EFFECTS OF PHOTOCOAGULATION OF CILIARY BODY UPON OCULAR TENSION

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EFFECTS OF PHOTOCOAGULATION OF CILIARY BODY UPON OCULAR TENSION*

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1. Method, instrumentation and scope

Light that traverses the transparent media of the eye becomes converted into heat on striking a pigmented tissue by which it is absorbed. This principle forms the basis of the Meyer-Schwickerath technique of photocoagulation. The apparatus has an intense luminous source, produced by a bulb filled with Xenon under high pressure. Filters eliminate most of the infrared and ultraviolet and thus limit the radiation to wavelengths in the 350-1000 millimicron range. An optical system focuses these rays on the retina and choroid (figs. 1 and 2). Meyer-Schwickerath[3] has effectively treated with photocoagulation diverse affections of these tissues. An added accessory (fig. 3) empowers the apparatus to concentrate rays on the anterior segment and has extended thereby the indications for this technique. Photocoagulation of the iris, for instance, is the method of choice for producing a useful pupil in an aphakic eye with an updrawn iris.[3, 4, 6]

The aim of this study is to investigate the effects on the ocular tension by the photocoagulation of the ciliary body. Transillumination demonstrates that the bulbar conjunctiva and sclera are translucent and that the ciliary body is relatively opaque to light. On the other hand, some preliminary trials made on a rabbits' eye have shown that chorioretinitis occurs through photocoagulation just as easily externally through the sclera as through the cornea, lens and vitreous body.

Photocoagulation can therefore electively heat a ciliary body without causing any injury to the bulbar conjunctiva and sclera.

The experience gathered from diathermy shows that the heating of the ciliary body causes ocular hypotension. This hypotension is not due to an increase of the facility of aqueous outflow but to a lowering of the formation of aqueous. This hypotension can be obtained either through retrociliary diathermy or angiodiathermy of the long posterior ciliary arteries.[5]

These observations suggested that the activity of the ciliary body could be likewise reduced by photocoagulation. This idea was investigated by (a) an anatomico-pathologic study of the lesions induced by photocoagulation of the ciliary body in 10 rabbit eyes and in two human eyes destined for enucleation because of sarcoma of the choroid; (b) an analysis of the changes in ocular tension after photocoagulation of the ciliary body in 15 rabbits and in 22 human eyes affected with advanced primary or secondary glaucoma. Though the method proved successful in reducing ocular tension, it showed no superiority to the various forms of cyclodiathermy currently employed. This analysis is still in the experimental stage.

2. Operative technique, evolution and postoperative complications

A. In rabbits the operation and the measurement of ocular tension were performed under general anesthesia with intravenous nembutal (0.5 cc/kg. of 6.0-percent solution). During photocoagulation the cornea was irrigated with ice-cold physiologic saline.

a. *Transconjunctival-transscleral technique.* The image of the electrodes in the photocoagulating lamp was focused on the

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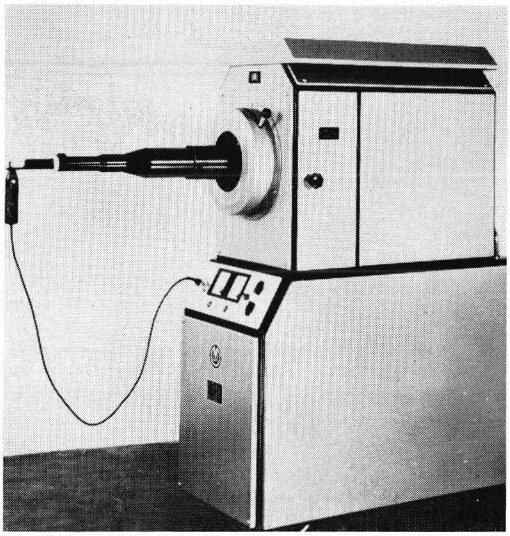

Fig. 1 (Weekers, et al.). The Meyer-Schwickerath apparatus for photocoagulation. (Made by C. Zeiss.)

sclera through the conjunctiva. The modalities employed were: optic diaphragm completely open; beam, six-degree diameter; duration, one second; intensity, 45 to 70 amperes. Photocoagulations were made at the limbus and at some millimeters posterior.

b. *Transscleral technique.* A conjunctival flap in the selected sector was dissected to the limbus and turned down over the cornea. Since blood absorbs light and so reduces the effect of photocoagulation, meticulous hemostasis of the operative field is imperative. The dosage did not exceed 45 amperes; otherwise the procedure was identical with that already described. The conjunctiva was sutured with catgut.

