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THERMOGRAPHIC DIAGNOSIS OF ARTHRITIS IN PERIPHERAL JOINTS

Oblinger W, Engel JM, Franke M.

ABSTRACT

The measurement of absolute temperatures on the surface of the human body using quantitative thermography allows this technique to be used in rheumatology, for the diagnosis and monitoring the course of inflammatory diseases of the locomotor system. The patient is exposed to a room temperature of 18 degrees C and the skin temperature measured over the joint for a defined area (region of interest). Inflamed joints show distinctly higher absolute temperatures than normal ones within the observation time of 40 minutes. Moreover, the skin over healthy joints cools faster and to a greater extent than skin over inflamed joints, whose temperatures remain the same or even rise minimally in more acute cases. Using two measurements, the determination of the absolute temperatures (static thermography), and the changes in these temperatures within a definite time interval (dynamic thermography) it is thus possible to establish a diagnosis of arthritis in the regions of the peripheral joints with the help of standardised nomograms with an accuracy of more than 90%, and to follow the course of the disease more exactly.

PMID: 4050143 [PubMed - indexed for MEDLINE]

Publication Types, MeSH Terms

Publication Types:
- English Abstract

MeSH Terms:
- Ankle Joint/physiopathology
- Arthritis/diagnosis*
- Arthritis/physiopathology
- Computers
- Humans
- Knee Joint/physiopathology
- Skin Temperature*
- Temperature
- Thermography/methods*
  - more resources

THERMOGRAPHY IN THE ASSESSMENT OF PERIPHERAL JOINT INFLAMMATION--A RE-EVALUATION.
Rajapakse C, Grennan DM, Jones C, Wilkinson L, Jayson M.

ABSTRACT

The reproducibility and sensitivity of quantitative infra-red thermography as a measure of peripheral joint inflammation was reassessed. Experiments were carried out in a temperature-controlled room at 20 degrees C. Initial stabilization experiments showed that in normal, medium sized, joints, there was an initial rapid cooling phase followed by a slower cooling phase which lasted longer than two hours. In the knees the differences between normal and active rheumatoid joints increased the longer patients remained in the room but for practical reasons a 30-minute stabilization period was subsequently chosen. In views of hands and fingers, rebound increases in skin temperature after entering the room, together with lesser differences between inflamed and non-inflamed joints, were found. The results suggested that the
thermographic technique examined was adequate for detecting inflammatory changes in knee, ankles and elbows but unsatisfactory for quantification of inflammation in the small joints of the hands.

PMID: 7280484 [PubMed - indexed for MEDLINE]


[ADVANCES IN RHEUMATOLOGY. THERMOGRAPHY--A NEW METHOD OF STUDYING ARTICULAR INFLAMMATORY PROCESSES].

Pakula A.

PUBLICATION TYPES, MESH TERMS
Publication Types:
- Review
MeSH Terms:
- Acute Disease
- Body Temperature
- Bone Neoplasms/diagnosis
- Chronic Disease
- Humans
- Inflammation
- Joint Diseases/complications
- Joint Diseases/diagnosis*
- Joints/blood supply
- Thermography*

[QUANTITATIVE THERMOGRAPHY OF THE KNEE JOINT].

Engel JM.

ABSTRACT

Computer-assisted evaluation of thermography of the knee joints allows diagnosis and quantitation of inflammatory processes. This needs an adequate thermography camera, registration standards and a thermographic index. With the aid of this index normal knee joints and those with inflammatory changes can clearly be differentiated: an index of less than 3.5 is normal, values above 5.0 indicate an inflammation. The author proposes to correct the thermographic index with reference to actual rectal temperature in order to improve inter- and intra-individual comparability of thermograms. Apart from the thermographic index, the formal analysis of the line-scan over the joint space and the maximal temperature of the joint can be used as further diagnostic criteria.

PMID: 695998 [PubMed - indexed for MEDLINE]


THERMOGRAPHIC ASSESSMENT OF BONE AND JOINT DISEASE.

Rothschild BM. St. Elizabeth Hospital Medical Center, Youngstown, Ohio.

ABSTRACT

Thermography, a noninvasive technique with no known toxicity, represents a useful addition to our diagnostic armamentarium. It has documented efficacy in specific diagnostic circumstances and possible motivational applications. Its eventual position in our general diagnostic armamentarium will be dependent upon additional, well-designed clinical-pathologic correlation studies, the bases of which are presented herein.

PMID: 3331176 [PubMed - indexed for MEDLINE]

ASSESSMENT OF INFLAMMATION IN THE RHEUMATOID KNEE JOINT: CORRELATION BETWEEN CLINICAL, RADIOISOTOPIC, AND THERMOGRAPHIC METHODS.


ABSTRACT

Standard clinical methods of assessing joint inflammation are being supplemented increasingly by radioisotopic and thermographic studies. However, the correlation between these different methods has not been firmly established. In the quantification of synovitis by infrared thermography we have shown that the heat distribution index (HDI) based on thermal pattern is more reliable and is less affected by diurnal variations in joint temperature than the commonly used thermographic index, which is based on average skin temperature values. In 20 patients with rheumatoid arthritis whose knees were being treated with intra-articular steroid we obtained 184 serial paired observations over a period of 24 weeks for clinical assessment, HDI, and 99mTc pertechnetate uptake. We found significant correlations (p less than 0.001) between the three methods of assessment (except for pain and HDI (p = 0.116)).

LITERATURE SURVEY ON BIOMEDICAL APPLICATIONS OF THERMOGRAPHY.

Yang WJ, Yang PP.

Department of Mechanical Engineering and Applied Mechanics, University of Michigan, Ann Arbor 48109.

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.

NEUROMUSCULOSKELETAL THERMOGRAPHY: A VALUABLE DIAGNOSTIC TOOL?

Meeker WC, Gahlinger PM.

