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The historical development of thermal imaging in medicine

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The association between disease and human body temperature is as old as medicine itself. Hippocrates defined fever in different forms, such as malignant, benign and acute. It was claimed that if wet mud was applied to the skin, and one area dried rapidly while the remainder was still moist, that an underlying tumour may be suspected.

It was not until Galileo Galilei developed his simple thermoscope in 1595 that attempts to measure temperature really began, and some hundred years later before closed thermometers and calibrated scales were used. Carl Wunderlich made the greatest progress in medicine by his development of the clinical thermometer and systematically recorded the progression of temperature in a large number of sick patients in 1871 [1]. His treatise *On the Temperature in Disease* carries a substantial

section on temperature graphs from diseased patients, some with 'rheumatic fever'. He argued for the routine measurement of temperature and that a graphic record be established for every patient.

Following the work of Horvath and Hollander in the late 1940s [2], temperature measurements were used as a means of monitoring intra-articular steroid therapy by a number of authors. However, intra-articular temperature and isotope clearance techniques were invasive, unlike the infrared remote sensing techniques, which were available from the late 1950s.

The story of infrared radiation began in 1800, when Sir William Herschel, the astronomer, detected heating rays beyond the visible red of the spectrum. After his death in 1840, his son John Herschel made the first thermal image from sunlight using the evaporograph technique. He used the term thermogram to describe the image, which is still in common use today [3].

Early infrared imaging systems were developed during the 1940s and became available to industry and medicine first in 1959. The Pyroscan (a 1942 instrument) was first used in Bath in 1959 (Fig. 1) and was used to image the increased heat over arthritic joints. Picture quality improved with the Mark 2 instrument (Fig. 2), although each image took 3–4 minutes to acquire and was almost impossible to quantify. Later, with improved equipment, better dynamic (and objective images) were obtained that could usefully supplement radiological investigation [4].

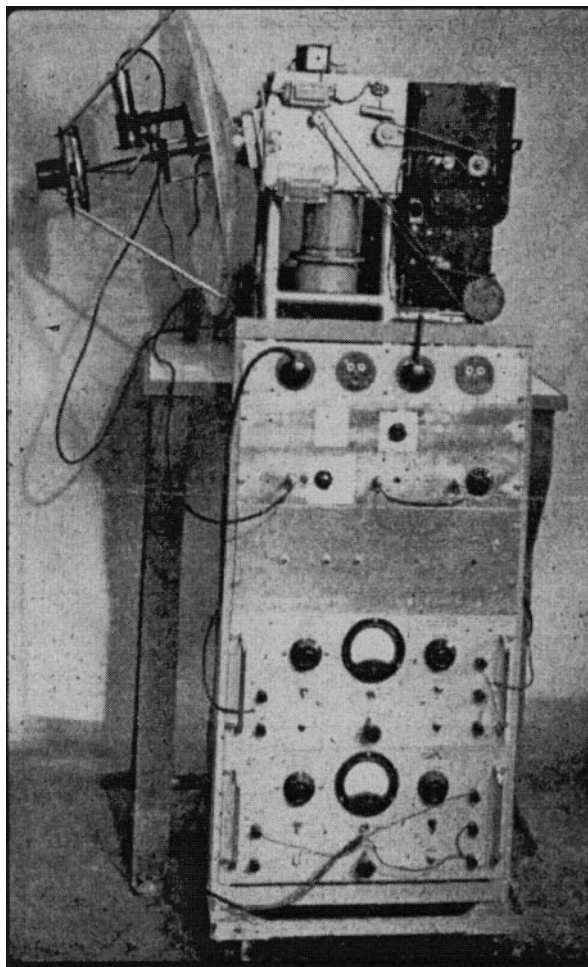


FIG. 1. Prototype Pyroscan used in Bath in 1959.

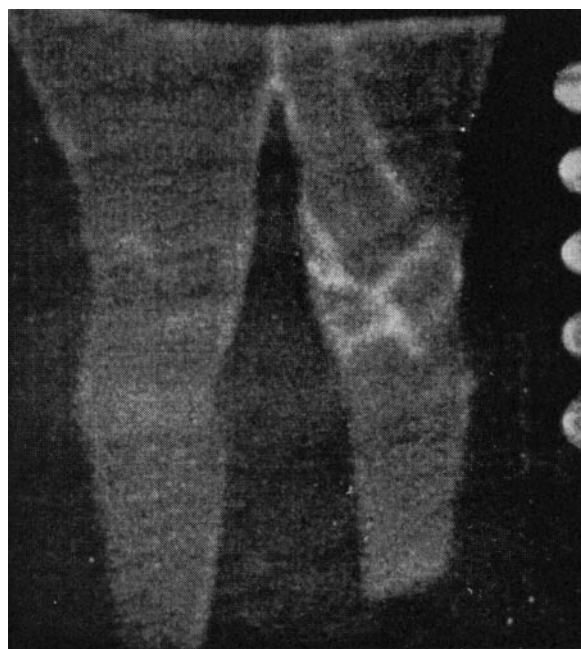


FIG. 2. Early thermogram of RA knees recorded with Mark 2 Pyroscan in 1963.

