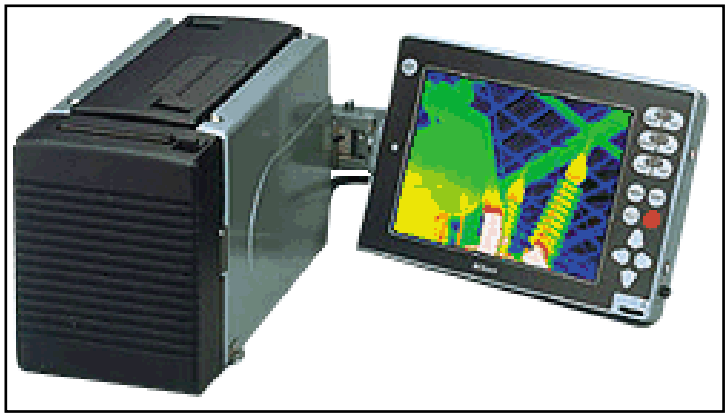
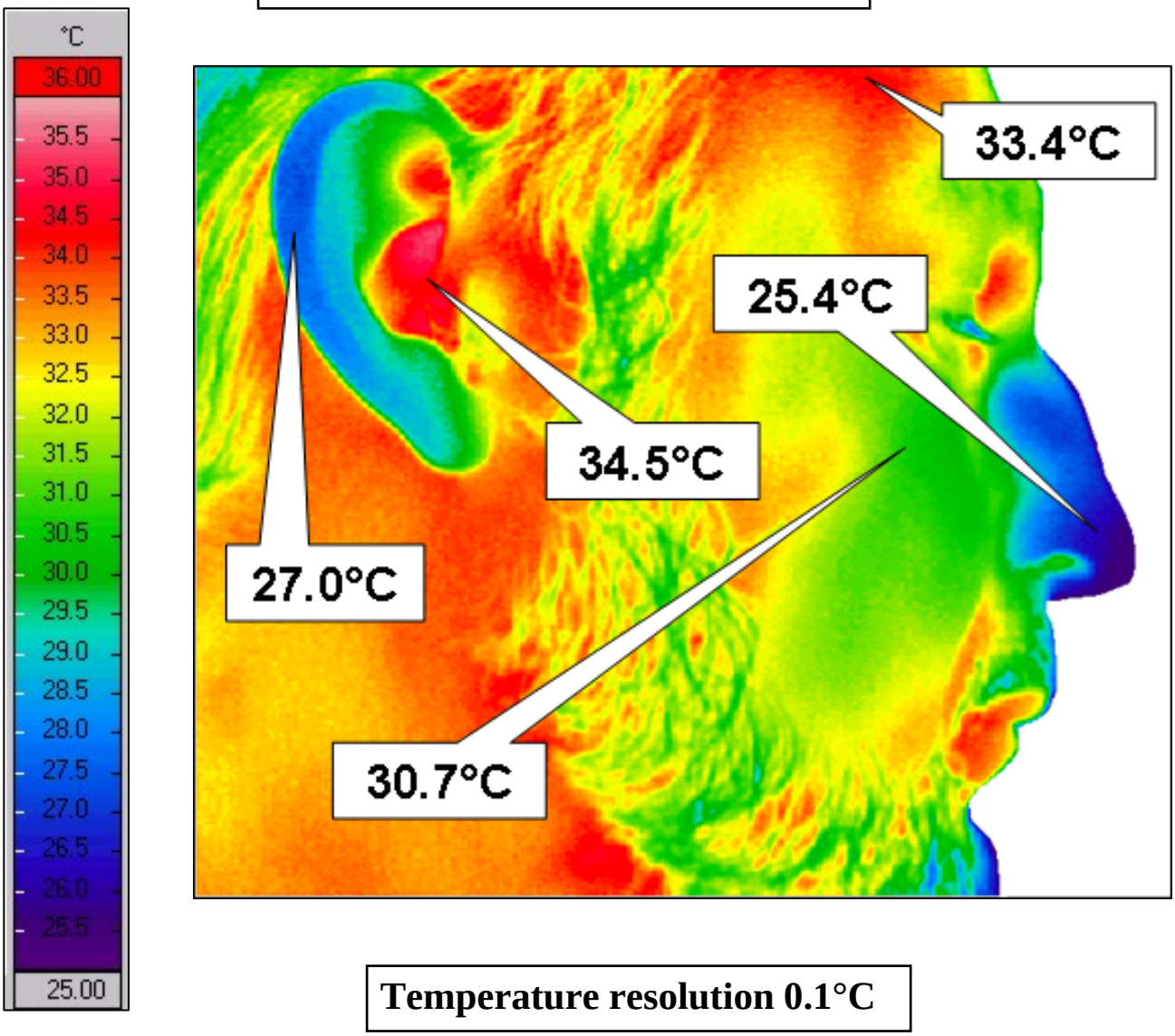
Infrared Thermography

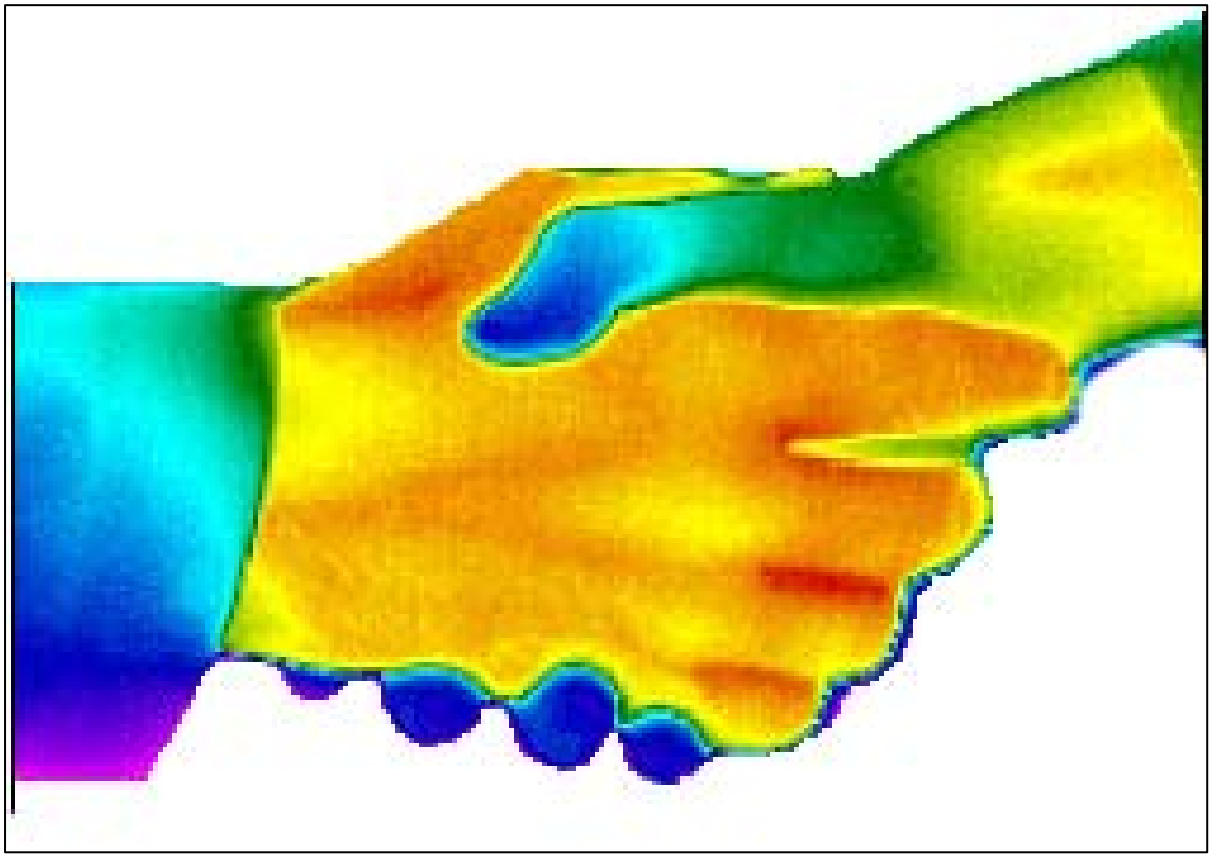


Nikon Laird-S270 Infrared camera

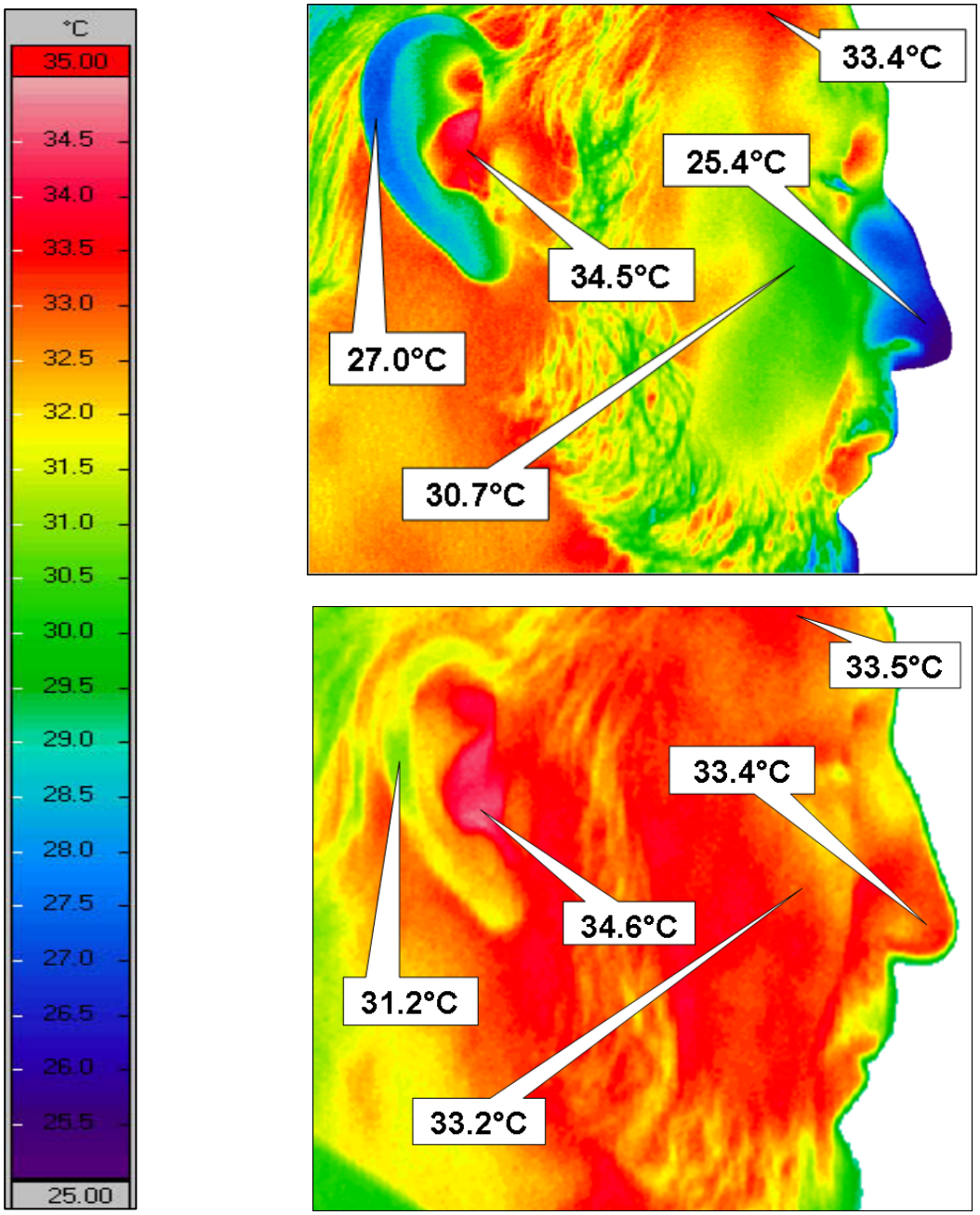


Temperature resolution 0.1°C

Temperature measurement range	−20 to 250 °C
Temperature accuracy	0.2 °C
Spectral band	3–5 μm
Detector type	270,000 pixel PtSi Schotty-Barrier IR CCD
Frame rate	1/60 s (30 Hz)
Effective number of pixel	475 (H) 442 (V)
Shooting distance	0.5 m–∞

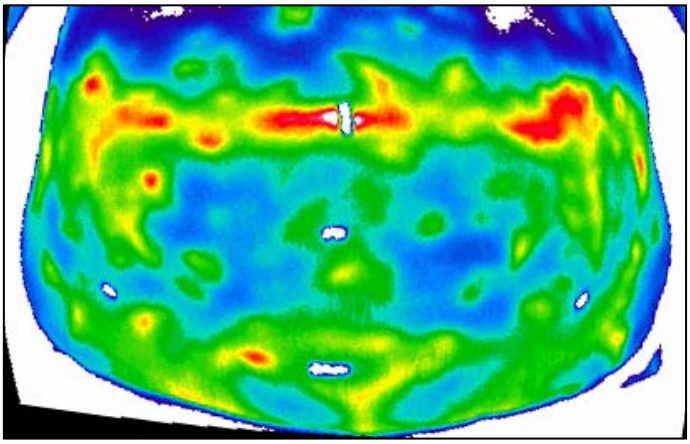


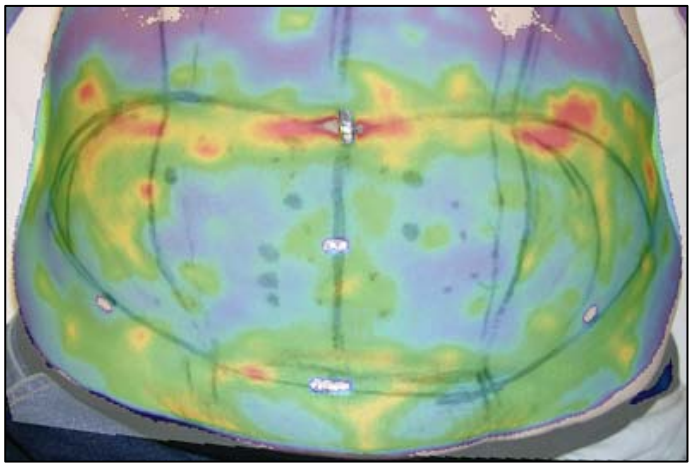
Thermal interaction

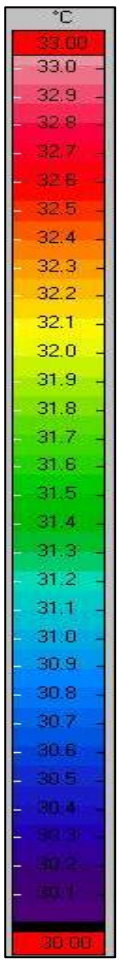


Thermograms of a healthy 52 year old male subject in a cold environment (ca. 15°C; upper panel)and in a warm environment (ca.25°C; lower panel). In the cold environment arteriovenous anastomoses in the nose and the auricle region of the ears are closed, resulting in low skin temperatures at these sites. Also note reduced blood flow in the cheeks but not on the forehead, where the blood vessels in the skin are unable to vasoconstrict.

