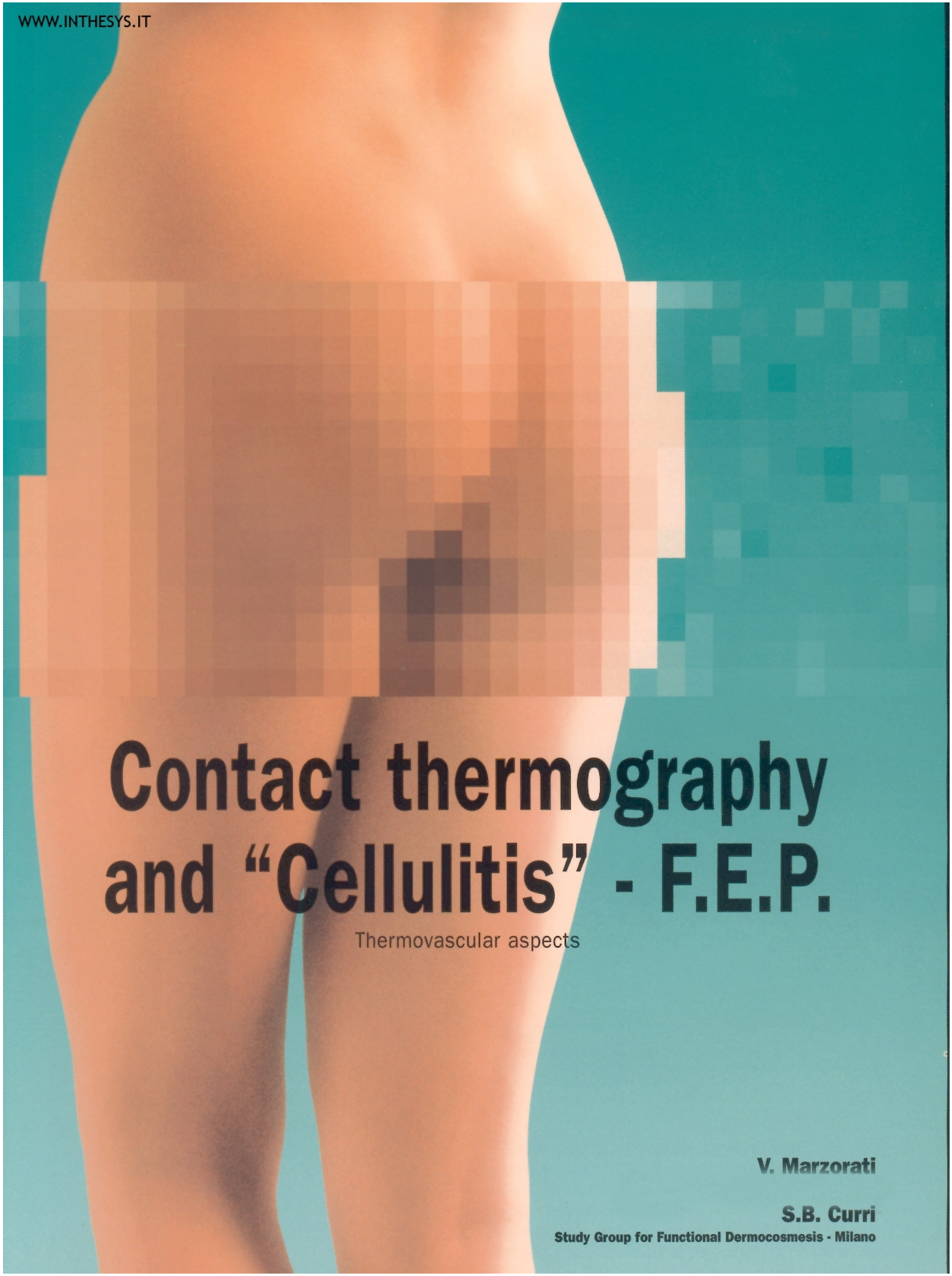

Contact thermography and "Cellulitis" - F.E.P.

Thermovascular aspects

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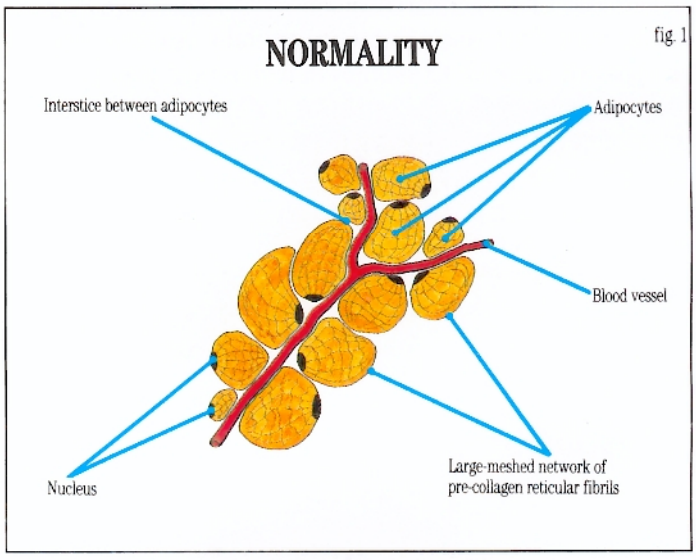
SUMMARY

1. "Cellulitis" (Fibrosclerotic Edematous Panniculopathy - F.E.P. or Liposclerosis)

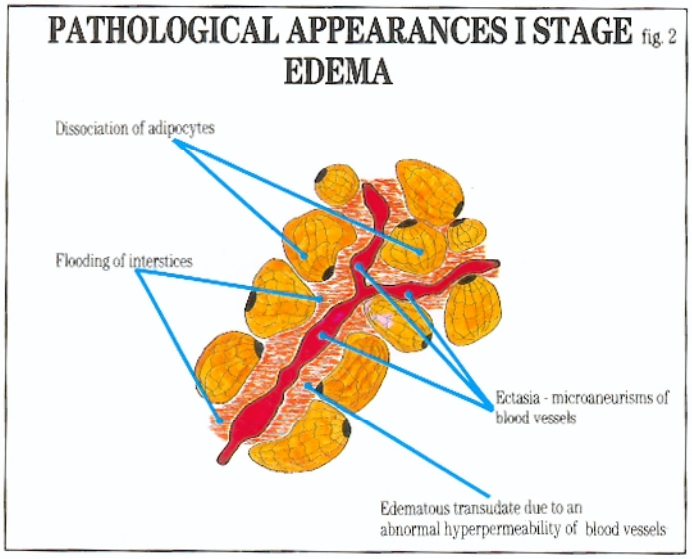
Recent studies, carried out in conjunction with biopsies of adipose tissue taken from the bodily regions affected by so-called "cellulitis", show a multiplicity of dynamics and aspects that completely overturned current notions on this topic.
In the first place, it has been determined that "true" cellulitis is a disease and not merely an unsightly condition; that it should not be taken for a mere localized adiposity, with adipose cells that are perfectly normal in biochemical terms, but present hypertrophy and/or hyperplasia in morphological terms, while remaining free from regressive alterations.



