An Assessment of the Role of Low-Level Laser Therapy in the Treatment of Lymphedema

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Light has been used to treat disease since the dawn of time. Nevertheless, its popularity has fluctuated over the years. Early use, such as that recorded by the Greeks and Romans, emphasized its thermal effects and, as recently as the early 1900's, the Nobel Prize in Physics was awarded for the use of the ultraviolet portion of the light spectrum in the treatment of tuberculosis. Subsequent improvements in medical care, however, led to a gradual decline and near extinction of interest in the therapeutic use of light.

The invention of the laser (Light Amplification by Stimulated Emission of Radiation) in the early 1960's led to a new attention to light's non-thermal capabilities and a reversal of this trend. At the heart of this interest was the belief that specific wavelength of light (i.e. colors) at intensities too low to increase a tissue's temperature more than a few tenth's of a degree can alter cellular and tissue activities. Initial work began in Eastern Europe and focused on the treatment of non-healing wounds.

The next few decades saw a rapid expansion of interest and a variety of names applied to the approach. Although terms such as Biostimulation, Cold Laser and Low Intensity Laser have been used, nowadays, Low Level Laser Therapy (LLLT) is the most generally accepted term.

Scientific Background and Support

As noted above, LLLT involves the application of low powers and energies of laser irradiation to tissue with the goal of producing benefits by non-destructively altering cellular or tissue function. Early lasers were gas-filled devices (e.g., helium and neon, krypton and argon), but by the 1980s these instruments began to be replaced with cheaper and easier to use superluminous diodes. Today, diode use prevails and with the exception of some helium-neon lasers, most "laser treatments" are in reality performed with individual or groups of Gallium-Arsenide (GaAs) and Gallium-Aluminium-Arsenide (GaAlAs) diodes.

While laser and diode radiation might have therapeutic benefits, the conditions most likely to respond and the extent of these benefits remain areas of active investigation. The answer to the first question, why these devices may have benefits, is now generally accepted to be that as their radiation is purer (in other words has a narrower bandwidth) than light from other sources, it is more capable of producing wavelength-dependent resonant frequency interactions with cell organelles such as the mitochondria. There is also a general, but not universal, acceptance that multiple treatments are necessary, that the treated tissue must be under stress, and the energies involved in treatment should be low (between 1-4 J/cm2). Most devices, in fact, are relatively low-powered and have outputs between 30 and 500 mW (power). Treatment typically is delivered at multiple sites with the laser applicator in contact with the skin, or in a noncontact approach in which the beam is scanned over the area to be treated. While attention may be placed on waveform of a device's output, evidence supporting the benefits of a specific pattern of pulsing over a simple continuous wave is limited.

Safety and Benefits

LLLT, by definition, involves low amounts of energy and no risk of thermal injury. While some have raised the thought that stimulation could accelerate cancer growth, this issue remains theoretical. As a result, safety concerns related to LLLT are low and adverse effect reports rare. In fact, an attractive aspect of LLLT is that treatment does not raise tissue temperature significantly. Therefore, LLLT can be used during the acute stages of an injury or in conditions for which heat might be expected to worsen swelling or inflammation.

Soft tissue and musculoskeletal injuries have proven particularly intriguing as these sites tend to be superficial and LLLT is claimed to have both analgesic and tissue healing effects. Laboratory studies support the concept that LLLT can increase collagen production, alter DNA synthesis, reduce the expression of inflammatory markers, and enhance the function of damaged muscles and nerves. Extension of these effects to animals and humans has proven more difficult to establish. Although many investigations find benefits from LLLT in a variety of musculoskeletal, arthritic, soft tissue, and painful conditions, differences in their designs, parameter choices, and subject populations make it difficult for systematic and meta-analytic studies to confirm LLLT's clinical benefits. Fortunately, study designs are improving and the existence of a growing number of larger, well-designed studies may change the current situation. Similarly, a frequent lack of a head-to-head comparison with alternative treatments such as ultrasound and massage often complicates assessment of clinical utility.

