

A Clinical Study of some points in the  
Management of injuries of the Eyeball.

A Thesis for the Degree of M.D. in the University  
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BY

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P R E F A C E.

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While acting as house-surgeon, and afterwards as assistant surgeon and electrician, in the Glasgow Ophthalmic Institution, I have had numerous cases of injury to the eye brought under my observation, and these form the basis for the brief account contained in the following pages.

To Dr. Maitland Ramsay, Surgeon to the Ophthalmic Institution, I am indebted for permission, not only to make use of the ward journals, but also of his valuable apparatus, in order to illustrate my remarks, as well as for much help and encouragement throughout the progress of the work.

I have also referred to the following books:-

Atlas of External Diseases of the Eye (Ramsay); Lehrbuch der Speciellen Pathologischen Anatomie Von Dr. Johannes Orth, Neunte Lieferung Von Prof. Dr. Greeff, Berlin 1902; Diseases of the Eye (Berry); Glasgow Hospital Reports 1901; Text-book of Ophthalmology (Fuchs); Handbook of Diseases of the Eye (Swanzy); &c.

J.G.



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During the past three years I have had a large number of patients suffering from diseases of the eye brought under my notice at the Glasgow Ophthalmic Institution. It is my intention in this thesis to record the results of treatment, to give my observations on the healing of wounds, and to illustrate my remarks by typical examples and by photographs.

In the first place it is necessary to divide injuries of the eye into separate groups, and a clinical classification convenient for my present purpose, is to divide them into contusion injuries and to penetrating wounds.

Contusion Injuries.

These are always due to a blow from a blunt object. In the simpler forms it is usually the cornea which is struck, and the actual lesion may be nothing

nothing more than an abrasion of its epithelium. Trivial as this may seem, the hospital journals contain numerous reports of cases in which disastrous consequences have followed. The reason of this is not far to seek. A coalminer, a stonebreaker, or an agricultural labourer gets his eye injured at his work, but so little does he think of it that he merely rubs his eye with his dirty hand, or perhaps goes the length of protecting it with a filthy pocket-handkerchief, and then continues his employment. Or again, a workman gets a "fire" in his eye, and owing to the intense discomfort, he appeals to a fellow-workman for assistance. His friend may remove the fire quite dexterously, but the instrument that he employs is the blade of a pocket knife which, but a few minutes before, he may have been using for cutting tobacco, or some similar purpose. Under these circumstances then, it is no wonder that if the cornea has not been infected at the time of the accident, the wound becomes inoculated afterwards and so, what, had it been taken care of, would have been a very simple accident becomes a suppurative

suppurative inflammation of the cornea which, if not arrested will produce complete destruction of the eye. Such traumatic infective ulcers of the cornea(Plate 1 )are usually described by the name of serpiginous ulcer, and the main features of this disease are briefly as follows:-

"The ulcer is usually situated towards the centre of the cornea. It is somewhat crescentic in shape, and while its floor shews only a shallow depression, rough and glistening, its margins are opaque, raised, undermined, and suppurating. One of the most striking characteristics of this ulcer, and that from which it derives its name, is the tendency it has to creep over the surface of the cornea, but while progressive in one direction, it usually tends to cicatrise along the opposite borders although in some cases it spreads with such intense rapidity that the whole cornea may be eaten away in a few days. Its peculiarly infective nature may be early diagnosed by its extreme painfulness, by the occurrence of deposits on Descemet's membrane, and by the formation of pus in the most dependent parts of the aqueous chamber, while corresponding with these there

there are always more or less intolerance of light, injection of the conjunctival and ciliary bloodvessels and swelling of the lids. The early involvement of the deeper parts of the cornea leads to inflammation of the iris, and with the occurrence of iritis there is always an increase in the hypopyon."

In trying to arrive at some accurate conclusions with regard to the cause, the course, the duration, the pathology, and treatment of this disease, I have gone carefully over the Ward journals of the Ophthalmic Institution for the past three years, and during that time I find that 135 patients were under treatment in the hospital. The patients were all adults, for the most part, miners, iron-workers and stonebreakers, and in almost every case the injury was in the first instance considered so trivial that it had been neglected. All our present knowledge goes to prove that in typical serpiginous ulcer the Pneumococcus is the specific microorganism. In many cases, however, the infection is a mixed one, and then the ulcer departs somewhat from the typical clinical picture just given; the course being more rapid, and the destruction more virulent, ending

ending in early perforation and necrosis of the cornea (Plate 2 ) I have said that it is the pneumococcus which is the infecting micro-organism in *Ulcus serpens*. It may inoculate the cornea either at the time of the injury or gain access through the abraded surface with discharge from the tear passages or conjunctival sac. After it has implanted itself in the substance of the cornea, it multiplies rapidly, and the toxins which it manufactures appear to be of a most virulent character. We are in great part indebted to Leber for our knowledge of the pathology of this disease.

The corneal epithelium is absent over the surface of the ulcer proper, and for some distance beyond the spreading margin it is separated from Bowman's Membrane and forms the undermined border referred to in the clinical description. At the healing margin there is evidence of attempts having been made to restore the epithelium which varies here both in its distribution and its thickness. Bowman's membrane is eaten through and the substantia propria is oedematous owing to dilatations of the lymph spaces, and to fibro-cellular exudation separating the lamellae. This exudation is most abundant in the superficial

superficial layers in the early stages, but in the later it extends throughout the whole thickness of the cornea. Descemet's membrane usually remains intact and does not rupture until all other parts of the cornea have been destroyed. Verdesse, Elschmig, and others, however, hold the contrary opinion, that the posterior elastic lamina is destroyed early and maintain that this rapid destruction is brought about through the histolytic action of the leucocytes in the hypopyon, but as these authorities carried out their researches on eyes which were suffering from Glaucoma, it is very probable that the malnutrition of the tissues contributed largely to induce the early perforation of Descemet's membrane which they have so carefully described. It seems on the whole very likely that the posterior elastic lamina remains intact to the very end as in many instances a keratocele appears before perforation occurs. Even although actual rupture does not take place, there is early implication and destruction of the endothelial cells of Descemet's membrane immediately behind the site of the

the ulcer, thus explaining the formation of the greasy looking spots referred to in the clinical description. Detached endothelial cells are also found in the hypopyon the origin of which has been much discussed. The older view that the hypopyon originated from the pus in the cornea can no longer be held as it has been demonstrated that it comes in large part if not entirely, from an immigration of leucocytes through the walls of the bloodvessels of the iris and ciliary body distended from the irritation of toxins manufactured by the microbes on the ulcer and rapidly diffused through the cornea, a process which is now known by the name of chemotaxis, (Plate 3 )

This brief account of the pathology of serpiginous ulcer forms a convenient starting point from which to consider the prognosis and treatment of the disease.

If it be granted that the great danger in all abrasions of the cornea is the occurrence of infection, it is obvious that in all cases the prognosis is favourable, if the ulcer does not become inoculated, or if, when infection has taken place, means

means are at hand for the destruction of the micro-organisms.