NORMALITY
In normal conditions the adipose tissue is well sprinkled:
the capillary vessels are very close to the adipocytes' cytoplasmatic membrane, the distance of diffusion is very limited and the exchanges very active.

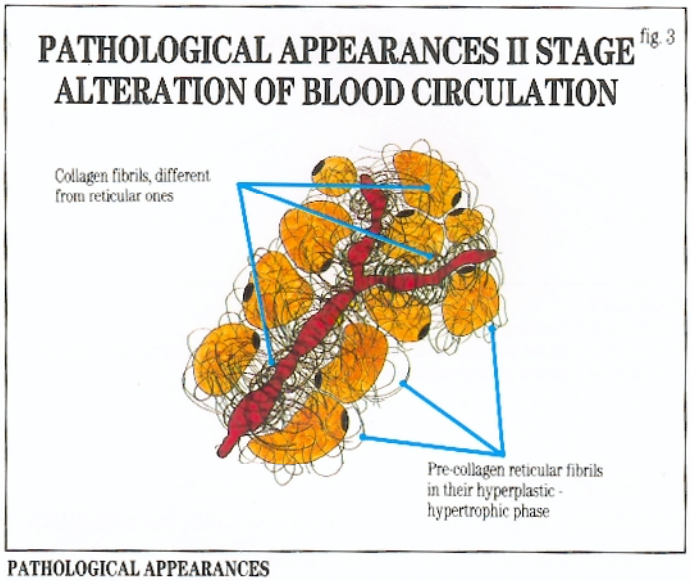
Cellulitis is, in fact, a **fibrosclerotic edematous panniculopathy** which affects the adipose cells, but also affects interstitial tissue and small blood vessels. (fig. 1)
The process develops quite slowly.
It generally begins with an **interstitial edema,** reversible at first, triggered by an abnormal permeability of the blood vessels.

What happens is that there is an alteration in the permeability of the capillary walls that provokes a transudation of plasma. This plasma then accumulates and stagnates in the interstitial tissue between adipose cells, which are therefore disorganized and dissociated (formation of the edema)
(**first stage of cellulitis**). (fig. 2).



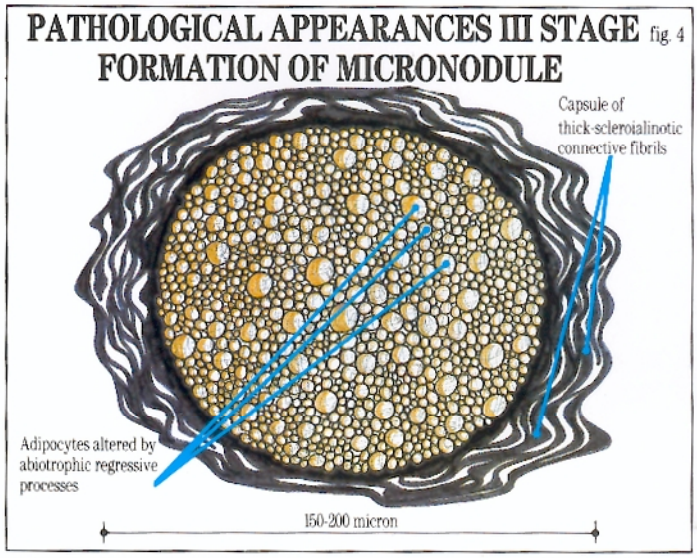
PATHOLOGICAL APPEARANCES
I stage of cellulitis - edema
The first consequence of the venular stasis is the abnormal endothelial permeability followed by the transudation of plasma into the interstitial tissue. The scheme represents the dissociation of the single adipocytes caused by edematous transudate.

The continuation of this phenomenon over the years provokes an abnormal reaction from the defense systems of the individual adipose cells. Under normal conditions, each fat cell is enveloped by a network of extremely fine reticular fibrils. Once the edema has appeared, these fibrils multiply in number and grow in thickness (hypertrophy and hyperplasia of the reticular system surrounding both blood vessels and fat cells), leading to a subversion of the lobular structure of the adipose tissue, and inducting alteration in the microcirculation
(**second stage of cellulitis**). (fig. 3)



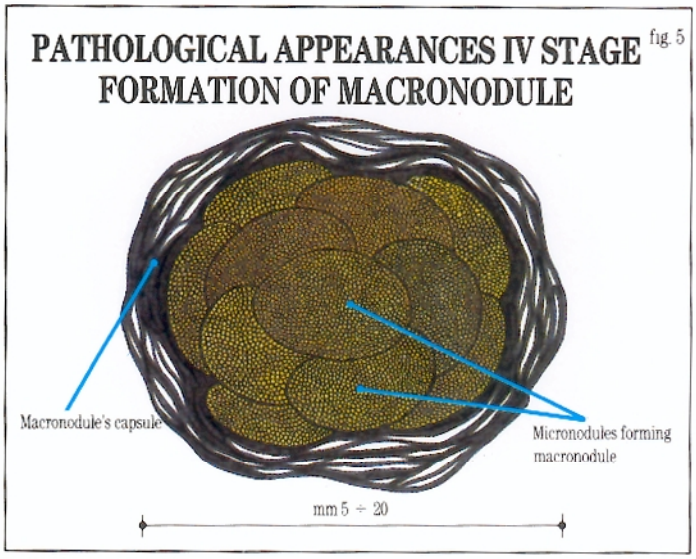
PATHOLOGICAL APPEARANCES
II stage of cellulitis - alteration in the microcirculation
Schematic representation of the proliferation of reticular fibrils surrounding blood vessels and adipocytes.

