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Late complications of pterygium treatment

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SUMMARY Long-term complications of pterygium excision and beta irradiation in 63 eyes of 57 patients are described. The age of the patients at treatment ranged from 27 to 69 years (mean 48 ±11), and complications were assessed 3 to 20 years later (mean 12 ±3). The pterygia were excised, leaving bare sclera, and beta irradiation of total dose 750 to 5200 rads (mean 3475 ±916) was given, except in 7 patients who had repeated courses or overlapping fields of beta irradiation. Scleral ulceration was present in 51 eyes and sectorial lens opacities with normal visual acuity (VA) in 19 eyes. Radiation induced cataract occurred in 3 eyes, with reduced vision. Ptosis, symblepharon, and iris atrophy were also seen. Pseudomonas endophthalmitis occurred in 4 patients with scleral ulceration. Beta irradiation to prevent recurrence of pterygia is a significant cause of iatrogenic ocular disease. There is a need to modify the beta irradiation dosimetry at present in use.

Pterygium excision is a common ophthalmic operation that is often considered trivial, but without conjunctival radiotherapy recurrence rates may be as high as 69%, especially in the hot, dry, sunny environments of Australia[1] and the Middle East.[2] Numerous surgical modifications to simple excision have been reported, but none are notably advantageous.[2] Beta irradiation after excision reduced the recurrence rate to a range of 0·5%[3] to 16%.[1] Apart from local steroids, artificial tears, and dark glasses postoperatively, the only alternative treatment is topical thiotepa. Although reported to be as effective as radiotherapy,[4] thiotepa has not been widely accepted.

Pterygium recurrence rates have often been reported, but late complications of pterygium treatment have received little emphasis. Fifty-seven patients with late complications are presented and their relationship to beta irradiation discussed.

Patients and methods

Patients with conjunctival, corneal, or scleral complications from previous pterygium treatment were obtained on request from other ophthalmologists and by a search of the records of 3 teaching hospitals. Four new cases presented at hospital clinics during the study. All but 5 patients were examined by one of us (K.H.T.). Adequate records and photographs for inclusion in parts of the study were available on these 5.

Details of pterygium treatment, the course of ocular symptomatology, corrected visual acuities (VA), biomicroscopic measurement of avascular conjunctival patches, size of scleral ulceration and distance from the limbus, the position and assessment of ulcer depth, colour, and presence of overlying tissue were recorded. In addition telangiectatic vessels were noted, and after pupillary dilatation lens opacities were drawn and graded. The tear meniscus, break-up time, and results of an unstimulated Schirmer's test were recorded together with fluorescein and rose Bengal staining. Any other ocular pathology was noted and an external photograph was taken. Radiotherapy records with complete details of treatment were available in all but 2 patients. Of the 57 patients examined, 46 (51 eyes) had scleral ulceration, 2 had corneal ulceration, and 9 (10 eyes) had pathology confined mainly to the conjunctiva. The age of initial pterygium treatment with excision and beta irradiation ranged from 27 to 69 (mean 48 ±(SD) 11). Examination took place 3 to 20 years later (mean 12 ±3). There were 32 males and 25 females, of whom 1 was aboriginal and the rest were European.

Pterygium excision leaving bare sclera was used in all patients. In 15 eyes recurrent pterygia had been re-excised, and 8 of these had previously had beta irradiation (Table 1). Beta irradiation was repeated in 5 eyes and involved overlapping fields in 2 other

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Table 1 *Summary of pterygium treatment in 57 patients with late complications: treatment is outlined for eyes with corneal or scleral ulceration, with surface pathology without ulceration, and for fellow eyes*

	Treatment							
	$E_1+\beta_1$	E, $E_1+\beta_1$	E_1, E_2 E_3 $E_4+\beta_1$	$E_1+\beta_1$ E_2	$E_1+\beta_1$ $E_2+\beta_2$ E_3 E_4	E_1 $E_2+\beta_2$ $E_3+\beta_2$	$E_1+\beta_1$ $E_2+\beta_2$	*E only*
Ulcerated	45*	2	1	0	1	2	2	0
Surface pathology only	7	2	0	1	0	0	0	0
Fellow eyes	9	1	1	1	0	0	1	5

E=excision; β=beta irradiation; subscript indicates sequence of E and β respectively. *Includes 2 corneal ulcers.

