Time does not allow me to deal with secondary glaucoma, with juvenile glaucoma, or with buphthalmos.

Many of the views that I have expressed in this lecture are heterodox. I hope that you will regard them as my own opinions, but that you will keep them in mind and try to ascertain in your own future practices to what extent they are true or false.

SOME REMARKS ON FINCHAM'S CAPSULAR THEORY OF ACCOMMODATION

BY

J. W. NORDENSON

STOCKHOLM

SOME years ago a new theory of accommodation, called the capsular theory, was presented by Fincham.* It was an attempt to conciliate the two diverging theories of v. Helmholtz and Tscherning. Fincham agreed with v. Helmholtz so far as to accept the idea that the alteration of the curvature of the lens was due to a slackening of the zonula, allowing the elasticity of the lens-capsule to exert its influence; on the other hand he accepted the idea of Tscherning that the lens in accommodation takes a conoidal shape, forming a lenticonus anterior. According to him this conoidal form is due to the fact that the capsule of the lens is of varying thickness in different parts. As this capsular theory, which has attracted a certain amount of interest, is incompatible with certain facts about accommodation, I here allow myself to advance some critical remarks on it.

In forming an opinion on this new theory we have to consider two questions. The first is whether the lens really assumes a conoidal form in accommodation; the second is whether a conoidal form can be caused by the varying thickness of the lens-capsule in different parts.

Before entering on the first of these questions—whether the lens assumes a conoidal shape or not—it is necessary to remark that Fincham's conception of a conoid does not coincide with the generally accepted scientific definition of this word. Thus the ancient mathematicians used it to denote a surface, engendered by an element of a parabola or a hyperbola rotating round its axis, in other words a truncated rotation—paraboloid or hyperboloid. In later times it has been used to denote the surface engendered by a straight line—generatrix—running both along a

* FINCHAM, E.—The Mechanism of Accommodation. Monograph Supplement VIII. *Brit. Jl. of Ophthal.*, 1937.

curve—directrix—and along a straight line—axis—being constantly parallel to a given plane—planum dirigens. Fincham's conception of a conoid on the other hand does not seem to coincide with any of these definitions; he obviously holds that it is a segment of a sphere, resting on a truncated cone or, at any rate, on a body of rapidly decreasing meridional curvature. The following argumentation is based on the assumption that this is Fincham's definition of the word.

Resuming the question whether the lens assumes a conoid form or not in accommodation, we now have to examine the arguments given in favour of a positive answer. The main argument is drawn from an experiment, which was devised by Tscherning in his time, and has now been repeated by Fincham. It was carried out in the following way: Four sources of light were arranged on an arc in such a way that the image of them, formed by the centre of the anterior surface of the lens, was a straight vertical line. The pupil was dilated, and the eye was accommodated about 5 dioptries. The fixation was first adjusted so that the line of images was formed by the central area of the lens surface; then the fixation was altered slightly, so that the images were formed away from the centre. In the latter case the two peripheral images were seen to be elongated and splayed out. This, according to Fincham, indicates "the shallow conoidal form of the surface."

This way of concluding, however, leaves room for several objections. No notice is taken of the influence of the forelying cornea, and no comparison is made with the conditions in the non-accommodating eye. The conclusions must therefore be very uncertain. The only permissible conclusion to be drawn from the experiment in question is that the curvature of the peripheral part of the apparent anterior surface of the lens is slighter than the curvature of the centre. It does not allow of the conclusion that the difference of curvature between centre and periphery is so great that the denotation "conoidal" is justified. (What is to be understood by "shallow conoidal" remains to be explained). The effect seen can easily be produced by an ordinary surface of the second degree.

If any conclusions are to be drawn about the form of the anterior surface of the lens from the images that it gives, it is necessary first to determine the influence of the cornea on the rays that reach the lens through it and are reflected. As I have had the opportunity of demonstrating in a previous investigation,* a study of the peripheral parts of the anterior surface of the lens,

* NORDENSON, J. W.—Über die Form der Linsenflächen bei der Ackommodation. Skand. Arch. f. Physiol., 1916.

preceded by a survey of the cornea, gives an aspect of the form of this surface in accommodation totally different from the one described by Fincham. The investigation in question consisted of a trigonometrical survey of the anterior surface of the lens, first in accommodative rest and then in accommodation, preceded by a similar survey of the corneal system, *i.e.*, of the anterior surface of the cornea. In that way due allowance was made for the influence of this system on the rays, that pass through it twice. Contrary to the assertions of Tscherning and Fincham the measurements showed that the radius of the anterior surface of the lens was diminished in accommodation, not only, as is generally admitted, in the central part, but also in the periphery. Thus the radius of the central element of the horizontal meridian temporal to the axis, was, in rest, 9°,54 mm. in accommodation 7°,38 mm.; and the most peripheral of the measured elements, situated about 20° temporally, showed a radius of 16°,2 mm. in rest and of 10°,62 in accommodation. Similar results were found on the nasal side; measurements in other directions were not made, the possibilities of obtaining exact results there being considerably less than in the said meridian. Thus these measurements showed that a very marked increase of the curvature of the anterior surface of the lens takes place, and that the radius of the peripheral parts, although still greater than that of the central parts, is, however, always smaller in accommodation than in accommodative rest.

