SHORT REPORTS

Ultrasonic B-scanning of the Human Skin

An Introduction of a New Ultrasonic Skin-scanner

G. TIKJØB, V. KASSIS and J. SØNDERGAARD

Department of Dermatology, Hvidovre Hospital, University of Copenhagen, Copenhagen, Denmark

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A high frequency, high resolution dynamic ultrasonic skin-scanner is described. The skin-scanner is shown to give a cross-sectional image of the skin and provides an accurate, simple and non-invasive method for measuring full-thickness human skin. In addition to the skin thickness it is demonstrated that the underlying subcutaneous fat and muscles can also be non-invasively explored with the possibility of identifying a variety of skin and underlying tissue lesions. *Key words: Skin thickness; Subcutaneous structures.* (Received June 10, 1983.)

G. Tikjøb, Dept. of Dermatology, Bispebjerg Hospital, Bispebjerg Bakke 23, DK-2400 Copenhagen NV, Denmark.

Non-invasive and suitable three-dimensional imaging of skin lesions has until recently been an unobtainable goal in dermatology. A limited development of ultrasonic technology has prevented accessible solution to this problem. Already high frequency ultrasound methods have been successfully used for two-dimensional measurements of epidermal and dermal thickness (1). The validity of this technique was acceptably correlated with conventional techniques, including xeroradiography (2). More recent attempts have been made to provide ultrasonic B-scanning of skin (3). Several problems, however, remain unsolved. We present here some newer technical data and preliminary results of ultrasonic mapping of human skin structures.

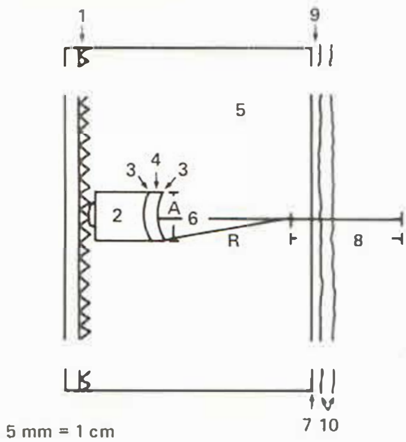
TECHNICAL DATA

The construction of our B-skin-scanner was based on accessible techniques and was carried out in collaboration with the electronic firm Brüel & Kjær and The Danish Institute of Biomedical Engineering.

The transducer is a disc-shaped spherically curved piezoelectric ceramic with a resonance frequency of 13 MHz. The disc is moved by a rack in a rectilinear manner, making a total excursion of 25 mm per sec. The transducer assembly is housed in a sealed waterbath headed with a thin PVC membrane. Good acoustic coupling is assured by a layer of coupling gel, enabling scanning in all directions without a waterbath immersion. By designing the radius of the disc curvature and its distance to the membrane equally the focal zone appears at the outermost layers of the skin. Technical data for the transducer are given in Table I, and a graph of the transducer in Fig. 1. The received echo signals are amplified, compressed and detected in a specially designed very low noise analog signal processor. In

Table I. *The transducer, technical data*

Distance from the transducer to the skin surface	15 mm
Zone of focus	13–24 mm
6 dB radiation beam-width	0.6 mm
Transducer center frequency	13 MHz
Axial resolution	0.25 mm



1. rack
2. backing
3. silver electrodes
4. spherically curved ceramic disk, A = 5 mm, R = 15 mm
5. water
6. beam of sound
7. plastic window
8. zone of focus
9. space with coupling gel
10. skin

Fig. 1. Cross-sectional drawing of the transducer.

