

LOW-LEVEL LASER THERAPY FOR THE TREATMENT OF CARPAL TUNNEL SYNDROME

A Technology Assessment

INTRODUCTION

The California Technology Assessment Forum has been asked to review the scientific literature on the safety and efficacy of low-level laser therapy for the treatment of hand and wrist pain from carpal tunnel syndrome.

BACKGROUND

Carpal Tunnel Syndrome

Carpal tunnel syndrome is characterized by pain and tingling in the first three fingers of the hand (thumb, index finger, middle finger) due to compression of median nerve by surrounding structures as it passes through the carpal tunnel in the wrist.¹ The radial half of the fourth finger and the palm can also be involved. The syndrome can progress to weakness and atrophy of the muscles in the thenar eminence. Symptoms are often worse at night and can awaken patients from sleep. Patients may also have weakness of the thumb muscles reducing pincer strength and coordination.

Symptoms are usually worsened by activities involving frequent, prolonged, or forceful flexion or extension of the wrist. Examples include prolonged driving (wrist extension), sleeping with flexed wrists and the use of vibrating tools (like jackhammers). Some diseases that cause inflammation or thickening of soft tissues or bone growth can be associated with carpal tunnel syndrome, although the pathophysiology is not always understood. Some associated conditions include acromegaly, amyloidosis, pregnancy, menopause, diabetes, hypothyroidism and rheumatoid arthritis, as well as cysts and tumors of the wrists.^{2, 3}

Several diagnostic maneuvers can help support the diagnosis of carpal tunnel syndrome.⁴ The Hoffman-Tinel's test involves tapping the wrist at the site of the median nerve – it is positive if the tapping reproduces the patient's pain and paresthesias. In studies of diagnostic accuracy, the sensitivity of the Tinel's test ranged from 23% to 60% and its specificity from 64% to 87%.⁴ The Phalen maneuver is performed by having the patient flex both wrists 90° by pushing the dorsal surface of both hands together. This position is maintained for approximately one minute. Again, the test is positive if it reproduces that patient's symptoms. In studies of diagnostic accuracy, the sensitivity of the Phalen's maneuver ranged from 51% to 91% and its specificity from 33% to 88%.⁴

Electrodiagnostic testing with measurements of nerve conduction velocity in the median nerve is usually considered the gold standard for the diagnosis of carpal tunnel syndrome and it can help localize the site of nerve entrapment. The earliest abnormalities are usually increased sensory nerve conduction latency followed by increased motor conduction latency. Nerve conduction velocity decreases from about 50-60 m/second to about 30 m/second. Chronic carpal tunnel syndrome can result in abnormalities on electromyographic testing as well.

The mainstay of treatment is conservative therapy with non-steroidal anti-inflammatory drugs, limiting activities that exacerbate symptoms, and splinting of the wrist, particularly at night. Activities demonstrated to increase pressure in the carpal tunnel include making a fist, pushing with the hand and typing as well as wrist flexion and extension.⁵ The wrist splint should hold the wrist in a neutral position and should include a rigid insert.⁶⁻⁹ Other non-surgical treatments that have good evidence supporting efficacy include oral prednisone therapy, local steroid injections and ultrasound therapy.⁹⁻¹¹ Unfortunately, many patients find that these interventions are only effective for several months.

Patients who fail conservative therapy or who present with advanced disease (muscle atrophy) usually benefit from surgical decompression of the carpal tunnel.¹² Intermediate term outcomes (12 month) appear to be better with surgery than with corticosteroid injections.¹³⁻¹⁷

Low-level Laser Therapy

Low-level laser therapy refers to a broad range of applications of laser light ranging from therapy directed at specific points to treatments covering a broad area with laser light. The wavelengths are usually in the infrared range, but red wavelengths are also used (between 600 and 1000 nm). They have been used to promote wound healing and to treat a variety of musculoskeletal conditions including back pain, neck pain, osteoarthritis, rheumatoid arthritis and fibromyalgia. When used to treat carpal tunnel syndrome, the light is sometimes applied along the course of the median nerve and sometimes to specific acupuncture points.

