



# THERMO SCAN Diabetes

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***Abstract Collections on Clinical Thermography***

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## **VARIATIONS OF PLANTAR THERMOGRAPHIC PATTERNS IN NORMAL CONTROLS AND NON-ULCER DIABETIC PATIENTS: NOVEL CLASSIFICATION USING ANGIOSOME CONCEPT.**

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### **ABSTRACT**

Thermometry of the plantar skin temperature has been one of the important parameters for assessing ulceration risks in diabetic patients. Recent progress of infrared thermographic technology allows us to obtain imaging of temperature distribution of the whole plantar skin. However, it has not been fully elucidated to what extent the individual variation of the plantar thermographic patterns shows different trends between normal controls and diabetics. In this study, we made a novel framework of conceptual classification with 20 different categories of plantar thermographic patterns according to the foot angiosome concept. The thermographic images from 32 normal volunteers and 129 non-ulcer diabetic patients, recruited from Diabetes Foot Outpatient Clinic of the University of Tokyo Hospital, were allocated to the above-mentioned framework categories. In the normal group, thermographic patterns of more than 65% of feet were allocated to the two typical categories, including the 'butterfly pattern' among the 20 categories, whereas 225 feet (87.2%) of the diabetic groups were variously allocated to 18 out of the 20 categories. This is the first study, which describes detailed plantar thermographic patterns, showing wider variations in the diabetic patients than in the normal subjects. Thermography will be one of the screening options to assess circulatory status in both daily foot care and surgical intervention.

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J Diabetes Sci Technol. 2010 Jul 1;4(4):857-62.

## **THERMAL IMAGING TODAY AND ITS RELEVANCE TO DIABETES.**

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### **ABSTRACT**

From the historic and simple assessment of temperature by the clinical thermometer, modern infrared technology has opened up new perspectives, especially in the use of thermal imaging to map body surface temperature with a remote sensing camera. Since the 1960s, there is now a greater understanding of thermal physiology and the relationship between skin temperature and blood perfusion. Furthermore, the examination technique, and the advantages of computer-aided digital imaging has greatly improved the reliability of this technology in medicine. Studies in diabetology have shown the value of this new facility and its relevance to clinical assessment of peripheral perfusion and tissue viability.

2010 Diabetes Technology Society.

PMID: 20663449 [PubMed - indexed for MEDLINE]PMCID: PMC2909517 [Available on 2011/7/1]

Publication Types, MeSH Terms

J Diabetes Sci Technol. 2010 Jul 1;4(4):773-9.

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## **WOUND INFLAMMATORY INDEX: A "PROOF OF CONCEPT" STUDY TO ASSESS WOUND HEALING TRAJECTORY.**

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### **ABSTRACT**

Diabetes around the globe results in one major limb amputation every 30 seconds, over 2500 limbs lost per day. The underlying pathophysiology sometimes leads to a chronic inflammatory stage, which may prevent appropriate healing, and therefore, the need for a clear strategy for assessing and classifying wounds and wound healing cannot be overstated. Temperature is a surrogate marker for inflammation. Quantitative thermography using a numerical index provides a useful way to assess wound healing. Advances in technology have afforded the availability of low-cost, high-resolution thermal imaging systems, which can be used to quantify sensitive changes on the skin surface and may be particularly useful to develop monitoring strategies for wounds. This article provides a standardized technique for calculating a thermal index (TI) supported with a case report from assessment of a diabetic foot ulcer. In this single case study, the TI/wound inflammatory index indicates a shift from negative to positive ( $p < .05$ ) before it reaches zero.

2010 Diabetes Technology Society.

PMID: 20663437 [PubMed - indexed for MEDLINE]PMCID: PMC2909505 [Available on 2011/7/1]

Publication Types, MeSH Terms, Grant Support

Eur J Ophthalmol. 2009 Nov-Dec;19(6):1004-8.

## **OCULAR SURFACE TEMPERATURE IN DIABETIC RETINOPATHY: A PILOT STUDY BY INFRARED THERMOGRAPHY.**

*Sodi A, Giambene B, Miranda P, Falaschi G, Corvi A, Menchini U.*

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### **ABSTRACT**

**PURPOSE:** To compare ocular surface temperature (OST) measures in patients with nonproliferative diabetic retinopathy (NPDR) and healthy controls.

**METHODS:** A total of 51 consecutive patients with different severity degrees of NPDR and 53 age- and gender-matched healthy volunteers were recruited. OST was evaluated by infrared thermography in five conjunctival (points 1, 2, 4, 5) and corneal (point 3) points.

**RESULTS:** In diabetic eyes, OST values were lower than in controls at all the studied points ( $p < 0.001$  at points 1, 2, 3, 4, and  $p = 0.003$  at point 5).

**CONCLUSIONS:** Ocular surface temperature measurements, by estimating ocular blood flow, may be helpful in the management of patients with diabetic retinopathy.

PMID: 19882575 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Diabetes Technol Ther. 2009 Oct;11(10):663-7.

## **FEASIBILITY OF A THERMOGRAPHIC METHOD FOR EARLY DETECTION OF FOOT DISORDERS IN DIABETES.**

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### **ABSTRACT**

**BACKGROUND:** Foot complications due to diabetes impose a major economic burden to society and loss of health-related quality of life for the patients. Early diagnosis and intensified preventive

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measures have proved useful to limit the incidence of foot ulcers and lower limb amputations in diabetes, and the development of new tools for early diagnosis has therefore become an attractive option. This article covers a feasibility study of the SpectraSole (Linköping, Sweden) Pro 1000 foot indicator, an innovation based on liquid crystal thermography. The technology identifies increases in temperature, a known indicator of inflammation.

