was about 75 per cent of the normal lens when the cataract first appeared. As shown in the earlier studies the ATP level was only slightly depressed at this period so that the availability of biological energy does not appear to be a limiting factor. Since the curve depicting the changes in leucine incorporation into protein closely parallels the curve of the uptake data, the possibility exists that the apparent decrease in protein synthesis may simply be a reflection of changes in the uptake mechanism. It is possible that there is no impairment in the protein synthetic mechanism in the earlier stages of the cataract.

The leucine uptake is depressed by 20 to 25 per cent at the two-week stage. Previously it was shown that at the two-week age period the cation pump mechanism was decreased by 50 per cent. Whether there is any relationship between the impairment of the cation pump mechanism and amino acid uptake process requires further study.

The major changes in the Nakano cataract appear to occur at three weeks after birth. At this time there is the first appearance of the opacity and the marked increase in sodium content which is accompanied by an increase in lens hydration. An increase in the permeability to cations, as judged by the increase in rubidium runout, is also observed. It is at this time the lens apparently ceases to grow. Thus although the lens is capable of synthesizing proteins there is no apparent increase in the dry weight of the lens after the three week age. Since the dry weight of the lens is primarily due to protein, it appears that no further increase in protein content occurs. It appears obvious that the lack of growth is not due to any major impairment in protein synthesis. Our previous histological study of the Nakano cataract revealed no apparent defect in the formation of new fibers in the early stages. It appears that new fibers are laid down and the only obvious defect early in the course of the cataract is the persistence of cell nuclei in the deep layers of the lens. At the time of the "pin-head" opacity there was considerable liquefaction of fibers beginning in the posterior nuclear region. Perhaps the extensive liquefaction observed histologically also involves proteolysis which may account for the observed low protein content. In addition, at this stage of the cataract, the increased hydration may lead to leakage of proteins or partially digested proteins.

From the Laboratory of Vision Research, National Eye Institute, National Institutes of Health, United States Department of Health, Education, and Welfare, Bethesda, Md. Submitted for publication Nov. 10, 1975. Reprint requests: Henry N. Fukui, Laboratory of Vision Research, National Eye Institute, Bldg. 6, Rm. 237, Bethesda, Md. 20014.

Key words: Nakano mouse cataract, lens growth, lens protein synthesis, lens uptake of leucine, hereditary cataract.

REFERENCES


The thickness of the human lens cortex in the different types of senile cataract. JEAN NORDMANN AND MICHELE EISENKOPF.

In every type of beginning senile cataract the cortex of the lens measured with the slit lamp appears thinner than the normal lens cortex in the same age group. The decreased rate of fiber formation and of proteosynthesis precedes the first appearance of lens opacities.

Until a few years ago, it was generally thought that the normal human lens weight and volume increase steadily after the age of 10. Now it is established that weight and volume increase, while the rate of the growth decreases with age. On the other hand it is well known that we have to distinguish in the lens between the anatomically defined nucleus which is easily unshelled between two fingers, and the biomicroscopical nucleus observed with the slit lamp. The first increases with age, the second remains unchanged in its axial part after the age of 20 and in the beginning senile cataract. Thus the slit lamp measure of the cortex enables us to draw conclusions on the formation of new fibers and on the importance of proteosynthesis. By this method it was possible to recognize considerable reduction in these parameters in the normal human lens at the age of about 70.

Now the question is, what is the thickness of
the lens cortex in the different types of senile cataract?

**Material and methods.** Our investigation concerned only the first stage of lens opacities in persons at least 60 years old without other local or systemic anomalies which could intervene in cataract formation. The classification of the different types was:

A. **Cortical:**
   1. Cupuliform simple.
   2. Cupuliform with nuclear.
   4. Supranuclear with nuclear.

B. **Nuclear.**

For the measurement of the cortex thickness the device I attached to the 900 Haag-Streit slit lamp was used. The lens capsule is aligned with the deepest limit of the anterior adult nuclear zone.

The apparent axial thickness is read on the scale, when the two images are exactly aligned, it is expressed without correction in pachymetric units (PU). The results obtained by at least two independent observers were in general identical; when there was a small difference a mean value was calculated.