In a subsequent phase – after a period of time that can vary from subject to subject – and especially following the differentiation of collagen fibers from reticular fibrils, the formation of the **micronodule** takes place. This is a rounded nodular structure, microscopic in size, surrounded by a full-fledged capsule of collagenous fibrils
(**third stage of cellulitis**). (fig. 4)



PATHOLOGICAL APPEARANCES
III stage of cellulitis - formation of micronodule
Representation of a micronodule: a considerable number of altered adipocytes is surrounded by a full-fledged capsule of collagenous fibrils and consequently isolated from the tissue.

When several micronodules merge, the **macronodule** appears. This can be detected through palpation, can shift to underlying layers, and is painful when pressed. This is the so-called **"cellulitic nodule"**
(**fourth stage of cellulitis**). (fig. 5)



PATHOLOGICAL APPEARANCES
IV stage of cellulitis - formation of macronodule
The merging of several micronodules, having microscopic dimension, give rise to so-called macronodule, that can be detected through digital palpation. This is the painful subcutaneous nodule of nodular liposclerosis at the IV stage.

Characteristic signs of cellulitis can be seen in the presence of the following conditions:

a) **circulatory disturbances**, chiefly in the venous system, cause the development of "cold" regions, which can be detected by simply touching the skin; alongside these "cold" areas are others whose temperature is normal or at least greater. These "cold" areas are the result of an insufficient circulation of the blood at the microcirculatory level.

b) **nodules** - these are the most characteristic symptom of cellulitis. In cases of localized adiposity, in fact, these nodules are not present, and the tissue is neither painful in response to deep pressure nor spontaneously, unlike in cases of true cellulitis.

This second aspect of the cellulitic process recently led to the definition of cellulitis as **"fibrosclerotic edematous panniculopathy - F.E.P."** or **liposclerosis**, sclerosis of adipose tissue.

The conditions described above lead to a common condition: **modification of skin temperature.**

2. Contact thermography and "cellulitis"

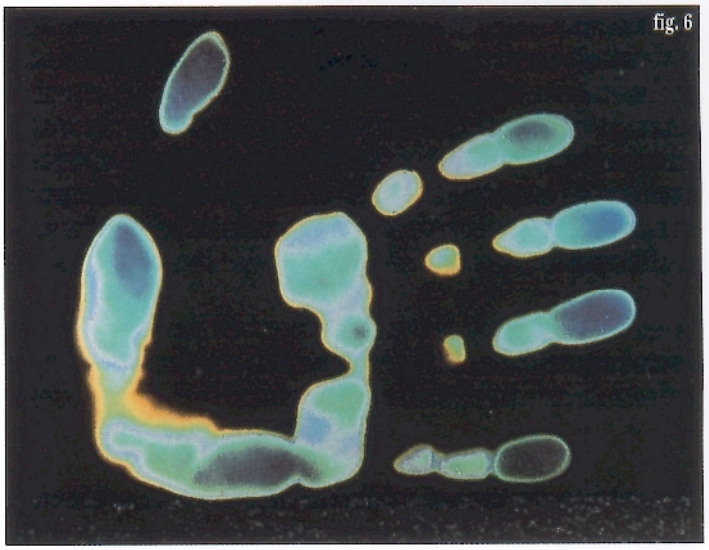
In general, only in very advanced stages of cellulitis it is possible to detect drops in skin temperature and, hence, "cold" areas, by placing the palm of the hand upon the area in question. Under these conditions, one can detect, through in-depth palpation, individual nodules or masses of nodules that have agglomerated into clusters that are painful when subjected to pressure, with retraction of the skin surface, giving rise to the so-called "orange-peel skin" or "mattress skin".

In less advanced stages, on the other hand, it is particularly difficult to evaluate temperature differences on the skin surface by touch alone.
It is therefore necessary to develop a method that can be applied rapidly and easily; ideally this method would be capable of supplying, in a brief time span, a thermal map of the skin surfaces to be examined. The method should fit with the practical needs of technicians, both in the cosmetic field and in the proper medical field.

These requirements have been met by a new method: **MICROENCAPSULATED LIQUID CRYSTAL THERMOGRAPHY.**

Thermography means literally writing (or recording) of heat (from Thermós, meaning heat in ancient Greek, and Graphein, meaning to write). (fig. 6)

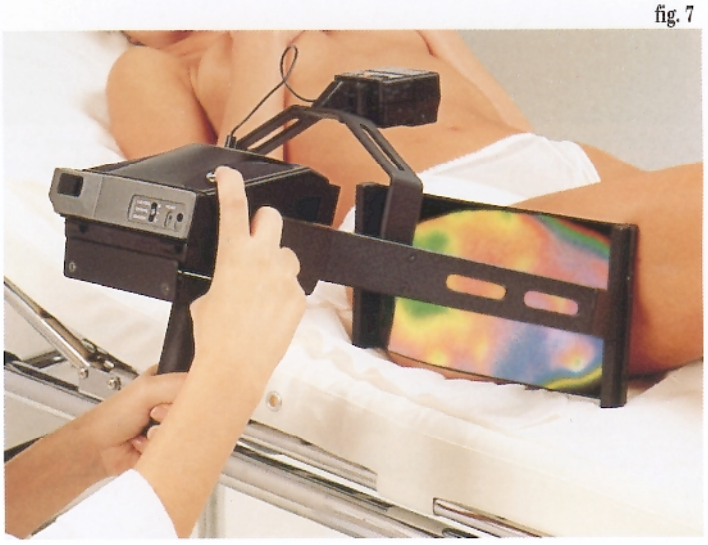
fig. 6



Thermographic image of the palm from which one can detect the varying blood distribution in the capillary network: "coldest" points (colour brown-green) correspond to the less sprinkled areas.

In the case under examination, the heat is that emanated by the human body. The method is extremely easy to apply, inasmuch as is consists of placing upon the skin surface in question special plates containing cholesterol microcrystals – suitably encapsulated – which change color according to the temperature to which they are exposed. (fig. 7)

fig. 7



Thermo-Cell-Test® Mac in use.