Table 2 *Late complications of pterygium treatment: summary of patients with repeated or overlapping fields of beta irradiation*

	Beta irradiation treatment	*Total dose (rads)*	*Age at initial irradiation**	*Years of follow-up*	*Visual acuity*	*Lens opacity*	*External eye appearance*
1.	3600 r over 2 weeks repeated 2 years later	7200	57	13	3/60	Dense cataract	Deep scleral ulcer
	Fellow eye	—	—		6/6	Minimal	Normal
2.	4500 r over 2 weeks, 5 yr later 2300 r over 1 week	6800	28	15	6/6	Sectorial	Deep scleral ulcer
	Fellow eye	—	—		6/5	Nil	Normal
3.	3000 r over 2 weeks repeated 7 years later	6000	44	19	6/6	Sectorial	Deep scleral ulcer
	Fellow eye, only initial 3000 r	3000	44	19	6/6	Nil	Normal
4.	3600 r over 2 weeks, 1 yr later 2300 r	5900	45	13	6/36	Sectorial	Moderately deep scleral ulcer
	Fellow eye, only initial 3600 r	3600	45	13	6/5	Nil	Recurrent pterygium
5.	To both eyes: 4000 r over 5 weeks	6400	48	15	6/6	Nil	Full thickness vertical linear defect, uveal prolapse, covered by conjunctiva (Fig. 5)
	10 months later, 2400 r to each of 2 overlapping fields	(8800)			6/6	Nil	Normal
6.	4000 r over 1 week, then at 1 month, 1300 r to each of 2 overlapping fields	5300 (6600)	30	12	6/5	Sectorial	Moderately deep scleral ulcer
	Fellow eye, 2400 r over 2 weeks	2400	37	5	6/4	Nil	Normal
7.	3200 r over 3 weeks to 2 overlapping fields	3200 (6400)	56	14	6/4	Nil	Deep scleral ulcer
	Fellow eye	—	—		6/4	Nil	Normal

*In years; r=rads.

eyes (Table 2). Beta irradiation was started within the first week after excision in 55 eyes (87%). Twice as many were treated during winter as during summer. All but 2 eyes had fractionated treatment (Table 3). Two strontium-90 applicators were used. One was a 1·5 cm circular plaque with an emission rate of 8·7 rads s^{-1} when supplied in 1962. The other was an ellipse with active surface dimensions of 13×18 mm and an emission rate of 15·3 rads s^{-1} in 1966. For the 3-year periods of 1970–2, 1973–5, 1976–8, 1470, 4525 and 4864 patients respectively had beta irradiation after pterygium excision in Perth.

Results

SYMPTOMATOLOGY

On examination ocular pain or irritation, epiphora, and photophobia were severe in 15 (26%) of the patients with ulceration and in 2 of 9 patients referred with mainly conjunctival abnormalities. Symptoms were absent in 12 patients (21%). These symptoms had been present from the time of initial pterygium treatment in 24 patients (42%). Severe ocular pain and photophobia during or immediately following beta irradiation was present in 18 (32%).

Table 3 *Late complications of pterygium treatment: fractionation and dosage* of initial beta irradiation*

	Single dose at operation	*3 doses over <1 week*	*3 doses over 2 weeks*	*4 doses over 3 weeks*	*4 or 5 doses over 4 weeks*
Ulcerated†					
number	1	15	27	3	4
dose range	750	2100–5100	2400–5100	3200–5200	4000–5300
mean	—	3135	3350	4400	4475
Surface pathology					
number	1	2	7	0	0
dose range	2200	4500	2400–4800		
mean	—	each	2700		
Fellow eyes					
number	0	3	8	1	1
dose range		2600–4500	2400–4000	4800	4000
mean		3433	3125	—	—

*In rads; †2 unknown.

Table 4 *Patients with severe visual loss or aphakia*

	Age at treatment	*Years of follow-up*	*Visual acuity*	*Radiation dose**	*Ocular pathology*
1.	45	13	6/36	3600+2300 1 yr later	Marked posterior sectorial and anterior crescentic opacity Moderately deep scleral ulcer
			6/5	3600 only	Normal
2.	52	11	6/6	4500	Aphakic (8 yr after treatment) Deep scleral ulcer
			6/5	Nil	Normal
3.	57	13	3/60	3600+3600 2 yrs later	Marked posterior sectorial and anterior cortical opacities Deep scleral ulcer
			6/6	Nil	Minimal wedge opacities
4.	60	13	6/9	3600	Aphakic (12 yr after treatment) Deep scleral ulcer
			Nil	Nil	Enucleated (trauma)
5.	55	11	3/CF	3900	Aphakic (8 yr after treatment) Deep scleral ulcer
			6/12	3900	Aphakic and deep scleral ulcer
6.	65	12	6/12	2700	Aphakic (8 yr after treatment) Deep scleral ulcer
			6/12	Nil	Aphakic (9 yr after treatment) No ulceration
7.	69	11	6/36	3000	Aphakic (5 yr after treatment) Deep scleral ulcer
			6/24	Nil	Aphakic (6 yr after treatment) No ulceration
8.	69	12	3/CF	4500	Dense cataract, deep scleral ulcer
			6/18	4500	Aphakic (8 yr after treatment)
9.	65	9	6/HM	2400	Posterior polar cataract Moderately deep scleral ulcer
			6/18	2400	Posterior polar cataract
10.	55	3	Nil	2400	Deep scleral ulcer Pseudomonas endophthalmitis Eviscerated
			6/12	2400	No lens opacity Deep scleral ulcer
11.	53	11	Nil	2800	Deep scleral ulcer Pseudomonas endophthalmitis Eviscerated
			6/6	Nil	Normal

