23rd Thermological Symposium of the Austrian Society of Thermology Quantitative Thermal Imaging in Medicine

13th November 2010 Raddisson BLU Palais Hotel, Parkring 16, 1010 Vienna

8.00-8.30 Welcome-Coffee

Programme

Chair: Prof Dr. Anna Jung (Poland), Dr.Kevin Howell (UK)

8.30-8.50 **K.Ammer** (Austria)
Evaluation of Infrared Thermal Images from a Patient Suffering from Primary Raynaud´s Phenomenon
8.50-9.00 Discussion

9.00-9.20 B.Kalicki, A. Jung, **EFJ Ring,** M.Saracyn , S.Niemeczyk (Poland/UK)
Thermographic Monitoring of the Hand In Renal Dialysis Patients: Comparison of High and Low Resolution Cameras
9.20- 9.30 Discussion

9.30- 9.50 **R.Vardasca** (Portugal)
The Need of A Standard False Colour Scale For Medical Thermography Analysis
9.50-10.00 Discussion

10.00- 10.30 Viennese Coffee Break

Chair: Prof Dr. Francis Ring (UK), Prof Dr Kurt Ammer (Austria)

10.30- 10.50 **C. Hildebrandt** ; C. Raschner (Austria)
Recording sports injuries with thermography
10.50-11.00 Discussion

11.00- 11.20 **K. Howell**, R.E. Smith (UK)
Temperature of the face in children
11.20- 11.30 Discussion

11.30- 11.50 Gabrhel J, **Popracová Z**, Tauchmannová H, Chvojka Z. (Slovak Republic/Czech Republic)
Thermographic Findings In The Lower Back
11.50-12.00 Discussion

12.00-12.20 **A. Cholewka** (Poland)
Thermal Imaging In Venous Diseases of The Lower Extremities
12.20-12.30 Discussion

12.30-12.40 **R. Thomas** (UK)
Thermography In Monitoring Laser Therapy
12.40-13.00 Discussion

13.00-13.20 **K.Ammer** (Austria)
Thermology international- 20 anniversary
13.20- 13.30 Discussion

13.30 Close

Abstracts

EVALUATION OF INFRARED THERMAL IMAGES FROM A PATIENTS SUFFERING FROM PRIMARY RAYNAUD´S PHENOMENON

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Introduction: A number of criteria have been proposed in the past for diagnosing Raynaud´s phenomeno by temperature measurements. These include recovery time, percentage recovery, absolute temperature, gradient fingertip to dorsum and combient gradients, which summarises the gradient prior to cold challenge with the gradient at a defined time, usually 20 minutes post cold challenge.

Objective: The validity of all these criteria for diagnosing Raynaud´s phenomenon is unknown. The results of a simple experiment might help to better understand the diagnostic power of the parameters mentioned above.

Methods: A female patient who received the diagnosis of primary Ray- naud´s phenomenon 10 years ago, underwent on three consecutive days thermographic investigations of her hands and fingers.

All studies were performed at the same time in early afternoon and after acclimatisation with bare arms to a room temperature of 24° degrees for 15 minutes. Then the hands were covered with plastic gloves were immersed in water for 1 minute. The water temperature varied from 1 day to the other and was 10, 15 or 20 °C.

Prior to and immediatly after the cold challenge 20 thermal images were recorded at a time interval of 1 minute.

Circular regions of interest (ROI) were defined in a way that the outline of the circle was adjacent to the outline of the fingertip of the little finger. ROIs were positioned on the tip and over the mid of metacarpal bone of each finger. Temperature gradients were calculated by subtracting the metacarpal temperature from the temperature of the finger tip. This method of evaluation was found to be the most sensitive in detecting diagnostic temperature gradients [2]. A combined temperature gradient (CTG) was calculated by summing up the temperature gradient prior to cold challenge with the gradient 20 minutes post cold challenge.

