INTRA-OCULAR METALLIC FOREIGN BODIES*

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THE purpose of this paper is to study the mass of an intra-ocular metallic foreign body and the problem of infection in a series of patients seen at the Glasgow Eye Infirmary. Although there is much work on the problem of sepsis, there are few references in the literature to the mass of the fragment.

The fibrous macromolecules of collagen in the outer coat of the eye are so arranged in compact bundles and layers as to resist with ease the stresses produced by the pull of the six extra-ocular muscles. The depth to which a flying fragment will penetrate into or through this tough tissue will depend on resistance, the configuration of the leading part of the fragment, the mass, and the velocity. Of these the mass is the most readily available for measurement. In the literature I found two references discussing the mass of the intra-ocular fragment. Morax and Moreau (1917) classified their fragments into less than 250 mg., 250 mg. to 5 g., and greater than 5g.; their cases were all war injuries. Grönvall and Hultgren (1959) reviewed 131 cases in which the mass of the fragments ranged from 0.01 mg. to 12.3 g.; they were mainly concerned with the metallurgy of the fragments. Other authors have classified the intra-ocular fragments by volume (Roper-Hall, 1954; Stevens, 1956), and by shape, as "spicules", "scales", or "chunks" (Brownlie, 1915).

During the quinquennium January, 1956, to December, 1960, at the Glasgow Eye Infirmary, 81 patients with intra-ocular foreign body were admitted to the wards, and these accounted for one in 200 ophthalmic in-patients from all causes and one in 2,000 of all ophthalmic accident patients. The mass of 73 fragments was found and the results are shown in Fig. 1.

FIG. 1.—Mass of fragments (mg.).

Table I shows the corrected visual acuity of these 73 cases related to the mass of the fragment.

TABLE I
VISUAL ACUITY WITH CORRECTION IN 73 CASES OF INTRA-OCULAR FOREIGN BODY, BY MASS OF FRAGMENT

Mass (mg.)	No. in Group	Enucleation	Visual Acuity		
			6/60 - P.L.	6/18 - 6/36	6/12 +
<0.001-0.001	16	0	2	0	14
0.0015-0.01	24	0	5	6	13
0.011-0.1	29	8	10	3	8
0.15-0.445	4	3	1	0	0
Total	73	11	18	9	35

In general a fragment weighing 0.01 mg. might be represented by a sphere which could be contained within the "o" of N 6 type.

Of the 81 cases it was found that the left eye was injured in 57 and the right eye in 24. When the mass of the fragment was related to the side injured, it was found that the proportion in the range of 0.001 - 0.01 mg. left:right was 2:1; in the range 0.011 - 0.445 mg. it was 3:2, which is in agreement with the findings of Stevens (1956). In common with other authors (Roper-Hall, 1954; Levy, 1958), I have found that work within arm's length was the most common circumstance of injury. 66 patients were working within arm's length and three at distances greater than arm's length; a hand hammer used alone or with a chisel accounted for 57 injuries, drilling or turning for eight, welding for two, and an air pressure hose for one. The mode of injury was unknown in twelve cases. In one case it was established that the patient was 7 feet away from the area of hammering at the time of his injury.

The time interval between the injury and seeking medical advice shows a similar pattern to that reported by Trevor-Roper (1944); the bulk of the patients attended for treatment within the first 24 hours after the injury.

Site of Fragments

The distribution of the fragments within the globe was found to agree closely with that reported by Stevens (1956) and Roper-Hall (1959). The distribution of 79 fragments is shown in Table II.

TABLE II
SITE OF 79 FRAGMENTS IN PRESENT SERIES COMPARED WITH PREVIOUS REPORTS

Site of Fragment		Present Series		Stevens (1956) (Per cent.)	Roper-Hall (1959) (Per cent.)
		No.	Per cent.		
Anterior Segment	Lying free in anterior chamber	3	15	21	20
	Lying free in posterior chamber	2			
	Caught up in iris	7			
	Embedded in lens	14	18	16	10
Posterior Segment	Lying in vitreous	53	67	63	70
	Lying on retina				

When the mass of the fragment was related to its final position, it was found that, of 23 fragments in the anterior segment, four weighed less than 0.001 mg. (17 per cent.) and seven more than 0.01 mg. (35 per cent.). Of fifty fragments in the posterior segment, six weighed less than 0.001 mg. but only one of these had entered by the cornea (2 per cent.), and 26 weighed more than 0.01 mg. (52 per cent.).

This would suggest that the lighter fragments penetrate the least. Seventeen metallic fragments were obtained which had been deeply embedded in the cornea following similar types of injury, and 45 superficial corneal foreign bodies were found following grindstone injuries.

