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Dynamic thermography of shape memory alloy surgical fixators

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Summary

Thermally activated shape memory alloy (SMA) adopts a predefined parent shape when it is heated beyond a critical temperature. This phenomenon can be exploited in various devices and actuators. Our present interest relates to the use of NiTi SMA as a tissue approximation device in minimal access surgery (MAS). The function of such suture-fixators is to replace conventional intracorporeal suturing as this is a difficult and laborious task during minimal access operations because of the kinematic restrictions imposed by the MAS approach. Of critical importance during the thermal activation of the suture-fixator is the dissipation of heat into the surrounding tissue. If tissue temperature becomes excessive, then local necrosis can occur which may compromise the integrity of anastomosis or 'suture' line and lead to dehiscence and leakage with serious clinical consequences. In order to quantitatively monitor heat dissipation processes in real time, we have undertaken thermographic investigations using an infrared imaging camera. Mathematical modelling suggests that the implementation of pulsed (t ≈0.1s) heating minimises heat loss to the surroundings. Therefore, the specific aim of the present study was to determine whether pulsed current heating could affect fixator closure whilst maintaining a safe (T<45°C) temperature along the body of the fixator. We present observational evidence confirming this assertion and therefore validating future employment of such devices in MAS procedures.

Keywords: Thermography, Shape Memory Alloy, Laparoscopy, Keyhole Surgery

Dynamische Thermographie von an Form erinnernden chirurgischen Metallklammern

Thermisch aktivierte, Form erinnernde Legierungen (FEL) erhalten eine vorbestimmte Form, wenn sie über eine kritische Temperatur hinaus erhitzt werden. Dieses Phänomen kann in unterschiedlichen Geräten genützt werden. Unser aktuelles Interesse gilt dem Einsatz von NiTi Legierungen als Klammermaterial in der minimal traumatischen Chirurgie (MAC). Solche Klammern sollen das herkömmliche Nahtmaterial ersetzen, da ihre Verwendung wegen der für die MAC typischen Bewegungseinschränkung des Operateurs schwierig und arbeitsaufwendig ist. Die Wärmeabgabe an das umgebende Gewebe ist der kritische Punkt bei der thermischen Aktivierung der Klammern. Bei sehr hoher Temperaturentwicklung können lokale Nekrosen entstehen, die ihrerseits die Integrität einer Anastomose oder der Naht beeinträchtigen und damit zur Wunddehiszenz mit beträchtlichen klinischen Komplikationen führen können. Um die Menge der Wärmeabgabe in Echtzeit zu überwachen, haben wir mittels einer Infrarotkamera thermographische Untersuchungen vorgenommen. Eine mathematische Modellbildung hat vorausgesagt, dass ein Erwärmung mittels Wärmeimpulsen(t ≈0,1s) die Wärmeabgabe in das umgebende Gewebe verringern wird. Deshalb war es das erklärte Ziel unserer Studie festzustellen, ob eine Erwärmung mittels Stromimpulsen den Schluss einer chirurgischen Klammer beeinträchtigt, wenn die Temperatur im Bereich der Klammer sich in einem sicheren Bereich(T<45°C) bewegt. Es werden beweiskräftige Beobachtungen dargestellt, die diese Annahme bestätigen und deshalb den zukünftigen Einsatz derartiger Geräte bei minimal traumatisch-chirurgischen Eingriffen empfehlen.

Schlüsselwörter: Thermographie, Form erinnernde Legierung, Laparoskopie, Knopfloch-Chirurgie

Introduction

In a medical context, thermography is most often associated with mapping diseased regions of the body via thermal contrast with the surrounding tissue [1]. Our motivation for undertaking thermographic investigations is some what different in that our goal is to monitor temperature on thermally activated shape memory alloy (SMA) sutures. SMA undergoes a crystallographic phase transition from a martensite structure to an austenite phase when the system temperature exceeds some critical threshold. There is a large recoverable strain accompanying the martensitic phase transformation [2]. This property can be harnessed for a number of device and actuator applications [3]. In our own context, SMA based devices provide an effective alternative to conventional thread-based suturing, which is a difficult and time-consuming procedure in minimal access (laparoscopic or keyhole) surgery (MAS), due to a reduction in both tactile feedback and limited degrees of movement (essentially only 4) imposed by the endoscopic approach; during which long (300mm) surgical instruments introduced through narrow cylindrical ports are used to perform the operation.

It is critical that thermally-activated SMA tissue-approximation systems must not impair the viability of the local tissues to be approximated through overheating, as this would cause local necrosis that precludes healing of the suture line or anastomosis. In the human, the maximum temperature tolerance that will not cause permanent tissue damage is reported as 45°C [4].

For modelling purposes, the physical situation may be approximated with the differential equation for heat flow [5]:

$$\frac{1}{\alpha}\frac{\partial T(\mathbf{r},t)}{\partial t} = \nabla^2 T(\mathbf{r},t) + \frac{g(\mathbf{r},t)}{k}$$

where g ($\mathbf{r}$,t) is a function describing the rate of heat generation in the system, $\mathbf{r}$ is a spatial vector, t represents time, T is the temperature, and α is the thermal diffusivity of the medium, defined thus,

$$\alpha = \frac{k}{\rho c_p}$$

combining k, the thermal conductivity, together with the density, ρ and the specific heat, c_p.

Calculations based on this equation show that closure of the SMA device via a pulsed ($t \approx 0.1$s) energy source ensures that heat loss to the surrounding tissue is minimised [6]. Adoption of such a pulsed approach, together with the small size of the SMA sutures (and limited extent of their local volume of influence) negates the use of conventional thermometry or thermocouple approaches for monitoring the temperature changes, as these techniques exhibit comparatively slow reaction times and indeed, may affect the local thermal environment of small thermal systems by their very presence. For this reason we chose to undertake our measurements using a high specification thermal imaging system. In this article we describe initial proof of concept experiments illustrating the ex-vivo temperature activation of SMA fixators via the application of short pulses of electrical current. Our preliminary goal has been to quantitatively monitor the temperature on the suture body in order to check whether pulsed heating can induce suture self closure whilst containing the temperature within a safe regime. The experimental measurements suggest that this is indeed the case: pulsed current heating can affect closure without excessive temperature rise on the body of the SMA alloy suture.

Method

Figure 1(a) shows a schematic illustration of the SMA fixator staple, which exhibits dimensions of 5mm by 2.5mm, and is fashioned from 0.5mm diameter wire (55.5:44.5 wt% Ni:Ti (Thomas Bolton, UK)) and mechanically tapered to sharpen the prongs. The fixator was configured to have a closed parent shape whilst in the high temperature austenitic phase. Subsequent cooling of the SMA to obtain the martensitic form then allows the material to be plastically deformed into the open staple shape as illustrated in figure 1(a). Any subsequent heating beyond the austenitic transition temperature then causes the shape memory effect to occur and the SMA fixator will adopt its closed parent shape.

We had determined from the outset to undertake computational finite element (FE) (ANSYS (7)) based modelling of the dynamic thermal processes involved and to validate our model with experimental data generated ex-vivo. Indeed, the illustration in figure 1(a) highlights the refined spatial finite element mesh used for computational modelling. Imaging must therefore be undertaken with high spatial and temporal resolution in order to provide data useful for subsequent validation of the model. The measurements were undertaken under ambient conditions using a Stirling cooled FLIR

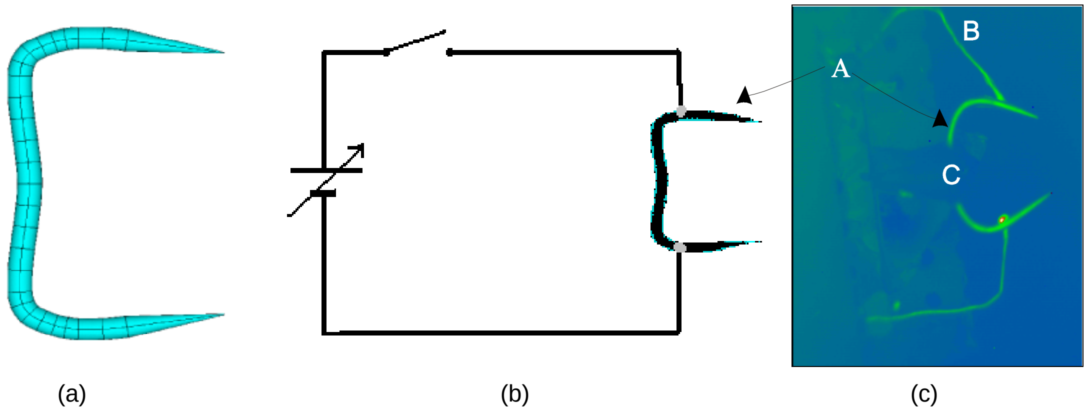

Figure 1
(a). FE schematic of an SMA fixator staple, constructed from 0.5mm diameter NiTi wire.
(b) The experiments were undertaken by supplying a pulsed current to the fixator via thin copper supply rails. The copper wires were conductively bonded to the fixator using silver paint. A short pulse could be administered by closure of the switch.
(c) Thermogram of the experimental set-up showing fixator (A) which is resistively heated via thin copper contacts (B). The fixator is held by embedding the middle section of its backbone within a small blob of epoxy resin (C).

SC3000 thermal imaging camera operating with an image acquisition rate of 50Hz. Emissivity (e) correction was controlled automatically through declaration of specific material parameters within the software: a value of e = 0.9 was used, in accordance with similar composition Ni alloys listed in the Handbook of Chemistry and Physics [8]. Figure 1(b) shows a simplified schematic of the electrical circuit involved: the fixator is bonded to thin Cu supply rails via silver paint and the circuit can be completed by timed closure of a switch. The switch was manually activated via a Morse key and timings are estimated from the thermogram sequence: the thermal signature from the adhesion contacts act as a convenient indicator of the duration of current flow through the system. A second generation approach using a programmable PC controlled switch is presently under development. From this we hope to accurately determine the effect of both pulse height and width on temperature generation and temporal distribution along the suture-fixator.

The high temperature austenitic phase was thus induced by resistive heating on the fixator via an electrical current pulse (2A, for 0.16s). The backbone of the fixator was held fast by embedding it within a blob of epoxy resin (labelled C in figure 1(c)) which was supported on a plastic substrate. Orientations were such that the camera look-angle was exactly orthogonal

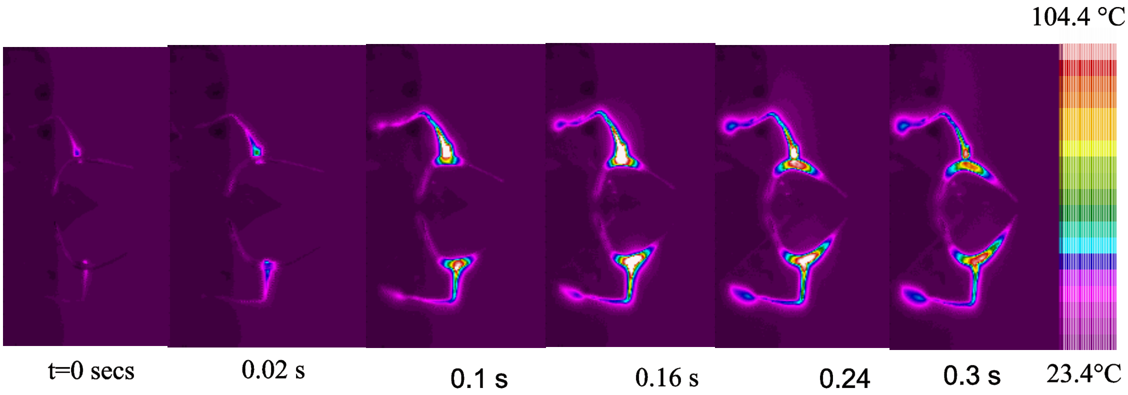

Figure 2.
Time lapse sequence of fixator closure taken with infrared camera using a 100mm close-up lens. The arms of the fixator staple move from the open position (start angles of about 10 degrees to the horizontal) to the closed position (45 degrees) within about 0.3 seconds. Heating is pronounced at the silver painted electrical connection nodes, but rises only by about 5.5°C on the fixator backbone.

to the plane of the fixator, (i.e. into the page when viewing figure 1(a). Figure 1(c) shows a thermogram illustrating the architecture of the experimental set-up used to monitor temperature distribution on the fixators as a function of time.

