

TRIAL OF THERMAL IMAGING IN THE EVALUATION OF LOW LEVEL LASER THERAPY EFFECTIVENESS IN PATIENTS WITH KNEE JOINT PAIN SYNDROME

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Abstract

Aim of the study: The article presents trial of using thermal imaging parameters in monitoring gonarthrosis and low level laser therapy to alleviate the pain symptoms.

Material and methods: The double-blind research involved 69 patients among whom 53 with confirmed gonarthrosis were treated. Group A n=24 knee joints, contact laser irradiations were applied with a semiconductor laser (400mW, wave length 810nm). Total surface energy density on therapeutic point consisted of fractionated doses of energy (9.5J/cm² + 4.8J/cm²) with 30 min. interval between the 6J dose and 3J dose application. One series of 10 procedures was performed, five times per week. Group B (n=84 knee joints) with placebo therapy was accomplished. Group C (n=32 knee joints) had no pain syndrome and any treatment, only thermal images were conducted. The intensity of the pain in group A and B were evaluated on the Visual Analogue Scale and a modified version of the Laitinen questionnaire. Thermal imaging parameters Knee-Leg Temperature Index (TI) were conducted in all patients.

Results: There was statistically significant reduction in pain by VAS and Laitinen questionnaire after laser therapy. In group B there was no statistically significant changes in pain disorders and TI index.

Conclusions: Pain reduction (VAS and Laitinen questionnaire) has been evaluated after laser fractionated doses of energy in patients with knee osteoarthritis. There were not significant statistical changes in pain reduction and thermal imaging parameters in placebo group. This needs further studies according to different methods of laser irradiations, thermal imaging parameters and more groups of patients.

Key words: gonarthrosis, low level laser therapy, thermal imaging parameters

Introduction

The degenerative disease is the most common disorder of joints. It occurs mainly after the age of 50 years but may also be a serious health problem in the younger [1]. Hip and knee joint degeneration is the most common reason of disability. The disease is progressive, accompanied by pain and range of joint motion limitation. It generates the huge social costs [2]. There are no drugs which could make the pain and the reasons of disease completely subside [3].

Laser therapy has an established position in the treatment of pain syndromes of various origin [4-6]. It is emphasized this method has not only symptomatic (pain relief) but also causal (anti-inflammatory and swelling alleviating) effects [7-11].

Thermal imaging is a method presenting body surface temperature distribution. It gives opportunity to estimate localization, intensity and extension of pathological process [12,13].

Thermal imaging found applications in many medicine branches e.g. oncology, dermatology, rheumatology, angiology and neurology [14-16]. The thermal imaging application in rehabilitation gives opportunity to monitor a disease and estimate the treatment objectively.

Objective

The aim of the study was to establish the analgesic effect of laser radiation (administered by the method of fractionated doses versus placebo) in the chronic knee pain syndrome in the patients with gonarthrosis and to analyze pain intensification correlation before and after the treatment with the periarthritic tissue temperature distribution in thermal imaging.

Materials and methods

69 patients were included in the study: 53 patients with chronic knee pain syndrome (of both knee joints)

and both knee joints degenerative disease (with the criteria of the ARA) who were treated in Lodz Medical University Rehabilitation Clinic and 16 volunteers – without any dysfunction or morphological abnormalities in the knee joints. The study was performed in 3 groups of patients. 138 joints were examined. 53 patients with the chronic knee pain syndrome were randomly included in the group A (12 patients, $n=24$ knee joints, mean age 55 ± 16.1 years – laser biostimulation was performed in this group) and group B (41 patients, $n=82$ knee joints, mean age 54.4 ± 16.8 years – placebo procedures were performed in this group). 16 healthy volunteers were included in the group C ($n=32$ knee joints, mean age 25.0 ± 4.0 years – patients had been performed only thermal imaging examination). Laser biostimulation procedures were performed by means of the semiconductor laser (continuous radiation, wave length $\lambda = 810$ nm, power - 400 mW, probe lens surface 0.63 cm^2). The method of contact point radiation was performed, energy doses of $6 \text{ J} + 3 \text{ J}$ were administered on each one point with 30 minutes intervals between 6 J and 3 J , it gave mean surface energy density $E = 9.5 \text{ J/cm}^2$ and 4.8 J/cm^2 . Knee joints were irradiated in 13 points. Total energy dose was 117 J per one knee joint. Procedures were performed once daily during 2 weeks, 5 days a week. The analgesic effectiveness of the performed laser therapy procedures was evaluated by means of modified Laitinen questionnaire. Pain intensity was also evaluated by means of the Visual Analogue Scale (VAS).

