A comparison of effects of therapy with the NIR laser diode and MLS® laser system.

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ABSTRACT

Laser therapy can be applied as a rehabilitation treatment in patients affected by musculoskeletal diseases. The target of the present study was an assessment of therapeutic effects achieved applying laser therapy to treat three different musculoskeletal disorders: arthrosis, vertebrogenic algesic syndrome (VAS) and enthesopathy. Two different sources were compared: a single wavelength (830 nm), pulsed NIR laser (BLT2000) and a dual wavelength (808 nm, continuous emission, and 905 nm, pulsed emission) NIR laser (Multiwave Locked System - MLS®). Moreover, as regards the MLS® source, the efficacy of two different doses was compared.

Not only therapeutic effects but also the comfort of the patient associated with the therapeutic procedures here evaluated was considered.

INTRODUCTION

Musculoskeletal disorders are likely to be the most frequent problems which can adversely affect the quality of life in patients. In particular, pain is a very limiting factor in day life. Among the many different types of physical therapies offered to the patients to alleviate the symptoms due to musculoskeletal diseases, laser therapy can be particularly useful due to its analgesic effect.

The effects of laser radiation on the target tissue is obtained through the conversion of light energy to different forms of energy. In the organism, the mechanism of light energy conversion to other forms of energy, with achieving desirable biological effects, has not yet been exactly described.

In the tissues, cells are sensitive to laser irradiation. As a consequence of the activation of signal cascades, the processes of apoptosis, cytoskeleton rearrangement, transcription regulation and cytokine synthesis can be triggered. Based on literature, mitochondria play the principal role in the mechanisms underlying laser effect [1]. The function of mitochondria is to supply energy for cell functions, since the synthesis of adenosine triphosphate occurs within them due to cell respiration. For laser treatment, suitable physical parameters must be chosen, which will make possible the penetration of sufficient radiation energy into the tissue without immediate prevalence of thermal effects. In this way, it is possible to provide therapeutic effects avoiding side effects. It is also necessary to take into account optical properties of tissues, particularly of the skin, in which water, melanin and haemoglobin are present in sufficient amounts. It is thus possible to state that optical characteristics of tissues, through which the laser beam propagates during its application, also play their specific roles. In agreement with current knowledge verified by objective clinical studies, including histological examinations, laser can be reasonably applied either under conditions of the continuous regimen or at a frequency not exceeding 50 Hz. Higher values are no more effective in therapy, since the cell is not capable of response in the manner required [1]. At the onset of using the high power therapeutic lasers, opinions concerning the suitable density of energy applied were considerably modified. Due to the power of diodes in low power lasers, which typically does not exceed 400 mW, the usual energy density is of 8 to 10 J/cm^2 in many indications [2,3,4]. By using high power laser sources, the value is increased by factors of ten to fifty [5,6].

It has been hypothesized that a way for transfer of information among individual cells during the irradiation is based on GAP junctions (connexons), the bystander effect [1].

Laser therapy is widely used for the treatment of musculoskeletal disorders, most frequently on patients with diagnoses of arthrosis, vertebrogenic algesic syndrome (VAS) and disorder of soft tissues (enthesopathy) [2,3,6,7,8,9,10].

In the present study, two different laser sources were compared for their effectiveness when applied to the treatment of musculoskeletal disorders. Moreover, one of the laser sources was tested for its effectiveness when applied with two different doses.

MATERIALS AND METHODS

The clinical study was carried out at the healthcare facility THERAP TILIA, Praha. Based on the most frequent occurrence of selected diagnoses in the field of musculoskeletal disorders, we collected three groups of patients affected by arthrosis, vertebrogenic algesic syndrome (VAS) and enthesopathy, respectively. We monitored and compared the therapeutic effects of a laser apparatus from the company BTL (BTL Health Technique a.s., Brno, Czech Republic) and those of a dual wavelength MLS® laser (MLS®, ASA srl, Arcugnano, Italy). In the latter case, two different doses were considered.

The BTL 2000 apparatus consists of a source emitting radiation with 830 nm wavelength, 200 mW power, operating in pulsed regimen with 10 Hz frequency.

The Multiwave Locked System (MLS®) laser emits radiation with 808 nm wavelength in the continuous regimen and 905 nm wavelength in the pulsed regimen. Maximum power is 1.1 W.

Within each of the three different groups, three subgroups of patients were randomly selected.

The patient group A was treated by using the MLS® apparatus with parameters set by the manufacturer, 1500 Hz, 9.62 J/cm^2. The laser treatment was applied four times at intervals of seven days.

The patient group B experienced laser therapy by using the MLS® apparatus, but with altered physical parameters of the therapy based on our many years´ experience. In the beam, we set a frequency of 10 Hz and the application time was chosen in such a way that the area treated was exposed to an energy density of 30 J/cm^2. Similarly as in the first group of patients, we applied laser four times at intervals of seven days.