Results: Figure 1 shows that the baseline readings vary from one day tom the other by 1 centigrade. Figure 2 presents the tem. perature gradients before and 20 minutes after cold challenge.

figure1

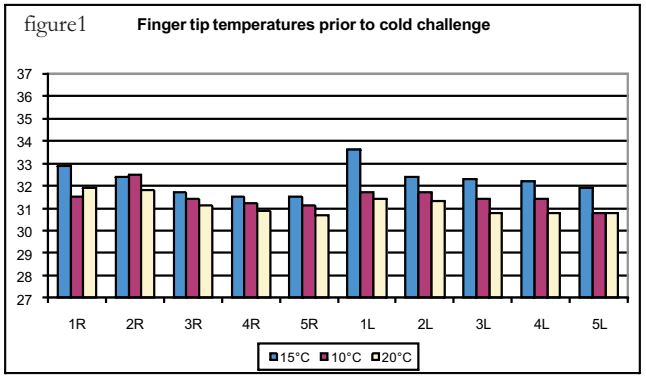
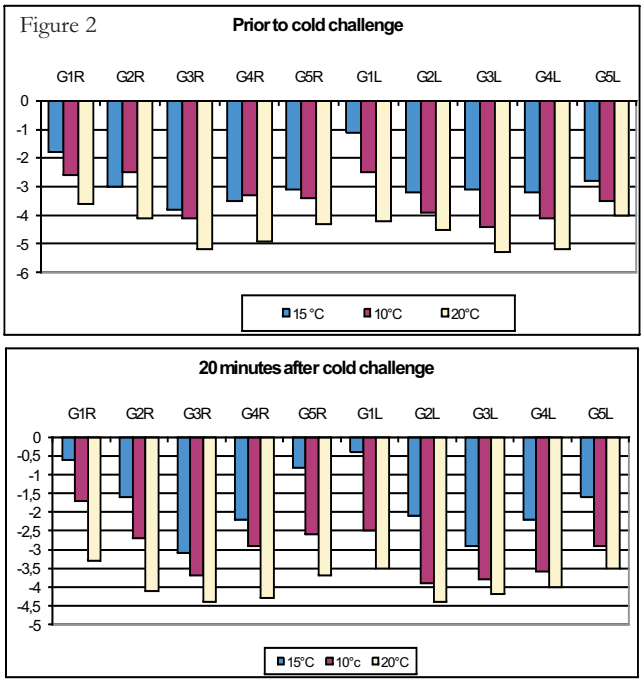


Figure 2



The magnitude of these gradientes is nearly identical. These diagram clearly show that cold fingers cool down after immersion in cold water, the extent of cooling depends on the water temperature and the recover to baseline temperature within 20 minutes.

Conclusion: The diagnostic criteria recovery time and percentage recovery failed to identify the proven primary Raynaud´s phenomenon in this patient. The absolute temperature varies from day to day, but could detect the established low temperature on the finger tips. In case of warm fingers that do not recover after an even mild cold challenge, measurement of the absolute temperature will also miss the disease The performance of the temperture gradient fingertip to dorsum is much better, but will loose his discrimination power in case that the gradients become reverse at different time points. Obviously the best diagnostic criterium for thermographically diagnosed Raynaud´s phenomenon is the combined gradient, which can also identify minor various of vasospastic finger diseasae, when two negative gradients below the threhold of 1 degree cumulated and finally result in a negative value above the cut-off point.

THERMOGRAPHIC MONITORING OF THE HAND IN RENAL DIALYSIS PATIENTS: COMPARISON OF HIGH AND LOW RESOLUTION CAMERAS

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Renal dialysis requires regular cannulation for connection to the apparatus. This is achieved by the insertion of shunts in the arms or groin. After repeated use the risks of arterio-venous fistulae increase. This in turn can lead to vasoconstriction and reduction in peripheral circulation. Thermographic monitoring of hand

temperatures can provide useful information of changes in peripheral circulation. During dialysis it is necessary to use a thermal camera for obtaining objective evidence of peripheral temperatures.