After both techniques, chemosis and subconjunctival hemorrhages appeared in 24 hours. The pupil dilated—a dilatation that

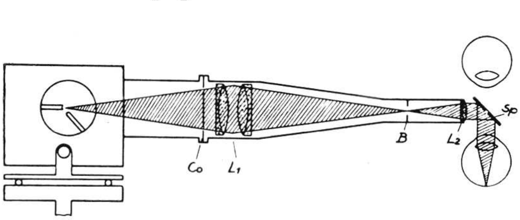

Fig. 2 (Weekers, et al.). Course of rays in photocoagulation of the deep membranes of the eye.

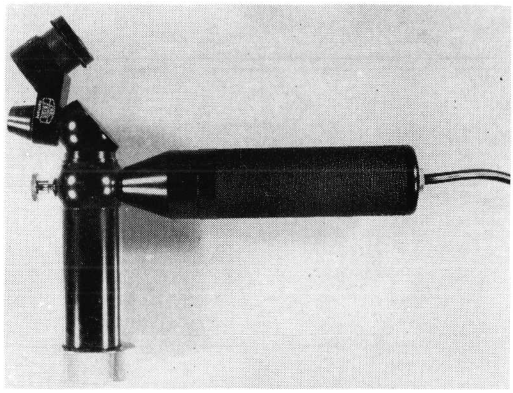

Fig. 3 (Weekers, et al.). Accessory for photocoagulation of the anterior segment.

was asymmetric and irregular when the photocoagulation was confined to but one sector of the ciliary body. The photomotor reactions were sluggish and iridic vessels became more apparent. The cornea near the limbus occasionally showed transient clouding. Hyphema and fibrin in the anterior chamber appeared in three eyes but was completely absorbed in two; the third eye went on to atrophy.

B. IN MAN, a retrobulbar injection of 1.0 cc. of 4.0-percent procaine combined with instillations of a surface anesthetic produced very adequate local anesthesia. During photocoagulation the cornea was irrigated with ice-cold physiologic saline.

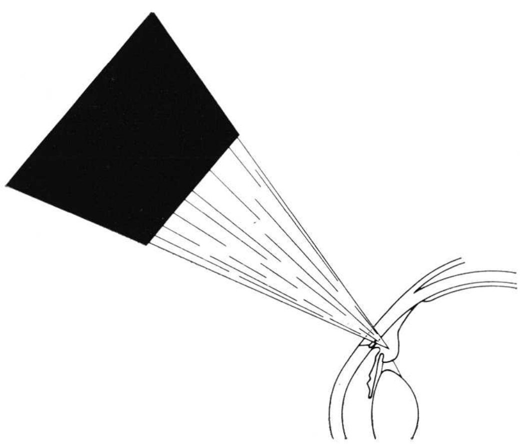

Fig. 4 (Weekers, et al.). Diagram illustrating transscleral photocoagulation of the ciliary body.

