Original Article

PTRS Physical Therapy Rehabilitation Science

http://dx.doi.org/10.14474/ptrs.2014.3.1.1
pISSN 2287-7576
eISSN 2287-7584

Phys Ther Rehabil Sci
2014, 3 (1), 1-6
www.jptrs.org

The effects of low-level laser therapy in patients with wrist pain: is this Mickey Mouse science?

Jerrold S. Petrofsky[a], Wendy Chung[b], Lesley De Fazio[b], Holly Harris[b], Michael Laymon[c], Haneul Lee[a]

[a]Department of Physical Therapy, Loma Linda University, Loma Linda, CA, USA
[b]Azusa Pacific University, Azusa, CA, USA
[c]Touro University, Henderson, NV, USA

Objective: Low level laser treatment (LLLT) is widely used in physical therapy practice. It is combined with physical therapy or LLLT alone. The purpose of this study is to evaluate the effectiveness of LLLT on patients' perception of general wrist pain.
Design: Longitudinal study.
Methods: Forty-eight subjects with wrist pain who were in the age range of 18-70 years old were examined. The subjects were asked, via an interview and a visual analog scale, to grade their wrist pain. They were asked to rotate their wrists through full range of motion and the angle at which any pain occurred was assessed. Each subject was then exposed to one of the following: 1) treatment with an infrared laser with the power turned off (placebo), 2) treatment with an infrared therapeutic laser, 3) treatment with a red therapeutic laser, 4) treatment with an ultraviolet laser, 5) treatment with a blue laser, 6) treatment with a Mickey Mouse flashlight. The duration of the treatment was 3 sessions in 3 days.
Results: The results of the experiments showed that while pain was reduced both immediately after and the next day after laser therapy ($p<0.05$), there was no significant difference between the laser groups and the placebo group. However, the Mickey Mouse flashlight treatment groups had a greater range of motion than the laser groups ($p<0.05$).
Conclusions: While pain was reduced in all laser groups, it was probably a placebo effect. The Mickey Mouse flashlight group probably received benefit from the heat of the flashlight.

Key Words: Lasers, Pain, Therapy, Wrist pain

Introduction

With the dawn of the computer age, wrist and hand pain have become the most common complaint involving the upper extremity [1]. Nearly 500,000 Americans have surgical treatment for carpal tunnel syndrome (CTS) each year [2]. The increasing use of computers predisposes more people to wrist inflammation due to repetitive movements of the wrist and fingers [2,3].This causes swelling and puts pressure on the median nerve. The resulting pain radiates through the wrist and hand, and it may possibly travel up the arm to the elbow. Other causes of wrist pain may include bruising, swelling, or a broken bone caused by trauma. Wrist pain may also result from arthritis, most commonly osteoarthritis or rheumatoid arthritis. Bursitis, tendonitis, sprains, strains, gout, and pseudo gout are among the common causes of wrist pain [3]. There are several ways to treat wrist pain, but a newer, yet poorly understood, treatment under study is the use of lasers.

Laser is an acronym for light amplification by stimulated emission of radiation [4]. Light produced from lasers is highly ordered and well organized due to its single wavelength and the fact that light is generated in phase. Therefore, lasers are termed coherent as the electromagnetic waves have the same wavelength and are generated in a single plane [5]. It is thought that coherent light has the ability

Received: 17 May, 2014 **Revised:** 11 June, 2014 **Accepted:** 15 June, 2014

Corresponding author: Haneul Lee

Department of Physical Therapy, Loma Linda University, 11234 Anderson St., Loma Linda, CA 92350, USA
Tel: 1-909-558-7274 **Fax:** 1-909-558-0481 **E-mail:** hlee@llu.edu

to positively affect human tissues [6]. Lasers can be classified as high power or low-level lasers. High power lasers are commonly used in surgical settings for their thermal effects enabling them to cut, coagulate, and evaporate tissues [5]. Lower-level laser treatment (LLLT) has non-thermal effects but may stimulate cell function [7]. This may be caused by the photochemical reactions in the cells upon laser light irradiation [8,9]. Chromophores in cells absorb light, which can stimulate increased production of adenosine triphosphate [6]. The theory is that this may lead to normalization of cell function, pain relief, and healing by increasing cellular energy [2,10].