**METHODS:** Sixty-five patients with diagnosed diabetes were examined with the foot indicator immediately after their ordinary foot examinations according to current practice, and findings from the two investigations were compared.

**RESULTS:** Sixty-nine examinations were performed. The foot indicator identified increased temperature in 31 cases, of which six had not been detected in the preceding ordinary examinations. The instrument was perceived as easy to use, and the thermographs could be used to visualize problem areas of the foot, which might contribute to better compliance with therapeutic advice.

**CONCLUSIONS:** The foot indicator detected a relatively high share of the different types of complications but not all. It can be used as a complement to current practices for foot examination. The instrument provides rapid imaging of the foot temperature, and the study indicates that it yields valuable diagnostic information in early stages of foot disease.

PMID: 19821759 [PubMed - indexed for MEDLINE]

Diabetes Res Clin Pract. 2009 Sep;85(3):304-9. Epub 2009 Jul 7.

## **ULTRASONOGRAPHIC AND THERMOGRAPHIC SCREENING FOR LATENT INFLAMMATION IN DIABETIC FOOT CALLUS.**

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### **ABSTRACT**

**AIMS:** Inflammation within the diabetic foot callus may be an earliest, predicting symptom of foot ulcer developing later. The purpose of this study was to identify latent inflammation within the foot callus using thermography and ultrasonography, and to investigate relationship between the inflammatory findings in callus and presence or absence of diabetes.

**METHODS:** This was a cross-sectional study of 60 cases with asymptomatic foot callus; the 30 diabetic patients and the 30 non-diabetic matched volunteers. Inflammation was defined using physiological imaging techniques; as skin temperature elevation in thermography and low echoic lesion in ultrasonography.

**RESULTS:** Sixty-three and ninety-four calli were observed in the diabetic and non-diabetic groups, respectively. The inflammation signs were detected by both of the two techniques in 10% of the calli in the diabetic group. No inflammation was noted in the non-diabetic group ( $p=0.014$ ).

**CONCLUSIONS:** The inflammation signs presented here were specifically observed in the diabetic group. We consider that the physiological imaging techniques may be valuable screening tools for potential risk of diabetic foot ulcers.

PMID: 19586674 [PubMed - indexed for MEDLINE]

MeSH Terms

## **COLD IMMERSION RECOVERY RESPONSES IN THE DIABETIC FOOT WITH NEUROPATHY.**

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### **ABSTRACT**

The aim of this article was to investigate the effectiveness of testing cold immersion recovery responses in the diabetic foot with neuropathy using a contact thermography system based on thermochromic liquid crystals. A total of 81 subjects with no history of diabetic foot ulceration were assigned to neuropathy, non neuropathy and healthy groups. Each group received prior verbal and written description of the test objectives and subsequently underwent a comprehensive foot care examination. The room temperature and humidity were consistently maintained at 24 degrees C and less than 50%, respectively, with air conditioning. The right foot for each subject was located on the measurement platform after cold immersion in water at 18-20 degrees C. Whole-field thermal images of the plantar foot were recorded for 10 minutes. Patients with diabetes with neuropathy show the highest 'delta temperature', that is difference between the temperature after 10-minute recovery period and baseline temperature measured independently at all the three sites tested, that is first metatarsal head (MTH), second MTH and heel. This clinical study showed for the first time the evidence of poor recovery times for the diabetic foot with neuropathy when assessing the foot under load. A temperature deficit (because of poor recovery to baseline temperature) suggests degeneration of thermoreceptors, leading to diminished hypothalamus-mediated activity in the diabetic neuropathic group.

PMID: 18783470 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

## **WARM IMMERSION RECOVERY TEST IN ASSESSMENT OF DIABETIC NEUROPATHY--A PROOF OF CONCEPT STUDY.**

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### **ABSTRACT**

The aim of this article was to present results of warm immersion recovery test in the diabetic foot with neuropathy using a liquid crystal-based contact thermography system. It is intended to provide a 'proof of concept' for promoting the role of supplementary thermal assessment techniques and evidence-based diagnosis of diabetic neuropathy. A total of 81 subjects from the outpatient department of MV Hospital for Diabetes, India, were assessed using a liquid crystal thermography system. Each subject was assigned to one of three study groups, that is diabetic neuropathy, diabetic non neuropathy and non diabetic healthy. The room temperature and humidity were consistently maintained at 24 degrees C and less than 50%, respectively, with air conditioning. The right foot for each subject was located on the measurement platform after warm immersion in water at 37 degrees C. Whole-field thermal images of the plantar foot were recorded for 10 minutes. Local measurements at the most prevalent sites of ulceration, that is metatarsal heads, great toe and heel, show highest temperature deficit after recovery for diabetic neuropathy group. The findings of the current study support the ones of a previous study by the authors,

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which used cold immersion recovery test for the neuropathic assessment of the diabetic foot. A temperature deficit between the recovery and the baseline temperature for the neuropathic group suggests degeneration of thermoreceptors. Thermal stimulus tests can be useful to validate the nutritional deficits' (during plantar loading and thermal stimulus) contribution in foot ulceration.

PMID: 18783469 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Int Wound J. 2008 Oct;5(4):570-6. Epub 2008 Sep 1.