Results

Figure 2 shows six frames from a typical time-lapse thermography sequence acquired using the thermal camera in combination with a close-up lens capable of 100 mm pixel resolution. Timings are taken relative to the initiation of the current pulse, with the first frame in the sequence of figure 2 captured just as the current begins. At this stage the entire fixator is in thermal equilibrium with the ambient at 23.4°C and is barely visible against the background. However, small hot spots are apparent at the bonding sites between the current supply wires and the fixator. This is because the silver paint used to form these thin electrically conducting adhesions has a much higher resistance ($\geq 0.5\Omega$) compared with either the copper supply wires or the fixator (0.02Ω) itself and thus is resistively heated much more effectively by the electrical current, as is clearly evident in figure 2. By monitoring these hot-spots from initiation until maximum temperature is achieved, we have a convenient estimate for the duration of the applied pulse. Temperature rise at the hot spots is roughly linear over the duration of the pulse, and reached a maximum of about 160°C, (as shown by the red plot in figure 3b). The heat generated at these bonding junctions subsequently propagates along the thin copper wire and and throughout the fixator itself. The temperature is seen to rise more quickly in the copper wire (frames 2-3 of figure 2) compared with the SMA (frames 4-6, figure 2) due to the lower specific heat of Cu compared with SMA. Interestingly, the temperature of the fixator in the earliest stages (as illustrated in black in figure 3b) does not actually rise much beyond ambient, even though the extent of fixator closure is substantial (figure 3a). The temperature of the fixator backbone (measured between the Cu wire-to-fixator adhesion point and the epoxy fixed region that is arrowed in frame 2 of figure 2) rises only by about 5.5°C above its initial ambient equilibrium level whilst complete closure of the fixator (i.e. both fixator arms having deformed through an absolute angle of approximately 45 degrees towards each other) is seen to occur on the order of 0.3s after pulse initiation. This indicates that the austenitic transition

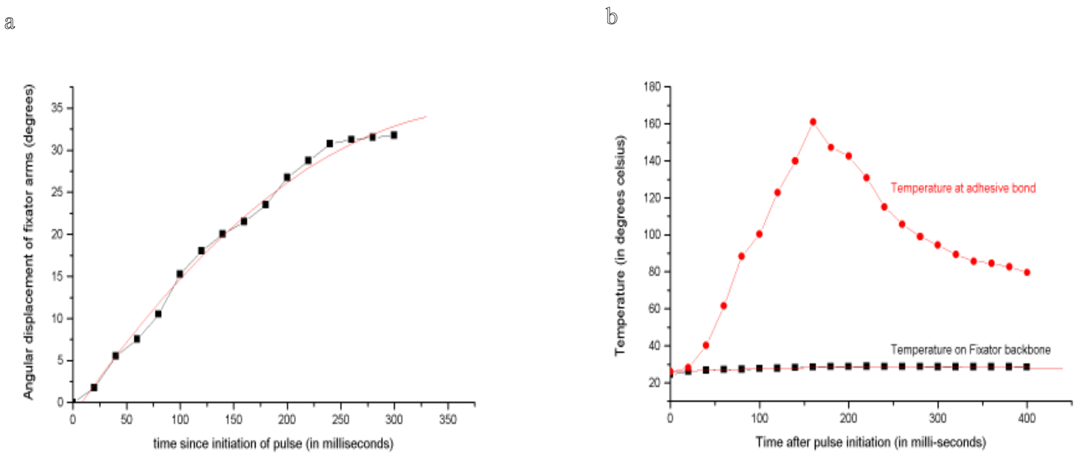

Figure 3
(a) Average angular displacement of the two fixator arms as a function of time. The graph is approximately linear over the duration of the current pulse (0.16s) and the rate of closure in this regime is 0.28 radians per millisecond. When the pulse ends, the rate of closure is seen to gradually slow, as indicated by the polynomial fit [generated with Microcal Origin V4.1] to the data.
(b) The temperature of the fixator backbone undergoes a sharp jump of 2.8°C in the initial 20 milliseconds after the pulse, and then undergoes only a gradual heating to a maximum of 28.8°C within 240 milliseconds of pulse initiation. At the adhesive bonding sites where the fixator and supply wires are joined however, the temperature rapidly rises to about 160°C over the pulse duration and then decays exponentially with time after the pulse has ended.

start temperature, A_s , was just above ambient room temperature, as is desirable [6], and also that the austenite finish temperature, A_f , was within only a few degrees of this. This measurement and observation tallies well with those previously found using the complementary technique of differential scanning calorimetry (DSC) [6].

Discussion

In this ex-vivo study, real time thermographic imaging provides confirmation that SMA suture-fixators can be thermally activated via pulsed current resistive heating. Moreover, the quantitative data acquired by the high resolution thermal imaging camera indicates that suture-fixator temperatures are maintained within a clinically safe region that can be exploited within the context of minimal access surgery. We postulate that the local tissue temperatures around the limbs of the suture-fixator in the in-vivo clinical situation would be lower because of the heat-sink effect of the circulating blood. In-vivo animal experiments are planned to document the further reduction of the temperature profile when these SMA suture fixators are used in living blood perfused tissues. The results also indicate that the heat conductivity of the arms of the applicator system and their contact time with the suture-fixator during the heating pulse are crucial factors in the design of a safe delivery system for these constructs.

The use of a conducting adhesive to ensure a good conductive path from the supply wires to the suture-fixator is a construction that would not be present in the end product suture delivery device. In this latter case, the pulse will be generated as the SMA fixators are instantaneously slid over a small hot plate at the exit port of the delivery system. However, for the purposes of illustrating our proof of concept, the use of silver paint offered several advantages, as well as ensuring open architecture and thus good visibility during the experiments. These advantages were: (i) the paint is applied at room temperature (as opposed to high temperature molten solder bonding) and thus ensures the SMA suture-fixator remains in the martensitic form until the current pulse is applied; (ii) due to the very low dimension of the resultant conductive bridge, the paint has an intrinsically high resistance, and therefore undergoes fast resistive heating upon application of the current pulse. This provides a convenient thermal signature against which the pulse width can be estimated.

The major complication due to the use of silver paint arises when we consider the effect of the current pulse on the SMA suture-fixator. Two possibilties arise as to the closure mechanism:

(i) the current pulse causes resistive heating on the SMA fixator, inducing the austenitic phase transformation and forcing the SMA suture into its closed parent shape;

(ii) the generation of high temperatures at the hot-spots and subsequent conduction throughout the alloy structure induces the phase transformation and causes suture closure. For the data illustrated in figure 2, it is likely that a combination of both these factors contribute to the overall closure process.

However, when pulses are applied to SMA suture fixators that are pressed into mechanical contact with the supply wires (rather than adhesively bonded) and similar pulses (2A, circa 0.1s) are applied, we find that closure of the devices is also successfully achieved. Evidently, hot-spot generation due to silver paint is not a prerequisite for affecting pulsed suture closure. Future ‘paint-free’ experiments are planned with a custom designed SMA suture holder and should allow for a more intuitive picture of the fixators’ response to specific pulse parameters.

Finally, we have observed that the high temporal and spatial resolution of the digitally archived data is most useful for the accurate validation of computational models.

Acknowledgements

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Objective Detection of Breast Cancer by DAT – an Update

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Summary

The feasibility of breast cancer detection using dynamic computerized infrared imaging has been demonstrated in a preliminary clinical study of 100 patients including 34 cases of pathologically established breast cancer and 66 with benign breast lesions found by pathology. Several alternative parameters and combinations of these have been tested for their effectiveness in separating cancerous breasts from benign ones. Also the separation between ductal carcinoma in situ and invasive cancer in breasts has been explored. This report, which updates the findings published in this journal in 1999 on a much smaller number of cases and with less elaborate analysis, confirms the adequacy of DAT as an objective testing method that can detect cancer in human breasts with a >98% sensitivity and >98% specificity.

Key words: Skin temperature modulation, Perfusion, Breast cancer, Dynamic area telethermometry, Nitric oxide, Cancer marker, Computerised diagnosis

Zuverlässige Entdeckung des Brustkrebses mittels dynamisch-flächiger Thermometrie (DFT)- eine aktuelle Ergänzung

Die Brauchbarkeit der Brustkrebserkennung mittels dynamischer computer- gestützer Infrarotthermographie wurde in einer vorläufigen klinischen Studie an 100 Patientinnen gezeigt, wobei 34 Patientinnen histologisch gesicherte Brustkarzinome hatten und bei 66 Personen gesicherte benigne Läsionen vor lagen. Verschiedene alternative Parameter und deren Kombinationen wurden hinsichtlich ihrer Fähigkeit überprüft nachweislich karzinomatöse Brüste von Brüsten mit benignen Läsionen zu unterscheiden. Ebenso wurde untersucht, ob ductale Karzinome in situ von invasiven Karzinomen differenziert werden können. Dieser Bericht, aktualisiert die Ergebnisse eines deutlich kleineren und statistisch einfacher ausgewerteten Kollektivs, das 1999 in dieser Zeitschriftt publiziert wurden, und bestätigt die Eignung von DFT als objektive Untersuchungsmethode, die mit einer diagnostischen Sensitivität von >98% und einer Spezifität von >98% Brustkrebs beim Menschen entdecken kann.

Schlüsselwörter: Modulation der Hauttemperatur, Durchblutung, Brustkrebs,dynamisch-flächiger Stickoxyd, Thermometrie, Karzinommarker, computer-gestützte Diagnose

Introduction

The possibility of objective diagnosis of breast cancer by dynamic area telethermometry (DAT) was predicted by Anbar in 1994 (1, 2). Preliminary results, using data of a very small group of patients (8 with cancerous and 16 with benign breast lesions), were published in this journal in 1999 (3). Additional information on our preliminary findings was published elsewhere(4, 5). Affected breasts were studied from three directions, obtaining medial, frontal and lateral views (3,5). Because of the scarcity of clinical data, with little statistical justification, we treated at that time the three views of a breast as independent measurements. Yet, our very preliminary findings, using naïve statistical computational techniques, encouraged us to continue in our efforts and reach the current, more trustworthy stage. Our goal has been to automatically process series of 1024 digital infrared images, obtained from patients in less than 11 seconds, and extract from them a single quantitative diagnostic parameter. This goal was recently achieved and the improved methodology has been tested on 100 patients (34 with cancerous and 66 with benign breast lesions). While the detailed computational procedures used will be published elsewhere, the levels of diagnostic precision attainable by this methodology are briefly presented in this paper.

The methodology described here is based on Anbar's 1994 hypothesis that the abnormalities observed in the thermal behaviour of cancerous breasts are due to excessive regional vasodilatation caused by nitric oxide (NO) originating from the cancerous lesion (1,2). NO is a well known chemical messenger in the neuronal control of vascular tone. The generation of NO by inducible nitric oxide synthase (iNOS) in breast carcinoma and other mammary tumors has been subsequently confirmed by numerous independent studies (6-19). It has also been shown that the rate of NO production can be related to the invasiveness of the cancer (6,11,13, 15,17-19).

Since 1995, similar enhanced iNOS activity has been demonstrated in practically every type of cancer studied. These range from lymphomas (20-22) to solid tumors, including lung cancer(23-28), colorectal cancer(29-31), prostate cancer (32,33), stomach cancer (34,35), skin cancer (36-39), melanoma (40-43), cancer of the cervix and ovarian cancer (44,45), brain tumors (46,47), pancreatic cancer (48,49), esophagal cancer (50,51), thyroid cancer (52), cancer of the bladder (53) and Kaposi's sarcoma (54).

The production of NO by tumors in nanomolar quantities undoubtedly causes regional vasodilatation and thereby increases the supply of nutrients and oxygen to the incipient tumor. It obviously overrides the effect of endothelial NO synthase (eNOS), which produces picomolar quantities of NO inside blood vessels in response to autonomic neuronal stimulation. Interestingly, the expression of eNOS in breast cancer tissue was found negatively correlated with malignancy(55), most probably as a result of the negative feedback by the overwhelming amounts of extravascular NO produced by the cancerous lesion. Next, other studies have shown that NO enhances angiogenesis (56,57), which is essential for tumor growth. NO was also shown to increase the permeability of tumors' microvasculature (58), further enhancing supply of nutrients to the tumor. NO-induced vasodilatation also facilitates spread of neoplastic cells, which may be enhanced further by a NO-mediated decrease of adhesion of renegade cells to walls of the microvasculature, analogous to the observed behavior of leukocytes (58,59). Each of these NO-mediated enhancements is vital to a different aspect of successful proliferation and spread of cancer. It might be hypothesized, therefore, that the expression of iNOS in cancerous cell lines is a characteristic, necessary condition of cancerous diseases. Consequently, NO can be considered a cancer marker, the effect of which on the adjacent vasculature can be detected indirectly by DAT.

There is a substantial difference in the behavior of a cancerous lesion producing NO and an aggregate of macrophages reacting to a foreign entity, as occurs in inflammation. In the latter case, large amounts of superoxide radicals are generated and these scavenge NO at a diffusion controlled rate (60). Consequently, there is little chance for the buildup of a significant level of extravascular NO near an actively inflamed site.

In brief, attenuation of autonomic neuronal effects on the vasculature by extravascular NO produced by cancerous cells is a specific marker for neoplastic lesions. We have recently found that NO-induced attenuation of temperature modulation seems to be confined to certain subareas of affected breast, suggesting that the DAT methodology could be used to localize cancer. However, our immediate goal has been the objective identification of cancerous breasts, irrespective of the location of the cancerous lesion. Computational techniques were thus used to detect abnormalities in the distribution of attenuated areas on cancerous breasts without trying to localize the abnormality.

