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A decade of intraocular foreign bodies*

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This communication is based on a retrospective survey of 245 intraocular foreign bodies (IOFB) seen at the Birmingham and Midland Eye Hospital between 1961 and 1970 inclusive. Because the numbers have been swollen by patients referred from other regions after failed extraction, the results are not strictly comparable with those of other authors, as there tends to be a higher rate of complications: however, it is of interest to review the changing scene of IOFB in an industrial city, and to compare the present findings with those of the comprehensive survey from Birmingham carried out by Roper-Hall (1954) covering the 20 years from 1932 to 1951.

Material

Case records are derived from the files of the Birmingham and Midland Eye Hospital and are taken from those perforating injuries and IOFBs listed in the computerized diagnostic index, and, as a double check, from the operating theatre records. Corneal and scleral foreign bodies are excluded unless a penetration had occurred, and orbital foreign bodies after double perforation are also excluded. Several patients were able to attend a special follow-up clinic (Table X) when investigations included applanation tonometry, gonioscopy, examination of the fundus periphery with the Goldmann three-mirror contact lens, and retinal function tests if these were considered necessary.

Incidence, age, and sex

Fig. 1 shows that the incidence of IOFB is slowly declining and is currently around twenty a year or just under two a month, compared with an average of 35 a year between 1932 and 1951. As is to be expected, the majority of patients were young adult males. Only eight of the injuries occurred in females. Only seventeen of the men involved were over 49 years of age, and six were under 15, three of the latter being unfortunately injured by an air-gun pellet.

Cause of injury

The hammer and chisel is still the most common single cause (Table I) and the resulting injuries tend to do better than those from other causes as the foreign bodies tend to be smaller. Of the 218 known causes, the incidence of hand-hammer injuries was 63 per cent. compared with 73 per cent. in the 1932–1951 period. Although the incidence of machine-tool injuries was 24 per cent. compared with 18 per cent., the incidence per year of these injuries is actually decreasing, owing, probably, to the greater sense of protection in industry. The number of non-magnetic foreign bodies was 25 (10 per cent.) but, contrary to the forecast by Kraus and Briggs (1945), the number of these occurring as

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Table I *Cause of intraocular foreign body* (218 *cases*)

Cause	*Number*	*Per cent.*	*Enucleation rate* (*per cent.*)
Hammer and chisel	45	63	5
Hammer and other instrument	91		
Machine tool	53	24	13
Other	29	13	23

Table II *Causes excluding hammer and machine injuries* (*29*)

Air- or shot-gun pellet	8
Shovelling	3
Explosion	2
Glass injury	2
Wire cutting	2
Miscellaneous	12

the result of industrial accidents is not increasing, and there were only four non-magnetic machine-tool injuries. A breakdown of non-industrial injuries (Table II) shows that a few IOFBs result from shovelling or hoeing (these were magnetic) as recorded also by Roper-Hall (1954), and that there is a striking increase in air-gun or shot-gun injuries. There were six air-gun pellets which penetrated the eye compared with none in Roper-Hall's series, and because of the resulting gross disorganization, the air-gun pellet is, in this series, the chief single cause for excision of an eye after IOFB.

Excision

There was a total of 23 excised eyes in the series (Fig. 1). In seven cases the excision was performed within 12 days because of gross ocular disorganization, in two cases within a week because of endophthalmitis, in ten cases between the 14th and 30th day because of persistent inflammation in a blind eye, and in four cases because of pain or inflammation more than 3 months after the injury.

Despite the increase in air-gun injuries (there were five requiring enucleation), there is a satisfactory fall in the excision rate compared with that during the years covered by Roper-Hall. Fig. 2 shows the trend in 5 year averages taken from both series and therefore includes the pre-antibiotic era.

