OCULAR SIDEROSIS

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SUMMARY

The authors report their experience in the management of 8 patients with ocular siderosis due to a retained intraocular foreign body (IOFB). All patients were male, aged between 19 and 39 years. Seven had a definite history of trauma; 3 had presented at the time of injury to a casualty department, and the diagnosis had been missed. The interval between injury and diagnosis ranged from 2 to 24 months. IOFB removal was performed in 7 patients: through a sclerotomy and magnet or foreign body forceps in 4 eyes and via a pars plana vitrectomy and intraocular foreign body forceps in 3 eyes. Cataract extraction was performed in 4 patients. Histological examination of specimens removed at the time of surgery showed iron deposition in the conjunctiva, anterior lens capsule and pars plana. Transmission electron microscope X-ray microanalysis showed that iron was contained in siderosomes, intracytoplasmic membrane-bound dense bodies. Final visual acuity was 6/12 or better in 6 patients and reduced to light perception in the remaining 2 due to proliferative vitreoretinopathy.

Ocular siderosis is caused by retention of an iron-containing intraocular foreign body (IOFB). The injury classically occurs while hammering or grinding metal and thus it frequently presents in males. A preceding history of trauma is not, however, invariable. The commonest presenting feature is reduced visual acuity. Clinically there is heterochromia, pupillary mydriasis, iron deposition on the corneal endothelium and beneath the anterior lens capsule, lens opacification and retinal pigmentary change with an associated subnormal electroretinogram (ERG).[1]

We present a series of 8 consecutive patients with ocular siderosis seen at the vitreoretinal clinics at the Royal Victoria Hospital, Belfast, and at the Birmingham and Midland Eye Hospital, Birmingham. Based on our experience, we present the indications and techniques for IOFB removal and document the long-term outcome of eyes with ocular siderosis. Histological analysis was performed to evaluate the extent of tissue damage due to iron retention.

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MATERIALS AND METHODS

Patients

The medical records of all patients seen at the vitreoretinal clinic at the Royal Victoria Hospital from January 1983 to December 1990 with a diagnosis of ocular siderosis were reviewed. We also reviewed the medical records of all patients with ocular siderosis seen at the vitreoretinal clinic at the Birmingham and Midland Eye Hospital from January 1991 to April 1991. Cases were identified by examining the outpatient index, theatre book and records from the electrophysiology department. The clinical courses of 8 consecutive patients with ocular siderosis were examined. All patients were subsequently reviewed by one of the authors (M.H.–R.).

Pathology

The results of histological analysis of tissue removed at the time of surgery are also presented. Informed consent was obtained prior to surgery.

Vitreous samples were obtained at the time of vitrectomy and IOFB removal in 2 patients and analysed for iron content. A biopsy of the pars plana was obtained from 1 patient during IOFB removal. At the time of cataract extraction, samples of conjunctiva and anterior lens capsule were obtained from 1 patient.

Samples of conjunctiva and anterior lens capsule were stained with Perl's and Schmeltzer's stain for iron. An age- and sex-matched control sample of conjunctiva and lens capsule was also stained.

A biopsy specimen of pars plana was placed overnight in 2.5% glutaraldehyde in 0.1 M cacodylate buffer, pH 7.2. The tissue was post-fixed in 2% osmium tetroxide, dehydrated in ascending grades of alcohol and embedded in epoxy resin. Ultrathin sections were taken for transmission electron microscopy and stained with uranyl

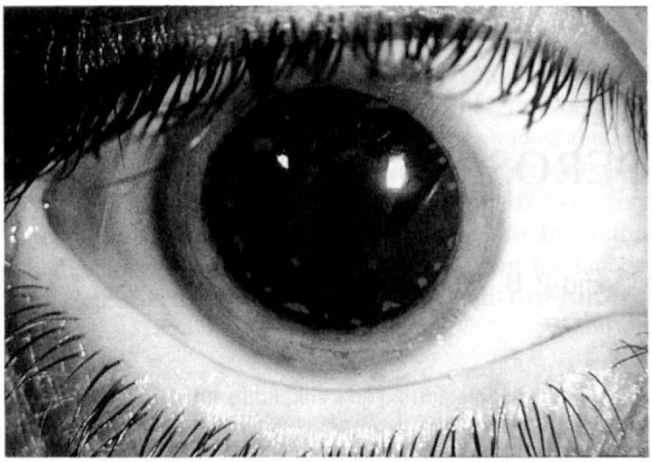

Fig. 1. *Slit lamp photograph showing iron deposits beneath the anterior lens capsule and anterior lens opacity.*

acetate and lead citrate. Ultrathin sections were taken for transmission electron X-ray microanalysis, stained lightly with uranyl acetate, and mounted on copper grids.

