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Research paper

Thermovision analysis of the surface of the lower limbs in patients with symptomatic lumbosacral discopathy before and after surgery

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Abstract

Introduction: The subject of the study is analyzing of the temperature distribution on the lower limbs in patients with discopathy of the lumbosacral spine requiring surgery.

Aim: The answer to the question whether surgical treatment reduces temperature differences on the lower limbs of patients undergoing surgery.

Material and methods: Thermograms of the lower limbs were performed before and on the second day after microdiscectomy or microdiscectomy with posterior lumbar interbody fusion. The study group consisted of 37 patients of the Neurosurgery Department, while the control group consisted of 18 healthy people. Comparative analyzes of temperatures on the lower limb with pain with the temperatures on the lower healthy limb in the same patient indicate significant statistical differences in temperature distribution. Based on the thermograms, two region of interest's (ROI) of the same area were determined on the thigh and the lower leg. The maximum, minimum and average temperatures were determined for those areas.

Results and discussion: Comparative analyzes showed statistically significant differences for both areas and all temperatures between healthy and affected limbs in the group of patients before surgery. In turn, after surgery, no statistically significant differences were observed between the respective limb temperatures for both ROI areas. The analysis of the temperature parameters determined for analogous ROIs in the control group did not show statistically significant differences for all measured temperatures.

Conclusions: After selective surgical treatment of lumbar discopathy by microdiscectomy previous significantly statistical temperature differences between the lower limbs in analogical ROIs in those patients decreased to not statistically significant differences.

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1. INTRODUCTION

Thermography is an infrared imaging process and is widely used in medical research.[1] Each point on the thermogram is assigned a temperature with an suitable accuracy (e.g. 0.1°C) which allows to compare temperatures of selected areas of the tested objects. Thermal imaging is a non-invasive research and it is safe for the patient.

Skin temperature is the result of a dynamic balance between heat released in metabolic reactions and heat released into the environment.[2] Thermographic analysis applies in the general case of venous, arterial and lymphatic circulation disorders.[3,4] Thermography has also been used for many years in oncology as an accessory examination in the diagnosis of breast cancer[5] as a method for screening a large group of patients.[6] The effectiveness of histological, mammographic assessment in the diagnosis of early detection of breast cancer was also compared with thermographic studies,[7] as well as with USG tests.[8] Generally, tissue damage is manifested by a change of its color, density and temperature distribution in the tissue.

Discopathy is a concept involving pathology of the intervertebral disc, the most common symptom of this pathology is pain radiating the innervation path through compressed spinal roots.[9] Sensory tingling and numbness of the limb, as well as paresis of the lower limb in terms of innervation by a compressed spinal root may also occur.[10] An intervertebral disc hernia can be clinically asymptomatic, it can also cause moderately severe pain syndrome or cause severe pain accompanied by paresis or muscle paralysis.[1] The pain experienced by the patient depends on the severity of the degenerative process and his individual psychosomatic sensitivity.[1,9,11] In most of cases, properly conducted pharmacotherapy and rehabilitation help to control pain associated with discopathy.[12] On the other hand, clinically confirmed symptoms (correlating with MR) in the affected limb that persists for a long time despite conservative treatment is an indication for surgery.[13] Combined MRI changes in do not always correlate with pain intensity, depressive and anxiety syndromes or quality of life in patients with low back pain.[14]

Scientific reports show that patients with symptomatic discopathy often have lower limb warming disorders understood as the difference in temperature distribution on the affected limb compared to the healthy limb.[15] Similar symptoms were observed in the case of oppression or peripheral nerve blood supply disorders in the course of diseases causing neuropathy.[16] In addition, thermography is used to predict the appearance of ulceration in the neuropathic foot, due to diabetes[16,17] Tests using a thermal imaging camera are increasingly used to diagnose low back pain.[1] Changes in the temperature distribution on the back can be observed during epidural anesthesia.[18] Thermography is also increasingly used in imaging of neurological disorders as a diagnostic and monitoring tool of patients with neuropathies, particularly in complex regional pain syndrome, and stroke.[19] Thermovision is used in predicting muscle flap necrosis in reconstructive surgery.[20–22]

2. AIM

The article analyzes the thermographic difference of the temperature distribution on the lower limbs in patients suffering from low back leg pain. Another issue was the answer to the question whether surgical treatment reduces temperature differences on the lower limbs of patients undergoing surgery. A control group of healthy people was also selected, for which thermograms of the lower limbs were made in similar conditions as in the examined group, analyzed for differences in temperature distribution in analogous areas of the lower limbs.