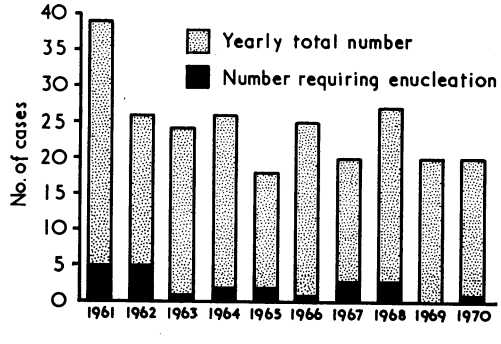

FIG. 1 *Eyes enucleated*

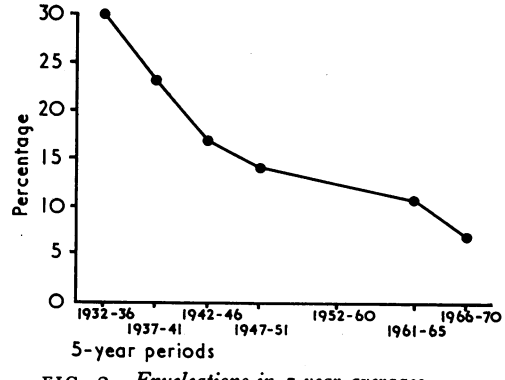

FIG. 2 *Enucleations in 5-year averages*

Size, side, and type of injury

159 IOFBs were available for measurement, the approximate volume being recorded rather than the length of the greatest dimension. As is to be expected the visual prognosis deteriorates with increasing size (Table III). The recording of one anaesthetic death of a boy in his early twenties is a salutary reminder that, even with modern anaesthesia, emergency surgery is still not without risk.

Table III *Visual prognosis related to size* (159 *foreign bodies*)

Size (*cu. mm.*)	*No. of cases*	*Visual acuity* (*per cent.*)		*Enucleations* (*per cent.*)
		6/9 *or better*	*Counting fingers or worse*	
>15	21	9	71	42
1–15	55*	44	27	7
<1	83	78	6	1

*includes one death

Table IV relates the size of IOFB with the cause of injury and side involved. As recorded by previous authors (Goulden, 1908; Sweet, 1914; Duggan, 1933; and others), there is a preponderance of left-sided injuries. When broken down, it is found that this is especially so for foreign bodies of small size, a large proportion of which are caused by hand hammers. This finding supports the original explanation by Goulden (1908) that as hammers tend to be aligned uniocularly by the master (usually the right) eye, the left eye is usually nearer the area of danger and the right eye tends to be somewhat protected by the nose. Taking this series as a whole, however, there were 130 left-sided and 115 right-sided injuries; of the 136 hand-hammer injuries 54 per cent. were left-sided, and the preponderance of left-sided injuries seems to be of greatest statistical significance when small IOFBs are under consideration (Table IV). The preponderance of IOFB over 15 cu. mm. in size for the right eye in this Table is mainly due to the fact that five of the six air-gun pellets entered the right eye. It was not possible to support the earlier findings of Roper-Hall (1954) who, working on a smaller number of cases, suggested that the left eye was more commonly involved by large-size foreign bodies, and that the right eye was the more likely to be affected by a hammer and chisel accident.

Table IV *Size related to cause and side* (141 *foreign bodies*)

Side		*Right*			*Left*		
Size (*cu. mm.*)		<3	3–15	>15	<3	3–15	>15
Cause	Hammer	27	7	2	39	7	3
	Machine	10	3	3	10	4	2
	Other	3	3	6	6	3	2
Total		40	13	11	55	14	8

Site of foreign body

An attempt was made to place the IOFB clinically in all but five cases (Table V). However, as the study was retrospective, and depended sometimes on notes such as "FB seen at 7 o'clock", there may have been on overstatement of vitreous placements. The cases listed as retina/choroid were clinically impacted in the wall of the globe. The two lenticular foreign bodies that led to enucleation were both of large size, and were in all probability lento-vitreous in site. As will be seen in the next section, *x* ray localization was unreliable in placing the site, and the charts were therefore not used for this purpose. When the visual prognosis is considered (Table V), it will be seen that, in agreement with Rubinstein (1954), results are either very good or poor, there being few patients with a resulting

Table V *Site and visual acuity*

Site	Total no.	Final visual acuity (corrected)				Enucleations	
		6/12 or better		6/60 or worse		No.	Per cent.
		No.	Per cent.	No.	Per cent.		
A/c, P/c, Iris	52	46	88	3	6	0	
Ciliary body	16	13	81	1	6	0	
Lens	17	11	65	4	24	2	12
Vitreous	114	59	52	46	40	16	14
Retina/choroid	39	20	51	11	28	1	3
Transfixion	2	1		1		1	
Uncertain	5	0		5		3	
Total	245	150 (61 per cent.)		72 (29 per cent.)		23 (9 per cent.)	

visual acuity between 6/12 and 6/60. The relatively poor prognosis of vitreous foreign bodies is explained by the fact that this group includes several injuries in which the IOFB was large and accompanied by extensive haemorrhage.