Thermography, in fact, makes use of the property of cholesteric liquid crystals, which rotate upon their own axis, tending to modify their spatial arrangement according to the temperatures to which they are subjected; each modification of said molecular structure creates a difference in the light rays refracted, thus generating different colors, as the light encounters varying incidence upon the faces of the cholesteric microcrystal – much like what occurs in a prism.

3. Thermographic classification, according to CURRI, of "cellulitis" through high performance contact thermography plates

The thermographic images that can be obtained with the THERMO-CELL-TEST® system can be split up into four fundamental groups:

Thermographic appearance of normality

"UNIFORM" THERMOGRAPHIC IMAGE.

Complete absence of patches of color indicating hotter or cooler points (lack of hyperthermal regions equals lack of nodules/lack of hyperthermal zones equals capillary-venular stasis). (fig. 8).

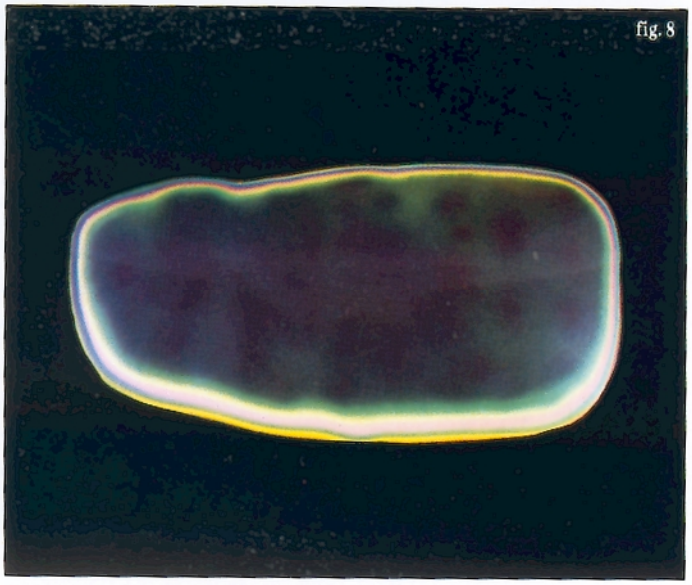


fig. 8

Uniform thermal image, without colour differences, showing an optimal blood flow in the capillary network of the skin's subpapillary plexus.

The skin surface appears to be smooth. Surface and in-depth palpation detect no variations in substances and texture. No nodular formations can be detected. Lack of painfulness.

Pathological thermographic appearances

"MOTTLED" THERMOGRAPHIC IMAGE

First and second stage of cellulitis (edema and alterations in the circulation of blood, chiefly at the microcirculatory level). A **"MOTTLED"** appearance, i.e., with hyperthermal patches of varied shape with **blurred edges**, at times in contact (edema, stagnation of venous blood) surrounded by cooler haloes (zones with reduced blood supply equals a reduction in the local supply of blood) which may be of considerable size (fig. 9).

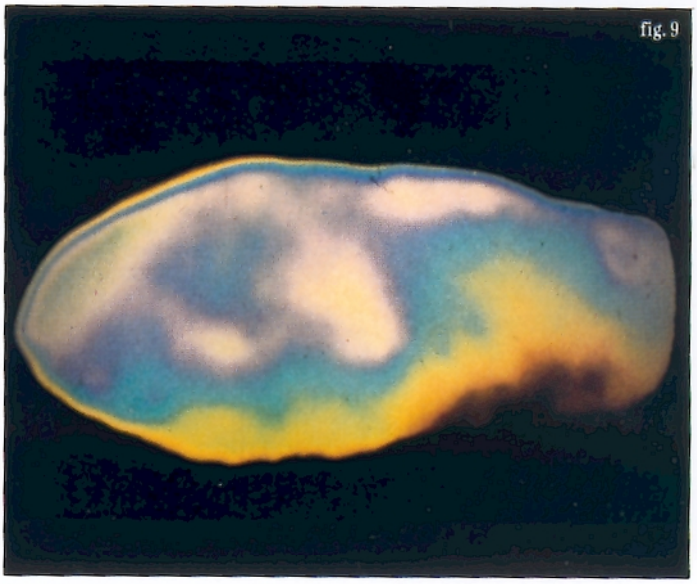


fig. 9

"MOTTLED" thermographic appearance, typical of the I and II stage of the liposclerotic process.

The skin surface begins to roughen slightly. Through palpation, one can detect a moderate increase in doughiness, and at times the elasticity and tone of the skin may decrease somewhat.

Pathological thermographic appearances

"LEOPARD-SKIN" THERMOGRAPHIC IMAGE

Third and fourth stage of cellulitis (venular-venous stasis - micronodules and macronodules).
The so called **"LEOPARD-SKIN"** thermographic appearance is typified by numerous hyperthermal patches which may be smaller than those mentioned previously, generally with sharply defined edges, scattered irregularly over a generally "cold" area (micronodules) (fig. 10).

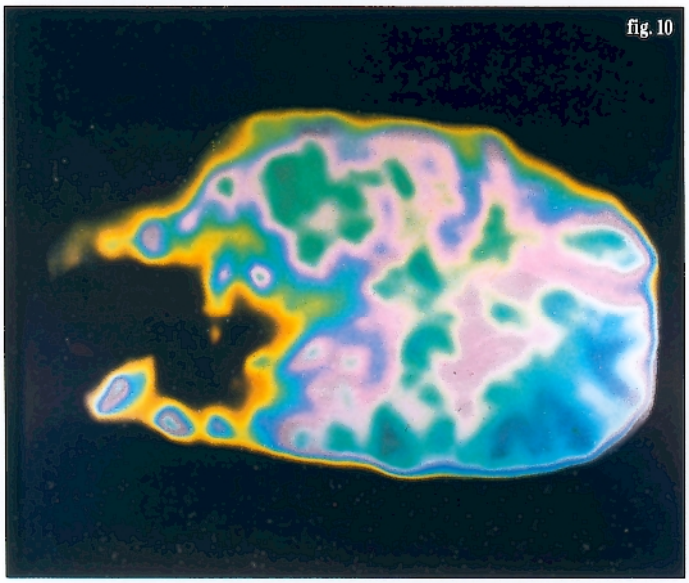


fig. 10

"LEOPARD SKIN" thermographic image of venous stasis, typical of the III stage of the liposclerotic process.