## **WARM IMMERSION RECOVERY TEST IN ASSESSMENT OF DIABETIC NEUROPATHY--A PROOF OF CONCEPT STUDY.**

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### **ABSTRACT**

The aim of this article was to present results of warm immersion recovery test in the diabetic foot with neuropathy using a liquid crystal-based contact thermography system. It is intended to provide a 'proof of concept' for promoting the role of supplementary thermal assessment techniques and evidence-based diagnosis of diabetic neuropathy. A total of 81 subjects from the outpatient department of MV Hospital for Diabetes, India, were assessed using a liquid crystal thermography system. Each subject was assigned to one of three study groups, that is diabetic neuropathy, diabetic non neuropathy and non diabetic healthy. The room temperature and humidity were consistently maintained at 24 degrees C and less than 50%, respectively, with air conditioning. The right foot for each subject was located on the measurement platform after warm immersion in water at 37 degrees C. Whole-field thermal images of the plantar foot were recorded for 10 minutes. Local measurements at the most prevalent sites of ulceration, that is metatarsal heads, great toe and heel, show highest temperature deficit after recovery for diabetic neuropathy group. The findings of the current study support the ones of a previous study by the authors, which used cold immersion recovery test for the neuropathic assessment of the diabetic foot. A temperature deficit between the recovery and the baseline temperature for the neuropathic group suggests degeneration of thermoreceptors. Thermal stimulus tests can be useful to validate the nutritional deficits' (during plantar loading and thermal stimulus) contribution in foot ulceration.

PMID: 18783469 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Int J Low Extrem Wounds. 2006 Dec;5(4):250-60.

## **THERMOGRAPHY AND THERMOMETRY IN THE ASSESSMENT OF DIABETIC NEUROPATHIC FOOT: A CASE FOR FURTHERING THE ROLE OF THERMAL TECHNIQUES.**

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### **ABSTRACT**

There are currently 3 established techniques employed routinely to determine the risk of foot ulceration in the patient with diabetes mellitus. These are the assessment of circulation, neuropathy, and foot pressure. These assessments are widely used clinically as well as in the research domain with an aim to prevent the onset of foot ulceration. Routine neuropathic evaluation includes the assessment of sensory loss in the plantar skin of the foot using both the Semmes Weinstein monofilament and the biothesiometer. Thermological measurements of the foot to assess responses to thermal stimuli and cutaneous thermal discrimination threshold are relatively uncommon. Indeed, there remains uncertainty regarding the

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importance of thermal changes in the development of foot ulcers. Applications of thermography and thermometry in lower extremity wounds, vascular complications, and neuropathic complications have progressed as a result of improved imaging software and transducer technology. However, the uncertainty associated with the specific thermal modality, the costs, and processing times render its adaptation to the clinic. Therefore, wider adoption of thermological measurements has been limited. This article reviews thermal measurement techniques specific to diabetic foot such as electrical contact thermometry, cutaneous thermal discrimination thresholds, infrared thermography, and liquid crystal thermography.

PMID: 17088601 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources

Foot Ankle Int. 2005 Oct;26(10):847-53.

## **ASSESSING FOOT TEMPERATURE USING INFRARED THERMOGRAPHY.**

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### **ABSTRACT**

**BACKGROUND:** Previous reports recommended using skin temperature as a guide to monitor neuropathic feet during their rehabilitation course. However, the diagnostic usefulness was limited because of poor thermal measurement and procedures. The purpose of this study was to propose a standardized protocol to quantify foot temperature.

**METHODS:** An infrared image system was used to measure skin temperature. The first experiment was conducted on 16 healthy volunteers to study temperature variation with respect to time. This study mapped out six subregions of anatomic interest over the sole, and average temperature values for each were studied. The second experiment was conducted on 62 diabetic patients, with and without sympathetic skin response (SSR), to study proposed sole temperature normalization with respect to forehead temperature for clinical diagnosis.

**RESULTS:** In the first experiment, the temperature in each plantar subregion varied as a function of time. In the sole area, the highest temperature was noted in the arch region (29.3 +/- 0.9 degrees C). The toes had the lowest temperature value (26.2 +/- 1.2 degrees C) in all areas. Equilibrium was reached after 15 minutes for the mean plantar temperature (27.8 +/- 1.0 degrees C). In the second experiment, the diabetic patients without SSR had a slightly higher mean plantar temperature (27.6 +/- 1.8 degrees C) than those with SSR (26.8 +/- 2.2 degrees C), but the difference was not statistically significant ( $p > 0.05$ ). The SSR-absent group (0.19) and the SSR-present group (0.24) had significant differences in their normalized temperatures as proposed ( $p < 0.05$ ).

**CONCLUSIONS:** The mean temperature of the entire plantar area was found to be more stable than the individual subregions, serving as a more practical indicator for thermoregulatory functions. The study also found that the overall mean plantar temperature stabilized after 15 minutes, and, thus, this time was recommended for clinical thermographic measurements. The normalized temperature may have more useful application than the plantar absolute temperature, as exemplified by the better correlation in diabetic feet. The mean plantar temperature, the wait time to start measurement, and the proposed normalization are believed to play important roles in neuropathic foot disorders.

PMID: 16221458 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources

## [THERMAL IMAGING PROPERTIES OF TOES AFTER WALKING STRESS TEST IN DIABETIC PATIENTS].

[Article in Japanese]

Minamishima C, Kuwaki K, Shirota E, Matsuzaki M, Yamashita K, Kamatani M, Maeda K, Yano F.

Department of Clinical Physiological Laboratory, Nishitokyo Metropolitan Police Hospital, Kokubunji.