The main indications for treatment, therefore, are to keep the eye at rest, to promote healing and to apply remedies to the surface of the ulcer to stop the destructive action of the microbes. In every case the eye must be carefully examined and any foreign body removed; the patient should be put to bed, atropine instilled into the eye and a bandage applied. If the pupil dilates readily a favourable prognosis may be given and nothing further will be required than to keep the conjunctival sac clean by repeated douching with a hot saturated solution of boracic acid. The occurrence of pain is a sure sign that the ulcer is spreading and that the iris is becoming involved. The patient's sufferings are to be relieved by opiates preferably by morphia, injected under the skin of the temple and if the cornea is breaking down rapidly quinine should be administered in doses sufficient to produce its physiological effects. Locally antiseptics should be applied to the surface of the ulcer. Of these the most

most generally useful are nitrate of silver 2% solution, protargol 5 to 20 per cent solution, carbolic acid liquified by camphor 1 in 3, iodoform very finely triturated &c., while chinosol 1 in 4,000 is used as a lotion to irrigate the conjunctival sac. Should the ulcer show signs of perforation and more especially if it be situated near the margin of the cornea, atropine in virtue of its power to raise the intraocular tension may precipitate rupture of the cornea, so in such cases it is better to intermit its use and substitute eserine or pilocarpin. With such treatment the great majority of serpiginous ulcers heal rapidly, but if from the amount and virulence of the infection or from some special vulnerability of the corneal tissue, the disease progresses more active means must be taken to arrest it. At this stage the ulcer is always complicated by iritis and hypopyon, and until Saemisch of Bonn proposed to boldly incise the cornea and evacuate the pus the prognosis was most unfavourable. It must at once be obvious, however, that this method of treatment, although it has saved

saved many eyes which would otherwise have been lost, has certain disadvantages.

Pus in the anterior chamber cannot be evacuated like pus from an abscess cavity because in the eye, whenever the aqueous and pus escape the iris comes forwards and adheres to the incision in the cornea, consequently although the patient may be saved from the loss of his eye he may afterwards lose his sight from secondary glaucoma. The introduction of the actual cautery to ophthalmic practice has rendered it more and more unnecessary to perform the operation suggested by Saemisch. It may be said indeed that incision of the cornea through the base of the ulcer ought nowadays never to be required unless in those cases where, from neglect, the cornea has become very extensively involved. If however, it is to be of any real service the cautery must be resorted to early and applied thoroughly. A safe rule to follow is, that if after twenty four to forty eight hours of medicinal treatment the pupil is not dilating, the hypopyon not lessening, and the pain not abating, to cauterise at once. Cauterise thoroughly, and this can only be done

done by the aid of an alkaline solution of Fluorescein which maps out the spreading border of the ulcer by a bright green line. A very fine cautery heated to dull redness should be used and as the infection extends into the cornea beyond the apparent boundaries of the ulcer, the cautery should be applied to the outside of the green line of demarcation, and its application continued until every trace of the fluorescein stain has been destroyed. It is now most important in order to promote healing that all tension be taken off the cornea. Nature herself teaches us this, for in many cases a turn for the better takes place after perforation occurs, but like Saemisch's incision, perforation is attended by all the risks consequent upon anterior synechia. These risks can be avoided if the cornea be carefully incised at its margin and the anterior chamber slowly emptied. The escape of the aqueous and the pus is always followed by excruciating pain owing to the forward displacement of the inflamed iris and ciliary body. The patient's sufferings, however, are speedily relieved by the immediate application of a fomentation and the subcutaneous injection of morphia

morphia. As a rule he falls asleep soon after his return to bed and this may be the first sleep that he has enjoyed since the accident to his eye. If the cauterisation has been carried out in the manner above described it is very seldom that there is any necessity for its repetition. The healing of the ulcer goes on uninterrupted unless through carelessness fresh infection has occurred. This is at once indicated by the recurrence of pain, and these relapses are as a rule more difficult to overcome than the original disease. The site of the healed ulcer is marked by a white scar and this is always permanent if the substantia propria of the cornea has been involved. As a rule it is not so dense after the cautery as one would expect. The cicatrix may be lessened by massage with the yellow oxide of mercury ointment and of recent years the beneficial effects of massage have been aided by the use of a special electrode attached to the negative pole of a galvanic battery, the amount of current employed varying from one half to one milliampere. I have used this method of treatment in

in a number of cases and although in some improvement has followed, yet on the whole the results have not been so satisfactory as some writers have led us to expect. After serpiginous ulcer care must be taken not to apply electrical massage prematurely because the eyeball tends to inflame very readily, and this may cause an increase rather than a diminution of the opacity in the cornea. On the whole my experience is that electrical massage is most serviceable in the scars following superficial ulceration complicating inflammations of the conjunctiva. In thirty five such cases which I have recently treated, twelve per cent had their vision restored to the normal standard, others were improved in greater or less degree, while in sixty per cent the opacity on the cornea remained unaltered. In a number of the cases in which vision considerably improved the ophthalmometer showed a marked decrease in the amount of the corneal astigmatism. The misfortune in serpiginous ulcer is that the cicatrix is usually situated right in front of the pupil, and, when, after all efforts to remove it have failed resort to surgical means is

is necessary in order to improve the patient's vision by displacing the pupil opposite the most transparent part of the cornea. An iridectomy for optical purposes is best performed by a broad needle and a Tyrrel's hook. The iris is caught by the hook at the pupillary margin, and the part gently withdrawn from the eye and snipped off with de Wecker's scissors. In order to obtain the best vision possible the new pupil should be as narrow as possible and situated downwards and inwards.

The following summary gives the results of the 135 cases treated in the wards of the Ophthalmic Institution during the period covered by this Thesis. Sixty-two of these were bad septic ulcers which were admitted shortly after the accident and before any serious complications had occurred. All these recovered completely without any operative treatment. The remaining seventy three cases were all complicated with severe iritis and hypopyon and in twenty three of them it was found necessary to apply the cautery and evacuate the anterior chamber. In one only was the cornea incised according to the method devised by Saemisch, and in this case the ulceration had advanced so far that the operation was

was of no avail, and the eye had ultimately to be enucleated. The following case, in which, after a very trivial injury the cornea suppurated rapidly and panophthalmitis followed within forty eight hours, and the eye had to be enucleated, is worthy of being put on record:-

T.A., aet.56, was playing with a cat when it accidentally scratched the right cornea and the edge of the lower lid. Three days afterwards he was brought to the Ophthalmic Institution, and on admission it was found that the whole cornea had suppurated. There was pus in the anterior chamber and, owing to intense orbital cellulitis, there was marked proptosis with chemosis of the ocular conjunctiva, while the skin over the eyelids, forehead, and cheek was so red and inflamed as to raise the suspicion that the appearance might be due to erysipelas. Numerous pyogenic organisms were found in cultures taken from the cornea, but there can be no doubt that the peculiarly virulent course followed in this case was largely determined by the fact that the patient's tissues had been rendered peculiarly vulnerable by a lifetime's indulgence to excess in alcohol.

The

The two cases which follow have been under my own special care and are not included in the statistics given above. I record them for the purpose of illustrating the favourable results of suitable treatment in cases where at the outset the condition seemed well-nigh hopeless:-

B.P., aet.57, a platelayer by occupation, was admitted to the Glasgow Ophthalmic Institution on 8th.October 1898, suffering from Hypopyon Ulcer of the left eye. Twelve days before, he had been struck on the cornea by a chip of metal, but had paid little heed to the accident until he was compelled to seek advice owing to the severity of his symptoms. The greater part of the central area of the cornea was ulcerated, the iris was acutely inflamed, the anterior chamber half full of pus, the eyeball very red, and excessively tender to touch and vision so much reduced that he could only distinguish the light.

Bacteriological examination revealed both the Pneumococcus and the Staphylococcus in cultures taken from the surface of the ulcer.

On admission to the hospital the patient was put

put to bed, atropine instilled into his eye, which was constantly fomented with carbolic boracic solution. On the following morning the ulcer, having increased, the cornea was raised according to the directions laid down by Saemisch, and the anterior chamber emptied of pus. The wound was kept open to allow any pus to escape, and protargol in 5% solution was freely instilled with atropine. At the end of three days the pain and other symptoms were very much less, and the ulcer showed signs of healing at its nasal aspect. On the 21st. of the month, that is about a fortnight after the patient's admission to the hospital, it was noted that the ulcer was healing rapidly, that the cornea was regaining its transparency, that the pupil was yielding to the influence of atropine, that pus had disappeared completely from the aqueous chamber, and that vision had been regained sufficient to enable the patient to count fingers at two feet. From this time on the patient made uninterruptedly good progress, and when he was dismissed from the ward on the 4th. of November the cornea was firmly healed and the vision equalled

equalled one-tenth of the normal acuity.