Table VI lists the complications of IOFB related to site. Inflammation was the most common complication of anterior segment foreign bodies, and the overall incidence of glaucoma was very rare. The relatively high incidence of siderosis in lenticular foreign bodies was due to the fact that these were often left *in situ* or did not present until the cataract was complete. But, in all except one patient, the siderosis had remained localized and had not affected the visual prognosis. As complications of posterior segment foreign bodies, and in particular the factors relating to retinal detachment, are to be published elsewhere (Percival, 1972), further details of these will not be considered here.

Table VI *Complications related to site of foreign body*

Site		A/c, P/c, iris	Ciliary body	Lens	Vitreous		Retina/ choroid		Total	
					No.	Per cent.	No.	Per cent.	No.	Per cent.
Complication	Lens opacity	4	2	17	67	59	15	38	105	44
	Vitreous haemorrhage	1	4 (25%)	4	52	46	19	49	80	34
	Vitreous and/or uveal prolapse	9	3	3	43		8		66	28
	Inflammation	11 (21%)	1	2	26	23	5	13	45	19
	Retinal detachment	0	1	1	29	25	11	28	43	18
	Siderosis	1	1	7 (44%)	3		8	21	20	8
	Macular scar*	2	0	0	5		4		11	5
	Glaucoma†	0	0	1	7		0		0	3
Total cases		52	16	17	114		39		238	

*When unrelated to foreign body site or extraction site
†Excluding that caused by swelling lens matter

Localization

The methods at present available in Birmingham include *x* ray techniques, the electro-acoustic locator (Roper-Hall, 1957), indirect ophthalmoscopy, and trans-scleral illumination using fibre optics. When a magnetic foreign body can be seen lying free in the vitreous, it is usually extracted through the pars plana without difficulty and accurate localization is unimportant. However, when the foreign body lies buried in the retina,

choroid, or ciliary body, accurate localization becomes highly important. It is also common for a posterior segment foreign body to lie ensheathed in a preretinal position and if these are not localized accurately, haemorrhage or retinal damage may be caused by dragging the foreign body over to an adjacent site.

The unsatisfactory results from using *x* ray localization by Sweet's method are shown in Table VII, where on 28 of the 94 localization charts obtained the foreign body was stated to be extraocular. The percentage accuracy for localization of foreign bodies clinically impacted in the posterior wall of the globe was shown to be only 30 per cent. Innacurate localization of these foreign bodies tended to lead the surgeon to an incorrect incision and sometimes surprise when the extraction failed. The most that a single *x* ray localization may be expected to provide, therefore, is the approximate area of the globe over which further studies may be made, and some idea as to the size of the foreign body. However, when the Roper-Hall electroacoustic locator is used during surgery, the correct incision for removal of a foreign body near the wall of the globe may be accurately made.

Table VII X-*ray localization of posterior segment IOFB (Sweet's method)*

Clinical site	*Number*	*Localization*			
		Vitreous	*Wall of globe*		*Extraocular*
			Accurate	*Inaccurate*	
Vitreous	64	39	–	8	17
Retina/choroid	30	5	9 (30%)	5	11
Total	94	44	9	13 (14%)	28 (30%)

As can be seen from Table VIII, even when the foreign body is visible in the fundus, the overall incidence of failed extractions at the first attempt in this survey was around 30 per cent. These were all posterior segment foreign bodies, but entry site removals (which were all successful at the first attempt) were excluded. The results may be compared with the cases when the electronic locator was used over the period 1966 to 1970,

