eye (10 min.). Recently, it has been found in monkeys in which strabismic amblyopia was induced experimentally, so that a significant reduction occurred in cell section areas in all layers of LGN that receive input from the strabismic eye. While our report was in press, Sokol and Bloom (Invest. Ophthalmol. 12: 936, 1973) using spatially alternating stimuli also reported reduction of the VEP amplitude due to strabismic amblyopia.

From the Vision Research Laboratory, Hadassah University Hospital, P. O. Box 499, Jerusalem, Israel. Supported by Stiftung Volkswagenwerk under Contract No. 11-1538. Submitted for publication Sept. 20, 1973.

Key words: checkerboard stimulation, pattern stimulation, strabismic amblyopia, visual evoked potential, visual cortex.

REFERENCES

An evaluation of the pilocarpine Ocusert.*

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Forty patients with open-angle glaucoma who were responsive to pilocarpine have been studied for up to eight months regarding their response to the use of the pilocarpine Ocusert with a delivery rate of 20 micrograms per hour. Using pilocarpine drops, the 40 patients had a mean intraocular pressure of 20.7 plus or minus 5.6 mm Hg. When the pilocarpine was discontinued their pressure rose to a mean of 25.6 plus or minus 5.6 mm Hg. Using a pilocarpine Ocusert, mean pressure was reduced to 19.9 plus or minus 3.9 mm Hg on both a short- and long-term basis. The reduction in pressure with use of the Ocusert is significant with a p-value of less than 0.01. Subjectively, the patients responded that they preferred the Ocusert system to pilocarpine drops. No side effects from the Ocusert have been noted.

Armaly and Rao have reported on the short-term effects of pilocarpine drops versus pilocarpine Ocusert on intraocular pressure and pupil size. In another paper they reported the response of intraocular pressure to various release rates. The purpose of this report is to share our experience over an eight-month period of time in the treatment of 40 patients with the pilocarpine Ocusert.

The theoretical advantages of the Ocusert system would include: (1) round the clock pressure protection from elevated pressure, (2) less miosis, (3) reduced untoward side effects associated with transient overdose, and (4) possible greater patient compliance with a drug regime.

Methods and materials. The Ocusert is a polylaminated structure utilizing a diffusional process for drug delivery. Pilocarpine-free base diffuses through the copolymer membrane at a predetermined rate. Fig. 1 is a diagram of an Ocusert showing its construction and dimensions.

Forty patients were selected from the Glaucoma Clinic of the Veterans Administration Hospital, Gainesville, the Eye Clinic of the University of Florida, and the Eye Clinic at the University of Jacksonsive Hospital. The patients were known to be responsive to pilocarpine (generally 2 per cent) and had not had: recent surgery, infections, or inflammatory conditions; optic neuritis; retinal detachment; severe abnormalities of the lids, conjunctiva, cornea, or lens; diabetic retinopathy; or macular lesions. At the initial visit the history and general physical findings were recorded. The pressures recorded were at various times after pilocarpine administration, but not less than four hours. Three days later, slit-lamp examination, ophthalmoscopy, tonometry, visual field acuity, perimetry, and gonioscopy were performed. The patient continued off medication and was seen two days later, at which time the visual acuity,
Fig. 1. A diagram of the Ocusert construction. The pilocarpine is sandwiched between two polymeric membranes which control the release rate. In this study the rate was 20 micrograms per hour.

slit-lamp examination, and tonometry were repeated. Twenty-four hours later the patient returned and a pilocarpine Ocusert was placed in the cul-de-sac of each eye and the patient was instructed in insertion and removal. The patient was then seen at the same time every 24 hours for four visits. At each visit, an interim history was taken with specific questioning as regards symptoms, retention difficulties, and satisfaction as compared to pilocarpine drops. Visual acuity, slit-lamp examination, and tonometry were repeated. The device was removed at the end of the fourth day and the patient seen three days later. At that time the history, slit-lamp examination, visual acuity, and tonometry were recorded and a new Ocusert inserted in each eye and the patient returned every 24 hours for another four days. The Ocusert was then removed and the patient seen three days later. At this fourth control visit the same data were gathered and finally the patient was seen two days later at which time it was determined if the patient would continue on an extended study or be returned to their pilocarpine drops. If they continued in the extended study the patients were seen weekly for a month and then monthly. At each of these visits the lot number of the Ocuserts, time the Ocusert had been in place, position of the Ocusert, visual acuity, slit-lamp examination, tonometry, and any other indicated examinations were conducted and recorded. In addition, the patient was quizzed about specific symptoms and difficulties of insertion or removal of the Ocusert, plus difficulties with retention. Ocusert wear was discontinued if any untoward events or symptoms occurred.