T.R., aet. 26, a miner was admitted to the Ophthalmic Institution on 25th. March, 1899. Four days before admission he was struck on the left eye with a piece of coal. At first he thought nothing of it, and just continued at his work, but the eye soon became very painful, and he noticed that the vision was dim. On admission a small infected ulcer was seen at the inner margin of the left cornea, there were pus in the anterior chamber, iritis, and considerable chemosis of the ocular conjunctiva. The treatment prescribed was, absolute rest in bed, antiseptic fomentations, and frequent instillations of atropine, and protargol. These means, however, did little to relieve the pain which was excessively severe during the night. The intraocular tension was increased so the chemosis was freely scarified and the anterior chamber paracentesed. These operations were repeated on the following day, but although they gave relief for the moment the suffering returned as severely as ever during the night, and the ulcer, which for several days seemed to remain stationary

stationary in size, now showed signs of increase. Saemisch's operation was now performed, and the wound was kept open daily for a fortnight, by the end of which time the ulcer had begun to heal, and the purulent discharge had practically disappeared. On the 14th. May vision was restored by means of an optical iridectomy.

The limits of my space prevent me from discussing at length the various other injuries to the eye which are produced from a blow. I have, however, seen numerous examples of such injuries ranging in severity from cases in which there has simply been swelling and ecchymosis of the lids and subconjunctival tissues to those in which there has been haemorrhage into the interior of the globe, rupture of the iris, dislocation of the lens, rupture of the choroid, oedema and detachment of the retina and lastly cases where the eyeball was burst and its contents extruded from the severity of the traumatism.

I shall now pass on to the second part of my subject viz:-

#### Penetrating Wounds.

I need not repeat what I have already said, with reference

reference to ulcer, regarding the distinction which must always be drawn between a simple wound and one that has become infected either at the time of the accident or subsequently. My attention has been chiefly directed to those cases in which in addition to the wound a foreign body has been lodged in the interior of the eyeball. I have examined fifty-two cases of penetrating wounds in which from the history given by the patient and from the appearances presented by the eye it was suspected that a foreign body might be present, (Plate 4. Fig. A.) All these cases I have submitted to examination by the Röntgen rays and in twenty-three of them a foreign body was discovered. In twenty-one of these the foreign body was in the eyeball, in one it was situated in the air spaces connected with the nose, while in another it was lodged immediately below the skin covering the nasal bone. In all those cases in which a foreign body was present its exact position has been carefully determined and as the localising apparatus which I am in the habit of using differs in some respects from any of those in general use I shall here give a short description of it, (Plate 5).

It

It consists of an upright brass tube which can be raised or lowered, firmly fixed to a solid base and connected by a circular hinge joint with a horizontal bar graduated as a centimetre and millimetre scale running on either side of a central point called zero. A vulcanite upright rod at either extremity supports the wires connecting the Crooke's tube with the terminals of the induction coil. It carries a travelling clamp to which the Crooke's tube is attached. The second part of the apparatus consists of a chair with a support for the head to the upright of which two curved arms are attached. One of these carries a pocket to receive the sensitive plate while the other serves as a support for the patient's chin. By means of this arrangement the photographic plate can be brought closely into contact with the parts surrounding the eye to be X rayed, and any movement of the patient's head is effectually prevented by means of the chin rest. It will be obvious that when taking a photograph the position of the anode of the focussing tube can be varied at will by sliding the clamp along the graduated

graduated horizontal bar.

The method of using this apparatus is as follows:-

1. A small cross wire or loop is fixed by means of adhesive plaster to the external orbital margin on the side of the injured eye on a level with the outer canthus and in contact with the sensitive plate.
2. The patient is seated with the photographic plate in contact with that side of his head which corresponds to the injured eye, the Crooke's tube is on the opposite side of the head 30 cm. from the plate, the centre of the anode exactly opposite the centre of the small cross-wire or loop placed on the external orbital margin, (Plate 6).
3. Two skiagrams are taken, one upon the plate with the anode of the Crooke's tube 3 cm. behind the zero mark of the scale, or the centre of the cross wire, and the other upon another plate 3cm. in front of the zero mark or the centre of the cross wire, (Plate 7).

4. Each plate is now placed on a sheet of celluloid which is of the same size and shape as the plate. Through the transparent celluloid the shadows of the localising mark and of the foreign body are distinctly seen and their position marked with a pencil on the celluloid. When both plates are thus dealt with the distance between the shadow of the cross wire and those of the foreign body can be accurately measured. If the foreign body be on the same side of the cross wire on each plate the difference between the position of the shadows must be taken for a basis of calculation, but on the other hand if the shadows be on opposite sides of the cross wire the position of the one must be added to that of the other. It is obvious that the distance of the anode of the tube from the cross wire is a known quantity, as is also the amount of the displacement of the tube on either side of the zero point of the graduated scale on the cross-bar of the localiser. Having now obtained three known constants it is easy from them to determine the position of the foreign

foreign body as measured from the centre of the cross wire fixed to the external orbital margin. (Plate 8.)

5. The simplest way to determine the position of the foreign body in its relation to the anteroposterior axis of the eyeball, is to expose a third plate when the anode of the Crooke's tube has been fixed to the zero point and set so that the most active rays impinge upon the centre of the cross wire. If the shadows of the cross wire and foreign body are now mapped out on the sheet of celluloid all that requires to be done is to measure the distance between the two shadows. The third plate however, is not necessary because from the two plates first taken the position of the shadows in their relation to the cross wire gives the anteroposterior location of the foreign body. In this instance, however, it is obvious that if both shadows of the foreign body be on the same side of the cross wire, the sum of the mean of the distances must be taken, while if they be on opposite sides the difference of

of the mean of the distances must be taken.

6. To determine the vertical position of the foreign body all that requires to be done is to note whether the shadow be above or below the cross wires and then to measure the distance.
7. All that is necessary now is to estimate as nearly as possible the size of the foreign body and as the distance between the Anode of the tube and the shadow of the foreign body on the photographic plate is known, as is also the distance of the foreign body from the localising mark on the plate, a simple calculation from these data will give the approximate bulk of the foreign body.

Obviously the nature of the foreign body has a very important influence upon the prognosis. Out of the 25 cases which I have X rayed, and in which a foreign body was seen, in 18 of these the foreign body was a piece of steel or iron, in three copper, in two lead, in one hardened white lead paint, and in one stone. When the foreign body becomes lodged in the vitreous chamber, and when it is

is of such a nature that the magnet will not attract it, the eye is almost inevitably lost, for even although the foreign body be accurately localised, it is exceedingly difficult to grasp it with forceps and so to withdraw it from the eye. In all the cases under my observation, where the foreign body was other than steel or iron, enucleation had to be resorted to. In the 18 cases in which the foreign body was known to be steel or iron, the electro-magnet was applied in 15, and in twelve of these it was successfully removed. Of the six unsuccessful cases the failure of the magnet to affect extraction was due in three to the foreign body being of extremely small size, and embedded firmly in the tissues so as to be completely insulated and consequently beyond the influence of magnetic attraction, in two the eyeball was so completely shattered that it was necessary to resort to primary enucleation, while in the last, the foreign body was localised in the anterior ethmoidal air-spaces although the patient gave a very clear history of a wound of the eye and orbit eighteen months previous to his visit to the Ophthalmic Institution. Of the twelve

twelve cases in which the foreign body was successfully extracted, the eyeball was preserved in seven, and in all of these vision, varying in amount, from the power to count fingers, to an acuity equal to  $\frac{6}{9}$  was obtained. In one case after a capsulotomy operation haemorrhage and detachment of the retina occurred, and the eye was subsequently enucleated for sympathetic irritation. (Plate 9 Fig.A.)