Pain intensity was evaluated two times in each patient – before laserotherapy (or placebo) procedures and after the procedures. Thermal images before and after the treatment were obtained by means of the thermal imaging camera A40MF (FLIR SYSTEM). The examinations took place in the Termography Laboratory of the Lodz Polytechnic Diagnostic and Laser Therapy Centre where examination and preparatory rooms were placed. The temperature in the

Termovision Laboratory was stable - 18°C - 19°C and humidity was 50-70%. The precautions of sunlight and air currents were minimalized (blinds and doubled rooms). Adjustment and body surface temperature stabilization lasted 15 minutes and was carried out in the preparatory room (in order to minimize psychogenic influence on the thermoregulation processes).

The images recordings were obtained in the same positions of patients and camera. Thermal images analysis was made by means of computer programs - Agema Research 2.1 and Microsoft Excel. A circle with a radius of a half knee width was marked around patella on the AP projection image. Vertical line crossing the middle of the circle around patella was marked in the axis of the limb. (Fig. 1).

Temperature indicators (TI) were calculated for each patient on the basis of a temperature difference between the area around patella and the line in the axis of the limb. The following TI were calculated:

- mean TI ($^\circ\text{C}$) – the difference between arithmetic average of the temperatures measured in the area around patella and arithmetic average of the temperatures measured in the line in the axis of the limb.
- maximal TI ($^\circ\text{C}$) - the difference between maximal temperature measured in the area around patella and arithmetic average of the temperatures measured in the line in the axis of the limb.
- minimal TI ($^\circ\text{C}$) - the difference between minimal temperature measured in the area around patella and arithmetic average of the temperatures measured in the line in the axis of the limb.

The laser therapy and placebo analgesic effect in both groups was evaluated by the score in the VAS scale and in the modified Laitinen questionnaire. TI were compared within the groups and among the groups.

Statistical analysis was made by means of Statgraphics Plus v. 5.0. In all cases the 0.05 level of significance was assumed.

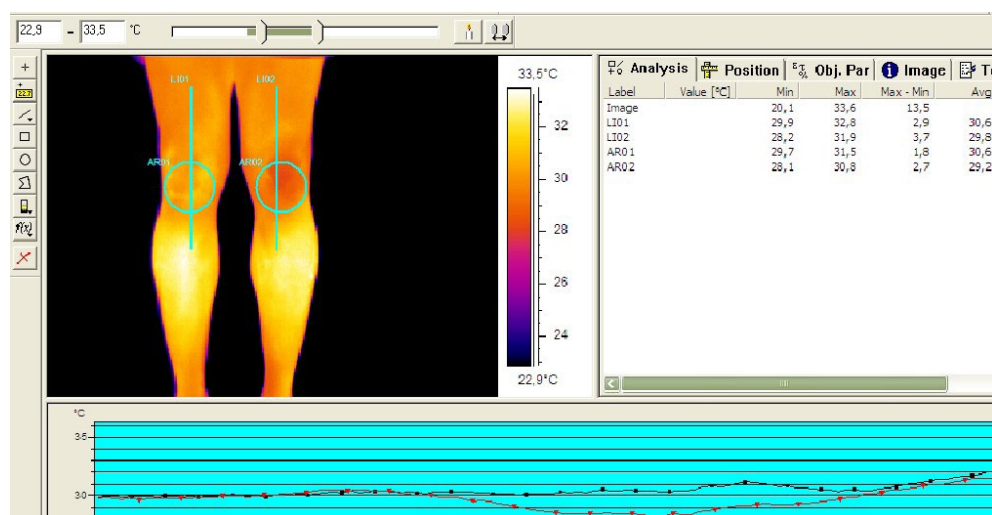


Figure1. Analysis of the thermovision image $TW(^\circ\text{C}) = \text{mean temperature of the knee minus mean temperature of the leg}$