### ABSTRACT

In consecutive 50 diabetic patients hospitalized for medical education, without subjective symptoms of autonomic neuropathy (DM group), performed treadmill walking stress test and thermography, for clarify the feature of the pattern typical of diabetic autonomic neuropathy. Thermal images were collected, before, immediately after, 3, 6, 12 minutes after walking. The mean temperature of toes fell more than 1 degree C than that of baseline level and returned within 0.5 degrees C of baseline level within 6 minutes (N type) in 66% of 30 normal subjects (C group) and 24% of DM group. In 10% of C and 24% of DM, the temperature fell but not returned within 0.5 degrees C of baseline level in 6 minutes (D type). In 17% of C and 38% of DM, the temperature changed within 0.5 degrees C (F type), or rose more than 0.5 degrees C after exercise (U type) in 7% in C and 14% in DM groups. Pts D, F group, have more complications (HbA1c, nephropathy, retinopathy or somatic neuropathy), but not so in C, U type. We concluded D, F types were the typical thermographic features of the toes of pts with diabetic autonomic neuropathy.

PMID: 15796044 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources

Exp Clin Endocrinol Diabetes. 2000;108(7):463-9.

## THERMOGRAPHIC MEASUREMENT OF SKIN TEMPERATURE RECOVERY TIME OF EXTREMITIES IN PATIENTS WITH TYPE 2 DIABETES MELLITUS.

Fujiwara Y, Inukai T, Aso Y, Takemura Y.

Department of Medicine, Koshigaya Hospital, Dokkyo University School of Medicine, Japan.

### ABSTRACT

To elucidate the relationship between the recovery of skin temperature in an extremity after exposure to cold water and various factors associated with diabetes, we measured skin temperature in type2 diabetic patients (N=61) and control subjects (N=16). A thermo-tracer was used in thermographic measurements. The right third toe of each subject was immersed in cold water at 0 degrees C for 10 sec. Rt represents the recovery rate of skin temperature at t min after exposure. Rt was significantly reduced in the diabetic patients every 5 min in the 20 min period following exposure compared with control subjects. The diabetic patients group exhibited a significantly positive correlation between R20 and the ankle-brachial index. R20 in the diabetic patients showed a significantly positive correlation with the reduction in systolic blood pressure at the arm observed in Schellong's test. In addition, R20 showed a significantly negative correlation with plasma levels of fibrinogen and plasminogen activator inhibitor-1. However, the severity of diabetic retinopathy and nephropathy was not significantly related to R20 in the diabetic patients. The present data indicate that the recovery of skin temperature after immersion in cold water was markedly reduced in patients with type 2 diabetes mellitus as compared with healthy control subjects. Peripheral arteriosclerosis, impaired sympathetic nerve function and the activation of the blood coagulation system may all contribute to this reduced recovery of skin temperature.

PMID: 11083067 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

**[A CLINICO-THERMOGRAPHIC ASSESSMENT OF THE EFFICACY OF NAPHTHALAN THERAPY IN PATIENTS WITH DIABETIC MICROANGIOPATHIES OF THE LOWER EXTREMITIES].**

[Article in Russian]

*Musaev AV, Nasrullaeva SN, Namazov DZ.*

**ABSTRACT**

Naphthalan was applied in 58 patients with diabetic microangiopathy of the lower limbs. Clinical and infra-red imaging proved high effectiveness of the treatment as naphthalan relieved symptoms of diabetic microangiopathy by means of correction of microcirculation and peripheral blood flow. Infra-red imaging showed that exercise and single procedure tests are able to give prognosis of the treatment effect. The success of naphthalan therapy is very important as microangiopathy of the lower limbs underlies serious complications in diabetics.

PMID: 9855771 [PubMed - indexed for MEDLINE]  
Publication Types, MeSH Terms, Substances

J Rehabil Res Dev. 1997 Jul;34(3):317-21.

**MONITORING HEALING OF ACUTE CHARCOT'S ARTHROPATHY WITH INFRARED DERMAL THERMOMETRY.**

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**ABSTRACT**

The purpose of this study was to describe the use of skin temperature assessment in diabetics with acute Charcot's arthropathy to monitor resolution of inflammation longitudinally throughout the course of treatment and to predict development of neuropathic ulcers. Thirty-nine diabetic subjects presenting with acute Charcot's arthropathy received thermometric monitoring throughout their treatment course. Subjects were treated with a standard protocol involving total contact casting, removable cast walkers, and progression to therapeutic shoes. There was a steady decrease in temperatures during the casting regimen. After temperature gradients normalized, subjects were progressed to custom therapeutic shoe gear and insoles and were followed for a mean 22.6 +/- 7.1 months. Following quiescence, 8% returned during the follow-up period with a new-onset neuropathic ulceration. Temperature gradients during the visit prior to ulceration were significantly higher in this group than for the rest of the population. Elevated temperatures were strongly correlated with the location of arthropathy. Temperatures decreased in a predictable manner as acute arthropathy resolved. Additionally, increased temperature gradients may be predictive of future ulceration.

PMID: 9239625 [PubMed - indexed for MEDLINE]  
MeSH Terms  
LinkOut - more resources

**INFRARED DERMAL THERMOMETRY FOR THE HIGH-RISK DIABETIC FOOT.**

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**ABSTRACT**

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**BACKGROUND AND PURPOSE:** The purpose of this study was to compare skin temperatures in patients with asymptomatic peripheral sensory neuropathy, patients with neuropathic ulcers, and patients with Charcot's arthropathy using the contralateral limb as a control.