Methods

We used a fast digital infrared camera with a QWIP (quantum-well infrared photodetector) 8 to 9 mm detector (AIM, Heilbrunn, Germany) at a rate of 100 frames/sec. The camera was calibrated daily with a high precision 4" flat blackbody calibration source (CI Systems, Inc. Westlake Village, CA). This calibration and the sensitivity of the camera allowed us to achieve a temporal sensitivity of DT/dt > 1 mK/msec.

Our recent studies included only patients that were identified by X-ray mammography to have suspicious lesions in a breast that warrant excisional biopsy. All patients were examined after signing an IRB approved Informed Consent form. Following DAT examination, those patients underwent excisional biopsy or mastectomy and were classified according to their histopathology. We report here differentiation among four groups of breasts:

1. Cancerous breasts; these could be subdivided into:
1a. Breasts with invasive cancer and
1b. Breasts with ductal carcinoma in situ (DCIS).

2. Breasts with benign lesions.

3. Breasts contralateral to cancerous breasts.

4. Breasts contralateral to benign breasts.

The protocol used in our studies has been previously described.(3) The patients were seated in front of the infrared camera and their affected breast was examined from three directions – obtaining medial, frontal and lateral views. During the 11 seconds of each examination, the patients were asked to sit still and hold their breath. We also examined the contralateral breast in the same manner.

The first step in interpreting DAT data involved fast Fourier transformation (FFT) of time series of the average temperatures of sub-areas of interest (3,4). These sub-areas (spots) were 4 x 4 pixels, corresponding to squares approximately 4 x 4 mm on the breast surface. The reported studies analysed 1024 consecutive thermal images collected at a rate of 100 images per second. This phase of the DAT data analysis produced FFT power spectra for each of the 1500 to 2500 spots over the studied breast. An acquisition rate of 100 images per second optimally covers the 0.1 to 10 Hz range of perfusion modulation.

Generically, after the FFT analysis, our research methodology involves two stages. In the first stage we extract from the infrared images different parameters that, based on our working hypothesis, might differentiate between cancerous and non-cancerous breasts. Then we select the most effective of those for statistical analysis. In the second stage we analyse those selected parameters by a variety of statistical procedures trying to identify the one most suited for yielding a diagnostic measure of disease.

DAT analysis yields information on two aspects of modulation of cutaneous perfusion —modulation of temperature and modulation of the homogeneity of the cutaneous capillary bed (61,62). Temperature modulation, in the order of tens of millidegrees, follows changes in the level of perfusion. Spatial thermal homogeneity (STH) is derived from the spatial variance of temperature measured at different pixels in a given small (< 1 cm^2) subarea of skin (61). Modulation of STH of skin manifests changes in homogeneity of perfusion of the cutaneous capillary bed. STH is modulated by filling and shunting of capillaries as well as by hemodynamic pressure pulses. STH, which is of the order of a few millidegrees, is generally modulated over <10 mK (62). In handling of breast data, we analysed FFT spectra of both temperature and STH.

Based on the hypothesis that cancerous lesions affect the spatial distribution of temperature and STH modulation over breasts with cancerous lesions, we identified three potential diagnostic parameters: **Bav(a)**, **Cpr(a)** and Cav(a) that are likely to change in the presence of cancer.

Bav (a) is the mean modulation amplitude of spots with the lowest a percentile of amplitudes. When all spots on a breast were rank-ordered by amplitude, the mean of the amplitudes of the group of lowest percentile (e.g., a = 10%) was defined as Bav(a). If the presence of cancer results in attenuation of amplitudes in parts of the breast at specific frequencies, this is expected to manifest lower values of Bav.

Analysis of the spatial distribution of the spots with the a% lowest amplitudes identifies clusters of such spots.(3-5) Clusters are defined as spots of low amplitude adjacent to other similar spots. Such clusters manifest larger subareas of attenuated modulation. **Cpr(a)** (Cluster Percent Ratio) is the ratio between the number of clustered spots of low modulation and the total number of spots with amplitudes <= a% of the total range of modulation. The presence of cancer is expected to be manifested in a higher degree of clustering because the effect of cancer on perfusion is expected to be localized.

The third parameter of interest, **Cav(a)** (Cluster Average amplitude), is the average amplitude of the spots of the cluster that has the

Table 1
Result of Student's t test on DDP for the groups of benign and cancerous breasts.

Variable	N Benign	N Cancer	Mean Benign	Mean Cancer	StDev Benign	StDev Cancer	***p***	1 – ***p*** Specificity	**Sensitivity**	**Sensitivity**
DDP	64	32	-0.111	-1.236	0.362	1.289	3.60E-09	1.00E+00	0.999996	*0.999977*

lowest average amplitude. If the presence of cancer results in a cluster of spots with low amplitudes, the average value of the amplitudes of spots in that cluster is expected to be lower than if that cluster was found on a non-cancerous breast.

We then calculated the means of the values of those three parameters at different frequencies over a range of frequencies, e.g., between 2 and 10 Hz. Using a statistical procedure, which is beyond the scope of this review paper, we extracted from the six spectra of each of the three views in both the temperature and STH mode, a single diagnostic parameter, DDP (DAT diagnostic parameter). Because clustering parameters (Cpr and Cav) were chosen in order to detects localized changes in perfusion caused by the presence of cancer, the three views exhibited substantial differences in significance of separation between the cancerous and the benign breasts,. These differences were taken into account in calculating DDP. DDP is thus derived from a combination of Bav(a), Cpr(a) and Cav(a) values of the three views over the frequency range studied.

Results

Table 1 shows the result of Student's t test on DDP for the groups of benign and cancerous breasts.

Figures 1 to 3 are graphic presentations of the same results as well as of those of other groups of breasts studied. Figure 1 shows the level of distinction between cancerous and benign breasts.

In Figure 2 we broke up the group of cancerous breasts into two: those with invasive cancer and those with DCIS. One can see here that although breasts with DCIS seem to be statistically distinct from benign breasts, the value of DDP becomes more negative and better separated from the mean value of the benign group when the cancer is invasive. While it is suggested by the mean values of the DCIS and the invasive cancer groups, our clinical sample is too small at this point in time to reach a reliable

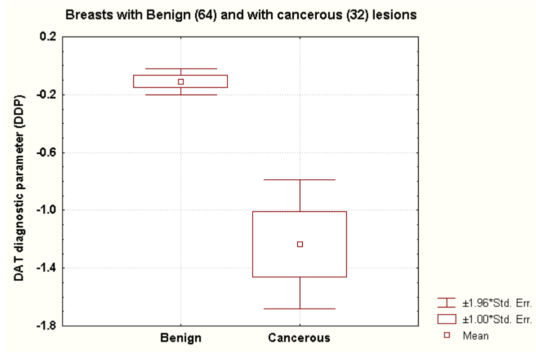

Figure 1
Breasts with benign (64) and with cancerous (32) lesions

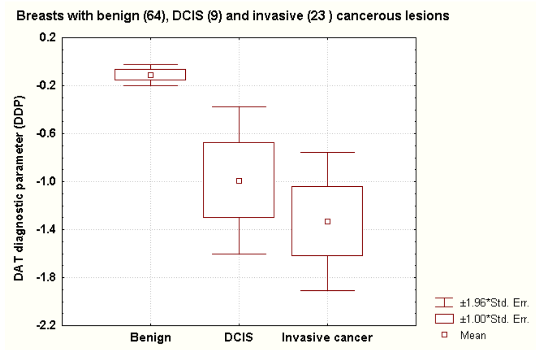

Figure 2
Breasts with benign (64), DICS (9) and invasive cancerous lesions (23)

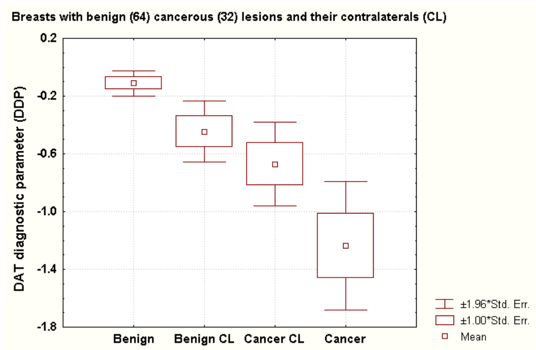

Figure 3
Breasts with benign (64), cancerous (32) lesions and their contralaterals (CL)

conclusion on the potential use of the DAT as a tool that determines the severity of malignant disease.

In Figure 3 we see that the mean of DDP of the group of breasts contralateral to the benign ones has a slightly lower value (a little closer to the cancerous value) than the mean of the benign breasts. The simplest explanation of this observation is that the breasts of the former group, which according to X-ray mammography were free of cancer, may contain a few cancerous breasts. Even more interesting is the observation that the breasts contralateral to cancerous breasts show an even more negative mean DDP, suggesting that this group is quite likely to contain cancerous breasts. This is consistent with well-known epidemiological observations that breast malignancy is often bilateral. It might be speculated, therefore, that the DAT test could detect breast cancer earlier than X-ray mammography. This possibility has been suggested and discussed earlier.(1) However, this suggestion must be corroborated by prospective longitudinal clinical studies on a large number of subjects.

Discussion

The use of thermal imaging in the detection of breast cancer has probably been the most widely known, most difficult and surely the most controversial problem in the history of thermology (2). No other clinical problem has drawn this much attention to the use of thermal imaging and at the same time given thermology so much disgrace. Today, we must thank the pioneer thermographers in the sixties and seventies for discovering this potential application of our technology and for their intuitive persistence that measurable thermal abnormalities are manifested in cancerous breasts [for a review see (2)]. Those early findings prompted the development of a physiological model to explain the reported observations and to specify conditions for achieving a reliable diagnosis (1,2). It still took a few more years for technology to progress and meet those operational conditions (62). Our early findings (3,5), corroborated by the recent results reviewed in this paper, show that thermal imaging, when appropriately applied can be used to detect breast cancer non-invasively and possibly also to localize it. The DAT test could also be used for the management of the disease after it has been detected. The non-invasive detection of the involvement of lymph nodes in the axillae is an obvious extension of our findings. If proven effective, this application of DAT could avoid many unnecessary troublesome surgical interventions. DAT could also be used for post- surgical follow-up and for monitoring the effects of radiation treatment and chemotherapy.

Our research, pioneering the use of computerized dynamic infrared imaging as an objective, quantitative diagnostic technique, is still in progress. We are still looking for more effective and more robust diagnostic parameters, more efficient use of statistical methods, and, obviously, we are trying to substantially increase our clinical database. It will be difficult, however, to meet the latter goal without additional clinical research centers joining our effort. A major goal of this review paper has been to prompt such collaboration.

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The clinical application of thermography to osteoarthritis of the hip

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Summary

The clinical application of medical thermography to osteoarthritis of the hip was investigated, using pre- and post-operative measurements. The data show that the skin temperature of the gluteal region is lower on the diseased than on the healthy side, and, if both sides are diseased, the more seriously affected side has a lower temperature. The mean temperature of each side and the temperature difference between the two sides were calculated using our own improved analysis. The method is based on selecting the region of interest within a polygon. Results from 50 patients with unilateral disease indicate that the temperature difference between the two gluteal regions correlates with the grade of symptom using the hip functional evaluation score. In 20 surgical cases, the lowered temperature found before operation improved along with the relief of symptoms after operation. The temperature difference between both sides became smaller over time. From our recent study, it has been shown that the low temperature exists not only on the gluteal region, but also on the diseased side whole leg and on the plantar region. Local circulatory insufficiency caused by gluteal muscular atrophy and shortening, and hip joint pain, which are the result of osteoarthritis of the hip, are thought to play a major role in the lowered temperature in the affected areas.

The clinical application of thermographic examination to cases of osteoarthritis of the hip is considered to be of value in evaluating the progress of disease, deciding on appropriate treatment, and in follow-up evaluation.

Key words: Thermographic evaluation, Mean temperature, Temperature difference, Osteoarthritis of the hip, Gluteal region.

Die klinische Anwendung der Thermographie bei Koxarthrose

Die klinische Anwendung der Thermographie wurde vor- und nach Operation bei Patienten mit Koxarhrose überprüft. Die Ergebnisse zeigen, dass die Hauttemperatur der Glutealregion an der erkrankten Seite niedriger als an der gesunden Seite ist, bzw bei beidseitiger Erkrankung zeigt deutlicher veränderte Seite die geringeren Temperaturen.The mittlere Temperatur jeder Seite wurde bestimmt und die Temperaturdifferenz beider Seiten wurde mit Hilfe eigener verbesserter Analysemethoden errechnet. Die Methode beruht auf der Auswahl des Messareal durch ein Polygon. Die Ergebnisse bei 50 Patienten mit einseitiger Erkrankung weisen darauf hin, dass die Seitendifferenz der Temperatur in der Glutealregion mit der Schwere der Symptome korrelieren, die mit dem Funktionellen Hüftskore erhoben wurden. Bei 20 Patienten erhöhte sich die präoperativ niedrige Temperatur gemeinsam mit der postoperativen Symptomverbesserung. Die Seitendifferenz der Temperatur wurde mit der Zeit kleiner. In einer rezenten Studie konnte gezeigt werden, dass eine niedrige Hauttemperatur nicht nur auf die Glutealregion beschränkt ist, sondern an der gesamten unteren Extremität einschließlich der Fußsohlen vorkommt. Eine durch die Atrophie und Verkürzung der Hüftmuskulatur bedingte lokale Zirkulationsstörung dürften gemeinsam mit den durch die arthrotischen Veränderungen verursachten Hüftgelenksschmerz die wesentlichsten Ursachen für die verminderte Hauttemperatur im betroffenen Gebiet sein.