The Flir i5 and i7 cameras are extremely portable, and therefore convenient for use in the Renal Dialysis Department. To ascertain if the results from these low resolution hand held systems are of adequate performance, a group of patients on regular dialysis have been studied in parallel with a high resolution camera FLIR P640.

The main differences in specification are shown in table1

Camera	FLIR i5	FLIR i7	FLIR P640
Resolution, pixels	80x80	120 x 120	640x 480
Thermal resolution	0.1°C	0.1°C	30mKelvin
weight	0.35Kg	0.35Kg	1.9Kg
Visible light camera	NO	NO	YES

Method After 3 months experience with the i5 camera, an i7 was used with a P640 high resolution camera on a group of adult , male and female patients. The palmar and dorsal surfaces of both hands, the dialyzed and non dialyzed while the patient was undergoing the procedure. A cool background was placed under the hand to obtain a clear image. In some cases, cannulae carrying warm blood were lying close to or even crossing the hand or arm. The use of the visible light camera with the p640 camera provided useful documentation of the sometime complex thermal structures around the patient. The images were downloaded to a computer after each recording session and analyzed with FLIR reporter software.

Two regions of interest were selected over the index and middle finger, and a larger region selected over the centre of the dorsal or palmar area. From these selections mean temperature differences from the centre of the hand to the distal areas of the selected fingers was calculated. The identical procedure was followed with the i7 camera, with the exception of the visible light images.

Results. All comparative temperature readings were analyzed from both surfaces of both hands yielding 60 measurements from each camera. The absolute mean values summed were 33.0C from the P640 camera, and the corresponding values from the i7 camera were 32.6C. The mean difference was 0.4 C the averaged signed difference being -0.4C. The maximum difference obtained in one instance was 1.7C, due to difficulties in selecting the region of interest. Many of the readings were less than 0.3C different between the two cameras.

Conclusion. While the P640 gave superb images, and the additional visible pictures were extremely helpful in interpreting the thermograms, the additional weight was the only disadvantage. The i7 camera gave adequate image quality sufficient for later analysis, and provided a convenient instrument for positioning at any angle required at the bedside. AS this instrument is fixed focus, it had to be used at least 0.6meter from the patient.

The lightweight i7 camera is a suitable instrument for remote temperature sensing in dialysis patients.

THE NEED OF A STANDARD FALSE COLOUR SCALE FOR MEDICAL THERMOGRAPHY ANALYSIS

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The frequent use of false color scales in medical thermal images has the objective of being a visual aid for human eye interpretation. However, several scales are being used, which may lead to different subjective interpretations. Is objective of this study to raise the need of uniformity in adoption of an internationally accepted standard false color scale and for that purpose a scale is proposed. A set of IR medical images of different regions of the body containing temperature measurements in grayscale values is used. These images are loaded into MATLAB prototyping software and a range of different false color scales are applied and its differences in subjective interpretation evaluated. The proposed false color scale to be accepted as standard is a mean between the natural color spectral wave distribution and the human eye color perception wave, based in the three main color components (Red, Green and Blue). The adoption of the proposed false color scale will enforce the standardisation of the analysis of medical IR images.

RECORDING SPORTS INJURIES WITH THERMOGRAPHY

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Background: Football is one of the most popular sports in the world (1). High intensity training combined with frequent competitions pushes the locomotor system to its anatomical and physiological limits. Woods et al. stated that young footballers are at a greater risk of slight and minor injuries, overuse injuries, lower leg injuries and muscle strains during the preseason period (2). The so-called "little traumatologies" are very frequent; therefore, their early detection is important. The efficiency, safety and low cost of Infrared Imaging make it an auxiliary tool in medical imaging to detect and locate thermal abnormalities characterized by a temperature increase or decrease found at the skin surface.

The aim of this study was to predict overuse injuries through infrared monitoring of soccer-specific injuries. Traumatic injuries will be observed over time to evaluate the individual healing process.