Combining IR-images with digital photography



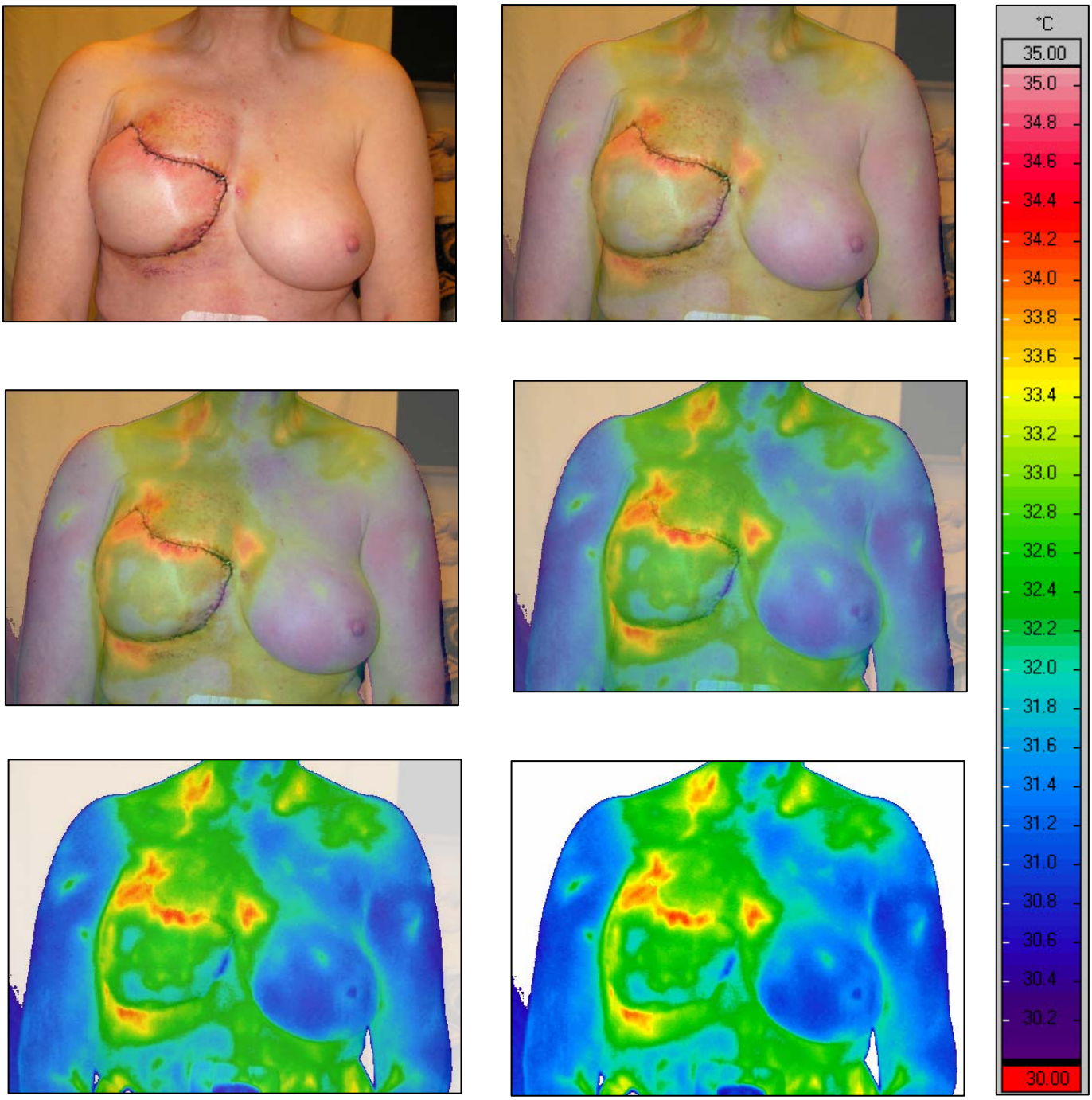




Especially designed image analysis software* allows one to superimpose an IR-thermal images onto a normal digital photograph. The degree of superimposition can be varied from 0-100%. This technique allows one to more easily relate an IR-image with surface anatomy. The image shows the abdominal region of a patient prior to autologous breast re-construction surgery (1 day pre-operative).

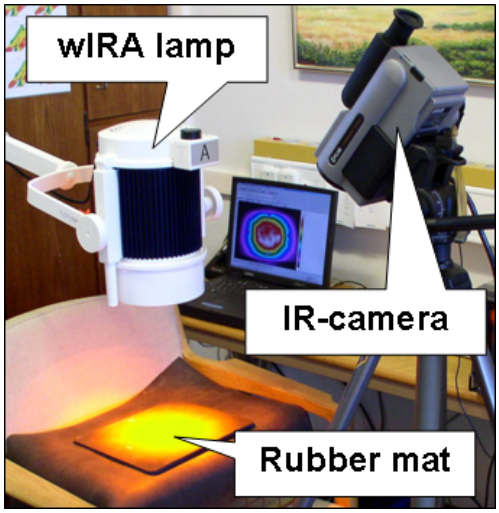
Medical Computing Research Group, University of Glamorgan, Wales, UK.

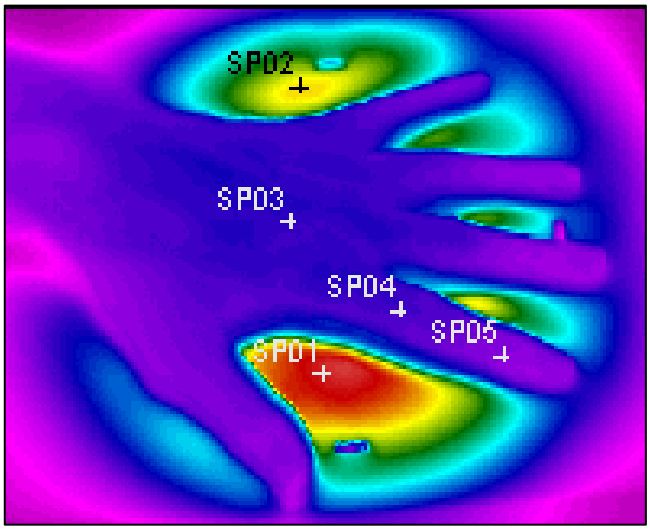
Combining IR-images with digital photography

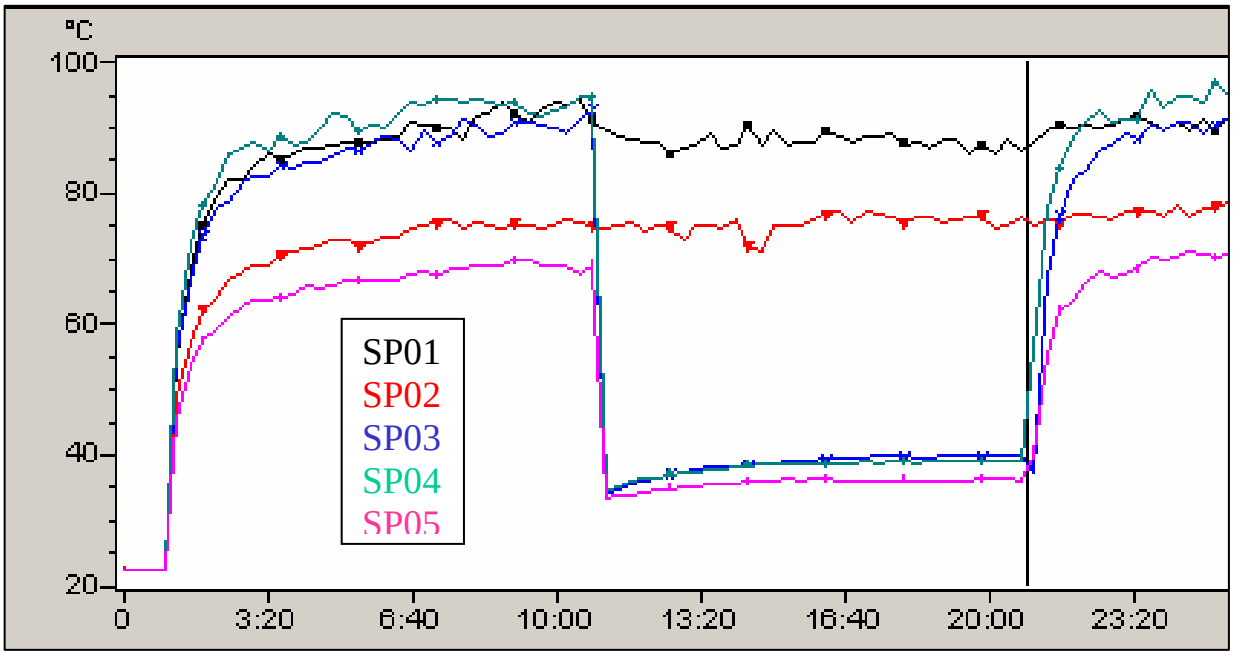


Especially designed image analysis software* allows one to superimpose an IR-thermal images onto a normal digital photograph. The degree of superimposition can be varied from 0-100%. This technique allows one to more easily relate an IR-image with surface anatomy. The image shows a patient who has undergone autologous breast re-construction surgery (6 day post operative).

Medical Computing Research Group, University of Glamorgan, Wales, UK.

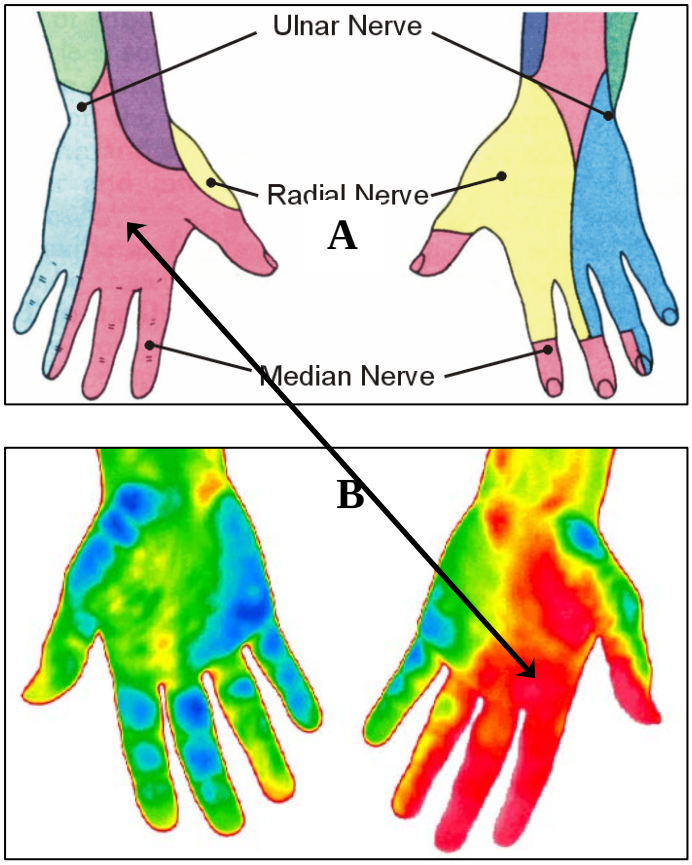


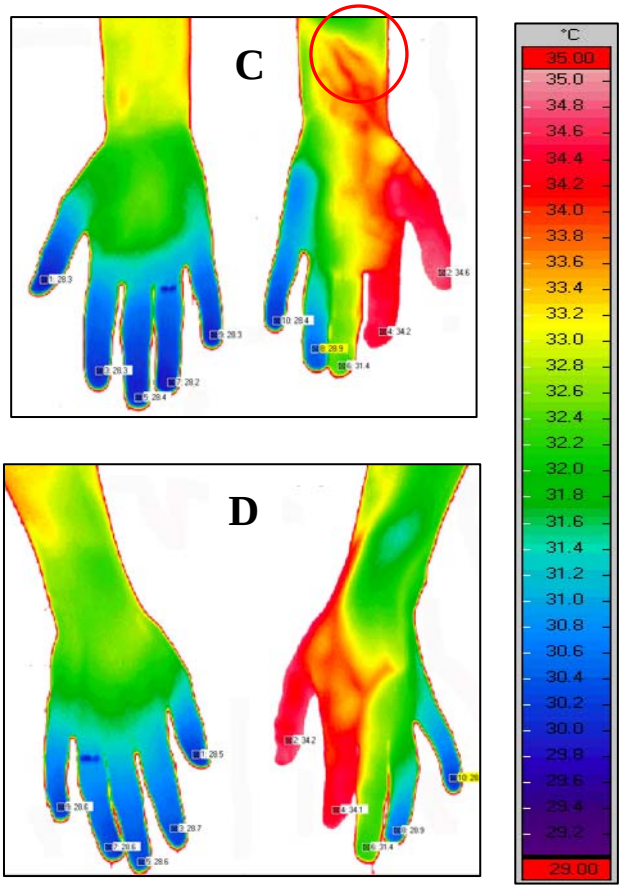




Efficiency of skin blood flow as a heat transporter. The photograph in the upper left panel shows a rubber mat being heated with a water filtered infrared-A irradiator at high intensity (400 mW/cm^2) for a period of 20 minutes. In the lower panel the time course of surface temperature of the mat at 5 selected spots as measured by an IR-camera is given. During the last 10 minutes of the 20-minute heating period the left hand of a healthy 54 year old male subject was placed on the mat. Note that skin surface temperature of the hand remains below 39°C.