ABSTRACT

The use of neuromusculoskeletal thermography is rapidly increasing. Recent studies have begun to document the types of diagnostic and other clinically useful information which may be derived from the procedure. This paper provides a review and summary of current research and a comparison with myelography, computerized tomography, electromyography and clinical and surgical findings in cases of presumed musculoskeletal pain syndromes. The importance of diagnostic sensitivity, specificity, positive and negative predictive value, and accuracy (validity) are discussed. In general, the literature reports high sensitivity and negative predictive value, but lower specificity and positive predictive value. The
implications of these findings are examined in regard to clinical case management, with emphasis on potential usefulness to chiropractors. Although thermography appears to be a promising diagnostic tool, there remain a number of threats to the scientific validity of current research which must be accounted for in future work.

PMID: 3543187 [PubMed - indexed for MEDLINE]

USE OF THERMOGRAPHY FOR INITIAL DETECTION OF EARLY REFLEX SYMPATHETIC DYSTROPHY.
Karstetter KW, Sherman RA.
Department of Surgery, Fitzsimons Army Medical Center, Aurora, CO 80045-5001.

ABSTRACT
Reflex sympathetic dystrophy is one of a complex of overlapping, sympathetically maintained pain syndromes which are usually initiated by a minor injury that resolves quickly but leaves behind a persistent pain that generalizes to much or all of the limb. The pathophysiology of reflex sympathetic dystrophy is reviewed to show that the pain is accompanied by cooling of the limb, beginning with the distal end and gradually progressing throughout. Thermography is shown to be an effective way to monitor near-surface blood flow in the limbs and to be sensitive to changes accompanying painful conditions. The usefulness of this technique for early detection of reflex sympathetic dystrophy is demonstrated and illustrated with several examples.

THERMOGRAPHY IN POSTTRAUMATIC PAIN.
Pochaczevsky R.

ABSTRACT
Posttraumatic pain is often associated with complex disturbances of the sympathetic nervous system which also controls microcirculation of the skin. Circulatory skin changes are in turn reflected by altered superficial thermal emission, which can be reliably imaged by thermography. Examples of classic thermographic patterns associated with commonly occurring injuries and detected along cutaneous distributions of peripheral nerves or spinal root dermatomes are presented. Thermographic abnormalities may also occur in odematomal distributions to involve an entire hand, foot, or extremity as observed in reflex sympathetic dystrophy. Such thermographic findings often appear before skin or roentgenographic changes become manifest and lead to earlier diagnosis. Prompt and more effective treatment, particularly in reflex sympathetic dystrophy, may thereby be initiated so that full blown, difficult to manage, chronic disability may be averted. The diagnosis of malingering may also be strengthened or suspected if thermographic studies together with other examinations are normal.

REFLEX SYMPATHETIC DYSTROPHY: ELECTRONIC THERMOGRAPHY AS AN AID IN DIAGNOSIS.
Perelman RB, Adler D, Humphreys M.
Tarzana Sports Injury and Orthopedic Medical Group, Tarzana, California.

ABSTRACT
Reflex sympathetic dystrophies can be distressing conditions for patients as well as physicians. In the full-blown case, the diagnosis is easy to make; however, many more subtle forms of reflex sympathetic dystrophy exist. In the full-blown case, diagnosis may be quite simple when the physical findings are present. In the more subtle forms, however, one must have a high index of suspicion in order to make the diagnosis. Clinical testing, such as stellate ganglion blocks, may or may not be helpful. Electronic infrared

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thermography emerges as a helpful tool in the aid to diagnosis. We have presented several cases in order to illustrate this.

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THERMOGRAPHY IMAGING DURING STATIC AND CONTROLLED THERMOREGULATION IN COMPLEX REGIONAL PAIN SYNDROME TYPE 1: DiAGNOSTIC VALUE AND INVOLVEMENT OF THE CENTRAL SYMPATHETIC SYSTEM.

Niehof SP, Huygen FJ, van der Weerd RW, Westra M, Zijlstra FJ.
Department of Pain Treatment, Erasmus MC, University Medical Center, Dr. Molewaterplein 40, 3015 GD Rotterdam, The Netherlands. s.niehof@erasmusmc.nl

ABSTRACT

BACKGROUND: Complex Regional Pain Syndrome type 1 (CRPS1) is a clinical diagnosis based on criteria describing symptoms of the disease. The main aim of the present study was to compare the sensitivity and specificity of calculation methods used to assess thermographic images (infrared imaging) obtained during temperature provocation. The secondary objective was to obtain information about the involvement of the sympathetic system in CRPS1.

METHODS: We studied 12 patients in whom CRPS1 was diagnosed according to the criteria of Bruehl. High and low whole body cooling and warming induced and reduced sympathetic vasoconstrictor activity. The degree of vasoconstrictor activity in both hands was monitored using a videothermograph. The sensitivity and specificity of the calculation methods used to assess the thermographic images were calculated.

RESULTS: The temperature difference between the hands in the CRPS patients increases significantly when the sympathetic system is provoked. At both the maximum and minimum vasoconstriction no significant differences were found in fingertip temperatures between both hands.

CONCLUSION: The majority of CRPS1 patients do not show maximal obtainable temperature differences between the involved and contralateral extremity at room temperature (static measurement). During cold and warm temperature challenges this temperature difference increases significantly. As a result a higher sensitivity and specificity could be achieved in the diagnosis of CRPS1. These findings suggest that the sympathetic efferent system is involved in CRPS1.


COMPUTER-ASSISTED SKIN VIDEO THERMOGRAPHY IS A HIGHLY SENSITIVE QUALITY TOOL IN THE DIAGNOSIS AND MONITORING OF COMPLEX REGIONAL PAIN SYNDROME TYPE I.

Huygen FJ, Niehof S, Klein J, Zijlstra FJ.
Department of Anesthesiology, Pain Treatment Centre, Erasmus MC, PO Box 2040, 3000 CA, Rotterdam, The Netherlands.

