THE BRITISH JOURNAL
OF
OPHTHALMOLOGY

MARCH, 1940

COMMUNICATIONS

THE X-RAY TREATMENT OF MALIGNANT
TUMOURS IN THE REGION
OF THE EYES

BY

D. WALDRON SMITHERS, M.D., D.M.R.

FROM THE X-RAY DEPARTMENT OF THE
ROYAL CANCER HOSPITAL (FREE)

The Effect of X-rays on the Eyes

THERE is no part of the body where greater care and accuracy is necessary in the radiation treatment of malignant tumours than the region of the eyes. The effect of radiation on the eye has been the subject of extensive research, a very full account of which was given by Desjardins.¹ The changes produced by irradiation of the eyes have been so thoroughly investigated that the dangers of X-ray and radium treatment of tumours in this vicinity have been exaggerated. Desjardins suggested that this was very largely due to the reports of Birch-Hirschfeld, who has been the most important single contributor to the literature on this subject. Desjardins said: "The partly unwarranted conclusions which Birch-Hirschfeld drew from his experimental studies and clinical observations made such a profound impression that many ophthalmologists and radiologists have never quite recovered

their assurance and still hesitate to irradiate the eye for fear of injury."

The effects of radium and X-rays on the eye are essentially the same and there is an absolute relationship between the dose of radiation given and the pathological changes produced. The eyelids are slightly more radio-sensitive than the surrounding skin of the face and the conjunctiva slightly more radio-sensitive than the eyelids. The cornea is distinctly less sensitive than the lids and conjunctiva, and the iris is less sensitive still. The retina and optic nerve are remarkably insensitive to radiation. The lens, in adults, is not very susceptible to the effects of radiation but the late development of cataract is a serious complication that must be guarded against. Clapp² in 1932 found 34 cases in the literature from 1903 in which it had been suggested that cataract developed as the result of irradiating the eye. In two of these cases the latent period was 35 years, which suggests that radiation may have played little part in the causation of the pathological change. There is little doubt, however, that cataract does occur as the result of radiation and that a 5-year latent period is not uncommon. The protection was quite inadequate in most of the cases that Clapp reviewed. In X-ray treatment, therefore, the immediate danger to the eye is severe conjunctivitis followed by corneal ulceration and the late danger, the development of cataract. Treatment of tumours of the inner canthus may damage the lacrymal duct and result in troublesome epiphora; this may be due to contraction during healing as the result of treatment to this region or to the fact that the duct was itself involved by the growth.

Methods of Treatment

Tumours which invade the eyeball or encroach upon the walls of the orbit are a problem apart, for their situation renders damage to the eye as a result of treatment an unavoidable risk and a secondary consideration. Much can be done to protect the eye from serious damage even in these circumstances, but complete protection is not possible if the tumour is to be treated adequately. Tumours of the eyelids or neighbouring skin are in a different category and any injury to the eye in the treatment of such tumours should now be regarded as due to a serious error in technique.

In the past radium held the field as the method of choice in the treatment of these tumours. Martin³ advocated stitching the lids together when interstitial irradiation of the tissues round the eye was proposed, so as to limit the degree to which the conjunctiva could swell by the pressure of the lids. She favoured the

1 gramme radium unit for treatment of tumours in this neighbourhood as she stated that the conjunctival reaction was less, stitching the lids together was often unnecessary, and that the onset of the reaction was more gradual so that there was ample time for closure of the eye should this be required. X-rays were formerly less adaptable to such delicate work as the effect could not be localized to a small enough volume of tissue. Treatment in most cases was given either by means of a single massive dose or a few large doses the usual factors being 100 K.V. about 20 cms. F.S.D. and little or no added filtration. With the introduction of short-distance low-voltage X-ray therapy (Chaoul or Contact therapy) with special apparatus by Chaoul and Adam⁴ this has become the method of choice wherever available. This form of therapy employs an X-ray tube with the anode at one end so that a short focal-skin distance can be obtained and the effect of the radiation limited to a small volume of tissue. A full account of this method has been given by Flood and Smithers⁵ and this paper should be referred to for a description of the technique and dosage employed in the treatment of the patients discussed below.