**SUBJECTS:** On a retrospective basis, patients with diabetes (N = 143) were divided into three groups: patients with asymptomatic sensory neuropathy (n = 78), patients with neuropathic foot ulcers (n = 44), and patients with neuropathic fractures (Charcot's arthropathy) (n = 21).

**METHODS:** We evaluated the subjects' skin temperatures with a portable hand-held infrared skin temperature probe at the time pathology was initially identified and at subsequent clinical visits for an average of 22.1 months (SD = 6.4). Skin temperatures of the contralateral foot were measured as a control.

**RESULTS:** There were differences in skin temperature between the affected foot and the contralateral (i.e., nonaffected) foot among the patients with Charcot's arthropathy (8.3 degrees F) and the patients with neuropathic ulcers (5.6 degrees F), with no difference identified among the patients with asymptomatic sensory neuropathy. Five patients with neuropathic ulcers experienced reulceration a mean of 12.2 months (SD = 6.4) after initial healing, with a corresponding increase in skin temperature. (89.6 degrees +/- 1.2 degrees F versus 82.5 degrees +/- 2.9 degrees F) at the clinic visit immediately preceding reinjury.

**CONCLUSION AND DISCUSSION:** The data suggest that monitoring of the corresponding contralateral foot site may provide clinical information before other clinical signs of injury can be identified.

PMID: 9037217 [PubMed - indexed for MEDLINE]Free Article

Diabetes Res Clin Pract. 1996 Apr;32(1-2):55-9.

## **ABNORMAL VASOREACTION OF PERIPHERAL ARTERIES TO COLD STIMULUS OF BOTH HANDS IN DIABETICS.**

*Fushimi H, Inoue T, Yamada Y, Matsuyama Y, Kubo M, Kameyama M.  
Department of Medicine, Sumitomo Hospital, Osaka, Japan.*

### **ABSTRACT**

Abnormal vasoreactions of peripheral arteries to cold stimulus of both hands were studied in controls and NIDDM patients by measuring changes of toe skin temperatures using thermography, and compared with thickness and calcification of wall and inner diameters of popliteal and dorsal pedal arteries using B mode ultrasonic imaging. Cold stimulated vasoreactions were divided into four patterns: (1) normal type (skin temperature going up and down within 1 degree C on the basal line), (2) increasing type (temperature going up), (3) decreasing type (temperature going down) and (4) flat type (no change of temperature). The difference in patterns was suggested to be related to the degree of atherosclerotic changes of the dorsal pedal artery obtained from the ultrasonic studies. The mechanism of abnormal vasoreactions of arteries with atherosclerosis is not clear, but cold stimulated thermography may be a useful tool in evaluating the state of peripheral atherosclerosis.

PMID: 8803482 [PubMed - indexed for MEDLINE]

Int J Clin Monit Comput. 1994 Feb;11(1):31-4.

## **ASSESSMENT OF CHEMICAL LUMBAR SYMPATHECTOMY IN CRITICAL LIMB ISCHAEMIA USING THERMAL IMAGING.**

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### **ABSTRACT**

Objective assessment of chemical lumbar sympathectomy (CLS) is lacking. Its success is usually judged in terms of the patient's clinical improvement. We have thermographically measured the immediate temperature changes of the lower limb following CLS using a thermal imager (SAN-EI Thermotracer 6T61). Seven patients with critical limb ischaemia and one patient with Raynaud's phenomenon underwent

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unilateral ablation of the lumbar sympathetic chain using 5% phenol. Four patients were diabetic, two of whom had undergone previous sympathectomy on the same side. Within fifteen minutes of injection, all patients showed a rise in skin temperature in parts of the sock distribution of between 0.8 degrees C and 8.5 degrees C. We conclude that the haemodynamic effects of CLS are immediate and can be objectively measured with thermal imaging.

PMID: 8195656 [PubMed - indexed for MEDLINE]

Biomed Mater Eng. 1992 Spring;2(1):7-18.

## **LITERATURE SURVEY ON BIOMEDICAL APPLICATIONS OF THERMOGRAPHY.**

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### **ABSTRACT**

Thermography is a noninvasive technique through which temperatures are monitored and recorded, thereby allowing visualization of heat flow. There are three types of thermography: liquid crystal thermography (LCT), infrared thermography (IRT) and microwave thermography (MWT). This paper presents a survey of the literature pertinent to the biomedical applications of these types of thermography. The noninvasive and high resolution characteristics of the thermographic systems make them valuable diagnostic as well as therapeutic aids. Typical research areas include detection of blood flow, diagnosis of joint inflammation and cancer, thermal modeling of various body parts, and use in reproductive problems. The survey discloses that thermography has found applications in various fields in medicine, veterinary medicine, pharmacy, and dentistry.

PMID: 1458204 [PubMed - indexed for MEDLINE]

Diabetes Care. 1991 Oct;14(10):918-22.

## **CONTACT THERMOGRAPHY OF PAINFUL DIABETIC NEUROPATHIC FOOT.**

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### **ABSTRACT**

**OBJECTIVE:** To investigate regional differences in skin blood flow (measured by contact thermography) in the diabetic neuropathic foot and to examine the effect of foot temperature on the severity of neuropathic pain.

**RESEARCH DESIGN AND METHODS:** Thirty-five diabetic patients with painful polyneuropathy (PPN) and 33 healthy age- and sex-matched control subjects comprised the study. Mean foot temperature (MFT) in PPN (mean +/- SE 28.3 +/- 0.3 degrees C) was significantly higher (P less than 0.001) than in the control subjects (25.9 +/- 0.5 degrees C), with the highest temperatures over the metatarsal areas and heel. Visual analogue scale pain score (mean +/- SD 5.3 +/- 1.9 cm) did not correlate with MFT (r = -0.14, P = 0.52). In 10 patients with PPN followed for 2-8 mo (mean 4.6), MFT fell by 1.6 degrees C (P = 0.05), but pain scores did not alter.

