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# Effects of low-level laser therapy on wound healing

## *Efeitos da laserterapia de baixa potência na cicatrização de feridas cutâneas*

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## A B S T R A C T

**Objective**: To gather and clarify the actual effects of low-level laser therapy on wound healing and its most effective ways of application in human and veterinary medicine. **Methods**: We searched original articles published in journals between the years 2000 and 2011, in Spanish, English, French and Portuguese languages, belonging to the following databases: Lilacs, Medline, PubMed and Bireme; Tey should contain the methodological description of the experimental design and parameters used. **Results**: doses ranging from 3 to 6 J/cm$^2$ appear to be more effective and doses 10 above J/cm$^2$ are associated with deleterious effects. The wavelengths ranging from 632.8 to 1000 nm remain as those that provide more satisfactory results in the wound healing process. **Conclusion**: Low-level laser can be safely applied to accelerate the resolution of cutaneous wounds, although this fact is closely related to the election of parameters such as dose, time of exposure and wavelength.


**Key words**: Skin. Wound healing. Anti-inflammatory agents. Laser therapy, low-level.

## INTRODUCTION

The incorporation of laser as a therapeutic tool has been accompanied in the biomedical field since 1960 by Theodore Maiman. One of the first published experiments on the effects of low-level laser dates from 1983, with HeNe (Helium Neon) laser irradiation of wounds in rats for 14 consecutive days[1].

The effects of low-level laser can be observed in the behavior of lymphocytes, increasing their proliferation and activation; on macrophages, increasing phagocytosis; and on fibroblasts, increasing the secretion of growth factors and enhancing the uptake of both fibrin as collagen. In addition, it contributes to increase the motility of epithelial cells, the amount of granulation tissue and may reduce the synthesis of inflammatory mediators[2-5]. Its action can be observed on the reduction of the area of skin wounds in humans and animals, although the adoption of physical variables involved in the treatments is still not a consensus among authors[6-9].

Regarding the irradiation protocol, the use of lasers may differ in the type of activation means, the power and dose, and also on the manner and time of irradiation and number of applications[3].

From the above, and with the growing interest in alternatives to conventional drug therapies, the objective of this was to gather and clarify the actual effects of low-level laser therapy on wound healing and its most effective ways of application in human and veterinary medicine.

## METHODS

This was a qualitative study from original articles published in journals indexed in the following databases: Lilacs, Medline, PubMed and Bireme. We included all original articles whose publication occurred between the years 1984 and 2011 in Spanish, French, English and Portuguese languages and provided methodology containing the parameters used by the applied laser mode. We excluded the research articles that did not contain the methodology regarding the description of the parameters used in their work.

## LITERATURE REVIEW

The acronym LASER has its origin in the English language, abbreviating "light amplification by stimulated emission of radiation". The word laser is established by usage and defines a source of monochromatic, intense, coherent and collimated light, whose emission of radiation is done by stimulating the external field, with varied and growing applications in industry, engineering, human medicine and more

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recently, veterinary medicine[10,11]. In the latter, the rat has been used to study the different aspects involved in cutaneous healing process, being the elected experimental model due to ease of handling[12].

Lasers are classified into high and low power. The first is generally applied for the removal, cutting and coagulating of tissues, while the low-power ones are more commonly applied in the processes of tissue repair, such as muscle, joint, nerve, bone and skin injuries[6,13,14].

The photobiological effects of laser radiation can be conventionally divided into short and long term. The responses in the short term are those in which the effect can be observed in a few seconds or minutes after irradiation. The effects observed in the long term are those that occur hours or even days after the end of irradiation and usually involve new cell biosynthesis, especially in the proliferative phase of inflammation[12,15,16].

A wide variety of lasers that promote wound healing can be found in the literature, including:. Helium-Cadmium, Argon, Helium-Neon, Krypton, Gallium Arsenide and Aluminium and $CO_2$ [6]. It is known, however, that the success of low power therapy and its respective effects is dependent on wavelength, power, dose and time of application[4-8,11,16-23] (Table 1).

## DISCUSSION

The repair process is complex and comprises vascular and cellular alterations, epithelial and fibroblasts proliferation, synthesis and deposition of collagen, elastin and proteoglycan production, revascularization and wound contraction[8]. Noteworthy still are the trophic-regenerative, anti-inflammatory and analgesic effects[2,8,24]. It is also claimed that the low-level laser therapy can lead to increased mitochondrial activity, with a consequent increase of adenosine triphosphate (ATP), vasodilation, protein synthesis, decrease in prostaglandin levels, presence of cellular mitosis, migration and proliferation of keratinocytes and neoangiogenesis[18,19,23,25].

