SCANNING PHOTOMETRY OF THE CONJUNCTIVA OF SCLERA AND CORNEA

I. P. Pshenichnyi, P. N. Aleksandrov, A. M. Chernukh, A. I. Bartyzel', and P. S. Aref'ev

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A method based on the principle of photometry and enabling optical scanning of the anterior portion of the eye to be carried out, making allowance for the radius of curvature of the conjunctiva of the sclera and cornea, is described. A method of studying the optical properties of the spherical surface and stroma of the cornea and the permeability of the blood–eye barrier is suggested.

KEY WORDS: ophthalmology; photometry.

The photometric method of investigation of some parameters of the eye has a great advantage over other methods because its results can be recorded without any mechanical effects on the eyeballs. There is no question about the good prospects for the use of the photometric method in ophthalmologic practice [2]. The method can be used to record parameters such as the optical density of the sclera, the degree of opacity of the cornea, the optical density of a cataract, the concentration of fluorescein (injected intravenously) in the anterior chamber of the eye, the blood flow in the iris, the permeability of the blood–eye barrier, and so on.

All instruments based on the photometric method consist of a stabilized light source, a light receiver, and an electronic system for measuring and recording the photic flux. By scanning photometry the optical density of any object can be recorded along the line of photometry.

The method of scanning photometry has also been used with success in the experimental investigation of problems connected with the microcirculation [1, 3-6]. However, because of the lack of a suitable technique, this method has not been used to study the anterior part of the eye, in which the parameters mentioned above can be studied by biomicroscopy.

The writers have accordingly devised a technique of scanning photometry of the conjunctiva covering the sclera and cornea. For scanning photometry a device automatically shifting the optical system along the stationary eye (animal or human) and allowing for the radius of curvature of the structures forming the anterior part of the eye, was used. The special scanning device with an optical system fixed to two platforms arranged crosswise, is set in motion by means of a crank and connecting rod mechanism so that during longitudinal displacement of the lower platform along the anterior part of the eye there is simultaneous transverse displacement of the upper platform, allowing for the radius of curvature of the conjunctiva covering the sclera and cornea.

A block diagram of the scanning device is shown in Fig. 1. For work with animals (rabbits) there is a special halter 1, fixing the animal's head securely but without injury, and enabling the head to be shifted if necessary so that the center of the eye coincides with the optical axis of the system. By using the illuminating system 3, the sharpness of the image can be verified through the ocular 5 allowing for the focal length of the objective 2. Objectives with magnifications of 3, 6, 10, and 20 times can be used. After

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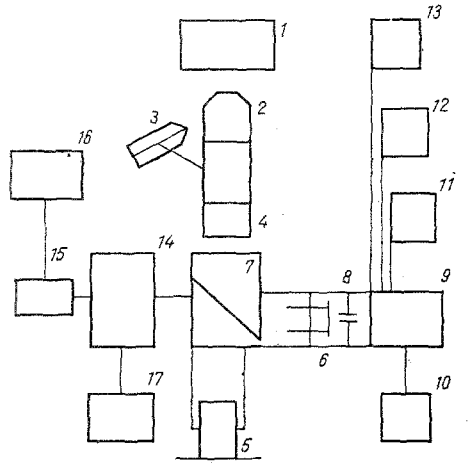

Fig. 1. Block diagram of device for scanning anterior part of eye: 1) halter; 2) objective of optical system; 3) illuminating system; 4, 5,6) oculars in different parts of the optical system; 7) refracting prism; 8) diaphragm; 9) photoelectronic multiplier (FÉU-19) in jacket; 10) high-voltage stabilized rectifier; 11) microammeter (M-95); 12) oscillograph; 13) amplifier with automatic writer; 14) device for moving optical system automatically across anterior part of eye and allowing for its radius of curvature; 15) reversing motor (SD-54) of this device; 16) power unit of this device with relay circuit for changing direction of motion; 17) tenso-electric system for recording pathway of motion of optical system (mechanography).

the optical system has been centered and the sharpness of the image verified, the mechanical displacement system (14) is activated, starting up a reversing electric motor (15) with automatic control, the circuit of which consists of the relay (16) and microswitches. During displacement of the optical system across the eye, the reflected or fluorescent photic flux falls through the 10× ocular (4), the prism (7), the 20× ocular (6), and the diaphragm (8) on the screen of the photomultiplier (9). The anode voltage is led to the photomultiplier from a high-voltage stabilized VSV-2 rectifier (10). The photoelectric current thus obtained is recorded by a milliammeter (11) or, after amplification, by an oscillograph (12) and automatic writer (13).