Table VIII *Posterior route extraction of magnetic IOFB from vitreous, retina/choroid, or ciliary body*

Series	1961–1970			1966–1970 only		
	Total	*Failed extraction at 1st attempt*		*Total*	*Failed extraction at 1st attempt*	
		No.	*Per cent.*		*No.*	*Per cent.*
All cases*	104	30	29	58	15	26
Foreign body visible in fundus	44	13	30	22	8	36
Electronic locator used at surgery	38	10	26	24	4	17
Positive response from electronic locator	31	5	16	19	0	

*Excluded are cases where the size of the foreign body was over 20 cu. mm., and other cases of entry route removal where the wound was large or the foreign body was located by inspection.

for when a positive magnetic response was sounded the success rate for removal became 100 per cent. If the locator does not produce a response, then nothing has been lost and the surgeon may still attempt to remove the foreign body in the usual way.

Route of extraction

The poor results from anterior route extraction (Table IX) are now well documented (Roper-Hall, 1954; McCaslin, 1960), but it is interesting to note that the incidence of complications in this series for the posterior route was much the same whether the pars plana or direct posterior approach was made, and in agreement with Amalong (1970) the direct posterior approach should certainly be advocated when the foreign body is lying in a retinal or preretinal position. This has the advantage that the magnet is able to exert a greater pull on the foreign body being a shorter distance away, but accurate localization is of prime importance and preoperative assessment of the fundus should be as detailed as time permits. As is suggested elsewhere (Percival, 1972), the mere presence of retinal perforation is not in itself a factor leading to retinal detachment.

Table IX *Complications related to method of removal. Posterior segment foreign bodies less than 15 cu. mm., excluding entry site removals*

Complication	*Method of removal*		
	Anterior route (12)	*Pars plana* (43)	*Direct posterior* (67)
Inflammation (%)	58	9	6
Vitreous haemorrhage (%)	66	37	43
Retinal detachment (%)	50	21	19
Glaucoma (%)	25	2	1
Final visual acuity 6/60 or worse (%)	75	28	25
Enucleation rate (%)	33	2	4

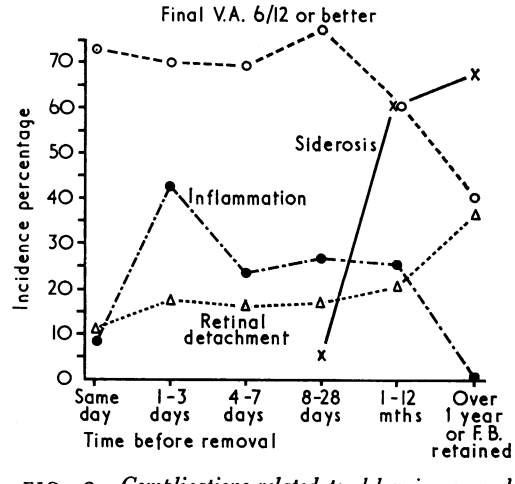

FIG. 3 *Complications related to delay in removal of foreign body*

Delay in removal

The argument for surgery on the same day as the injury is the prevention of an inflammatory reaction which tends to organize and bind the foreign body, possibly in a preretinal position. Fig. 3 shows complications related to delay in removal of 188 magnetic foreign bodies. The incidence of severe inflammation was already high by the second day. Inflammation in this survey was defined preoperatively when a hypopyon or plastic exudate was present in the anterior chamber. Postoperatively it was used only when keratic precipitates were noted, when flare and cells continued for longer than a month, or when severe inflammation was suggested by other clues such as the use of systemic prednisolone. When foreign bodies over 15 cu. mm. and enucleations are excluded (Fig. 3), the incidence of retinal detachment rises with delay in removal, and of the five patients who developed detachment after retention of a magnetic foreign body for over a year, three were preoperative.

Siderosis was not reported until after the second month, except for one case where localized siderosis was noted towards the end of the first month. The final level of visual acuity tended to fall, especially after a delay of over 2 months before IOFB extraction.