Methods: We conducted pre-season measurements of 25 football players (mean age 17.6± 3.9 years, height 176.1± 8.1 cm, mass 67.8±9.1 kg) from the Football Academy Innsbruck. After an acclimatisation period of 15 minutes, baseline images of four different aspects of the lower leg were recorded using an infrared camera (VarioCam HiRes Ultimate D Clinic &Portable). Following a 20 minute sport-specific warm-up, recordings on the standing subject were repeated to assess changes in haemodynamics. The software Exam 5.6.2. was used to analyse the thermogram.

Results: 52% of the athletes reported no injuries, 28% had an overuse injury and 20% sustained a traumatic injury within the previous 6 months. Most thermograms of the non- injured athletes showed no asymmetrical pattern. However, side to side differences on structures of the knee were found in 31% of these athletes. Overuse reactions such as diffuse knee pain following training occurred in two athletes. The thermogramm at rest demonstrated symmetrical patterns. Following sport-specific exercise, local side differences on the knee were visible.

Thermograms of traumatic injuries defined the extent of pathophysiological reactions in structures involved. An athlete with an achilles tendon rupture (6 months previous) and a loss of feeling in the toes showed a clear temperature decrease in the affected area. The thermogram of an ankle joint ligament reconstruction indicated high metabolic activity.

Conclusion: The preseason measurements are the first step to create a sport-specific database with individual thermograms. Baseline recordings and images following a sport-specific strain should be conducted to visualise thermal regulatory processes. Repeated follow-up measurements will clarify if symptom-free

asymmetrical temperature distributions are predictive for pre-sy mptomatic identification of overuse injuries. In terms of traumatic injuries such as ligament ruptures, further research will determine if tissue remodelling is still ongoing after symptoms disappear.

References:

1. R. J Shephard; Biology and medicine of football: An update. J Sports Sci 1999;17:757–86.

2. C Woods, R Hawkins, M Hulse, A Hodson; The Football Association Medical Research Programme: an audit of injuries in professional football—analysis of preseason injuries. Br J Sports Med 2002;36:436–441.

TEMPERATURE OF THE FACE IN CHILDREN

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Background: Infrared thermography of the inner canthus of the eye offers the potential to detect febrile subjects rapidly and non-invasively at, for example, airports or hospital entrances during episodes of pandemic fever. Children are a key group likely to spread respiratory infection. The ideal "cut-off" eye temperature for detecting a febrile child will depend upon the temperature distribution across the population of afebrile and febrile children, as well as the reliability of the temperature measurement. Consequently, interest is now increasing in the collection of "normal" facial temperature data in both children and adults, and ISO standards have been published in an attempt to regulate thermal imager specification and application. Nonetheless, facial temperature data in both healthy and febrile children remain scarce, and historically recommendations for fever-screening protocols have been either poorly-applied or ignored by manufacturers and practitioners. Our retrospective study presents facial temperature data from a small group of afebrile children who attended the Royal Free Hospital on multiple occasions for another thermographic research project.

Method: Twenty girls and eleven boys were included in the analysis. Mean temperature from a region of interest of 7x7 pixels was recorded from each subject at the tip of the nose, the forehead above the eyebrow, and the inner canthus of the eye. In a sub-group of 18 of these subjects who attended for thermography on 3 or more further occasions, the analysis was repeated using the thermogram at each visit.

Results:Facial temperatures recorded at first visit are presented below:

	Male		
	Nose	Forehead	Canthus
Median Temp./ ºC	33.5	34.1	35.7
Range / ºC	5.2	1.8	0.9
	Female		
	Nose	Forehead	Canthus
Median Temp/°C	31.8	34.4	35.5
Range /°C	7.8	2.2	1.3

We found no significant temperature differences due to sex, but there were significant differences in temperature between all face sites ($p<0.01$, Mann-Whitney). The inner canthus of the eye was both the warmest site, and the site that exhibited the smallest range across all subjects. We found similar intra-individual variability in temperature on repeated visits: the maximum range of inner canthus temperature was 1.4ºC in a boy who attended on five occasions.