Results

The study revealed that laser radiation decreases knee pain in patients with gonarthrosis. The results are as follows: group A (with laser therapy procedures) has more significant pain decrease after the treatment than group B (placebo procedures) evaluated according to VAS scale (Tab. 1, Fig. 2).

On the basis of the VAS scale results the mean pain intensity score in the group A was 6.33 ± 1.07 before and 4.48 ± 1.16 after the treatment (the difference is statistically significant), the score in the group B 5.76 ± 1.20 before and 5.48 ± 1.16 after the placebo procedures (the difference is not statistically significant). The mean score evaluated according to modified Laitinen

Table1. Pain intensity according to VAS scale analysis in the study groups A and B

Pain intensity according to VAS scale							
Laser therapy procedures				Placebo procedures			
Group A n= 24				Group B n= 84			
before therapy		after therapy		before therapy		after therapy	
mean $\pm$ SD	median	mean $\pm$ SD	median	mean $\pm$ SD	median	mean $\pm$ SD	median
6.33 $\pm$ 1.07	6	4.48 $\pm$ 1.16	4	5.76 $\pm$ 1.20	6	5.48 $\pm$ 1.16	5

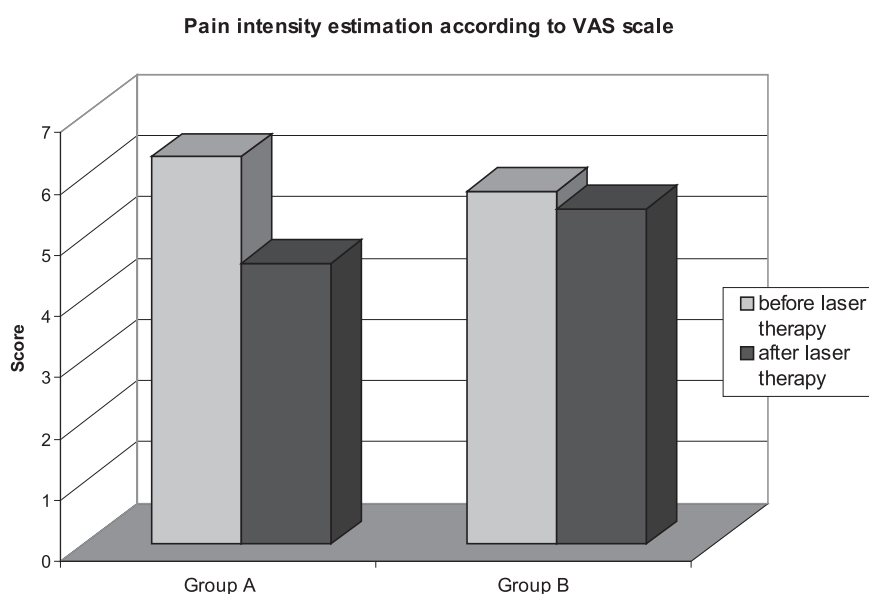


Figure2. Analysis of pain intensity (according to VAS scale) in the study groups (group A- before and after laser therapy, group B – before and after placebo therapy)

Table 2. Pain intensity assessment according to VAS scale in the study groups A and B before and after laser/placebo therapy

Pain intensity assessment according to VAS scale		
Compared groups	Test	P - value
A before laser therapy vs A after laser therapy	Signed-rank test	0.0029
B before placebo therapy vs B after placebo therapy	Signed-rank test	0.8823
A before laser therapy vs B before placebo therapy	Test Wilcoxon (U-Mann- Whitney)	0.1835
A after laser therapy vs B after placebo therapy	Test Wilcoxon (U-Mann- Whitney)	0.020