**Results.** In all types of beginning senile cataract the mean of the cortical thickness is reduced when compared with normals of the same age group. In this series after the age of 80 we did not find a totally transparent lens; so it was impossible to compare the oldest cataractous group with a normal one. It is also interesting to note that after 80 years the cupuliform cataract is always associated with a nuclear one and it is very likely that, using other methods, this age limit would be considerably lower.

The thickness of the anterior axial cortex was measured in 150 beginning senile cataracts; in 110 of them the comparison with normal lens could be made. In the two simple types of cortical opacities the difference of the means is highly significant in both age groups; in the other forms the difference is less pronounced, but always significant (Fig. 1).

**Discussion.** The relative thinness of the cortex indicates that the fiber formation and the proteosynthesis are more deficient in the beginning senile cataract than in the normal lens of the same age. This result may be compared with those obtained by measuring in vivo the whole lens thickness or the depth of the anterior chamber. They all show the same anomaly characteristic for lens opacities, but it seems better to investigate directly on the cortex than outside on the anterior chamber. Furthermore the slit lamp examination on the lens concerned only one special type of presenile cataract and in the echographic study of presenile and unilateral senile lens opacities the more
advanced stages were not discarded. In our case the thickness of a rather active zone in the lens was measured and its mean was found significantly reduced already in the very early stage of all types of senile cataract.

In view of these observations the question arises, if in fact the pathological slowing down of fiber formation and proteosynthesis precedes the lens opacities. The answer is affirmative: Goldmann and Favre have indeed shown a thinning of the adult nuclear zone in a certain form of presenile cataract. This anomaly is obviously dependent on the reduction of fibrogenesis; it exists years before the first lens opacities.

On the other hand, Delmarcelle and Luyckx-Bacu measured the depth of the anterior chamber in eyes with transparent lenses, but having a fellow eye with senile cataract. In such cases the still normal lens becomes nearly always opaque sooner or later, but before this change occurs, the anterior chamber is deeper than it is in equally aged nondiagnosed eyes. The lens is smaller, the formation of fibers is depressed before the clinical symptoms of cataract are apparent.

Finally, we can quote our observations on 80-year-old patients with a few small opacities in their lenses. In these cases the rate of fibrogenesis and proteosynthesis is in general considerably reduced for about 10 years and yet it seems, that the opacification process began only recently.

It is concluded that the decrease of fiber formation and proteosynthesis precedes the appearance of lens opacities.

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Key words: human lens, cortex, slit lamp, senile cataract, fiber formation, proteosynthesis.

REFERENCES


Metabolism of 14C palmitic acid by the lens. RUTH VAN HEYNINGEN AND JANE LINKLATER.

14C palmitic acid is oxidised in vitro by the intact human, monkey, bovine, rabbit, and rat lens. 14CO2 and 14-C-glutamic acid are formed.

Everett Kinsey discovered that only the epithelial cells of the lens contain cytochrome C and cytochrome oxidase, and that flavoprotein and ATP are at a much higher concentration in these cells than in the rest of the lens. The cytochrome system was detected not only in the bovine and rabbit lens but also in a human lens removed for senile cataract. He postulated that "an important . . . function of the epithelium may be to provide energy for the maintenance of the entire lens" and from measurement of lactate and pyruvate he deduced that the epithelium is functioning "in the oxidation of carbohydrate, and not solely in the oxidation of amino acids and fats."

In spite of their justified assumption that amino acids and fats were substrates for oxidation by the lens epithelium, this is, as far as we know, the only, and belated paper on the subject of fatty acid oxidation by the lens of a variety of species. Werner and Cotlier in a brief abstract, affirm that the rabbit lens oxidizes 14C palmitic acid to 14CO2.

Free fatty acids have been measured in the bovine aqueous humor and, after saponification, in the rabbit aqueous humor. In both cases, palmitic acid was the most abundant. Since blood contains free fatty acids it is reasonable to assume their presence in the aqueous humor of other species. In the in vitro experiment of Table I the concentration of palmitic acid in the incubation medium was low, 0.02 µmol per milliliter or less.