In the remaining five cases the eyeball had to be enucleated within a few days or weeks of the magnet operation. In all these cases the cause of the failure was the occurrence of iridocyclitis due to traumatic infection. (Plate 9 Figs.B.C.D.E.F.)

In all these cases the nature of the injury was such that the eye was so seriously destroyed at the time that it was quite unable to recover from the shock, and in three of the cases the eyes were infected by the foreign body at the time of the injury and the cyclitis was purulent.

In the remaining two the eye remained quiet after the operation, but sight was never regained, and in from four to six weeks shrinking of

of the eyeball commenced necessitating enucleation, and in one of these, sympathetic inflammation implicating the optic nerve and characterised by increase of the intraocular tension, occurred within a month of the enucleation.

The Magnet in use at the Glasgow Ophthalmic Institution is one which has been specially designed to combine the advantages of the ordinary Hirschberg's electromagnet with the high traction power of Haab's giant magnet. This large portable magnet can by the attraction of its core lift a mass of iron weighing 2 cwts, but the aim in its construction was to produce an instrument which would attract a small fragment of metal a considerable distance rather than one capable of lifting a very heavy weight. When ready for use it is suspended from the roof of the operating room by two pulleys, and carefully balanced by a counterpoise. Into one end of the core a number of tips varying in size and shape can be screwed, and when it is arranged in the manner just described and connected with an electric main of 250 volts, controlled by a special switch, its manipulation is quite easy. In practice.

practice it is better, however, to have in addition a Hirschberg's magnet at hand, because if the rough edge of a chip of metal become entangled in the iris there is great danger that the large magnet will extract it so rapidly and forcibly that a considerable portion of the iris will also be dragged out at the same time. It is better indeed after the foreign body has been displaced from the deeper parts of the eye into the aqueous chamber, to complete the operation for its removal, with a less powerful instrument. (Plate 10).

The treatment of penetrating wounds of the eyeball always occasions great anxiety. A perfectly aseptic wound is probably met with only in surgical operations, and in the whole body no better culture medium for the growth of germs is found than the vitreous humour. Cyclitis, plastic or suppurative, is therefore a very frequent sequel to penetrating injuries of the eyeball, and the surgeon's anxiety is rendered all the greater by his knowledge that this cyclitis may not only destroy the sight of the injured eye, but may also imperil its neighbour from sympathetic inflammation. The main indications therefore, in the treatment of penetrating injuries of the eye are to prevent infection and to promote

promote the rapid healing of the wound. Obviously when a foreign body has entered the eye the first duty is to effect its extraction, and in the preceding pages I have already spoken of the means at our disposal for this purpose, and the amount of success which is likely to attend our efforts. I shall now confine myself to the treatment of cases where the eye contains no foreign body, or where the foreign body has been successfully extracted.

Wounds of the cornea as a rule admit of a much more favourable prognosis than those involving the sclerotic, but the depth of a wound is always a much more serious matter than its surface extent. That is why puncture wounds are always so disastrous for they not only involve the cornea or sclerotic but they implicate also the iris, ciliary body, and lens. (Plate 11). When the last is wounded it becomes cataractous, and swelling up rapidly as it often does, it acts as a foreign body, and greatly augments the damage done to the eye. Simple wounds of the cornea heal very rapidly. In a specimen, of which I show a microphotograph, the eye was enucleated about four hours after the accident, and already

already the lips of the corneal wound were beginning to be covered by a new development of epithelial cells, and if the reparative process had been allowed to proceed, the cut edges would have united firmly together within a very few days. (Plate 12). The healing of a corneal wound is seen to best advantage after incisions for surgical purposes, and there the union is oftentimes so complete that the scar is only visible on careful examination by the help of transmitted light. It is of the utmost importance therefore that nothing shall intervene to prevent the lips of a corneal wound from uniting accurately the one to the other (Plate 13), hence after an accident the iris which is so apt to have become caught and to prolapse between the lips of the wound, must be carefully excised. (Plate 14). This effects the double purpose of allowing the edges of the wound to approximate accurately and of removing a source through which the micro-organisms might enter the eye to infect its deeper structures, It is altogether different with the sclerotic. Wounds of the sclera always implicate the underlying choroid and retina and even although they may under favourable

favourable circumstances heal quietly, subsequent changes leading to detachment of the retina are very prone to occur and to progress and to terminate in softening of the globe. One reason for this is, that the sclerotic, unlike the cornea, does not unite of itself. Microscopic demonstration has shown that the healing of a scleral wound is brought about in great part by changes occurring in the subjacent part of the choroid as well as by reparative processes taking place in the overlying conjunctival and subconjunctival tissues (Plate 9, Fig.G.& H.) The practical lesson to be learned from this is that in dealing with wounds of the sclerotic no benefit is to be got by suturing the sclera itself. All that is necessary is to suture the conjunctiva in such a way as to prevent gaping of the wound, and to cover it securely, and so prevent, as far as possible, any infection. This is best accomplished as Berry has suggested, by excising a piece of conjunctiva, and drawing the opposite side in the form of a flap over the wound and fixing it in that position by sutures. When the lens has been wounded, it ought to be washed out by

by irrigation with warm sterile saline solution, because if the great bulk of the lens be got rid of at the beginning, there is much less risk of any complication occurring during the healing process. The conjunctival sac having been thoroughly cleansed, the anterior chamber irrigated if necessary and the wound closed, all that now remains to be done is to instil atropine, bandage the eye carefully, and put the patient to bed. The pain which is usually felt just as the patient is recovering from the anaesthetic is often very severe, and is best relieved by the application of ice. If, however, this pain persists, it is well, after twenty four hours, to stop the ice, and apply heat in the form of antiseptic fomentations. The immediate danger is the occurrence of inflammation of the iris and ciliary body which must be moderated and controlled by the free use of atropine. If infection has occurred at the time of the accident, pain is always a very marked feature, - pain deep-seated and throbbing - and within twenty four hours the lips of the wound are infiltrated, the conjunctiva chemosed and the iris discoloured. Under

Under such circumstances the conjunctival sac should be irrigated freely with hot sterile saline solution, which, by washing away all discharge, diminishes the number of the micro-organisms, and so holds the suppurative process in check. The congestion of the eye is diminished, and the pain relieved by snipping the conjunctiva and encouraging the bleeding by hot applications. If, however, infection has penetrated into the interior of the eyeball, these means are of no avail, and inflammation proceeds unchecked. Pain continues and is always marked by periods of exacerbation during the night, the eyeball is exceedingly tender to the touch, the iris is intensely inflamed and a yellowish reflex is seen in the pupil. Very soon pus appears in the anterior chamber, and the condition of the eye is critical in the extreme. But even at this stage the suppuration may be controlled if the interior of the eye be treated by injections of fresh chlorine water (Berry), but as a rule the infection has gone deeper than can be reached safely by any antiseptic injection and the chances are that the eye

eye will be lost from panophthalmitis. Of internal remedies opium and quinine in full doses are the drugs which seem to have the most decided effect in moderating and controlling traumatic inflammations of the eyeball, and in all cases the patient must be well-fed, comfortably housed, and skilfully nursed. Whenever it is evident that sight is to be lost or that the eye is to be attacked by a suppurative cyclitis, it is by far the wisest course to enucleate at once because by that means the patient is not only saved much needless suffering but is protected from the risk of sympathetic ophthalmitis. When, however, suppuration of the eyeball has fairly set in a certain element of danger attends enucleation for there is always a chance of purulent meningitis following the operation. In such cases then it is perhaps wiser to eviscerate rather than to enucleate. Lastly in all cases where the wound is large and gaping and there has been a large escape of vitreous leading to collapse of the globe it is useless to try to preserve the eye which ought to be removed with as little delay as possible. I shall now append a few cases for the purpose of illustrating the main facts which I have tried to expound

expound in this thesis.