*In rads given as 3 doses over 2 weeks except the 2300 given as a single dose. CF=count fingers; HM=hand movements.

Table 5 *Clinical details of patients with scleral or conjunctival complications after pterygium treatment excluding repeated or overlapping fields of beta irradiation**

External pathology	*Age at initial treatment (no.)*	*Years of follow-up*	*Total dose of irradiation*	*Ulcer size† (no.)*
Superficial ulceration	40±11 (6)	12±3	3710±1415	5·1±4·7 (5)
Moderately deep ulcer	52±10 (11)	11±3	3183±771	5·4±3·4 (10)
Deep ulceration	49±10 (26)	12±3	3507±891	6·3±3·6 (25)
Surface pathology only	42±11 (9)	9·5±4	3111±1121	—

*In rads; †6 unknown.

Reduced vision was a major complaint in 6 patients (10%) (Table 4). Four patients (7%) presented with an acute red eye of which two had pseudomonas endophthalmitis.

SCLERAL ULCERATION

Scleral ulceration occurred in 51 eyes of 46 patients. Five patients had bilateral ulceration and 1 had a nasal and a temporal ulcer on the one eye. Clinically ulceration was classified into 3 grades. Superficial ulceration was characterised by exposed sclera with an irregular white surface and shallow ulceration less than one-third scleral thickness (6 eyes) (Fig. 1). Moderate ulceration was characterised by a depth of one-third to two-thirds scleral thickness and a white base (14 eyes) (Fig. 2). Deep ulceration was characterised by a depth of two-thirds or greater with a dark base (31 eyes with 32 ulcers) (Fig. 3). Often only a thin layer of scleral fibres covered uveal tissue. In all 3 groups frequency and severity of symptoms were similar. There was no significant difference between the groups with respect to age at treatment ($P<0·1$), follow-up time ($P<0·3$), or total irradiation dosage when retreated cases were excluded ($P<0·2$) (Table 5).

The typical ulcer was 2–3 mm in diameter, had a corneal edge 1–2 mm from the limbus and was centred within half a clock hour of the horizontal meridian (Fig. 3). The ulcer usually had steep edges surrounded by very white avascular sclera, which was usually bare, and avascular conjunctiva with telangiectasia. The area of ulceration varied from 2·5 mm^2 to 16 mm^2 (mean 6·2±3·7 mm^2). There was no correlation between area and ulcer depth (Table 5). The centre of ulceration was more than 1 clock hour from the horizontal meridian in 9 eyes (17%). Seven (13%) were inferiorly situated (Figs. 2 and 4). It was often difficult to ascertain whether the sclera was completely bare of any tissue. A thin transparent layer of tissue was present in 11 eyes (21%) on careful biomicroscopy with cobalt blue light. Four (7%) had a documented history of persistent bare sclera with punctate rose Bengal staining and failure of conjunctival regrowth after initial treatment for 1 to 7 years before ulceration developed. In 3 eyes a row of 2–4 translucent small spots were present. These were separate spots equidistant from the limbus by 1·5 to 2 mm, in line with the scleral ulcer. From 2 of these a small (0·5 mm) vascular tuft arose. This was not connected to surrounding surface vessels. Similar tufts were seen within the bare area unassociated with translucent spots in a few other eyes. A small encrustation occurred on the adjacent conjunctiva or in the ulcer bed in 10 eyes (20%). This was rough, hard, and stained with fluorescein and rose Bengal. An analysis revealed calcium and other crystals which were birefringent negative to a red plate compensator, suggesting urate. Episcleral vessels partially covered the ulcer base in 13 eyes (25%). In 4 eyes previous photographs revealed minimal vessel extension over 2 to 6 years. Telangiectasia surrounded the bare sclera in 48 eyes (92%) and was severe and cosmetically unacceptable in 18 (34%).