ABSTRACT

The use of thermography in the diagnosis and evaluation of complex regional pain syndrome type 1 (CRPS1) is based on the presence of temperature asymmetries between the involved area of the extremity and the corresponding area of the uninvolved extremity. The interpretation of thermographic images is, however, subjective and not validated for routine use. The objective of the present study was to develop a sensitive, specific and reproducible arithmetical model as the result of computer-assisted infrared thermography in patients with early stage CRPS1 in one hand. Eighteen patients with CRPS1 on one hand and 13 healthy volunteers were included in the study. The severity of the disease was determined by means of pain questionnaires [visual analogue scale (VAS) pain and McGill Pain Questionnaire], measurements of mobility (active range of motion) and oedema volume. Asymmetry between the involved
and the uninvolved extremities was calculated by means of the asymmetry factor, the ratio and the average temperature differences. The discrimination power of the three methods was determined by the receiver-operating curve (ROC). The regression between the determined temperature distributions of both extremities was plotted. Subsequently the correlation of the data was calculated. In normal healthy individuals the asymmetry factor was 0.91 (0.01) (SD), whereas in CRPS1 patients this factor was 0.45 (0.07) (SD). The performance of the arithmetic model based on the ROC curve was excellent. The area under the curve was 0.97, the P value was <0.001, the sensitivity 92% and specificity 94%. Furthermore, the temperature asymmetry factor was correlated with the duration of the disease and VAS pain. In conclusion, in resting condition, videothermography is a reliable additive diagnostic tool of early stage CRPS1. This objective tool could be used for monitoring purposes during experimental therapeutic intervention. PMID: 14735366 [PubMed - indexed for MEDLINE]

USING SKIN SURFACE TEMPERATURE TO DIFFERENTIATE BETWEEN COMPLEX REGIONAL PAIN SYNDROME TYPE 1 PATIENTS AFTER A FRACTURE AND CONTROL PATIENTS WITH VARIOUS COMPLAINTS AFTER A FRACTURE.

Niehof SP, Beerthuizen A, Huygen FJ, Zijlstra FJ.
Department of Pain Treatment, Erasmus MC, University Medical Center, CA Rotterdam, The Netherlands.
s.niehof@erasusmc.nl

ABSTRACT

OBJECTIVE: In this study, we assessed the validity of skin surface temperature recordings, based on various calculation methods applied to the thermographic data, to diagnose acute complex regional pain syndrome type 1 (CRPS1) fracture patients.

METHODS: Thermographic recordings of the palmar/plantar side and dorsal side of both hands or feet were made on CRPS1 patients and in control fracture patients with/without and without complaints similar to CRPS1 (total in the three subgroups = 120) just after removal of plaster. Various calculation methods applied to the thermographic data were compared using receiver operating characteristics analysis to obtain indicators of diagnostic value.

RESULTS: There were no significant differences in demographic data and characteristics among the three subgroups. The most pronounced differences among the subgroups were vasomotor signs in the CRPS1 patients. The involved side in CRPS1 patients was often warmer compared with the noninvolved extremity. The difference in temperature between the involved site and the noninvolved extremity in CRPS1 patients significantly differed from the difference in temperature between the contralateral extremities of the two control groups. The largest temperature difference between extremities was found in CRPS1 patients. The difference in temperature recordings comparing the palmar/plantar and dorsal recording was not significant in any group. The sensitivity and specificity varied considerably between the various calculation methods used to calculate temperature difference between extremities. The highest level of sensitivity was 71% and the highest specificity was 64%; the highest positive predictive value reached a value of 35% and the highest negative predictive 84%, with a moderate 0.60 > or = area under the curve < or = 0.65.

CONCLUSION: The validity of skin surface temperature recordings under resting conditions to discriminate between acute CRPS1 fracture patients and control fracture patients with/without complaints is limited, and only useful as a supplementary diagnostic tool.
INFRARED THERMAL IMAGING AS A PHYSIOLOGICAL ACCESS PATHWAY: A STUDY OF THE BASELINE CHARACTERISTICS OF FACIAL SKIN TEMPERATURES.

Nhan BR, Chau T.
Bloorview Research Institute, 150 Kilgour Road, Toronto, ON M4G 1R8, Canada.

ABSTRACT

In this study we examine the baseline characteristics of facial skin temperature, as measured by dynamic infrared thermal imaging, to gauge its potential as a physiological access pathway for non-verbal individuals with severe motor impairments. Frontal facial recordings were obtained from 12 asymptomatic adults in a resting state with a high-end infrared thermal imaging system. From the infrared thermal recordings, mean skin temperature time series were generated for regions of interest encompassing the nasal, periorbital and supraorbital areas. A 90% bandwidth for all regions of interest was found to be in the 1 Hz range. Over 70% of the time series were identified as nonstationary (p<0.05), with the nonstationary mean as the greatest contributing source. Correlation coefficients between regions were significant (p<0.05) and ranged from values of 0.30 (between periorbital and supraorbital regions) to 0.75 (between contralateral supraorbital regions). Using information measures, we concluded that the greatest degree of information existed in the nasal and periorbital regions. Mutual information existed across all regions but was especially prominent between the nasal and periorbital regions. Results from this study provide insight into appropriate analysis methods and potential discriminating features for the application of facial skin temperature as a physiological access pathway.

PLANTAR INFRARED THERMOGRAPHY MEASUREMENTS AND LOW BACK PAIN INTENSITY.

Zaproudina N, Ming Z, Hänninen OO.
Department of Physiology, University of Kuopio, Kuopio, Finland. nina.zaproudina@uku.fi

ABSTRACT

OBJECTIVE: To study the skin temperature disorders in low back pain (LBP) patients compared with reference persons without LBP and to evaluate the relationship between pain intensity and other clinical signs and temperature abnormalities.

METHODS: Sixty-five patients with unilateral chronic LBP with or without referred nonradicular leg pain (29 men and 36 women; age range, 30-51 years) and 20 reference persons without LBP (7 men and 13 women; age range, 30-49 years) participated in this study. The pain level was recorded by the use of a visual analog scale (0-100). Questionnaires and a series of spinal mobility tests (the modified Schober, straight leg-raising test, finger-floor distance, side bending) were used. Thermographic images of the low back area and legs (anterior, lateral, and posterior surfaces and the plantar surfaces of feet) were taken with an infrared video camera.

RESULTS: The temperature changes in the plantar surface correlated with LBP intensity. The pain levels differed in the groups with the different types of temperature changes. There were significant lower extremity regional skin temperature alterations (at least 1 regional interside difference more than 0.3 degrees C) in most cases both in LBP patients and in reference persons, but plantar interside temperature difference was significantly higher in LBP patients.
CONCLUSION: Temperature changes of the plantar surface seem to be connected with LBP intensity. Temperature measurements may be useful as an adjunctive physiological test in the evaluation and documentation of autonomic dysfunction in LBP patients.