Nerve block and hand injury





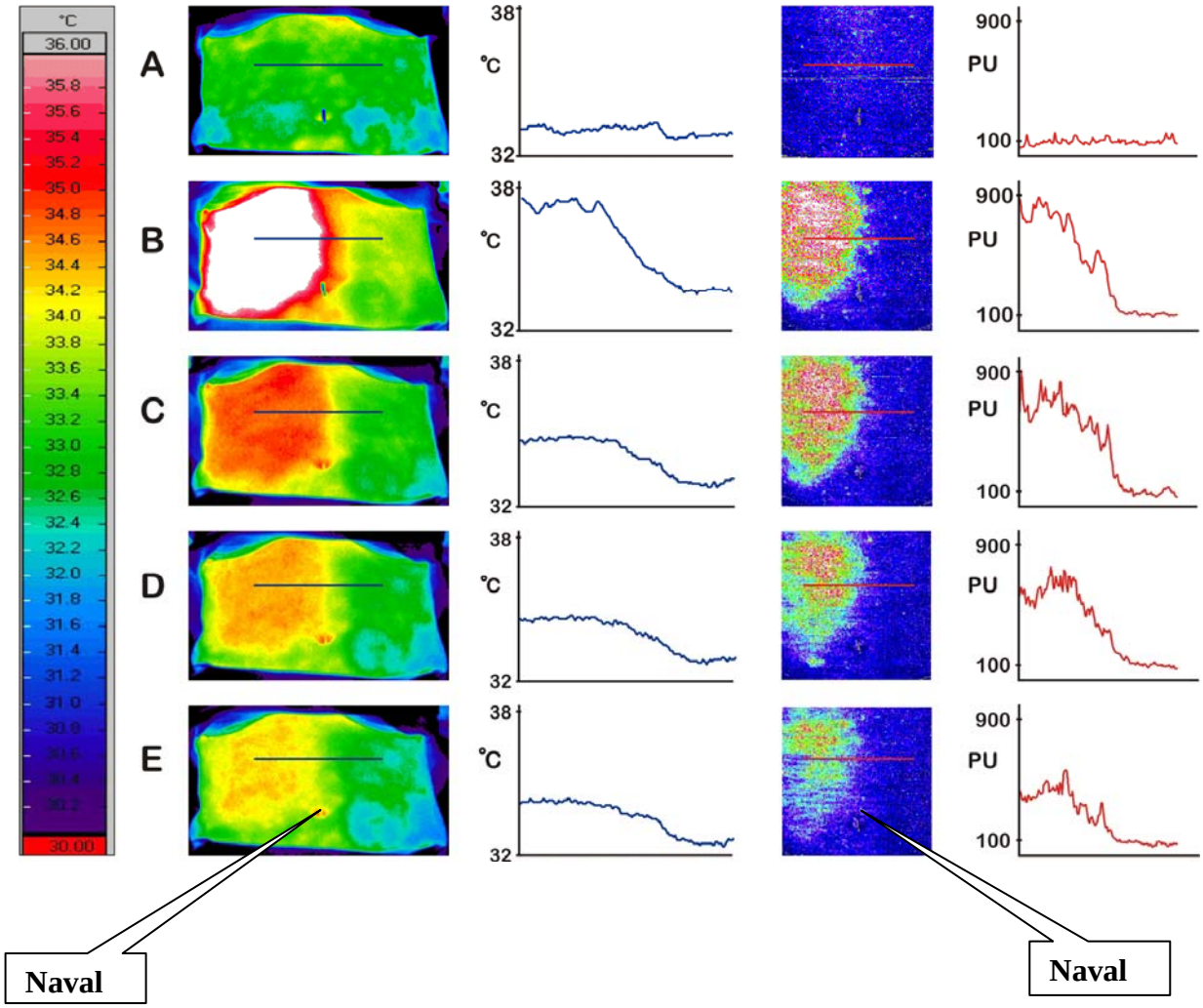
Nerve block
left median nerve

Stab injury
(red circle)

Panel A. The distribution of cutaneous nerves of the hand.

Panel. B. IR-thermogram (palmar view) of a 40 year old female patient following a successful nerve block of the left median nerve. Note the strong vasodilatory response (area of highest temperature) due to suppression of autonomic input and how the affected area nicely coincides with the predicted distribution of this nerve.

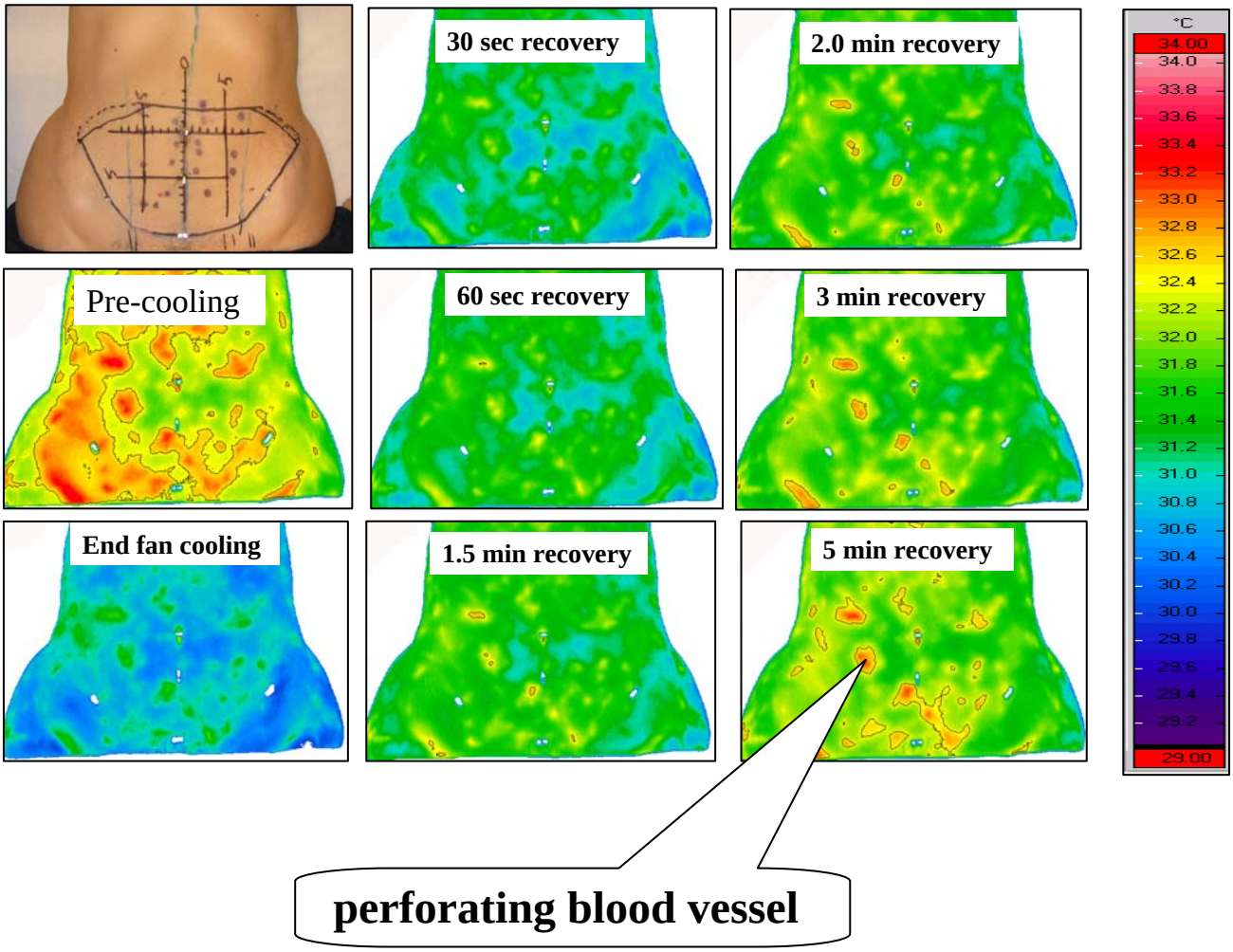
Panel C (palmar) & D (dorsal) IR-thermograms of the hands of a 36 year old female patient whose left wrist (middle of the red circle) was punctured with a sharp object resulting in partial nerve damage (motor and sensory loss). The strong vasodilatory (increased skin temperature) response resulting from partially severed nerves can easily be seen.



IR-THERMOGRAM **TEMPERATURE PROFILE** **SLD MAP** **BLOOD FLOW PROFILE**

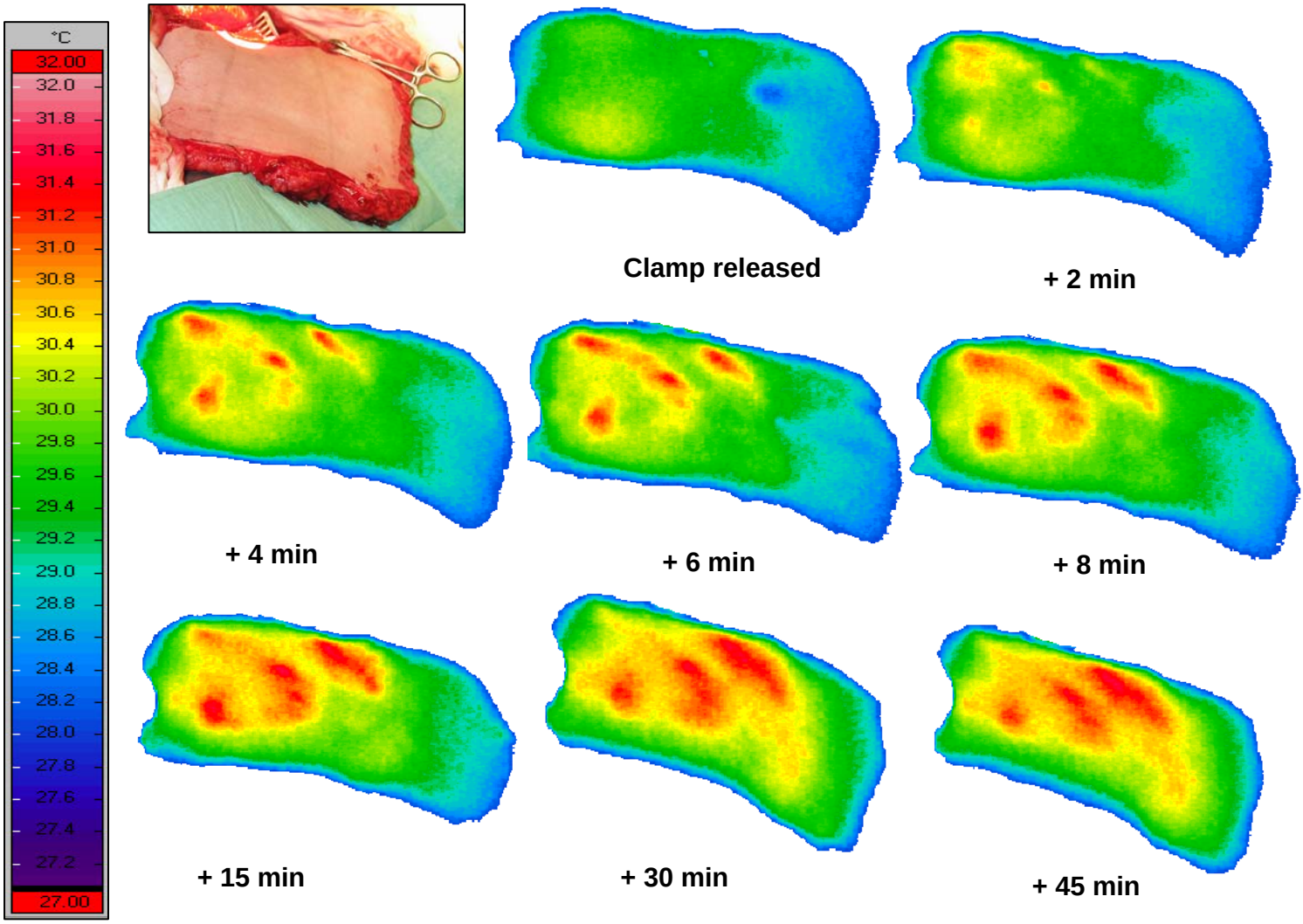
IR-thermograms, Temperature profiles, Scanning laser Doppler scans (SLD), and blood flow profiles (perfusion units PU) of the abdominal area of a 44 year old healthy female subject before (A), immediately after (B) and 5 minutes (C), 10 minutes (D) and 20 minutes (E) after a 20 minute heating of the right side of the abdomen with a water filtered infrared-A irradiation lamp. The blue horizontal lines in the IR-thermograms indicate the position of the temperature profiles. The red horizontal lines in the SLD scans indicate the position of the blood flow profiles. In IR-thermogram B the white colour indicates skin temperatures greater than 36°C.