However, there is some controversy as to their effectiveness. While some studies show improvements in skin blood flow and wrist pain with LLLT [11], others do not. Many times LLLT is combined with physical therapy and no controls with physical therapy alone or LLLT alone were examined. Therefore it is unknown what the real cause of healing is and what the placebo effect might be [12].

Thus, the purpose of our study is to evaluate the effectiveness of LLLT on patients' perception of general wrist pain.

Methods

Subjects

Forty-eight research subjects from the University staff and faculty participated in the week-long study. Five of these subjects had bilateral wrist pain. Four of these subjects participated in the study twice but on opposite arms. All had complaints of chronic wrist pain for more than 3 months but less than 5 years. The pain could not be continuous for more than 3 weeks. The pain could not be due to fractures or bone diseases such as bone cancer or bone tumors. They were within the age range of 18 to 70 years. Both male (n=21) subjects and female (n=27) subjects were eligible to participate based on the criteria above. The most common diagnosis was CTS in 78% of the subjects. All procedures were explained to each subject who signed a statement of informed consent as approved by institution review board of Azusa Pacific University. The general characteristic of the subjects are in Table 1.

Measurements

Pain

Wrist pain was assessed by interview and an absolute Visual Analogue Scale (VAS) that spanned from 0-10 [13]. The subjects were asked to rate how much pain they are experiencing and during what activities (0=no pain&10=extreme). Their involved wrist was evaluated through range of motion (ROM) to find the critical angle, as assessed by goniometry, where pain was reported. The level of pain was assessed at end-point flexion and extension of each subject.

Range of motion

ROM of the wrist was measured with a goniometer. Active range of motion (AROM) for wrist flexion, extension, radial, and ulnar deviation was recorded along with the point where pain was brought on. AROM was recorded before and after each treatment. ROM was always measured by the same person. Before the study, repeated ROMs was conducted over a week on this same person to establish their reliability.

Laser

A low level laser was used for the intervention in the red, infrared, ultraviolet, or blue laser. These are low level lasers sold commercially to treat pain. The infrared laser was produced by Microlight Corp. (Orlando, FL, USA; wavelength 890 nm). The other lasers, except the ultraviolet, were produced by LC LED Inc. (Brooklyn, NY, USA; red wavelength 660 nm). The ultraviolet laser was produced by United Nuclear (Gardia Park, New Mexico; wavelength 420 nm). In addition, a Mickey Mouse flashlight was obtained from the Disney Store (Las Angeles, CA, USA) and masked

Table 1. General of characteristics of subjects (N=48)

	Age (y)	Height (cm)	Weight (kg)	Body mass index (kg/m^2)
Blue laser (n=8)	41.4 (11.5)	166.8 (7.2)	92.6 (24.6)	33.5 (9.6)
Red laser (n=8)	34.4 (11.3)	165.2 (6.1)	82.2 (24.6)	30.0 (8.5)
Ultra violet (n=8)	45.4 (17.0)	170.6 (7.1)	76.5 (11.6)	26.2 (3.0)
Mickey mouse (n=8)	47.6 (21.0)	174.1 (10.6)	82.3 (20.0)	27.0 (5.2)
Infra-red (n=8)	42.2 (12.9)	168.1 (6.5)	72.1 (15.7)	25.5 (5.8)
Placebo (n=8)	43.8 (16.1)	165.1 (6.1)	73.4 (15.0)	26.9 (4.8)

Values are presented as mean (SD).

in a new case. Subjects were told that this was a type of white laser.

Procedures

Subjects were randomly allocated into one of six groups: 1) no treatment (laser off) (placebo), 2) infrared treatment, 3) red laser treatment, 4) blue laser treatment, 5) ultraviolet laser, or 6) Mickey Mouse flashlight. There were three treatment sessions. Pain was assessed before and after each session. Gender, age, height, and weight were recorded at the initial treatment session. Measurements of baseline parameters of a VAS of subject's current pain, AROM, and the point at which pain was brought on were taken at the beginning of each session. The patient was then positioned with the painful surface of the wrist facing up on a table. Both the researcher and patient put on goggles for eye protection during the treatment session. The patient then underwent 8 minutes of therapy according to the group they were randomly placed in. This is a fairly common time for laser therapy. The laser was rotated three times for full coverage over the area of wrist pain. The patient was then shown a VAS to re-evaluate their pain. AROM was then reassessed and the point of pain was recorded if there was one. The patient was asked to record their pain 24 hours after treatment again with the VAS. This procedure was performed three times over the course of two weeks. After all three treatment sessions the patient was asked to fill out a questionnaire on wrist pain again.

