Clinical Application of Low-reactive Level Laser Therapy and Polarized Light Therapy for Chronic Pain Syndrome

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Chronic pain can be an extremely debilitating condition. Treatment protocols for chronic pain in our institution include nerve blocks, oral medication, transcutaneous electrical stimulation(TENS) and others. The use of low-reactive level laser therapy(LLLT) and polarized light therapy(Super lizer) in pain management are relatively new treatments and have been used with increasing frequency in the management of chronic pain.

Basic Considerations of LLLT

The history of the use of lasers in medicine is comparatively recent, just over 30 years. However, the principle behind laser medical applications and phototherapy has been around for many thousands of years. The Ancients understood the healing and beneficial properties of the sun. The sun is a two-sided light source: on the one hand, there are the benefits, and on the other there are adverse side effects from exposure to sunlight. Too much sun light can make barren deserts out of green areas, but the gentle rays of the sun are capable of giving plants their color, and giving life to humans. We would like to class LLLT as a member of the gentle side of light.

LLLT has its roots in 1960, when Dr. Maiman succeeded in firing the first laser. In 1969, the godfather of LLLT, professor Endre Mester, published his first paper in English on the clinical applications of LLLT to treat non-healing ulcers. Dr. Plog in Canada used LLLT for acupuncture therapy in 1973. In 1981, the first session at an international congress dedicated to laser therapy and laser acupuncture took place at the Fourth Meeting of the International Society for Lasers in Surgery and Medicine, in Tokyo. A double blind trial comparing YAG and diode laser irradiation for pain therapy was given there and the dedicated LLLT system had arrived. In 1988, at an international laser conference in London, a number of anxious workers in the laser therapy and bioactivation field met, and decided to form the International Laser Therapy Association, and the ILTA was born. In 1989, the Japan Laser Therapy Association(JaLTA) was formed, and the first international meeting of ILTA was successfully held in Okinawa. In July 1992 the Fourth Meeting of JaLTA was held in the Hokkaido University campus, Sapporo Japan.

What is laser therapy? How can it occur?

There are the usual areas of photothermal destruction, ranging from vaporization to protein destruction, in high-reactive level laser treatment(HLLT) by the carbon dioxide laser that is a typical beam impact of high-powered surgical laser. At the very periphery of the damage, however, the power density is so weak that there is little or no heating of the tissue. The target cells are activated by the low levels of light energy to increase various aspects of their metabolism, and this area we refer to as the non-photothermal activation zone. Because the level of reaction in the tissue is below the destructive threshold, we refer to that as low-reactive level laser therapy(LLLT). There are three main body systems targetable by LLLT: the nerve system, the blood system and the lymphatic system. The primary target in all three systems is the cell. Each cell has several specific laser targets, including the membrane enclosing the cell, the lysosomes providing the cell and its environs with essential enzymes; the mitochondrion, the power-house of the cell; the rough and smooth endoplasmic reticula, the genetic transcription areas, and the nucleus of the cell.

What can we treat with LLLT? There are a number of main headings: pain, sports medicine related applications; rehabilitation; wound healing and metabolic control. Pain management is a rapidly growing area where LLLT will have real benefits to patients with chronic pain syndrome. This is also true for injured or pain-suffereing athlete. In rehabilitation, LLLT has been shown to half the time required to turn a non-weightbearing injury into a weightbearing one, getting the patient back into useful social and business life much earlier, and at less cost, compared to conventional physical theraphy methods. In wound healing, one of the first applications from the late Professor Mester, a number of specific actions have already been shown in controlled scientific experiments and published in the literature. In metabolic control, LLLT appears to have a balancing effects, restoring a normal balance to both hyper and hypo conditions in for example hormonal problems and in blood pressure related complaints. Some of the basic reasons why LLLT can be, and is being successfully applied in a larger and larger group of medical specialities are described here. The laser scalpel is without a doubt the light that cuts, but LLLT has a much wider application, and truly is "the light that heals".

LLLT for Pain Attenuation

1) Case presentation

(A): The patient was a 67-year-old man who had been suffering from postherpetic neuralgia (PHN) for 2 years and had received 60 stellate ganaglion blocks(SGB) at a pain clinic in the city. However, no improvement in his pain was obtained and he was referred to our clinic. He complained of pain in the right forehead and eyelids. His pain score(VAS) was reduced from 10 before LLLT to 7 after the first LLLT(10 min by Ga-Al-As diode lasers, 60 mW, 830 nm), which lasted for 2 to 3 hours. Pain score was gradually reduced by LLLT and it became 5 after 6 treatments, 3 after 35 treatments. The effect persisted for days and pain score became 1 to 2 after 54 LLLT(Fig. 1).

