a wavelength of 830nm, concluded that LLLT group did not produce superior results than the placebo group in the Boston questionnaire score and ultrasonography results reported post treatment among the experimental groups and the control groups. However on parameter analysis, faulty calculations were noted which lead to a total dose of 2400J/cm^2 in the first group and 1200J/cm^2 in the second group, which is suggestive of overdosage. There was also an increase in the tissue temperature after treatment which confirms overdosage [4]. Shooshtari1 S. M. J. et al. conducted a randomised controlled trial using a wavelength of 785nm with an energy of 9-11 J/cm^2, a power of 400 mW and at a pulsed frequency on the anterior aspect of the wrist for a period of 15 sessions and concluded that there was an increase in grip power and attributed this to improvement in clinical signs, decrease in pain and decrease in the fear of using the hand [10]. A study done by Bakhtiary and Rashidy-Pour drew a conclusion that Ultrasound gives better results as compared to LLLT for the treatment of carpal tunnel syndrome. However a study done by Dincer et al. much after Bakhtiary and Rashidy- Pour's study contradicted their study by proving that splinting plus LLLT brought about much more improvement in visual analog scale scores, electroneuromyography results and patient satisfaction assessments than the splinting plus ultrasound group [8].

The main problem in assessing the effect is thought to be the variation seen in therapeutic regimes with respect to parameters such as wavelength, power output and pulse frequency [8]. The 'World Association for Laser Therapy' (WALT) puts forward the parameters for laser treatment: 904nm wavelength, mean output> 5mW, 4J, 2J/point. Or 780-860nm wavelength, mean output 5-500 mW, 8J, min 4J/point [15]. Ohshiro in his study focused on finding the relationship between the wavelength of laser energy and its penetration and came to a conclusion that a wavelength of 830-904nm had the best absorption and penetration characteristics [9]. Most studies carried out used laser with a wavelength of 830nm and have shown positive results for the reduction in pain and improvement is nerve conduction study [3]. Bjordal et al. stated that an energy density > 4J/cm^2 or power density > 30mW/cm^2 will cause inhibition of fibroblast activity, improper collagen production and damage to superficial tendons [4]. Tascioglu F et al. used a scanning mode of laser which was similar to the mode used by El-Wakil et al. and was suggested to be safer and thus minimizing the side effects because the laser beam is not in direct contact with the skin [5]. However, studies have shown that scan type lasers result in decreased dose per unit area as compared to spot lasers due to the scattering of light [9]. Low level laser therapy however proves to be a good supportive treatment which is less expensive and which helps reduce treatment time as compared to other electrotherapeutic modalities [10].

CONCLUSION

In addition to the clinical benefits, Low level laser therapy also reduces the treatment time in each session and is of less expense as compared to other electrotherapeutic modalities. However, due to the wide range of dosages and different treatment methods used in various clinical trials, there is a lack of consensus on the specific dosage to be used. Further research is needed to standardize the dosage of Low level laser therapy in Carpal tunnel syndrome.

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