Visualization of perforating blood vessels with dynamic IR-thermography



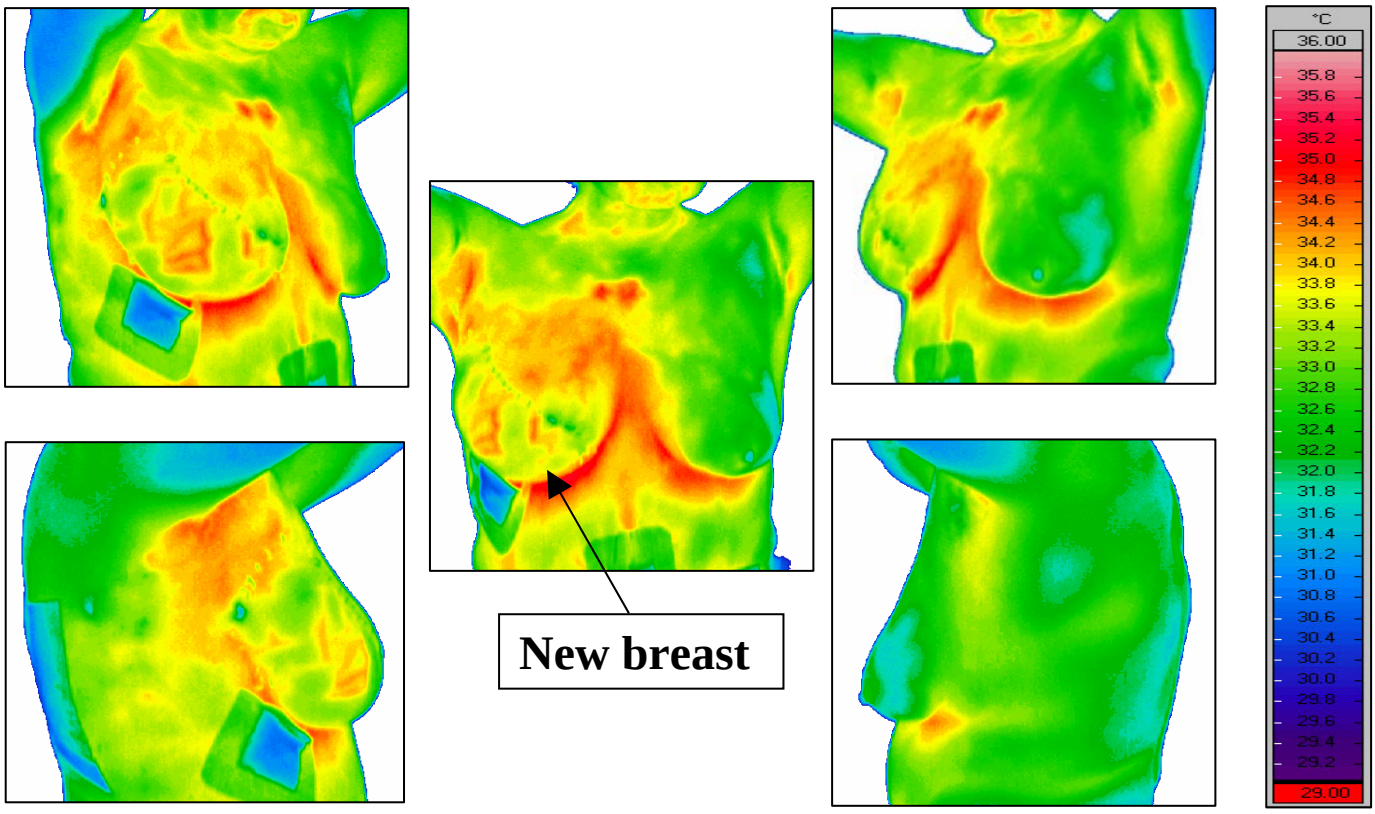
Visualization of perforating blood vessels in the abdominal area with the use of dynamic IR-thermography. The IR-thermograms show skin temperatures before and at various times after a mild skin cooling (2 minute fan cooling) in a 32 year old female subject. To help highlight the perforating vessels an outline function has been employed in which all skin areas having a temperature greater than 32.5°C are enclosed in solid lines.

Infrared thermal imaging and autologous breast reconstruction surgery



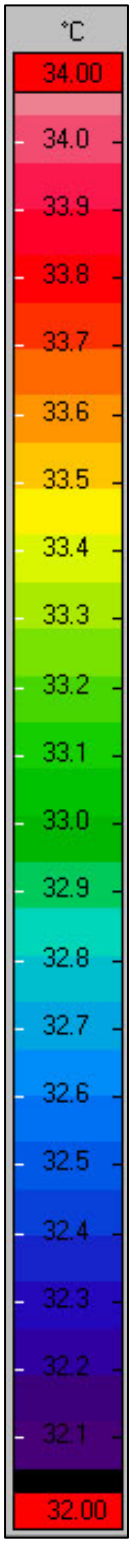
Infrared thermal images of an abdominal skin flap during breast reconstruction surgery. The sequence of IR-thermal images demonstrates the return of heat to the excised skin flap following re-establishing its blood supply (anastomising of a mammary artery and vein to a single branch of the deep inferior epigastric artery and a concomitant vein). Prior to this procedure the excised skin flap had been without a blood supply for about 50 minutes and consequently cooled down. The photograph in the upper left panel shows the skin flap in position on the chest wall prior to being shaped into a new breast.

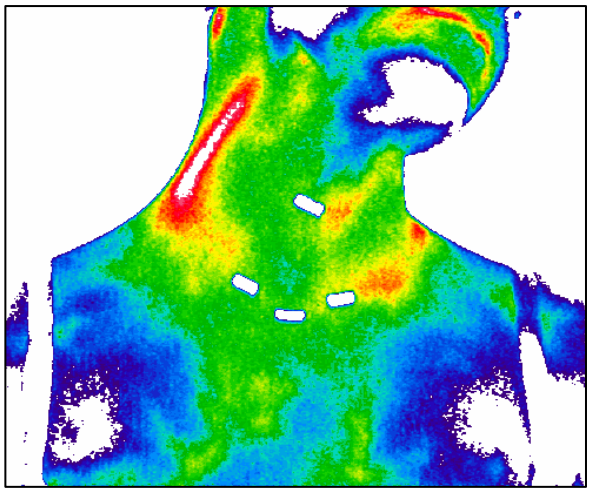
Infrared thermal imaging and autologous breast reconstruction

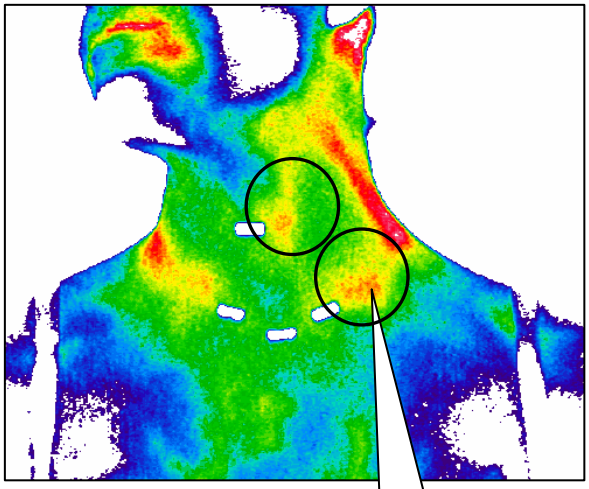


Infrared thermograms of a patient 6 days after autologus breast reconstruction surgery. The new breast was constructed using skin and fat tissue excised from the lower abdomen - a so called DIEP (deep inferior epigastric perforating artery) flap. The thermal images give information about circulation in the new breast, which depends on the patency of the anastomoses between the vessels of the transplant and the recipient vessels on the thoracic wall.

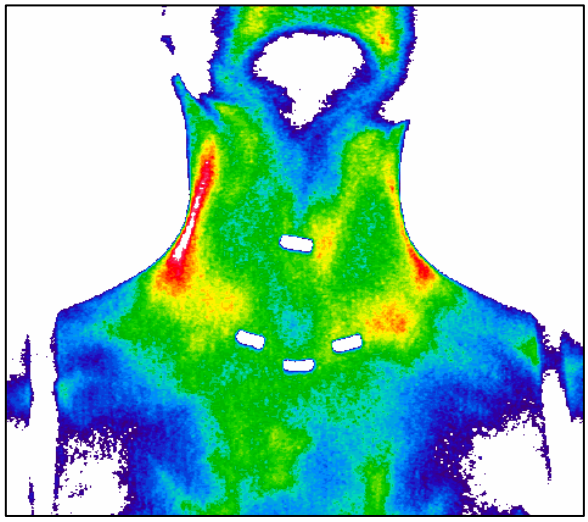
Example of IR-thermography as a tool in cancer diagnostics

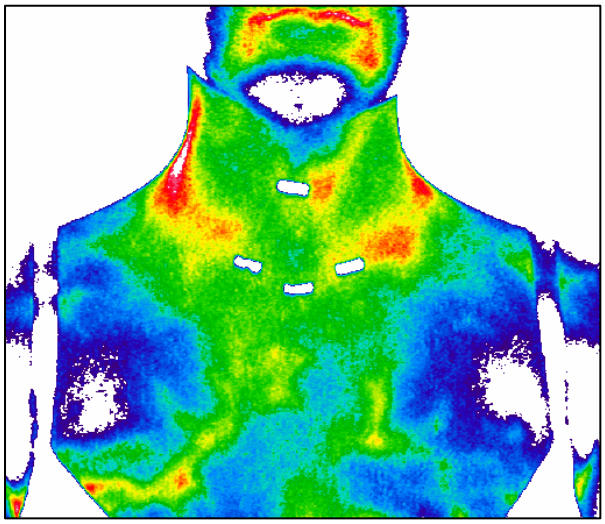






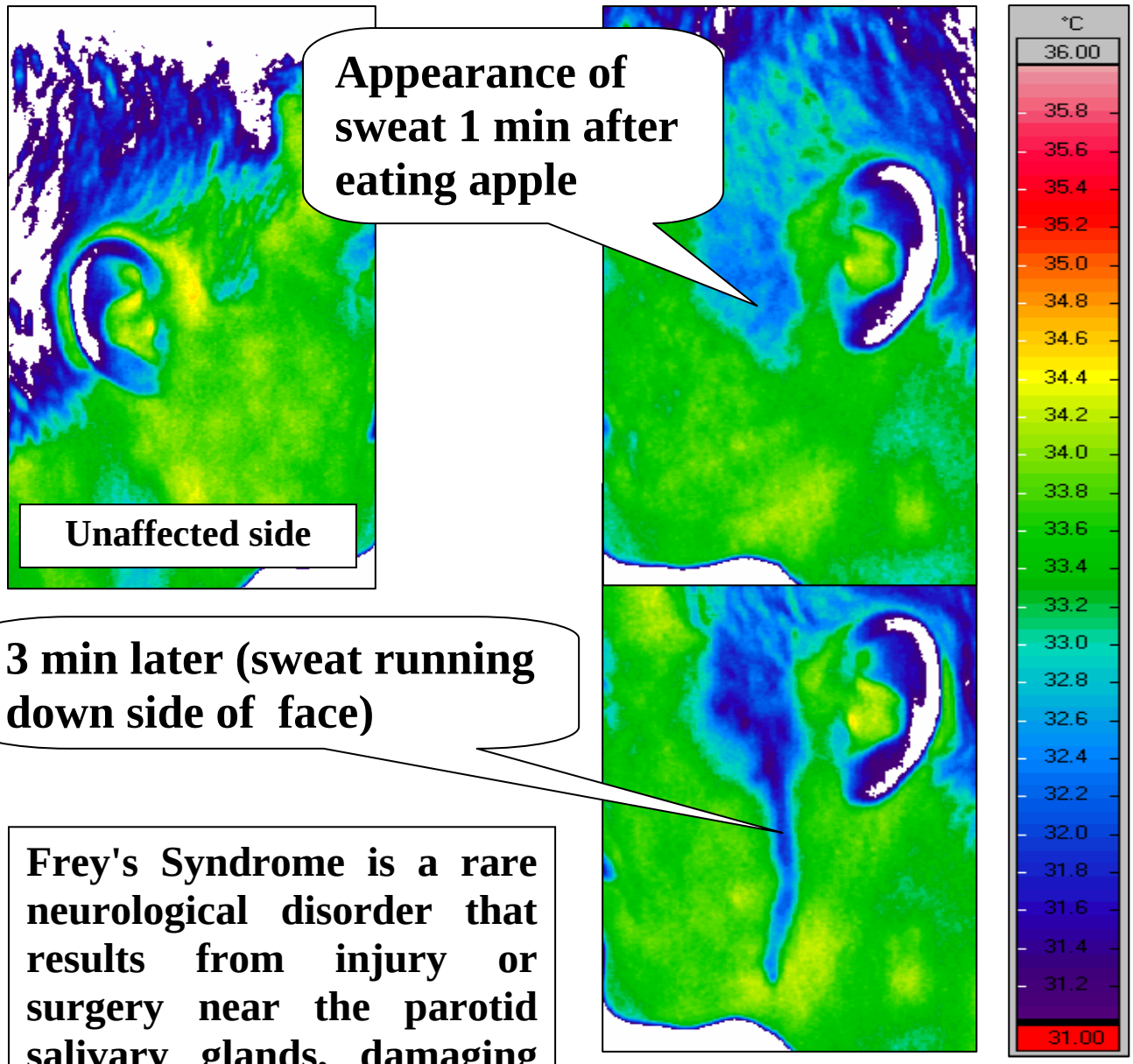
The hot spots were later confirmed as lymphomas





22 year old female patient
ØNH avd, UNN. 13.09.04

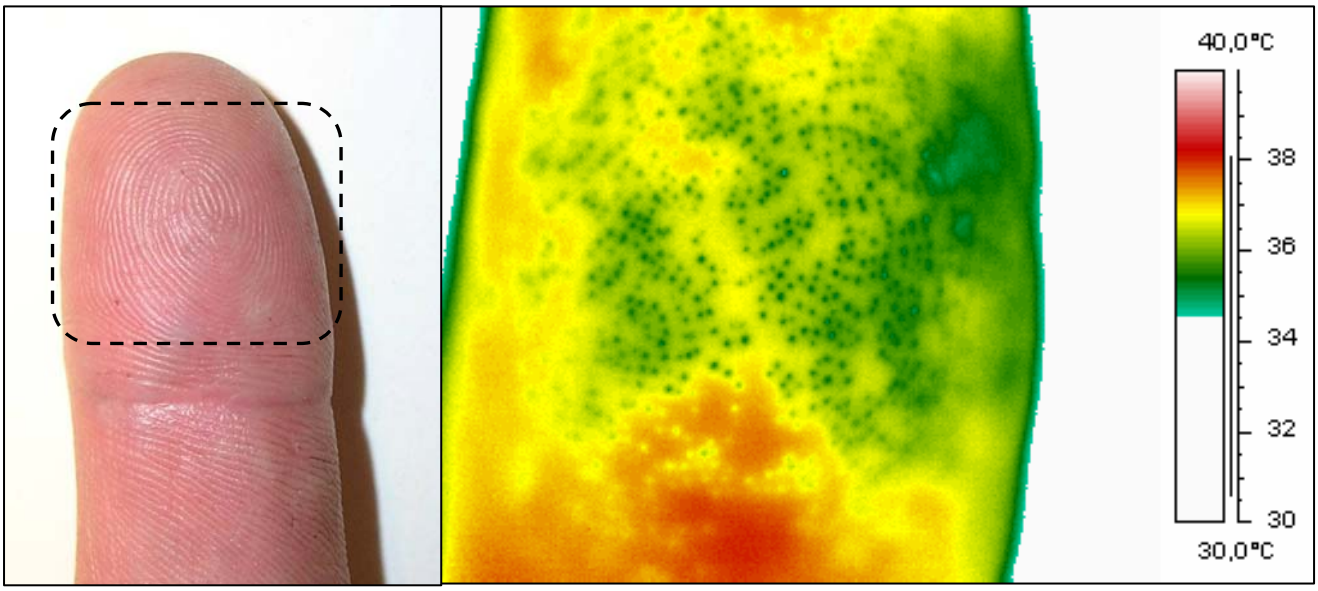
Frey's Syndrome - 50 year old male



Frey's Syndrome is a rare neurological disorder that results from injury or surgery near the parotid salivary glands, damaging the facial nerve. The parotid salivary glands are located on the side of the face below and in front of the ear. This syndrome is characterized by flushing or sweating on one side of the face when eating. IR-thermography provides a convenient non-invasive method for localizing the affected area for treatment with botox.