**CONCLUSIONS:** Neuropathic pain is unaffected by alterations in skin temperature. Elevated skin temperatures at recognized sites of weight bearing (metatarsal heads and heels) are common in the diabetic neuropathic foot and may indicate tissue injury or inflammation induced by pressure trauma or increased arteriovenous shunting. Follow-up studies will determine whether thermographic hot spots are more susceptible to ulceration.

PMID: 1773693 [PubMed - indexed for MEDLINE]

Nippon Rinsho. 1990 Dec;48 Suppl:580-7.

**[CLINICAL SIGNIFICANCE OF THERMOGRAPHY --A NON-INVASIVE AND NON-CONTACT METHOD TO EVALUATE PERIPHERAL CIRCULATORY FUNCTION IN THE DIAGNOSIS OF DIABETIC COMPLICATIONS].**

[Article in Japanese]

*Mabuchi K.*

*Research Center for Advanced Science and Technology, University of Tokyo.*

PMID: 2086937 [PubMed - indexed for MEDLINE]

MeSH Terms

LinkOut - more resources

Rinsho Byori. 1990 Oct;38(10):1119-25.

**[PATHO-PHYSIOLOGICAL ANALYSIS ON PERIPHERAL CIRCULATION USING THERMOGRAPHY AS AN EXAMPLE OF FUNCTIONAL BODY IMAGING].**

[Article in Japanese]

*Hitoi A, Matsuoka A.*

*Department of Clinical Laboratory, Hyogo College of Medicine, Nishinomiya.*

**ABSTRACT**

The various body imaging systems can be classified into structural body imaging and functional body imaging. Thermography is a typical example of the latter category. Thermography is regarded to mainly represent peripheral circulatory function on hands and feet. We have studied the patho-physiology of peripheral circulation in normal subjects and in patients with diabetic microangiopathy, using the thermography system. Analysis of the cold loading test by thermography revealed that the recovery after cold loading was decreased with aging in healthy subjects. In diabetic patients, recovery after cold loading was apparently lower than in senile healthy subjects on foot. Thermography was also considered as a useful tool for evaluation of the effect of medicines such as PGE1, in a long-term study, as well as single dose test. Furthermore, thermography proved to be the first choice study in serious peripheral circulatory failure such as diabetic gangrene, since it is a non-invasive and non-contact examination.

PMID: 2262971 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms, Substances

Wiad Lek. 1989 Jan 1;42(1):25-9.

**[USEFULNESS OF THERMOGRAPHIC EXAMINATION IN THE DIAGNOSIS OF EARLY PERIPHERAL ISCHEMIA OF THE EXTREMITIES IN PATIENTS WITH DIABETES MELLITUS].**

[Article in Polish]

*Sroczyński J, Bresler M, Cincia A M.*

**ABSTRACT**

Vascular damage is the main complication of diabetes. An early sign of this complication is damage to the arterial and capillary vessels in the lower extremities with later impairment of peripheral blood flow. The aim of the present study was evaluation of the usefulness of thermography in the detection of early circulatory disturbances in the lower extremities during diabetes, and comparison of its results with those obtained in oscillometry. The study comprised 28 patients with type I diabetes aged from 16 to 57 years and 27 patients with type II diabetes aged from 35 to 65 years. The control group included 10 clinically health subjects in similar age group. It was found that thermographic changes were much more frequent than pains in the extremities and abnormal values of oscillometric++ index in diabetes type I and II. Nearly half the patients with evident thermographic disturbances had no oscillometric changes, and 2/3 of the patients felt no pains in the extremities.

PMID: 2781801 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

*Abstract Collections on Clinical Thermography -Diabetes* [www.cgnresearchlabs.com](http://www.cgnresearchlabs.com)

Eur J Vasc Surg. 1989 Aug;3(4):355-61.

## **THE VALUE OF SKIN TEMPERATURE MEASUREMENTS IN FORECASTING THE HEALING OF A BELOW-KNEE AMPUTATION FOR END-STAGE ISCHAEMIA OF THE LEG IN PERIPHERAL VASCULAR DISEASE.**

*Stoner HB, Taylor L, Marcuson RW.*

*Department of Surgery, Hope Hospital, Salford, U.K.*

### **ABSTRACT**

In order to forecast the healing of a Burgess type below-knee amputation the skin temperature of the leg has been studied before operation in 39 instances using infra-red thermography in a 26 degrees C environment. Healing bore no relation to the mean skin temperature of the calf or that of the skin at the site of the anterior incision. However, when the skin temperature at the site of the incision for the long posterior flap was greater than 30.4 degrees C or when the ratio of the temperatures at the posterior and anterior incision sites (P/A) was greater than 0.98 healing was significantly more likely to occur. It is proposed that the temperatures at these sites should be used to assess the prospect of such an amputation healing.

PMID: 2767257 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Br J Rheumatol. 1989 Jun;28(3):195-200.