1. Case of a simple wound of the cornea:-

E.W., aet.17, was admitted to the Ophthalmic Institution with the history that the spectacle glass of her right eye was broken by being struck with a stone, and that pieces of the glass were driven into the eye. Several of the fragments had been removed by a friend. On examination there was a wound extending from the middle of the right cornea vertically downwards to its periphery and passing through the iris which was prolapsed. There was also a small abrasion of the cornea above the wound, a large subconjunctival haemorrhage in the right upper quadrant of the globe, and a few small superficial wounds of the edges of the lids. The intraocular tension was diminished. A small fragment of glass was removed from the conjunctival sac which was thoroughly douched with a sterile saturated solution of Boracic acid, the iris was replaced and a bandage applied.

The patient was afterwards put to bed. There was very little pain and the wounds healed by first intention.

On

On examination about ten days after the accident, and before she was dismissed from hospital her vision was found to be 1/10th. of the normal standard, and when a suitable correcting glass was prescribed some weeks afterwards the vision was found to be practically normal.

2. Case of a lacerated wound of the cornea with prolapse of the iris:-

V.D., aet.16, was pulling a bottle of herb beer when it exploded in his hand and a fragment of glass struck his right eye inflicting a lacerated wound involving the cornea at its lower aspect. There was a superficial cut also of the sclerotic. The iris was prolapsed, and the anterior chamber was half-full of blood. Vision was reduced to a bare perception of light, the intraocular tension was subnormal. After the conjunctival sac and the skin of the eyelids had been thoroughly disinfected the patient was put under the influence of chloroform and the prolapsed iris carefully and thoroughly excised. The lips of the wound were then placed in accurate apposition, and covered by a flap of conjunctiva

conjunctiva. The healing was painless and uninterrupted, and a fortnight after the accident the wound had perfectly cicatrised, the vision was equal to 1/4th. of the normal standard the diminution being largely due to irregular astigmatism.

3. Case of puncture wound of the cornea, iris, and lens:-

J.G.aet., 8 was climbing through a hedge when he was struck on the left eye by a branch, and a thorn perforated the cornea wounding the lens. When he was brought to the Institution two days after the accident the lens was swollen and completely cataractous. There was no pain nor any sign of inflammation. The lens was removed by irrigation and the patient made an uninterruptedly good recovery.

4. Case of an infected wound of the cornea, with hypopyon:-

N.M., aet.12, was struck on the left eye with a stone. On admission the cornea was ruptured near its centre, the anterior chamber empty, the lens cataractous

cataractous, the pupil was inactive and the tension subnormal. There was oedema and ecchymosis of the lids, and haemorrhage from the left nostril.

The parts were thoroughly douched with hot saturated solution of boracic acid and atropine was instilled. On the following day the pupil had not dilated and there was pus in the corneal wound. The patient was put under chloroform, the lips of the wound cauterised, and the lens removed by irrigation through a superior linear incision. In the course of a week, during which time the eye had been frequently dressed and douched the anterior chamber reformed, the pus disappeared, and the cornea regained its normal appearance except in the region of the cicatrix.

When the patient left the hospital her vision was much impaired, partly due to the corneal cicatrix and partly to the dense lens capsule which occluded the pupil. She returned to the hospital four months later when the lens capsule was removed and a piece of iris excised. As a result of this operation vision was restored to  $\frac{6}{9}$ th. of the normal acuity.

5. Case of an infected wound of cornea rapidly followed by suppurative uveitis:-

A.T., aet.10, on returning from school was struck on the right eye by a belt. The cornea was ruptured. He was first seen two days later when the corneal wound was infiltrated, there was pus lying on the iris and a yellowish exudate was mixed up with the cataractous lens. The eyeball was intensely inflamed and exceedingly painful. After the eye had been thoroughly cleansed the wound was reopened and freshly prepared chlorine water was injected into the interior of the globe, pus and lens matter were washed out, but it was evident that the deep parts of the eye were seriously involved in the suppuration and it was found necessary therefore, twenty-four hours afterwards to eviscerate.

This operation was followed by immediate relief to all the symptoms and the healing process proceeded smoothly. There is now a good stump upon which an artificial eye has been fitted and the movements of the prothesis are thoroughly satisfactory.

Synopsis of those cases which I have X rayed and in which a foreign body has been found

Case	Age	Sex	Occupation	Eye injured	Appearances presented by eye	Interval of time between accident and admission	Result of Skiagraphy	No. of Plate	Treatment	Nature and size of F.B.	Result of Treatment
I.	39	M.	Pipelayer	Right	Corneal wound; prolapse of iris; lens cataractous T.-. No fundus reflex.	Five hours	X ray photo taken 7 days after admission demonstrated F.B. in Vitreous.	Pl.15 Pl. 9 Fig.B	Snell's electro-magnet gave negative result on admission. F.B. extracted by Hirschberg's magnet seven days after accident.	Iron 6mm.x3 $\frac{1}{2}$ mm.	Enucleation on account of suppurative choroiditis.
II.	24	M.	Steelsmelter.	Left	Penetrating corneal wound; A.C.empty; lens cataractous No fundus reflex.	Six hours.	Foreign body in lens about its centre	Pl.16	Wound enlarged and F.B. extracted by Hirschberg's magnet. Lens removed by irrigation.	Steel 1mm.x $\frac{1}{2}$ mm.	After optical iridectomy V L c correcting glass = $\frac{6}{12}$ and J4.
III.	19.	F	Farm Servant	Left	Penetrating corneoscleral wound; Iris prolapsed; conjunctival haemorrhage. No fundus reflex.	Twenty-four hours.	F.Bs. visible in neighbourhood of eye but as localising apparatus was not perfected it was doubtful whether or not a pellet had lodged within the globe.	Pl.17	Prolapsed iris excised; lens removed by irrigation	Lead pellet No.4 shot.	Enucleation 10 days after on account of acute cyclitis when one pellet was found in ciliary region.
IV.	28	M.	Collier	Right	Choroiditis with large atrophic patches; floating bodies in vitreous and atrophy of optic nerve.	Eight years	Large foreign body in ethmoidal air-spaces.	Pl.18	No operation attempted	Said to be lead 12mm.x10mm.	

Case	Age	Sex	Occupation	Eye injured	Appearances presented by eye	Interval of time between accident and admission	Result of Skiagraphy	No. of plate	Treatment	Nature and size of F.B.	Result of treatment.
V.		M	Blacksmith	Right	Deep penetrating corneo-scleral wound; iris prolapsed. T-.	Three hours	Foreign body in upper and back part of Vitreous	Pl.19 Pl. 9 Fig.E.	Extraction by Hirschberg's magnet through a small sclerotic incision.	Steel 7mm.x3mm.	Enucleation 3 months after accident.
VI.	26	M	Iron-turner	Right	Cyclitis; lens cataractous, iris discoloured.	Sixteen months	F.B.in lens	Pl.20	Lens and F.B. removed by irrigation and skiagram after operation showed no F.B.	Steel	
VII.	15	M	Apprentice Blacksmith	Left	Punctured wound of upper lid at inner aspect and deep scleral wound. Lens unaffected.	Three hours	F.B.in vitreous	Pl.21	Magnet exploration of eyeball negative.	Cartridge Casing (Copper) 5mm.x2mm.	Enucleation 3 days after accident.
VIII.	38.	M	Quarryman	Left	Linear wound about 7mm.long at lower and inner corneo-scleral margin; large prolapse of iris and ciliary body V = faint, P.L.	Thirty-six hours	F.B.in vitreous said to be granite.	Pl.22	Primary enucleation owing to the collapsed condition of the eye.	Steel 8mm.x5mm.	