(B): LLLT was applied for a 68-year-old female with PHN suffring from burning pain in the right forehead for 11 years. SGB and supraorbital nerve block with oral medication were not effective. LLLT(3 min) induced warm sensation in her face followed by an excellent pain relief(PS: 10 to 2). Thermograms illustrated a remarkable increase from 30.6 C to 31.5 C in

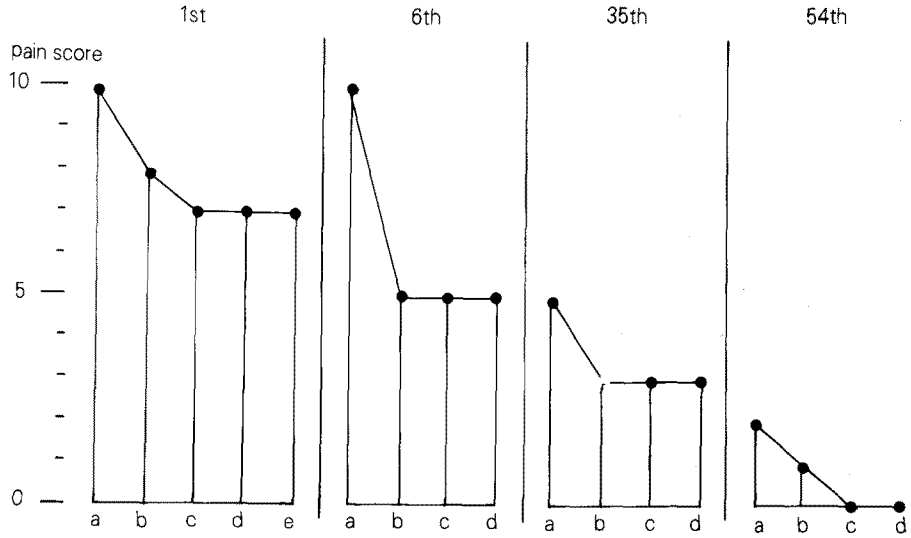

Fig. 1. Changes of pain score after LLLT.

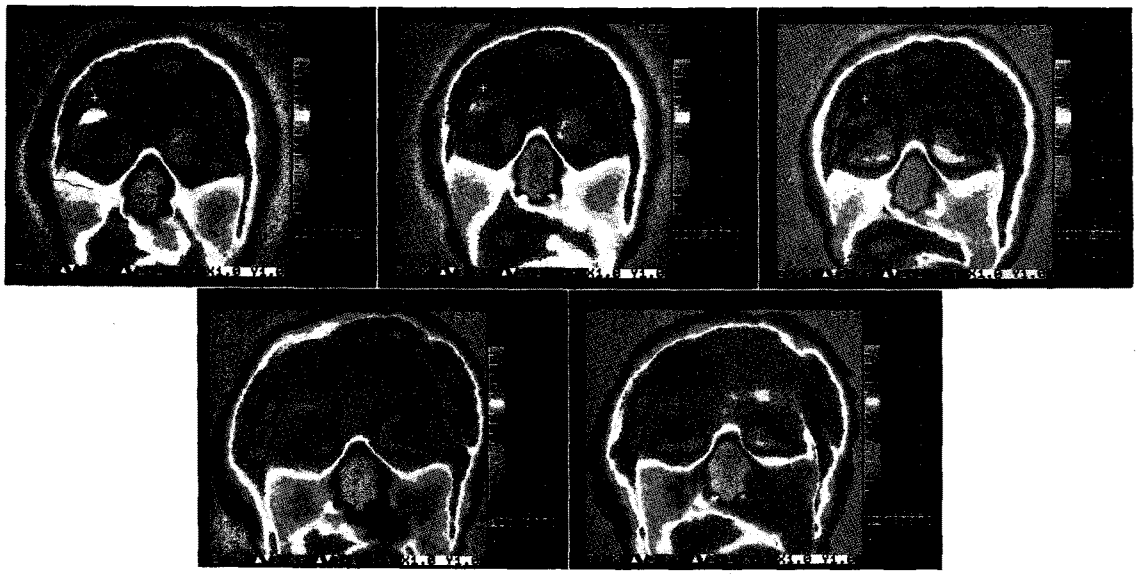

Fig. 2. Thermograms for case B.
A: before LLLT, B: left SG area LLLT, C: right SG area LLLT
D: 4 hours later, E: Right carotid artery LLLT

temperature of her right face. The irradiation near the right carotid artery also had the similar effect(Fig. 2).