If the fluorescence of the structure to be studied is recorded, the scanning is carried out through an FS-1 filter (in front of the light source) and a ZhS-2 filter (in front of the objective).

It will be clear from the graphs in Fig. 2 that during the recording the optical density of the structures examined (Fig. 2b) the number of reflected beams and, consequently, the magnitude of the photic flux was maximal in the region of the sclera. During movement of the optical system into the zone of the cornea the photic flux fell rapidly. The central zone of the healthy cornea is characterized during illumination by the presence of a "flash zone," which is reflected on the record of the scanning. However, scanning the central part of the cornea outside the "flash zone" (Fig. 2C) enables the region of the pupil to be observed, where the decrease in photic flux was maximal.

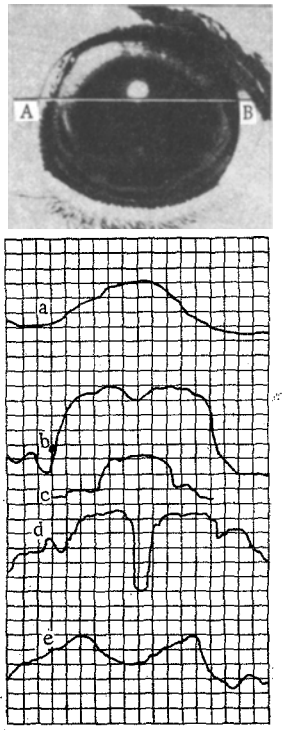

Fig. 2. Recording of scanning of anterior part of rabbit's eye. Above: photograph of eye showing scanning line AB. Below, records: a) movement of optical system along asigned curvature (mechanogram); b) optical density of anterior part of eye; c) the same, in the region of the pupil, outside "flash zone"; d) the same, after local anesthesia of cornea; e) fluorescence of anterior part of eye after intravenous injection of fluorescein. Upward movement of the pen denotes a decrease in photic flux. Tape of automatic writer moves at 1 mm/sec. Objective 3×, oculars 10 and 20×.

Application of decicaine to the cornea leads to the development of "porosity" of the epithelial layers of the cornea, to "perforation" of its superficial, spherical layer. The number of reflected beams increases under these circumstances, the scatter of light becomes irregular, and the "flash zone" becomes larger and brighter. The scannogram of the cornea of such an eye (Fig. 2d) is characterized by: 1) a smaller degree of photic flux; 2) the appearance of oscillatory movements of the automatic writers, and 3) a sharp increase in the photic flux in the "flash zone," i.e., optical scanning reflects the character of the changes described above.

Fluorescence is observed in the region of the scleral conjunctiva and the pupil 1 h after intravenous injection of fluorescein-Na-uranyl (2.5% aqueous solution, 0.3 ml/kg body weight). Special investigations showed that the increase in fluorescence in the central part of the eye is explained by penetration of the fluorescein through the blood–eye barrier into the aqueous humor.

The suggested method of scanning photometry can be used not only under experimental conditions, but also in clinical ophthalmology to determine the optical density of the anterior part of the human eye and also to record fluorescence of the cornea during the clinical fluorescein test.

LITERATURE CITED

1. P. N. Aleksandrov and A. M. Chernukh, Byull. Éksperim. Biol. i Med., No. 8, 121 (1971).
2. A. Ya. Bunin, Hemodynamics of the Eye and Methods of its Investigation [in Russian], Moscow (1971).
3. E. P. Smolichev and V. M. Volodin, Pat. Fiziol., No. 3, 72 (1968).
4. A. M. Chernukh, Pat. Fiziol., No. 1, 83 (1967).
5. P. S. Johnson, J. Appl. Physiol., 23, 393 (1967).
6. P. S. Johnson and W. H. Greatbaten, Methods Med. Res., 11, 220 (1966).