Comparative Study Using 685-nm and 830-nm Lasers in the Tissue Repair of Tenotomized Tendons in the Mouse

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FROM ABSTRACT

Objective:
The objective of this study was to evaluate the effects of 685- and 830-nm laser irradiations, at different fluences on the healing process of Achilles tendon of mice after tenotomy.

Data:
Low-level laser therapy (LLLT) is able to accelerate the healing process of tendinuos tissue after an injury, increasing fibroblast cell proliferation and collagen synthesis.

However, the mechanism by which LLLT acts on the healing process is not fully understood.

Methods:
Forty-eight male mice were divided into six experimental groups:

Group A, tenomized animals, treated with 685 nm laser, at the dosage of 3 J/cm^2.

Group B, tenomized animals, treated with 685-nm laser, at the dosage of 10 J/cm^2.

Group C, tenomized animals, treated with 830-nm laser, at dosage of 3 J/cm^2.

Group D, tenomized animals, treated with 830-nm laser, at dosage of 10 J/cm^2.

Group E, injured control (placebo treatment); and group F, non-injured standard control.

Animals were killed on day 13 post-tenotomy, and their tendons were surgically removed for a quantitative analysis using polarization microscopy, with the purpose of measuring collagen fiber organization through the birefringence (optical retardation [OR]).

Results:
All treated groups showed higher values of OR when compared to injured control group.

The best organization and aggregation of the collagen bundles was shown by the animals of group A (685 nm, 3 J/cm^2), followed by the animals of group C and B, and finally, the animals of group D.

Conclusion:
All wavelengths and fluences used in this study were efficient at accelerating the healing process of Achilles tendon post-tenotomy, particularly after the 685-nm laser irradiation, at 3 J/cm^2.

It suggests the existence of wavelength tissue specificity and dose dependency.

THESE AUTHORS ALSO NOTE:

Low-level laser therapy (LLLT) is an innovative clinical approach to repairing damaged tissues. **[Important]**

"A series of studies have demonstrated that LLLT is effective at reducing post-injury inflammatory processes and accelerating soft tissue healing."

"LLLT, at the cellular level, produces increased ATP synthesis, increased mitochondrial respiration, and increased production of molecular oxygen, thus stimulating DNA synthesis and cell proliferation." **[Very Important]**

LLLT can accelerate the healing process of tendinuos tissue after injury.

"LLLT seems to create new blood vessels, to increase collagen fiber deposition, and to promote higher fibroblast cell proliferation in the site of the lesion."

Studies show that 632.8-nm laser "produced a higher deposition of collagen, increasing the tensile strength of completely severed and surgically repaired rat tendons."

In this study, laser irradiation started 24 h after the tenotomy of the Achilles tendon. A total of 12 sessions were performed on consecutive days. The rats were killed on day 13, and the injured tendons were surgically removed and analyzed with polarized light microscopy to analyze the organization and molecular order of the collagen fibers.

RESULTS

Both laser wavelengths and both dosages used produced a statistically significant increase of the optical retardation (OR) of the collagen fibers in the injured tendons compared to injured controls "suggesting that the laser irradiation was able to accelerate tendon healing."

"However, the better tissue response was observed after the irradiation with the 685-nm laser, at the dosage of 3 J/ cm^2."

"The animals irradiated with the 830-nm laser, at the dosage of 10 J/ cm^2 presented the weaker response to laser irradiation."

"The best tissue response was obtained after the 685-nm laser irradiation, at the dosage of 3 J/cm^2." Specifically, the 685-nm laser irradiation at 3 J/cm^2 showed:

16% improved tendon healing over the 830-nm laser at 3 J/cm^2.

33% improved tendon healing over the 685-nm laser at 10 J/cm^2.

54% improved tendon healing over the 830-nm laser at 10 J/cm^2.

Compared to the control tendons, the improved tissue response was as follows:

101% improved tissue response with the 830-nm laser at 10 J/cm^2.

114% improved tissue response with 685-nm laser at 10 J/cm^2

167% improved tissue response with the 830-nm laser at 3 J/cm^2.

208% improved tissue response with 685-nm laser irradiation at 3 J/cm^2

DISCUSSION

These results have demonstrated that laser irradiation, "produced an acceleration of the healing process of the tenotomized tendons, particularly after 685-nm laser irradiation, at the fluence of 3/cm^2 (group A)."

These authors reference 9 additional studies that support:

> "These findings agreed with the results obtained by several authors, who also observed that LLLT produced a stimulatory effect on tendon healing process."

"Our results suggest that laser irradiation (particularly using the 685-nm laser, at the dosage of 3 J/cm^2) produced an increase of cell proliferation through changes in mitochondrial physiology, subsequently affecting RNA synthesis, which, in turn, alters the expression of various cell regulatory proteins."

"LLLT was able to promote neovascularization, re-establishing circulation at the site of injury, thus limiting ischemic necrosis and accelerating tissue repair."

"We propose the existence of a wavelength dependency response of the tendon to laser irradiation. We compared the effectiveness of two distinct wavelengths and the best response was observed after the irradiation with 685-nm laser."