Conclusions: This small study, as an adjunct to the work of others, helps to characterise the variability in inner canthus temperature in afebrile children. For effective fever screening, it will also be necessary to characterise the febrile population. Compared to our figures, other authors have published higher inner canthus temperatures in healthy children. This may be, in part, due to differences in image analysis. However, it should also be remembered that the variation in results between centres is much less than the stated accuracy of most thermal imagers (±2ºC). Co-ordinated fever-screening across multiple sites will require careful calibration and traceability of thermal imagers to achieve a measurement accuracy of a few tenths of a degree Celsius.

THERMOGRAPHIC FINDINGS IN THE LOWER BACK

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[2] National Institute of Rheumatic Diseases, Piešťany, Slovak Republic;
[3] Private Clinic of Medical Rehabilitation, Myoskeletal Medicine and Acupuncture, Břehy, Czech Republic.

Introduction The etiology of lower back pain is multi-factorial. It can develop due to a series of organic, non-vertebrogenic diseases, degenerative changes in the spine and functional changes in the joint and musculoskeletal systems. In many patients who suffer from back pain, no morphological findings can be detected even through recent diagnostic methods. The pain information is generated by several factors. Pain in discopathies can arise due to inflammatory mechanisms even without any inter-ve rtebral disc prolapse or nerve root compression. It develops due to pH alteration and the chemical composition of the intervertebral disc.

With accidents and any damage to soft structures, overloading or micro-traumas, various biochemical processes induce inflammation in the damaged structure. Acitvation of thermally active trigger points (TrP) triggers pain that the patient localises either in the lumbar spine or it is propagated in the lower extremities, with an imitation of radicular pain. By the possible irritation of sympathetic nerve fibres in r. dorsalis n. spinalis in intervertebral functional disorders of facet joints in the back area and in n. meningicus recurens (n. sinuvertebralis) in ligamentous lesions in the back induce hypothermal site patterns in the pertinent thermotom of the back area. It is a type of nociceptive sympathetic efference. An indirect effect of neural pathophysiology called nociceptive motor efference, results in increased tone of a muscle or muscle group with an aggregation of acid products of metabolism and shifts in electrolytic environment. This can lead to relative hyperthermia of the area of skin above.

Objective: Thermal images of the lumbar and gluteal areas were analysed retrospectively in a group of 141 patients (77 male, 64 female, average age:43.2 years) suffering from pain in the lumbar and sacral parts of the body. Patients with post-traumatic and rheumatic disorders were excluded. Out of a total of 141 patients, X-rays, CTs and MRIs were carried out. Ultrasound scans and laboratory examinations were performed on patients with past urogenital ailments.

Results: 89 patients, who presented with painful manifestations but without structural and disorders, showed active thermal findings in small sites in the gluteal area caused by local trigger points and over the crista iliaca due to enthesopathy. In a small number of these patients with functional disorders, hypothermal patterns showed over the spine and in the paravertebral area due to nocireactive sympathetic efference in discogenic, facet, muscular and other disorders. The majority of the 28 patients with struc-

tural changes in the lower back area (discopathy, facet syndrome) showed various hyperthermal patterns over the lumbar spine and paravertebral areas.

Conclusion: The thermographic examination is significant for the more specific localisation of affected regions and is helpful in differentiating the inflammatory etiology of low back pain from painful syndromes of a reflexive origin induced either through the mechanism of nociceptive sympathetic efference, nociceptive motor efference or reflexive - autonomic reactions. In this respect, it offers a solid basis for adequate diagnostics and treatment.

THERMAL IMAGING IN VENOUS DISEASES OF THE LOWER EXTREMITIES

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Thermal imaging was used for estimation of lower limbs veins diseases. The studies were conducted for 15 patients (7 women and 8 male in age 62,3 ± 12,9) suffered from venous embolism and thrombosis of veins. The investigations were carried out at the Chair and Clinic of Internal Diseases and Physical Medicine, Silesian Medical University in Bytom. All patients were examined by a physician. They were requested not to smoke, drink alcohol or hot drinks for 4 hours before thermovision studies. The distribution of the skin surface temperature was monitored by using a Thermovision Camera A40M in a special room where temperature was 23±1°C.