RESULTS

Seven of the 8 patients had a definite history of trauma: all had been hammering metal and remembered being hit in the eye by an object. One patient could not recall a specific incident, but worked as a mechanic and frequently hammered metal. None had been wearing goggles at the time of injury. Three of the patients presented for medical attention immediately following the accident, and were seen in an Accident and Emergency Department. A radiograph was not done, the diagnosis was missed and they were discharged.

Siderosis was diagnosed between 2 and 24 months following injury. Seven patients presented complaining of reduced visual acuity; 1 in addition complained of unilateral mydriasis and 1 patient complained of floaters. All patients were male. All patients had classical ocular siderosis, with iris heterochromia, pupillary mydriasis, lens opacities, iron deposition on the corneal endothelium and beneath the anterior lens capsule (Fig. 1) and a subnormal ERG. In addition 1 patient had disc swelling at presentation (patient 8, Table I). There was a full-thickness corneal wound in 5 patients, indicating the foreign body had entered through the cornea. In 3 patients the entrance wound could not be identified and was presumed to be scleral. The IOFB was ophthalmoscopically visible in 7 patients. It was located inferiorly in all cases. In 1 patient an IOFB could not be identified, in spite of typical ocular siderosis, and it was assumed that the IOFB had resorbed (patient 4, Table I).

A radiograph of the orbit was performed in all patients, and demonstrated an IOFB in 6. In 1 patient the IOFB was not visible on the radiograph but was visible on computed tomography (CT) (patient 2). In 1 patient, in whom the IOFB was presumed to have resorbed, the radiograph was negative (patient 4).

Surgical removal of the IOFB was performed in 7 patients (Table II). Once the diagnosis of retained IOFB and ocular siderosis had been made, IOFB removal was performed immediately. There was one exception, patient 5, who was seen in 1983. At that time he was followed

Table I. Clinical features of patients with ocular siderosis

Patient No.	Age (yr)	Time between injury and presentation (months)	Heterochromia	Iron deposition on cornea and lens capsule	Mydriasis	Cataract	Entrance wound	Location of IOFB
1	30	3	Yes	No	No	No	Cornea	Pars plana
2	24	24	Yes	Yes	No	Yes	Uniden	Retina
3	31	12	Yes	Yes	Yes	Yes	Cornea	Pars plana
4	21	?	Yes	Yes	No	No	Cornea	Unidentified
5	19	2	Yes	Yes	Yes	Yes	Unidentified	Ora serrata
6	38	7	Yes	Yes	Yes	Yes	Cornea	Pars plana
7	39	12	Yes	Yes	Yes	Yes	Cornea	Pars plana
8	29	11	Yes	No	Yes	Yes	Uniden	Pars plana

IOFB, intraocular foreign body.

Table II. Management and final outcome of patients with ocular siderosis

Patient No.	Treatment	Cataract extraction	Visual field	ERG	Visual acuity		Complications	Follow-up (months)
					Initial	Final		
1	S+M	No	N	Red	6/9	6/9	—	21
2	PPV+F+L	L	BBS	Red	6/60	6/9	Vasculopathy	10
3	S+M	ECCE+PCL	NP	Red	6/9	6/9	—	36
4	None	No	NP	NP	PL	PL	PVR	72
5	S+M,SBP, PPV+F+L	L	NP	SN, Red	6/12	PL	PVR	84
6	PPV+M+F+SBP	ECCE+PCL	P.cons	Absent	6/9	6/12	—	11
7	S+F	No	N	Red	6/6	6/6	—	72
8	S+F	No	NP	Red	6/9	6/12	—	3

S, sclerotomy; M, magnet; F, forceps; PPV, pars plana vitrectomy; L, lensectomy; SBP, scleral buckling procedure; ECCE+PCL, extracapsular cataract extraction and posterior chamber lens; N, normal; BBS, baring of the blind spot; P.cons, peripheral constriction; NP, not performed; Red, reduced; SN, supranormal; PL, perception of light; PVR, proliferative vitreoretinopathy.