Der klinische Einsatz der Thermographie bei Patienten mit Koxarthrose gestattet die Progression der Erkrankung einzuschätzen, hilft bei der Auswahl einer entsprechenden Therapie und erlaubt Verlaufsbeobachtungen.

Schlüsselwörter : Thermographische Überprüfung, Durchschnittstemperatur, Temperaturdifferenz, Koxarthrose, Glutealregion.

Introduction

Temperature changes on the surface of the human body are known to be a sensitive reflection of pathological conditions within the body, and to provide a variety of important information. In consequence, the clinical application of medical themography is increasingly accepted in many fields (1). Improvements in the thermographic imaging systems used have resulted in heightened accuracy, and greatly advanced facilities exist for the analysis of data. The author has published thermographic studies on joint diseases. Thermographic examination and its clinical application in various joint diseases have been found useful in the evaluation of the extent of disease, deciding appropriate treatment, and in follow-up evaluation of such cases (2-5). Patients with osteoarthritis complain of pain, motion and gait disturbance of the diseased hip joint, and muscle atrophy occurs on the gluteal region. In this study, the skin temperature was measured pre- and post-operatively on patients with osteoarthritis of the hip.

Materials and Methods

The study was based on patients currently undergoing treatment for osteoarthritis of the hip at departments of orthopaedic surgery and rehabilitation medicine of the Nagoya City University Hospital. 50 patients with unilateral disease and 20 patients who has undergone total hip arthroplasty, both before and after operation, were selected for study.

The apparatus used was a thermoviewer JTG-3300 and -5310 made by JEOL Japan. The patient was positioned by standing with legs slightly apart, any difference in leg length being corrected by use of a board placed under one foot to eliminate pelvic tilt. A thermogram was taken of the gluteal region, from the posterior view from the buttocks downwards, and additionally for the plantar region, in the knee-standing position on a chair. Average temperatures and temperature difference between left and right sides were calculated within the polygonal enclosure region of interest.

Results

To illustrate the results of the measurements made using our method, a representative case is presented. A 66-year-old female patient with osteoarthritis of the right hip had a clearly defined area of decreased temperature on the

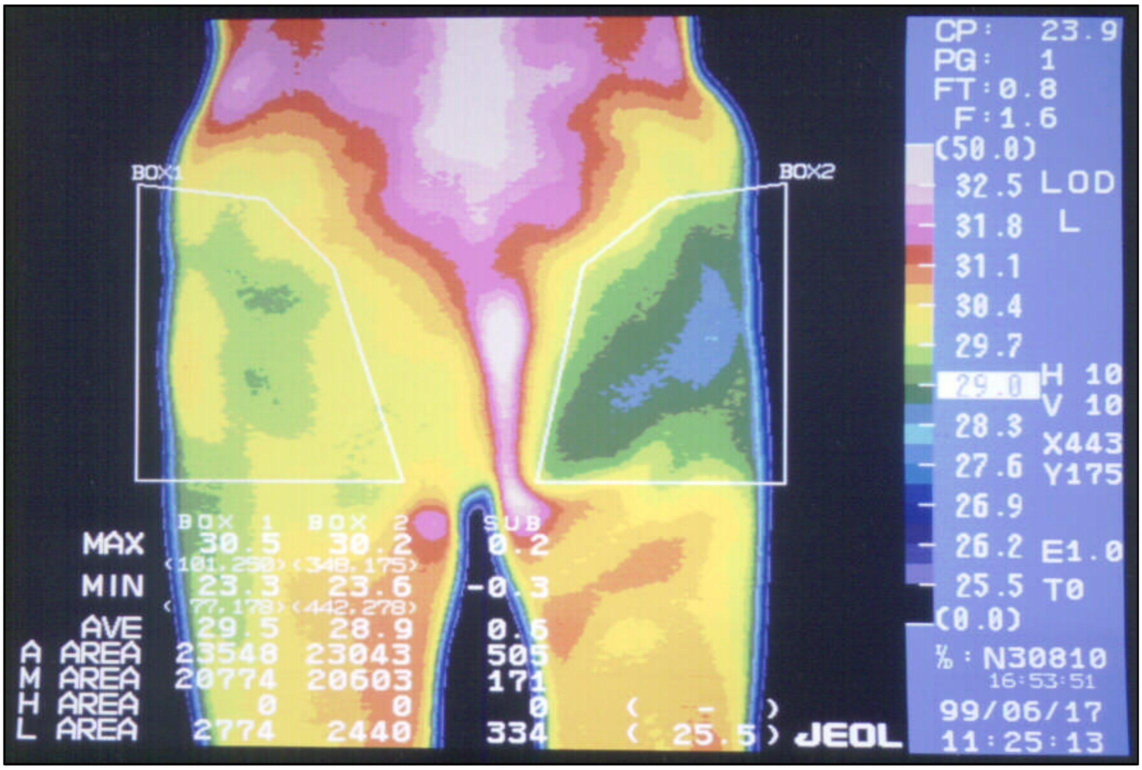

Figure 1
Data analysis using the polygonal region of interest method on the thermogram of a patient with right hip osteoarthritis.

right-side gluteal region. In t his case the temperature difference between both gluteal regions was 0.6° , being lower on the diseased right side (Figure 1). Decreased skin temperature on the diseased side in the gluteal region, extending from the hip joint to the proximity of the thigh, was a characteristic finding in all 50 of the patients.

Furthermore, in patients whose disease development was observed over the course of time, worsening of symptoms was observed to be accompanied by a further lowering of the skin temperature on the diseased side, and hence an increased temperature difference between the two sides.

On 50 osteoarthritic patients with unilateral disease, left-right temperature difference in the gluteal region was compared with the Japanese Orthopaedic Association's Hip Function Evaluation Score. The perfect functional score is 100 points; the score is reduced with presence of pain, impairment of gait, range of hip motion, and daily living activity. The relationship is displayed in the graph in Figure 2 which shows a good correlation between the two factors.

In cases with disease on both sides, both the gluteal regions show a temperature drop, but the greater decrease in skin temperature was observed on the side on which the disease is more advanced, and correlated with the patient complaints of more severe symptoms. However, since the temperature was low on both sides, the temperature difference between sides was small and therefore can not be used as a basis of comparison. The possibility of using some other body region as a reference comparison point of temperature change is now under investigation.

Pre- and post-operative left-right temperature differences were compared in surgical patients. In 20 post-operative cases, the low temperature found before operation improved along with the lessening of symptoms after operation, and the temperature differences also became smaller over time. It is clear that there is a correlation between the two, namely a fall in the left-right temperature difference accompanied by improvement in symptoms (Figure 3).

From our recent study, it has been shown that the low temperature areas exist not only on the gluteal region, but also on the diseased side whole leg from the buttocks distally to the foot, and on the plantar region.

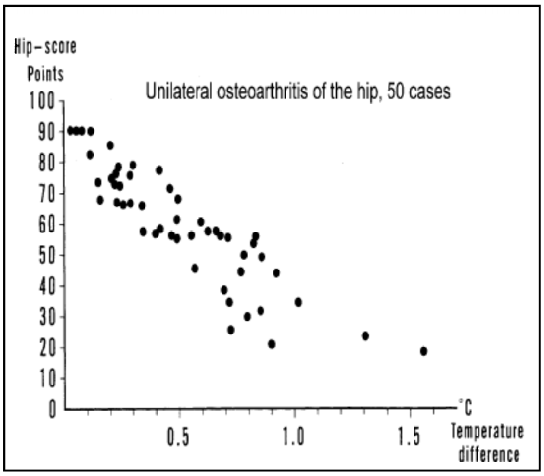

Figure 2
Temperature difference between the two gluteal regions and the hip function scores in 50 osteoarthritic patients with one affected hip joint

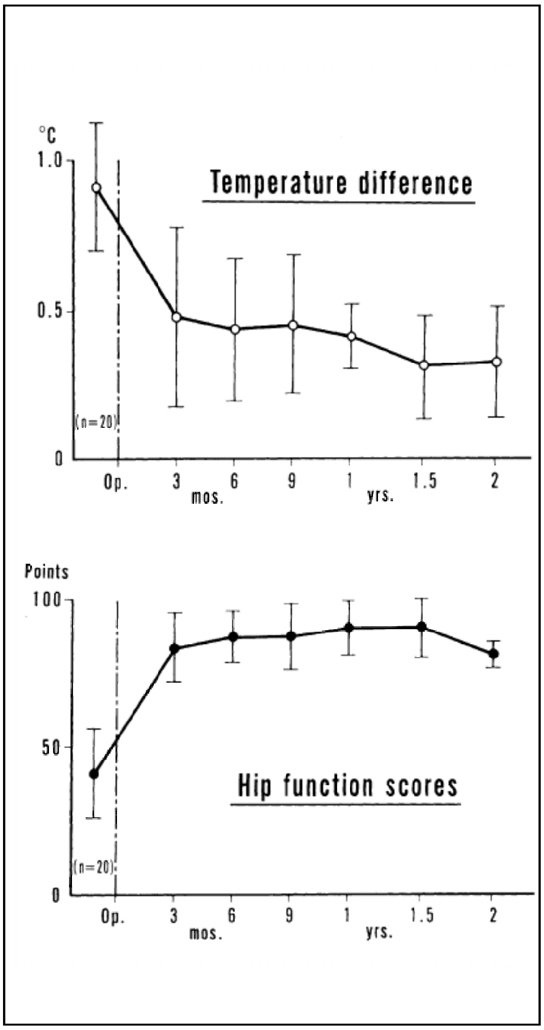

Figure 3.
Pre- and post-operative temperature difference (top) and hip function scores (bottom) in 20 surgical patients. .

The thermogram of a 54-year-old female patient with osteoarthritis of the left hip is shown in Figure 4. From the buttocks distally through the left leg to the foot, the lower temperature can be observed in comparison with the healthy right side. The decreased temperature is remarkable, especially on the gluteal region. This tendency was observed in almost all of the patients studied.

Figure 5 shows the thermogram of the plantar region of a left hip diseased 71-year-old female patient. The temperature on the whole left planta, particularly on the left heel region is

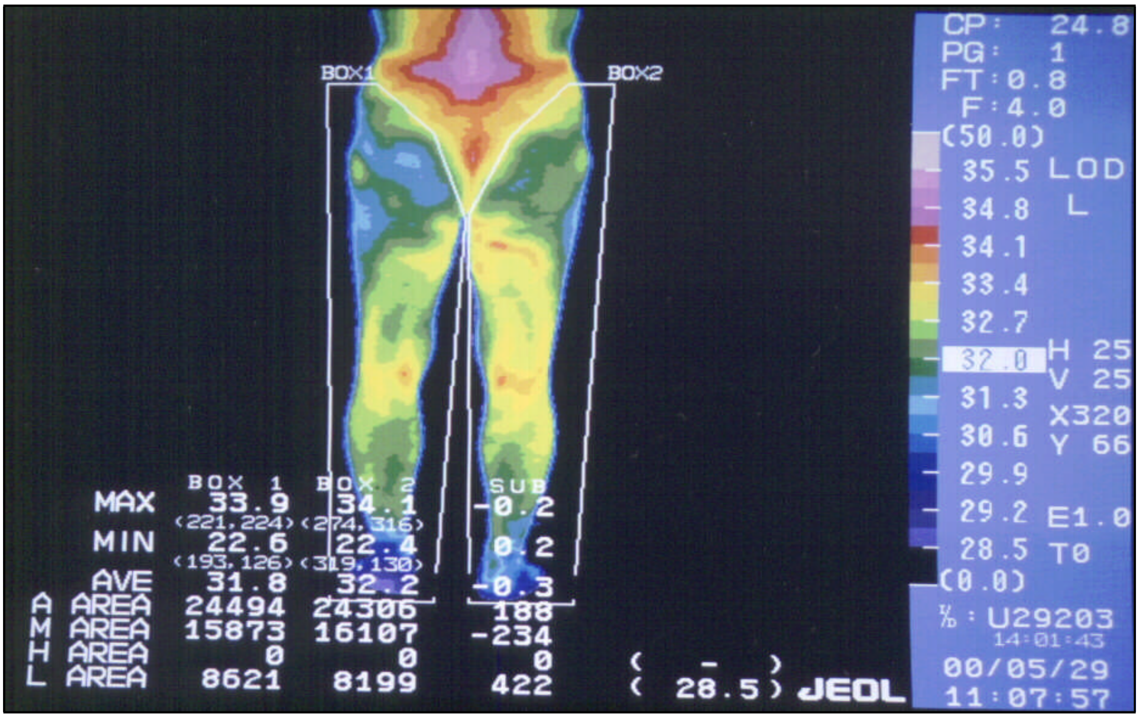

Figure 4
Thermogram of a patient with a diseased left hip..