Statistical analysis

Statistical analysis was performed using SPSS 22.0 software (SPSS Inc., Chicago, IL, USA). Data analysis was accomplished by calculating means and standard deviations (SD). Kolmogrov-Smirnov test was conducted to examine the distribution of outcome measures. Mixed factorial analysis of variance (ANOVA) was used to examine mean VAS, wrist angle for pain, and wrist ROM at three different days among six different treatments. LSD pairwise comparisons test for multiple comparisons was used to compare means of variables between any two treatments. The level of significance was $p < 0.05$.

Results

Visual analogue scale

As shown in Figure 1, all groups showed a significant reduction in pain over the 3 day period ($p < 0.05$). All groups also showed a return in pain 24 hours post the last treatment ($p < 0.05$). There was a tendency for the blue laser group to sustain the reduction in pain but it was not significant. The placebo group showed the same pre- post- treatment reduction in pain as the laser groups.

Wrist angle for pain

Figures 2 and 3 show the angle that the wrist could be rotated before pain was felt. These figures, rather than showing the angle, show the difference in angle that occurred comparing data just before the treatment and just after. The Y axis then shows the gain in angle of movement of the wrist before pain occurred due to the treatment. As shown in Figure 2 (first day of treatment) and Figure 3 (third day of

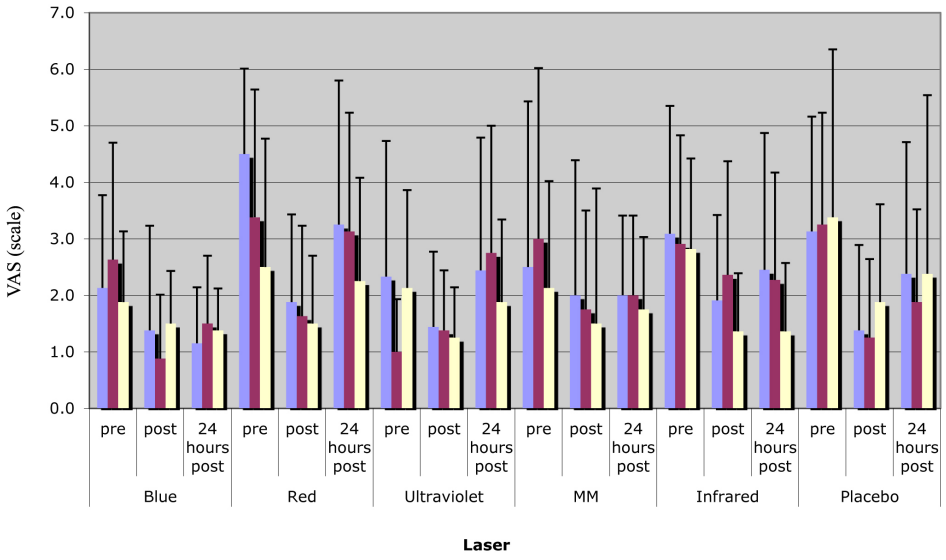

Figure 1. The mean visual analog pain scale for the 6 groups of subjects (8 subjects per group). The groups were blue laser, red laser, ultraviolet laser, mickey mouse, infrared, and the placebo groups. For each laser, data is shown pre treatment, post treatment, and 24 hours post treatment measured at the onset (column 1, blue), after the second treatment session (red column, and after the thrid session (white column). VAS: Visual Analogue Scale.

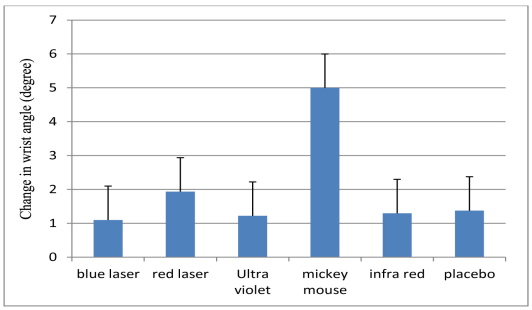

Figure 2. The angle of the wrist at which pain occured after the first treatment comparing the data from the pre and post treatment measures. The change in angle in degrees reflects, as the average for all 8 subjects in each group, the increase in range of motion before pain occurred comparing pre treatment and post treatment data.