In this sense, a study with HeNe laser, applied at the rate of 4J/cm$^2$ showed better effects in the production of collagen type III. In another, it was observed that doses between 7 and 9 J/cm$^2$ caused the opposite effect, reducing the production of collagen fibers[2,18].

It is understood that the increased collagen production occurs through photostimulation mechanisms on which certain frequencies/doses may act, thereby modulating cellular proliferation and increasing the amount of fibroblast growth factors. Another possible explanation for this, according to the authors above, would be the better absorption of such energy by the mitochondria and consequently increased production of ATP and nucleic acid, the result being an increase in collagen production, accelerated epithelial repair and facilitated growth of granulation tissue[26].

According to Zanotti *et al.*[9], excitatory doses (up to 8J/cm$^2$) are indicated when the goal of the intervention includes the enhancement of the sodium/potassium pump; stimulating production of ATP; restoration of the membrane potential; increased metabolism and cell proliferation.

Laser therapy has been administered with the aim of promoting better resolution of inflammation, reducing pain, preventing the occurrence of edema and preserving tissues and nerves adjacent to the site of injury. Such effects can be achieved via wavelengths between 600 and 1000nm and power from 1mW to 5 W/cm$^2$. The authors also emphasize that very low (2.5W/cm$^2$) or very high (25 W/cm$^2$) power can cause the opposite effect[27].

In a study treating the inflammatory process present in induced arthritis of the knee joint of rats with anti-inflammatory and low-level laser therapy, beneficial effects have been observed both at a dose of 3J/cm$^2$ and 30J/cm$^2$, although the latter proved more effective in reducing the painful area over 120 hours after the start of treatment, when associated with lower power and applied for ten minutes[19]. Bashardoust Tajali *et al.*[3] reported that the wavelength of 632nm improved resolution of fractures, thereby demonstrating that there are many results for the use of this therapy.

Although laser has been successfully applied on the symptoms of various diseases, investigators showed that malignant melanoma cells irradiated by Indium-Gallium-Aluminum-Arsenic-Phosphorus (InGaAlAsP) laser at 660nm wavelength and dose of 1050J/cm$^2$ revealed worsening behavior[17]. Furthermore, the use of laser is contraindicated in cases of localized or irradiated malignant tumor; epilepsy; on the thyroid gland; on pregnant abdomen; high hypersensitivity; and thrombosis of pelvic or deep leg veins[28,29].

## FINAL CONSIDERATIONS

It is concluded that low-level laser therapy, when applied to skin wounds, is able to promote major physiological effects, such as anti-inflammatory resolution, neoangiogenesis, epithelial and fibroblasts proliferation, collagen synthesis and deposition, revascularization and wound contraction. It is also possible to say that doses of 3-6 J/cm$^2$ appear to be more effective and doses above 10 J/cm$^2$ are associated with deleterious effects. The wavelengths between 632.8 and 1000 nm remain as those having more satisfactory results in the wound healing process.

**Tabela 1 -** Breve descrição das propostas de tratamento com laserterapia de baixa potência e seus principais resultados.