An alteration in the doughiness of the skin, with lessened elasticity and a decrease in skin tone verging on flaccidity.

Pathological thermographic appearances

"BLACK HOLES" THERMOGRAPHIC IMAGE

Corresponding to the macronodules and liposclerotic areas, we see a thermographic image that has been dubbed the **"BLACK HOLE"** image, i.e., surfaces of various shapes and sizes, black or brown, and sharply "hypothermal" (**macronodules – fourth stage**), adjacent to hyperthermal patches of various size (venular-venous stasis) (fig. 11).

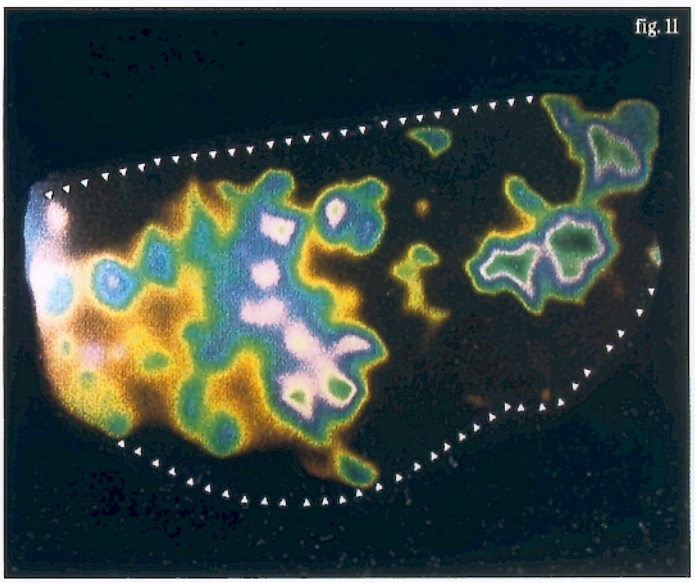


fig. 11

"BLACK HOLES" thermographic image, typical of the IV stage of the liposclerotic process. Hypothermic areas (black holes) correspond to ischemic areas.

Considerable alteration of the microcirculatory flow, with venous stasis. Palpation reveals discontinuity in the subcutaneous tissue, with the sensation of fine granules in the deeper layers and/or of the presence of macronodules. By gripping a fold of skin between thumb and forefinger, one can provoke a sharp pain which – especially in the fourth stage – lasts for some time, even after the skin is released (pinch test).

4. Advantages of contact thermography

Contact thermography offers the following advantages:

a) It is unrivalled in detecting "minor symptoms" of cellulitis (first and second stage), and hence, initial circulatory disruption – otherwise undetectable – but which represent an alarm bell in a process of slow evolution toward "nodular cellulitis" (third and fourth stage), which may not develop until many years later.

b) It permits the evaluation of variations in temperature and, hence, makes it possible to detect modifications in local blood flow (stasis equals hyperthermal zones/nodules equal hypothermal zones).

c) It is an absolutely innocuous and non-invasive technique. It can be repeated easily – it is therefore possible to follow, in the same subject, modifications of the thermal map of the skin and hence improvements in the circulation of the blood, permitting verification following such treatment as masso-physiotherapy, laser-therapy, iontophoresis, pressure therapy, mesotherapy, or epicutaneous applications of drugs or cosmetics.

A fundamental prerequisite in combatting cellulitis is the improvement of venous return and an increase in the supply of arterial blood (fig. 12). All this affects the skin temperature, which clearly becomes more uniform with the microcirculatory improvement. (fig. 13).

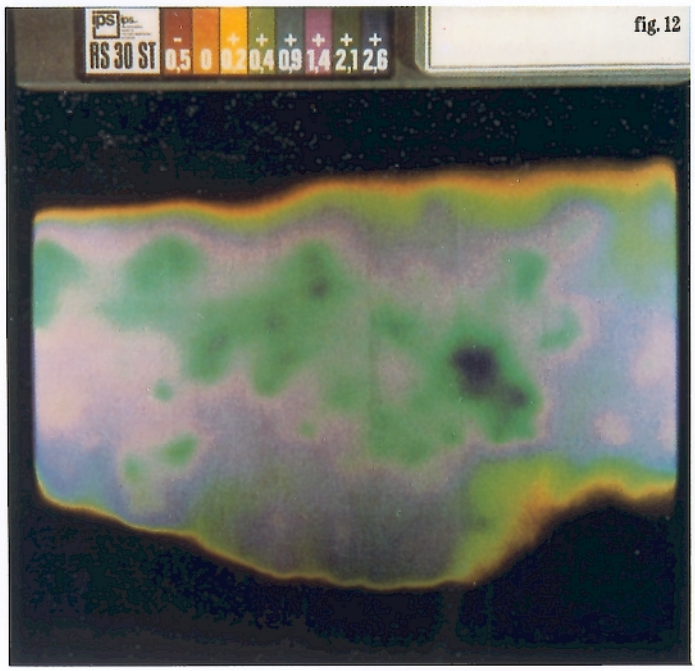


fig. 12

Medial-lateral thigh. MOTTLED thermographic appearance (second stage). Warmer areas (blue colour) represent venous stasis, while coldest areas (violet-green) are the less sprinkled ones.

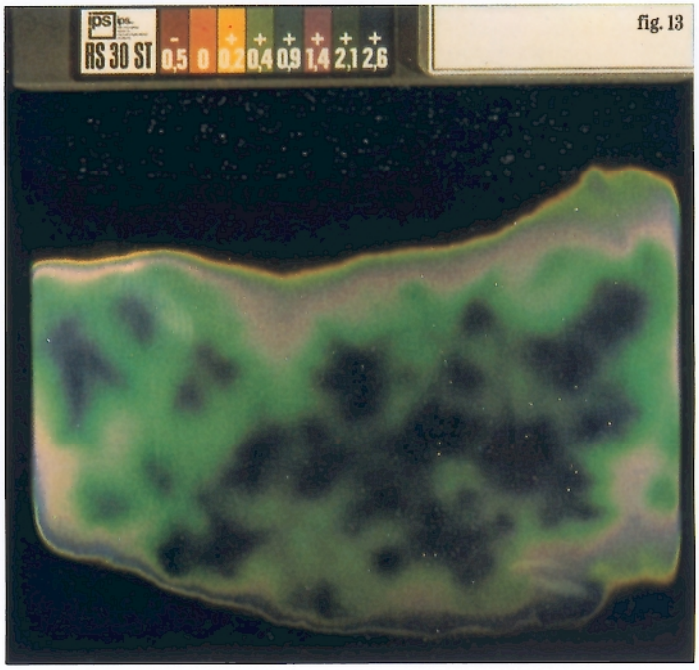


fig. 13

Same subject as fig. 12. Thermographic examination effected after a masso-physiotherapeutic treatment. It is possible to observe an increased number and extension of hyperthermic areas after the treatment. Amelioration of microcirculatory maldistribution.

d) It orients one toward the most appropriate treatments for the individual case, allowing one moreover to check the "response" in each case (fig. 14-15).