The mechanism of action of low-level laser therapy is not known. Proposed mechanisms include increased mitochondrial ATP production,^{18, 19} repair of damage via cellular proliferations,²⁰ local anti-inflammatory effects,¹⁹ endorphin release^{21, 22} and improved blood flow.¹⁹ Two randomized controlled trials in healthy volunteers demonstrated changes in median nerve latencies in response to low-level laser therapy.^{23, 24}

Technology Assessment (TA)

TA Criterion 1: The technology must have the appropriate regulatory approval.

There are at least three low-level lasers approved for the treatment of carpal tunnel syndrome. The MicroLight 830 Laser (MicroLight Corporation of America, Missouri City, TX) received FDA 510K approval on February 6, 2002. The THOR DD11 830L3 Laser System (THOR International, Ltd., Buckinghamshire, UK) received FDA 510K approval on February 10, 2003. The Lapex 2000 (Meridian Co., Ltd., Kang Won Do, Republic of Korea) received FDA 510K clearance on January 21, 2005.

TA Criterion 1 is met.

TA Criterion 2: The scientific evidence must permit conclusions concerning the effectiveness of the technology regarding health outcomes.

The Medline database, Cochrane clinical trials database, Cochrane reviews database and the Database of Abstracts of Reviews of Effects (DARE) were searched using the key word laser. These were cross-referenced with the keywords carpal and human. The search was performed on December 20, 2005 and identified 50 articles. The abstracts of citations were reviewed for relevance and all potentially relevant articles were reviewed in full. The PubMed "related articles" search was also performed for each relevant publication. The bibliographies of systematic reviews and key articles were manually searched for additional references.

One difficulty in the literature is the fact that a minority of the literature is published in English and indexed by Medline. One review²⁵ reported that only 28% of double blind studies of low-level laser therapy identified in their systematic review were indexed in Medline.

The search identified four case series and three randomized clinical trials using low-level laser therapy to treat patients with carpal tunnel syndrome. Two of the randomized clinical trials were quite small (11 and 15 patients, respectively).

Level of evidence: 1, 2, 5.

TA Criterion 2 is met.

TA Criterion 3: The technology must improve the net health outcomes.

Case Series

Wong et al, treated 35 patients diagnosed with carpal tunnel syndrome who also had pain and tenderness at the spinous processes from C5 to T1.²⁶ They used a near infrared 830 nm, 100 mW laser (12-30 J per point) directed at acupuncture points in the C5 to T1 region of the neck. Using 10 treatments over eight months, 91% of the patients had successful relief of their symptoms. However, no nerve conduction study results were presented. According to the authors, these patients usually had poor posture with their head and neck stooped forward and shoulders rounded. They postulated that many patients labeled as having carpal tunnel syndrome, in fact have predominantly cervical radicular dysfunction resulting in pain to the upper extremities. They conclude that successful long-term management of such patients involves treating the soft tissue lesions in the neck combined with correcting the abnormal head, neck and shoulder posture by taping, cervical collars and clavicle harnesses, as well as improved work ergonomics.

Weintraub et al, treated 30 hands in 23 patients with moderate to severe carpal tunnel syndrome.²⁷ They used a near infrared 830 nm 30 mW laser (MicroLight) directed at five points (9 J per point) along the median nerve. The primary outcome measure was the disappearance of paresthesias for at least 48 hours. Symptoms resolved completely in 23/30 (77%) of the hands. Nerve conduction studies demonstrated normalization of distal latency for compound muscle action potential in 11 of 30 hands. No adverse events were observed. The authors note that these strongly positive results are provocative and underscore the need for larger, controlled studies.

In a letter to the editor in response to the Weintraub article, Padua et al. reported similar positive results in 17 hands (10 patients) with carpal tunnel syndrome.²⁸ They also used a near infrared 830 nm laser delivering light energy to the affected wrist three times a week. Their outcomes included changes in nerve conduction study measurements and changes in the Boston Carpal Tunnel Questionnaire with measures assessed throughout therapy as well as up to one year later. The largest benefit was apparent at two months after therapy. By one year, there was still a significant reduction in distal motor latency in the median nerve ($p < 0.05$), but improvements in the Boston Carpal Tunnel Questionnaire Symptom and Function subscales were no longer significant. The results were subsequently published in greater detail. In that article, the authors suggest that the results of therapy with low-level laser therapy were similar to those of steroid injections: decreased symptoms in the first several months following therapy, but a gradual increase over the next year.