The authors were concerned that topical anesthetic and applanation tonometry could increase the penetration of pilocarpine into the eye if a
constant pool were available from the Ocusert. Such an increased penetration could be a source of error in the study. Therefore, a study was done in which measurements of intraocular pressure with the Ocusert in place were conducted on 20 eyes every 15 minutes using the noncontact tonometer. Since the noncontact tonometer requires no anesthesia and does not contact the cornea it was felt these values would be reliable to monitor the effect of topical anesthesia and applanation tonometry. After two hours of measuring the pressure every 15 minutes, the patient had a drop of proparacaine placed on the eye and the applanation pressure checked. The noncontact tonometer pressure was then measured every 15 minutes for another two hours.

**Results.** Of the 40 patients in this study, 29 were males and 11 were females. Twenty-five patients were Black and 14 patients were Caucasian. Five of the cases had newly discovered glaucoma, seven cases had been diagnosed within the previous year, 22 cases within one to five years, five cases between six and ten years, and only one case beyond eleven years. Two of the patients were between 40 and 49 years of age, 8 patients between 50 and 59 years of age, 15 patients between 60 and 69 years of age, and 15 patients were over the age of 69.

At some time during the study, which consisted of numerous visits, one of the patients complained of mild blurring of vision, one of brow or eye ache, and one of tearing. One complained of redness, one of itchesiness, and another of discharge from the eye. One of the patients complained of location difficulty and another of discomfort from the edge. Three complained of mild awareness and one of frequent mobility of the Ocusert. When seen in the clinic during nine per cent of the visits, the patients said the Ocusert had fallen out at least once, one per cent said twice, and two per cent had an Ocusert fall out more than twice. Only one per cent of the patients had removed them because of discomfort. Overall retention was 100 per cent of the time in 35 of the 40 patients.

During all the visits, 36 of the 40 patients reported were of the opinion that the Ocusert was better than pilocarpine drops, two felt it was the same, and one was less satisfied with the Ocusert than with drops. The only objective sign was mild bulbar conjunctival erythema in one case.

Analysis of the location of the Ocusert found at each visit was: above in 53 per cent of the cases, found laterally in eight per cent, medially in two per cent, and below in 37 per cent. The most common locations were either upper outer, or in the lower cul-de-sac. There was no significant change in the visual acuity, fundus examination, or perimetry during the course of investigation.

The mean intraocular pressure when the patients were first seen, while taking pilocarpine, was 20.7 ± 8.6 mm. Hg. At the three control visits the mean pressure values were 25.6 ± 5.6 mm. Hg. The mean pressures of all the Ocusert visits is 19.9 ± 3.9 mm. Hg. Long-range follow-up of over one year has shown similar reductions with no apparent loss of effect, taking into account interpatient variability. The overall pressure reduction of 21.4 per cent ± 10.4 per cent. These reductions have a significance with a p-value of less than 0.01. Twelve patients did not go into extended wear because of moving, change in their medical status, and in two cases because of a preference on the part of the patient to use drops rather than the Ocusert. In one case, the Ocusert was discontinued for two weeks because of what was probably a spontaneous subconjunctival hemorrhage. The hemorrhage cleared and has not recurred. No infections have been noted while Ocuserts were being used.