Fig. 2. *A reduced ERG from the left eye, showing a reduction of the B wave and absence of oscillatory potentials. The response from the right eye is normal.*

with serial electrophysiology. Over the course of 10 months there was a deterioration of the ERG; it was then decided to remove the IOFB.

In 4 cases the IOFB was removed successfully via a sclerotomy and either a magnet or foreign body forceps. Three patients required a pars plana vitrectomy (PPV) to remove the IOFB. In one patient a PPV and lensectomy was performed and the IOFB was removed with intraocular foreign body forceps (patient 2). In 1 patient an attempted removal of the IOFB via a sclerotomy and mag-

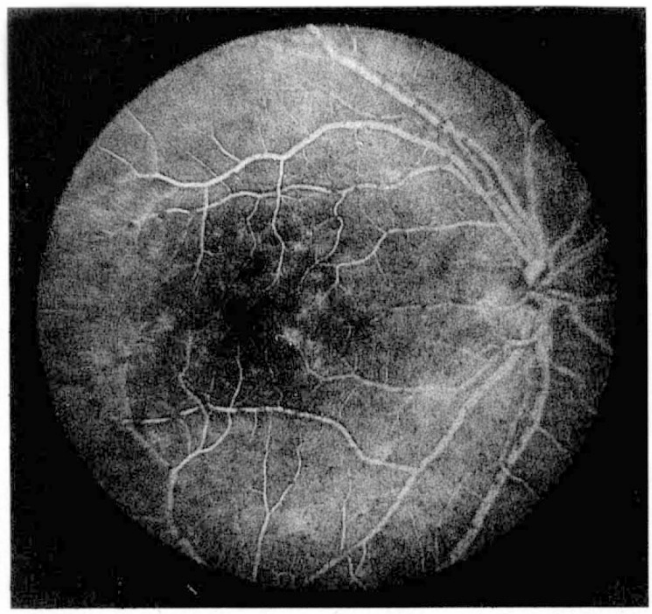

Fig. 3. *Microvasculopathy due to metallic deposits. A fluorescein angiogram shows diffuse staining around the perifoveal arcades. The flecks throughout the posterior pole do not stain with fluorescein and are probably metallic deposits.*