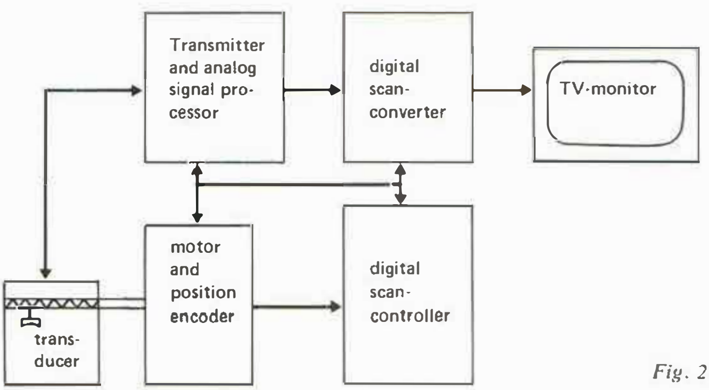


Fig. 2. Diagram of the scanner.

the digital scan converter the detected echo information is digitized by an analog to digital converter with a sampling frequency of 15 MHz and a resolution of 5 bits, corresponding to 32 descrete gray levels. The tv-image memory is organized as a 128×512 matrix resulting in a rectangular image composed of up to 128 scan lines each consisting of 512 samples. A uniform video-image with high resolution is obtained by interpolation between the component scan lines. A gray scale mapping system compensates for the non-linear properties of the human vision and the tv-tube. In order to achieve a better utilization of the video screen the vertical dimension of the image is expandable 2, 3 or 4 times. As an extra facility scale marks can be superimposed in the tv-image. The spacing between scale-marks are ajustable and currently based on a sound velocity of 1 538 m/sec. A graph of the scanner is given in Fig. 2.

RESULTS AND DISCUSSION

The skin-scanner records reliable in vivo measurements of skin thickness. The scanner also informs about coarser skin structures, e.g. the extent of an urticarial reaction or an

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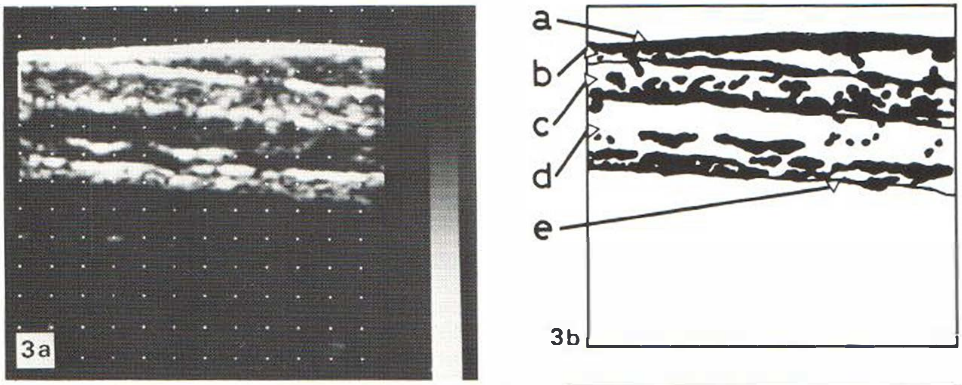
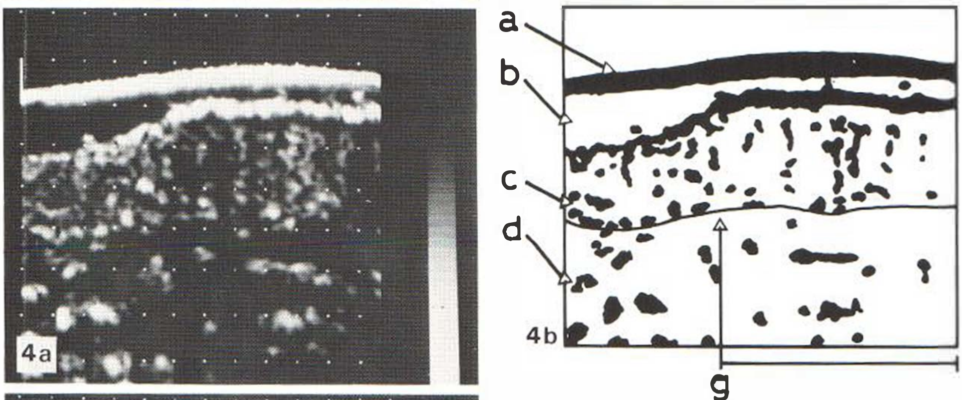
Fig. 3 a, b. Normal skin from the volar aspect of the forearm. Scale marks, horizontal 2 mm, vertical 1 mm. *a* = plastic membrane, *b* = coupling gel, *c* = epidermis/dermis, *d* = subcutis, *e* = muscle fascia, *f* = urticarial wheal, *g* = psoriasis plaque.