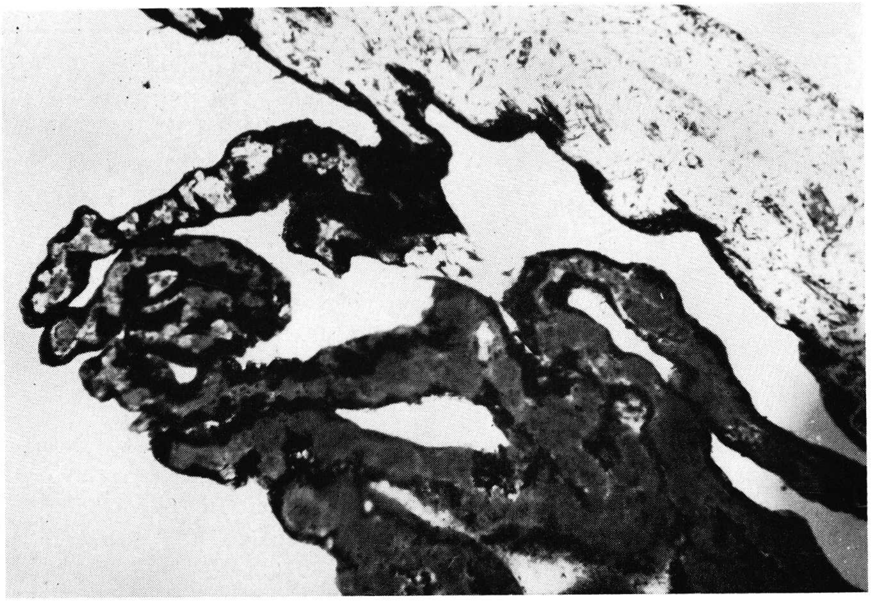

Fig. 5 (Weekers, et al.). *Rabbit 1.* Enucleation seven days after photocoagulation of ciliary body. Note marked thrombotic lesions in ciliary processes. (×80.)

a. *Transconjunctival superficial transscleral technique.* The image of the electrodes was focused on the sclera through the conjunctiva. The modalities employed were: optic diaphragm completely open; beam, six-degree diameter; duration, one second; intensity, 75 amperes. Photocoagulations were made at three to four mm. from the limbus.

b. *Transconjunctival deep transscleral technique.* Here, instead of focusing the image of the lamp electrodes, the luminous points produced by six rays passing through a stop-screen served to guide the placing of the maximum concentration of light at two to three mm. below the scleral surface, that is, within the ciliary body (fig. 4). The same modalities were used as in the previous technique.

c. *Transscleral technique.* A conjunctival flap in the sector chosen was dissected to the

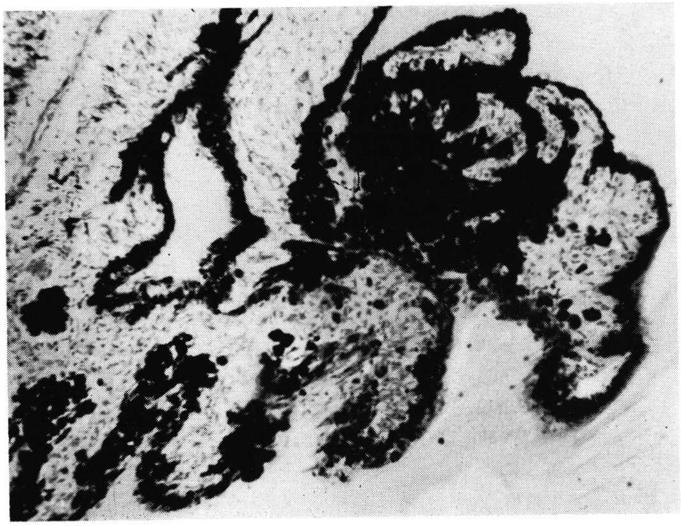

Fig. 6 (Weekers, et al.). *Rabbit 10.* Enucleation two months after photocoagulation of the ciliary body. Note pigmentary reaction and disorganization of both pigmented and nonpigmented epithelium. (×80.)