The patient group C experienced a treatment performed by BTL laser source. The laser emits radiation with 830 nm wavelength in the pulsed regimen 10 Hz, the area treated was exposed to an energy density of 6 J/cm^2.

In this group of patients, 12 applications three times a week were prescribed.

The benefit of the treatment was always evaluated during each visit associated with a session of laser therapy. The last evaluation was implemented 7 days after the last laser application. In all the patients, we also evaluated negative feelings in course of therapy.

RESULTS

In the three groups, laser therapy was tested, in particular, for its analgesic effect. Pain perception is a subjective symptom, thus, the following four-point scale was employed for the effect assessment:

1 – Vanishing of problems
2 – Considerable improvement
3 – Moderate improvement
4 – Unaltered condition (no improvement of the condition).

Parameters summarized in Tables 1 to 3 show that, in our study, patients in a broad age range (17-81 years) were represented.

Results summarized in Table 1 demonstrate that in all the three groups of patients, the expected therapeutic effect was achieved and the parameters under monitoring, i.e. pain which limited the activity of patients, decreased. In terms of subjective feelings of patients in all the groups, there was a considerable improvement of the problems.

Table 1: Results of MLS® therapy with the use of parameters set by the manufacturer (group A).

Diagnosis	Sex	MLS®					
		Age		Number of applications		Therapeutic effect	
		n	x ± SD	n	x ± SD	n	x ± SD
Arthrosis	men	2	36.5 ± 6.5	2	3.5 ± 0.5	2	2.5 ± 0.5
	women	2	44.0 ± 9.0	2	4.0 ± 0	2	2.0 ± 0
	total of	4	40.3 ± 8.7	4	3.8 ± 0.4	4	2.3 ± 0.4
VAS	men	7	51.6 ± 16.7	7	3.9 ± 0.3	7	2.6 ± 0.7
	women	19	54.3 ± 15.7	19	3.8 ± 0.4	19	2.4 ± 0.5
	total of	26	53.6 ± 16.0	26	3.8 ± 0.4	26	2.4 ± 0.6
Enthesopathy	men	3	49.0 ± 7.3	3	3.7 ± 0.5	3	2.3 ± 0.5
	women	4	70.3 ± 11.5	4	3.5 ±0.5	4	2.5 ± 1.1
	total of	7	61.1 ± 14.5	7	3.6 ± 0.5	7	2.4 ± 0.9

VAS – vertebrogenic algesic syndrome

Diagnosis	Sex	MLS®					
		Age		Number of applications		Therapeutic effect	
		n	x ± SD	n	x ± SD	n	x ± SD
Arthrosis	men	0	– – –	0	– – –	0	– – –
	women	2	63.5 ± 1.5	2	4.0 ± 0	2	2.5 ± 0.5
	total of	2	63.5 ± 1.5	2	4.0 ± 0	2	2.5 ± 0.5
VAS	men	9	55.2 ± 16.9	9	3.9 ± 0.3	9	2.4 ± 0.7
	women	26	58.9 ± 16.7	26	3.9 ± 0.3	26	2.4 ± 0.5
	total of	35	58.0 ± 16.8	35	3.9 ± 0.3	35	2.3 ± 0.6
Enthesopathy	men	1	65.0 ± 0	1	4.0 ± 0	1	3.0 ± 0
	women	4	49.0 ± 8.6	4	4.0 ± 0	4	2.8 ± 0.8
	total of	5	52.2 ± 10.0	5	4.0 ± 0	5	2.8 ± 0.7

VAS – vertebrogenic algesic syndrome

Table 2: Results of MLS® therapy with the use of parameters set by the user (group B). The laser emits radiation with 808 nm wavelength in the continuous regimen and 905 nm wavelength in the pulsed regimen 10 Hz, the area treated was exposed to an energy density of 30 J/cm^2.

Table 2 demonstrates that the treatment conditions applied in this group were also effective. However, considering the therapeutic effects versus the different diseases, interesting differences were observed. In patients belonging to VAS and arthroses groups, there was a considerable improvement of the problems. In the group of enthesopathies, there was an only moderate improvement of pain in the patients monitored.

Results summarized in Table 3 documenting the effect after the BTL application also show a therapeutic benefit in the treatment of VAS and enthesopathies. Minimum effects were observed in the treatment of arthroses; there was no pain relief in women. However, the low number of subjects should be taken into account. In the groups of VAS and enthesopathies, the resulting therapeutic effects were comparable to those obtained by MLS® therapy.