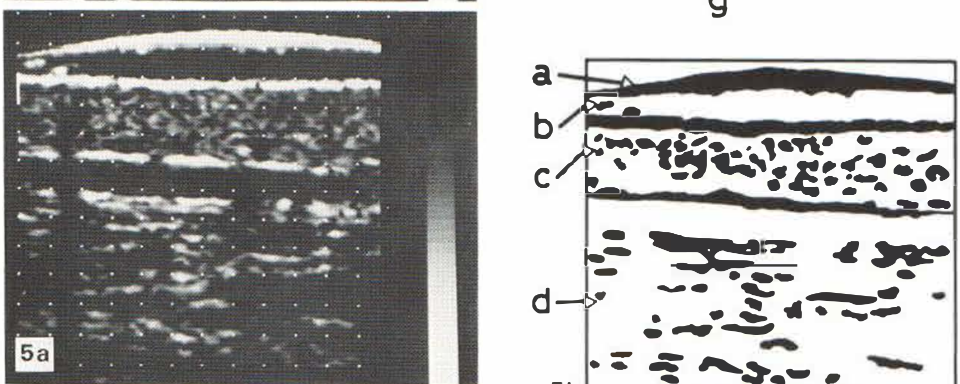
Fig. 4 a, b. Psoriasis plaque from the extensor side of a forearm.

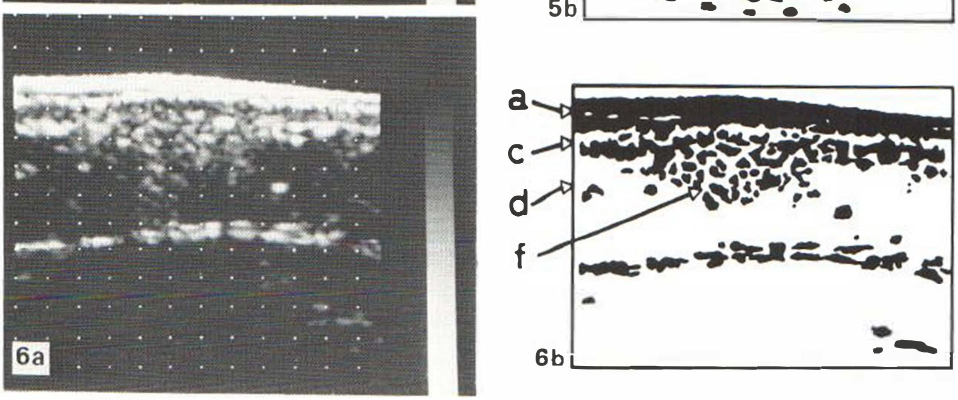
Fig. 5 a, b. Scleroderma. Epidermis/dermis 2.1 mm thick.

Fig. 6 a, b. Cross-section of an urticarial wheal.


3a
a
b
c
d
e
3b


4a
a
b
c
d
4b
g


5a
a
b
c
d
5b


6a
a
c
d
f
6b

infiltrating process as demonstrated in Figs. 3 *a+b* to 6 *a+b*. The scanner should be regarded as a first generation apparatus and it is our conviction that further developments will occur in this field, especially concerning new transducer material as described by Jones & Babott (4) and Payne & Quilliam (5) in order to get higher transducer-frequency and a greater resolution.

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