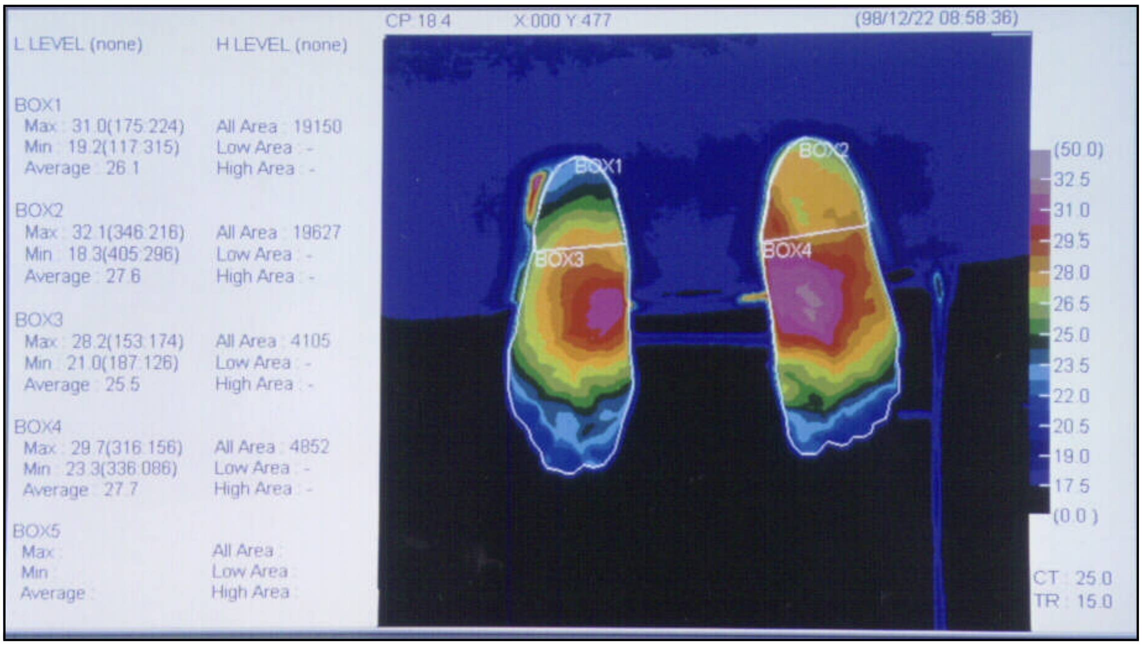

Figure 5. Thermographic analysis on the plantar region of a patient with left hip osteoarthritis.

lower than the healthy right side. We observed this in 92% of the patients examined.

Discussion

With regard to the mechanism of these abnormal thermal images in osteoarthritis of the hip joint, it is postulated that a major role may be played by local circulatory insufficiency caused by gluteal muscular atrophy and hip joint pain (6).

In our previously reported studies, it has been demonstrated with Computed Tomography of the pelvic region in osteoarthritis of the hip, that the images frequently show the presence of atrophy of the gluteal muscles on the diseased side (7). It has also been shown with a strain gauge measuring device, that the isometric muscular strength of the hip abductor gluteal muscles in osteoarthritis is lower on the diseased side (8). These results indicate that skin temperature decreases in the region of atrophied muscle.

The main cause of the temperature decrease is thought to be reduced blood flow through the atrophic gluteal muscles. The existence of pain may also activate a regional sympathetic reflex resulting in local reduction of blood flow. This results in further aggravating pain-related vasospasms and disuse atrophy of surrounding muscles due to pain. It also results in muscle fatigue and insufficiency of muscular action caused by muscle shortening, as well as other factors from stagnation of blood flow. These are therefore likely to combine to cause local circulatory insufficiency, which results in the observed fall in skin temperature (Figure 6).

Furthermore, disturbance of the hip motion may influence the various muscles, and cause muscular atrophy and circulatory insufficiency in the diseased leg as a whole. The incomplete weight bearing gait on the diseased leg continues for a long time. From these facts, the low temperature on the diseased limb and the plantar region observed in almost all these cases can be explained.

A closer relation between skin temperature changes and clinical symptoms in cases of osteoarthritis of the hip demonstrated the value of thermography as a clinical examination procedure. As a non-invasive technique it is considered to be valuable, for assessing the severity of the symptoms, evaluating the progress of disease, deciding on appropriate treatment, and in follow-up evaluation of postoperative recovery.

Local circulatory insufficiency caused by gluteal muscular atrophy and shortening, and hip joint pain are thought to play a major role in the temperature decrease over the affected areas. Thermography may therefore be of assistance in further elucidating the pathogenesis of osteoarthritis of the hip.

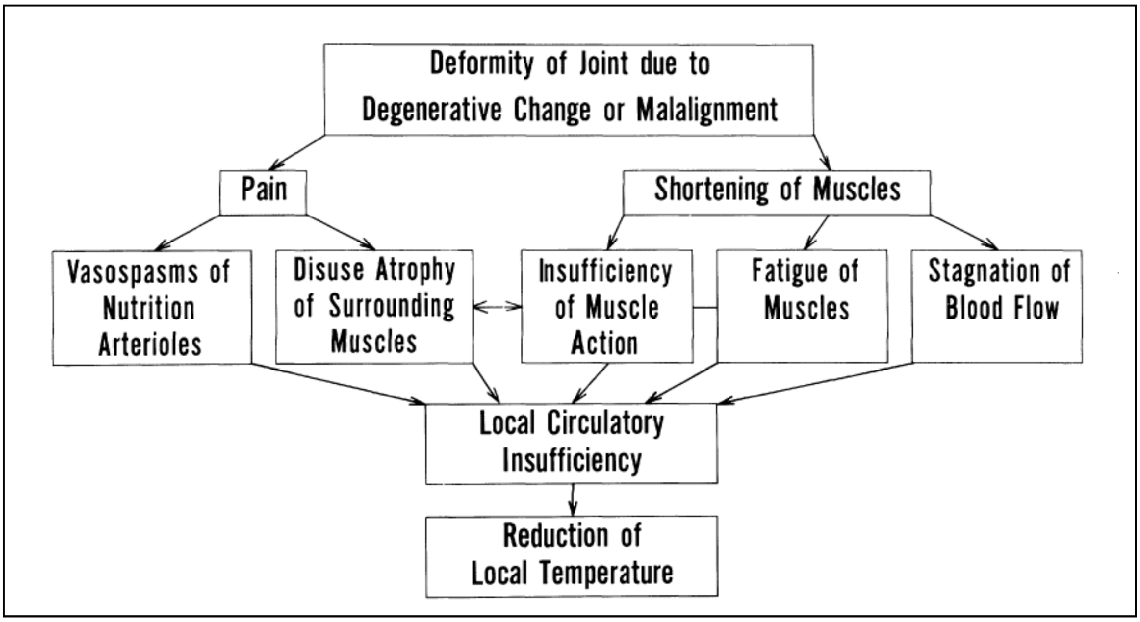

Fig. 6.
Proposed pathogenesis of the abnormal thermal image in osteoarthritis of the hip joint.

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A New Thermal Coronary Angiography System

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Summary

Thermal coronary angiography (TCA) is a medical imaging system, which measures blood flow distribution in the coronary artery network. Recent advances in far infrared imaging system are thermal camera heads without liquid nitrogen cooling and with television frame rate. We have developed a TCA system, which can be installed in an operating room, and have evaluated its use in clinical coronary bypass graft operations.

Keywords: Far-infrared imaging, Coronary angiography, Thermal imaging, Thermography, Image fusion

Ein neues System zur thermischen Koronarangiographie

Die thermische Koronarangiographie (TKA) ist ein bildgebende medizinische Methode, welche den Blutfluss im koronaren Arteriennetz erfasst. Der rezente Fortschritt der Infrarotthermographie Technik kann heutzutage handliche Kameras, die ohne Stockstoffkühlung mit der Bildfrequenz von Fernsehkameras arbeiten, zur Verfügung stellen. Wir haben ein TKA-System entwickelt, mit der ein Operationsaal ausgerüstet werden kann, und wir haben die Brauchbarkeit des Systems zur Überwachung von koronaren Bypassoperationen bestätigt.

Schlüsselwörter: Infrarotabbildung, Koronarangiographie, Wärmebild, Thermographie, Bildverschmelzung

Introduction

Thermal coronary angiography (TCA) is a cardiac imaging system based on a far infrared sensing technology. The main purpose is to display coronary arterial networks for surgical grafting procedures of the coronary artery using a non-invasive method. TCA has been studied in the past when medical thermology was at a very early stage. However, many technical limitations such as, size of the sensing head, use of liquid nitrogen for the sensor cooling, and slow frame rate of the infrared imaging system, have prevented the development of a clinical system. Recent advances of medical infrared imaging devices, especially small uncooled instruments with high frame rate, enable some of the earlier clinical applications to be revisited. TCA is a typical appliction of such technology.

Objective

The objectives of this study were to develop a a new thermal coronary angiography system consisting of a far-infrared imaging device to obtain thermal images, and an ordinary video camera for visible images. In addition, it was necessary to carry out feasibility studies on the clinical application of the system for monitoring coronary bypass graft operations.

The TCA system consisted of a far-infrared camera (FIR camera), Thermal Vision LAIRD S270 (*Nikon*), and a video camera, Handyscope HVS-10 (*Aishin Cosmo Co. Ltd.*). The FIR camera has an image sensor with 410,000 picture elements of PtSi Shottky-barrier charge-couple-device cooled with a Stirling engine, a camera head of 140(W) x 390(D) x 175(H) mm in size and 9.2 kg in weight. The FIR camera and the video camera were mounted on an aluminium sheet and assembled into a combined optical head. We have developed two types of optical heads. The FIR image and visible image of the one system were on the same optical axis (Figure 1), the others are on separate optical axes (Figure 2). The FIR image and the video image were fused in a digital video mixer [1]. The fused images were displayed on television monitors in the operating theatre through a camera control system. Images and control signals between the optical head and the camera control system, which contained the digital thermal images (via IEEE 244 interface), thermal video images (as NTSC), visible images (NTSC), and control signals for camera head (via optically modulated RS-232C interface), were connected by an electrically shielded line of 20 m in length. The configuration of the TCA system is shown in Figure 3.

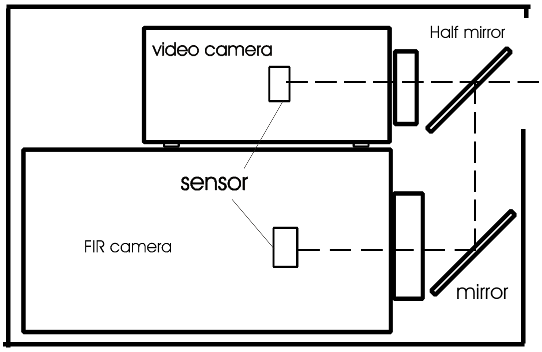


Figure 1
A camera head system in which the optical axis of the FIR camera and video camera are converged.

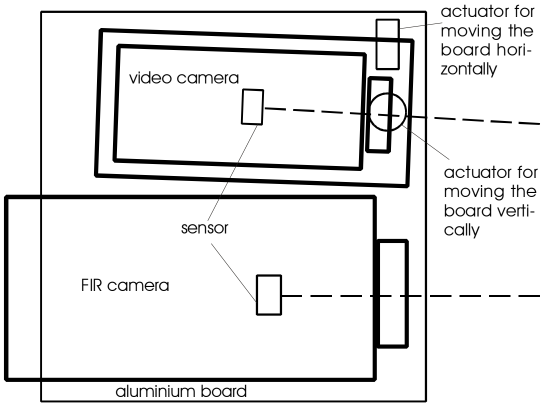


Figure 2
A camera head system in which the optical axis of FIR camera and video camera are separated.

Experimental Procedure and Results

The TCA system has been installed in a cardiac operation room since October 1999. The optical head was mounted on a moving arm designed for monitoring devices and located near the ceiling. Three coronary bypass graft operations with a median section of the sternum were used in the feasibility study. The required specification for the TCA system obtained from the feasibility study is summarised as follows:

1) Minimum requirement of temperature sensitivity for imaging the coronary artery network is precisely 0.15°C.

2) Adequate number of picture elements is more than 100,000 pixels.

3) Minimum field time should be less than 1/30 sec.

4) Minimum working distance from the surface of operation table to the optical head should be more than 0.8 m.

5) The visible image should be overlapped temporarily for locating the coronary artery and discriminating them from other vessels

6) The temperaure range of cardiac muscle surface is limited to 30°C ~ 37° C and that of coronary arteries without cooling by extra corporeal circulation is 34°C ~ 35°C.