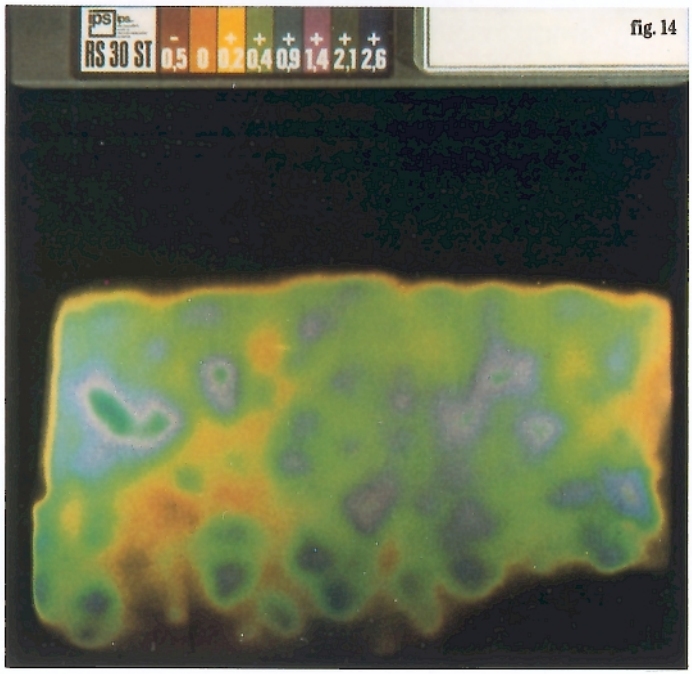


fig. 14

Leopard skin thermographic image (III and IV stage of cellulitis) with "bird's eye" spots and small black holes. Thermographic picture of panniculopathy in venous stasis.

e) Another extremely important benefit is the detection of situations that have nothing to do with cellulitis, such as the so-called "cushions of fat", which are the expression of an innocuous localized adiposity.
These are nothing more than an accumulation of healthy adipose cells, larger than normal, but perfectly functional. Even thermography, while detecting colder areas, will not reveal small warm zones (a complete absence of microcirculatory stasis) (fig. 16).

fig. 15

Same subject as fig. 14. Thermographic examination effected after a masso-physiotherapeutic treatment. Net modification of thermovascular pattern: hyperthermal venous spots are still present (blue areas) but coldest areas have disappeared. Amelioration of blood circulation in the capillary networks.

fig. 16

In cases of localized adiposity – where the microcirculation is not compromised – the typical "mottled" or "leopard skin" thermographic images cannot be found, even though you can see an irregular blood distribution

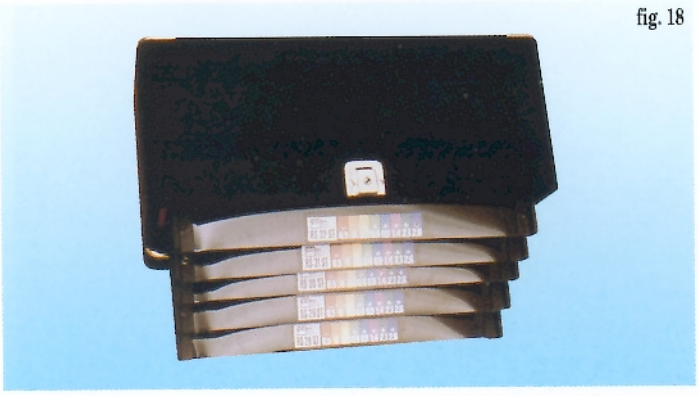
5. High Performance Contact Thermography (H.P.C.T.)

This is based on a sophisticated technology that makes it possible to modify in a specific manner both the size of the cholesteric liquid-crystal microcapsules and the thickness of the layer in which they are arranged, and above all to create blends of liquid crystals with different thermal sensitivity.
It thus became possible to create the so-called "panoramic" or **"screening"** plates in which each of the various colors corresponds to temperature differences of Celsius degrees (6-color plates) and plates with greater sensitivity, or **"specific"** plates, in which each color tone corresponds to fractions of a Celsius degree (8-color plates) (fig. 17-18).

fig. 17

Contact thermography "screening" and "short screening" plates – 6 and 7 colors – supplied with Celluvision® and Cell-Meter® systems.

fig. 18



High-resolution contact thermography "specific" plates – 8 colors – supplied with the Thermo-Cell-Test® Mac system.

These technical specifications allow High Performance Contact Thermography (H.P.C.T.) to reveal numerous aspects of the thermal skin condition, and therefore to detect in a very clear manner the various thermal aspects of cellulitis, as well as to execute full-fledged "thermovascular maps".

6. Technical specifications of H.P.C.T. termographic plates

1. **Operating temperatures**
The range of operation covered by the series of plates varies from 27.3°C to 35.1°C. Special plates for higher or lower temperatures are available upon request.

2. **Temperature resolution (ΔT)**
Stands for the plates' capacity to distinguish among the lowest temperature variations:
- for wide-range plates (4.8°C), the resolution ranges from **0.7°** to **1°C** (RW-ST and RW-S series 6-color screening and panoramic plates).
- for medium-range plates (4°C) the resolution ranges from **0.5°** to **1°C** (RSW-S series 7-color short-screening plates).
- for short-range plates (3°C) resolution is **0.2°C** (8-color RS-ST series specific plates).