The most recent case-series treated 26 women with carpal tunnel syndrome with infrared laser therapy (920 – 940 nm).²⁹ The patients received daily treatment for three weeks. The nerve conduction study measurements (latency, amplitude and velocity conduction) did not change with treatment. However, all patients reported disappearance of pain and numbness in the affected hands.

Uncontrolled case series are inadequate to assess the effectiveness of interventions for carpal tunnel syndrome. The primary manifestations of carpal tunnel syndrome are subjective symptoms, which are known to be sensitive to placebo effects. Well done randomized trials using validated pain and disability questionnaires as well as nerve conduction studies are essential for an adequate assessment of the efficacy of low-level laser therapy.

Randomized Clinical Trials

Naeser et al. compared the effects of two forms of low-level laser therapy combined with microcurrent transcutaneous electrical nerve stimulation (TENS) to sham treatment in a randomized, double-blind trial of 11 patients using a cross-over design.³⁰ There were nine men and two women with a mean age of 54 years. All had failed conservative therapy with nonsteroidal anti-inflammatory drugs and wrist splints for a mean of 16 months (range 3-30 months). One patient had undergone carpal tunnel release surgery 12 years prior to this study. Patients were randomized to active or sham therapy first, followed by the alternate therapy. Four patients received the active therapy first. Active therapy included low-level laser therapy using a 633 nm 15 mW red beam laser (Dynatronics Model 1620) applied to shallow acupuncture points located in the fingers and affected hand and a 904 nm 9.4 W infrared laser (Respond System Model 2400) applied to deeper acupuncture points in the elbow, shoulder, upper back and cervical paraspinal area. Active therapy also included a microamps TENS device (MicroStim Inc. Model 100) applied to the affected wrist. Sham therapy used the same devices with the same protocol. Both active and sham treatments were performed with the patient's arm placed through a black curtain to maintain blinding. Each patient underwent two series of treatments three times a week for three to four weeks. Outcomes were assessed within a month prior to randomization and within a week after completion of each series of treatments. The primary outcome measure was change in pain as assessed by the McGill Pain Questionnaire (MPQ). Secondary outcome measures included median nerve sensory peak latency, motor latency, Phalen's test and Tinel's test. The first sentence in the results section is: "Any patient who reported a greater than 50% pain reduction after a series of sham treatments was considered to be a placebo responder and was removed from further statistical analyses of the MPQ scores." This clear violation of the intention to treat principle introduces a strong bias in favor of the active group as any patient with a greater than 50% placebo response in the active phase is included in the analysis. Thus, the MPQ results will not be considered further. Furthermore,

the authors appeared to concentrate on within group analyses for their outcomes. The correct approach to analyzing crossover studies is with repeated measure analysis of variance. This allows for an assessment of both treatment effects and any carry-over effect due to the order of randomization. Using an alternate approach to analysis, the authors reported a significant improvement in the sensory peak latency for active therapy, but not for sham therapy. No between group analyses were reported and a significant proportion of the data was missing for this outcome. There were no improvements in median nerve motor latency within either group and there were no missing data. Again, no analyses of differences between the active and sham treatment were presented. The authors also reported that there were improvements in the Phalen and Tinel tests after the active, but not the sham treatment.

Crossover designs are inherently difficult to interpret because of concerns about carry over effects. Adding the small size of this study³⁰, the lack of between group comparisons and the bias introduced by excluding patients with a large response in the sham phase makes it impossible to conclude anything from the results of the study. Even if there were interpretable results, the multiple co-interventions would not allow us to determine whether the findings were due to one of the laser therapies or the TENS.