Eye-Protection

Numerous methods of protecting the eyes have been described and several substances employed such as gold, gold-plated brass, silver, lead glass and lead. Lead is the most effective shield, for the protection afforded increases with the density and atomic number of the element. Several forms of lead shield have been advocated according to the type of treatment employed. Regaud, Coutard, Monod and Richard⁶ used a sheet of lead 2 mm. thick lined with rubber on its under surface. Wölfflin⁷ constructed a lead shield covered with a layer of nickel to absorb the characteristic radiation of the lead. This device is inserted under the lids and its use is advocated by Cutler, Jaffe and Grossman.⁸ Several radiotherapists use a simple curved lead shield, such as that described by Watson and Wuester,⁹ coated with paraffin to absorb the secondary radiation and offer a less abrasive surface to the cornea. These shields are effective in giving adequate protection to the eye in most cases, but have certain disadvantages. They do not fit accurately, tend to lose their shape and are liable, in themselves, to damage the eye.

To overcome these disadvantages an accurate contact glass lens was constructed for a particular patient and covered with a layer of lead 1 mm. thick. The absorption was measured under contact therapy conditions and it was found that less than 0.1 per cent. of the radiation was transmitted. The patient was treated for an epithelioma involving the inner canthus of the eye with the lead

covered glass inserted daily under the lids for the few minutes necessary for treatment. This eye shield fitted the patient accurately, as it had been specially made and fitted before being covered with lead; the glass backing maintained the shape of the shield and, by virtue of its highly polished surface, reduced the possibility of corneal abrasion to a minimum. In treatment by contact therapy the kilo-voltage is not high enough to excite the characteristic radiation of the lead and the glass absorbs any β -ray emission. As it was not practicable to construct such a shield for each individual patient because of the time, labour and expense involved, a set of contact glasses of varying sizes was made. These glasses were made in duplicate in six sizes for each

FIG. 1.

Box of eye shields containing contact glass lenses in six sizes for each eye for fitting, with corresponding lead-covered glass shells for use during treatment.

FIG. 2 (a)

Lead-covered glass shell inserted under the lid for protection of the eye during treatment.

FIG. 2 (b)

Two months after treatment.

eye, one set being covered with lead (Fig. 1). For any individual patient it is now only necessary to fit the glass shell that is most suitable and then employ the corresponding lead-covered shell for that patient during treatment (Fig. 2). There must be ample clearance between the inside corneal radius and the front surface of the cornea in order to avoid abrasion and the shell must be made larger than the normal contact glass in the scleral portion, to afford maximum protection. The eye is anaesthetized with some drops of 1.0 per cent. "decicaine" before the lead-covered shell is introduced; after treatment the shell is removed and two drops of "parolein" applied to protect the eye while it is still anaesthetized. These shells offer no protection to the eyelashes, and in treating one eyelid, a separate lead strip should be applied over the other to preserve the lashes.

These shells proved satisfactory in practice but were too easily broken. For this reason "perspex," a transparent thermo-plastic resin produced by Imperial Chemical Industries, was substituted for the glass. This substance has the same advantages as glass for this purpose but is less brittle. A lead covered "perspex" shell can be dropped from a height of four feet on to a wooden floor without breaking. "Perspex" is dissolved or attacked by a wide range of reagents including material with a high alcohol content, iodine, or chlorinated solvents. As these shells would be damaged by boiling it was necessary to find a safe antiseptic solution for cleaning them after use. Tests were carried out with a variety of antiseptics with the result that a modified form of Harrington's solution is now used. In this solution the mercuric chloride has been increased, the percentage of spirit reduced and the methylene blue omitted.

The formula is as follows:

Hydrarg. Perchlor.	...	0.1 per cent.
Acid Hydrochlor. ...	...	6 per cent.
Spirit Vini. Indust.	...	50 per cent.
(64 over proof)		
Aqua. Dest. ad	...	100 per cent.

"Perspex" immersed in this solution continuously for one week showed no evidence of being affected and was unchanged in weight.

When the shells have been used they are placed in this solution, and then rinsed with distilled water and dried with a soft leather. The soft leather is necessary as "perspex" is easily scratched by harsh fabrics.

Construction of set of lead-covered Contact "Perspex" Shells

Selection was made from a large number of copies of actual contact lenses previously constructed for patients by Messrs. Clement Clarke in order to give a range of fixed sizes of both right and left scleral fittings. The inside corneal radius was modified to ensure effective clearance of the cornea and limbus. These lenses are those used for preliminary fitting to determine which shell affords maximum scleral protection with ample corneal clearance. Further shells of the exact size and shape are then covered on the outside with a coating of lead 1.0 mm. in thickness and these are used during treatment. At first three trial shells, large, medium and small were used. During the last nine months since the full set illustrated in Fig. 1 has been available there has been occasion to use each size at least once. Sizes 3, 4, and 5 have been used most frequently. In a department where a number of patients require protection of this kind the full set is of value, but where such shells would be required infrequently those numbered 3, 4, and 5 without fitting glasses will probably prove sufficient for all but a very few cases.