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INFRARED THERMOGRAPHIC IMAGING IN THE ASSESSMENT OF SUCCESSFUL BLOCK ON LUMBAR SYMPATHETIC GANGLION.
Kim YC, Bahk JH, Lee SC, Lee YW.
Department of Anesthesiology and Pain Medicine, Yonsei University College of Medicine, Yongdong Severance Hospital, Yonsei University College of Medicine, 146-92 Dogok-dong, Kangnam-gu, Seoul 135-720, Korea. ywleepain@yumc.yonsei.ac.kr

ABSTRACT
This study examined the net changes in temperature at various regions of the lower extremities in an attempt to identify the regions demonstrating the most significant temperature changes following a lumbar sympathetic ganglion block (LSGB). Thermography was performed before and after the LSGB in 26 sympathetic nerve system disorder cases. The inspection points were the anterior and posterior surfaces of the thigh, the knee and leg, and the dorsal and plantar surfaces of the feet. The net increases in skin temperature following the LSGB (deltaT(net)) at the plantar and dorsal surfaces of the feet, were 6.2 +/- 2.68 degrees C (mean +/- SD) and 3.9 +/- 1.89 degrees C, respectively, which were higher than those observed in the other regions of the lower extremities (p < 0.05). The areas, in order of decreasing deltaT(net), are as follows: the plantar surface of the foot, the dorsal surface of the foot, the shin, the anterior surface of the knee, the calf, the posterior surface of the knee, the anterior surface of the thigh, and the posterior surface of the thigh. There was one case of orthostatic hypotension during the thermography procedure. In conclusion, thermographic imaging is a useful method for demonstrating the success of a LSGB in various diseases. An evaluation of the deltaT(net) on the plantar surface of the feet using thermographic imaging is the most effective, simple, and safe method for assessing a successful LSGB.

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PLANTAR INFRARED THERMOGRAPHY MEASUREMENTS AND LOW BACK PAIN INTENSITY.
Zaproudina N, Ming Z, Hänninen OO.
Department of Physiology, University of Kuopio, Kuopio, Finland. nina.zaproudina@uku.fi

ABSTRACT
OBJECTIVE: To study the skin temperature disorders in low back pain (LBP) patients compared with reference persons without LBP and to evaluate the relationship between pain intensity and other clinical signs and temperature abnormalities.

METHODS: Sixty-five patients with unilateral chronic LBP with or without referred nonradicular leg pain (29 men and 36 women; age range, 30-51 years) and 20 reference persons without LBP (7 men and 13 women; age range, 30-49 years) participated in this study. The pain level was recorded by the use of a visual analog scale (0-100). Questionnaires and a series of spinal mobility tests (the modified Schober, straight leg-raising test, finger-floor distance, side bending) were used. Thermographic images of the low back area and legs (anterior, lateral, and posterior surfaces and the plantar surfaces of feet) were taken with an infrared video camera.

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degrees C) in most cases both in LBP patients and in reference persons, but plantar interside temperature difference was significantly higher in LBP patients.

CONCLUSION: Temperature changes of the plantar surface seem to be connected with LBP intensity. Temperature measurements may be useful as an adjunctive physiological test in the evaluation and documentation of autonomic dysfunction in LBP patients.

PMID: 16584947 [PubMed - indexed for MEDLINE]


THE CUT-OFF RATE OF SKIN TEMPERATURE CHANGE TO CONFIRM SUCCESSFUL LUMBAR SYMPATHETIC BLOCK.
Park SY, Nahm FS, Kim YC, Lee SC, Sim SE, Lee SJ.
Department of Anaesthesiology and Pain Medicine, Seoul National University College of Medicine, Seoul, Republic of Korea.

ABSTRACT
The purpose of this study was to find the best cut-off value for the rate of change in temperature of the plantar surface of the foot for predicting the success of lumbar sympathetic block (LSB). A total of 185 LSBs were performed on 82 patients via a posterolateral approach under fluoroscopic guidance. Successful LSB was considered to have occurred when changes in the ipsilateral temperature between pre-block and post-block were > or = 2 degrees C. A receiver operating characteristic (ROC) curve for the minimum rate of temperature change was constructed as a predictor of the onset of a successful LSB. The area under the ROC curve was 0.971 at the rate of 0.4 degrees C/min with a sensitivity of 89.5% and a specificity of 91.8%. Achieving a rate of temperature change of 0.4 degrees C/min within approximately 5 min of the injection of local anaesthetic could be used as an indicator of the onset of successful LSB.


THE RELATIVE INCREASE IN SKIN TEMPERATURE AFTER STELLATE GANGLION BLOCK IS PREDICTIVE OF A COMPLETE SYMPATHECTOMY OF THE HAND.
Stevens RA, Stotz A, Kao TC, Powar M, Burgess S, Kleinman B.
Department of Anesthesiology, Loyola University Medical Center, Maywood, Illinois, USA.

COMMENT IN:

ABSTRACT
BACKGROUND AND OBJECTIVES: Although an increase in skin temperature of the hand implies sympathetic block after stellate ganglion block (SGB), it does not indicate complete sympathetic block unless accompanied by an absence of sweating because skin temperature may increase even with a partial sympathetic block. This study examined the efficacy of the SGB to block sweating in the hand and to determine if the magnitude of temperature change in the hand is predictive of a negative sweat test.

METHODS: Fifty-nine SGBs were performed in 30 patients (15 women and 15 men) for diagnostic or therapeutic indications. Stellate ganglion block was performed via an anterior paratracheal approach at C6 using 15 mL 0.25% bupivacaine. Skin temperature was measured bilaterally on the index finger. A cobalt blue sweat test was performed bilaterally pre- and post-SGB on the middle finger. Successful sympathetic block after SGB was considered present when: (a) (change in ipsilateral temperature (postblock-preblock)] (Di)-[change in contralateral temperature] (Dc) > or = 1.5 degrees C; (b) Horner's syndrome present; and (c) sweat test changed from positive to negative. Logistical regression was applied to determine what value of Di - Dc could be used to predict a negative sweat test.