Irvine et al. conducted a randomized, double-blind study of low-level laser therapy in 15 patients with carpal tunnel syndrome.³¹ Patients were required to have at least one of the following symptoms: paresthesias in the distribution of the median nerve, similar symptoms brought on by repetitive hand activities, waking at night from similar symptoms or weakness in thumb abduction. Additionally, all patients were required to have evidence of focal median nerve compression in the carpal tunnel on nerve conduction studies. Patients were excluded if they had evidence of marked axonal loss, trauma to the wrist or prior carpal tunnel release surgery. The intervention was treatment with 860 nm laser beam (Eriel TOP 250, Coradon Rehabilitation) delivered three times a week for five weeks. Twenty sites over and surrounding the carpal tunnel were irradiated. The control group was treated according to the same protocol using an identical sham probe. The patients, investigators and staff assessing outcomes were all blinded to the intervention. Blinding was assessed at the end of the study by asking which was the active probe. Outcomes were assessed at baseline, mid treatment, at the end of treatment and four weeks after the final treatment. A validated questionnaire, the Levine Carpal Tunnel Syndrome Questionnaire, was used as the primary outcome measure. Hand function was assessed using the Purdue pegboard test, which evaluates fine motor skills of the hand. Nerve conduction studies were also performed. Of 173 eligible patients, 15 agreed to participate. Seven were randomized to active treatment and eight to sham treatment. Baseline characteristics including age, sex, severity, disability, hand dexterity and nerve conduction measurements were similar between the two groups. Changes in the Levine Carpal Tunnel Syndrome Questionnaire were not different between groups at baseline ($p=0.89$) or at the end of treatment ($p=0.69$) although patients in each group improved

significantly ($p < 0.05$ for both within group comparisons). There were no differences between or within groups in hand function or nerve conduction measurements. Blinding was effective as three out of seven patients in the active group thought they received the active therapy, as did six out of eight patients in the sham group. Both the treating therapist and clinician thought the sham probe was the active laser.

This study³¹ highlights the importance of including either a sham or active control group when using self-reported symptoms as an outcome. Both groups improved significantly from baseline to treatment end on the validated Carpal Tunnel Syndrome Questionnaire, but there were no differences between the sham and laser groups in the degree of improvement. Furthermore, there were no significant improvements in the more objective nerve conduction and hand function measures for either group. The study was well designed with excellent blinding using a sham laser probe, but suffers from small numbers. A larger study may have been able to detect subtle improvements.

Bakhtiary and Rashidy-pour³² randomized 90 hands in 50 consecutive patients with mild to moderate carpal tunnel syndrome confirmed by nerve conduction studies to treatment with either ultrasound therapy or low-level laser therapy. The inclusion criteria were paresthesias in the distribution of the median nerve, a positive Phalen's test and positive Tinel's test with an abnormal nerve conduction study (motor latency > 4 ms or sensory latency > 3.5 ms). Patients were excluded if they had received prior ultrasound or laser therapy, steroid injections or if they were diagnosed with thyroid disease, diabetes or a systemic peripheral neuropathy. Laser therapy consisted of 830 nm infrared laser (Enraf, Endolaser 830) delivered to five points (1.8 J per point) during five sessions per week for three weeks (total of 15 sessions). All outcomes were measured before and after treatment at four weeks after treatment. The outcomes included pain assessment using a visual analog scale (VAS), nerve conduction studies, pinch and grip strength. Outcome assessment was performed by staff blinded to the treatment assignment. Intention to treat analysis was used for all between group comparisons. At randomization, there were no significant differences between groups in the length of symptoms (seven months), pain by VAS (6.9/10), grip strength, pinch strength and nerve conduction studies. All 50 patients had complete follow-up. Ultrasound therapy had greater improvements on all measures than low-level laser therapy ($p < 0.01$ for all comparisons). Pain decreased more in the ultrasound group at the end of therapy (-5.6 vs. -2.4, $p < 0.001$) and at four weeks after the end of therapy (-6.3 vs. -2.0, $p < 0.001$). Similarly there was greater improvement in finger pinch strength in the hands randomized to ultrasound therapy at the end of therapy (9.1 vs. 2.6, $p < 0.001$) and at four weeks after the end of therapy (9.9 vs. 2.9, $p < 0.001$). In nerve conduction studies, motor latency decreased more in the ultrasound group at the end of therapy (-1.0 vs. -0.3, $p < 0.001$) and at four weeks after the end of therapy (-1.1 vs. -0.2, $p < 0.001$). Handgrip strength, sensory latency, muscle action potential amplitude and sensory action potential amplitude were also significantly improved in the ultrasound group compared to the laser