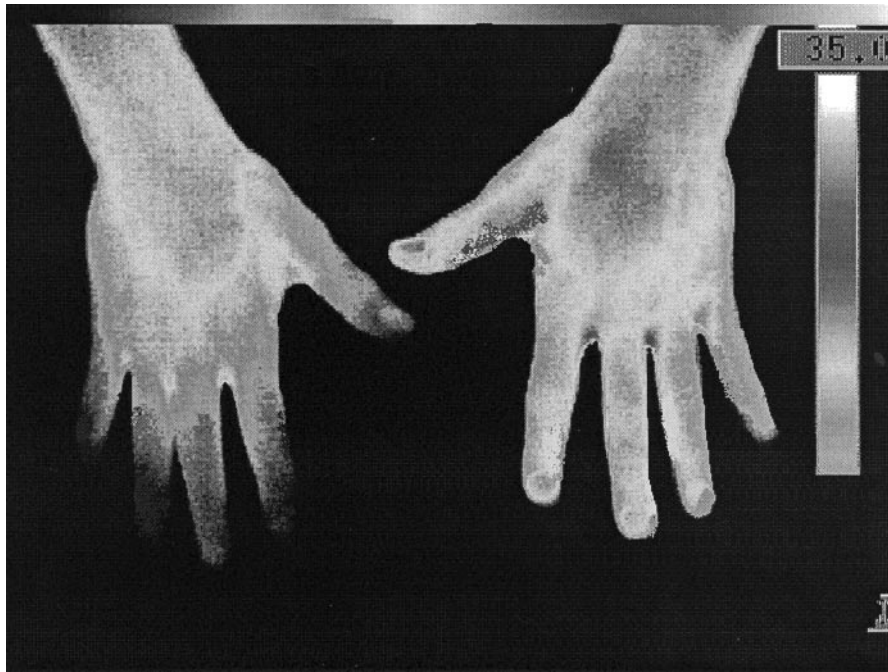


FIG. 3. A modern thermal image of hands.

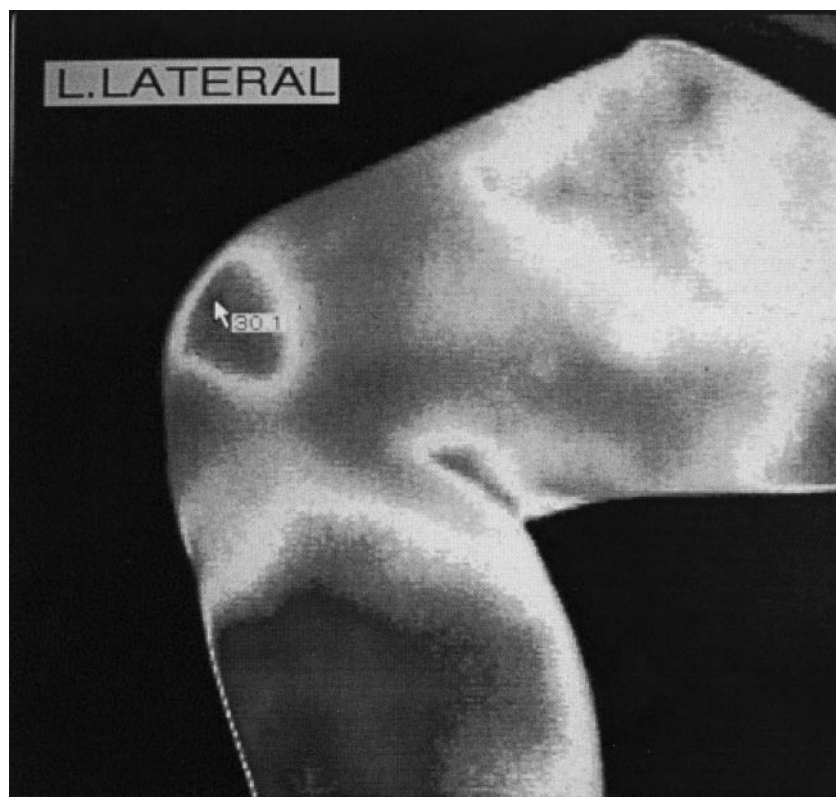


FIG. 4. Thermogram of knee synovitis.

During the 1960s and 1970s a new generation of thermal imaging systems were developed in Europe, the USA and Japan. Oscilloscope displays were introduced and electronic isotherms were added to the image. By multiple exposure colour photography, the first colour thermograms were produced in the 1960s. Mini-computers for image processing arrived in the mid- to late

1970s providing colour displays, image analysis and, importantly, data and image storage. This marked the beginning of quantitative thermography [5].

Modern systems introduced within the last three years use focal plane array detectors, with high speed images at high thermal and spatial resolution. Image quality has dramatically improved,

modern digital thermograms are now very different from the crude clinical images obtained 40 years ago (Figs 3, and 4).

Today, applications in rheumatology include the quantitative study of inflammation and anti-inflammatory therapies, peripheral circulatory disorders related to connective tissue diseases, and Raynaud's phenomenon, sympathetic disturbances, pain syndromes and locomotor injuries [6].

References

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