7) Temperature of cardiac muscle surface during anastomosing coronary bypass graft using the cardioplegia method fell less than

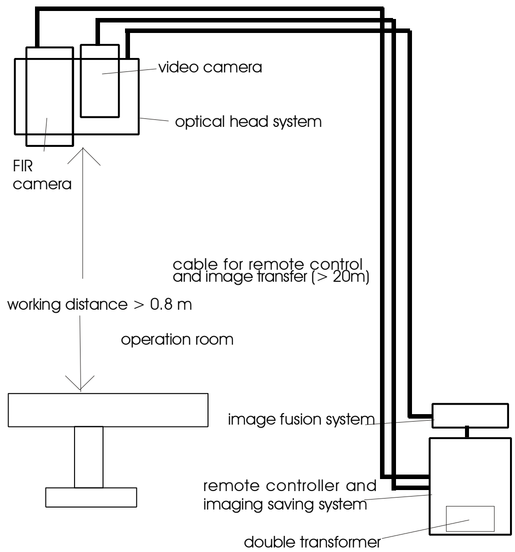


Figure 3. The configuration of a TCA system

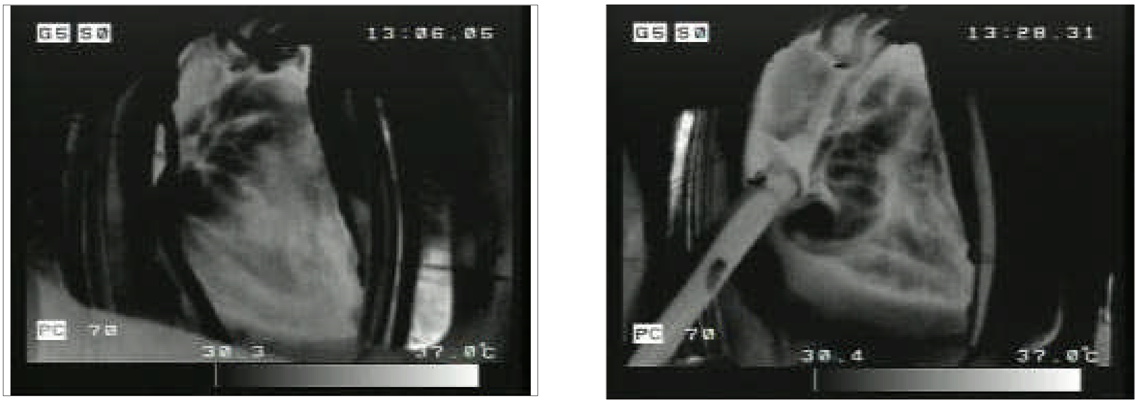
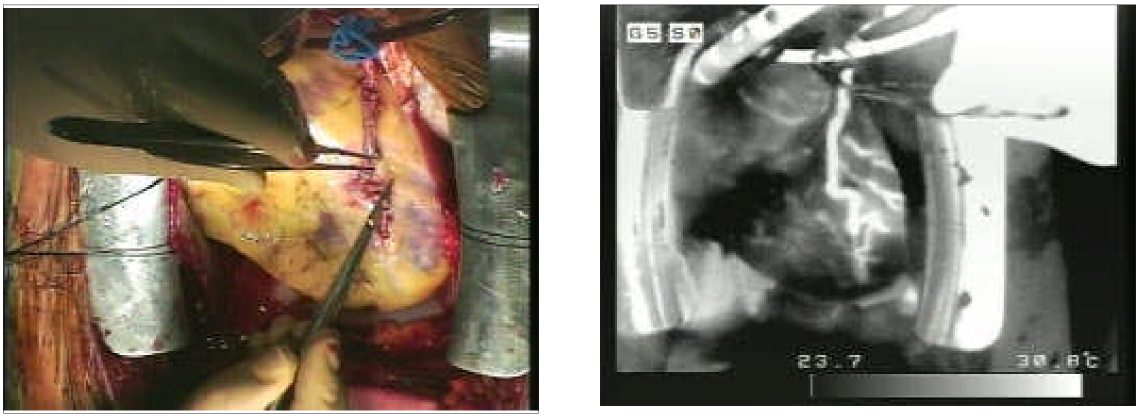


Figure 4
A thermal image of the heart before coronary bypass graft (on the left) and after bypass graft (on the right). The surface temperature of the heart is increased after the operation.



Blood flow pattern in a coronary arterial graft and peripheral coronary arterial network. An ordinary video image is on the left and a thermal image on the right

23°C at first and gradually increase to 27°C. After releasing the coronary clip, high temperature coronary artery image appeared in periphery regions of the artery.

8) The viability of the cardiac muscle was evaluated by comparing the surface temperature between the pump-on baseline image before and after anastomosis.

As the optical head system is installed on a high out of reach location, a long interface cable for control devices and data collection should be developed. Every manipulation procedure for controlling the optical head should be performed from a remote location (ca. 20 m from the camera head).

Discussion

Coronary angiography is one of the most useful clinical procedures for estimating coronary arterial blood flow at surgery for coronary bypass grafts. Conventional methods of blood flow measurement such as cineangiography, ultrasonic angiography, and laser Doppler flowmetry have not been used during surgery. As the operation procedure of coronary by- pass grafting is well established, almost all cardiac surgeons have only regarded the viability of cardiac muscle from its colour and have not try to measure coronary blood flow. The surface of internal organs are not covered by thermal insulation like the skin is to the human body. It cools according to the Newton´s law, if the organ exposed in a cool environment. The temperature is determined mainly by blood flow perfusion of the tissue. For this reason, the viability of cardiac muscle can be evaluated by continuous observation of cardiac thermal imaging (Figure 4). If there is an arterial network on the organ and warm blood is supplied to the network, the pattern of the arterial network is clearly seen on the thermal images of that organ. The coronary arterial network exists on the cardiac surface. After exposing the heart to the air, it shows up quite clearly. When a clip on a branch of coronary artery is released after anastomosis of a coronary bypass graft, we can observe the pattern of warm blood flowing in the peripheral coronary arteries (Figure 5). Thus the coronary blood flow rate can be observed remotely and non-invasively with this technique. If the TCA system is installed in the cardiac operating room, other operations of open heart surgery beside the coronary bypass graft operation will be practised safely.

Acknowledgment

This research was supported by Grant from the Japanese Society of Promotion of Science.

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(Manuscript received on 9.9.2000, accepted on 10.01.2001)

News in Thermology

5th International Congress of Thermology 2001 in Vienna

The Austrian Society of Thermology will organize this meeting on behalf of the EAT and hope, that the conference will be as sucessful as the European Thermology Congress held at the same place in 1997. Similar to last time, the International Conference is combined with the 14th Thermological Symposium of the Austrian Society of Thermology and the Annual Meeting of the German Society of Thermology. A distinguished panel of experts will form the Programme Committee which will bring together the leaders in the field from around the world.

Main intention of the meeting is to intensify the cooperation of all users of infrared imaging for the purpose of diagnosis, which is the detection of disease in medicine, but may cover many other fields in technical and industrial applications.

In medical thermology, other aspects than thermo-diagnosis must not be forgotten such as thermo-physiology and heat treatment, both for superficial and deep body tissues. In particular for temperature monitoring of deep body hyperthermia techniques other than infrared such as magnetic resonance imaging are used. Invited speakers will present state of art lectures for these topics.

“Standards for medical thermal imaging” is the topic for a round table discussion, which will bring together experts from Europe, Japan and US to discuss and finalize a consensus report on this very important task.

A small exhibition of latest developments of equipment for thermal imaging and for heat treatment will be shown on site of the conference.

The conference will be organized by

e + o incentives & conventions
Kramergasse 1, 1010 Vienna; Austria
Tel: + 43 1 533 87 32, Fax: +43 1 535 99 31
E-mail: mailbox @eoinc.at URL: www.eoinc.at/icmt5
which will also provide accomodation facilities.

Deadline for early registration at a reduced fee is January 31, 2001.(ATS 3000.- instead 3500.- before March 7, and 4000.- after March 7) . Registration will include admission to all scientific sessions, the book of abstracts, lunch on April 28 and 29, and coffee breaks during the whole conference. One day registration at ATS 1350.- will be available on site, but excludes meals. Use the registration form printed on page 47.

All Registration forms must be sent to the organizing secretariat e +o incentives & conventions, which will also provide information on the conference and facilities for registration on their web- site in due course.

The organizing Committee definitely expects an interesting, stimulating and exciting conference in the lovely Viennese springtime of 2001. A trip to the lovely Danube Valley Wachau combining a guided tour at the famous baroque Abbey of Melk with a typical “Heurigen”-Dinner with nice local vine on Monday afternoon will close the conference.

Venue: SAS Radisson Palais Hotel, Vienna

Main Theme:
Thermology- the science of heat

Topics: Thermo-Physiology,
Body temperature measurement by infrared and other techniques
Diagnostic infrared imaging
Thermo-Therapy
Monitoring (maintenance) by thermometry

Papers dealing with new infrared equipment for use in medicine, vascular disorders, Raynaud´s phenomenon, applications in neurology, breast cancer, dermatology and rheumatology are already submitted.

Round table discussion:
Standards for medical thermal imaging

Participants:
Prof.Dr. EFJ.Ring, U.K.,
Prof. Dr. I. Fujimasa, Japan,

Prof.Dr.M.Anbar, USA;
DDr.K.Ammer, Austria,
Dr. Frauenrath; Germany;
Dr. S. Govindan; USA;
Prof. Dr. Y-S. Kim; Korea

Organizing office & hotel reservations:

e + o incentives & conventionsKramergasse 1, 1010 Vienna; Austria

Tel: + 43 1 533 87 32, Fax: +43 1 535 99 31
E-mail: mailbox @eoinc.at

URL: www.eoinc.at/icmt5
(this site can be used for the conference registration !)

12th International Conference on Thermal Engineering and Thermogrammetry (THERMO)

from the 13th to 15th of June, 2001
in the OSSKI Center (Törley Palace)
Budapest, XXII. (Budafok), Anna u. 5.

The Conference Organizer

Branch of Thermal Engineering and Thermogrammetry (TE and TGM),

Hungarian Society of Thermology (HST) at MATE

European Association of Thermology (EAT),

International Center for Heat and Mass Transfer (ICHMT).

Sponsored By

- National Committee for Technological Development (OMFB)
- Foundation for Industry, Budapest (IMFA)
- Hungarian Ministry of Economic Affairs, Budapest (GM)
- Hungarian Energy Office, Budapest (M.E.H.)
- Budapest University of Technology and Economics (BME), Department of Energy (DoE)
- EGI-Contracting/Engineering Co. Ltd., Budapest (EGI Rt.)
- Research and Development Company for the Combustion Technology, Miskolc (TÜKI Rt.)
- -'Frédéric Joliot-Curie' National Research Institute for Radiobiology and Radiohygiene, Budapest (OSSKI).

Scientific Committee

Chairman: Dr. I. Benkõ BME, DoE, Hungary (EAT, HST, President of TE & TGM)

Secretary: I. Kovacsics, Msc.
EGI-Contracting/Engineering Co. Ltd., Budapest, Hungary (HST, TE & TGM)

About The Conference

Since 1977 a successful series of Symposia has been organised by our Society every year. At the beginning these events were named "Symposium on Thermogrammetry" after a newly developed branch of thermal mapping methods which played a significant role in the program. As the scope of the symposia widened in 1982 they received the new name "Symposium on thermo-technical measurements".

Due to the broad and increasing interest shown by the international thermal engineering and physician communities, in 1987 it was already organised as the International Conference on Thermal Engineering and Thermogrammetry (THERMO). This conference is a series of biennial meetings. The Conference is intended to be an event worthy of the attention of all engineers, scientists, physicians and researchers who are involved in the solution of thermal or energy related problems, as well as in the applications of thermal imaging.

Objectives

The developments of measurement theory and technologies help the energy- conscious design of thermal engineering equipment and processes as well as the better understanding of thermal phenomena in living organisms.

The Conference will cover topics both the field of theory and application including new measurement concepts; transducer technique; thermal mapping; contact, optical and IR imaging; biomedical and biotechnological applications; thermal informatics, automatic methods and sys tems for industrial energy management and process control; heat loss detection and analysis; heat and mass transfer; utilization of alternative energy; thermophysical properties as well as the common practice of thermal engineering.

This Conference will provide the latest information on the above topics together with a good opportunity for personal discussions among experts in the fields of energy conservation, control of energy release and loss, protection of human environment, medical and veterinary applications, remote control through infrared sensors.

Main Topics

The structure of the sessions will be fixed after receiving the papers, but the topics will cover the following fields:

General thermal engineering; theory of measurements; thermal informatics, thermo-CAD and its applications; industrial energy management and process control systems; practice of thermal engineering; infra-red imaging science & technology: thermogrammetry, micro- and nanoscale thermal phenomena and sensing techniques, thermal defectometry; applied thermo-optics; thermophysical properties; heat and mass transfer; cooling of electronic components; heat exchangers; combustion; thermophysics of the environment; building services; environmental aspects of energy use; thermo-ergonomy and thermo-psychology; thermo diagnostics; system analysis in thermo-biology; IR-imaging in biomedical and bio-engineering applications; remote sensing through IR-imaging, multidisciplinary topics.