group at both time points. The authors concluded that ultrasound therapy was more effective than low-level laser therapy in the treatment of mild to moderate carpal tunnel syndrome.

The study appeared to be of good quality. Randomization, allocation concealment and blinded outcome assessment were all well done. Follow-up was 100% for all outcomes, the two groups appeared balanced, and intention-to-treat analysis was done. Co-interventions were not well described, but were unlikely to be different between groups as most patients had bilateral disease. It is unclear whether patients were blinded to the type of treatment received, but potential biases arising from patient unblinding are mitigated by the fact that all wrists received some form of active treatment and the use of objective outcome measures like grip and pinch strength and several nerve conduction measurements. The findings were consistent on all measures.

In summary, the only randomized trial reporting a benefit from low-level laser therapy suffered from significant methodological flaws and was very small. The only randomized trial comparing low-level laser therapy to sham treatment reported no benefit. Finally, the largest and best quality study compared low-level laser therapy to ultrasound and reported significantly better outcomes on all measures with ultrasound compared to laser therapy. No harms were reported in any of the trials, and there was no reporting of adverse events in any of the trials. Thus, the current published literature does not provide evidence for a net improvement in health outcomes with low-level laser therapy.

TA Criterion 3 is not met.

TA Criterion 4: The technology must be as beneficial as any established alternatives.

Standard treatment for carpal tunnel syndrome usually begins with avoidance of activities that increase pressure in the carpal tunnel combined with splinting of the involved wrist. Patients who do not respond initially may receive steroid injections just proximal to the carpal tunnel. Patients with intractable pain or muscle wasting are often referred for surgical release procedures. None of the trials directly compare laser therapy with any of these therapies. The one comparison with an alternative therapy, albeit not an established alternative, reported that low-level laser therapy was associated with significantly worse outcomes than ultrasound.³² Furthermore, low-level laser therapy has not been shown to improve net outcomes for patients suffering from carpal tunnel syndrome.

TA Criterion 4 is not met.

TA Criterion 5: The improvement must be attainable outside the investigational setting.

Studies of low-level laser therapy for carpal tunnel syndrome include a variety of laser devices of different wavelengths used in widely disparate protocols. As none of the studies have clearly demonstrated improvements in the investigational setting, it is impossible to assess the effectiveness of the technology in the community setting.

TA Criterion 5 is not met.

CONCLUSION

The variability in the outcomes reported with laser therapy may reflect the heterogeneity in the interventions. There is no standard wavelength used for treatment of carpal tunnel syndrome nor is there a standard protocol for the points to be treated. Some irradiate points along the median nerve while others focus the light on known acupuncture points. Some early case series suggested benefit, but these have not been consistently supported in the better quality randomized clinical trials. The only randomized trial comparing low-level laser therapy to sham treatment reported no benefit over sham therapy. There was a large placebo effect on self-reported symptoms. Finally, the largest and best quality study compared low-level laser therapy to ultrasound and reported significantly better pain relief and larger improvements in all nerve conduction study measurements in patients randomized to ultrasound.

RECOMMENDATION

- It is recommended that the use of the low-level laser therapy for the treatment of carpal tunnel syndrome does not meet Technology Assessment Criterion 3 through 5 for safety, effectiveness and improvement in health outcomes

The California Technology Assessment Forum panel voted to approve the recommendation.

February 15, 2006

RECOMMENDATIONS OF OTHERS

Blue Cross Blue Shield Association (BCBSA)

The BCBSA Technology Evaluation Center has not conducted a formal review of this technology.

Centers for Medicare and Medicaid Services (CMS)

CMS does not have a coverage policy specific to the use of this technology.