Synopsis of those cases which I have X rayed and in which a foreign body has been found

Case	Age	Sex	Occupation	Eye injured	Appearances presented by eye	Interval of time between accident and admission	Result of Skiagraphy	No. of plate	Treatment	Nature and size of F.B.	Result of treatment
IX.	24	M	Miner	Right	Corneal wound the result of an explosion; globe semi-collapsed.	Twenty-four hours	F.B. in vitreous	Pl.23	Primary enucleation	Cartridge Casing (Copper) 7 mm.x3mm.	
X.	31	M.	Soldier	Left	Eye painful and tender to touch; pupil small and irregular pus in A.C.; no details of fundus; vision nil.	Twenty-seven years	Small F.B. in ciliary region	Pl.4 Fig.C	Enucleation	Steel 2mm.x1½mm.	
XI.	36.	M.	Ironworker	Left	Corneal cicatrix; anterior synechia pupil small and irregular; lens cataractous; T.n; P.L. good.	six months	F.B. in lower and outer quadrant of the globe immediately behind the cataract.	Pl.24 Pl.9 Fig.A.	F.B. extracted by large Electro-magnet	Steel 5mm.x 4mm.	Capsulotomy 4 months after extraction of F.B. followed in 10 months by haemorrhage after a second capsulotomy. Enucleation.
XII.	22	M.	Baker	Right	Eye divergent; lens cataractous. History of previous injury by chip of metal.	Ten years	F.B. in ciliary region.	Pl.25	Large electro-magnet failed to extract F.B. Lens removed		Vision improved but a second skia-gram shews F.B. in same position as before.
XIII.	30	M.	Miner	Left	Wound of left upper lid; deep penetrating wound at corneo-scleral margin, A.C. deep; hyphaema T-	Twenty-four hours	F.B. in vitreous.	Pl.26	F.B. extracted by large electro-magnet.	Iron 5mm.x5mm.	Enucleation on account of shrinking of Eyeball and sympathetic inflammation.
XIV.	21.	m.	Stonecutter.	Left	History of injury; iris discoloured pupil irregular lens cataractous. T.n. P.L. good.	Two months	F.B. in vitreous	Pl.27	F.B. drawn through lens into A.C. by large magnet then extracted by small magnet	Steel 2½mm.x1½mm.	Useful vision.

Case.	Age	Sex	Occupation	Eye injured	Appearances presented by eye	Interval of time between accident and admission	Result of Skiagraphy	No. of plate	Treatment	Nature and size of F.B.	Result of Treatment
XV.	14	M.	Schoolboy	Left	Punctured wound of cornea iris & lens.	Three hours	Round F.B. in ciliary region	Pl.28	F.B. felt with probe but could not be dislodged, Primary enucleation.	Lead pellet. No.6 shot.	
XVI.	21	M.	Ironworker	Right	Corneal wound; A.C. empty.	Five hours	F.B. in vitreous	<del>Pl.29</del> Pl.4 Fig.B	F.B. extracted by large electromagnet	Iron 7mm.x3mm.	Enucleation in four weeks for Iridocyclitis.
XVII.	28	M.	Quarryman	Left	Deep penetrating wound of Sclerotic the result of a blasting explosion.	Twenty-four hours	F.B. in vitreous	Pl.30	Primary enucleation.	Stone	
XVIII.	17	F.	Pithead worker	Left	Penetrating wound at upper and outer aspect of cornea; iris torn; hyphaema; lens cataractous; tenderness in ciliary region; V= l & s.	Seven days	F.B. in ciliary region	Pl.30 Pl.4 Fig.A	Primary enucleation	Cartridge casing (Copper)	
XIX.	35.	M.	Boilermaker.	Left	Large vertical corneal wound; iris prolapsed and torn; lens cataractous.	Eight hours	F.B. in vitreous	Pl.32	Large electromagnet failed to extract F.B.	Hardened white lead 6mm.x5mm.	Enucleation after unsuccessful attempt to remove F.B. with forceps.
XX.	47.	M.	Ironmoulder	Right	Admitted suffering from cyclitis, said to be the result of an old injury.	Four years	F.B. lying on lachrymal bone	Pl.33	F.B. extracted by large electromagnet.	Iron 8mm.x5mm.	

Case	Age	Sex	Occupation	Eye injured	Appearances presented by eye	Interval of time between accident and admission	Result of Skiagraphy	No. of Plate	Treatment	Nature and size of F.B.	Result of treatment
XXI.	20	M.	Irondresser	Left	Wound of lower lid corresponding wound at lower and inner side of cornea. A.C. full of blood. Iris prolapsed T-.	Five hours	F.B. in vitreous at lower part of globe	Pl. 34 Pl. 9 Fig. D.	F.B. attracted to wound by large electro-magnet and extracted by small magnet	Steel 10mm. x 6mm.	Enucleation on account of shrinking of injured eye and threatened sympathetic irritation in the other.
XXII.	28	M	Machinist	Left	Central wound of cornea; lens cataractous. T-.	Twenty-four hours	F.B. in ciliary region	Pl. 35.	F.B. not attracted by large magnet	Steel firmly insulated in ciliary region. 3mm. x 2mm.	Enucleation 7 weeks after accident.
XXIII.	23	M.	Steelworker	Right	Oblique wound in upper ciliary region with prolapse of ciliary body.	Three hours	F.B. in ciliary region	No plate, examined by screen only.	F.B. seen and extracted by forceps. Primary enucleation.	Steel 12m x 7mm.	
XXIV.	36	M	Engine-fitter	Left	Wound in lower and outer part of cornea; iris engaged in wound; lens cataractous; T-.	Two hours	F.B. in vitreous immediately behind the lens	Pl. 7	F.B. extracted by large electro-magnet	Steel 6mm. x 1 1/2mm.	Still under treatment and doing well
XXV.	34	M	Riveter	Right	Wound at lower and outer part of cornea in which the iris is caught; pupil oval shaped; Hyphaema; T.-	Six hours	F.B. in vitreous at lower part of globe	Pl. 36	F.B. extracted by electro-magnet	Iron 5mm. x 4mm.	Still under treatment and doing well.