The series of 20 eyes studied using the noncontact tonometer are shown in Table I. The mean pressure before topical anesthesia and applanation tonometry was 17 mm. Hg, after it was 16 mm. Hg, or a change of 1 mm. Hg. The difference is

### Table I. Pilocarpine—Ocusert system

| Change in NCT readings after applanation tonometry |
|-----------------|-----------------|-----------------|-----------------|
| Before | After | Change | Before | After | Change |
| 22 | 22 | 0 | 31 | 24 | -7 |
| 21 | 22 | +1 | 12 | 12 | 0 |
| 8 | 8 | 0 | 14 | 11 | -2 |
| 18 | 20 | +2 | 15 | 13 | -1 |
| 9 | 8 | -1 | 15 | 15 | 0 |
| 24 | 24 | 0 | 20 | 15 | 0 |
| 18 | 20 | +2 | 23 | 17 | -3 |
| 11 | 12 | +1 | 24 | 21 | -2 |
| 11 | 9 | -2 | 24 | 22 | -2 |
| 9 | 8 | -1 | 17 | 16 | -1 |

Average of 20 eyes: -1
significant using the t-test at a level less than 0.05. This change when it occurred did so at one-half hour or later. On the basis of that experience, it is felt that the pressure measurements in this study are valid in that they were taken immediately after use of topical anesthetic and there was no time lapse which would allow an increased penetration of pilocarpine.

Discussion. Using the two mean values, the Ocusert with a mean value of 19.9 mm. Hg compared to pilocarpine at 20.7 mm. Hg would appear to be comparable. Statistical testing of the change in the intraocular pressure from the control period to the treatment period shows significance. In this study, the patients preferred the Ocusert to drops. The Ocusert tended to lodge in the upper outer quadrant and in the lower cul-de-sac immediately beneath the cornea. In general, the patients were more comfortable if the Ocusert were in the upper outer quadrant. Most patients found they could maneuver the Ocusert with their finger through a closed lid to a position where it was easy to remove or where it was comfortable. A number of patients reported that an Ocusert had fallen out during sleep but they simply washed it off and replaced it or put in a new Ocusert. In using this pilocarpine Ocusert system there is the precaution that, if a pressure is measured with application and repeated again within a half an hour to an hour, a pressure drop could be due to the greater penetration of pilocarpine.

In the twelve months the authors have been studying the pilocarpine Ocusert, we have seen no untoward side effects or infections. We are both objectively and subjectively impressed that this treatment modality shows promise in the treatment of glaucoma.


Key words: glaucoma, Ocusert, pilocarpine, pressure response.

REFERENCES


Intraocular pressure measurement with instrumented contact lenses. M. E. GREENE AND B. G. GILMAN.

Flush-fitting, silastic gel contact lenses instrumented with strain gauges have been used to measure changes in the meridional angle of the corneoscleral function of a rabbit due to variation in intraocular pressure. Output from these strain gauges appears to be well defined and the sufficient magnitude to drive a miniature telemetry package which could be used to continuously monitor intraocular pressure without changing the pressure level due to the measurement itself.

Although there are several instruments currently available which can measure intraocular pressure reasonably accurately, all of them depend on applanation, indentation, or deformation of the ocular globe to determine the intraocular pressure. Continued and repeated use of these instruments will eventually induce changes in the very parameters which are being measured and thus generate inherent errors. A possible exception may be the new Non-Contact Tonometer manufactured by the American Optical Company. There is some limited data which indicate no change in measured intraocular pressure with repeated use. However, this instrument requires clinical utilization and could not be used to continuously monitor intraocular pressure during normal living and working conditions.

Our method of monitoring intraocular pressure change is to observe the deformation in the angle where the cornea joins the sclera. The structure of the eye suggests that this area may vary more with changes in intraocular pressure than any other. We have used distensibility data for rabbit cornea and sclera to estimate changes in the corneoscleral angle due to intraocular pressure variations. Typically, the theoretically predicted change in angle is about 0.020 to 0.016 radians per millimeter of mercury for intraocular pressures over the range of 10 to 45 mm. Hg, respectively. Measurement of angular deflections of this magnitude using strain-gauge techniques are well within the current state-of-the-art.

The eventual goal of this project is to measure intraocular pressure in a continuous manner with strain gauges mounted in a properly fitted hydrogel contact lens so as not to deform the eye in any manner. Absolute pressure-level signals, as well as diurnal variations and behavior.