Another study "observed increased fibroblast proliferation after 665-nm and 675-nm laser irradiation, whereas the 810-nm laser irradiation produced an inhibitory effect. Thus, it is clear the importance of identifying the most appropriate wavelength to stimulate a specific tissue." **[Important]**

"We found that the lower fluence used (3 J/cm^2) was more likely to produce a more pronounced effect of tendon healing."

"Many authors have stated that a dose of 1–5 J/cm^2 increases the tensile force of tenotomized tendons, accelerating collagen synthesis and facilitating the formation of membrane-bound intra-cytoplasmic collagen fibrils in tendon fibroblasts and myofibroblasts." **[Very Important]**

"The 632-nm laser, at the dosages between 0.5 to 5.0 J/cm^2 can stimulate the healing process of the conjunctive tissue in studies in vivo, whereas it was found that dosages higher than 10 J/cm^2 produced a decrease in fibroblast cell proliferation."

CONCLUSION

"The results of the present study show a beneficial effect of LLLT on the repair process of the Achilles tendon in mice."

"The tissue response to laser irradiation has a dose and a wavelength dependence. It was found that the 685-nm laser, at the dose of 3 J/cm^2, appeared to be most effective at accelerating tendinous repair."

KEY POINTS FROM DAN MURPHY

1) Low-level laser therapy accelerates the healing process of injured tendons, increasing fibroblast cell proliferation and collagen synthesis.

2) Low-level laser therapy is an innovative clinical approach to repairing damaged tissues. **[Important]**

3) "LLLT is effective at reducing post-injury inflammatory processes and accelerating soft tissue healing."

4) "LLLT, at the cellular level, produces increased ATP synthesis, increased mitochondrial respiration, and increased production of molecular oxygen, thus stimulating DNA synthesis and cell proliferation." **[Very Important]**

5) Studies show that 632.8-nm laser "produced a higher deposition of collagen, increasing the tensile strength of completely severed and surgically repaired rat tendons."

6) "The best tissue response was obtained after the 685-nm laser irradiation, at the dosage of 3 J/cm^2." Specifically, the 685-nm laser irradiation at 3 J/cm^2 showed:

16% improved tendon healing over the 830-nm laser at 3 J/cm^2.

33% improved tendon healing over the 685-nm laser at 10 J/cm^2.

54% improved tendon healing over the 830-nm laser at 10 J/cm^2.

7) Compared to the control tendons, the improved tissue response was as follows:

101% improved tissue response with the 830-nm laser at 10 J/cm^2.

114% improved tissue response with 685-nm laser at 10 J/cm^2.

167% improved tissue response with the 830-nm laser at 3 J/cm^2.

208% improved tissue response with 685-nm laser irradiation at 3 J/cm^2.

8) "Our results suggest that laser irradiation (particularly using the 685-nm laser, at the dosage of 3 J/cm^2) produced an increase of cell proliferation through changes in mitochondrial physiology, subsequently affecting RNA synthesis, which, in turn, alters the expression of various cell regulatory proteins."

9) "The lower fluence used (3 J/cm^2) was more likely to produce a more pronounced effect of tendon healing."

10) "Many authors have stated that a dose of 1–5 J/cm^2 increases the tensile force of tenotomized tendons, accelerating collagen synthesis and facilitating the formation of membrane-bound intra-cytoplasmic collagen fibrils in tendon fibroblasts and myofibroblasts." **[Very Important]**

11) "The 632-nm laser, at the dosages between 0.5 to 5.0 J/cm^2 can stimulate the healing process of the conjunctive tissue in studies in vivo, whereas it was found that dosages higher than 10 J/cm^2 produced a decrease in fibroblast cell proliferation."

12) In this study, all laser wavelengths and fluences used were efficient at accelerating the healing process of Achilles tendon post-injury.

13) The best organization and healing was accomplished by the shortest wavelength (685 nm) with the least intensity (3 J/cm^2).

14) The least efficient laser for improved tissue organization and healing was the longest wavelength (830 nm) with the greatest intensity (10 J/cm^2).

COMMENTS BY DAN MURPHY

This study adds to the evidence that low level lasers work by improving the mitochondria's ability to produce ATP energy, which is then used to synthesize proteins, including the repair proteins in this study.

It seems counter intuitive to observe that shorter wavelengths at lower fluences achieve the best healing results. However, this study adds to the evidence that shorter wavelengths and lower fluences achieved significantly better tissue healing than longer wavelengths with greater fluences. In this study, the shortest wavelength at the lowest fluence was more than twice as effective in tissue healing than the longest wavelength at the greatest fluence (208% v. 101% improvement). Several other articles that we have reviewed have shown the same or similar responses. This study references others that claim that some laser wavelengths and higher fluences my actually be inhibitory to healing.

I have clinically used lasers for 18 years. I have 4 lasers made by 4 different companies, each with varying wavelengths and miliwattage. This study supports the technology and teachings for my Erchonia laser. Erchonia is located in McKinney, TX. Erchonia lasers are used extensively in chiropractic, medicine, and physical therapy. Erchonia offers an array of post-graduate continuing education classes on laser technology with hands-on clinical applications, as well as adjunct topics such as subluxation neurology and phospholipid neurobiology. I am one of Erchonia's team teachers. For more information, Erchonia can be contacted at:

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