Results of Treatment

This method of short-distance low-voltage X-ray treatment has only been employed in this country for four years so that it is still too early to lay much stress on the results obtained. Furthermore, the technique of treatment is still in process of development and the method of eye protection described has only recently been introduced. Nevertheless the results published by Chaoul¹⁰ and other workers show over 90 per cent. of cases of cutaneous cancer symptom-free from one to five years, and there are certain advantages inherent in the method itself which suggest that it is the best form of treatment at present available for accessible malignant tumours. These advantages apply with special force to the treatment of tumours in the region of the eyes. The concentration of the radiation effect to a small volume of tissue in itself tends to protect the eye so that no other protection is necessary unless the actual lids or canthi are themselves involved. In the report of cases that follows only those where extra eye protection was considered necessary are included and lesions close to the eye but not actually involving the lids, such as that illustrated in Fig. 3, are omitted. Treatment takes only a few minutes each day for from ten to fifteen days in most cases, though small superficial lesions may be treated with a single massive dose. Hospitalisation

FIG. 3 (a)
Epithelioma before treatment.

FIG. 3 (b)
One year and five months after treatment.

is avoided in the majority of cases and large numbers of patients can be treated at comparatively low cost.

During the four years that this treatment has been employed at the Royal Cancer Hospital (Free) 57 patients with malignant tumours involving the eyelids or canthi have been treated; 18 of these were treated for recurrence following some other form of treatment and 39 were treated primarily by this method.

Primary Treatment Group

Of the 39 primary cases, 3 required re-treatment to a small volume of persistent growth at the tumour edge, due to the failure to include sufficient surrounding tissue in the original field, all three were situated at the inner canthus and all are now free from growth. All but two of the primary treatment cases are now alive and well with no sign of recurrence. These two patients died of inter-current disease one one month and one three months after completing treatment. Microscopical confirmation was only obtained in 13 cases, 8 epitheliomata and 5 rodent ulcers, the remainder being classed clinically as rodent ulcers, with the exception of one pitch wart. The period of observation ranges from 3 years and 6 months to 3 months. Of the 37 patients alive and symptom-free, 9 have been observed for more than 2 years, 10

FIG. 4 (a)

Epithelioma of outer canthus and upper lid before treatment.

FIG. 4 (b)

Three months after treatment and removal of the eye.

from 1-2 years, 7 from 6 months to 1 year and 11 for less than 6 months.

Before the introduction of the eye shields described above, thin pieces of lead were cut to the required shape and inserted under the affected lid. With this method some conjunctival reaction was the rule, but this cleared up rapidly in all but one case. The one exception was a patient with an epithelioma involving the outer canthus and the upper lid (Fig. 4). In this case a severe purulent conjunctivitis supervened with corneal ulceration and the eye was removed. It was thought that the loss of the eye was due more to inadequate treatment to the conjunctivitis than directly to the effect of the X-rays. Since the introduction of the new eye shields, no sign of ocular conjunctivitis has been seen even with a full moist reaction of the affected lid. With the shells in place doses of 9,000 r. in 17 days and of 4,500 r. in a single dose have been given to the eyelid without any sign of ocular conjunctival reaction following treatment. One patient has persistent epiphora as the result of obliteration of the lacrymal duct. Figs. 5, 6 and 7 show the results of treatment in three cases in this group.

FIG. 5 (a)

Tumour of the lower eyelid before treatment.

FIG. 5 (b)

Six months after treatment.

FIG. 6 (a)

Rodent ulcer of lower eyelid before treatment.

FIG. 6 (b)

Two months after treatment.

FIG. 7 (a)

Rodent ulcers of cheek and upper eyelid before treatment.

FIG. 7 (b)

Two years and ten months after treatment.

Group of Treated Recurrences

Driver and Cole¹¹ in a report of 324 cases of tumours involving the eyelids and canthi found that failure to effect a cure was nearly twice as frequent in those patients who had received previous treatment. Of the 18 patients referred to above treated for recurrence following some other form of therapy (6 epitheliomata, 4 rodent ulcers and 8 no biopsy) one died six months after treatment without healing, there being considerable bone involvement, and four have recurred again since treatment. In one of these the eye has had to be removed as the conjunctiva and floor of the orbit were involved, one continued to extend almost as soon as treatment finished and two were re-treated and are now symptom-free. Thirteen are alive and well with no sign of growth over a period varying from 3 years and 6 months to 3 months. One of these patients developed cataract which, however, was almost certainly the result of the previous X-ray and radium treatment to the rodent ulcer of the upper eyelid. This was reported as having consisted of $\frac{1}{3}$ of a pastille dose four times in September, 1928, four times in April, 1930, and $\frac{1}{3}$ P.D. five times from March to July, 1931, a recurrence in February, 1934, was treated with a radium applicator (1,365 mg. hrs.). The growth recurred again in June, 1936, and was treated by the short-distance low-voltage X-ray method. There is now no sign of growth present but the patient is blind in that eye, dimness of vision being noticed first in 1936. Figs. 8 and 9 show the result of treatment in two of the

FIG. 8 (a)

Tumour involving the lower eyelid. Eye shield inserted.