| Authors | Treatment | Resiults |
|---|---|---|
| Busnardo, Simões, 2010[8] | HeNe with power 4J/cm² applied for 12 seconds per wound site in continuous mode, 5mW, wavelength of 632.8 nm and the laser beam area of 0.015 cm². | Increase of type III collagen, decreased inflammatory infiltrate and early resolution of wound inflammatory phase. |
| Silva *et al.*, 2010[16] | Laser applied in 15 Wistar rats divided into three groups: G1 (control), G2 (2J/cm²) and G3 (4 J/cm²), with wavelength of 670 nm and irradiated for 10 consecutive days on skin lesion. | The dose of 4J/cm² differed significantly from the others concerning the re-epithelialization process. |
| Frigo *et al.*, 2009[17] | Application of laser once a day on tumor cells, for three consecutive days, with the following parameters: 632nm, 50 mW, 2mm² pointer, irradiation area of 2.5 W/cm² and times of 60 and 420 seconds at doses of 150J/cm² (group 1, in vitro) and 1050J/cm² (group 2, in vivo), respectively. The third group was not irradiated (control group). | Between the in vitro and the control group, there was no statistically significant difference in the growth of tumor cells. Comparing group 2 and control, there was significant growth of mass and volume to the tumor, as well as a large number of blood vessels in the *in vivo* group. |
| Felice *et al.*, 2009[7] | Application of AlGaInP laser (658 nm, 4J/cm²) in a localized and scanned manner on human decubitus and venous ulcers. | Reduction of the wounds area. |
| Maiya *et al.*, 2009[18] | He-Ne laser on skin wounds in diabetic rats, with a wavelength of 632.8 nm and doses of 3-9J/cm², five days / week until complete healing. | Increased production of granulation tissue in the animals that received doses of 4-5J/cm², especially on the fifth day of treatment. |
| Inoe *et al.*, 2008[11] | HeNe laser used in doses of 3 and 6J/cm², 45 W of power and wavelength of 632nm and a control group, for surgical wounds of healthy rabbits. The animals were evaluated at 7, 14 and 21 days. | Observed the presence of mature granulation tissue at 14 days and absence of hemorrhage and exudate at day 21. |
| Channual *et al.*, 2008[5] | Low power laser with a wavelength of 585 nm and a dose of 7J/cm² on skin wounds of rats. | Permanent vascular proliferation after the fifth day of application. |
| Pinto *et al.*, 2007[4] | First week twice with an interval of 48 hours in the weeks following 1x/week, in a localized manner and without the use of additional medication. | The results revealed granulation tissue, reducing inflammation and pain relief from the first application. |
| Castano *et al.*, 2007[19] | Arthritis in rats treated for five days with 810nm, power 79 and 790mW, doses of 3 and 30J/cm² and intensities of 5 and 50mW/cm². | Increase of adenosine triphosphate (ATP) and improved inflammatory process. |
| Rocha Júnior *et al.*, 2006[20] | Twelve animals divided into two groups: control and experimental. Wound treated for seven days with GaAs laser, pulsatile dose 3.8 J/cm² and power of 15mW time for 15 seconds. | Tissue repair significantly larger and more organized in the experimental group. |
| Hopkins *et al.*, 2004[21] | Abrasive damage induced in non-dominant upper limb in two groups of healthy people. One group was treated with a dose of 8J/cm², wavelength 820nm and two minutes exposure. The other group was treated under the same parameters for five seconds. A third group was not treated. | The groups treated with low level laser showed a statistically significant reduction in the wound when compared to the control group at the 6th, 8th and 10th days of treatment. |
| Envemeka, 2001[22] | HeNe laser (632.8 nm, continuous) and GaAs laser (904nm, continuous) in cutaneous lesions of rats. | Improvement of wound healing for both wave lengths adopted, though the latter presented more pronounced findings. |
| Landau, Schattner, 2001[23] | HeNe laser (632nm / 5mW and 904 nm/60W; 4 J/cm²) associated with topical hyperbaric oxygen supply for 20 minutes per session on diabetic foot ulcers over 14 weeks. | Complete healing of ulcers after 25 sessions and only 4% of recurrence. |
| Al-watban, Andres, 2001[6] | HeNe (632.8 nm wavelength, dose of 5 J/cm² and power of 10.53 mW/cm²), applied three times per week in *in vivo* cells until complete healing of the wound. | Increased cell proliferation (fibroblasts and mitochondria), as well as microcirculation, with a consequent increase in cellular metabolism. |

## R E S U M O

***Objetivo:*** *reunir e esclarecer quais os reais efeitos da laserterapia de baixa potência sobre feridas cutâneas e suas formas mais eficazes de aplicação na medicina humana e veterinária.* ***Métodos:*** *foram pesquisados artigos originais publicados em periódicos pertencentes às seguintes bases de dados: Lilacs, MedLine, Bireme e PubMed entre os anos de 2000 e 2011, na línguas espanhola, inglesa, francesa e portuguesa, que contivessem a descrição metodológica do modelo experimental e parâmetros utilizados no estudo.* ***Resultados:*** *doses compreendidas entre 3-6 J/cm² parecem ser mais eficazes e que doses acima de 10 J/cm² estão associadas a efeitos deletérios. Os comprimentos de onda compreendidos entre 632,8-1000nm seguem como aqueles que apresentam resultados mais satisfatórios no processo de cicatrização tecidual.* ***Conclusão:*** *o laser de baixa potência pode ser indicado com segurança para acelerar a resolução de feridas cutâneas, muito embora este fato esteja intimamente ligado à eleição de parâmetros como dose, tempo e comprimento de onda.*

***Descritores:*** *Pele. Cicatrização de feridas. Anti-inflamatórios. Terapia a laser de baixa intensidade.*

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