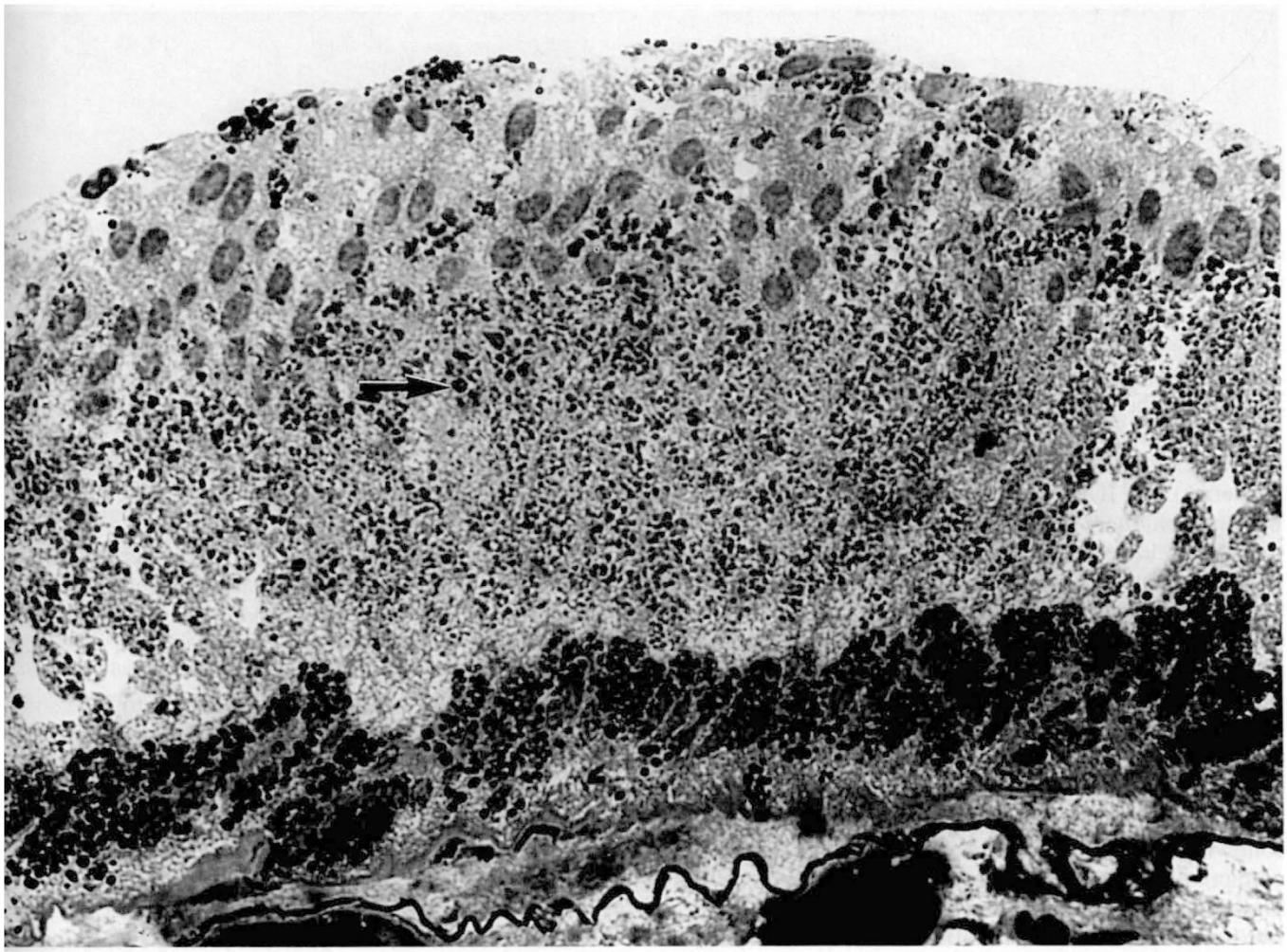

Fig. 4. *Light micrograph of the pars plana shows iron deposits (arrow) in the pigmented and the non-pigmented epithelium. There is gross swelling of the non-pigmented epithelium (Toluidine blue; original magnification ×400).*