Thermograms of tight's showed elongated areas characterizing with higher temperature what can be connected with pathological changes of veins (see Figure 1). Enhancement temperature in some areas of tights seem to be associated with blood stasis due to malfunction of veins valves. Such processes may lead to vein deformation and inflammatory states manifested on the skin surface as areas with higher temperature unlike healthy lower limb. The differences in temperature distribution can be easy correlated with medical diagnosis. Moreover thermal imaging can reveal abnormal ramification of arteries causing blood stasis in the vessels and ist deformation.

The peripheral circulation diseases seem to be very interesting and proper issue to thermal imaging especially for superficial veins malfunction.

THERMOLOGY INTERNATIONAL- 20TH ANNIVERSARY

K.Ammer (Austria)

Austrian Society of Thermology, Vienna; Austria

After the journal Thermology ceased publication in 1990, the idea arose in the newly founded AustrianSociety of Thermology to edit an own journal, which was named Thermologie Österreich. Six and a half volumes were published between 1991 and 1997, encompassing 21 issuesof this first version of Thermology international 27 papers from Thermologie Österreich were cited in the Thompsons database ISI resulting in 34 citations.

Most cited paper from this period was *"Thermological Implication of Vasodilation Mediated by Nitric Oxide" by Michael Anbar, published in Thermologie Österreich 1995, 5(1):15-27*

The third issue of volume 7, 1997, showed the new name of the journal which was European Journal of Thermology, suggested by a number of delegates of the European Association of Thermology during the assembly at the 7th European Congress of Thermology held in Vienna in spring 1997. This short period of this former version of Thermology international lasting from July 1997 to October 1998, was quite sucessfull in terms of receiving citations. 24 papers from the in total only 6 issues of the European Journal of Thermology were listed as cited in ISI, resulting in a total of 43 citations. Most, i. e. 17 times cited paper was " *Fast Dynamic Area Teletherrmometry (DAT) of the Human Forearm With a Ga/As Quantum Well Infrared Focal Plane Array Camera" by M.Anbar, Grenn WA, Marino MT, Milescu L and Zamani K, Eur. J Thermol 1997, 7(3) 105-118*. The paper " An open system for the acquisation and evaluation of medical thermological images"by P.Plassmann& E.F.J. Ring received in total 13 citations underlying the importance of software programmes in medical thermography.

As the journal served from 1999 on as publication organ for the American Academy of Thermology, the European Association of Thermology, the German, Austrian and British Society of Thermology the journal title was changed from European Journal of Thermology to Thermology international. Since 2002 Thermology international is listed in Embase and Scopus. In the last 12 years 66 papers were listed as citations in ISI resulting in 81 citing papers. The paper "*The technique of Infra red Imaging in Medicine"* by E:F.J. Ring & K.Ammer received 22 citations in ISI. Searching for this title in Google Scholar , which includes Citations in Scopus and in socalled gray literature such as theses resulted in 65 hits.