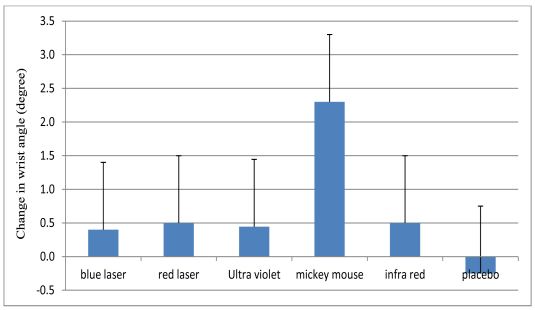

Figure 4. The range of motion of the wrist (ROM) for flexion after the first treatment day compared to the data before the first treatment. The change in angle in degrees reflects, as the average for all 8 subjects in each group, the increase in ROM before pain occurred comparing pre treatment and post treatment data.

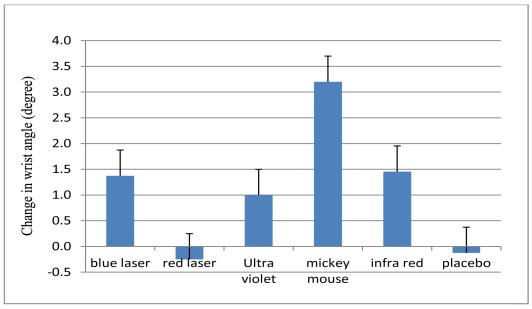

Figure 3. The angle of the wrist at which pain occurrred after the third treatment comparing the data from the pre and post treatment measures. The change in angle in degrees reflects, as the average for all 8 subjects in each group, the increase in range of motion before pain occurred comparing pre treatment and post treatment data.

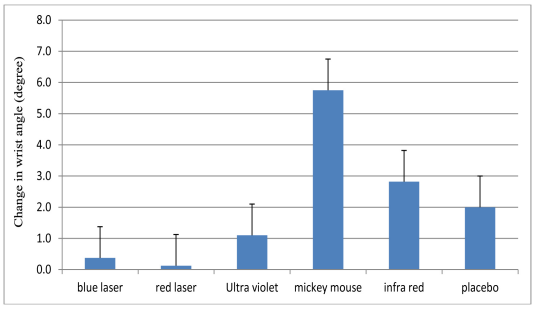

Figure 5. The range of motion of the wrist (ROM) for flexion after the treatment compared to the data before the treatment on the third day of treatment. The change in angle in degrees reflects, as the average for all 8 subjects in each group, the increase in ROM before pain occurred comparing pre treatment and post treatment data.

treatment) there was a gain in motion in all groups after the first day of treatment which was only significant for the MM group ($p < 0.05$). By the third day, this was also true with the only significant increase found in the MM group ($p < 0.05$).

Range of motion

The ROM for the wrist is shown in Figures 4 and 5. The data shown here compares the data on the first day of treatment (Figure 4) and the third day of treatment (Figure 5) as the difference in the ROM for wrist flexion measured before the treatment that occurred that day and the data after the treatment that day. Thus the number on the Y axis is the difference gain in ROM for wrist flexion if any occurred. For the entire group, the ROM for flexion of the wrist averaged 62.1±14.2 degrees before the first day of treatment and was 63.6±11.2 degrees after the third day of treatment. This difference was not significant. But for the MM group alone, there was a significant increase in ROM for wrist flexion ($p < 0.05$). These same phenomena were seen for wrist extension and rotation. Wrist extension averaged 48.4±11.2 degrees on the first day and 51.2±9.7 degrees on the day 3. Wrist radial deviation averaged 17.09±6.3 degrees on the first day and 17.2±6.4 degrees on the last day. Wrist ulnar deviation averaged 34.2±10.2 degrees on the first day and 34.7±9.6 degrees on the last day. These pre and post differences were not significant for the whole group or any placebo, MM or laser group.