Of the intracorneal foreign bodies, eight weighed less than 0.001 mg. (47 per cent.) and two more than 0.01 mg. (12 per cent.). Of the superficial corneal foreign bodies, the average mass was 0.0008 mg., *i.e.* all forty weighed individually less than 0.001 mg.

Depth of penetration from the anterior surface of the cornea was plotted against the percentage number of fragments in any segment for the two mass ranges being considered (Fig. 2). The largest proportion of fragments weighing less than 0.001 mg. were found in the first few millimetres of the anterior segment. Those which enter by way of the cornea rarely penetrate to the vitreous chamber. The curve for the heavier fragments shows that fully half of the fragments which reach the posterior segment weigh more than 0.001 mg.

FIG. 2.—Depth of penetration of fragments from corneal surface (mm.).

Culture

Previous authors have noted that a fair proportion of eyes was lost because of sepsis. Brownlie (1915) found that eleven eyes in 25 enucleations were lost because of sepsis, Stevens (1956) three in eleven enucleations, and Levy (1958) thirteen in 52 enucleations. Garrow (1923) reviewed 1,000 cases of ocular injury in which there were 149 enucleations, forty of which were attributed to sepsis. Brownlie (1915) observed that iridocyclitis or hypopyon indicated a poor prognosis, but Roper-Hall (1959) was able to state that "infection is at present a small consideration in perforating injuries with retained intra-ocular foreign body and up to a point this makes delay an unimportant factor".

During the quinquennium under consideration it was decided that, because it is commonly accepted that the great majority of high-velocity metallic fragments which enter the eye are sterile, the surgeon should place the fragment in a culture medium

after its successful removal. An infusion broth was used and incubated for 48 hours, and thereafter any growth was identified and subcultured onto a blood-agar plate for sensitivity studies. If there was no growth the medium was incubated for a further 24 hours. It was a standard procedure to give antibiotics on admission, the routine dose being 0.5 mega unit crystalline penicillin G. 6-hrly by intramuscular injection for 3 days followed by 600,000 units distaquaine penicillin twice daily for a further 2 days. In addition, 0.5 mega unit crystalline penicillin G. was given subconjunctivally at the time of removal of the fragment.

Of the 76 fragments shown in Table III, less than half were sterile after 72 hrs' incubation, and almost half of the growths yielded were sensitive to penicillin. Once the sensitivity of the organism was known, any alteration in treatment was made by the surgeon as he thought fit. In four cases the ocular condition was deteriorating and the antibiotics were changed with apparent improvement. 21 of the 43 cases in which the foreign body yielded a growth of bacteria had poor visual end-results. In the present series, four cases presented with hypopyon and only one underwent enucleation; this favourable result should be compared with the figures given by Brownlie (1915), who described six cases presenting with hypopyon, in five of which the eye was subsequently enucleated.

TABLE III
RESULTS OF CULTURE OF 76 FRAGMENTS

Result		Culture			Sensitivity		
		Sterile	<i>Staph. aureus</i>	<i>Staph. albus</i>	Sensitive	Resistant	
						Change	No Change
Visual Acuity	6/12 +	17	15	1	7	3	6
	6/18 - 6/36	8	5	1	1	1	4
	6/60 - P.L.	6	12	1	8	0	5
Enucleation		2	7	1	3	0	5
Total	No.	33	39	4	19	4	20
	Per cent.	43.4	51.3	5.3	44	9.5	46.5

Staphylococci are found as commensal organisms on the normal conjunctiva and as such are facultative pathogens. They have been reported by Khorazo and Thompson (1935) to be present as *Staphylococcus albus* in 41 per cent. and as *Staphylococcus aureus* in 23 per cent. of normal healthy conjunctival sacs. No evidence is presented to confirm that the organisms grown were present on the fragment before the injury, or that the fragment was contaminated by the conjunctival commensals at the point of penetration. However, it is emphasized that the threat of intra-ocular infection, as a result of this type of injury, is real.

Influence of Lens Injury

Goulden (1908) pointed out that good final vision depended on whether the lens was injured or not, and in this he is supported by Trevor-Roper (1944), Roper-Hall (1954), and Levy (1958). Würdemann (1932), however, considered that, in cases

with a corneal wound, the result should be good if the fragment was in the lens. Table IV shows details of 67 cases in which a degree of vision was preserved.