## **SKIN BLOOD FLOW AND LIMITED JOINT MOBILITY IN INSULIN-DEPENDENT DIABETES MELLITUS.**

*Mitchell WS, Winocour PH, Gush RJ, Taylor LJ, Baker RD, Anderson DC, Jayson MI.*

*University of Manchester, Rheumatic Diseases Centre.*

### **ABSTRACT**

Hand skin blood flow in 32 insulin-dependent (IDDM) diabetics was compared with 13 healthy controls at room temperature and after immersion of the hands in warm and cold water. Subjects were examined for limited joint mobility (LJM) to analyse the association between this and blood flow. Digital arteries remained patent in IDDM compared to controls after cold challenge ( $p = 0.0001$ ), and the difference persisted to a lesser degree 15 min ( $p = 0.009$ ) and 30 min ( $p = 0.03$ ) after recovery. Capillary blood flow was reduced in IDDM at room temperature at the finger nailbeds ( $p$  less than 0.02) and the palms ( $p = 0.004$ ) and remained so after warm water immersion in the palms ( $p = 0.002$ ), where further vasoconstriction was observed immediately after cold water immersion ( $p$  less than 0.001) and 15 and 30 min into recovery ( $p = 0.07$  and  $p = 0.009$  respectively). Thermographic analysis confirmed a pattern of predominantly distal rewarming after cold challenge in IDDM with a greater mean index finger temperature than the controls. Together, these features suggested enhanced arteriovenous anastomotic blood flow. All IDDM and IDDM males with LJM had reduced palm capillary flow immediately after cold challenge ( $p$  less than 0.05). After warm water ( $p$  less than 0.03) and 30 min after cold challenge ( $p$  less than 0.05) IDDM males with LJM had reduced palm capillary flow compared to those IDDM without. A microvascular aetiology for LJM is proposed by virtue of reduced nutritional blood flow and evidence of enhanced arteriovenous shunting in the hands of insulin-dependent diabetics.

PMID: 2730981 [PubMed - indexed for MEDLINE]

## **AMPUTATION FOR PERIPHERAL VASCULAR DISEASE: THE CASE FOR LEVEL SELECTION.**

*McCollum PT, Spence VA, Walker WF.*

*Department of Vascular Surgery, Ninewells Hospital, Dundee, UK.*

### **COMMENT IN:**

" Br J Surg. 1989 Jun;76(6):654.

### **ABSTRACT**

One hundred major lower limb amputations were performed for end stage peripheral vascular disease over a 15-month period. Selection of amputation level was made on the basis of laboratory criteria using skin blood flow and infrared thermography data. Eighty-one amputations were performed at the below-knee level with six failures. This resulted in a final below-knee: above-knee amputation ratio of 3:1. It is clear that there are still many centres in the UK where above-knee amputation is the accepted operation, despite the inherent drawbacks to this procedure. We recommend that more attention is given to achieving higher below-knee amputation rates to improve the chances of amputee mobility and therefore quality of life.

PMID: 3233468 [PubMed - indexed for MEDLINE]

MeSH Terms

LinkOut - more resources

Ter Arkh. 1987;59(4):97-100.

## **[THE USE OF THERMOGRAPHY IN THE CLINICAL EVALUATION OF MICROCIRCULATION].**

[Article in Russian]

*Iakhontova OI, Rutga?zer IaM, Somova EP.*

### **ABSTRACT**

A method of thermography of the hands including the cold test was employed to evaluate peripheral microcirculation in 116 patients (34 with atherosclerosis of the vessels of different sites, 38 with chronic diffuse liver diseases and 38 with chronic pancreatitis). In 29 patients with hepatocirrhosis and chronic pancreatitis microcirculation was also studied by conjunctival biomicroscopy. Microcirculatory disturbances by the method of thermography of the hands, particularly using the cold test, were revealed in a considerable number of cases of primary vascular pathology as well as in chronic liver and pancreatic diseases. Parallelism in the recognition of microcirculatory disturbances by the methods of thermography and conjunctival biomicroscopy was noted. The method of thermography of the hands permitted the evaluation of reactivity of the vessels of the microcirculatory bed. Taking into account its sufficient informative value, noninvasiveness, simplicity and an opportunity of dynamic observations it can be recommended for a wider clinical use to study microcirculatory disturbances.

PMID: 3590013 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Vestn Khir Im I I Grek. 1983 Jan;130(1):56-62.

## **[THERMOGRAPHY IN THE EVALUATION OF PERIPHERAL BLOOD FLOW IN PATIENTS WITH DIABETES MELLITUS].**

[Article in Russian]

*Volgin EG, Mel'nikova VP, Stroev IuI, Zakalinski? IA.*

### **ABSTRACT**

The method of thermovision was used for examination of lower extremities of 350 patients with diabetes mellitus. In 100 patients with diabetes mellitus the potencies of thermovision were assessed before and after cooling the lower extremities and in 38 patients with diabetes mellitus thermovision was used in the control of treatment of disturbances of the peripheral blood circulation. The data obtained have shown great diagnostic significance of thermovision.

PMID: 6836858 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources

Vestn Khir Im I I Grek. 1983 Aug;131(8):40-4.

## **[EARLY DIAGNOSIS OF DISEASES OF THE VESSELS OF THE LOWER EXTREMITIES BY THE THERMOGRAPHIC TECHNIC].**

[Article in Russian]

*Zenovko GI.*

### **ABSTRACT**

Results of the thermovision examination of 643 patients with obliterating atherosclerosis, varicose dilatation of veins, thrombophlebitis, diabetic angiopathy of lower extremities are analyzed. The significance of thermography in early diagnosis of these diseases is shown. The functional test with cooling is described.

PMID: 6649278 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Probl Endokrinol (Mosk). 1981 Sep-Oct;27(5):29-31.