Two scleral ulcers were atypical. One was a small 1·5 mm diameter punched-out moderately deep ulcer covered by mildly abnormal conjunctiva. It developed 10 years after excision and a single dose of 750 rads. The other was a vertical curvilinear full-thickness scleral defect with a knuckle of uveal tissue covered by avascular and telangiectatic conjunctiva (Fig. 5). It was noted on routine examination 12 years after repeated excision and beta irradiation. Both eyes were treated, initially with 4000 rads over 2 weeks, then 10 months later a further 2400 rads was given to 2 overlapping fields. The scleral slit was perpendicular to the axis of the overlap. The fellow eye had white avascular sclera covered by avascular conjunctiva with surrounding telangiectatic vessels.

SURFACE PATHOLOGY IN EYES WITHOUT ULCERATION

Ten eyes of 9 patients had no ulceration and pathology mainly confined to the conjunctiva. This group did not significantly differ from those with

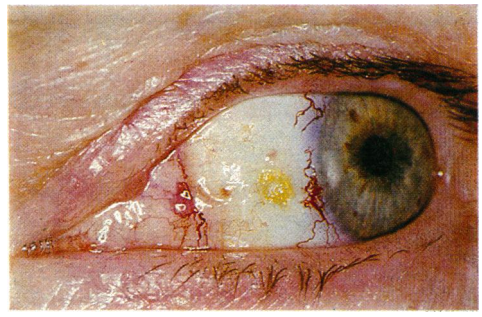

Fig. 1

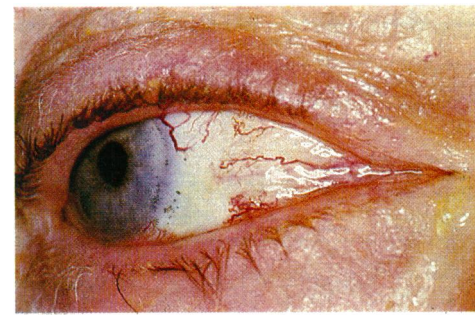

Fig. 2

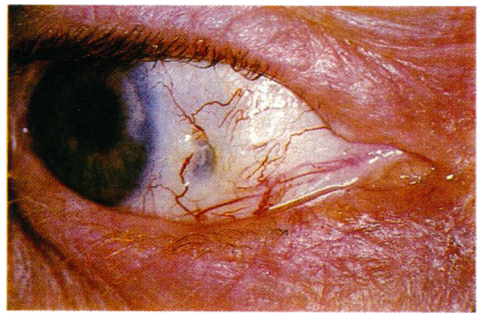

Fig. 3

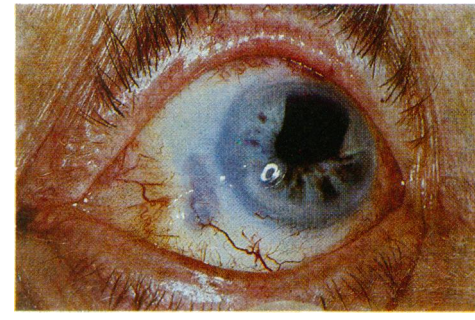

Fig. 4

Fig. 5

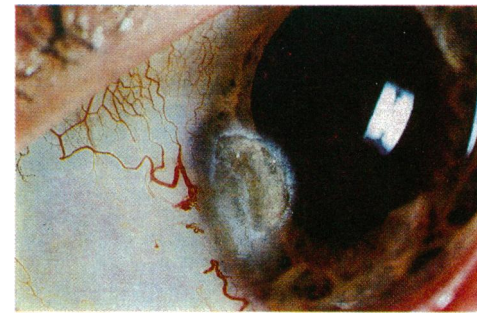

Fig. 6

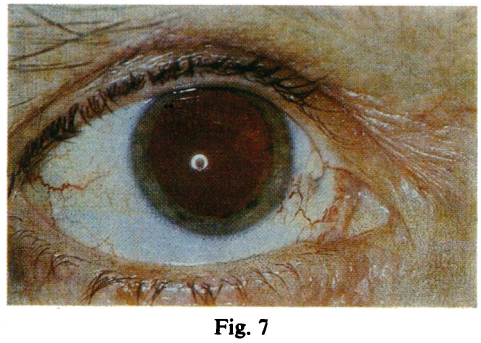

Fig. 7

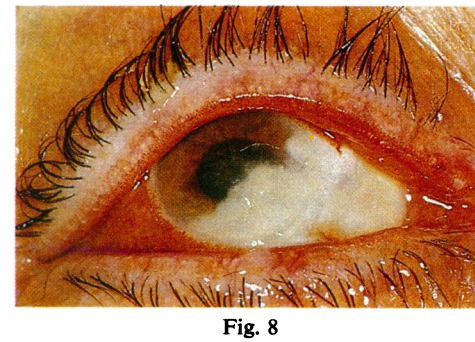

Fig. 8

ulceration with respect to age ($P<0.1$), follow-up ($P<0.1$), or total dose of beta irradiation ($P<0.2$) (Table 5). When analysed in combination with the superficial scleral group, the lesser affected patients were significantly younger than patients with deeper ulceration ($P<0.01$). Conjunctival pathology consisted of severe telangiectasia in 6 eyes (60%) and thinned avascular conjunctiva of area 3 to 18 mm (mean 9 mm) with an adherent encrustation in 3 (30%). Three (30%) had recurrent pterygia. The underlying sclera had a very white appearance in 8 (80%).