Lymphedema

Lymphedema, at first blush, might not appear to be particularly amenable to LLLT, given past emphasis on its use to promote healing and to alleviate musculoskeletal dysfunction and pain. Nevertheless, while still in its early days, the idea that LLLT might be beneficial may not be far-fetched, given its documented effects on processes as diverse as protein and prostaglandin synthesis, cell membrane transport, inflammation and intracellular metabolism. In fact, a number of investigators have reported reductions in swelling and improved comfort following treatment. As is true for LLLT in general, the initial studies, while intriguing, are too small and frequently too poorly designed to do more than suggest benefits. Subsequent work has been marked by improving designs and while the amount of research completed is still limited, it is worthwhile to review its strengths and weaknesses.

For example, a recent study by Kozanoglu and colleagues reports on 47 women with post-mastectomy edema following modified radical mastectomies and axillary dissections. Subjects were randomized to receive either twenty 2-hour sessions of pneumatic compression therapy or twelve 20-minute sessions of LLLT over the antecubital fossa and axilla with a 904nm infrared pulsed Ga-As laser device over a four-week period. All subjects received a home program of daily exercise, range of motion and skin care. The investigators found that while both groups showed significant improvements in their limb circumferences following treatment, those improvements in the LLLT group tended to be larger and more prolonged in the study's impressively long, 1-year follow-up period. No significant inter-group differences were noted in terms of pain relief or grip strength.

Carati and colleagues reported in 2003 on a rather complex trial in which 61 women with breast cancer-related arm lymphedema were divided into groups receiving either nine sessions of pulsed 904 nm irradiation at 17 sites along the axilla over a 3-week period, or an identical placebo treatment with an inactive device. At the end of this trial, a second experiment was performed comparing the relative benefits of one versus two courses of radiation.

Interesting and Related Findings

The investigators reported two interesting and related findings: while a single course of treatment had no effect on their subjects' lymphedema, two courses did; and the benefits became noticeable at follow-up one month after the completion of treatment. No effects on range of motion were noted.

Kaviani and colleagues reported in 2006 on a small double-blind controlled trial in which 11 women with post mastectomy lymphedema were assigned to either receive 890 nm radiation over the axilla and arm from a GaAs laser device or identical treatment with a sham device. Evaluation of the eight who completed the treatment over a 22-week period revealed improvement in both groups. The authors noted the improvements tended to be more pronounced in subjects treated with the active device. The authors concluded that their results were encouraging but that further research was needed.

Piller and Thelander provide two reports of a group of 10 women with post-mastectomy lymphedema who underwent an uncontrolled 10-week trial involving sixteen treatments with a laser which was scanned over the treated area rather than held at a number of fixed positions. Evaluation at the end of treatment revealed a roughly 20% reduction in volume, as measured by limb circumference. Follow-up of seven of these subjects indicated by self-assessment that their limb volume improvements persisted.

White and colleagues recently published an abstract describing a randomized trial that compared LLLT to "standard care" for the initial treatment of breast cancer-related lymphedema. The 148 participants received either two weeks of LLLT or decongestive therapy. A statistically significant reduction in arm circumference relative to the control group was noted after LLLT in participants with mild but not moderate lymphedema. It should be noted that while the results are intriguing, conclusions and generalization are limited, as bandages were not worn between therapy sessions in the decongestive group and details about the nature of LLLT were not provided in this preliminary report.

Summary

This paper has provided an overview of LLLT and the relevance of its research findings to lymphedema. A number of observations are possible. The first is that the evidence supporting the use of LLLT in its initial areas of pain and musculoskeletal applications is promising, but still limited by heterogeneity in study designs (with studies characterized by small sample size with limited follow-up in many cases), irradiation and outcome measures. The second is that the study of the application of LLLT to lymphedema is following a pattern similar to that of LLLT as a whole: small, uncontrolled studies (e.g., Piller and Thelander) followed by larger and better designed trials such as that by Carati and colleagues. The results are encouraging, but the pool of evidence is limited and further work by multiple investigators, as well as more comparisons with alternative treatments, is needed before the benefits of LLLT for lymphedema can be accepted comfortably as established. Further, how or whether LLLT should be integrated in conventional complex decongestive therapy (CDT) remains uncertain. Until rigorous trials permit therapeutic comparison of CDT and LLLT, patients should be informed that LLLT does not eliminate their need for phase II CDT maintenance treatments.

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