Table 3. Total point scores for pain symptoms (Laitinen) in the study groups A and B before and after laser/placebo therapy

Pain intensity according to modified Laitinen questionnaire							
Laser therapy procedures				Placebo procedures			
Group A n= 24				Group B n= 84			
before therapy		after therapy		before therapy		after therapy	
mean $\pm$ SD	median	mean $\pm$ SD	median	mean $\pm$ SD	median	mean $\pm$ SD	median
7.832 $\pm$ 2.48	8	4.50 $\pm$ 2.50	5	6.51 $\pm$ 2.73	6	6.15 $\pm$ 2.49	6

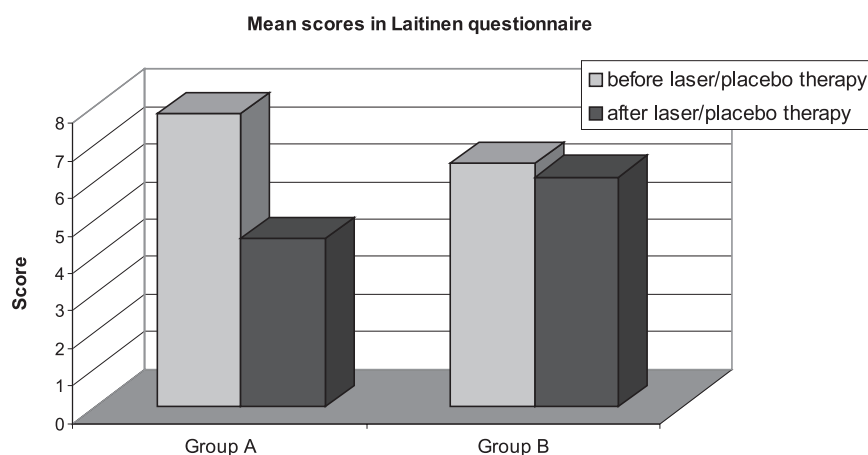


Figure3. The assessment of pain symptoms (according to Laitinen questionnaire) in the study groups (group A- before and after laser therapy, group B – before and after placebo therapy) – mean scores

Table 4. Pain intensity assessment according to Laitinen questionnaire in the study groups A and B before and after laser/placebo therapy

Pain intensity assessment according to Laitinen questionnaire		
Compared groups	Test	P- value
A before laser therapy vs A after laser therapy	Signed-rank test	0.003
B before placebo therapy vs B after placebo therapy	Signed-rank test	0.3604
A before laser therapy vs B before placebo therapy	Test Wilcoxon (U-Mann- Whitney)	0.1427
A after laser therapy vs B after placebo therapy	Test Wilcoxon (U-Mann- Whitney)	0.0397

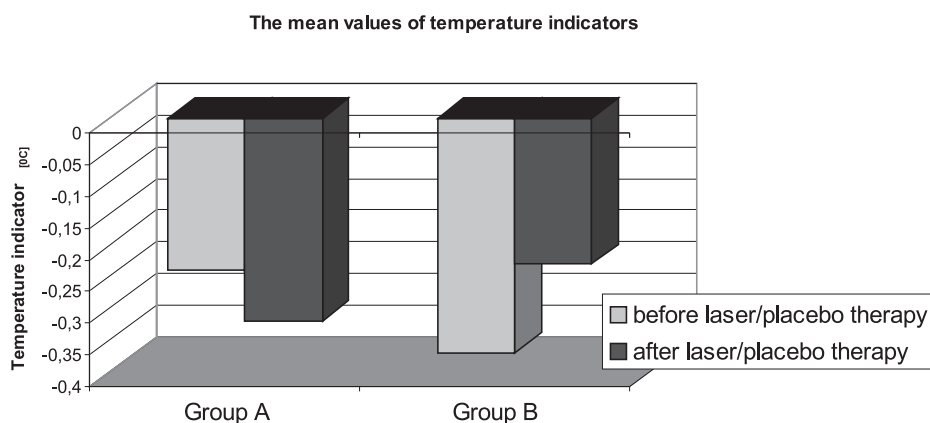


Figure4. The mean values of temperature indicators in the study groups (group A- before and after laser therapy, group B – before and after placebo therapy)