Organization of the Conference

The language of conference and abstracts is English. Together with oral presentation of papers a poster session will be organized.

Duration of each presentation will be limited to 15 minutes and additional time for discussion will also be provided.

Those intending to attend the conference are kindly invited to send a registration form to the address listed later, under "INFORMATION".

Exhibition

During the conference an exhibition of scientific and industrial instrumentation will be organised. Exhibitors from the field of temperature measurement and control, thermal properties, IR-imaging, anemometry, industrial energy control, heat loss detection equipment etc. are welcome.

Venue

The conference is hosted by the OSSKI Center (Törley Palace, Budapest, XXII. (Budafok), Anna u. 5.) located in the vicinity of the famous Budafok wine cellars.

Information

Application Forms and abstracts should be sent to:
Dr.Imre BENKÕ, MATE Secretariat,
House of Technology, III.318.,
H-1372 Budapest, POB. 451., Hungary.
Fax: +361-353-1406 Phone: +361-332-9571.
E-mail: mate@mtesz.hu

For any further information please contact the following address:

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H-1111 Budapest, Mûegyetem rkp. 7. D.208., Hungary. Office phone: +361-463-2183.
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BME Fax: +361-463-1110
E-mail: benko@eta.enrg.bme.hu

Annual Meeting of the AAT

The following letter from the AAT arrived from Auburn University

Greetings Fellow Thermologist:

We would like to personally invite you to the American Academy of Thermology Meeting which will be held at Auburn University on June 22-24, 2000. For those wishing to present scientific papers, the abstract deadline is February 1, 2001. Information about abstract submission has been provided below. We have planned a meeting that will be very informative and affordable. The meeting format has been developed to promote adequate time for the presentation of research and allow for interactive discussions. During the past several months, the excitement over this meeting has been very encouraging.

Besides this outstanding meeting, what else is there to do in or around Auburn? During the meeting, the Auburn campus and University activities are easily accessible by foot. If you wish to plan an excursion outside of Auburn, there are several great possibilities:

- Atlanta (Baseball games, The Underground, Shopping, Coke Museum, Metropolitan Museum, CNN Broadcasting Center, Centennial Olympic Park, Night Life, Airport - 90 minutes from Auburn
- Huntsville Space Museum and Space Center- 3.5 hours
- Bioloxi (Gambling and Casino Shows)- 4.5 hours
- New Orleans (Jazz, Food, Gambling, Shopping) - 6 hours
- Alabama/Florida Beaches (Warm clear blue water, white sand, rated as some of the top beaches in the world, shopping, food) - 4.5 hours

- Pensicola Air Base (Air and Flight Museum, beaches) - 4.5 hours
- World Famous Calloway'Gardens - 1 hour
- Mobile (Battleship Tour, Bellgrath Gardens, Beaches) - 3.5 hours

While we have heard from some of you, we hope the remainder of you will send their abstracts or a confirmation as an attendee. Hope to see you in June in Auburn.

Sincerely,

David D. Pascoe, Ph.D.,
Exercise Physiologist ,Scientific Meeting Director

Ram C. Purohit, DVM, Ph.D.,
Large Animal Clinic, Meeting Organizer

Richard Herrick, M.D.,
Orthopedic Surgeon, Meeting Organizer

Abstract

The abstracts will be printed in a conference meeting proceedings.

Due Date: February 1, 2001

Abstract Format: 250 words or less
(Those in excess will be truncated).
Single Space, 12 font, Times New Roman style

Abstract Layout:

First 1-2 lines will be the title (all letters capitalized) Space between Title and authors

Next few lines list authors and location
(city, state, country, zip code).

The author presenting the paper should be underlined.
Space between authors and abstract.
If research was sponsored by a grant, this will be italicized at bottom.

Submission Category: Please suggest the main submission category for your abstract. The following areas are provided as a guideline. lf your area is not listed, please state "other' and state your suggested area. The conference planning committee will make the final assignment of abstracts to conference sections based on topic area and abstract submissions.

Thermal Physiology,Pharmacological,Neurology / Neuroscience, Vascular; Orthopedics, Breast, Forensics, Technical/Equipment
Applied Thermography, Veterinary Medicine
Clinical Medicine/Surgery, Other Pathologies (RSD, diabetes, wound healing, etc.)

Information and Submission

Contact: Pam Helmke
College of Veterinary Medicine
105 Greene Hall
Auburn, AL U.S.A. 36849-5228

Phone: 01-334-844-3699
Toll free: 01-800-483-8633
Fax: 01-334-844-3697
Email:Pam Helmke(chambpj@vetmed.auburn.edu)

Scientific Director: David Pascoe
Department of Health and Human Performance
2050 Memorial Coliseum
Auburn, AL 36849
Phone: 01-334-844-1479
Fax: 01-334-844-4025
Email: pascodd@auburn.edu

Thermal Imaging in Medicine

A short course entitled "Thermal Imaging in Medicine" will be organised on July 4-5,2001 at the Thermal Physiology Laboratory at the University of Glamorgan.

The registration fee of £250 will include course notes, the book "Thermal Imaging in medicine and Biology, Ammer and Ring (Eds), a CD ROM of papers published in ACTA Thermographica and Thermology (1976-1991) and refreshments.

Lecturers are Prof E F J Ring (Glamorgan), Dr K Ammer (Vienna), Dr J R Harding (Gwent), Prof B F Jones (Glamorgan). On 6 July, 2001 a symposium of research papers in "Thermal Physiology in Medicine" will be the closing highlight of this event .

Call for papers: please send a title and request for further details to Prof B F Jones by 1 March, 2001.
(e-mail bfjones@glam.ac.uk; fax +44 (0)1443 482715)

Announcement for the Guenter Bergmann Award 2001

The Guenter Bergmann Award is announced for the second time according to the conditions of the award

The Award will be given in a 2 years cycle for outstanding work in the field of clinical application or clinical research of thermal imaging. Papers in German or English from around Europe are welcomed.

Manuscripts should meet the standard of scientific papers and be consistent with the instructions for authors of the journal “Thermology international”. A thesis will not be accepted. Members of the committee of the German Society of Thermology are not eligible for the Award.

The award winning paper will be published in the “Thermology international”. Other submitted papers will be also sent the journal “Thermology international” for possible publication.

The Award Committee will consist of

A committee member of the GermanSociety of Thermology

A member of the Bergmann family

A known personality as chairman of the committee.

The jury is allowed to consult external experts for reviewing papers. Deadline for submission (original manuscript and 2 copies) is **August 31, 2001**. Address for submissions is

The President of the German Society of Thermology

Dr Joachim-Michael Engel M.D.

marked PERSONAL

Rheumaklinik Bad Liebenwerda

Dresdener Straße 9

D-04924 Bad Liebenwerda,

Germany

Veranstaltungen (MEETINGS)

26.-27. January 2001

7thInternational Conference on Infrared Imaging in Tampa, Florida

Clinical & Industrial Sections

Fee: 195 US $ per person pre-registered
275 US $ after November 1, 2000

Payable to: Ashwin Systems International Inc. P.O. 1014m Dunedin, FL 34697 USA
Phone: +1 727 785 5844

Information:
G.J. Rockley
Director of Operations
Teletherm Infrared

E-mail: infrared@gte.net
Internet: http://home1.gte.net/infrared/7thinter.htm

14. March 2001

UK Thermography Association Meeting

11.00am to 5.00pm on 14th March, 2001, at the University of Glamorgan, Pontypridd.

The meeting is being held at the University of Glamorgan to mark the opening of the Infrared Thermal Imaging Laboratories in the School of Computing.

Provisional Programme Structure:

10.00am Registration and Coffee.

11.00am Progress in Infrared Imaging Technology

12.30pm Lunch and visit to the new Thermal Imaging Laboratories

1.30pm Progress in Industrial Applications of Infrared Imaging

2.30pm Tea

3.00pm Progress in Medical Applications of Infrared Imaging

5.00pm Close

Please Fax, post or e-mail to

Prof Bryan Jones at the

School of Computing,

University of Glamorgan,

Pontypridd,

CF37 1DL

Fax: +44 (0)1443 482715

e-mail : bfjones@glam.ac.uk

Website: http://www.comp.glam.ac.uk/pages/staff/ bfjones

Name: ____________________

____

Address: ____________________

____

Fax: ____________________

E-mail: ____________________

Please send me details of the Programme when it is finalised: YES ☐ NO ☐

I would like to make a presentation (30 minutes/15minutes) YES ☐ NO ☐

I would like to reserve commercial display space at £100 +VAT YES ☐ NO ☐
(First come, first served)

Travel

The University is just off the A470 about 6 miles north of the M4 (J32).

Trefforest railway station is adjacent to the University and can be reached by the Valley Lines from Cardiff Central Railway station (20 minutes).

Cardiff Airport is 45 minutes away.

For a location map, visit http://www.comp.glam.ac.uk/pages/staff/ bfjones

Accommodation is available at J32 of the M4 (Friendly Hotel £55 and the Village Hotel £75)

16 – 20. April 2001

XXVIII conference SPIE Aerosense Infrared Technology and Applications in Orlando

Conference Chairs:
Andres E. Rozlosnik, SI Termografia Infrarroja (Argentina);
Ralph B. Dinwiddie, Oak Ridge National Lab.

Topics: Applications of Infrared in:

Automotive Industry, Power Generation and Distribution, Manufacturing and Processing Industries, Aerospace Applications, Infrastructure, Environmental & Resource Monitoring; Research & Development; NDT & Material Evaluation; Night Vision; Maintenance Management;Miscellaneous

Panel Discussion and Invited Papers are expected in the following important fields:

Infrared cameras calibration ISO 9000 Industrial requirements Blackbodies NIST Traceability. Law Enforcement and Fire Rescue

Topical Workshops

Related Tutorial Short Courses

Joint sessions are being planned in which attendance in this conference will be combined with two other important conferences of the AeroSense symposium:

Joint Session with Infrared Imaging Systems: Design, Analysis, Modeling, and Testing XII (OR34):

Research and Development Applications

Although initially developed by the military, infrared imaging systems have a wide range of applications in the civilian and industrial communities. This joint session focuses on new technologies, developments, or approaches to existing methods that advance the field or lead to new application areas. Suggested topic areas include, but are not limited to, micro- scopy, enhanced spatial or time resolution, spectral analysis, fiber bundle applications, medical applications, and image interpretation.

Information:
Internet: http://spie.org/web/meetings/calls(or01/

28.-30. April 2001

5thInternational Congress of Medical Thermology combined with the 14th Thermological Symposium of the Ludwig Boltzmann Research
Institute for Physical Diagnostics and the
Austrian Society of Thermology and the Annual Meeting of the German Society of Thermology

Venue: SAS Radisson Palais Hotel, Vienna

Main Theme: Thermology- the science of heat

Topics:

Thermo-Physiology,

Body temperature measurement by infrared and other techniques

Diagnostic infrared imaging

Thermo-Therapy

Monitoring (maintenance) by thermometry

Round table discussion:
Standards for medical thermal imaging

Deadline for abstracts: January 31, 2001

Scientific Programme Committee:

DDr.K.Ammer (president)	(Austria)
Prof.Dr.M.Anbar	(USA)
Prof.Dr.I.Benkö	(Hungary)
Prof.Dr.R.Berz	(Germany)
Dr. A.Camargo	(Brazil)
Dr.G.Dalla Volta	(Italy)
Dr.J.-M.Engel	(Germany)
Prof. Dr. I. Fujimasa	(Japan)
Dr.S.Govindan	(USA)
Dr.J.R.Harding	(UK)
Prof.Dr.B.Jones	(UK)
Prof.Dr.A.Jung	(Poland)
Prof.Dr.Y-S.Kim	(Korea)
Prof.Dr.K.Mabuchi	(Japan)
Dr.H.Mayr	(Austria)
Prof. Dr.R.Purohit	(USA)
Prof.Dr.E.F.J.Ring	(UK)
Dr.O.Rathkolb	(Austria)
Prof.Dr.H.Tauchmannova	(Slovakia)

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Tel: + 43 1 533 87 32, Fax: +43 1 535 99 31

E-mail: mailbox @eoinc.at

URL: www.eoinc.at/icmt5 (this site can be used for the conference registration !)

Information:
OA.DDr.Kurt Ammer

Ludwig Boltzmann Research Institute for Physical Diagnostics, Hanuschkrankenhaus,
Heinrich Collinstr. 30; A-1140 Wien

Tel: +43 1 914 97 01; Fax: +43 1 914 92 64
E-mail: KAmmer1950@aol.com

13.-15. June 2001

12th International Conference on Thermal Engineering and Thermogrammetry(THERMO) in the OSSKI Center (Törley Palace), Budapest XXII (Budafok) Anna u.5.