RESULTS: Thirty-six percent (21/59) of blocks met all three criteria. Of the blocks where Di - Dc > or = 1.5 degrees C, 72% (21/29) had a negative sweat test post-SGB. Of the blocks where Di - Dc < 1.5
degrees C, 37% (11/30) had a negative sweat test postblock. If \( \text{Di} - \text{Dc} \geq 2.0 \) degrees C, a negative sweat test could be predicted with 69 +/- 12% sensitivity and 85 +/- 10% specificity.

CONCLUSIONS: Stellate ganglion block often fails to increase skin temperature in the ipsilateral more than the contralateral hand. A value of \( \text{Di} - \text{Dc} \geq 2.0 \) degrees C was a good predictor of a sympathetic block, but was not sufficient to guarantee a complete sympathetic block of the hand after SGB in all cases. An apparently successful SGB as measured by "usual" clinical criteria may not result in a complete sympathectomy of the hand as is often assumed. Therefore, if obtaining a sympathectomy is important for diagnostic or therapeutic purposes, performing a sweat test provides important confirmatory evidence of the genuine success of the sympathetic block.

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THERMAL IMAGING IN ACUTE HERPES ZOSTER OR POST-ZOSTER NEURALGIA.
Ammer K, Schartelmueller T, Melnizky P.
Ludwig Boltzmann Research Institute for Physical Diagnostics, Hanuschkrankenhaus, Vienna, Austria. kammer1950@aol.com

ABSTRACT

BACKGROUND/AIMS: Asymmetry of normal skin temperature patterns has been reported in patients with herpetic disorders. The aim of the study was to describe the temperature distribution in patients suffering from acute herpes zoster or post-herpetic neuralgia.

METHODS: Biographic data, including age, gender and time of onset of the skin lesions, were recorded. The distribution of pain was investigated by pain mapping, and the intensity of pain and dysesthesia was quantified by a visual analogue scale. Infrared thermal images of the affected body regions were performed in all possible views using either an Agema 870 or a NEC San-ei Thermotracer.

RESULTS: The mean temperature difference between the affected and the unaffected sides of the body in all patients was 0.52 +/- 0.30 degrees C. Higher temperatures were detected in early cases with a disease duration of 1-9 days (mean temperature difference: 0.62 +/- 0.36 degrees C) than in patients with pain scores greater than 79 (mean temperature difference: 0.48 +/- 0.33 degrees C). Only 6 of 57 patients
presented with a temperature difference between the affected side and contralateral side of less than 0.2 degrees C.

CONCLUSION: Thermal asymmetry of the skin is a common finding in patients with acute herpes. However, the thermal patterns seem to correlate better with the duration of the disease than with the intensity of pain.


ASSESSMENT OF HAND OSTEOARTHRITIS: CORRELATION BETWEEN THERMOGRAPHIC AND RADIOGRAPHIC METHODS.
Varjú G, Pieper CF, Renner JB, Kraus VB.
Box 3416, Duke University Medical Center, Durham, NC 27710, USA.

ABSTRACT
OBJECTIVE: Anatomical stages of digital osteoarthritis (OA) have been characterized radiographically as progressing through sequential phases from normal to osteophyte formation, progressive loss of joint space, joint erosion and joint remodelling. Our study was designed to evaluate a physiological parameter, joint surface temperature, measured with computerized digital infrared thermal imaging, and its association with sequential stages of radiographic OA (rOA).

METHODS: Thermograms, radiographs and digital photographs were taken of both hands of 91 subjects with nodal hand OA. Temperature measurements were made on digits 2-5 at distal interphalangeal (DIP) joints, proximal interphalangeal (PIP) joints and metacarpophalangeal (MCP) joints (2184 joints in total). We fitted a repeated measures ANCOVA model to analyse the effects of rOA on temperature, with handedness, joint group, digit and NSAID use as covariates.

RESULTS: The reliability of the thermoscanning procedure was high (generalizability coefficient 0.899 for two scans performed 3 h apart). The mean joint temperature decreased with increasing rOA severity, defined by the Kellgren-Lawrence (KL) scale. The mean temperature of KL0 joints was significantly different from that of each of the other KL grades (P < 0.002). After adjustment for the other covariates, there was a strong association of rOA with joint surface temperature (P<0.001). The earliest discernible radiographic disease (KL1) was associated with a higher surface temperature than KL0 joints (P = 0.01) and a higher surface temperature than any other KL grade. Joint erosions were not associated with a change in joint temperature.

CONCLUSION: Joint surface temperature varied with the severity of rOA. Joints were warmer than normal at the onset of OA. As the severity of rOA worsened, joint surface temperature declined. These data support the supposition that digital OA progresses in phases initiated by an inflammatory process. The cooler surface temperatures in later stages of the disease may in part explain the paucity of symptoms reported by patients with hand OA.

PMID: 15126670 [PubMed - indexed for MEDLINE]


THERMAL SIGNATURE ANALYSIS AS A NOVEL METHOD FOR EVALUATING INFLAMMATORY ARTHRITIS ACTIVITY.
Brenner M, Braun C, Oster M, Gulko PS.
The Robert S Boas Center for Genomics and Human Genetics, North Shore-LIJ Research Institute, 350 Community Drive, Manhasset, NY 11030, USA.

ABSTRACT
OBJECTIVE: To examine the potential usefulness of a novel thermal imaging technique to evaluate and monitor inflammatory arthritis activity in small joints using rat models, and to determine whether thermal changes can be used to detect preclinical stages of synovitis.

METHODS: Three different rat strains were studied in a model of inflammatory arthritis of the ankle induced by an intra-articular (IA) injection of complete Freund's adjuvant (CFA), compared with the contralateral ankle injected with normal saline. Arthritis activity and severity scores, ankle diameters, pain

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related posture scores, and thermal images were obtained at 10 different times between 0 h (before induction) and day 7. The pristane induced arthritis (PIA) model was used to study preclinical synovitis. Thermal images were obtained at each time point using the TSA ImagIR system and were digitally analysed.