3. **Spatial resolution (ΔS)**
Indicates the minimum distance at which it is possible to identify and visualize two adjacent "thermal points" on the skin.
- for 6-color plates, it is approximately 2 mm
- for 7-color plates, it is approximately 1.5 mm
- for 8-color plates, it is approximately 1 mm

4. **Precision of toning temperatures**
±0.5°C with respect to the temperature indicated on the color/temperature scale.

5. **Microencapsulation of the blend of liquid crystals**
by virtue of a special system developed by IPS, it is possible to obtain microcapsules less than 10μ in diameter, with the following advantages:
- perfect contact between the microcapsules during the coating process; elimination of spaces between one capsule and the next;
- rapid reaction (color changes).

6. **Application of the liquid crystals in "thin layers"**
which, along with the small size of the liquid crystals themselves, makes it possible to obtain, during the coating process, a perfectly uniform layer of encapsulated liquid crystals upon the substrate, with consequential brilliance, exceptional color contrast, and sharply defined images, free of blurring.

7. **Protection from ultraviolet rays (UV protection)**
obtained with a special chemical compound. It was thus possible to step up the stability of H.P.C.T. plates, which remain unaltered in terms of color tone and brightness far longer than normal liquid crystal plates.

7. Temperatures and colors of H.P.C.T. plates

As pointed out in the previous chapter, H.P.C.T. plates can be split in three principal series:
1) **"screening" plates** covering a wide range of temperatures (series RW – see point A)
2) **"short screening" plates** covering a medium range of temperatures (series RSW – see point B)
3) **"specific" plates** covering a short range of temperatures (series RS – see point C)

To understand better and interpret the colors in question, we offer an illustration with a color-temperature scale of the various H.P.C.T. plates.

COLOR-TEMPERATURE SCALE

A) "Screening" plates - series RW-ST

Temperature range: 4.8°C per plate.
Colors of the microencapsulated liquid crystals: 6

Principal colors

ΔT in °C (±0.5°)

Example: RW 28 ST plate (temperatures in °C)

The RW-ST plates are supplied, depending on the model, with the following systems: Thermo-Cell-Test® Professional Kit, Thermo-Cell-Test® Mac and Celluvision® Professional.
These formulations are available:
RW 28 ST (temperature range: from 27.3 to 32.1°C)
RW 29 ST (temperature range: from 28.3 to 33.1°C)
RW 30 ST (temperature range: from 29.3 to 34.1°C)
RW 31 ST (temperature range: from 30.3 to 35.1°C)
RW 32 ST (temperature range: from 31.3 to 36.1°C)

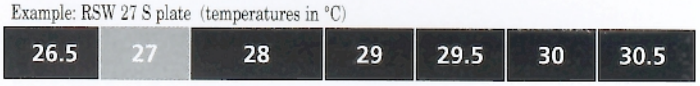
B) "Short Screening" plates - series RSW-S

Temperature range: 4°C per plate.
Colors of the microencapsulated liquid crystals: 7

Principal colors

ΔT in °C (±0.5°)

Example: RSW 27 S plate (temperatures in °C)



The RSW-S plates are supplied with the Cell-Meter® Professional Kit and these are the formulations available:
RSW 27 S (temperature range: from 26.5 to 30.5°C)
RSW 30 S (temperature range: from 29.5 to 33.5°C)
RSW 33 S (temperature range: from 32.5 to 36.5°C)

C) "Specific" plates - series RS-ST

Temperature range: 3.1°C per plate.
Colors of the microencapsulated liquid crystals: 8

Principal colors

ΔT in °C (±0.5°)

Example: RS 28 ST plate (temperatures in °C)

The RS-ST plates are supplied with the Thermo-Cell-Test® Mac systems.
These formulations are available:
RS 28 ST (temperature range: from 27.5 to 30.6°C)
RS 29 ST (temperature range: from 28.5 to 31.6°C)
RS 30 ST (temperature range: from 29.5 to 32.6°C)
RS 31 ST (temperature range: from 30.5 to 33.6°C)
RS 32 ST (temperature range: from 31.5 to 34.6°C)

8. Choosing the ideal H.P.C.T. plate

The choice of plate fundamentally depends on the following factors:
- whether the season in which the examination is performed is hot or cold
- the room temperature (minimum 20°C.; maximum 24°C.)

We suggest that you proceed as follows:
- In winter or in cool climates (room temperature below 22°C), use plates with low reaction-temperatures:
  - RSW 27 and RW 28 plates (Cell-Meter® Professional, Thermo-Cell-Test®)
  - RW/RS 28 and 29 (Thermo-Cell-Test® Mac)
- in the summer or in warm climates, use plates with high reaction-temperatures:
  - RSW 30 - 33 and RW 31 plates (Cell-Meter® Professional, Thermo-Cell-Test® Professional Kit)
  - RW/RS 30, 31 and 32 (Thermo-Cell-Test® Mac)

Check the colorimetric reaction of the plate you have selected by placing it upon the zone you intend to examine. Various colors will appear in rapid succession, and they will stabilize in the course of just a few seconds.

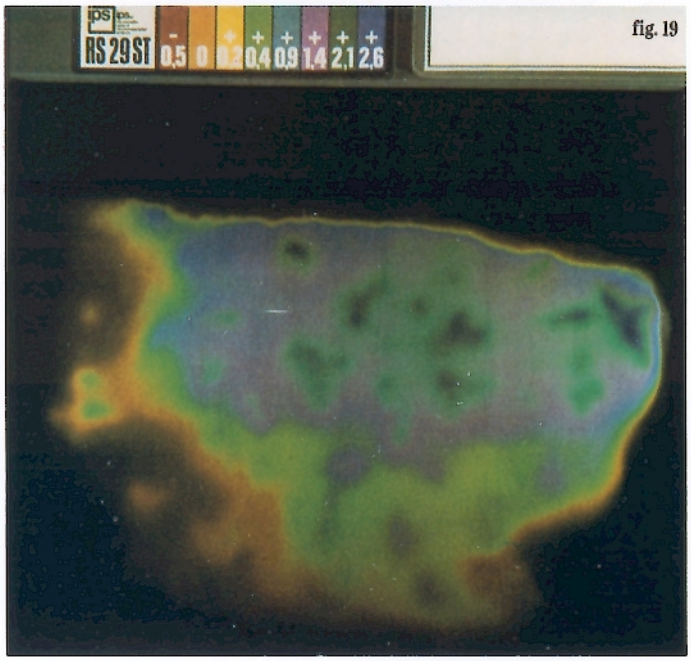


fig. 19

Thermography of the upper-lateral thigh. H.P.C.T. plate model RS29ST.
All the principal colours are present, brown-green-violet and blue included. Leopard skin thermographic appearance. III stage of cellulitis.