TABLE IV
RESULTS ACCORDING TO PRESENCE OF LENS INJURY

Lens Injury on Admission			Present		Absent	
Location of Fragments			Anterior Segment	Posterior Segment	Anterior Segment	Posterior Segment
Result	Visual acuity	6/12 +	2	9	9	11
		6/18 – 6/36	4	5	1	3
		6/60	7	10	2	3
Enucleation			0	7	0	5
Total			14	31	12	22

Of 44 eyes showing traumatic lens opacities on admission, seven were subsequently enucleated, nine became aphakic, six showed complete cataract after a period of follow-up, eight had increasing lens opacities, three became phthisical, and 11 showed stationary lens opacities. The vision in the cases with progressive lens opacities will deteriorate even further in the future. Levy (1958) observed that the visual result could be improved by cataract surgery in cases with opaque lenses and that the potential visual acuity could be made useful by the use of a contact glass, or anterior or posterior chamber lens implant. In the eleven cases with stationary lens opacities, the lens was retained but with a varying degree of visual impairment; eight had a visual acuity of 6/12 or better.

Entry Wound

The situation of the wound of entry was discovered in 77 cases. In Table V the results are compared with those of Roper-Hall (1959).

TABLE V
SITE OF ENTRY WOUND IN 77 CASES

Site	Present Series		Roper-Hall (1959) (per cent.)
	No.	Per cent.	
Corneal	55	71	60
Limbal	7	9	10
Scleral	15	20	30

The best results were found when the point of entry was corneal and the worst when it was scleral. Corneal wounds complicated by lens injury occupied a median position. Prolapse of uvea or vitreous in the presence of a scleral wound is thought by Roper-Hall (1954) and Levy (1958) to indicate the presence of a fragment with a volume of not less than 2.6 c.mm. In nine of the ten cases with such a scleral wound, the mass of the fragment exceeded 0.01 mg. The results obtained in these ten cases were very poor, only one achieving a visual acuity of 6/18.

Route of Extraction

Of the 81 fragments 78 were metallic and magnetic, one metallic and non-magnetic, and two non-metallic and non-magnetic.

Table VI shows the subsequent corrected visual acuity related to route of extraction of the 76 metallic-magnetic fragments which were removed by the magnet.

TABLE VI
ROUTE OF EXTRACTION OF 76 FRAGMENTS

Route of Extraction	No. of Cases	Site of Fragment	Lens Damage	Result			
				Enucleation	Visual Acuity		
					6/60 - P.L.	6/18 - 6/36	6/12 +
Anterior	23	Anterior Segment	No	0	2	2	8
		Anterior Segment	Yes	0	2	3	3
		Posterior Segment	Yes	2	0	1	0
Posterior	33	Posterior Segment	No	2	4	1	8
		Posterior Segment	Yes	1	4	5	8
Through Wound of Entry	20		No	3	3	1	3
			Yes	2	5	1	2

In cases with lens damage the damage was noted on admission. In the last section (fragments removed through wound of entry) in the presence of lens damage, nine of the ten cases had corneal wounds, and it is considered that the increase in intra-ocular damage caused by the extraction accounts for the poorer visual end-results in these cases.

Various surgeons have advocated their own favoured and well-tried method of extraction of fragments located in the posterior segment. Philps (1942) made a plea for the posterior route. Brownlie (1915), Trevor-Roper (1944), and Levy (1958) advocated the anterior route. Shipman, Delaney, and Seely (1953) attempted to regulate the choice of route by the size of the fragment as measured radiologically. Roper-Hall (1959) stated that the visual end-result was equally poor by either method, though the excision rate was higher when the anterior route was used.

In the present series, two of the three eyes from which the fragment was removed by a planned anterior route were enucleated, and of the five eyes from which the fragment was removed from the posterior segment through a corneal wound of entry, two were enucleated, two became phthisical, and the fifth developed a mature cataract.

Enucleation Rate

The enucleation rates reported by certain previous authors are shown in Table VII (overleaf).

In the present series twelve eyes were enucleated out of 81; in all of these the fragment was located in the posterior segment of the globe and the mass was greater than 0.01 mg. These twelve eyes may be divided into the following groups:

Intra-ocular Haemorrhage (6 cases).—In two of the eyes the fragment was removed at the second attempt after failure to extract through the wound of entry—the “trial by magnet” condemned by Stevens (1956).

TABLE VII
ENUCLEATION RATES IN PRESENT SERIES COMPARED WITH PREVIOUS REPORTS

Author	Date	No. of Cases	Enucleation Rate (per cent.)
Present series	1960	81	14.8
Levy	1958	272	19
Stevens	1956	47	12.7
Roper-Hall	1953	555	20
Trevor-Roper	1944	150	18
Garrow	1923	138	31
Brownlie	1915	51	45
Goulden	1908	118	35

Sepsis (4 cases).—One presented with hypopyon, three gave a growth of resistant *Staph. aureus*, and one a growth of sensitive *Staph. albus*. The fragments had all been removed within 24 hours of admission, and in one case evisceration had been performed as a primary procedure.