(C): Polarized light irradiation(Super lizer) near the stellated ganglion was applied in a 55-year-old female with Raynaud's sign. She was suffering from cold and numb pain in bilateral fingers for 1 year. SGB and LLLT near the stellate ganglion were not sufficient to relieve the symptom. Polarized light irradiation near the stellate ganglion(2 min) induced a sting stimulation and warm sensation in her hands. Thermograms revealed a remarkable increase in temperature of her hands(Fig. 3).

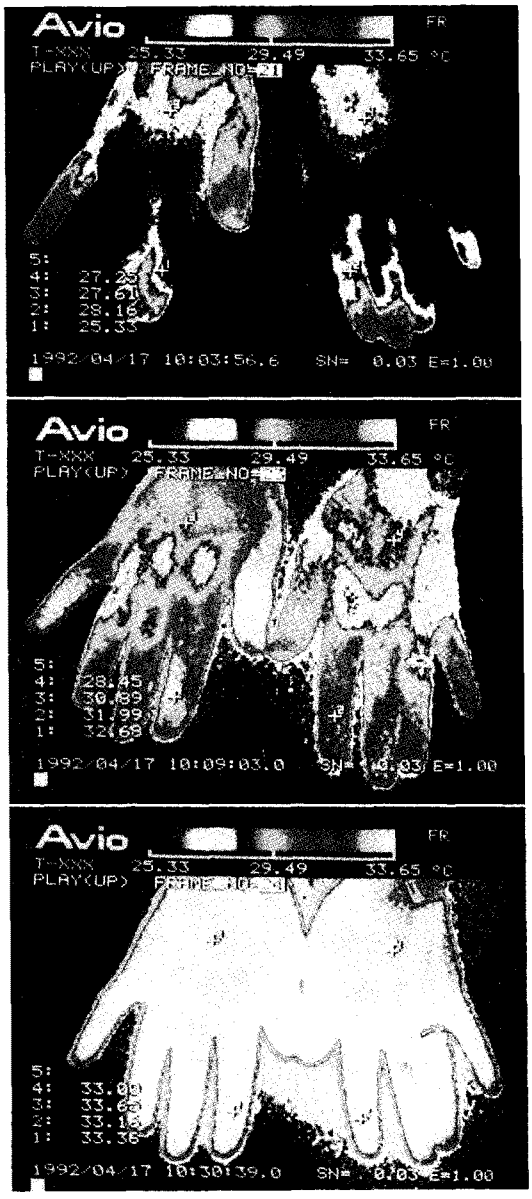

Fig. 3. Thermograms for case C.
Upper: control, Middle: Super lizer for 2 min
Lower: 20 min later

2) The immediate effect and long term effect

Two hundred and twenty-seven patients, including 94 with PHN, 22 shoulder neck syndrome, 16 frozen shoulder, 16 lumbago, 14 muscle contraction headache, were evaluated. The LLLT system used has 3 gallium aluminum arsenide(GaAlAs) diode lasers and when used as a continuous mode it has a maximum power output of 60 mW at 830 nm in the near infrared spectrum(Model MID-2001, Mochida, Japan). The power density is approximately 3 w/cm^2 well below that necessary to cause a photothermal effect. A touch sensor, mounted at the tip of the probe, allows activation of the laser only when the sensor is contact with the skin. Accordingly, the eyes of the patient and therapists are safe from accidental laser irradiation. The irradiation time and number of the treatment areas and sessions depended on the size of the affected areas and the type of pain. The total irradiation time for each session was 10 to 20 min using 10 to 30 sec for each painful surface spot along the anatomical pathway of the affected nerves. LLLT was applied 2 to 3 times a week for outpatients and 4 to 5 times a week for inpatients. Pain scores(PS) were obtained using a linear analog scale(0~10). A score of 10 indicated maximum pain, whereas 0 represented no pain. The effect of LLLT was evaluated in two fashions: the immediate effect and long

Table 1. Immediate Effect

	Very good	Good	No change	Worse	Total	ER(%)
Postherpetic neuralgia	28	39	26	1	94	71
Frozen shoulder	5	6	5		16	69
Lumbago	2	8	6		16	63
Muscle-contraction headache	0	7	7		14	50
Lower limb pain	0	6	6		12	50
Atypical facial neuralgia	1	2	4		7	43
Shoulder neck syndrome	0	9	13		22	41
Postoperative pain	0	2	4		6	33
Trigeminal neuralgia	1	1	4		6	33
Causalgia	0	1	6		7	14
Others	1	8	18		27	33
	38	89	99	1	227	55.9
	16.7%	39.2%	43.6%	0.4%		