FELLOW EYES

Thirteen patients with unilateral ulceration had fellow eyes with previous pterygium excision and beta irradiation (Table 1). None were symptomatic. Four had recurrent pterygia present, to make a total of 12 eyes (16%) with recurrent pterygia after excision and beta irradiation. The conjunctiva was mildly abnormal in 6 fellow eyes (46%). Thirty-eight fellow eyes had no previous beta irradiation. Six eyes (16%) had untreated pterygia. One of 5 pterygia previously treated by simple excision alone had recurred.

CORNEAL ULCERATION

Indolent corneal ulcers occurred in 2 patients. One was aged 34 years at the time of initial unilateral pterygium treatment with simple excision and beta irradiation with 5000 rads in 3 doses over 2 weeks. An elliptical strontium applicator, active area of 13×18 mm and emission rate of 14·8 rads s^{-1}, was used. The eye was persistently sore and irritable after treatment until 10 years later, when a diagnosis of corneal ulceration was made (Fig. 6).

The ulceration of half corneal thickness was vertically oval and measured 2×3 mm. The edge was 1 mm from the limbus and situated at the site of the previous pterygium head. The ulcer edge and base were irregular, and the bulbar conjunctiva had a large avascular patch surrounded by prominent telangiectatic vessels. The tear film was normal and there was no corneal staining elsewhere.

The other patient who developed corneal ulceration was aged 36 years at the time of treatment 12 years before examination. Bilateral pterygia were excised and beta irradiation with 3600 rads in 3 doses over 2 weeks given.

A round, flat strontium-90 plaque of emission rate 7·8 rads s^{-1} as well as the elliptical plaque mentioned above was used. The eye settled until 3 years prior to examination, when a sore left eye developed after irritation from sawdust. Nasally a 4×4 mm patch of bare sclera surrounded by a few telangiectatic vessels were present. Mild rose Bengal staining was found. A half-thickness oval corneal ulcer measuring $1·5\times2·5$ mm was situated at the site of the previous pterygium head and was separated from the limbus by 1 mm of almost normal cornea. The tear appearance was normal, but a Schirmer's test was 18 mm in the affected eye compared to 5 mm in the fellow normal eye.

SYMBLEPHARON AND PTOSIS

Three eyes (6%) with scleral ulceration had symblepharon. One patient treated with simple excision and 5200 rads over 3 weeks (12 years later) had marked symblepharon to the upper canalicular area and punctum. Another patient had simple excision 3 times to both eyes before excision and beta irradiation with 4800 rads over 4 weeks. Extensive symblepharon to both canalicular areas with punctal occlusion and tethering of the globe was present 16 years later. A third patient had recurrent bilateral pterygia treated by excision and beta irradiation with 3600 rads over 2 weeks. The right pterygium recurred within 3 months and was treated by excision and 2300 rads as a single dose. 3 mm of ptosis had persisted since treatment, and 11 years later symblepharon to the upper canalicular area was also present.

ASSESSMENT OF TEAR FUNCTION

A poor tear meniscus, decreased fluorescein break-up time, a Schirmer's test less than 5 mm in 5 minutes, and punctate corneal staining occurred alone or in combination in 17 patients (30%). Thirty-five patients (70%) had a normal tear assessment. In 14 patients (26%) the tear assessment was abnormal bilaterally despite the presence of an untreated fellow eye in 12 of these patients. Five patients were not examined. Ulcerated eyes had a Schirmer's range of 10 to 35 mm (mean 18 ± 10) in 5 minutes, while fellow eyes measured 2 to 35 mm (mean 14 ± 10). In none was tear production less and in 13 (25%) it was 6 mm more in ulcerated than in fellow eyes. Rose Bengal staining of the ulcer base was a constant feature. Adjacent bare sclera stained in 34 ulcerated eyes (63%).