3. MATERIAL AND METHODS

The thermograms of the lower limbs were performed on patients admitted for selective surgical treatment of lumbar discopathy by microdiscectomy using a thermal imaging camera (Ebx50, FLIR, Wilsonville, Oregon, USA). Thermograms were taken before surgery and on the second postoperative day. Each measurement session consisted of 8 thermograms of the hip, knee, ankle and total lower limbs in front projection. Before taking thermograms, the patient stays about 10 minutes in the room where the thermograms were taken. The control group consists of healthy people with no signs or symptoms of lumbar radiculopathy with no low back leg pain.

In the study group, 14 patients smoke cigarettes. In this group at the time of the survey, 2 patients required analgesics in connection with low back leg pain, 4 patients suffered from depression and required antidepressant medications, 3 patients were addicted to alcohol or drugs. In the control group 7 patients smoked cigarettes, none of them required the administration of painkillers, antidepressants, and were not addicted to alcohol or drugs.

Two ROIs of the same shape and area were determined on the thigh and the lower leg of a healthy and affected limb. The maximum, minimum and averages temperatures for these areas were determined. These temperatures were

Table 1. General characteristics of the study and control groups.

Characteristics	Study group			Control group		
	Women	Men	Total	Women	Men	Total
Number of patients, *n*	16	21	37	9	9	18
Age	44.88 ± 12.1	43.10 ± 12.3	43.87 ± 12.1	44.55 ± 10.6	33.0 ± 11.7	38.78 ± 12.7
BMI	27.77 ± 5.0	26.53±3.1	27.24 ± 4.0	21.80 ± 1.9	23.66 ± 3.1	22.73 ± 2.7
Smokers, *n*(%)	5(31%)	9(43%)	14(38%)	5(55%)	2(22%)	7(39%)

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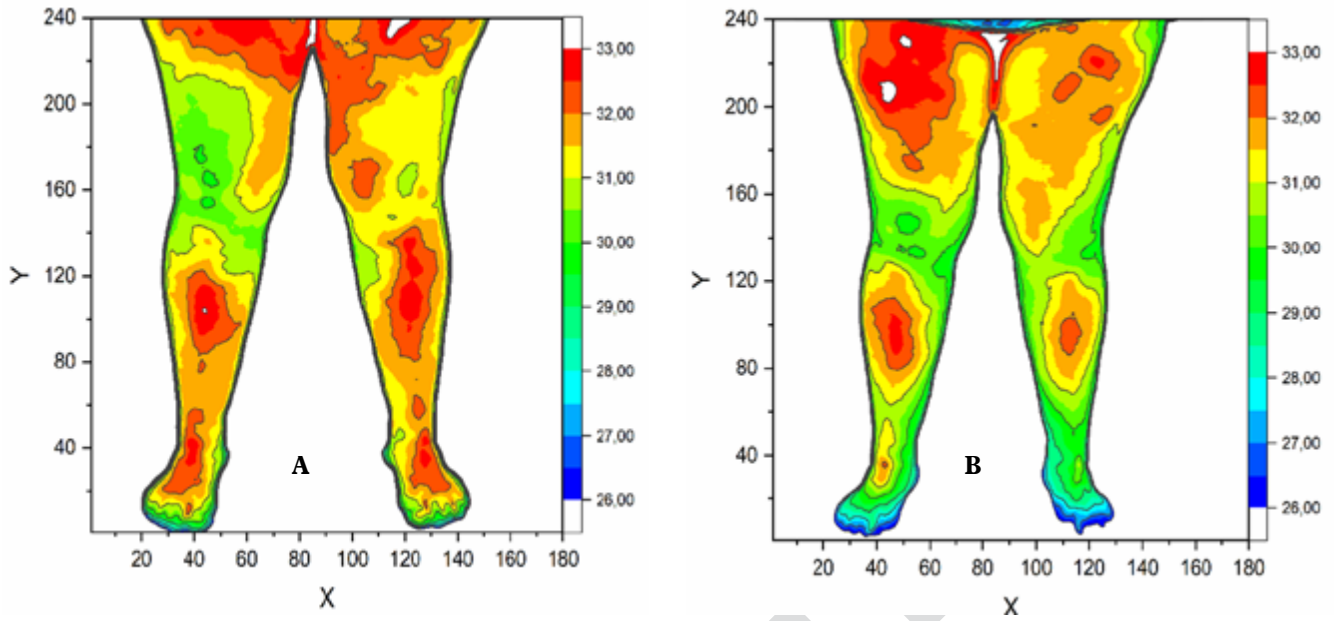