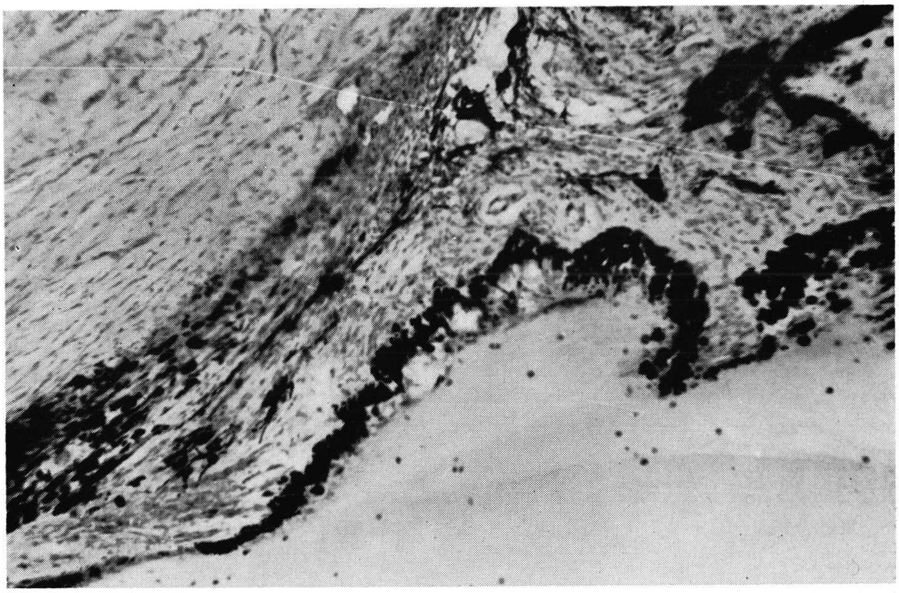

Fig. 7 (Weekers, et al.). *Rabbit 10.* Enucleation two months after photocoagulation of the ciliary body. Characteristic pigment reaction. Nonpigmented epithelium shows vacuoles. (×80.)

limbus for 90 to 180 degrees and folded down over the cornea. After complete hemostasis was obtained, the light was focused directly on the sclera as in the superficial transscleral technique, and the same modalities were used. The conjunctiva was then sutured with catgut.

After the transconjunctival superficial transscleral technique, the conjunctiva displayed for three to four days small ischemic burn-spots surrounded by moderate edema. After the transscleral technique, the immediate reaction was only that incident to conjunctival dissection. The ciliary reaction that came two days later was mild when the photocoagulation was directed to the sclera but very marked when the rays were concentrated within the ciliary body. Transient hyphema and fibrin in the anterior chamber were then occasionally evident.

Fig. 8 (Weekers, et al.). *Rabbit 9.* Enucleation nine weeks after photocoagulation of the ciliary body. Note atrophic ciliary process, cellular rarefaction and absence of vascularization. (×80.)

Fig. 9 (Weekers, et al.). *Human eye.* Enucleated 24 hours after photocoagulation of the ciliary body, showing vitrification of collagen. (×80.)

3. Anatomico-pathologic studies

The morphologic picture of the lesion and its extent depended on the intensity of photocoagulation and the lapse of time before enucleation.

A. In rabbit eyes enucleated a few days after photocoagulation, the ciliary processes presented thromboses; the pigmentary epithelium lost its cellular structure; and the nonpigmented epithelium had disappeared (fig. 5). Two months after a mild photocoagulation, the general structure of the ciliary body was modified only slightly but the pigmented and nonpigmented epithelium remained injured. The pigmented epithelium showed the characteristic "cannon-ball" masses of pigment, described by McDonald and Light.[2] In the nonpigmented epithelium most of the cells showed vacuolization (fig. 6).

The ciliary tissue in eyes enucleated two months after a more intense radiation presented very dense collections of pigment, rarefaction and vascularization. The nonpigmented epithelium exhibited no regeneration (fig. 7).

One globe became atrophic two months after photocoagulation. Its ciliary processes were altered or dissipated; the connective tissue was hyalinized; the vessels were attenuated; the pigmentary reactions were as previously described; and the nonpigmented epithelium had disappeared (fig. 8).

B. In the human eye, the thickness of connective tissue traversed by the luminous beam before reaching the pigmented epithelium is much thicker than in the rabbit eye and consequently the luminous intensity at the pigment level is probably less. The

Fig. 10 (Weekers, et al.). *Human eye.* Enucleated 24 hours after photocoagulation of the ciliary body. The arrows indicate disseminated thromboses. (×80.)