Retained Intra-ocular Foreign Body (1 case)*.

Prolapse of Ciliary Body (1 case).

Five of the twelve eyes were excised from the 7th to 14th day after injury, six were removed from 14th to 21st day, and one after the 21st day.

Only one eye was removed because it was considered to be running a risk of sympathetic disease, but this was shown histologically not to be the case.

Conclusions

At the Glasgow Eye Infirmary during the period 1956–1960, 81 patients suffering from intra-ocular foreign body were admitted to the wards. Of these 68 were considered suitable to subject to further analysis. They were all males who had sustained the injury at work. The fragments were metallic and had been removed by using the magnet, the mass was known, and a culture report on the fragment had been obtained. Corrected visual acuities were recorded during the follow-up period which ranged from 1 month to 6 years.

Table VIII was obtained by considering fragments with a mass of 0.01 mg. or less as light and fragments with a mass greater than 0.01 mg. as heavy. A good

TABLE VIII
RESULTS IN 68 CASES BY MASS OF FRAGMENT AND STERILITY OF FRAGMENT

Result		Good	Bad
Mass	Light	29	7
	Heavy	11	21
Culture	Sterile	23	7
	Infected	17	21
Total		40	28

* 69 fragments were removed at the first attempt (eight eyes being subsequently enucleated), ten at the second attempt (two eyes being subsequently enucleated), and the other two only after excision of the globe.

result is defined as one in which the final visual acuity was 6/36 or better, and a bad result is one in which the visual acuity was 6/60 or worse (including those patients in whom the eye was destroyed). Table VIII also classifies the results as good or bad according to whether the fragment was found to be sterile or infected.

Heavy fragments thus carry an unfavourable prognosis for good vision, two out of three having a bad result; with light fragments the prognosis is favourable, four out of five having a good result.

A good or bad result depends on the amount of intra-ocular damage caused by the entry and subsequent removal of the fragment, this in turn depends on the depth of penetrance of the fragment which, as has been shown, is related to the mass; the light fragments penetrate least and the prognosis is accordingly good.

This would only be so if no other factors were considered, but the Table also shows that sterile fragments carry a more favourable prognosis than infected fragments.

Table IX, which is obtained by rearranging the data in Table VIII, shows that light sterile fragments have the best prognosis of all, only one in ten producing a bad result. This is considerably better than the light infected fragments of which one in three is bad; furthermore one in three of the heavy sterile fragments and eight in eleven of the heavy infected fragments are also bad.

TABLE IX
RESULTS IN 68 CASES ACCORDING TO MASS AND STERILITY OF FRAGMENT

Mass	Culture	Result	
		Good	Bad
Light	Sterile	18	2
	Infected	11	5
Heavy	Sterile	5	5
	Infected	6	16
Total		40	28

The question of lens injury has been examined fully by Goulden (1908) and Roper-Hall (1954), and numerous authors have debated the choice of the route of magnetic extraction of a metallic intra-ocular fragment. The figures obtained in this analysis of these points confirm what earlier workers have said.

Because it was thought that good and bad results might be influenced by the age of the patients, they are shown in five age groups in Table X (overleaf) but contrary to expectation no significant difference between the groups was found.

The better results achieved in recent decades may be judged from the fall in the enucleation rate from Brownlie (1915) of 45 per cent. to Trevor-Roper (1955) of 18 per cent. and to the present series (1960) of 14.8 per cent. There is no doubt that this is due to the efficient control of intra-ocular sepsis by the early use of chemotherapeutic agents, as noted by Levy (1958), and it would appear this has played a larger part than any advance in surgical techniques in the improvement of the

TABLE X
RESULTS IN 68 CASES ACCORDING TO AGE OF PATIENT

Age Group (yrs)	Result	
	Good	Bad
20 and Under	9	7
21-30	13	7
31-40	5	4
41-50	8	4
51 and Over	5	6
Total	40	28

prognosis over the past 20 years. The cases included in this analysis were treated by numerous surgeons, but the chemotherapy was standard throughout. Similarly, the figures from the literature come from different sources and the only common factor of major importance has been the introduction of antibiotics.

Summary

An analysis of 81 cases of intra-ocular foreign body is presented. It is shown that both the mass of the intra-ocular fragment and its state of bacterial contamination have a bearing on the prognosis for good final vision. Light sterile metallic foreign bodies do better than heavy infected ones. Age played no part in determining the outcome.

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