California Orthopaedic Association (COA)

The COA did not have an opinion regarding the use of this technology and was not able to participate in the meeting.

California Association of Neurological Surgeons (CANS)

CANS does not have an opinion regarding the use of this technology and was not able to participate in the meeting.

Association of California Neurologists (ACN)

ACN does not have an opinion regarding the use of this technology and was not able to participate in the meeting.

California Society of Plastic Surgeons (CSPS)

CSPS does not have an opinion regarding the use of this technology and was not able to participate in the meeting.

ABBREVIATIONS USED IN THIS ASSESSMENT:

MPO: MCGILL PAIN QUESTIONNAIRE

TENS: TRANSCUTANEOUS ELECTRICAL NERVE STIMULATION

VAS: VISUAL ANALOG SCALE

REFERENCES

1. Simovic D, Weinberg DH. Carpal tunnel syndrome. *Arch Neurol*. May 2000;57(5):754-755.
2. Stevens JC, Beard CM, O'Fallon WM, Kurland LT. Conditions associated with carpal tunnel syndrome. *Mayo Clin Proc*. Jun 1992;67(6):541-548.
3. van Dijk MA, Reitsma JB, Fischer JC, Sanders GT. Indications for requesting laboratory tests for concurrent diseases in patients with carpal tunnel syndrome: a systematic review. *Clin Chem*. Sep 2003;49(9):1437-1444.
4. D'Arcy CA, McGee S. The rational clinical examination. Does this patient have carpal tunnel syndrome? *Jama*. Jun 21 2000;283(23):3110-3117.
5. Seradge H, Jia YC, Owens W. In vivo measurement of carpal tunnel pressure in the functioning hand. *J Hand Surg [Am]*. Sep 1995;20(5):855-859.
6. Gerritsen AA, de Vet HC, Scholten RJ, Bertelsmann FW, de Krom MC, Bouter LM. Splinting vs. surgery in the treatment of carpal tunnel syndrome: a randomized controlled trial. *Jama*. Sep 11 2002;288(10):1245-1251.
7. Gerritsen AA, Korthals-de Bos IB, Laboyrie PM, de Vet HC, Scholten RJ, Bouter LM. Splinting for carpal tunnel syndrome: prognostic indicators of success. *J Neurol Neurosurg Psychiatry*. Sep 2003;74(9):1342-1344.
8. Graham RG, Hudson DA, Solomons M, Singer M. A prospective study to assess the outcome of steroid injections and wrist splinting for the treatment of carpal tunnel syndrome. *Plast Reconstr Surg*. Feb 2004;113(2):550-556.
9. O'Connor D, Marshall S, Massy-Westropp N. Non-surgical treatment (other than steroid injection) for carpal tunnel syndrome. *Cochrane Database Syst Rev*. 2003(1):CD003219.
10. Gerritsen AA, de Krom MC, Struijs MA, Scholten RJ, de Vet HC, Bouter LM. Conservative treatment options for carpal tunnel syndrome: a systematic review of randomised controlled trials. *J Neurol*. Mar 2002;249(3):272-280.
11. Goodyear-Smith F, Arroll B. What can family physicians offer patients with carpal tunnel syndrome other than surgery? A systematic review of nonsurgical management. *Ann Fam Med*. May-Jun 2004;2(3):267-273.
12. Akelman E, Weiss AP. Carpal tunnel syndrome. Etiology and endoscopic treatment. *Orthop Clin North Am*. Oct 1995;26(4):769-778.
13. Hui AC, Wong S, Leung CH, et al. A randomized controlled trial of surgery vs. steroid injection for carpal tunnel syndrome. *Neurology*. Jun 28 2005;64(12):2074-2078.