The results demonstrated that the therapeutic effect is quite similar after the application of the three different cycles of therapy. Differences monitored at the end of therapies in the three groups studied (A, B, C) were not statistically significant. Nevertheless, the data show that in the treatment of arthroses MLS® therapy resulted more effective than BTL.

However, data reported in tables 1 to 3 highlighted a very important difference among the therapies, concerning the number of applications needed to obtain the desired therapeutic effect. It may be observed that a number of treatment sessions ≤ 4 was sufficient to obtain a significant improvement of patient status by applying MLS® therapy, while a number of sessions 10 was required by applying BTL apparatus. Therefore the pain relief was achieved much faster applying MLS® therapy. The differences between the two groups treated by MLS® therapy with different doses (J/cm^2) was not significant.

DISCUSSION

The patients were randomly included into our study. As mentioned above, patients in a wide range of age (17-81) were accepted. The comparison of the therapeutic effect according to the age will be a target of our further studies with providing sufficient representation of subjects in narrower ranges of age within the framework of the diseases considered. It is expected that the age plays an important role in the response to therapy, considering that physiological processes in tissues are affected in the course of laser therapy.

A comparison between the therapeutic benefits obtained by application of MLS® laser and BTL demonstrated that a significant improvement of symptoms was reached in both cases, but it required a number of MLS® treatment sessions ≤ 4, while a number of sessions 10 was applied in the case of the BTL apparatus. Therefore the pain relief was achieved

Diagnosis	Sex	LLLT					
		Age		Number of applications		Therapeutic effect	
		n	x ± SD	n	x ± SD	n	x ± SD
Arthrosis	men	16	55.8 ± 11.4	16	14.4 ± 3.0	16	2.6 ± 1.0
	women	2	59.0 ± 0	2	10.0 ± 0	2	4.0 ± 0
	total of	18	56.1 ± 10.8	18	13.9 ± 3.1	18	2.8 ± 1.0
VAS	men	8	47.5 ± 12.1	8	12.5 ± 2.5	8	2.5 ± 1.1
	women	6	24.3 ± 6.9	6	13.3 ± 2.4	6	2.3 ± 0.5
	total of	14	37.6 ± 15.3	14	12.9 ± 2.5	14	2.4 ± 0.9
Enthesopathy	men	6	29.7 ± 11.1	6	10.0 ± 0	6	2.3 ± 0.5
	women	14	30.6 ± 8.8	14	13.6 ± 2.3	14	2.6 ± 1.0
	total of	20	30.3 ± 9.6	20	12.5 ± 2.5	20	2.5 ± 0.9

VAS – vertebrogenic algesic syndrome

Table 3: Results of BTL therapy (group C).

much faster applying MLS® therapy.

Our results concerning the possibility of using laser therapy in the treatment of arthroses are in agreement with those presented by other authors. Ohkuni et al. [2], analysing results based on two-years monitoring, observed significant analgesic effects in chronic Joint pain after a four-week therapy (2 sessions/ week) with a NIR laser source (power 1 W and wavelength 830 nm). Significant therapeutic benefit in terms of analgesic effects in the pain due to knee joint arthrosis was described by Soleimanpour et al. [3], who applied a NIR laser with power 30 mW, wavelength 890 nm and energy density 6 6 J/cm². Recently some papers described the application of high power lasers in the treatment of lateral epicondylitis [8,9]. In patients with knee joint osteoarthrosis, Kheshie et al. [5] compared the therapeutic effects of high power laser (HIRO 3.0), low power laser (830 nm, 800 mW, energy density 50 J/cm²) and placebo. The therapy was supplemented by physical exercise in all the groups. The results demonstrated statistically significant differences between the laser application and placebo; the difference between HILT and LLLT was not statistically significant, though better results were observed with HIRO 3.0.

Ohkuni at al. [6] irradiated the sacroiliac joint in a pilot study of 9 patients for analgesic purposes (power of 1 W, wavelength of 830 nm, energy density of 20 J/cm²). They demonstrated analgesic effect and improvement in the blood circulation in ligaments maintaining the sacroiliac articulation.

There are fairly beneficial therapeutic effects of laser in the treatment of enthesopathies, which holds for both low power and high power types. The benefit in the treatment of lateral epicondylitis was already mentioned above [8,9] and similar results were also obtained in the treatment of myofascial pain. Demirkol et al. [3] compared the results of laser treatments in the temporomandibular joint movement disorder, characterized by myofascial pain, with the use of a splint, laser (Nd:YAG 1.064 nm, 250 mW, 8 J/cm²) and placebo. The authors observed no statistically significant differences between the treatment with the therapy associated to the splint or laser. In our work published in 2014 [11], we observed beneficial effects of laser (830 nm, 200 mW, 10 Hz, 4 J/cm²) in the treatment of pain in the dysfunction of the temporomandibular joint.