TABLE 1

EFFECT OF PHOTOCOAGULATION OF CILIARY BODY ON OCULAR TENSION IN RABBITS

Rabbits Right Eye No.	Ocular Tensions (mm.Hg) Before	Photocoagulation (technique)	After Photocoagulation (wks.) 1	2	3	4	5	6	7	8	9	10
1	18	Transconj., 180° temporal	7	—	—	—	—	—	—	—	—	—
2	15	Transconj., 90° supéro-temp.	0	8	—	19	—	—	—	—	—	—
2	15	Transconj., 90° supéro-nas.	6	12	—	17	—	—	—	—	—	—
4	29	Transconj., 360°	8	15	7	—	12	16	9	21	—	11
6	21	Transconj., 360°	13	24	24	17	—	—	—	—	—	—
6	17	Transconj., 360°	—	11	—	18	—	19	—	—	—	—
7	8	Transconj., 360°	11	17	14	17	—	—	—	—	—	—
7	17	Transconj., 360°	—	9	—	17	—	14	—	0	—	—
8	11	Transconj., 360°	6	19	10	—	—	—	—	—	—	—
9	20	Transconj., 360°	5	15	10	14	—	16	—	16	—	17
10	26	Transconj., 360°	6	14	22	—	21	—	—	—	—	—
11	20	Transscleral., 90° inf.-temp.	5	18	—	—	17	—	—	17	—	—
11	17	Transscleral., 90° sup.-temp.	6	—	13	—	—	16	—	—	—	—
12	30	Transscleral., 90° inf.-temp.	—	8	—	28	—	—	—	—	—	—
13	18	Transscleral., 90° inf.-temp.	0	13	—	27	—	—	—	—	—	—
13	27	Transscleral., 90° sup.-temp.	7	—	—	14	18	—	—	—	—	—
13	18	Transscleral., 90° inf.-nas.	—	23	—	—	20	—	—	—	—	—
14	21	Transscleral., 90° inf.-temp.	18	—	—	20	—	—	—	—	—	—
14	20	Transscleral., 90° sup.-temp.	—	—	20	20	—	—	—	—	—	—
14	20	Transscleral., 90° inf.-nas.	—	12	—	—	20	—	—	—	—	—
15	22	Transscleral., 90° inf.-temp.	0	—	—	22	—	—	15	—	—	—
15	15	Transconj., 180° supér.	6	—	11	—	—	11	—	—	—	—
16	18	Transscleral., 90° inf.-temp.	0	—	—	26	—	—	—	—	—	—
16	26	Transscleral., 90° sup.-temp.	—	—	18	21	—	—	—	—	—	—
16	21	Transscleral., 90° inf.-nas.	—	17	—	—	26	—	—	—	—	—

ciliary body in man is also better differentiated. One human eyeball was enucleated for study immediately after photocoagulation; the other, after a span of 24 hours. The lesions observed resembled those described in the rabbit but were more scattered and much milder (figs. 9 and 10).

4. Effects on ocular tension

In rabbits, the effect of transscleral photocoagulation on ocular tension is summarized in Table 1. In man, the effect of transscleral photocoagulation on ocular tension in 12 cases of open-angle glaucoma is summarized in Table 2; and the results of the same technique is aphakic glaucoma following a prolonged flat chamber are summarized in Table 3.

Discussion

Our work demonstrated that photocoagulation of the ciliary body reduced ocular tension in the normal eye of the rabbit and in human eyes affected with primary or secondary glaucoma. The normal formation of aqueous demands an anatomic integrity of the ciliary processes.[1] Our anatomico-pathologic observations show that photocoagulation disturbs the circulation of blood in the ciliary body and produces serious injury to the epithelium. Hence it may be presumed that photocoagulation of the ciliary body, like diathermy thereof, effects a lowering of ocular tension by lessening the production of aqueous. Tables 1, 2 and 3 show that this reduction was transitory. It would seem that spontaneous healing of milder lesions occurred or that a compensatory hypersecretion ensued from the healthy tissue remaining.

Our clinical observations indicate that the effects of photocoagulation are both more marked and more durable if the rays are focused in the substance of the ciliary body rather than on its surface. But this aug-