Discussion

Previous research on LLLT has shown some medical benefits. Some of these include increasing ROM, increasing blood flow, increasing tissue regeneration, decreasing inflammation, and decreasing pain. Skin circulation has also been reported to increase in diabetic patients due to LLLT [14]. But there is some controversy. An analysis of LLLT by

the BlueCross [15] showed no conclusive evidence as to its effectiveness. Although a variety of studies have been conducted in populations including fibromyalgia, cancer, low back pain, tempomandibular joint pain, sprains, headaches, andosteoarthritis, results have not revealed any statistically significant outcomes [16].

MicroLight 830 (Microlight Corp., Orlando, FL, USA) was the first low level laser device to be granted approval of a 510(k) from the Food and Drug Administration (FDA), this occurred in 2002 [17]. According to the FDA, it is equivalent to in safety Light-Force Therapy's "*Super Nova*", an infrared lamp for the use as "pain relief" and other "technological characteristics" [17]. The MicroLight 830 was said to be successful because patients had greater than a 30% decrease in their subjective pain in a study accomplished by MicroLight Corporation. However, there was also greater than a 30% decrease in subjective pain on the control group using a sham laser. Of the laser group, 55.8% of the patients had a 30% decrease in pain compared to the control group in which 40% of the patients had a 30% decrease in pain. Although the difference between groups was only 15.8% in patients who had decreased pain, no statistical analysis was cited to infer that this was a successful treatment.

Human tissue may be activated by light. However the frequencies that activate enzymes have been shown to scatter as light passes into and is reflected by the tissues [18]. The effect of light scattering raises questions as to the depth of penetration and absorption and internal activation of light. Absorption sensitivity in regards to light is dependent upon tissue chromospheres such as lipids, water, and photosensitizes [19]. Varying body types in regards to human tissue, amount, thickness, and densities of skin, fat, and fascia, will cause light to penetrate to different depths and will require different frequencies to penetrate tissues [6]. In 2004, an extensive analysis was done to determine how light interacts at each level within the human skin [20]. For light to reach the area affected by CTS, it needs to penetrate five layers of skin before reaching the deep fascia and muscles or tendons in the wrist. From the most superficial to deep, this includes the stratum corneum, epidermis, papillary dermis, reticular dermis, and hypodermis [21]. Within these tissues lie melanin, hemoglobin, beta-carotin, and water, all of which absorb light at different and specific wavelengths [22]. There is uncertainty that enough laser energy will be able to penetrate through all layers of the skin and fascia to the desired soft tissue [23]. But even if it did, chemical reactions in the cell are very frequency specific. The wavelength needed is only a few nanometers wide. For the mitochondrial enzymes and electron transport chain, none of the frequencies tested match the proper frequencies to activate electron transport even if light could reach the mitochondria. Other research has proposed a different theory on how LLLT can activate tissues [24]. These authors propose that superficial cells are stimulated creating an indirect spread through the blood and/or lymphatic circulatory systems to create reactions in other sites of the body. This theory is yet to be confirmed.

The more likely reason for the reported healing is a reported placebo effect. When people believe that a modality will work better, they feel better [25-27]. In many of the LLLT studies, there were either no control groups or the studies were poorly conducted [16]. Thus, in the present investigation, when a laser was not turned on or a Mickey Mouse flashlight was used, the reduction in pain was the same as was seen with laser therapy. The present study does not support the use of LLLT for pain reduction. Interestingly, a second study using only one laser color on 81 patients found similar findings [7]. The benefit of the MM treatment is probably related to heat. A conventional flashlight generates infra-red energy that warms deep tissue. The LLLT does not. Therefore charging patient for LLLT is probably not warranted.