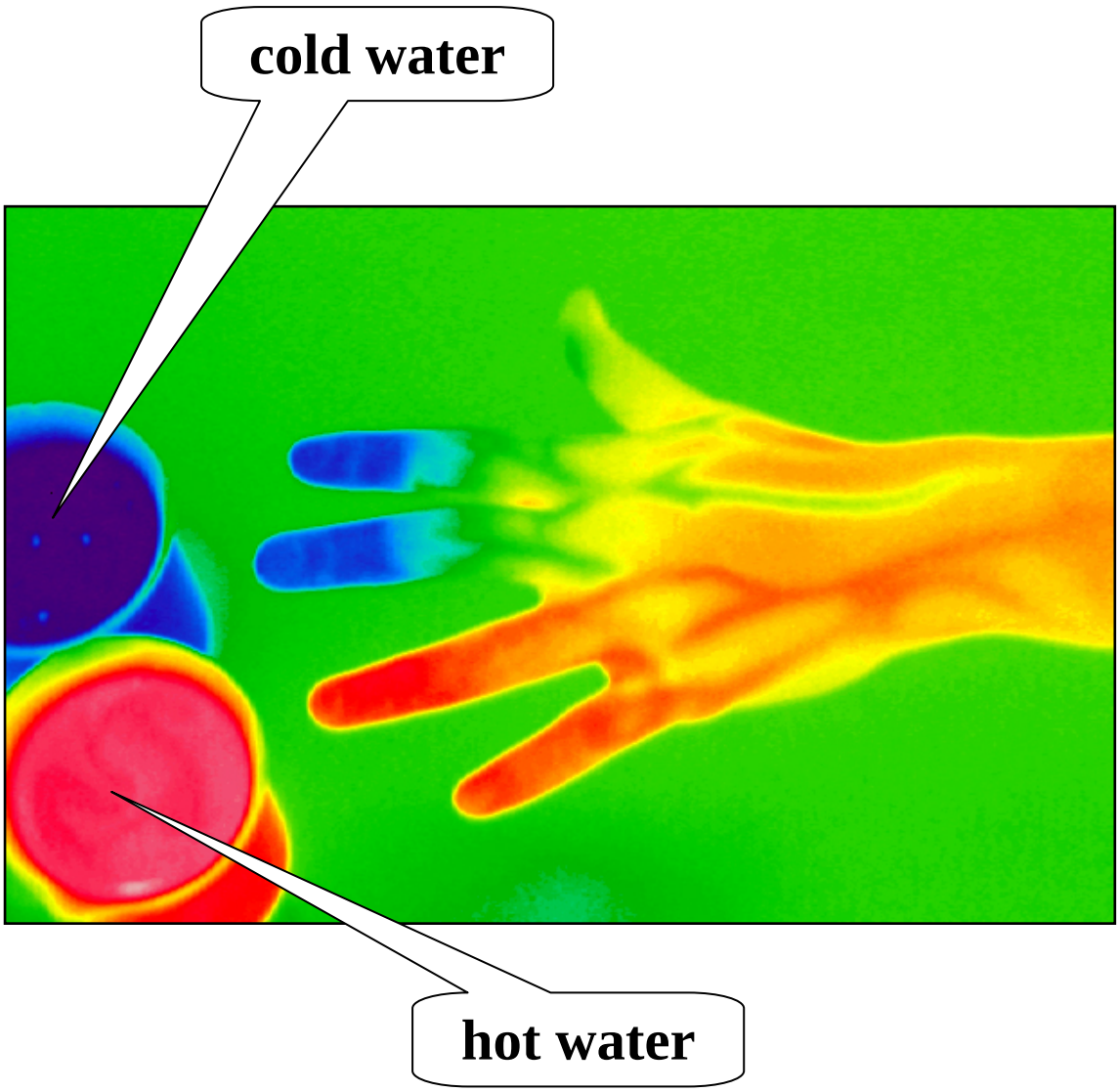
Minor's starch iodine test (Current method for identifying affected skin area)

Visualizing sweat glands (macro lens imaging)



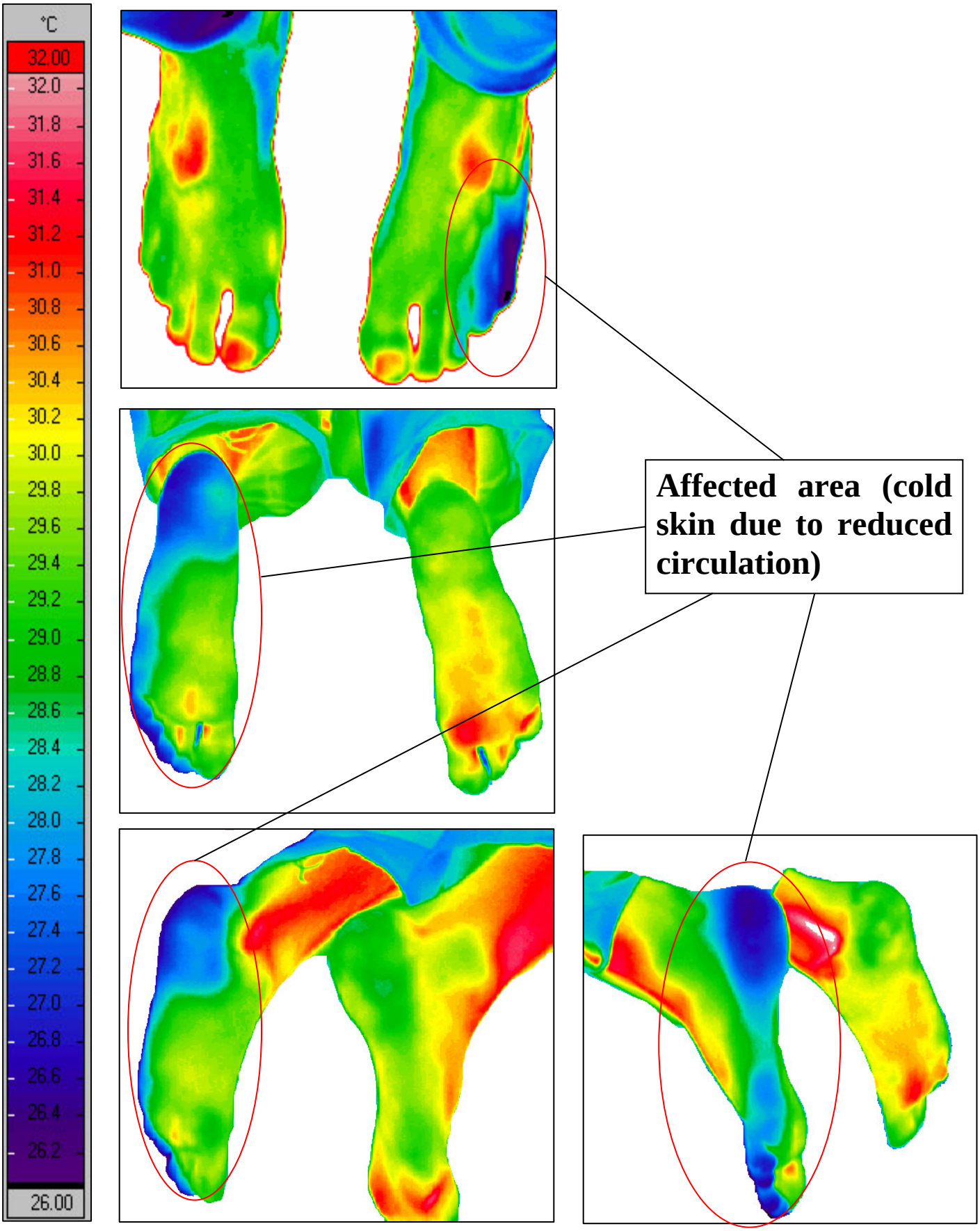
Visualization of sweat glands on fingertip (each dark spot in the IR-thermogram shows the opening of a sweat gland. The openings show up as dark (cold) spots due to evaporation of sweat).

Thermal visualization of superficial veins in the hand of a healthy subject

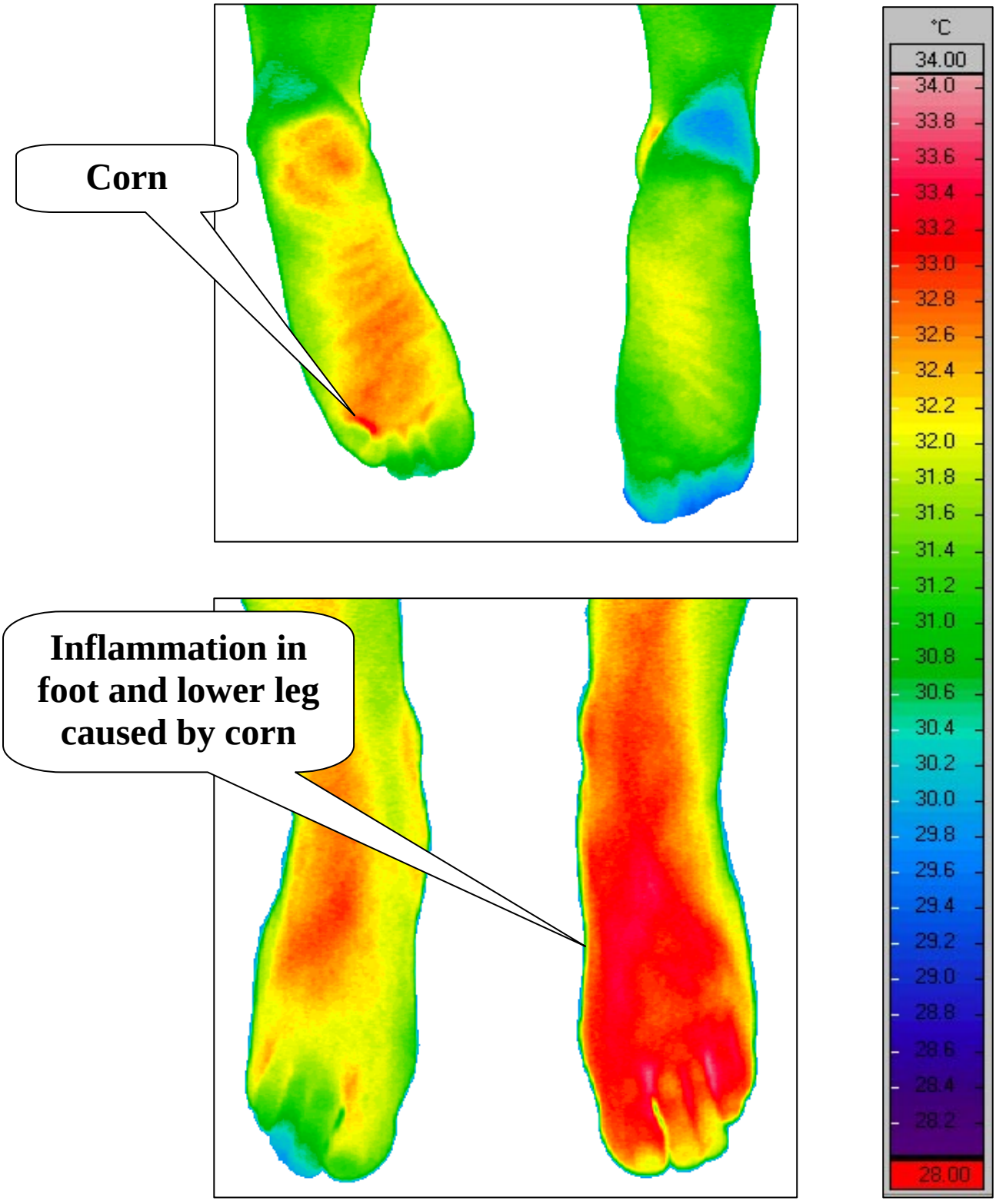


Drainage of blood in hand via superficial veins is influenced by finger temperature.