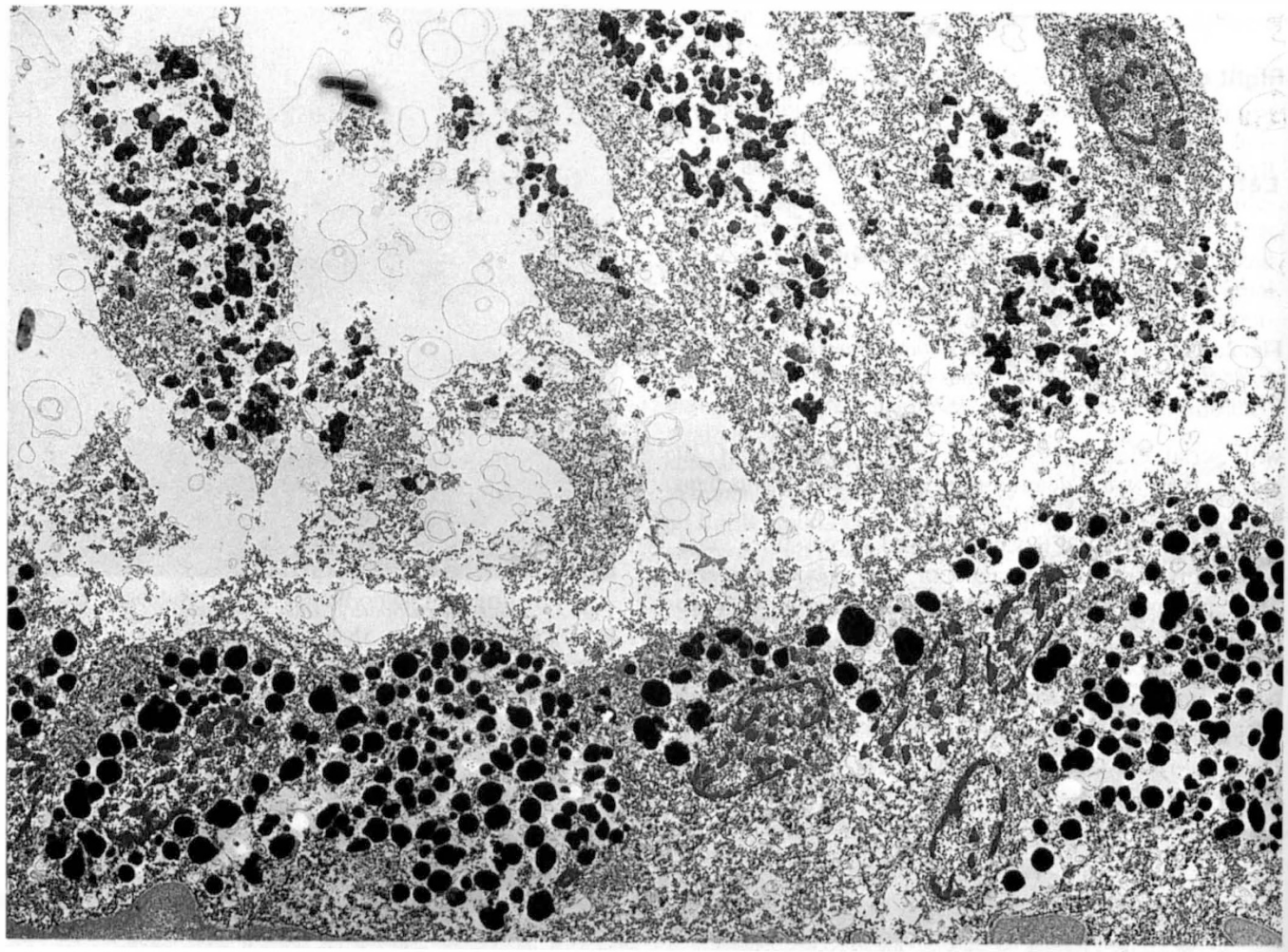

Fig. 5. *Transmission electron micrograph of the pars plana shows cell swelling and nuclear pyknosis in both pigmented and non-pigmented epithelium. The non-pigmented epithelial cells are filled with cytoplasmic dense bodies – siderosomes – which on analysis were shown to contain iron. Similar dense bodies are present in the pigmented epithelial cells. (original magnification ×17,000).*

net was unsuccessful, as the IOFB was embedded and appeared to be non-magnetic; a PPV, lensectomy and IOFB removal were subsequently performed (patient 5). In 1 patient the IOFB was removed via a PPV, magnet and intraocular foreign body forceps; a dialysis was present and a scleral buckling procedure was also performed (patient 6). The IOFB could not be identified in 1 patient at presentation, there was advanced proliferative vitreoretinopathy (PVR) and the detachment was judged to be untreatable; therefore no treatment was undertaken (patient 4).

Cataract was present in 5 patients and was extracted in 4 of these. In 2 patients the degree of lens opacification at presentation was sufficiently advanced to necessitate cataract extraction at the time of IOFB removal. In these 2 cases PPV, IOFB removal and lensectomy were performed as a primary procedure (patients 2 and 5). In a further 3 patients there was progression of the lens opacity following IOFB removal, and extracapsular cataract extraction with insertion of a posterior chamber lens was performed in 2 of these (patients 3 and 6). Cataract extraction has not yet been performed in the third patient (patient 8).

Serial ERGs were performed in 7 patients. The response of the B wave was subnormal in 6 patients (Fig. 2). The response of the B wave was supranormal initially in 1 patient and subnormal on follow-up (patient 5). One patient, with advanced PVR, in whom the IOFB was presumed to have resorbed, did not have an ERG performed (patient 4). Following removal of the IOFB serial ERGs were performed; no recovery of the ERG was demonstrated.

During the follow-up period, kinetic visual field examination was performed in 4 patients. In 2 the visual field was normal. Baring of the blind spot was found in 1 patient (patient 2) and peripheral constriction in another (patient 6).

The duration of follow-up varied from 3 to 84 months. Disc swelling, present initially in 1 patient (patient 8), resolved. Final visual acuity was 6/12 or better in 6 patients. One of these has a cataract which has not yet been removed (patient 8). One patient developed toxic vasculopathy 1 year after removal of the IOFB, causing a reduction in visual acuity from 6/9 to 6/12 (patient 2, Fig. 3).