Figs. 1–8 *Late complications of pterygium treatment.* (1) *Superficial scleral ulceration with avascular conjunctiva, mild telangiectasia, and encrustation.* (2) *Moderately deep scleral ulceration inferiorly situated.* (3) *Deep scleral ulceration.* (4) *Inferiorly situated scleral ulceration with aphakia.* (5) *An atypical scleral ulcer with overlying conjunctiva.* (6) *Indolent corneal ulceration and a large area of bare sclera.* (7) *Sectorial posterior lens opacity, scleral ulceration, and an encrustation.* (8) *Pseudomonas endophthalmitis with hypopyon and ulceration within an area of bare sclera.*

Table 6 *Late complications of pterygium treatment: correlation of lens complications with patient details, treatment, and external pathology*

Lens state	*Visual acuity*	*Patients (no.)*		*Eyes (no.)*				
		Age	*Follow-up*	*Total dose*	*Ulceration*	*Treated fellows*	*Surface pathology*	*Untreated*
Normal	6/9 or better	44±10 (30)	10±3·2	3101±1004 (34)	27	8	8	32
Significant opacity	6/9 or better	48±12 (13)	13±2·9	4179±730 (14)	14	3	2	3†
Cataract	6/18 or worse	62±6·7 (7)	11±1·2	3540±858 (10)	4	1	0	0
Aphakic					6	1	0	2
Excluded*		12 patients		18 eyes	2	0	3	0

*Repeated and overlapping fields of irradiation (7) and unknown (5). †None sectorial.

IRIS PATHOLOGY

Localised nasal iris atrophy was present in both eyes of 1 patient 9 years after bilateral pterygium excision with 4500 rads over 3 consecutive days. The atrophy involved the 1 to 5 clock hours central to the collarette in one eye and a patch extending from the nasal pupillary margin to the iris root in the other eye. Another patient had 2 abnormal iris vessels on the nasal side in association with a scleral ulcer.

CATARACT FORMATION

Nine patients (16%) had 14 eyes with reduced vision from cataract (Table 4). Ten of these eyes also had scleral ulceration. This group represented 19% of all ulcerated eyes. In 2 of the 5 cataracts marked sectorial opacities extended from the nasal side and reduced vision. Patients with reduced vision or aphakia were significantly older at age of treament ($P<0·001$) but had not been followed longer ($P<0·15$) than patients with normal vision. Total dose of beta irradiation was not significantly different from that given to eyes without cataract ($P<0·1$) (Table 6).

Sectorial cortical opacities with normal visual acuity were found in 19 treated eyes (25%) (Table 6). Minimal opacities limited to the equator or only faintly visible were excluded. Sixteen had a single course of beta irradiation with a total dose of 2900 to 5500 rads, while 3 eyes had additional beta irradiation (Table 2). The opacity was present mainly in the posterior cortex and in the same quadrant as the scleral ulceration (Fig. 7). The anterior cortex was involved in more severe cataracts. Thirteen eyes (25%) with scleral ulceration and 1 with corneal ulceration had such opacities. No equivalent opacities were seen in these eyes on the temporal side or in untreated fellow eyes. Three untreated eyes had diffuse equatorial or posterior polar cataracts. There was no significant difference in age ($P<0·15$) between patients with and without sectorial opacities, but those with opacities had been followed up significantly longer ($P<0·01$). The total dose of beta irradiation was significantly greater ($P<0·001$) for eyes with sectorial opacities and normal vision than for those without opacities (Table 6).

PSEUDOMONAS ENDOPHTHALMITIS

This has occurred in 4 patients. All had deep scleral ulceration. Three have been reported elsewhere by the authors.[5] The fourth developed endophthalmitis 3 months after inclusion in this survey. The patient, a 71-year-old female, had a pterygium excision and 4500 rads over 2 weeks 9 years before the sudden onset of ocular symptoms and the diagnosis of a scleral ulcer. Two years later, on inclusion in this survey, a 2×3 mm clearly defined deep scleral ulcer 2 mm from the limbus in the horizontal meridian was present associated with an encrustation and severe telangiectatic vessels. The tear film and Schirmer's test were normal. A nasal sectorial lens opacity was present. Three months later the eye spontaneously became red and painful. A large avascular area of sclera surrounded the ulceration. Peripheral corneal infiltration and a large hypopyon were present together with a mucopurulent discharge (Fig. 8). A moderate growth of *Pseudomonas aeruginosa* was cultured from the ulcer surface. Six days of treatment with gentamicin drops hourly and subconjunctival injection daily with oral amoxycillin was ineffective. This treatment was replaced by a continuous infusion of tobramycin into the upper fornix and intravenous ticarcillin as previously reported.[5] An initial rapid reduction in the hypopyon was followed by a slow improvement. During the following 3 weeks she developed peripheral corneal vascularisation, mild iritis, posterior synechiae, and a dense cataract. Visual acuity was perception of light. Treatment was then continued with Chloromyxin ointment (chloramphenicol and polymyxin B) 5 times a day for a further three

weeks. Two of the eyes with *Pseudomonas aeruginosa* infection were eviscerated and 2 salvaged after 6 to 7 weeks' hospitalisation. One retained normal visual acuity and the other suffered profound visual loss due to complicated cataract.