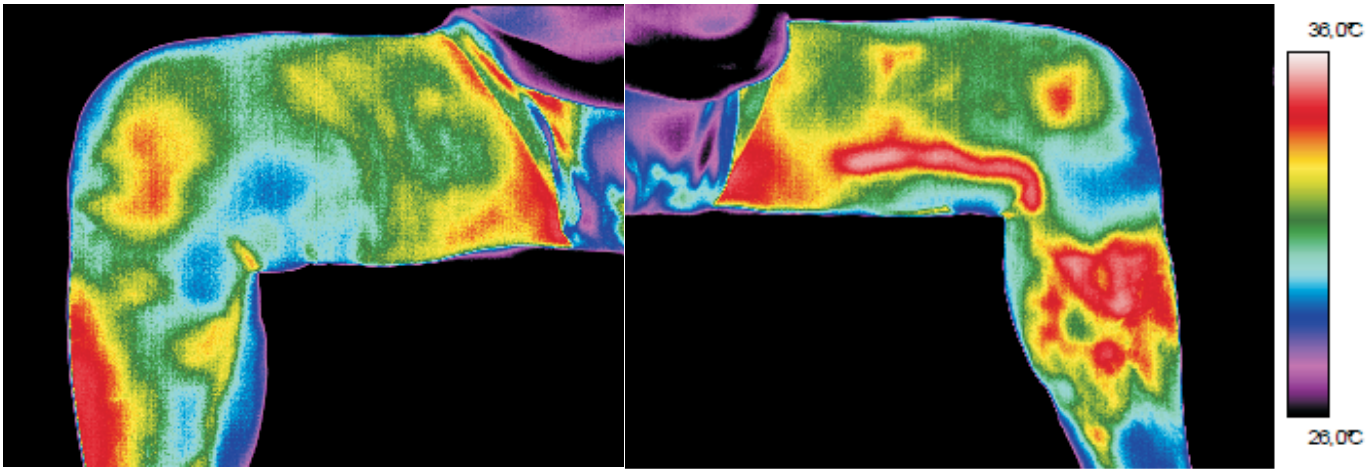

Figure 1.
Thermograms of inside tight's parts of patient suffered from insufficiency of atrioventricular saphena vena magna of lower left limb.

Although the journal thermology international is not yet listed in ISI or Medline, the 2008 index in SciImago Journal & Country Rank for Cites/Doc (2 years), which is equivalent to the ISI impact factor, was 0.87. The subject areas, from which citations were made, changed from clinical medicine during Thermologie Österreich over biomedical engineering for the European Journal of Thermology to biomedical and multidisciplinary engineering, medical imaging, optics and instruments & instrumentation in Thermology international.

Currently a DVD is in preparation, which will include all issues from Thermologie Österreich, the European Journal of Thermology and Thermology international plus the book "*The Thermal Image in Medicine and Biology*" edited by K. Ammer & E.F.J.Ring. The searchable data disk will probably available for purchase in the begining 2011.

THERMOGRAPHY IN MONITORING LASER THERAPY

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The use of thermography in laser therapy has proved to be a useful tool in reducing secondary unwanted damage and to speed up the therapeutic process. The treatment of vascular lesions is prime example where infrared thermography has resulted in a number of advantages including:

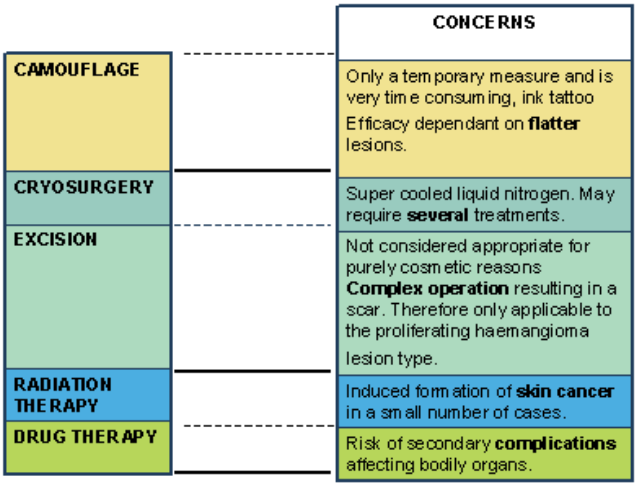
- Reduced risk of infection
- Bloodless surgery, an alternative to the traditional scalpel
- Improved therapeutic results
- Reduction to injury to normal skin
- Safe and portable.

Thermographic monitoring during laser therapy can be used to not only to set-up the laser for optimum performance such as energy density but also to visualise the laser-tissue interaction thereby reducing excessive temperatures and missed treatment areas.