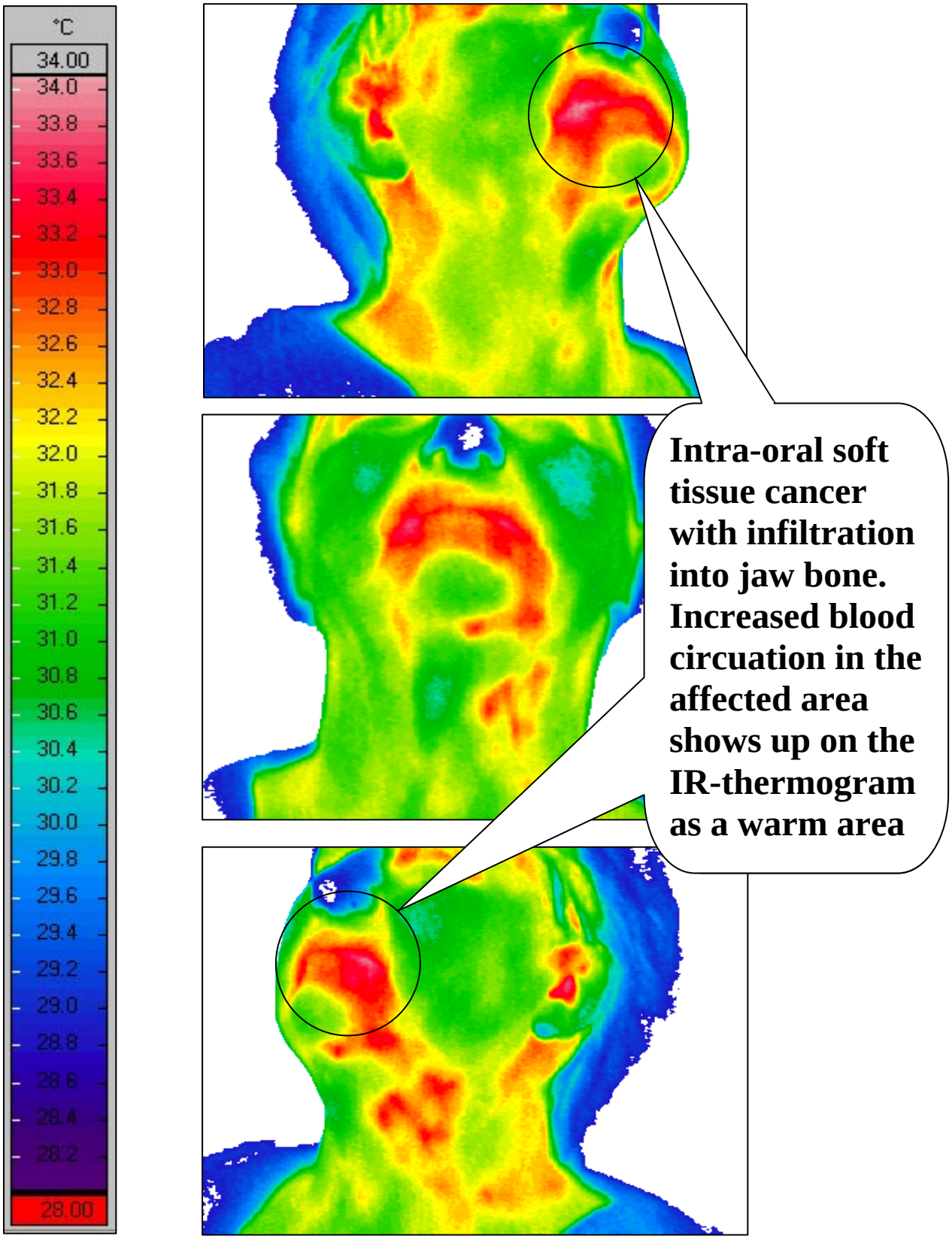
Non-freezing cold injury (NFCI) in left foot of 26 year old male subject following cold exposure during military exercise



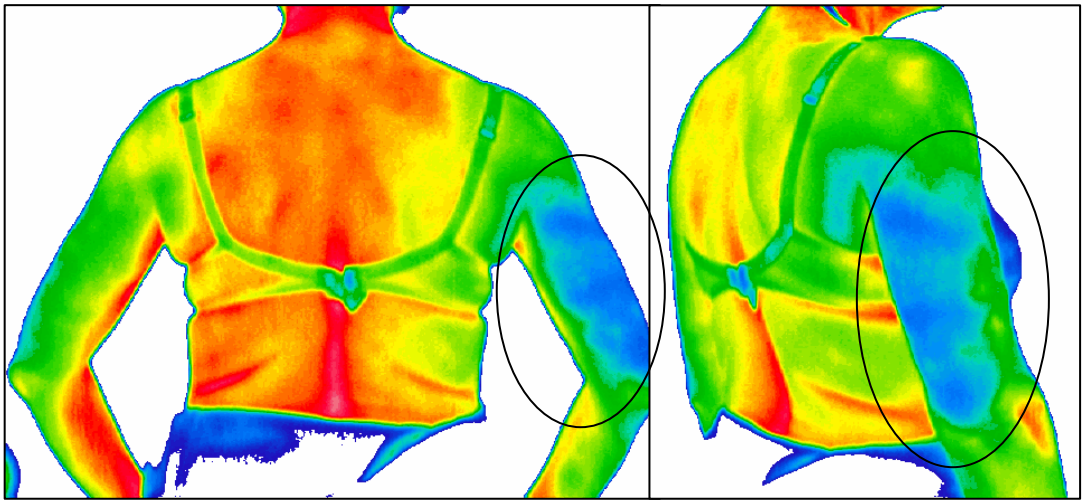
Visualizing pain and inflammation

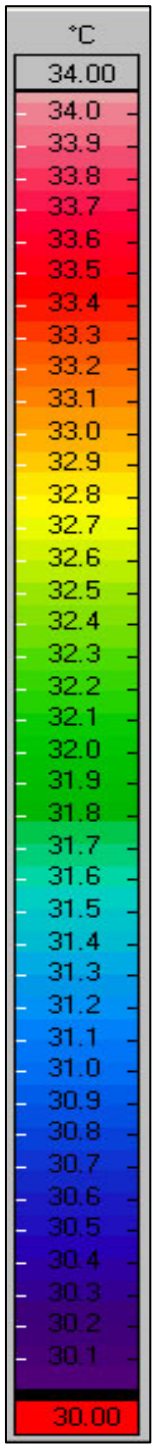


IR thermography and cancer diagnosis

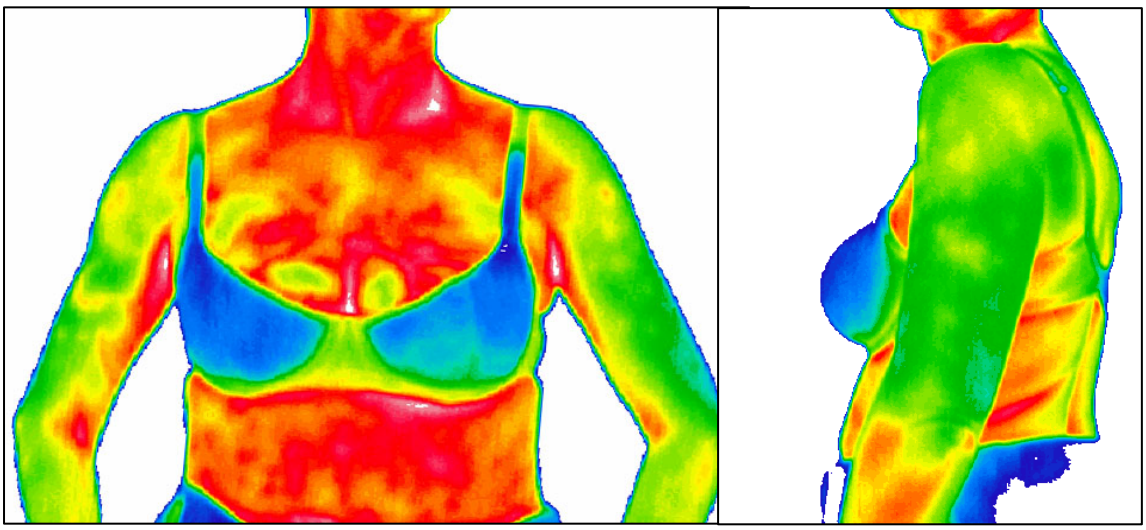


Infrared thermography
and
visualisation of pain

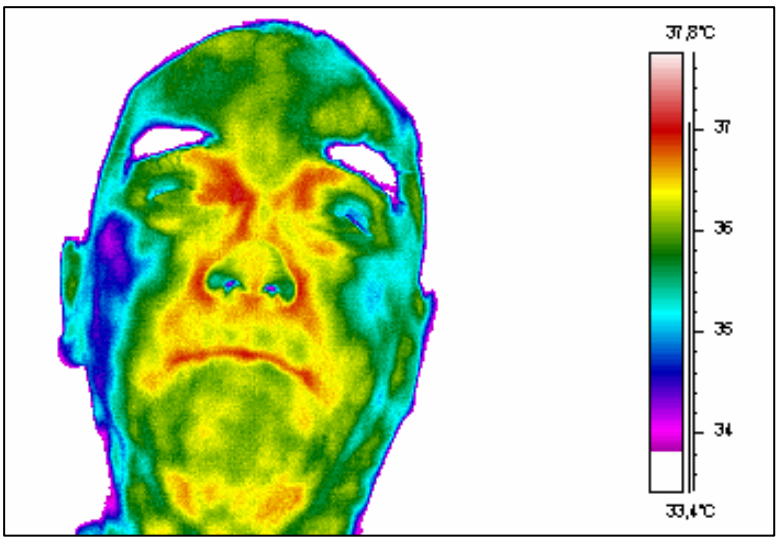


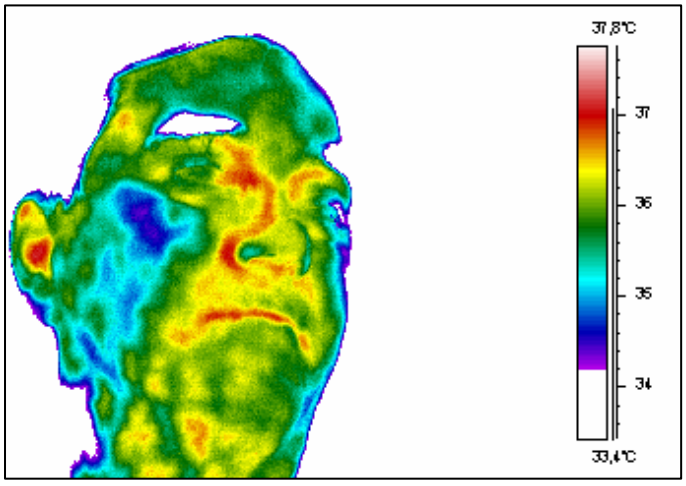


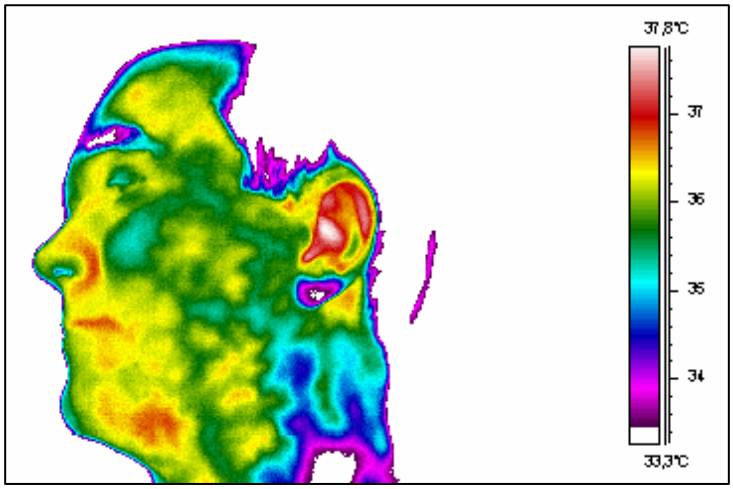
Non-specific muscle pain in upper right arm. The area of discomfort closely matched the area of cooler skin (blue coloured area inside black circles).



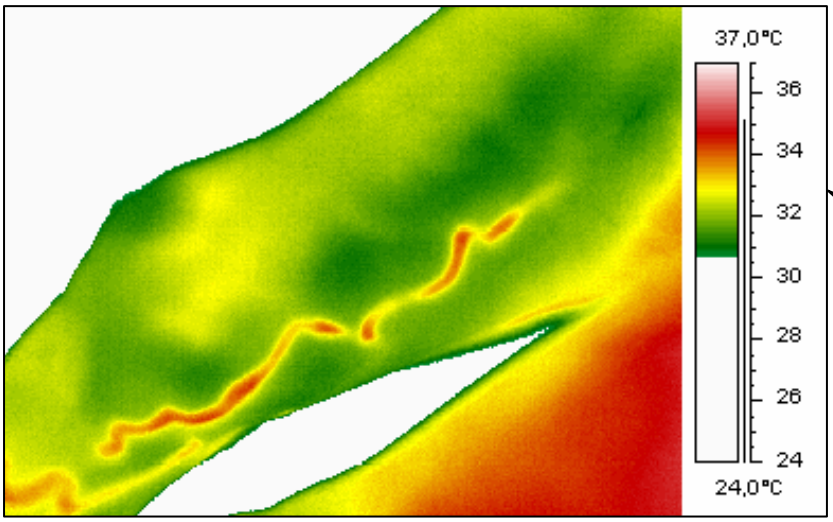
Occlusion of left internal carotid artery.
Total right side hemiparesis.
Infarction of left hemisphere