Table 5. TW indicators in the study groups (group A - before and after laser therapy, group B - before and after placebo therapy, C-no laser therapy or placebo, only termovision images)

TW [°C]	Group A				Group B				Group C	
	Before laser therapy		After laser therapy		Before placebo		After placebo			
	$\bar{x} \pm \sigma$	$\frac{\sigma}{\bar{x}} \cdot 100\%$	$\bar{x} \pm \sigma$	$\frac{\sigma}{\bar{x}} \cdot 100\%$	$\bar{x} \pm \sigma$	$\frac{\sigma}{\bar{x}} \cdot 100\%$	$\bar{x} \pm \sigma$	$\frac{\sigma}{\bar{x}} \cdot 100\%$	$\bar{x} \pm \sigma$	$\frac{\sigma}{\bar{x}} \cdot 100\%$
TW _{sr}	- 0.24 ± 0.44	182%	- 0.32 ± 0.43	135%	- 0.37 ± 0.41	111%	- 0.23 ± 0.63	274%	- 0.39 ± 0.77	200%
TW _{max}	1.48 ± 0.78	53%	1.43 ± 0.68	48%	1.25 ± 0.62	49%	1.59 ± 0.81	51%	1.47 ± 1.10	75%
TW _{min}	-1.82 ± 0.42	23%	-1.79 ± 1.17	66%	-2.16 ± 2.82	131%	-1.83 ± 1.21	66%	-1.78 ± 0.63	35%

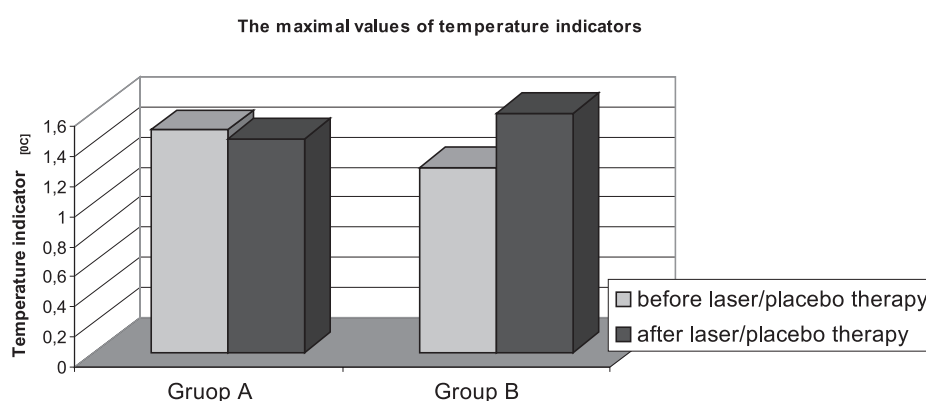


Figure 5. The maximal values of temperature indicators in the study groups (group A- before and after laser therapy, group B - before and after placebo therapy)

questionnaire has decreased in the group A (Tab. 3, Fig. 3) from 7.832 ± 2.48 to 4.50 ± 2.50 . In the group B the mean score has also decreased but not statistically significant (Tab. 4). There has been revealed significant score difference in the A group before and after laser therapy procedures evaluated according to modified Laitinen questionnaire and significant difference between point pain scale scores in the group B before and after placebo procedures. The studies made so far revealed that the temperature around patella was lower than in the thigh and shin in the patients without chronic knee pain. So TI has normally negative values. In our study the mean TI value was -0.24 ± 0.44 before and -0.32 ± 0.43 after the course of 10 laser therapy procedures in the A group. Similarly the mean TI was -0.37 ± 0.41 before and -0.23 ± 0.63 after placebo procedures in the B group.