In particular Dye lasers have the following advantages during and post treatment:

General Indicator	Dye Laser in Treating Vascular Lesions
During Treatment	Selective destruction of target chromophore (Haemoglobin) Can vary output parameters Manual or computerised (scanner) procedure Portable
Post Treatment (Desired effect)	Slight bruising (Purpura) Skin retains its elasticity Hair follicles are removed Skin initially needs to be protected from UV and scratching

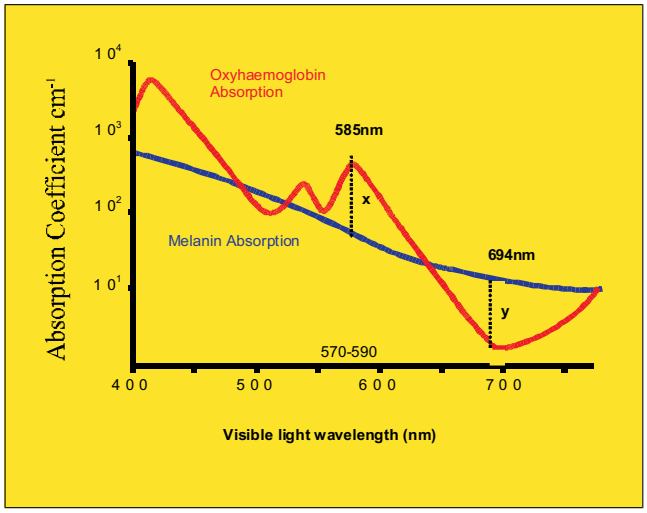
There are a number reasons why thermography is an alternative to traditional methods to treating vascular lesions each with its concerns



Selective Photothermolysis (SP) was developed for the treatment of vascular lesions. SP of blood vessels where the absorption in the oxyhaemoglobin dominates that in the melanin.

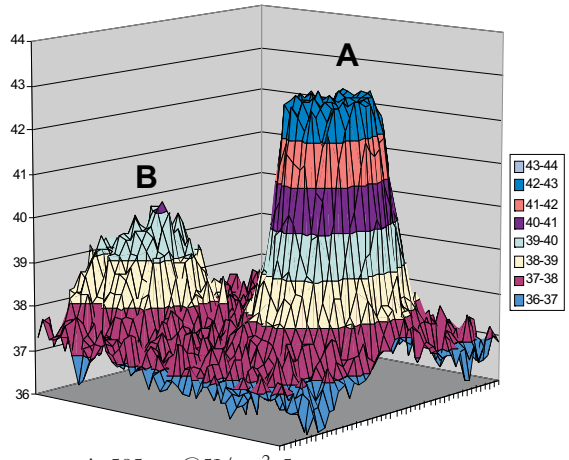
Whilst there will be some absorption in the surrounding skin, the main point is that the absorption rate in the target is in the order of magnitude greater than the other parts of the skin.

The energy needed to raise the temperature of the target is an approximation based on the volume, density and heat capacity of the target. Biological target is destroyed when it reaches the denaturation threshold temperature around 70°C.



Results reveal that various laser parameters such as wavelength (see image to the right), spot size and energy density have a significant impact on laser efficacy and that Infrared thermography is able to measure the effects of changing these parameters directly on the skin.

Thermography is also capable of accurately, repeatably, collecting changing temperatures occurring on the skin surface as a result of thermal diffusion occurring below the surface



A: 585nm @5J/cm^2, 5mm spot
B: 694nm @ 5J/cm^2 , 5mm spot

The selection and correct operation of the infrared radiometer is an essential requirement during laser therapy, for example the following table illustrates some key factors for optimum performance:

Wavelength	Key Factors
Detector	Geometric size of pixel Number of pixels Response Uniformity Cooled Uncooled
Resolution	Spatial (IFOV) Thermal ($IFOV_{meas}$)
Lens	Standard Macro
Emissivilty	0.98
Ambient temperature correction	Should be within 20 to 24°C
Humidity	Ideally 50%

More recent advances in detector technology suggest that there will be significant improvements in image quality such as spatial resolution, more and smaller detail and thermal resolution, highlighting extremely small temperature differences, very sensitively.