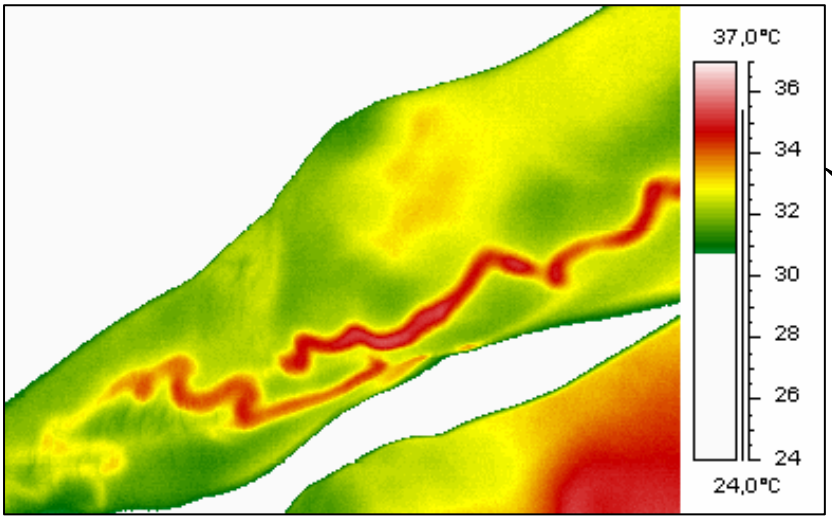




Visualizing blood flow varicose veins



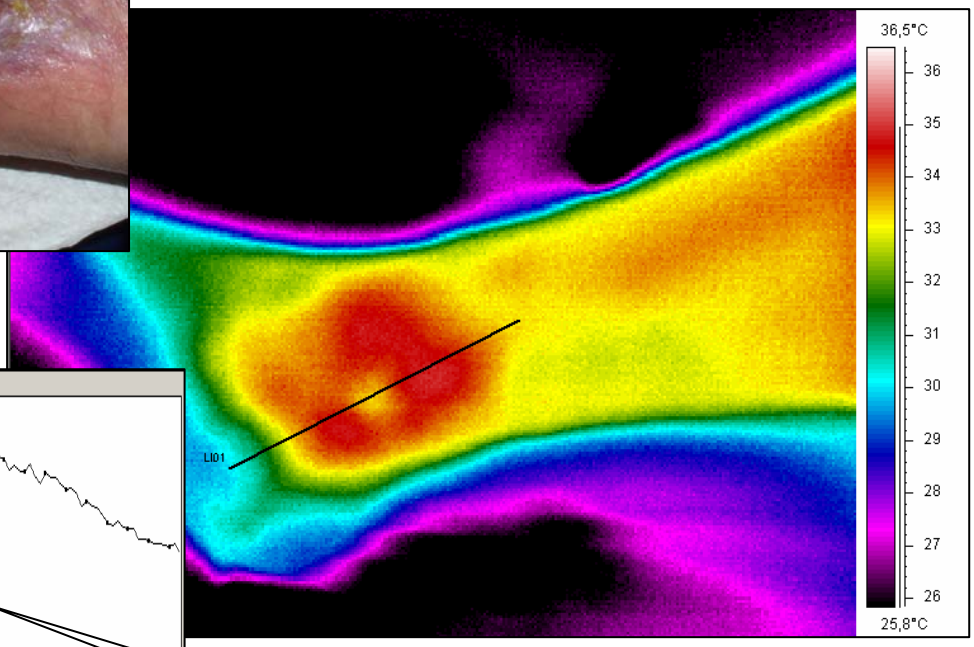
IR-image taken 5 seconds after leg elevation to drain the damaged veins

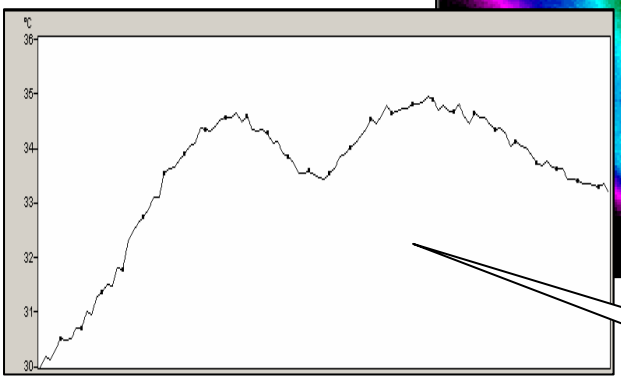


IR-image taken 16 seconds later

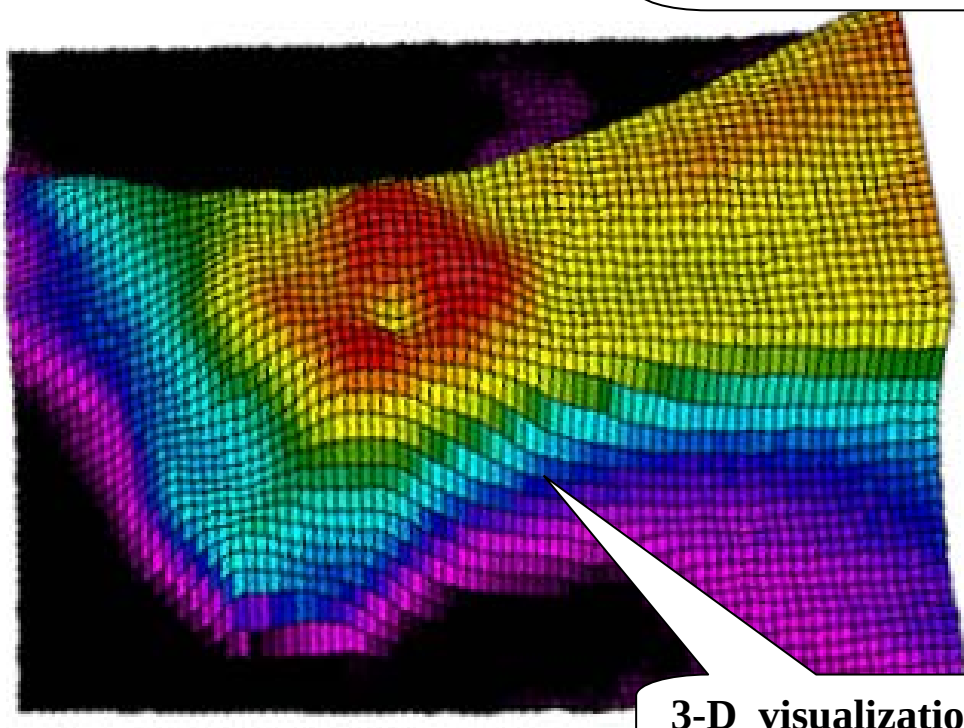
Retrograde re-filling of left saphenous vein following leg elevation

Chronic venous ulcer





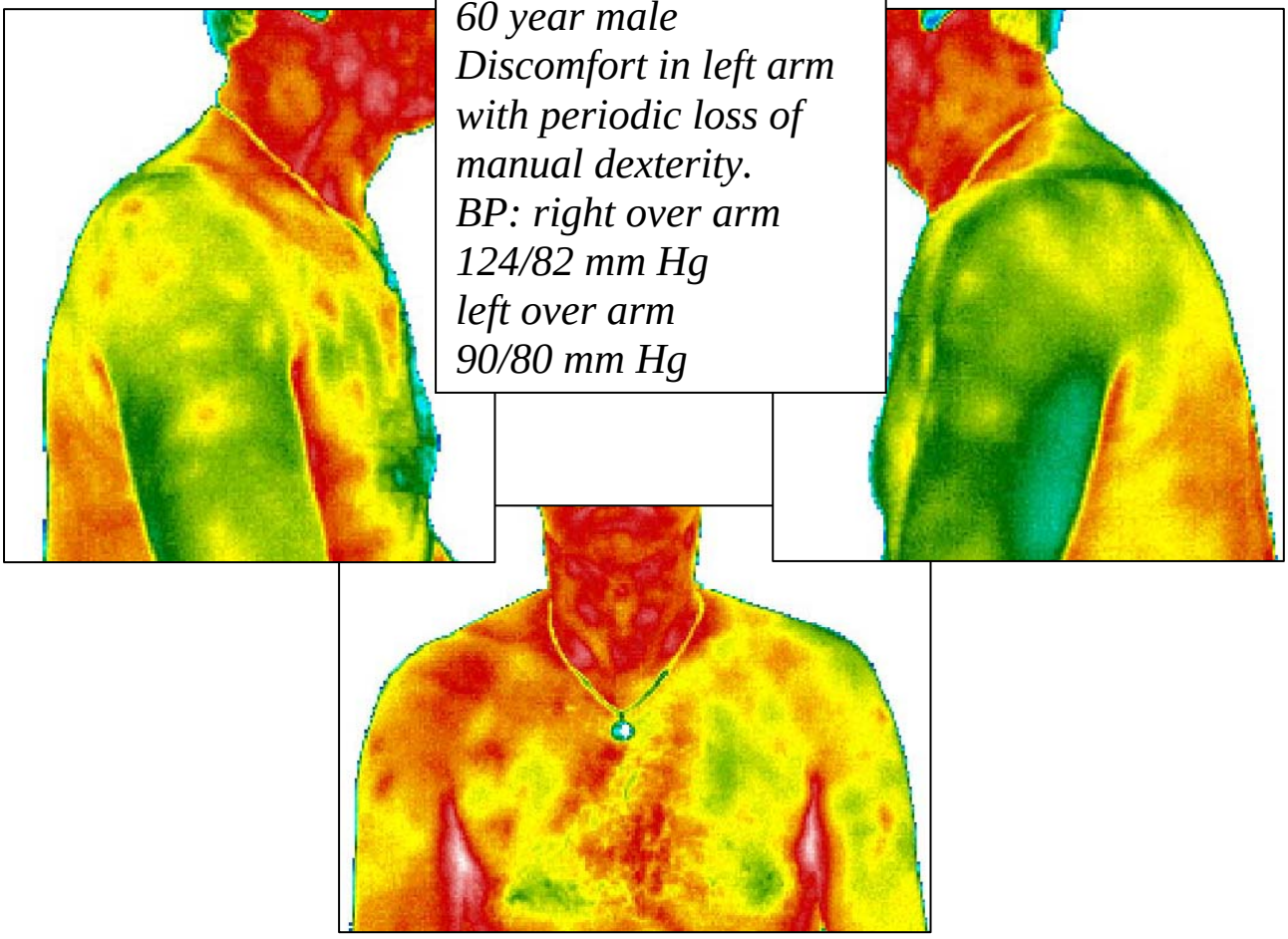
Temperature profile across ulcus

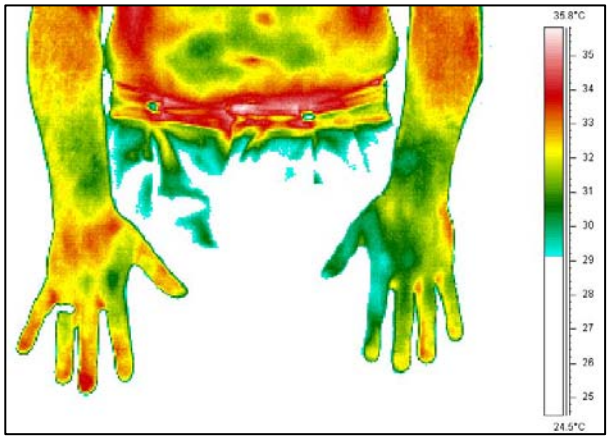


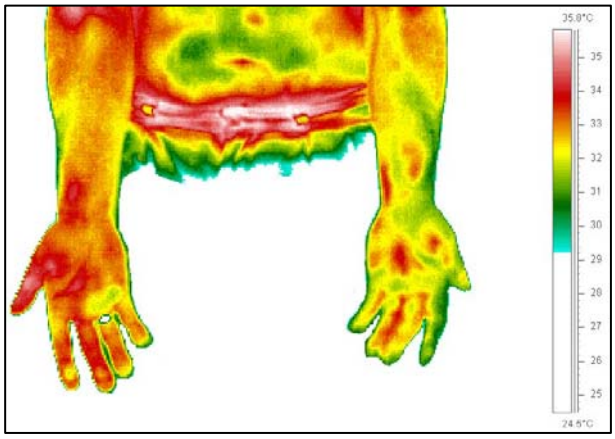
3-D visualization of infrared image

Subclavian artery steal syndrome

60 year male
Discomfort in left arm with periodic loss of manual dexterity.
BP: right over arm 124/82 mm Hg
left over arm 90/80 mm Hg

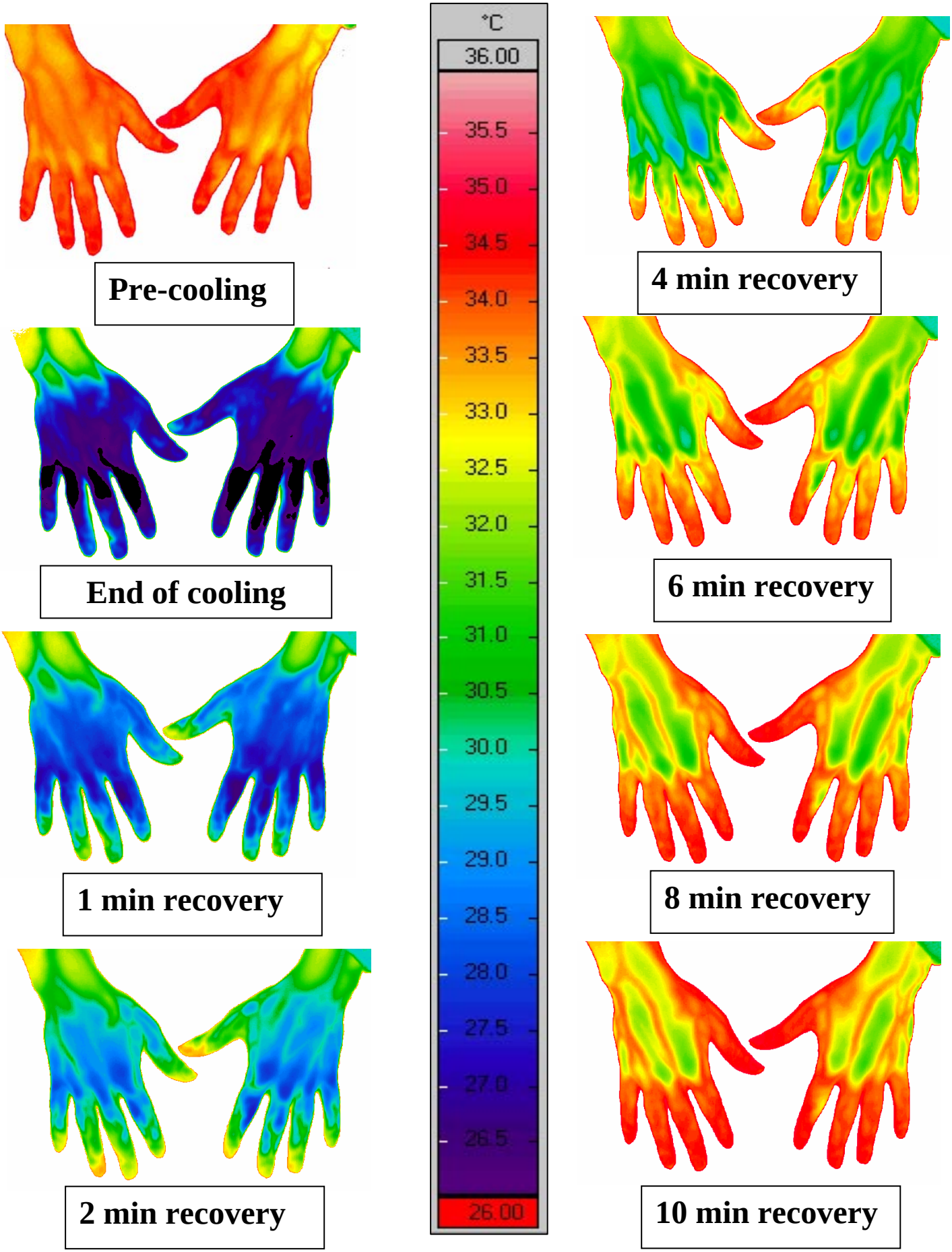






Subclavian steal syndrome is caused by occlusion of the proximal subclavian artery with subsequent retrograde filling of the subclavian artery via the vertebral artery. Note thermal asymmetry between right and left side of body.