RESULTS: Rats developed similar ankle arthritis detected six hours after the IA injection of CFA, which persisted for seven days. All ankle clinical indices, including arthritis activity and severity scores, correlated significantly with ankle thermal imaging changes in the monoarthritis model (p<0.003). No thermal imaging changes were detected in preclinical stages of PIA. However, PIA onset coincided with increased ankle thermal signature.

CONCLUSIONS: Thermal measurements correlated significantly with arthritis activity and severity indices. The technique was highly sensitive and could measure directly two cardinal signs of inflammation (warmth and oedema, based on ankle diameter) in an area (ankle) that is less than half the size of a human interphalangeal joint, suggesting a potential use in drug trials or clinical practice.

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USE OF A PORTABLE THERMAL IMAGING UNIT AS A RAPID, QUANTITATIVE METHOD OF EVALUATING INFLAMMATION AND EXPERIMENTAL ARTHRITIS.

Sanchez BM, Lesch M, Brammer D, Bove SE, Thiel M, Kilgore KS.
Department of Inflammation Biology, Pfizer Global Research and Development, Michigan Laboratories, Ann Arbor, MI 48105, USA.

ABSTRACT

INTRODUCTION: Thermal imaging has been utilized, both preclinically and clinically, as a tool for assessing inflammation and arthritis. However, previous studies have employed large, relatively immobile devises to obtain the thermal signature of the tissue of interest. The present study describes the characterization of a hand-held thermal imaging device in a preclinical model of general inflammation and a model of rheumatoid arthritis (RA).

METHODS: A hand-held ThermoView Ti30 portable thermal imager was utilized to detect the temporal changes in thermal signatures in rat model of carrageenan-induced paw edema (CFE) and a model of collagen-induced arthritis (CIA). In both in vivo models, the kinetics of the thermal changes were correlated to footpad swelling. In addition, the CFE model was utilized to examine the ability of this technology to delineate pharmacodynamic changes in thermal signature in response to the non-steroidal anti-inflammatory drug indomethacin (10 mg/kg; p.o.).

RESULTS: Thermal analysis of rat paws in the CFE model demonstrated a significant increase in the mean temperature difference between the inflamed and contralateral control paw by two hours post-carrageenan (8.3 +/-0.5 degrees F). Indomethacin significantly decreased the mean temperature difference in treated animals as compared to vehicle. In the rat CIA model, increases in footpad temperature, as determined by thermal imaging, were significantly elevated by Day 11 and remained elevated throughout the duration of the 28 day protocol. Thermal changes were also found to precede increases in footpad edema (swelling).

DISCUSSION: The results of this study demonstrate that the hand-held thermal imaging technology represents a rapid, highly-reproducible method by which to quantitate the degree of inflammation in rat models of general inflammation and rheumatoid arthritis. The ability to detect pharmacodynamic responses in paw temperature suggests that this technology may be a useful tool for the development of pharmacologic interventions for the treatment inflammation-related pathologies.

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DYNAMIC INFRARED IMAGING OF CUTANEOUS MELANOMA AND NORMAL SKIN IN PATIENTS TREATED WITH BNCT.
Dpto. de Instrumentación y Control, Comisión Nacional de Energía Atómica, Av. del Libertador 8250 (1429), Buenos Aires, Argentina. santacr@cnea.gov.ar

ABSTRACT
We recently initiated a program aimed to investigate the suitability of dynamic infrared imaging for following-up nodular melanoma patients treated with BNCT. The reason that makes infrared imaging attractive is the fact that it constitutes a functional and non-invasive imaging method, providing information on the normal and abnormal physiologic response of the nervous and vascular systems, as well as the local metabolic rate and inflammatory processes that ultimately appear as differences in the skin temperature. An infrared camera, with a focal plane array of 320 x 240 uncooled ferroelectric detectors is employed, which provides a video stream of the infrared emission in the 7-14 microm wavelength band. A double blackbody is used as reference for absolute temperature calibration. After following a protocol for patient preparation and acclimatization, a basal study is performed. Subsequently, the anatomic region of interest is subjected to a provocation test (a cold stimulus), which induces an autonomic vasoconstriction reflex in normal structures, thus enhancing the thermal contrast due to the differences in the vasculature of the different skin regions. Radiation erythema reactions and melanoma nodules possess typically a faster temperature recovery than healthy, non-irradiated skin. However, some other non-pathological structures are also detectable by infrared imaging, (e.g. scars, vessels, arteriovenous anastomoses and injuries), thus requiring a multi-study comparison in order to discriminate the tumor signal. Besides the superficial nodules, which are readily noticeable by infrared imaging, we have detected thermal signals that are coincident with the location of non-palpable nodules, which are observable by CT and ultrasound. Diffuse regions of fast temperature recovery after a cold stimulus were observed between the third and sixth weeks post-BNCT, concurrent with the clinical manifestation of radiation erythema. The location of the erythematous visible and infrared regions is consistent with the 3D dosimetry calculations.

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**THE USEFULNESS OF THERMOGRAPHY AS A DIAGNOSTIC METHOD IN DERMATOLOGY ON THE BASIS OF CLINICAL TRIALS IN 2001-2005**.

Mikulska D, Maleszka R, Parafiniuk M.

**ABSTRACT**

**INTRODUCTION:** Thermal imaging is a powerful tool for the study of temperature of the human body. Even though the skin lies superficially and as such is an ideal object for thermography, the method has not gained widespread acceptance as a diagnostic modality in dermatology. The aim of this study was to describe the methodology of thermography for applications in dermatology and to develop a method for computer processing of thermograms. In addition, we searched for skin factors, which could be responsible for false results in thermography and errors during interpretation of thermal images.

**MATERIAL AND METHODS:** Clinical trials were performed in 2001-2005. We enrolled 230 patients, including 70 who were hospitalized at the Department of Dermatology and Venereal Diseases, Pomeranian Medical University in Szczecin, and 160 who were referred from the Outpatient Dermatology Clinic. The control group consisted of 20 healthy volunteers. The skin was examined to disclose primary and secondary skin lesions. Thermography was performed according to recommendations of the European Association of Thermology. Therma CAM SC500 infrared camera was used and the thermograms were analyzed with Therma CAM 200 Professional software.