The study revealed that the mean TI was „more” negative (it means “more” normal) after the laser therapy procedures (Fig. 4). The maximal TI was 1.48 ± 0.78 before and 1.43 ± 0.68 after the laser therapy procedures in the A group. The maximal TI has increased after the placebo procedures in the B group (Fig. 5). It was found that each TI had normal distribution. There

are not significant differences within the groups and between them (Tab. 5).

Discussion

Laser therapy is a method useful in the process of rehabilitation in the chronic knee pain syndrome as a complication of osteoarthritis [17]. A mechanism of biostimulation analgesic effect in pain as a complication of osteoarthritis is still the subject of many studies [18,19].

Kujawa [20] proved that laser radiation depending on power and dose increased membrane enzymes activity (e.g. ATP-ase and acetylcholinesterase in human erythrocytes in vitro) but at the same time had no influence on lipids peroxidation products level and deoxidized glutation level. Results of laboratory and clinical studies concerning the role of laser radiation in medicine are ambiguous. Brosseau and Welch [21] proved that the results of the treatment are dependent on the method of laser light administration and device characteristic.

The results of the other studies suggest that laser radiation with surface density from 0.1 J/cm^2 to 12 J/cm^2 significantly decreases pain, fatigue and depres-

sion according to Hamilton Depression Rate Scale [22,23].

Altan [24] and Tascioglu [25] in experimental researches did not show laser therapy prevalence over placebo procedures during treatment. Gur and al. [26], Hegedus and Viharos [27] suggest that lower radiation doses are equally efficient as the treatment decreasing pain and improving the range of knee joint motion.

Gur and al. [28] has examined pain complaints in 75 patients with chronic low back pain (lumbar and sacral region) according to VAS before and after laser-therapy procedures. They claim that laser therapy seems to be an effective method of pain relief and improvement of low back and knee joints function. The fractionated doses (6 J + 3 J) per one treatment point in 30 minutes intervals were administered in the present study. We observed a significant pain decrease evaluated according to VAS and modified Laintinen Questionnaire.

In the present study thermal images were used to get the objective results of laser therapy effectiveness. Possible correlation between pain intensification changes evaluated according to VAS and the temperature index (an objective measurable indicator) in the treatment region were considered. Temperature Index (TI) mean, maximal and minimal in A, B and C groups were calculated. TI distribution was normal for each indicator. Kruszewski [29] in the group of 103 healthy volunteers proved that the temperature around patella is clearly lower than the mean temperature measured along the limb.

TI statistical analysis in the A (after laser therapy) and B (after placebo procedures) did not reveal significant decrease in any of TIs. In the earlier research made by Kujawa and Gworys [30] and Kujawa and Oborzyński [31] the results proved temperature distribution normalization when it was evaluated along the inferior limb after the treatment and study TI proved to have a big sensitivity and specificity in the chronic knee pain diagnosing.

Jasiak-Tyrkalska and al. [32] searched cervical spinal region thermal imaging pictures and proved a correlation between hyperthermia and the pain intensification in the cervical spinal region.

Huygen and al. [33] proved that the thermal imaging is a valuable and objective method of treatment results evaluation in algodystrophy.

Kwon and al. [34] have described a possible thermal imaging application in the acupuncture analgesic treatment evaluation in the patients with chronic knee pain.

The further investigations with the use of various laser types and power of radiation are necessary to confirm the potential clinical effects described in many publications.

Finally we can say that the thermal imaging application to objectivize potential laser therapy effects

requires further investigations to establish its position as a diagnostic tool.

Conclusions

- It was proved that laser radiation (fractionated doses, 6 J + 3 J) had an analgesic effect in the patients with chronic knee pain.
- The pain intensification (evaluated according to the subjective scales) and temperature indicators did not significantly change in the placebo group.
- A tendency to temperature indicators stabilization was observed in the treatment group. It is necessary to perform further investigations with the use of various radiation and thermal imaging modes in a more numerous groups of patients.

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