Conference Organizer:

Branch of Thermal Enineering and Thermogrammetry

Hungarian Society of Thermology at MATE

European Association of Thermology

International Center for Heat and Mass Transfer

Information
Dr.Irme BENKÖ, Technical University of Budapest (BME), Department of Energy
(DoE) H-1111 Budapest, Müegyetem rkp. 7.
D.208., Hungary,
office phone. +361-463-2183.
BME Fax: +361-463-1110,
DoE Phonelfax: +361-463-3273 or -463-3272.
E-rnail:benko@eta.enrg.bme.hu
or mate@mtesz.hu

19.-21.June 2001

8th International Symposium on Temperature and Thermal Measurements in Industry and Science (TEMPMEKO 2001) in Berlin, Germany

Organized by Physikalisch-Technische Bundesanstalt (PTB) und VDI-VDE-Gesellschaft Mess- und Automatisierungstechnik (GMA)

Topics: Instrumentation and Methods
Fundamental Aspects and Standards
Traceability and Dissemination
Sensors
Applications in Thermometry and Humidity

Information: VDI/VDE-GMA
Tempmeko 2001
Graf-Recke-Straße 84
D-40239 Düsseldorf
Phone:+49-2116214-215 Fax:+49-2116214-161

E-mail:tempmeko@vdi.de
Internet: http://www.vdi.de/gma/tempmeko.htm

22.-24. June 2001
American Academy of Thermology
Annual Conference, Auburn University, Alabama, U.S.A

Topics for presentation or poster session:

The conference planning committee will make the final assignment of abstracts to conference sections based on topic area and abstract submissions.

Thermal Physiology, Pharmacological, Neurology/ Neuroscience, Vascular, Orthopedics, Breast, Forensics, Technical/Equipment,
Applied Thermography, Veterinary Medicine, Clinical Medicine/Surgery, Pain, other Pathologies (RSD, diabetes, wound healing, etc.)

Deadline for Submission of Abstract:
February 1, 2001

Registration Fee (US dollars) :
* After April 1, 2001 add $25

Members $250
Non-Members $300
Residents, Nurses, Technicians $150

Teaching Courses and **thermography certifications** will be available at the conference.

For more Information, Abstract Forms, or Abstract Submission Contact:

Ms. Pam Helmke,
Conference Coordinator
College of Veterinary Medicine, 05 Greene Hall,
Auburn University, AL U.S.A 36849-5528 ; Phone (334) 844- 3699; (800) 483-8633
Fax (334) 844-3697;
Email chambpj@vetmed.auburn.eduS*

David Pascoe,
Scientific Director;Dept. of Health & Human Performance; 2050 Memorial Coliseum
Auburn University, AL U.S.A 36849,
Phone (334) 844-1479;
Fax: (334) 844-4025; Email pascodd@auburn.edu

3.-5. July, 2001

A short course entitled "Thermal Imaging in Medicine" at the Thermal Physiology Laboratory at the University of Glamorgan.

Registration £250 including course notes, the book "Thermal Imaging in Medicine and Biology, Ammer and Ring (Eds), a CD ROM of papers published in ACTA Thermographica and Thermology (1976-1991) and refreshments.

Lecturers:

Prof E F J Ring (Glamorgan),
Dr K Ammer (Vienna),
Dr J R Harding (Gwent),
Prof B F Jones (Glamorgan).

6 July, 2001

A symposium of research papers in
"Thermal Physiology in Medicine"

Call for papers: please send a title and request for further details to

Prof B F Jones (e-mail bfjones@glam.ac.uk;
fax +44 (0)1443 482715)
by 1 March,2001.

29.-30.September 2001

4th Congress of the Polish Society of Thermology in Zakopane

Information:
Prof.Dr.A.Jung

Pediatric and Nephrology Clinic,
Central Clinical Hospital, Military University, School of Medicine. Szaserow 128 str
00-909 Warsaw-60, PL

Tel/fax +48 22 6817236
email: ajung@cskwam.mil.pl

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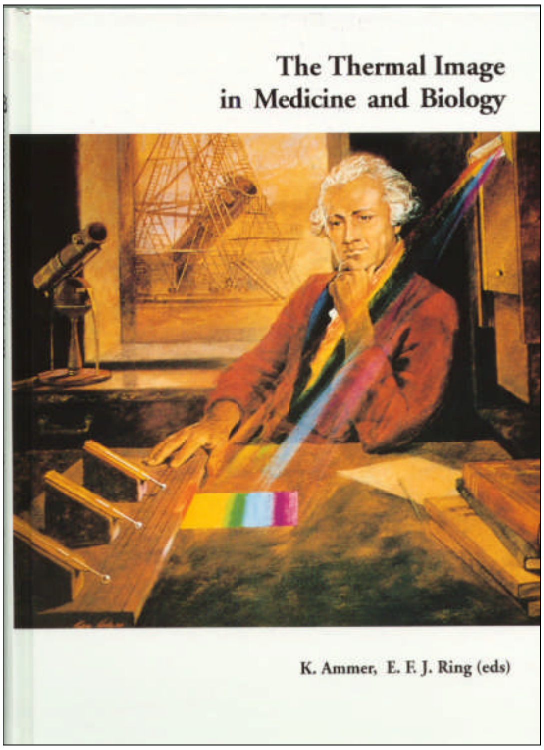

The Thermal Image In Medicine & Biology

1995, ISBN 3 900466 57 2
240 pp. plus XVI colour plates

ed. K.Ammer, EFJ.Ring

Thermal Imaging, Microwave Detection

Image Processing, Thermal Image Applications

Recent advances in medical thermography

Thermal physiology and the skin

Veterinary thermography

This book, based on the proceedings of an international conference, provides the most up to date review of the current state of the art in thermal imaging. The clinical applicatons include vascular skin reactions, varicosed veins, deep vein thrombosis and Raynaud's Phenomenon. Lumbar disc herniation, post surgical evaluation of the knee and the hand (carpal tunnel syndrome), tennis elbow and thoracic outlet syndrome are also described.
The methodology itself and comparative studies with other techniques such as ultrasound, CT and MRI make this a practical manual for the physician or technologist employing these investigations.

Only available from The European Association of Thermology, order below at the direct sale price of **$50 U.S. or 500.- Austrian Schillings** to the following account 965 023 054 at Bank Austria, No 20151 in Vienna, Austria. Price includes mail in Europe, all other destinations add $10 or 120.-Austrian Schillings.

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Hernalser Hauptstr. 209/14, A-1170 Wien, Österreich
Bank Austria, Vienna, Austria, bank number: 20151,
account :European Association of Thermology, account number: 965 023 054

Dr. med. Joachim-Michael Engel
Internist - Rheumatologe,
Ltd. Chefarzt der Rheumaklinik
Dresdener Straße 9
04924 Bad Liebenwerda
Telefon 035341 901161
Fax 035341 902705

Rheumatologie in voller Breite

Die Rheumaklinik Bad Liebenwerda bietet per sofort
- zu den anzeigenüblichen Bedingungen -

2 Weiterbildungsstellen in Vollzeit für AssistenzÄrzte oder ÄiP

mit der Möglichkeit neben der mehrjährigen Weiterbildung Innere Medizin und Rheumatologie oder Physikalische und Rehabilitative Medizin die Rheumatologie in ihrer ganzen Breite kennenzulernen, einschließlich wissenschaftlicher Arbeiten.

Als Stationsarzt versorgen Sie unter fachärztlicher Supervision ca. 35 Patienten von der Aufnahmeuntersuchung bis zum Entlassungsbericht, einschließlich sozialmedizinischer Stellungnahme. Sie können sich innerbetrieblich alle notwendigen Fähigkeiten und Kenntnisse aneignen, u.a. Sonographie, Infrarot-Thermographie, Röntgen des Bewegungssystems, Labor, immunologische Spezialuntersuchungen, Gelenkpunktion und Synovia-Analyse, EKG, Ergometrie, Langzeit-EKG, Spirometrie...........sowie zahlreiche Verfahren der physikalischen Therapie und Naturheilkunde.

Neben Ärzten in allgemeinärztlicher oder internistischer Weiterbildung möchten wir gerne auch einen **Internisten mit oder ohne Facharztqualifikation** ansprechen, der die **Weiterbildung als Rheumatologe** anstrebt mit der Option, innerbetrieblich in eine Oberarzt-Position aufzusteigen.

Um den Bewerbungsweg abzukürzen, vereinbaren Sie bitte direkt einen Vorstellungstermin unter Tel: 035341 901161.

Das therapeutische Team der Rheumaklinik freut sich auf Sie!

Die Rheumaklinik Bad Liebenwerda der RHM Altenheim- und Klinikgruppe ist eine moderne Spezialklinik zur Behandlung rheumatischer Krankheiten, einschließlich rheumatologischer Rehabilitation und AHB in enger Kooperation mit dem Rheumazentrum Leipzig und den Berliner Rheumazentren. Besondere Behandlungsschwerpunkte sind alle entzündlich-rheumatischen Krankheiten und die Fibromyalgie.

5th International Congress of Thermology

Radisson SAS Palais Hotel
Vienna / Austria -April 28-30, 2001

Please return to:
e+o Incentives & Conventions
Kramergasse 1, 1010 Vienna, Austria
Tel.: +43-1-5338732, Fax: +43-1-5359931
Email: mailbox@eoinc.at

REGISTRATION FORM

Please type or use blockletters
All prices are in Austrian Schillings

PARTICIPANT

Last Name: ________________________________First Name: ____________________________________Title:_________

Institution: ____

Street: ____

ZIP Code: __________________City: ________________________________Country: _____________________________

Tel.: ____Fax: ____

ACCOMPANYING PERSON

Last Name/First Name : ____

REGISTRATION FEE

	payment until January 31, 2001	payment until March 7, 2001	payment after March 7, 2001	
Members of ÖGT or DGT	¨ ATS 2.700,—	¨ ATS 3.000,—	¨ ATS 3.500,—	______________
Non-members of ÖGT or DGT	¨ ATS 3.000,—	¨ ATS 3.500,—	¨ ATS 4.000,—	______________
One day registrations*	¨ ATS 1.350,—	¨ ATS 1.350,—	¨ ATS 1.350,—	

* One day registrations are only available on site and do not include meals

HOTEL ACCOMODATION

I wish to book:	Single Room	Double Room			
Radisson Sas Palais Hotel*****	¨ ATS 2.400,—	¨ ATS 2.400,—	exl. breakfast	deposit ATS 2.500,—	______________
Hotel De France*****+	¨ ATS 1.750,—	¨ ATS 2.000,—	incl. breakfast	deposit ATS 2.000,—	______________
Hotel Royal ****	¨ ATS 1.400,—	¨ ATS 1.800,—	incl.breakfast	deposit ATS 1.500,—	______________
HotelViennArt ***	¨ ATS 1.180,—	¨ ATS 1.650,—	incl.breakfast	deposit ATS 1.500,—	______________

Arrival: ______________________________ Departure: ______________________________
All rates are per room/night and include breakfast. Deadline for reservations is March 7, 2001.

OPTIONAL PROGRAM

Wachau Trip plus guided tour at the Abbey Melk plus Heurigen-Dinner — Monday , April 30, 2001 — ATS 500,— per person — _______ person(s) — ______________

PAYMENT

Kindly order bank transfer to 5th International Congress of Thermology" account no. 09523637805 with CREDITANSTALT BANKVEREIN, bank code 11000 or send a cheque payable to E+O to above mentioned address.
Please charge my credit card ¨ ž Diners Club ž Mastercard/Eurocard¨ ž Visa

No.: _____________________________Exp. Date: ______________________________Amount: ______________

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____
Date Signature

Thermology international

Dr. Kurt Ammer
Österreichische Gesellschaft für Thermologie

Hernalser Hauptstr.209/14
A-1170 Wien
Österreich

This journal is a combined publication of the Ludwig Boltzmann Research Institute for Physical Diagnostics and the Austrian Society of Thermology. It serves as the official publication organ of the European Association of Thermology (EAT), the American Academy of Thermology, the German Society of Thermology, the UK Thermography Association (Thermology Group) and the Austrian Society of Thermology. An advisory board is drawn from a panel of international experts in the field. The publications are peer-reviewed.

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☐ Italian Association of Thermology
☐ Polish Society of Thermology
☐ Deutsche Gesellschaft für Thermographie

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Thermology international

Dr. Kurt Ammer
Österreichische Gesellschaft für Thermologie

Hernalser Hauptstr.209/14
A-1170 Wien
Österreich

Diese Zeitschrift ist eine gemeinsame Publikation der Ludwig Boltzmann Forschungsstelle für Physikalische Diagnostik und der
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Sie dient als offizielles Publikationsorgan der Europäischen Assoziation für Thermologie (EAT), der Amerikanischen Akademie für Thermologie, der Deutschen Gesellschaft für Thermologie, der Britischen Thermograpie Assoziation (Thermologie Gruppe) und der Österreichischen Gesellschaft für Thermologie.

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Bank Austria, Wien, Österreich, Bankleitzahl: 20151
Kontonummer: 965023054