RELATIONSHIP OF RADIOTHERAPY TO SCLERAL ULCERATION

Bilateral deep scleral ulceration occurred in 5 patients after identical treatment to each eye. Each eye had a single pterygium excision and beta irradiation with 2400 to 4400 rads (mean 3460 ± 780).

Unilateral ulceration occurred in the presence of an untreated fellow eye in 29 patients. Five were superficial, 7 moderately deep, and 18 deep ulcers. Three eyes had had repeated courses or overlapping fields of beta irradiation (Table 2). Apart from these 3 irradiation dosage ranged from 750 to 5200 rads (mean 3386 ± 1079). The remaining 12 patients had unilateral scleral ulceration despite bilateral pterygium treatment. Nine patients had similar treatment given to each eye. Eight had a single course of beta irradiation (range 2400 to 4800 rads, mean 3437 ± 944). One ulcer was superficial, 1 moderately deep, and 6 deep. One patient had bilateral repeated beta irradiation with unilateral atypical ulceration (Table 2, no. 5). Three patients developed ulceration only in the eye given additional beta irradiation (Table 2). Apart from retreated and overlapping fields of beta irradiation 1 eye had a single dose of 750 rads and the remainder had fractionated treatment (Table 3) with a total dose of 2000 to 2400 rads in 10 eyes, 2500 to 3400 in 9 eyes, 3500 to 4400 in 25 eyes, and 4500 to 5200 in 7 eyes. Six patients with ulceration were initially treated before 1964, 12 during 1964–6, 22 during 1967–9, 5 during 1970–2, and 1 in 1974.

Discussion

Cosmesis, irritation, or threatened vision are standard indications for pterygium treatment, yet most do not cause marked discomfort or limit vision.[1 6] Reduced visual acuity from untreated pterygia was present in only 0·2% of 1352 patients[7] in one series and other reports are of single cases.[1 8] The efficacy of pterygium treatment is limited by a high recurrence rate without beta irradiation[1 7] and other complications. Apart from recurrence rates, late complications have received little attention.

Patient acceptance of treatment and subsequent ocular discomfort should be important considerations in pterygium treatment. Treatment was a painful experience in 32% of the population we studied, and this was universally attributed to beta irradiation. Pain may arise from repeated mechanical damage during application or from acute punctate corneal erosion.[9] Ocular discomfort and photophobia persisted for many years in 42% of our subjects despite protective measures and topical treatment. The severity of symptoms did not correlate with the size or depth of scleral ulceration.

Scleral ulceration after pterygium excision and beta irradiation has been previously reported.[10–15] In our 46 patients with 52 scleral ulcers the depth of ulceration did not correlate with patient age at treatment, follow-up time, or total dose of radiation. The ulcer was inferiorly situated in 7 eyes (13%). This would be consistent with elevation of the eye during radiation treatment if ulceration occurs at the point of contact of the applicator on the eye. The nature and timing of ulceration, the appearance of the sclera and adjacent tissues, and the development of ulceration only after additional beta irradiation clearly implicate radiation induced pathology in the pathogenesis of scleral ulceration. However, sclera is generally known to be radioresistant. Very high doses of beta irradiation to rabbit eyes have produced no scleral ulceration.[16]

In man beta irradiation to the posterior sclera with up to 100 000 rads over 8–14 days did not cause necrosis in 62 patients followed up for 1 to 9 years (mean 4 years).[17] Reports of 'partial scleral sloughing'[18] and scleral necrosis[19 20] following very high doses of cobalt-60 plaque treatment do exist but are rare. At least 1 such case occurred anteriorly in association with the conjunctiva.[19] On the other hand high doses of radiation are not necessary for scleral ulceration to develop anteriorly.[15] Even with the currently used dose of 2400 rads or less, 11 scleral ulcers were seen in our series. It would appear that an additional factor contributes to 'radionecrosis' of the sclera anteriorly. Possible factors include surgical damage, scleral exposure, the influence of damaged conjunctiva, or the tears.