14. Hui AC, Wong SM. Surgery versus steroid injection in carpal tunnel syndrome: comment on the article by Ly-Pen et al. *Arthritis Rheum*. Aug 2005;52(8):2578; author reply 2578-2579.
15. Ly-Pen D, Andreu JL, de Blas G, Sanchez-Olaso A, Millan I. Surgical decompression versus local steroid injection in carpal tunnel syndrome: a one-year, prospective, randomized, open, controlled clinical trial. *Arthritis Rheum*. Feb 2005;52(2):612-619.
16. Thoma A, Veltri K, Haines T, Duku E. A meta-analysis of randomized controlled trials comparing endoscopic and open carpal tunnel decompression. *Plast Reconstr Surg*. Oct 2004;114(5):1137-1146.
17. Trumble TE, Diao E, Abrams RA, Gilbert-Anderson MM. Single-portal endoscopic carpal tunnel release compared with open release : a prospective, randomized trial. *J Bone Joint Surg Am*. Jul 2002;84-A(7):1107-1115.
18. Passarella S. He-Ne laser irradiation of isolated mitochondria. *J Photochem Photobiol B*. Aug 1989;3(4):642-643.
19. Cheng N, Van Hoof H, Bockx E, et al. The effects of electric currents on ATP generation, protein synthesis, and membrane transport of rat skin. *Clin Orthop Relat Res*. Nov-Dec 1982(171):264-272.
20. Ruzov VI. [The pharmacological and laser correction of disorders of the blood microcirculatory bed in myocardial ischemia]. *Vopr Kurortol Fizioter Lech Fiz Kult*. Sep-Oct 1996(5):5-7.
21. Pashnev V, Lavrent'ev lu N, Podvigin AV, Sukharev VV, Shitov PL. [The efficacy of intravenous laser therapy of patients with ischemic heart disease at a day hospital of a polyclinic]. *Voen Med Zh*. Dec 1989(12):38-39.
22. Tam G. Low power laser therapy and analgesic action. *J Clin Laser Med Surg*. Feb 1999;17(1):29-33.
23. Basford JR, Hallman HO, Matsumoto JY, Moyer SK, Buss JM, Baxter GD. Effects of 830 nm continuous wave laser diode irradiation on median nerve function in normal subjects. *Lasers Surg Med*. 1993;13(6):597-604.
24. Baxter GD, Walsh DM, Allen JM, Lowe AS, Bell AJ. Effects of low intensity infrared laser irradiation upon conduction in the human median nerve in vivo. *Exp Physiol*. Mar 1994;79(2):227-234.
25. Moshkovska T, Mayberry J. It is time to test low level laser therapy in Great Britain. *Postgrad Med J*. Jul 2005;81(957):436-441.
26. Wong E, Lee G, Zucherman J, Mason DT. Successful management of female office workers with "repetitive stress injury" or "carpal tunnel syndrome" by a new treatment modality--application of low level laser. *Int J Clin Pharmacol Ther*. Apr 1995;33(4):208-211.

27. Weintraub MI. Noninvasive laser neurolysis in carpal tunnel syndrome. *Muscle Nerve*. Aug 1997;20(8):1029-1031.
28. Padua L, Padua R, Aprile I, Tonali P. Noninvasive laser neurolysis in carpal tunnel syndrome. *Muscle Nerve*. Sep 1998;21(9):1232-1233.
29. Viera Aleman C, Puron E, Hamilton ML, Santos Anzorandia C, Navarro A, Pineda Ortiz I. [Evaluation of motor and sensory neuroconduction of the median nerve in patients with carpal tunnel syndrome treated with non-coherent light emitted by gallium arsenic diodes]. *Rev Neurol*. Apr 16-30 2001;32(8):717-720.
30. Naeser MA, Hahn KA, Lieberman BE, Branco KF. Carpal tunnel syndrome pain treated with low-level laser and microamperes transcutaneous electric nerve stimulation: A controlled study. *Arch Phys Med Rehabil*. Jul 2002;83(7):978-988.
31. Irvine J, Chong SL, Amirjani N, Chan KM. Double-blind randomized controlled trial of low-level laser therapy in carpal tunnel syndrome. *Muscle Nerve*. Aug 2004;30(2):182-187.
32. Bakhtiary AH, Rashidy-Pour A. Ultrasound and laser therapy in the treatment of carpal tunnel syndrome. *Aust J Physiother*. 2004;50(3):147-151.