Final visual acuity was poor due to the development of PVR in 2 patients, one of whom was judged to be inoperable at the time of presentation (patient 4). The second

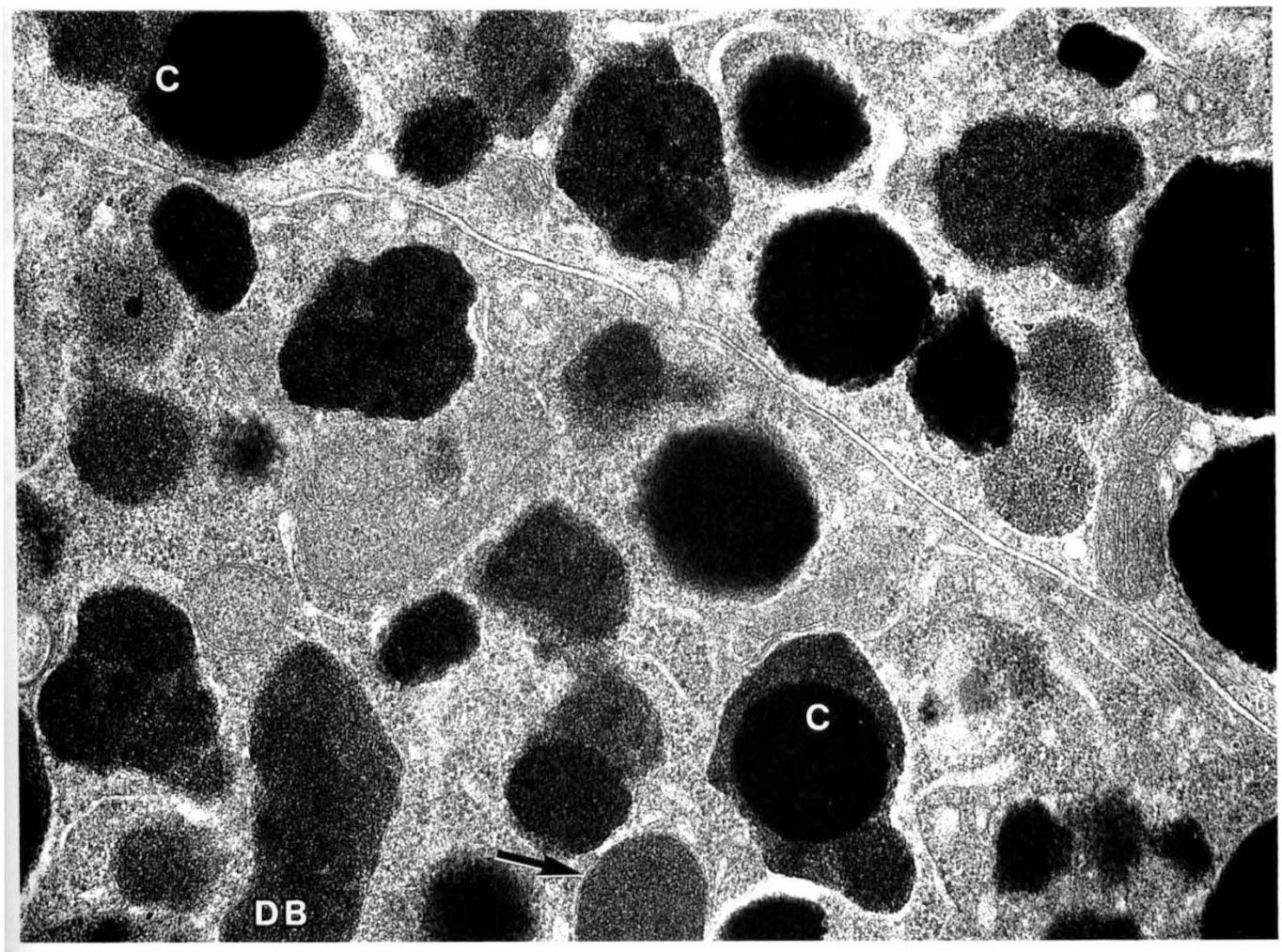

Fig. 6. *Transmission electron micrograph of pigmented epithelial cells shows iron-containing membrane-bound dense bodies (DB). The limiting membrane is arrowed. The cytoplasm also contains melanin granules and complex granules (C). The complex granules have a matrix with an identical appearance to the neighbouring dense bodies, but have enclosed melanin. (Original magnification ×1,500).*

patient developed inoperable PVR following IOFB removal (patient 5).