Figure 1. 1 Sample thermograms of a patient before (A) and after (B) microdiscectomy

measured for ROI on the surface of the thigh and the lower leg before surgery and on the second day after surgery. The maximum, minimum and average temperatures in the same ROI for control patients were measured in an analogous way. Thermograms were taken from a distance of 1 m.

The statistical analysis was performed with the use of Statistica v. 13.1 software (StatSoft, Inc., Tulsa, USA). The normality of the variable distribution was tested using the Shapiro–Wilk test. The *t*-test for dependent variables was performed to test the differences between the means of suitable temperatures in selected ROIs on the lower limbs (healthy and sick leg of this same patient) for group of patients before surgery, after surgery and for control group (between left and right leg). The non-parametric Wilcoxon test was used in cases where one of the comparable variables was lacking normality. The significance level $\alpha < 0.05$ was adopted for statistically significant difference between variables.

4. RESULTS

Thermograms of 37 patients before and after microdiscectomy (study group) and 18 people from the control group were analyzed. The results of temperature measurements on the lower limbs for the examined and control groups as well as the results of statistical calculations are summarized in tables and presented in exemplary figures. Figure 1 shows examples of the patient's lower limbs thermograms before (Figure 1A) and after (Figure 1B) surgery.

From Figure 1 it results that, there is a clear asymmetry in the temperature distribution between the affected (right) and healthy limb (left). On the right limb lower temperature fields (yellow fields) are clearly demarcated. After the procedure, there are no obvious differences in temperature distribution between the limbs. Based on the Figure 1B it is not possible to conclude which of the limbs is covered by pathology.

In turn, the Table 2 presents averages values with standard deviations of respective temperatures for ROI on the thigh and lower leg for the study group.

The maximum temperature on a healthy lower leg before surgery is 0.62°C higher than on an affected lower leg this is a statistically significant difference. After surgery, the difference in maximum temperature between healthy and symptomatic limbs is 0.13°C, it is not statistically significant.

The limbs affected by the disease process had lower temperatures compared to healthy limbs in the marked areas in patients from the study group before surgery, both for maximum, average and minimum temperatures in the appropri-

Table 2. Averages values and standard deviations of temperatures on the thigh and lower leg (anterior surface) covered by pathology and healthy in the analyzed area in patients from the studied group made before and after surgery.

Study group		Before surgery (N = 37)			After surgery (N = 37)		
		Affected	Healthy	P	Affected	Healthy	P
Thigh	T_{max}	32.61 ± 1.8	33.08 ± 1.7	0.00003	33.01 ± 1.4	32.99 ± 1.5	0.9693
	T_{av}	31.58 ± 1.9	32.03 ± 1.6	0.00001	31.89 ± 1.6	31.88 ± 1.7	0.2699
	T_{min}	30.01 ± 2.4	30.90 ± 1.9	0.00001	30.98 ± 1.8	30.96 ± 1.9	0.8551
Lower leg	T_{max}	32.79 ± 1.7	33.41 ± 1.2	0.00006	33.33 ± 1.1	33.46 ± 1.1	0.1404
	T_{av}	31.59 ± 1.7	32.15 ± 1.3	0.000001	32.14 ± 1.2	32.19 ± 1.2	0.4582
	T_{min}	29.57 ± 2.5	30.66 ± 2.0	0.000001	30.62 ± 1.5	30.69 ± 1.4	0.3868

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ate ROI's. In turn, the maximum, averages and minimum temperatures in the corresponding ROI's areas of the lower limbs after surgery are not statistically different. Maximum, minimum and average temperatures on the limbs marked in similar areas in control group did not differ significantly between the limbs.