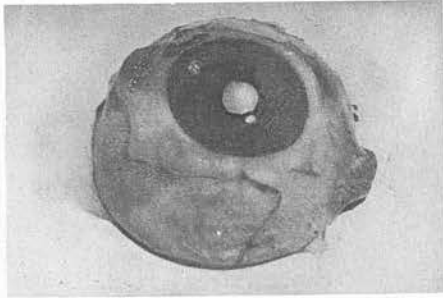


FIG. A

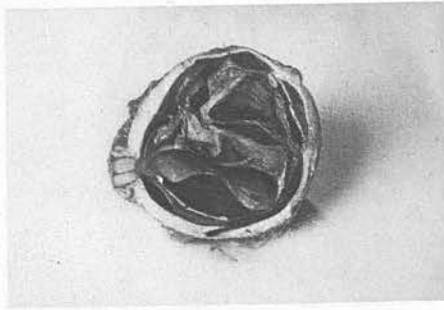
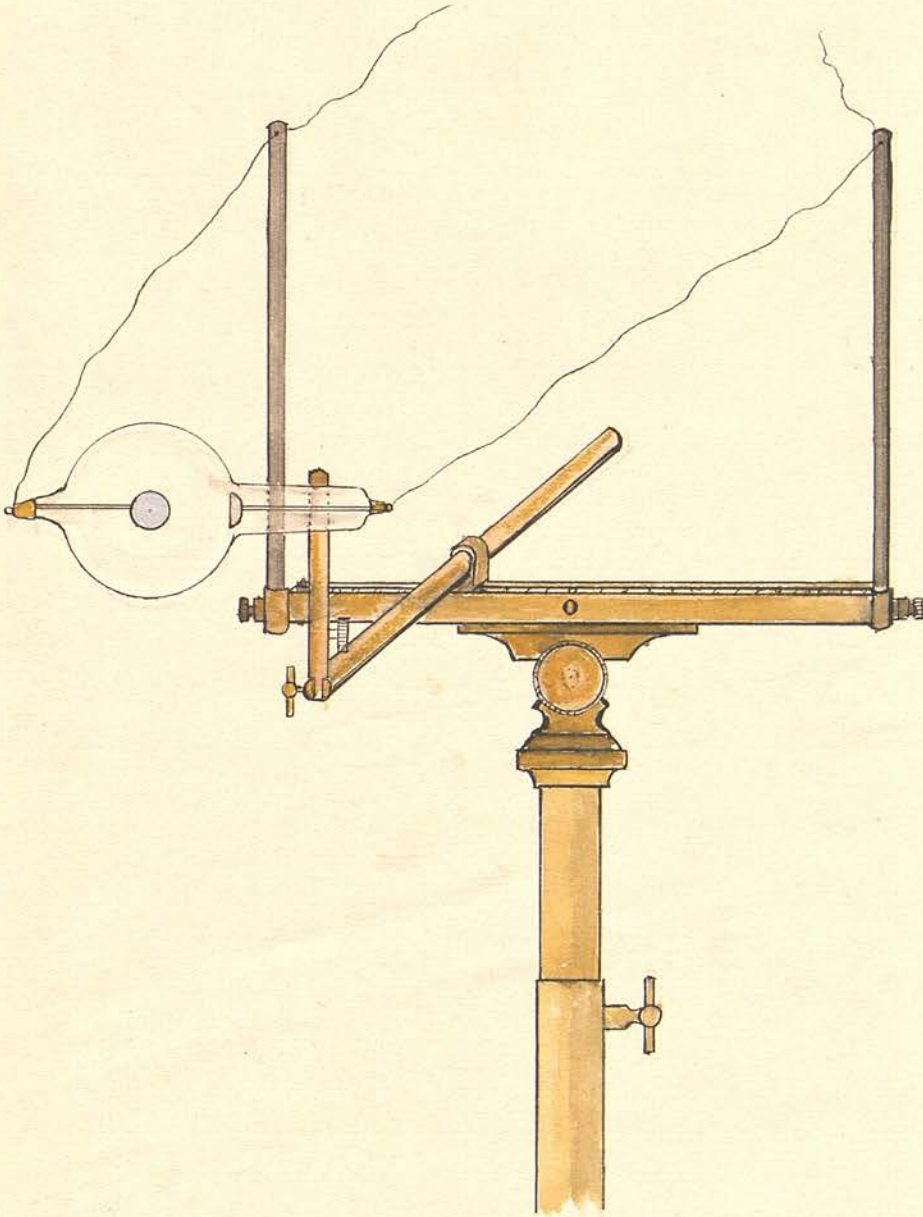


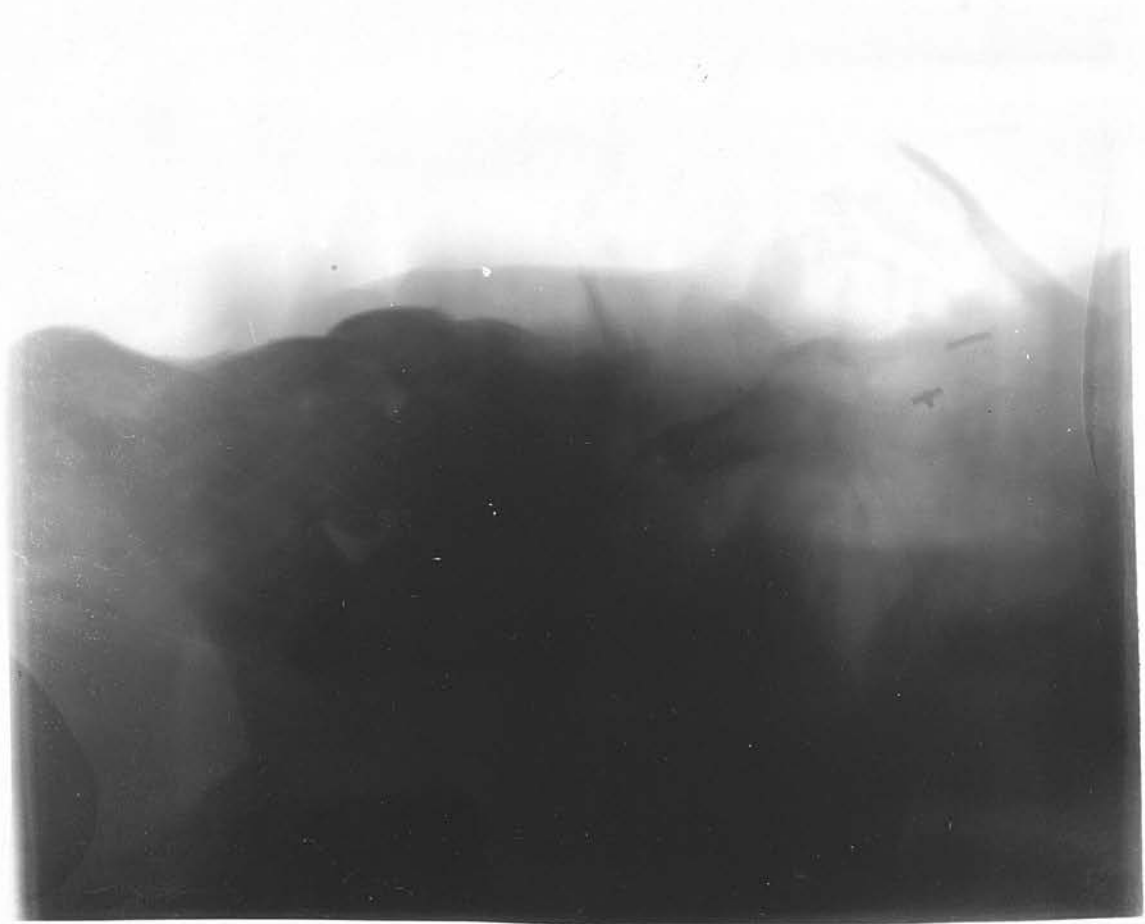
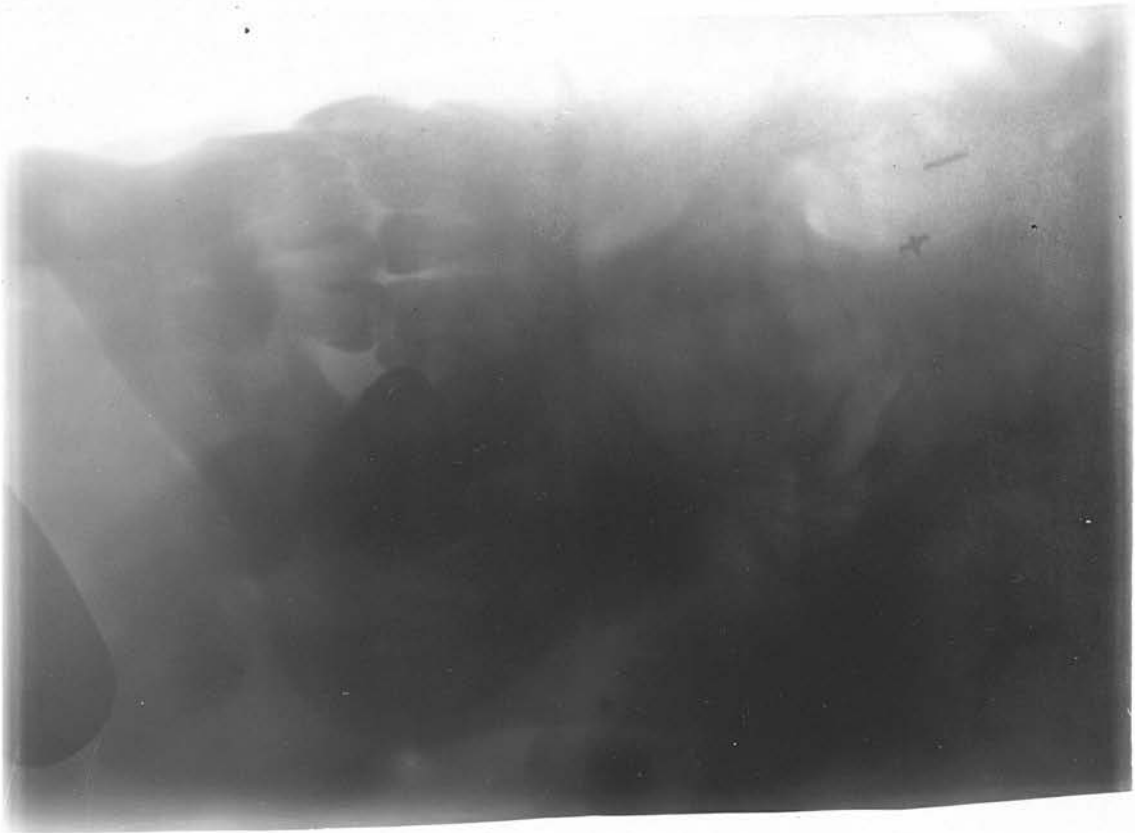
FIG. B