Pathology

Vitreous samples were analysed for the presence of iron. The iron level was 7.2 mmol/l in one sample (patient 5) and was undetectable in the second (patient 2).

Light microscopy of the conjunctiva was normal (patient 6). Perl's stain for ferric iron showed widespread iron deposition in the basal epithelial cells. The anterior capsule was also stained with Perl's stain and there was widespread deposition of iron beneath the capsule (patient 6). A control sample of conjunctiva and anterior capsule were negative. Schmeltzer's stain for ferrous iron was negative.

Light microscopy of the pars plana showed iron deposition and swelling of the non-pigmented epithelium (patient 8, Fig. 4). Transmission electron microscopy of the pars plana showed membrane-bound dense bodies within the cytoplasm of the pigmented and non-pigmented epithelium (Figs. 5 and 6). Both the pigmented and the non-pigmented epithelium were degenerating, but the changes were more advanced in the non-pigmented epithelium. Transmission electron microscope X-ray microanalysis showed that the dense bodies – siderosomes – were composed of iron (Fig. 7).

DISCUSSION

This study demonstrates the clinical features, management and outcome of 8 patients with classical ocular siderosis. Ocular siderosis, though rarely seen now, was common in the past.[1,2] Bunge originally described chronic degeneration due to iron retention in 1890 and termed the condition siderosis.[1] There is remarkably little in the current literature regarding management and outcome.

In spite of advances in modern medicine, IOFBs continue to be missed in Accident and Emergency Departments. Patients who are discharged may subsequently present with siderosis. All primary care physicians should be aware of the necessity of a complete ophthalmic examination in all patients with high-velocity metallic injuries.

Patients with ocular siderosis may present with blurred vision or pupillary mydriasis. Interestingly, despite the presence of iris heterochromia in all our patients, none of them complained of this.

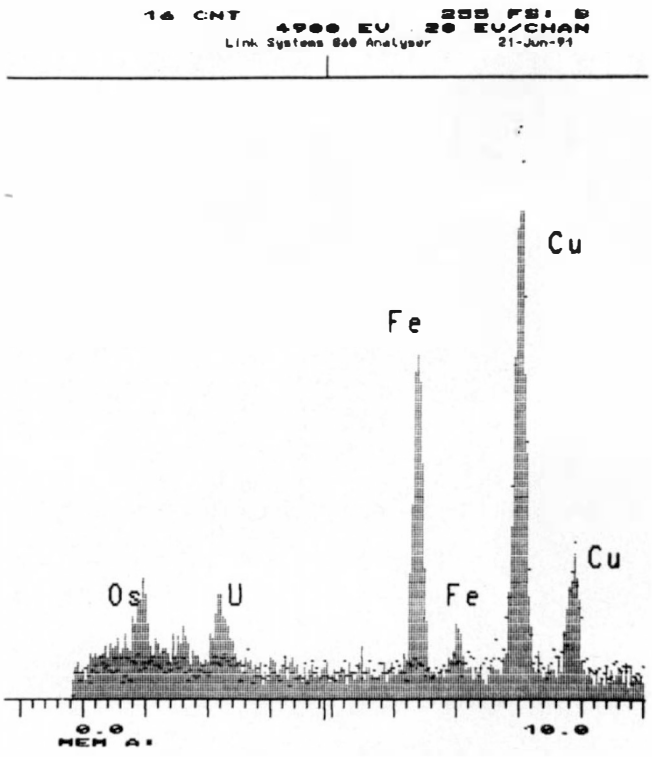

Fig. 7. *Electron microscope X-ray microanalysis of the dense bodies in the pigmented and non-pigmented epithelial cells of the pars plana, showing that the dense bodies are composed of iron.*

The clinical appearance is classical with dark-brown deposits beneath the anterior lens capsule, iris heterchromia, lens opacification and pupillary mydriasis. Optic disc swelling is less commonly seen and may regress following IOFB removal. The aetiology of the disc swelling is unknown and is unrelated to hypotony or vitreous inflammation.[3] It may be due to a direct toxic effect of iron. Secondary glaucoma, pigmentary retinal degeneration and phthisis bulbi may develop in the late stage of the disease.