In autonomic neuropathy normal thermoregulatory processes are impaired, resulting in altered peripheral temperatures due to impaired neurovascular function.[23] The thermoregulatory system is substantially symmetrical.[24] Asymmetrical patterns in an infrared thermogram are caused by pathology such as neuropathy.[25]

In order to check the methodological analysis of the thermograms, a control group was selected – people not requiring neurosurgery (without lower leg back pain) and for this group analogous temperature tests were carried out on the lower limbs as for the patients in the study group. The results are presented in Table 3.

The tests carried out for the control group show that no statistically significant differences were observed between the left and right limbs for all measured temperatures in the corresponding ROIs.

Thermographic studies conducted among patients undergoing surgery for discopathy show that for selected ROI areas (thigh and lower leg of lower limb) statistically significant differences were observed between the averages temperatures for respective ROIs on healthy and sick limbs before surgery ($P < 0.013$ for all compared temperatures corresponding to ROI). On the other hand, comparisons of average temperatures in the same patients in the corresponding ROI's on the second day after surgery did not show statistically significant differences between the corresponding temperatures in the corresponding ROI's of healthy and symptomatic lower legs ($P > 0.09$ for all temperature points of lower limbs of patients). We can state that surgical treatment reduces temperature differences on the lower limbs of patients undergoing surgery.

Table 3. Averages values and standard deviations of temperatures on the thigh and lower leg (on the front surface) for the control group.

		Control group ($N = 18$)		
		Right limb	Left limb	P
Thigh	T_{max}	33.42 ± 0.1	33.51 ± 0.9	0.1761
	T_{av}	32.71 ± 0.8	32.87 ± 0.9	0.1469
	T_{min}	32.16 ± 0.8	32.28 ± 0.8	0.0833
Lower leg	T_{max}	34.74 ± 0.6	34.80 ± 0.5	0.3638
	T_{av}	33.90 ± 0.7	33.93 ± 0.7	0.6291
	T_{min}	32.58 ± 1.2	32.64 ± 1.1	0.3621

5. DISCUSSION

It can be concluded from obtained results hat thermograms of the lower limbs obtained from the thermal imaging camera may indicate which of the limb is affected by low back leg pain, which causes disturbances in temperature distribution. In turn, surgery performed on patients with low back leg pain (thermogram on the second day after surgery) eliminates temperature differences between the respective lower limb ROIs. Therefore the method of thermogram analysis can be helpful in the initial assessment as an auxiliary examination during the classification of patients for surgery. This method could be useful to give the answer which patient will respond well to surgery.

The method has its limitations. One of them is the cost of the equipment (thermal camera). Another aspect that hinders the routine introduction to clinical practice is the duration of the examination. Pictures must be taken in a place with constant temperature and humidity. Additionally, it is necessary to analyze the photos taken before and after the procedure; and in everyday medical practice it may turn out to be too time consuming.

6. CONCLUSIONS

(1) The significantly statistical differences of the temperature distribution between the lower limbs in in selected ROIs of patients suffering from low back leg pain caused by symptomatic discopathy were stated.
(2) After selective surgical treatment of lumbar discopathy by microdiscectomy previous significantly statistical temperature differences between the lower limbs in analogical ROIs in those patients decreased to not statistically significant differences.
(3) The study of temperature distribution on the lower limbs in the control group of healthy people do not demonstrate the statistically significant temperature differences between lower limbs in analogical ROIs.
(4) Despite its limitations, this method may be an additional diagnostic tool in patients with discopathy.

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Conflict of interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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