As the measurements now quoted are somewhat complicated and difficult to undertake and cannot very easily be repeated by those wishing to form an independent opinion on these questions I shall here describe a simple method of controlling them: The eye of a young person, possessing a good range of accommodation, is dilated with cocaine. The person is then seated at a table with a chin and forehead support. At about one foot's distance from the eye a telescope of about three times magnification is placed. Vertically above the objective of the telescope is placed a strong slit-lamp. This slit-lamp is lit, and adjusted so that its image on the anterior surface of the lens appears in the pupil. A fixation mark consisting of a small mirror, mounted on a shaft, is then placed so that the images of the slit-lamp in the anterior corneal and in the anterior lens surface lie in a vertical line. The fixation-mark is hereby placed as close to the eye as possible, the patient still being able to read a small letter scratched on the glass of the mirror. The patient is then asked to fix alternately the letter and the image of a distant lumisource of light, which lies respectively behind the letter, thus alternately accommodating and resting the accommodation without changing the direction of the visual line. If now the slit-lamp has been adjusted in vertical

direction in such a way that its image in the anterior lens surface in accommodative rest lies close to the pupillary border, one can see how in accommodation, it moves towards the centre. This decidedly contradicts the assumption of a diminishing of the curvature in these peripheral parts of the surface, which would take place, if a lenticonus were to be formed.

The first of the above questions—whether the lens in accommodation assumes a conoidal form or not—being thus answered negatively it might seem unnecessary to discuss the factors that, according to Fincham, would bring about this form. However, some remarks on this presumed mechanism may be allowed here.

Fincham is of the opinion that a conoidal form of the anterior surface of the lens in accommodation is brought about by the varying thickness of the capsule in different parts. According to him, the capsule in its anterior surface is about $1\frac{1}{2}$ times thicker 2 mm. from the centre and according to the general theory of elastic spheres this difference should be sufficient to cause different curvatures there and in the centre. Experiments, demonstrating this fact, have been undertaken by Fincham, and they can easily be repeated by anybody by means of an ordinary football bladder, which generally has four seams twice as thick as the rest of the bladder, and which, when pumped up, shows a distinct bulging-out of the parts between the seams.

If the supposition that the capsule of the lens, owing to its varying thickness in different parts, should react like the india-rubber bladder when its tension is increased, were correct, the capsule would—as Odqvist* has pointed out—show a bulging-out of its thinner parts in the so-called Bowman experiment. The said experiment consists in placing the extracted lens in a hypotonic solution, in which it absorbs water and swells, the capsule being thereby considerably stretched. On inspection, the lens then presents a spheroid form and shows no obvious bulging-out of any part of the capsule. In order to ascertain, however, that this is actually the case, I have undertaken to measure the curvature of a meridional section of the anterior surface of the swollen lens.

The extracted lens that was to be measured, was placed in front of the Helmholtz ophthalmometer on a small tray at a distance of about 80 cm. Above it was placed a plane mirror that projected an image of the lens along the axis of the ophthalmometer, so that the measuring could be made in a horizontal position of the ophthalmometer. A small lamp was fixed close above the entrance to the plate-house of the instrument, and another was placed to the side of the ophthalmometer successively at a varying

* ODQVIST, B.—Studien ueber den Ackommodations Mechanismus. *Acta Soc. Med. Suec.*, 1937.

distance from the axis. The interval between the images of these two light-sources was then measured with the ophthalmometer, and from these measurements a trigonometric curve of a meridional section of the anterior surface of the lens was obtained. In a lens of a 55-year-old woman, extracted in the capsule, and placed in distilled water for a couple of days, the following results were obtained :—

Angular distance of element from axis	Approximative linear distance of element from axis	Radius after 4 hours	Radius after 48 hours
5°	0.5 mm.	6.3 mm.	8.1 mm.
15°	2.2 mm.	7.2 mm.	9.0 mm.
25°	3.8 mm.	7.4 mm.	9.2 mm.

Measurements of other lenses gave analogous results.

These measurements show that the lens actually assumes an almost spherical form when swelling, and that no bulging-out of the thinner parts takes place. The radius of the peripheral parts differs very little from that of the more central ones, whereas, if a conoid were formed, the radius would be of infinite magnitude. Likewise it would be considerably greater than in the centre, if the lens capsule, when swelling, assumed the form of a surface of the second degree.

As to the cause of the fact that the lens-capsule, when stretched, does not present the same reaction as the india-rubber bladder, Odqvist points out that is probably due to the fact that the capsule is not of a homogeneous structure and that therefore the general laws of distension are not applicable to this tissue.

ANNOTATION

Paralysis of the Abducens Nerve following Spinal Anaesthesia*

Hagman and Wood, of New York, report two cases of sixth cranial nerve palsy following spinal anaesthesia. They state that the abducens is affected in well over 90 per cent. of all cranial paralyses following lumbar anaesthesia.

* *Annals of Surgery*, May, 1942.