term effect. The immediate effect of LLLT was classified as very good when PS reduced from 10 before LLLT to 1 to 3 after LLLT; good when PS was reduced from 10 to 4 to 7; and no change when PS remained 8 to 10 after LLLT, or became worse. The effective ratio(ER%) for the immediate effect was calculated as follows: patients with a very good or good effect divided by all patients times 100. The final assessment was made at the end of the treatment as the long term effect. It was classified as no pain when PS reduced from 10 to 0 to 1; slight pain when PS became 2 to 5; no change or worse. The ER for the long term was calculated as follows: patients with no pain or slight pain divided by all patients times 100. Table 1 shows the immediate effect. The ER for the immediate effect was 71% for PHN, 69% for frozen shoulder, 63% for lumbago, giving an average of 56%. The average number of LLLT sessions was 38(Table 2). The long term ER was 80% for PHN, 75% for lumbago and frozen shoulder, 67% for trigeminal neuralgia, and 65% for the average(Table 3).

LLLT was most effective for PHN, and least effective for causalgia. Those results indicate

Table 2. The Average Number of Treatments

Shoulder neck syndrome	70
Postherpetic neuralgia	49
Trigeminal neuralgia	24
Lumbago	23
Lower limb pain	22
Atypical facial neuralgia	20
Causalgia	18
Muscle-contraction headache	13
Postoperative pain	10
Frozen shoulder	7
Others	38
Total	37.7

that LLLT effectively attenuate chronic pain, in particular PHN and provides immediate and long term pain relief. There are many reported treatments for PHN including nerve blocks, electrical stimulation(TENS, TEAS and SSP), acupuncture, analgesics and even surgical intervention.

However, no consistently reliable therapy for PHN has been found. This is because PHN, as most pain caused by damage to nervous system, does not respond to treatment in the same way

Table 3. Long-term Effect

	No pain	Slight pain	No change	Worse	Total	ER(%)
Postherpetic neuralgia	14	61	19	0	94	80
Lumbago	1	11	4		16	75
Frozen shoulder	5	7	4		16	75
Trigeminal neuralgia	0	4	2		6	67
Lower limb pain	0	8	4		12	67
Shoulder neck syndrome	2	10	10		22	55
Muscle-contraction headache	0	7	7		14	43
Atypical facial neuralgia	1	2	4		7	33
Postoperative neuralgia	0	2	4		6	14
Causalgia	0	1	6		7	37
Others	2	8	16		27	
	25	121	80	0	227	64.6
	11.0%	53.3%	35.2%	0.0%		

as pain resulting from other types of tissue damage. In our patients, PHN responded well to LLLT, which suggests that LLLT may promote healing of nerve tissues damaged by herpes zoster virus. Because LLLT is a noninvasive, painless, safe and effective method of treatment, an early intervention and repeated irradiation should be recommended.

3) Mechanism of LLLT for pain attenuation

Althouth the mechanism in effectiveness of LLLT for pain attenuation is not completely clear, the following are contributing factors: blood flow improvement; acupuncture-like effect; promotion of healing of damaged nerve tissue; inhibition of pain substances; and normalization of nerve cell function. The increased blood flow in the irradiation areas may be important and our previous study using a laser Doppler blood flow-meter also showed that LLLT increased the cutaneous blood flow by 30 % above control in patients with PHN. The increased blood flow produced by LLLT may contribute to pain reduction as do sympathetic nerve blocks by introducing vasodilation and subsequent increase in the transfer of pain mediating substances. Choi et al. reported that He-Ne laser relaxed spastic skeletal muscles in humans, which is also helpful for pain attenuation. However, these facts are not sufficient to explain the immediate effect of LLLT and the acupuncture-like effect of LLLT might also be expected. The analgesic action of LLLT can be antagonized by naloxone in rat. It has recently reported that LLLT can reduced the pain-producing action of bradykinin in rat peripheral nerve tissue, and it was also thought to assist with the pain reduction process that the irradiation of rat saphenous nerve achieved. Walker et al. reported that He-Ne laser produced somatosensory evoked potentials by stimulation on the pathway of painful stimuli. They also reported that the central nervous system was photosensitive because LLLT suppressed the epileptiform activity in hippocampal slices of rats. Further investigations in effects of LLLT on the nerve tissue will help us understand the

mechanism of LLLT for pain attenuation more precisely. Irradiation of either laser or polarized light near stellate ganglion has some merits: simple, noninvasive, bilateral irradiation if needed, and no side effects. There are some limitations including variable effects and unclear mechanisms. Polarized light(Super Lizer) is sometimes as effective as laser. Although Super lizer is not laser, it has photoactivation and thermal effect, better tissue penetration, and similar effects to LLLT. We need more clinical experiences on the polarized light irradiation.

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