References

1. Forman TA, Forman SK, Rose NE. A clinical approach to diagnosing wrist pain. Am Fam Physician 2005;72:1753-8.
2. Lindstrom L. The light stuff; cold laser therapy is joining the injury treatment team. The Washington Post; 2004.
3. Barbosa VR, Dantas FG, Cardoso MA, de Medeiros JL. Pain and numbness in the arms and hands and carpal tunnel syndrome diagnosis. Arq Neuropsiquiatr 2006;64:997-1000.
4. Michlovitz SL, Nolan T. Modalities for therapeutic intervention. 4th ed. Philadelphia: F. A. Davis Company; 2005.
5. Steen WM. Lasers materials processing. 2nd ed. London: Springer-Verlag; 1998.
6. Cameron MH. Physical agents in rehabiliation. 2nd ed. St. Louis: Elsevier; 2003.
7. Evcik D, Kavuncu V, Cakir T, Subasi V, Yaman M. Laser therapy in the treatment of carpal tunnel syndrome: a randomized controlled trial. Photomed Laser Surg 2007;25:34-9.
8. Youssef M, Ashkar S, Hamade E, Gutknecht N, Lampert F, Mir M. The effect of low-level laser therapy during orthodontic movement: a preliminary study. Lasers Med Sci 2008;23:27-33.
9. Schubert MM, Eduardo FP, Guthrie KA, Franquin JC, Bensadoun RJ, Migliorati CA, et al. A phase III randomized double-blind placebo-controlled clinical trial to determine the effi-

cacy of low level laser therapy for the prevention of oral mucositis in patients undergoing hematopoietic cell transplantation. Support Care Cancer 2007;15:1145-54.
10. Hall J, Clarke AK, Elvins DM, Ring EF. Low level laser therapy is ineffective in the management of rheumatoid arthritic finger joints. Br J Rheumatol 1994;33:142-7.
11. Anderson TE, Good WT, Kerr HH, Shumaker B, Bendick PJ, Nolta RG. Low level laser therapy in the treatment of carpal tunnel syndrome. Gen Mot Stud 1995.
12. Bjordal JM, Couppé C, Chow RT, Tunér J, Ljunggren EA. A systematic review of low level laser therapy with location-specific doses for pain from chronic joint disorders. Aust J Physiother 2003;49:107-16.
13. Carlsson AM. Assessment of chronic pain. I. Aspects of the reliability and validity of the visual analogue scale. Pain 1983;16: 87-101.
14. Schindl A, Schindl M, Schön H, Knobler R, Havelec L, Schindl L. Low-intensity laser irradiation improves skin circulation in patients with diabetic microangiopathy. Diabetes Care 1998;21: 580-4.
15. BlueCross. Low level laser treatment of neuromuscular pain disorders: Policy No:105. www.regence.com 2006.
16. Tunér J, Hode L. It's all in the parameters: a critical analysis of some well-known negative studies on low-level laser therapy. J Clin Laser Med Surg 1998;16:245-8.
17. Acculaser Inc. Summary of 501(k) Premarket Notification K020657, Acculaser Pro low lecel laser therapy device, 2000. San Diego. Avialable from : http://www.accessdata.fda.gov/cdrh_docs/pdf2/k020657.pdf.
18. Robinson JW. Practical handbook of spectroscopy. Florida: CRC Press; 2000.
19. Wang HW, Zhu TC, Putt ME, Solonenko M, Metz J, Dimofte A, et al. Broadband reflectance measurements of light penetration, blood oxygenation, hemoglobin concentration, and drug concentration in human intraperitoneal tissues before and after photodynamic therapy. J Biomed Opt 2005;10:14004.
20. Baranoski GVG, Kirshnaswamy, A. An introduction to light interaction with human skin. RITA 2004:33-63.
21. Moore KL, Dalley AF. Clinically oriented anatomy. 5th ed. Philadelphia: Lippincott Williams & Wilkins; 2006.
22. Palmgren N, Jensen GF, Kaae K, Windelin HC. Low-power laser therapy in rheumatoid arthritis. Lessions in Medical Science 1989;4:193-5.
23. Saunders L. The efficacy of low-level therapy in supraspinatus tendinitis. Clin Rehabil 1995;9:126-34.
24. Ohshiro T, Calderhead RG. Development of low reactive-level laser therapy and its present status. J Clin Laser Med Surg 1991;9:267-75.
25. Miwa H. Placebo effect in Parkinson's disease. Brain Nerve 2007;59:139-46.
26. de la Fuente-Fernández R. Placebo, placebo effect and clinical trials. Neurologia 2007;22:69-71.
27. Hung HM, Wang SJ, O'Neill R. Issues with statistical risks for testing methods in noninferiority trial without a placebo ARM. J Biopharm Stat 2007;17:201-13.