In most cases of siderosis the IOFB is ophthalmoscopically visible. It is typically situated inferiorly. If there is opacification of the mediae, which precludes a view of the fundus, radiography, CT or ultrasound can help to localise the IOFB.[4] Radiography can be negative in the presence of an IOFB and it is in these cases that a CT scan is helpful.[4] Complete IOFB resorption with progressive siderotic degeneration can occur, as was the case with one of our patients.

Much of the literature on ocular siderosis derives from the pre-vitrectomy era. There are no controlled studies on the management of ocular siderosis, and thus the treatment is controversial. Some elect to follow retained IOFBs with serial electrophysiology.[3] If there is a worsening of the ERG, IOFB removal is then considered.

In our patients, once the diagnosis of siderosis was made we elected to remove all IOFBs. Surgical technique for removal of the retained IOFB is dependent on the site and nature of the IOFB, the clarity of the lens, and whether or not the IOFB is embedded in the retina. In spite of the fact that the IOFB has been present for a considerable period of time, it could still be removed via a sclerotomy and a magnet in 4 cases, indicating that magnetism can be preserved. If a previous attempt via a sclerotomy and magnet had failed or if the IOFB was embedded in the retina, we performed a PPV and removed the IOFB with intraocular foreign body forceps.

Cataract formation occurs in the majority of patients with siderosis. If the cataract was sufficiently dense, we removed the lens at the time of IOFB removal. In such cases a pars plana lensectomy was combined with PPV and IOFB removal. Lens opacification may progress following IOFB removal and we performed extracapsular cataract extraction with insertion of a posterior chamber intraocular lens in 2 patients. The IOFB had penetrated the cornea and presumably passed straight through the lens in both these patients, yet there was no obvious posterior capsule defect and no presentation of vitreous at operation. Sneed and Weingeist reported similar findings in a series of 13 patients.[3]

The photoreceptors did not demonstrate any recovery of function following IOFB removal, as manifest by the ERG, which remained subnormal in all patients during the follow-up period. Iron retention causes a progressive deterioration of the ERG.[7] The response, however, is variable and it may remain stable.[3] It is for this reason that some authorities elect to follow retained IOFBs.[3]

Histological examination confirmed widespread deposition of iron in the conjunctiva, anterior lens capsule and pars plana. The deposits seen macroscopically beneath the anterior lens capsule were in the form of ferric iron. Iron was contained in siderosomes, which are membrane-bound intracytoplasmic organelles found in the pigmented and non-pigmented epithelium of the pars plana. Within the siderosomes, iron has been shown to be deposited in the form of ferritin.[5] The degree of cell degeneration in the pars plana was greater in the non-pigmented than in the pigmented epithelium. Iron is thought to be toxic due to the generation of free radicals. The melanin in the pigmented epithelium may have a protective role against cell damage by free radicals.[6]

Final visual acuity was compromised by the development of PVR and toxic vasculopathy. One patient had advanced PVR at presentation and PVR developed in another patient following IOFB removal. Toxic vasculopathy developed following IOFB removal in 1 patient. Perivascular deposits presumed to be iron were deposited in the posterior pole, and a toxic microvasculopathy developed. This has been described in previous reports.[1] Removal of the IOFB does not appear to prevent this complication. The prognosis following metal injuries with retained IOFBs has improved dramatically since the advent of vitrectomy techniques. In 1975, Neubauer reported that the removal of IOFBs was a thankless task, and the percentage of enucleations was in the order of 20%.[8] He reported good vision (better than 6/12) as a final result in 28% of all retained IOFBs. Our series is a considerable improvement on Neubauer's results: there were

no enucleations and 75% of our cases had a visual acuity of 6/12 or better.

We do not advocate long-term follow up of IOFBs, as the retained IOFB continues to release iron which exerts a widespread toxic effect on the eye. This toxicity is demonstrated in our study by the electrophysiological and histopathological findings. We feel that retained IOFBs should not be followed on a serial basis but should be removed once the diagnosis has been made.

All of our patients were injured at work, and none was wearing protective goggles. In view of the morbidity of these injuries we should continue to encourage the wearing of eye protection when working with metal.

We would like to thank Mr. Tom Gardner for his help with the electron microscopy and Miss E. Eagling for allowing us to review her patients.

Key words: Intraocular foreign body, Ocular siderosis, Siderosomes.

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