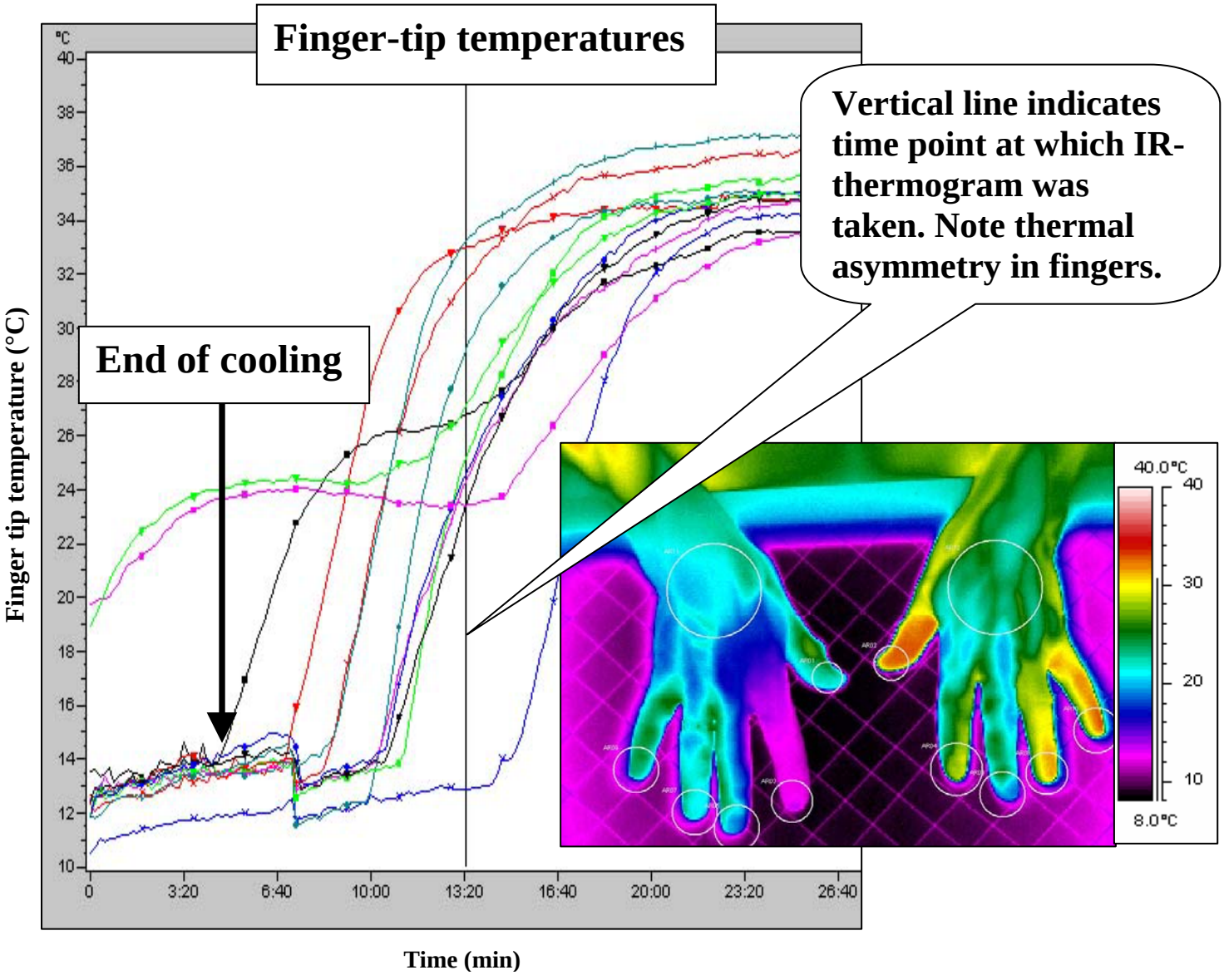
Dynamic IR-thermography can be used to examine circulatory responses in the skin during recovery from a cold provocation test (the hands were covered with thin plastic bags before being immersed in cold water for 2 min at 10°C)



Asymmetrical re-warming of fingers following cold provocation test in 69-year old female patient with Raynauds Syndrome.

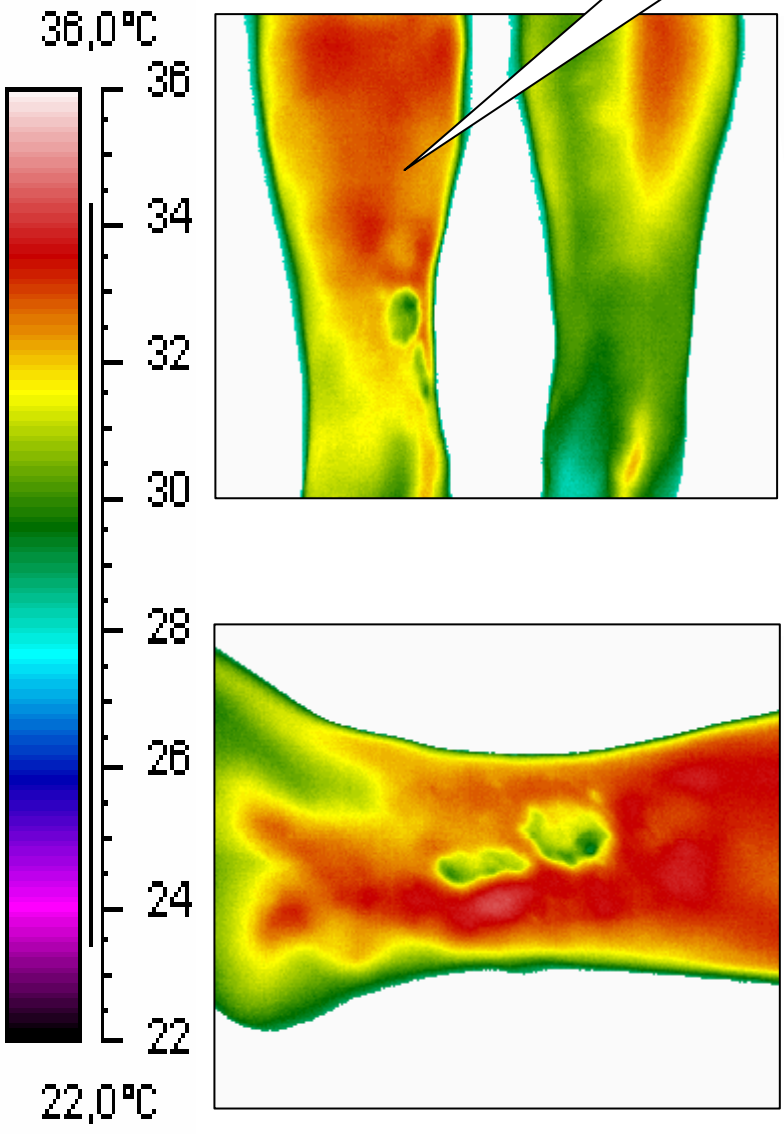
”white” fingers

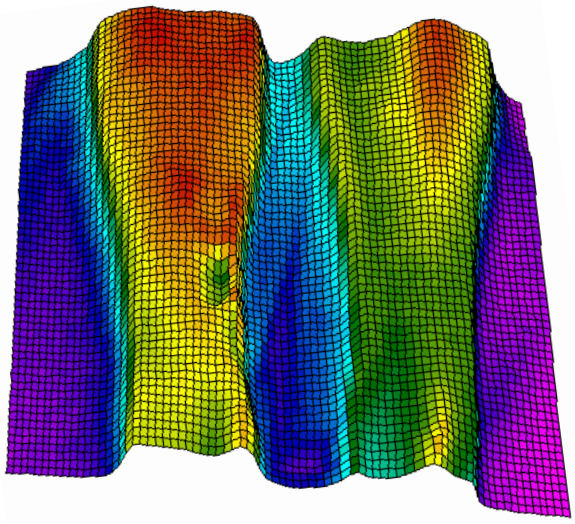
Cold water test

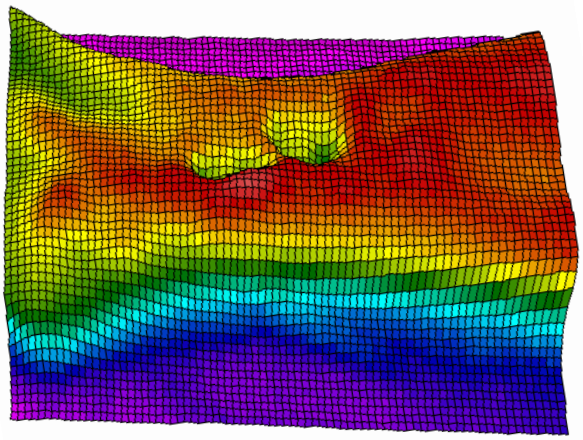


Normal and 3D-infrared thermograms of venous leg ulcers (inside of r. leg)

Note ”inflammed” right leg.







Circulatory loss in injured fingers

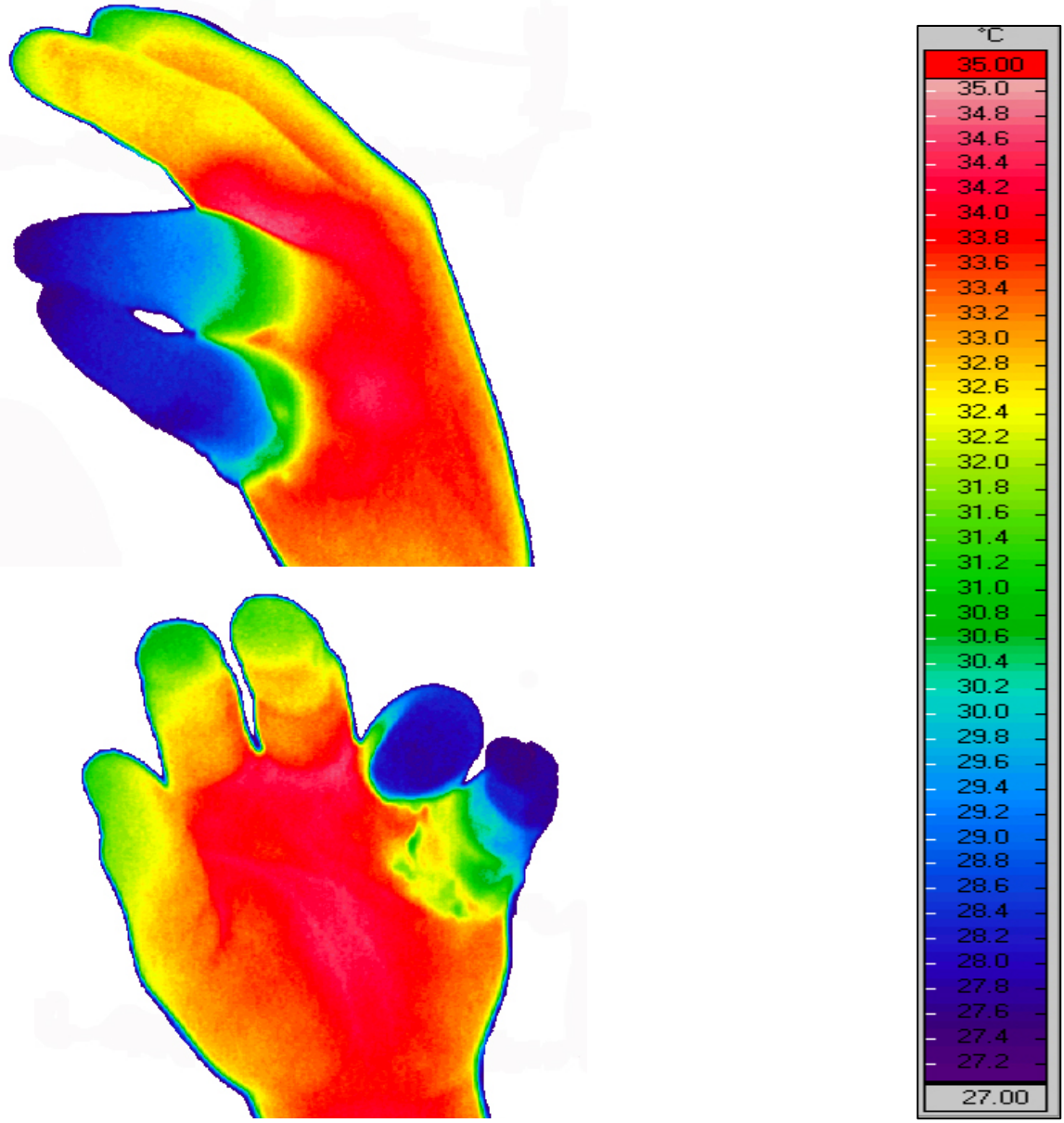


Image inversion

Comparison of left and right side using inversion of one image

Upper - normal view with left breast directed towards camera
Lower - inverted view with right breast is directed towards camera