**RESULTS:** 1. Areas of the skin with inflammatory reactions resulting from allergy, infection or other process causing local hyperthermia could be visualized. 2. Primary eruptions (papules, nodules) and secondary eruptions (scales) presenting as hypothermia in thermography were found in the skin of the patients and some individuals from the control group. 3. Interpretation of thermograms in dermatoses can be done using various colour scales, like "rain", "iron", "medical", "grey", "greyred" and the three-dimensional scale.

**CONCLUSIONS:** 1. Thermography is a useful diagnostic method in dermatology. 2. The normal thermogram, as well as thermograms specific for various dermatoses need to be described. 3. Compliance is indispensable with rules and principles concerning the examination itself, as well as analysis and clinical interpretation of the results. 4. The person performing the examination and interpreting the thermograms should take part in history-taking and physical examination of the patient and should be familiar with photographic documentation of the examined regions of the skin.

**INFRARED THERMOGRAPHY AS AN ACCESS PATHWAY FOR INDIVIDUALS WITH SEVERE MOTOR IMPAIRMENTS.**

Memarian N, Venetsanopoulos AN, Chau T.
Institute of Biomaterials and Biomedical Engineering, University of Toronto, Toronto, Canada.

**ABSTRACT**

**BACKGROUND:** People with severe motor impairments often require an alternative access pathway, such as a binary switch, to communicate and to interact with their environment. A wide range of access pathways have been developed from simple mechanical switches to sophisticated physiological ones. In this manuscript we report the inaugural investigation of infrared thermography as a non-invasive and non-contact access pathway by which individuals with disabilities can interact and perhaps eventually communicate.

**METHODS:** Our method exploits the local temperature changes associated with mouth opening/closing to enable a highly sensitive and specific binary switch. Ten participants (two with severe disabilities) provided examples of mouth opening and closing. Thermographic videos of each participant were analyzed with suitable software.

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were recorded with an infrared thermal camera and processed using a computerized algorithm. The algorithm detected a mouth open-close pattern using a combination of adaptive thermal intensity filtering, motion tracking and morphological analysis.

RESULTS: High detection sensitivity and low error rate were achieved for the majority of the participants (mean sensitivity of all participants: 88.5% +/- 11.3; mean specificity of all participants: 99.4% +/- 0.7). The algorithm performance was robust against participant motion and changes in the background scene.

CONCLUSION: Our findings suggest that further research on the infrared thermographic access pathway is warranted. Flexible camera location, convenience of use and robustness to ambient lighting levels, changes in background scene and extraneous body movements make this a potential new access modality that can be used night or day in unconstrained environments.


A PYROELECTRIC THERMAL IMAGING SYSTEM FOR USE IN MEDICAL DIAGNOSIS.

Black CM, Clark RP, Darton K, Goff MR, Norman TD, Spikes HA.
Department of Rheumatology, Royal Free Hospital, Hampstead, London, UK.

ABSTRACT

The value of infra-red thermography in a number of pathologies, notably rheumatology and vascular diseases, is becoming well established. However, the high cost of thermal scanners and the associated image processing computers has been a limitation to the widespread availability of this technique to the clinical community. This paper describes a relatively inexpensive thermographic system based on a pyroelectric vidicon scanner and a microcomputer. Software has been written with particular reference to the use of thermography in rheumatoid arthritis and vasospastic conditions such as Raynaud's phenomenon.

[STUDY ON TECHNIQUE OF THERMAL IMAGING AND SOFT-SENSING].

Qu J, Liao Q, Zhang X.
Faculty of Biomedical Engineering, The Fourth Military Medical University, Xi'an 710033, China.

ABSTRACT

The differences of body surface temperature reflect the changes of the status of body tissues. In this regard, detecting and forecasting the changes of the surface temperature is the objective of the technique of medical thermal diagnosis, and how to diagnose the disease earlier with the use of thermal images is a common problem in the field of medical diagnostics and biological engineering. The authors put forward that utilizing the soft-sensing techniques in the field of engineering will be a good solution.

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FUNCTIONAL INFRARED IMAGING IN MEDICINE: A QUANTITATIVE DIAGNOSTIC APPROACH.

Merla A, Romani GL.

ABSTRACT

The role and the potentialities of high-resolution infrared thermography, combined to bio-heat modelling, have been largely described in the last years in a wide variety of biomedical applications. Quantitative assessment over time of the cutaneous temperature and/or of other biomedical parameters related to the temperature (e.g., cutaneous blood flow, thermal inertia, sympathetic skin response) allows for a better and more complete understanding and description of functional processes involved and/or
altered in presence of ailment and interfering with the regular cutaneous thermoregulation. Such an approach to thermal medical imaging requires both new methodologies and tools, like diagnostic paradigms, appropriate software for data analysis and, even, a completely new way to look at data processing. In this paper, some of the studies recently made in our laboratory are presented and described, with the general intent of introducing the reader to these innovative methods to obtain quantitative diagnostic tools based on thermal imaging.

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The role and the potentialities of high-resolution infrared thermography, combined to bio-heat modelling, have been largely described in the last years in a wide variety of biomedical applications. Quantitative assessment over time of the cutaneous temperature and/or of other biomedical parameters related to the temperature (e.g., cutaneous blood flow, thermal inertia, sympathetic skin response) allows for a better and more complete understanding and description of functional processes involved and/or altered in presence of ailment and interfering with the regular cutaneous thermoregulation. Such an approach to thermal medical imaging requires both new methodologies and tools, like diagnostic paradigms, appropriate software for data analysis and, even, a completely new way to look at data processing. In this paper, some of the studies recently made in our laboratory are presented and described, with the general intent of introducing the reader to these innovative methods to obtain quantitative diagnostic tools based on thermal imaging.

IMAGE SEGMENTATION OF HUMAN FOREARMS IN INFRARED IMAGE.