FIG. 8 (b)

Two months after treatment.

FIG. 9 (a)

Recurrent rodent ulcer involving conjunctiva.

FIG. 9 (b)

Two months after treatment.

patients from this group. In the case shown in Fig. 8 radium treatment had been started five months before when the growth was "the size of a shilling." The patient shown in Fig. 9 was treated four years before with radium and eighteen months before with X-rays, the scarring resulting from this treatment is clearly visible. From a review of the cases that had had previous treatment it appears that the commonest cause of failure with radiation is under-dosage, in several cases this has taken the form of small radium doses spread over long periods of time. With adequate eye protection there should be no reason to give too small a dose.

The patients referred to above were all treated in less than three weeks, the majority in 10 to 15 days and three of them with a single dose. The minimum tumour dose in any of these cases was 4,500 r. in 12 days or 2,500 r. in a single dose, in the majority it was greater than this. The maximum tumour dose given was 9,000 r. in 17 days or 4,500 r. in a single dose. The greatest danger with short-distance low-voltage X-ray treatment is to use too small a field with the result that a portion of the growth persists at the edge or a recurrence occurs in this region.

Summary

The effect of X-rays on the eyes and the radiation methods of treatment of malignant growths in their vicinity are discussed briefly. Previous methods of eye protection are referred to and

new lead-covered contact "perspex" shells for protection of the eyes in short-distance low-voltage X-ray treatment are described. The advantages of this form of X-ray therapy and the results obtained in the treatment of tumours of the lids and canthi during the last four years at the Royal Cancer Hospital (Free) are discussed.

Acknowledgment.—I am greatly indebted to Mr. E. A. Plaice and Mr. W. Hoad of Messrs. Clement Clarke who have assisted me throughout in the preparation of the eye shields. They have been entirely responsible for their construction and I am most grateful to them for furnishing me with some notes on this subject which have been included in this paper. I am also indebted to Mr. J. H. Wood the pharmacist at the Royal Cancer Hospital who carried out the tests on "perspex" with various antiseptics.

REFERENCES

1. DESJARDINS, A. U.—*Amer. Jl. Roentgenol.*, Vol. XXVI, pp. 639-679, 789-819, 923-942, 1931.
2. CLAPP, C. A.—*Amer. Jl. Ophthal.*, Vol. XV, pp. 1039-1044, 1932.
3. MARTIN, P.—*Brit. Med. Jl.*, Vol. I, pp. 651-654, 1937.
4. CHAUL, H., and ADAM, A.—*Strahlentherapie*, Vol. XLVIII, pp. 31-50, 1933.
5. FLOOD, P. A., and SMITHERS, D. W.—*Brit. Jl. Radiol.*, Vol. XII, pp. 462-485, 1939.
6. REGAUD, C., COUTARD, H., MONOD, O. and RICHARD, G.—*Ann. d'Ocul.*, Vol. CLXIII, pp. 1-30, 1926.
7. WÖLFFLIN, E.—*Strahlentherapie*, Vol. XLIV, pp. 800-801, 1932.
8. CUTLER, M., JAFFE, H. L. and GROSSMAN, A.—*Amer. Jl. Ophthal.*, Vol. XXI, pp. 747-754, 1938.
9. WATSON, W. L. and WUESTER, W.—*Amer. Jl. Ophthal.*, Vol. XXI, pp. 261-263, 1938.
10. CHAUL, H.—*Strahlentherapie*, Vol. LVIII, pp. 611-613, 1937.
11. DRIVER, J. R. and COLE, H. N.—*Amer. Jl. Roentgenol.*, Vol. XLI, pp. 616-624, 1939.

POST-CATARACT HYPHAEMA

BY

A. SEYMOUR PHILPS, F.R.C.S.

LONDON

POST-CATARACT HYPHAEMA has long been one of the bugbears of ophthalmic surgery, for though it does not often affect the ultimate visual result, it prolongs the patient's stay in hospital sometimes for several weeks. In an endeavour to ascertain the origin and fate of the blood in these patients I have collected and recorded every such hyphaema that occurred in the wards of two London Hospitals during the years 1937 and the greater part of 1938.