1) if the chief colors are present, i.e., red-green-violet-dark blue, then **the plate is the correct one**. (fig. 19)
2) if the plate remains black, or only brown and red appear, this means that the reaction temperature is too high. **You must then select a plate with a lower reaction temperature**. (fig.20)

If the principal colours are not presented by this plate either, then the ambient or the cutaneous temperature is too low.
The test should thus be repeated after the ideal conditions have been established.

3) if the plate rapidly changes through all of the colors and then stabilizes on a darkblue color, it means that the reaction temperature is too low. **You must then select a plate with a higher reaction temperature**. (fig.21)

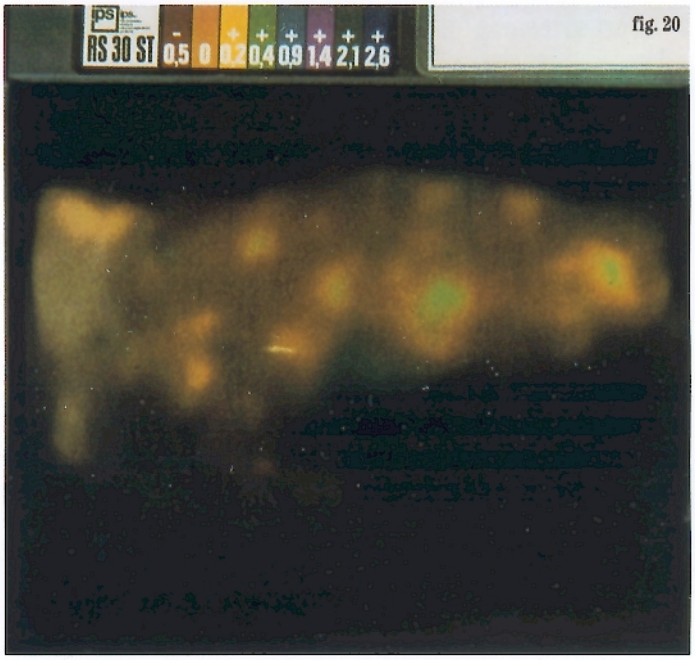


fig. 20

Same subject as fig. 19. H.P.C.T. plate model RS30ST.
The colours present are brown, red and a nuance of green. The plate is not sensitive enough to show warmer spots in the area to be examined.

If the image still remains a uniform blue with this plate we suggest that the examination area be cooled with an ordinary hairdryer (blowing cold air), and that the ambient air temperature be checked to ensure that it is not above 24°C.
The examination should then be repeated.

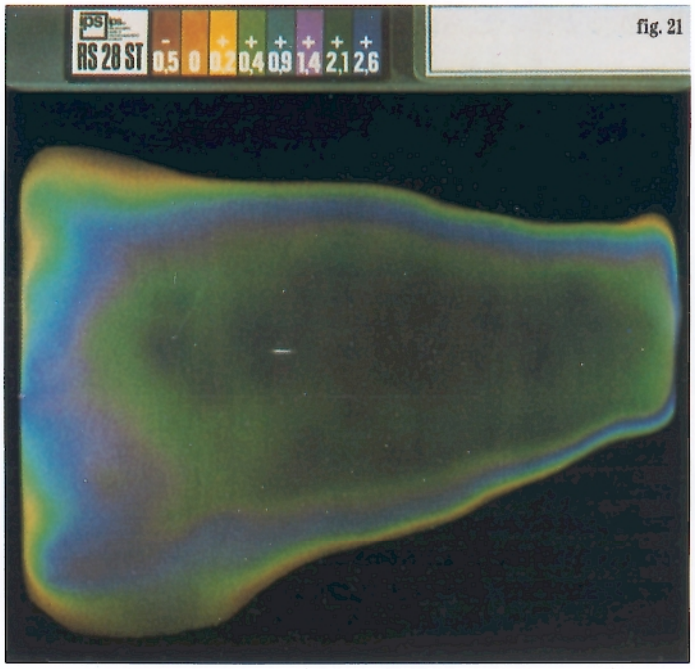


fig. 21

Same subject as fig. 19. H.P.C.T. plate mod. RS28ST.
The colours visible are only dark green and blue in different nuances. The plate is too sensitive and therefore unable to point out warmer points in the area under examination.

9. How to perform thermography properly

In order to perform thermography properly, you must follow these guidelines:

1) The room temperature must be relatively stable; therefore, leave no windows open, eliminate all drafts, do not turn on space heaters or equipment that could modify room humidity; the ideal room temperature is between 20 and 24°C.

2) It is advisable to begin the examination only after the patient has remained in a relaxed, reclining state for at least ten minutes, without smoking. Smoking is known to cause vascular constriction.

3) It is always a good idea to inquire as to the psychic and physical condition of the patient (are they upset, irritated, emotionally overwrought?); and whether they show subjective or objective symptoms of venous stasis or chronic venous insufficiency (heaviness of the legs, edemas, burning, paresthesia, cramps, varicosis, and so on) in order to compare results of later test at same conditions.

4) The region of the skin upon which the plate is placed must be dry, scrubbed, and clean. Avoid applying creams or other such products upon the region to be examined: a layer of cream or moist skin can compromise a proper thermographic evaluation.

5) Apply the plate with constant, uniform pressure, so that it adheres perfectly to the area of the skin to be examined – any gaps will compromise a proper reading. Before reading, wait for the color tones that may have appeared to stabilize into spots or patches that no longer tend to shift, that tend to maintain their shape, size, and color, over the entire testing period.

6) Take careful note of the placement of the plate during the test, so as to be able to carry out later tests in the same way.

7) Thermography should always be performed prior to such procedures as palpation, searching for nodules, or cosmetic treatments, since these procedures are liable to modify the thermal conditions of the zones under examination.

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