TABLE 2

EFFECT OF PHOTOCOAGULATION OF CILIARY BODY ON OCULAR TENSION IN OPEN-ANGLE GLAUCOMA

Tensions (mm.Hg) Before Photocoagulation	Photocoagulations in Patients		Ocular Tensions (mm. Hg) After Photocoagulation									
	No.	Techniques	Weeks								Months	
			1	2	3	4	5	6	7	8	3	6
32	1	Transconj., superficial, 12 areas through 360°	13	—	18	—	—	—	—	21	20	—
30	2	1·/transconj., superficial, 10 areas through 360°	20	30	—	—	—	—	—	—	—	—
30		2·/transconj., superficial, 12 areas through 360°	15	13	—	—	27	—	—	—	11	20
26	1	Transconj., superficial, 12 areas through 360°	15	20	—	—	—	—	—	—	24	—
45	2	1·/transconj., superficial, 16 areas through 360°	35	—	—	24	—	30	—	—	—	41
41		2·/transcleral, 25 areas 180° temporal	35	25	—	12	—	4	—	—	—	—
30		1·/transconj., superficial, 12 areas through 360°	20	—	—	23	—	22	—	—	—	26
26		2·/transconj., superficial, 20 areas through 360°	18	19	—	24	—	20	—	—	—	—
37	2	1·/transcleral, 15 areas 90° inféro-temporal	16	20	35	—	—	—	—	—	—	—
35		2·/transcleral, 15 areas 90° supéro-temporal	14	10	11	11	13	11	11	12	—	—
26	1	Transconj., superficial, 12 areas through 360°	25	—	—	—	—	—	—	—	—	—
32	1	Transconj., superficial, 8 areas through 360°	13	—	21	—	—	20	—	24	—	—
26	1	Transconj., deep, 25 areas through 360°	13	26	—	—	20	—	—	—	—	—
24	1	Transconj., deep, 16 areas through 270°	13	—	—	24	—	—	—	—	—	—
68	2	1·/transscleral, 20 areas 180° inférior	20	33	—	49	—	—	38	—	—	—
38		2·/transconj., deep, 20 areas 180° inférior	20	17	52	—	—	—	—	—	—	—
36	1	Transconj., deep, 25 areas through 360°	18	13	36	41	—	—	—	—	—	—

mented result in the reduction of ocular tension is accompanied by an aggravation of the postoperative ciliary reaction with more or less permanent implications, as manifested by hyphema, heterochromia iridis, and alterations in the size and reactivity of the pupil. As yet the desirable and undesirable effects cannot be dissociated. Unfortunately the reduction of ocular tension is but transitory when the procedure is innocuous while a lasting effect is obtained only through a marked and occasionally dangerous ciliary reaction. The dilemma is not unlike that involved in cyclodiathermy.

TABLE 3

EFFECT OF PHOTOCOAGULATION OF CILIARY BODY ON OCULAR TENSION IN APHAKIC GLAUCOMA

Tensions (mm.Hg) Before Photocoagulation	Photocoagulations		Ocular Tensions (mm.Hg) After Photocoagulation									
	No.	Techniques	Weeks								Months	
			1	2	3	4	5	6	7	8	3	6
40	2	1·/transconj., superficial, 12 areas through 360°	35	—	—	—	—	—	—	—	—	—
35		2·/transconj., superficial, 12 areas through 360°	17	—	41	—	—	—	—	—	—	—
50	1	Transconj., superficial, 18 areas through 360°	55	—	—	32	—	—	26	—	—	—
31	3	1·/transconj., superficial, 20 areas through 360°	37	—	—	—	—	—	—	—	—	—
37		2·/transconj., superficial, 24 areas through 360°	18	—	—	37	—	—	—	—	—	—
37		3·/transconj., superficial, 20 areas through 360°	39	—	—	39	—		—	29	—	17
50	3	1·/transconj., superficial, 20 areas through 360°	32	—	—	—	—	—	—	—	—	—
32		2·/transconj., superficial, 20 areas through 360°	37	30	30	38	43	—	—	—	—	—
43		3·/transscleral, 10 areas through 90° inféro-temporal	23	35	—	50	—	—	—	65	34	—
35	3	1·/transconj., superficial, 12 areas through 360°	13	23	28	—	—	36	—	—	—	—
36		2·/transconj., superficial, 15 areas through 360°	15	26	—	—	—	—	—	—	—	—
26		3·/transconj., superficial, 12 areas through 360°	11	8	11	12	9	11	—	13	—	20
35	1	Transconj., superficial, 15 areas through 360°	23	15	—	—	—	—	—	—	20	21
45	2	1·/transconj., superficial, 18 areas through 360°	14	19	29	40	—	—	—	—	—	—
40		2·/transconj., superficial, 15 areas through 360°	28	39	—	—	—	—	—	—	—	—

Conclusions

1. With the Meyer-Schwickerath apparatus the ciliary body can be reached by photocoagulation through the bulbar conjunctiva and sclera without opening the globe.

2. Photocoagulation of the ciliary body lowers the ocular tension both in the normal eye and that affected by primary or secondary glaucoma.

3. The lowering of ocular tension by photocoagulation apparently results from a lessened aqueous formation.

4. Further clinical research is required to determine whether photocoagulation of the ciliary body presents any advantage over cyclodiathermy.

Hôpital de Bavière.

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