A recent research [12] compared the effects of high power laser therapy (pulsed Nd:YAG laser supplemented by therapeutic physical exercise) in myofascial pains of the musculus trapezius to controls (application of placebo laser + therapeutic physical exercise). In addition to pain, the authors evaluated further 15 parameters (for example, the range of motion in the head rotation, flexion, and neck spine extension). The results demonstrated statistically significant beneficial effects of

the high power laser application.
An interesting study on a rat model investigated the effects of laser treatment (laser diode, wavelength 830 nm, power of 50 mW and energy density of 6 J/cm^2) on Achilles tendon inflammation induced by mechanical trauma [10]. The effect of laser treatment was compared to that of the anti-inflammatory drug Diclofenak and non-treated controls. The degree of the inflammation was verified based on the number of inflammatory cells, amount of types I and III collagen fibres and tensile strength of the tendon and tendon elasticity. The results unambiguously demonstrated that the effects of phototherapy and anti-inflammatory drug are comparable, both the therapeutic effects being highly statistically significant. After laser irradiation, the tendon elasticity was even higher compared to the healthy tendon. The experiment was implemented in animals. Thus, the results were not affected by the patient subjectivity, as is the case of clinical studies.

A further study [13] investigated the effect of laser therapy on fatigue and strength of a spastic muscle. The spasticity occurs as a result of a cerebrovascular event. The muscle performance was considered based on electromyography and the muscle fatigue was evaluated from the lactate concentration. A laser diode with 100 mW power and 808 nm wavelength was used. The muscle was irradiated on 30 points by a total energy of 120 J. After laser irradiation, intensive physical exercise was implemented with the help of a moto-splint. The laser application significantly increased muscle force and reduced lactate concentration in blood serum.

In an in vitro study [14], sixteen samples of Sprague-Dawley rat Achilles tendon were irradiated in culture medium. Then, the status of the tissue was evaluated by a series of analytical tests characterizing cell activity (number of living cells, percentage of Ki-67 NO production, PCNA activity (PCNA antigens are auxiliary proteins for DNA polymerase in the nucleus) and expression of cyclins A, B1, D1 and E. The samples were exposed to four different energy densities: 1, 1.5, 2 and 2.5 J/cm^2. Laser irradiation enhanced tenocyte proliferation, NO production, PCNA regulation and production of the cyclins A, B1 and E. It was, however, impossible to establish any clear dependence on the energy density.

The antiinflammatory effect of Low Level Laser Therapy (LLLT, 830 nm wavelength, 30 mW power, 4 J/cm^2 energy density) was unambiguously demonstrated in a study [4] performed by using mouse paw edema as a model. The inflammation was induced by a carrageenan administration. A number of selected parameters (size of oedema based on the amount of extravascular plasma proteins at the oedema site, intracellular production of free radicals, hydroperoxide concentration (LOOH) and reduced glutathione in the blood plasma) was simultaneously monitored to evaluate the effect of laser irradiation. Control groups were administered with bradykinin or prostaglandin E2, instead of laser application.

Other authors [15] demonstrated the effect of a NIR laser (MLS® laser source, two simultaneous emissions with 808 nm and 905 nm wavelengths, 195 mW and 230 mW power, 1000 Hz and 2000 Hz frequency, respectively) on erythrocytes. The total energy applied to the erythrocytic suspension ranged between 1.5 and 15 J. Changes in membranes were evaluated with the help of a fluorescence spectropolarimeter. The results demonstrated changes in the structure and function of erythrocytic membranes and fluidity.

A widely discussed issue concerns the number of laser therapy sessions needed to obtain the therapeutic effect and also the interval between the individual applications. Both in terms of public health care and quality of life of the single patient, the time and number of sessions required to obtain the benefits is very important. In this study, we demonstrated that the same therapeutic results were obtained with a mean of 4 therapeutic sessions in the case of MLS® therapy versus a mean of 12 sessions of BTL therapy. Thus, the former therapy strongly reduced the length of the rehabilitation period, that means time saving for patients and the medical facility, enhanced treatment comfort for the patient and early return to work and normal activities.

Negative side effects of the therapy have been observed in none of the patients participating in the study. The study supported our many-years clinical experience of work with therapeutic lasers, suggesting that laser effect is characterized by its rapid onset and persists for long periods of time [16, 17, 18, 19].

CONCLUSION

In the study presented here, we demonstrated important benefits due to laser therapy in rehabilitation care, particularly due to its analgesic effects. Technically different types of laser sources were tested (MLS® and BTL). The results demonstrated benefits from both types of laser, but there was a very significant difference in the number of applications needed. MLS® system induced significant therapeutic effects with only 4 sessions against 12 with BLT. This difference enhances the patient comfort and speeds up rehabilitation.

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