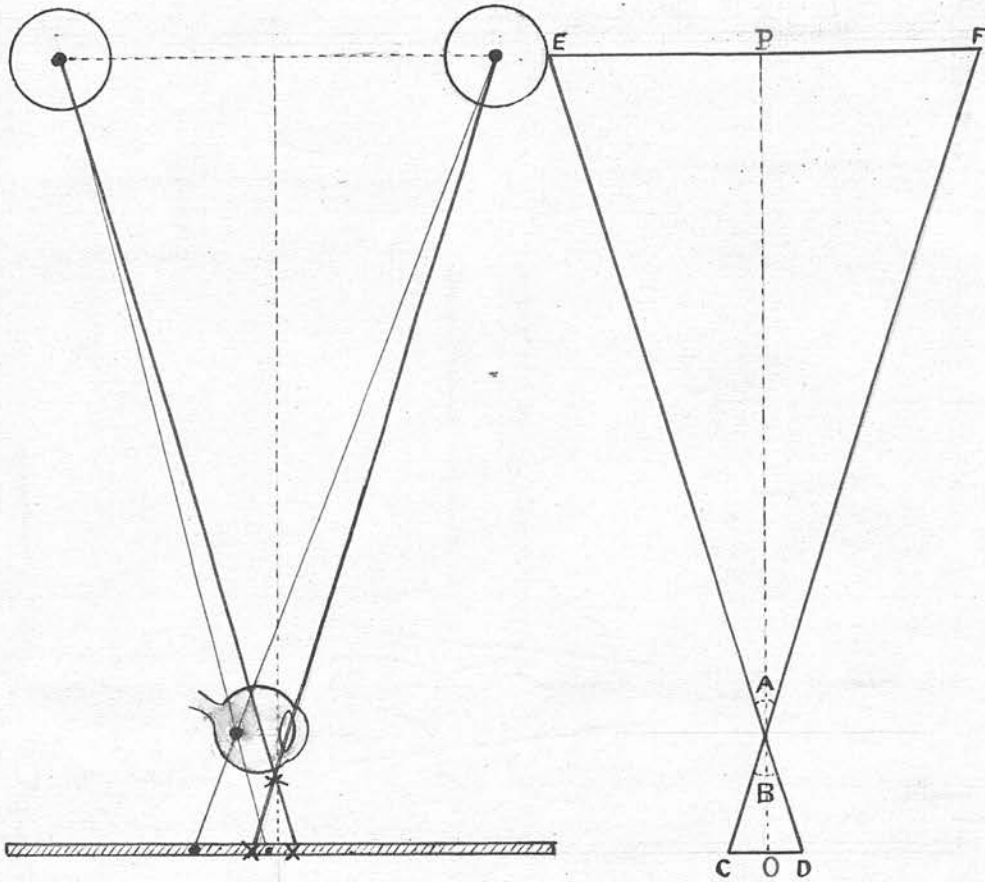


FIG. C









The calculation for the determination of the distance of the foreign body from the plate, or fixation mark , is as follows:-

$$CO : OB :: FF : PA$$

$$DO : OB :: EP : PA$$

$$CD : OB :: EF : PA$$

$$OB = \frac{PA \times CD}{EF}$$



FIG. A

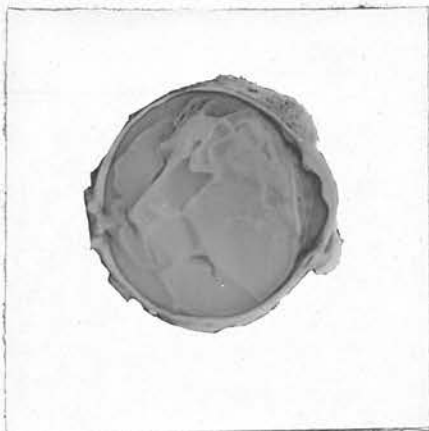


FIG. B

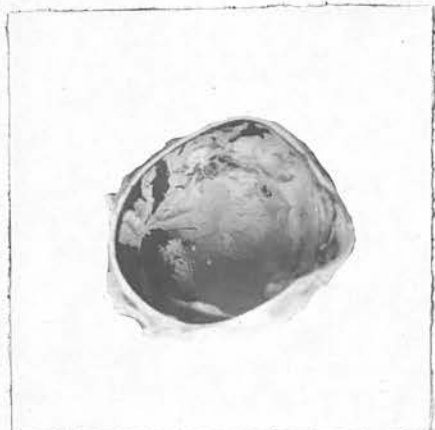


FIG. C



FIG. D

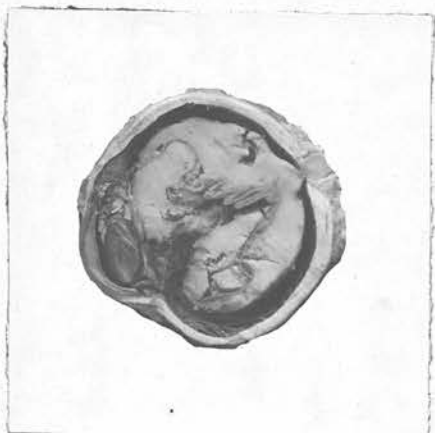


FIG. E

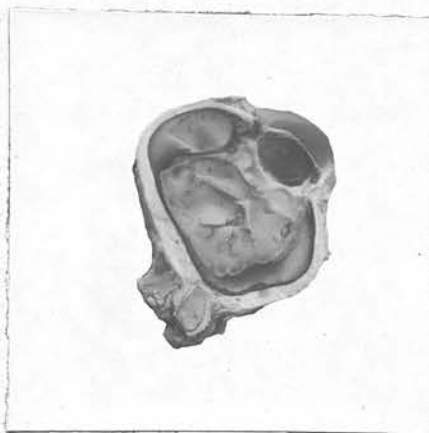


FIG. F



FIG. G

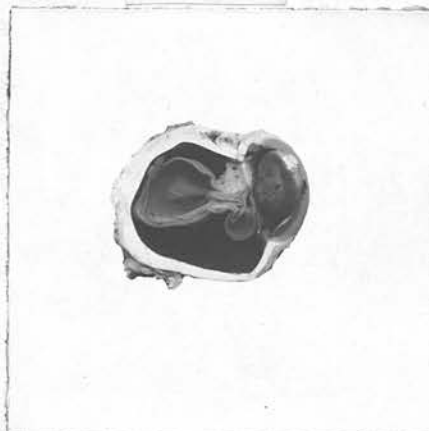


FIG. H