Yoon TH, Kim KS, Lee JW, Kim DJ, Song CG.
Coll. of Biomed. & Health Sci., Konkuk Univ., Chungju, Korea. apple@konkuk.ac.kr

ABSTRACT

Due to the possibility of detecting certain physiological conditions from thermal features of the skin surface acquired from infrared thermal imaging, the health conditions of a person can be revealed by analyzing the thermal signatures of his or her forearms regions in an infrared image. The assessment of hand’s or arm’s temperature distribution for clinical diagnosis or monitoring requires the confinement of region of interest (ROI) on the forearms regions. Hence, the purpose of this study is automatically to segment forearms regions in an infrared thermal image so that the clinicians can able to locate the interested regions and extract the skin temperature distributions with a high degree of reproducibility.
OVERLAY OF THERMAL AND VISUAL MEDICAL IMAGES USING SKIN DETECTION AND IMAGE REGISTRATION.
Schaefer G, Tait R, Zhu SY.
School of Computing & Informatics, Nottingham Trent University, Nottingham, UK.
Gerald.Schaefer@ntu.ac.uk

ABSTRACT
Thermography captures the temperature distribution of the human skin and is employed in various medical applications. Often it is useful to cross-reference the resulting thermograms with visual images of the patient, either to see which part of the anatomy is affected by a certain disease or to judge the efficacy of the treatment. An attractive approach to provide this information is to overlay the two image types and show a composite image to the clinician. Producing such an overlay however is a non-trivial task due to differences in image capturing conditions of the two modalities. In this paper we introduce an approach that produces accurate overlays of thermal and visual medical images. First unnecessary background information of the visual part are removed by an image segmentation step based on skin detection. The thermal image is then aligned through an intensity based image registration technique. Experimental results based on an set of visual-thermal image pairs demonstrate the effectiveness of the proposed approach.

PMID: 17946430 [PubMed - indexed for MEDLINE]

PERIORBITAL THERMAL SIGNAL EXTRACTION AND APPLICATIONS.
Shastri D, Tsiamyrtzis P, Pavlidis I.
Computational Physiology Lab, University of Houston, Houston, TX 77204-30101, USA. dshastri@uh.edu

ABSTRACT
We propose a novel method that localizes the thermal footprint of the facial and ophthalmic arterial-venous complexes in the periorbital area. This footprint is used to extract the mean thermal signal over time (periorbital signal), which is a correlate of the blood supply to the ocular muscle. Previous work demonstrated that the periorbital signal is associated to autonomic responses and it changes significantly upon the onset of instantaneous stress. The present method enables accurate and consistent extraction of this signal. It aims to replace the heuristic segmentation approach that has been used in stress quantification thus far. Applications in computational psychology and particularly in deception detection are the first to benefit from this new technology. We tested the method on thermal videos of 39 subjects who faced stressful interrogation for a mock crime. The results show that the proposed approach has improved the deception classification success rate to 82%, which is 20% higher compared to the previous approach.

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FOREHEAD THERMAL SIGNATURE EXTRACTION IN LIE DETECTION.
Zhu Z, Tsiamyrtzis P, Pavlidis I.
Computational Physiology Lab, University of Houston, Houston 77204-30101, Texas, USA.
zhu@cs.uh.edu

ABSTRACT
Previous work demonstrated that facial thermography can be successful in lie detection. In those studies the development was based on the thermal signature of the periorbital region. In the present paper a new source of psycho-physiological information is proposed: the forehead. We found that the corrugator muscle in the forehead is more active than usual, when the individual experiences sustained stress. As a result, more blood flows through the supraorbital vasculature, increasing the cutaneous forehead temperature. In order to monitor the thermal signature of the forehead's cutaneous tissue, a segmentation method based on active contours has been developed. This creates a virtual forehead probe that can monitor stress levels by measuring thermal radiation over the supraorbital vessels. Thermal videos of 38 subjects under interrogation for a mock crime scenario were used to test the new approach. The results show that the recovered forehead signal, enables 76.3% success rate in deceptive state classification. Thus, the forehead channel shows promise in lie detection.
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THERMAL PARAMETRIC IMAGING IN THE EVALUATION OF SKIN BURN DEPTH.
Rumi?ski J, Kaczmarek M, Renkielska A, Nowakowski A.
Department of Biomedical Engineering, Gdansk University of Technology, Narutowicza 11/12, Poland. jwr@computer.org

ABSTRACT

The aim of this paper is to determine the extent to which infrared (IR) thermal imaging may be used for skin burn depth evaluation. The analysis can be made on the basis of the development of a thermal model of the burned skin. Different methods such as the traditional clinical visual approach and the IR imaging modalities of static IR thermal imaging, active IR thermal imaging and active-dynamic IR thermal imaging (ADT) are analyzed from the point of view of skin burn depth diagnostics. In ADT, a new approach is proposed on the basis of parametric image synthesis. Calculation software is implemented for single-node and distributed systems. The properties of all the methods are verified in experiments using phantoms and subsequently in vivo with animals with a reference histopathological examination. The results indicate that it is possible to distinguish objectively and quantitatively burns which will heal spontaneously within three weeks of infliction and which should be treated conservatively from those which need surgery because they will not heal within this period.

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ASSESSMENT OF BURN DEPTH AND BURN WOUND HEALING POTENTIAL.
Monstrey S, Hoeksema H, Verbelen J, Pirayesh A, Blondeel P.
Department of Plastic Surgery, Gent University Hospital, De Pintelaan 185, Gent, Belgium. stan.monstrey@ugen.be

ABSTRACT

The depth of a burn wound and/or its healing potential are the most important determinants of the therapeutic management and of the residual morbidity or scarring. Traditionally, burn surgeons divide burns into superficial which heal by rapid re-epithelialization with minimal scarring and deep burns requiring surgical therapy. Clinical assessment remains the most frequent technique to measure the depth of a burn wound although this has been shown to be accurate in only 60-75% of the cases, even when carried out by an experienced burn surgeon. In this article we review all current modalities useful to provide an objective assessment of the burn wound depth, from simple clinical evaluation to biopsy and histology and to various perfusion measurement techniques such as thermography, vital dyes, video angiography, video microscopy, and laser Doppler techniques. The different needs according to the different diagnostic situations are considered. It is concluded that for the initial emergency assessment, the use of telemetry and simple burn photographs are the best option, that for research purposes a wide range of different techniques can be used but that, most importantly, for the actual treatment decisions, laser Doppler imaging is the only technique that has been shown to accurately predict wound outcome with a large weight of evidence. Moreover this technique has been approved for burn depth assessment by regulatory bodies including the FDA.

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