Faulty surgical technique, particularly cautery, has been implicated.[6 10 12] An irregular distribution of translucent spots within the bare sclera followed the use of a heavy tipped cautery in 1 reported case.[12] In our survey 3 eyes had translucent spots, but in an area equidistant from the limbus. A small vascular tuft arose from some spots. The appearance suggested that these spots developed at the penetration site of anterior ciliary vessels. The location would be more random if due to surgical damage. The appearance of 1 atypical case (Table 2, no. 5) did suggest a scleral incision.

The possible role of exposure has been the subject of a short-term experimental study in rabbits by the authors (to be published). It has been found that exposure alone may cause rapid and indolent scleral necrosis. Bare sclera persisting after pterygium treatment has been previously noted and may

occur without symptoms in many patients.[1 10 12 13] Four of our patients (61%) were noted to have persistent bare sclera for 1 to 7 years before developing ulceration. In eyes that do regain conjunctival cover late conjunctival necrosis could precede scleral ulceration. The presence of bare sclera in almost all ulcerated eyes and the occurrence of ulceration after low doses of radiation suggests that conjunctival breakdown is the first event.

In this survey ulcerated eyes had a slightly greater tear production than nonulcerated fellow eyes ($P<0.05$). Therefore it is felt that lack of tears is not a significant factor.

Pseudomonas endophthalmitis occurred in 4 patients with deep scleral ulceration. Three have been reported by the authors.[5] A spontaneous onset occurred in 3, and the relationship to scleral ulceration was undeniable. Two eyes came to evisceration and 2 were salvaged only after intensive and prolonged hospital treatment. The occurrence of endophthalmitis emphasises the importance of surgical repair of radiation induced deep scleral ulceration.

Corneal ulceration has been reported[9] after pterygium excision and very high doses of radium-D beta irradiation or in widespread corneal disease or from external beam irradiation. Two cases of corneal ulceration are described here. Both were indolent with necrotic margins and no inflammation or vascularisation. They occurred at the site of the previous pterygium head. Corneal erosions may persist for up to 1 year after beta irradiation, and 1 case of corneal dystrophy has been described previously.[21]

Less important complications of treatment were also seen. A thinned vascular area of conjunctiva surrounded by telangiectatic vessels was commonly seen. It was not more severe in eyes with scleral ulceration. Symblepharon was present in 3 patients associated with a tethered globe in one and ptosis in another. This is a recognised complication of pterygium excision but can also occur after radiation treatment.[19] Localised iris atrophy occurred bilaterally in one patient who also had lens opacities but normal visual acuity.

Beta irradiation-induced cataract is well documented. In one series 38 of 115 patients had nonprogressive lens opacities when examined a minimum of 8 years after beta irradiation.[22] 20% of patients who received less than 3600 reps developed opacities (1 rep=1·08 rads tissue). Hilgers[23] found no lens opacities 5 years after a fractionated dose of 3000 reps of strontium-90 beta irradiation, but 3 of 46 eyes (6%) developed lens opacities after 3000–5000 reps. This incidence was considered acceptable to maintain a low rate of pterygium recurrence. In addition a single dose of 2200 rads after pterygium excision has been considered safe even when repeated twice for subsequent recurrences.[1] Typical sectorial posterior cortical lens opacities, with a visual acuity of 6/9 or better, were present in 19 eyes (25%) in this survey. The total dose of beta irradiation ranged from 2900 to 5200 rads (Table 6). The anterior cortex was involved only in the more severe cataracts, an observation previously noted.[24] Compared to patients without cataract our patients showed no significant difference in age or length of follow-up, but a strong correlation was found with respect to the total dose of radiation ($P<0.001$). This survey confirms that some opacities will develop after a fractionated dose of 3000–5000 rads.

Reduced vision from beta irradiation-induced cataract is not common. Seven cases occurred 3 to 6·5 years after radium beta irradiation.[25] None has been reported after pterygium excision and strontium-90 beta irradiation. In this study radiation-induced cataract caused reduced vision in 3 patients. (Table 4, nos. 1, 2, 3). The influence of beta irradiation on cataract formation in the other 6 patients in Table 4 cannot be determined. The fact that these patients were older at treatment than those with normal vision ($P<0.001$) probably reflects the distribution of senile cataract rather than any susceptibility of the older lens to radiation. It is the younger growing lens that is particularly susceptible.

This survey would support a more cautious attitude both to the management of pterygium and to the use of beta irradiation. The complications of treatment, especially scleral necrosis and cataract, may lead to visual loss. With scleral ulceration, surgical treatment may be indicated to relieve symptoms alone and should certainly be considered for deep scleral ulceration to prevent pseudomonas endophthalmitis. The development of cataract after treatment of a benign lesion is not acceptable. There is a need to reconsider the indications for surgical treatment and the application of beta irradiation. Lower doses of radiation may reduce the complication rate but may also be less effective in preventing recurrence.

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