Long-term follow-up

85 previously discharged patients were asked to attend a special follow-up clinic (Table X) and of these the attendance rate was 46 per cent. Other patients were still attending the hospital because of late complications or for other reasons, but the overall figures do not show deterioration of vision with prolonged follow-up. Anterior chamber foreign bodies were excluded from this Table as almost all tended to produce good results; enucleated eyes were also excluded. There was no significant incidence of delayed aphakic detachment, and of those uniocular aphakics who were selected for contact-lens wearing (Table X) at least half were still using their contact lens at the time of follow-up.

These good results may be biased by the fact that patients who are grateful to the hospital

Table X *Follow-up (Anterior chamber foreign bodies and enucleations excluded)*

Period (yrs)	*Total number*	*Final corrected visual acuity (per cent.)*		*Contact lens ordered*	
		6/60 or worse	*6/12 or better*	*No. of cases*	*Per cent. wearing contact lens at follow-up*
7–10	22	23	68	6	50
3–7	33	36	51	9	55
1–3	43	39	49	9	55
Under 1	72	25	65	2	50

for their treatment may be more ready to attend a special follow-up clinic. However, as has been explained by Roper-Hall (1954), there is good evidence that complications provide a stronger motive for re-attendance and that the working man who is free from complications may forget the follow-up on purpose, in order to prevent loss of time from work.

Non-magnetic foreign bodies

Of the 25 cases, when the air- or shot-gun pellets are excluded, there remained only eleven metallic non-magnetic foreign bodies. This is too small a number for an opinion concerning prognosis to be formed, but a brief account of their outcome is of interest.

In the six eyes with cuprous foreign bodies, the prognosis was good only after early removal. Two were removed successfully from the vitreous cavity using forceps and indirect ophthalmoscopy.

In another two patients the electronic locator aided localization before direct removal from the posterior wall of the globe. One of these harboured a copper foreign body and did not present until 2 weeks after the injury, by which time endophthalmitis and a severely reduced electroretinogram had already developed.

A fifth eye was lost because of endophthalmitis from a brass foreign body retained some years before presentation.

The sixth patient had a brass foreign body in the posterior chamber which was retained despite surgery for cataract. This eye remained quiet for 4 years, then presented with kerato-uveitis and episodes of severe pain, with eventual extrusion of the foreign body in the region of the limbus.

Of the non-cuprous foreign bodies, one was aluminium and left untouched, one non-magnetic alloy was removed with intravitreous forceps, and three others were retained impacted in the posterior wall of the globe after failed attempts at magnet removal. Serial electroretinograms in these showed no deterioration in retinal function, and useful vision was retained.

Conclusions

In this 10-year survey of IOFB in an industrial city, the incidence of both magnetic and non-magnetic IOFB continues to fall and, although there is a rise in cases referred with intraocular air-gun pellets, the overall enucleation rate also continues to fall.

Use of the hammer and chisel is still the most common single cause of IOFB, but the IOFB in such cases tends to be small and carries a favourable prognosis. There is a slight preponderance of left-sided injuries, probably because a hand-hammer tends to be aligned uniocularly by the master (usually the right) eye, which tends to be the further away from the area of danger.

Late complications are uncommon and, if an eye recovers from the injury, the vision tends to remain good even after long-term follow up.

Approximately half of the patients considered suitable for contact-lens wearing find their lens beneficial enough for continued use.

If removal of IOFB is delayed, the incidence of endophthalmitis rises sharply after 24 hours. Siderosis is rare before the second month.

Finally, the Roper-Hall electroacoustic locator compares favourably with Sweet's method of *x* ray localization, and is found to be extremely useful during surgery when marking out the incision for direct removal of a posteriorly placed IOFB.

Summary

A retrospective survey has been made of 220 magnetic and 25 non-magnetic intraocular foreign bodies seen in an industrial city during the past 10 years. The findings are compared with those of an earlier comprehensive survey from the same city. Routine methods of localization, prognosis after delay in removal, and results from long-term follow-up are assessed, and certain conclusions are reached.

I should like to record my thanks to the consultant staff of the Birmingham and Midland Eye Hospital for permission to use their records, and in particular to Mr. M. J. Roper-Hall and Mr. S. J. Crews for their helpful advice and encouragement during the preparation of this paper.

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