## **[POSSIBILITIES OF INFRARED THERMOGRAPHY IN THE DIFFERENTIAL DIAGNOSIS OF FUNCTIONAL AND ORGANIC STAGES OF MICROANGIOPATHY IN DIABETES MELLITUS].**

[Article in Russian]

*Zykova TA, Popov VA.*

### **ABSTRACT**

The results of thermographic studies of the limbs of patients suffering from diabetes mellitus of different severity and duration are presented. Thermogram changes expressed by IR-radiation decrease in the foot and hand distal regions or "amputation" thermograms of feet and hands are characteristic of peripheral microangiopathy. Thermoasymmetry is more typical of the arterial atherosclerotic affection. The use of nitroglycerin test allows one of differentiate functional and organic vascular injuries and to judge the compensation of peripheral circulation.

PMID: 7291158 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources

Angiology. 1981 Mar;32(3):155-69.

## **AMPUTATION OF THE ISCHEMIC LIMB: SELECTION OF THE OPTIMUM SITE BY THERMOGRAPHY.**

*Spence VA, Walker WF, Troup IM, Murdoch G.*

### **ABSTRACT**

*Abstract Collections on Clinical Thermography -Diabetes [www.cgnresearchlabs.com](http://www.cgnresearchlabs.com)*

This report describes the value of infrared thermography in assessing the optimum level of amputation of an ischemic limb. Interpretation of thermograms and the factors that can significantly alter the thermal image of the lower limbs are detailed. Results from 104 patients demonstrate that the thermographic method is a reliable indicator of the level of a major limb amputation. A rationale for the inadequacy of the method when attempting to determine the outcome of a partial foot amputation is considered.

PMID: 7224225 [PubMed - indexed for MEDLINE]

MeSH Terms

Probl Endokrinol (Mosk). 1981;27(6):9-12.

## **[THERMOGRAPHY IN COMPLEX INSTRUMENTAL STUDIES IN THE DIAGNOSIS OF DIABETIC ANGIOPATHIES].**

[Article in Russian]

*Zhigalkin VN, Zenovko GI.*

### **ABSTRACT**

Microcirculation was examined in 182 patients with diabetes mellitus and 20 healthy subjects. According to the disease severity all the patients were divided, as follows: 23 patients with mild diabetes, 99 with moderate form of the disease and 60 subjects with severe diabetes. Thermoassymetry of the lower limbs of the patients under examination and proximal distal gradient of the temperature drop were determined to reveal circulation disturbance. The "cold test" promoted discovering vascular insufficiency, whereas local dosed ether anesthesia of the limbs favoured to reveal microcirculation disorder and to determine the time of temperature normalization in the anesthetized regions of patients with diabetes mellitus, comparatively to those of normal subjects. The "hot foot" symptom is pathognomonic for osteoarthropathy.

PMID: 7323034 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Phys Ther. 1979 Jan;59(1):23-9.

## **THERAPEUTIC FOOTWEAR FOR THE INSENSITIVE FOOT.**

*Hampton GH.*

### **ABSTRACT**

The patient with insensitive feet may be injured by poorly fitted or inappropriate footwear. The risk of soft-tissue injury from friction or pressure can be reduced by careful selection and fitting of footwear and frequent evaluation of both footwear and the patient's feet. Concepts, methods, and materials utilized in treating patients with Hansen's disease can be applied to the prevention and treatment of injuries secondary to sensory deficit caused by other conditions. The microcapsule sock test has been used to assess shear forces and pressures that occur while shoes are worn. Test method and interpretation of test results are described.

PMID: 424446 [PubMed - indexed for MEDLINE]

MeSH Terms

LinkOut - more resources

Ter Arkh. 1978;50(11):59-63.

## **[PERSPECTIVES OF USING THERMOGRAPHY FOR EARLY DIAGNOSIS OF ANGIOPATHIES OF THE LOWER LIMBS IN DIABETES MELLITUS].**

[Article in Russian]

*Volgin EG, Radzevich GI, Stroev IuI, Sukhanova VF.*

PMID: 725765 [PubMed - indexed for MEDLINE]

*Abstract Collections on Clinical Thermography -Diabetes [www.cgnresearchlabs.com](http://www.cgnresearchlabs.com)*

Publication Types, MeSH Terms

Pol Tyg Lek. 1977 May 30;32(22):833-5.

## **[THERMOVISION IN THE ASSESSMENT OF PERIPHERAL CIRCULATION IN JUVENILE DIABETICS].**

[Article in Polish]

*Otto-Buczowska E, Buczkowski M, Wanka-Noga M.*

PMID: 887487 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources

Expert Rev Med Devices. 2010 Sep;7(5):711-8.

## **AN OVERVIEW OF TEMPERATURE MONITORING DEVICES FOR EARLY DETECTION OF DIABETIC FOOT DISORDERS.**

*Roback K.*

*Center for Medical Technology Assessment (CMT), Department of Medical and Health Sciences, Linköping University, Linköping, Sweden. kerstin.robac@liu.se*

### **ABSTRACT**

Diabetic foot complications are associated with substantial costs and loss of quality of life. This article gives an overview of available and emerging devices for the monitoring of foot temperature as a means of early detection of foot disorders in diabetes. The aim is to describe the technologies and to summarize experiences from experimental use. Studies show that regular monitoring of foot temperature may limit the incidence of disabling conditions such as foot ulcers and lower-limb amputations. Infrared thermometry and liquid crystal thermography were identified as the leading technologies in use today. Both technologies are feasible for temperature monitoring of the feet and could be used as a complement to current practices for foot examinations in diabetes.

PMID: 20822392 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

LinkOut - more resources