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INTRA-OCULAR FOREIGN BODIES*

Problems of localisation and
operative procedure

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Introduction

NOT until this War did the vital importance of the posterior route approach for the extraction of intra-ocular foreign bodies become apparent. The method was not used to any large extent in Britain prior to the War and only to a limited degree elsewhere, but with the advent of new materials of low magnetic properties in the manufacture of instruments of war, and munitions, the posterior route has become the method of choice, except, of course, when the F.B. lies anterior to the lens. Nor is the method likely to fall into disuse after the war, for the employment of metallic alloys of low magnetic properties will extend into peacetime industry and thus experience gained in war should stand us in good stead in peace.

We approach the problem in the full knowledge that contributions have already been made towards a solution in the form both of localisation and operative technique. Advance has been made, but the fact that doubts and queries are constantly being raised, both in conversation between those of us who are together and in correspondence between those of us who are in different theatres

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of war, is enough evidence that unanimity has not been reached on what might be accepted by the majority as the ideal.

The object of this paper, therefore, is first to review what has been done to date, secondly to offer an explanation as to why present methods, because they are scientifically inaccurate, sometimes fail, thirdly to describe a new method of localisation and finally to set out in detail what we believe, in the light of present knowledge, to be the best procedure.

In doing this we realise that much that may be written has already been stated and will be already well known, but to get a complete picture we feel it is essential.

Localisation.—About thirty methods for localising intra-ocular F.B.'s have been devised, some merely fractional variations of others and they have been lucidly classified into six groups in Vol. III of "A Text Book of X-ray Diagnosis" by British Authors.

We would mention only the two of which we have experience and are being employed to any great extent, namely Sweet's Localising Apparatus and the "limbal ring" method. Of the two there is little doubt that Sweet's is the more accurate but depends on a somewhat complicated and delicate apparatus, of necessity only to be found at a well equipped base hospital. Also when the localisation has been made, the surgeon is presented with a chart showing the exact position of the F.B. but not with a definite measurement, he can make from a fixed point on the globe to that point on the sclera which is nearest to the F.B. he wishes to extract. Nor does it take into account the variation in size between a bigger and a smaller eye, so that a F.B. localised by Sweet's Method to be say on the retina or just outside the globe might require a double exposure X-ray with movement to determine whether it were inside or just outside the globe.

The "limbal ring" method (introduced to the Middle East by C. W. Graham) has the great advantage of simplicity and, in our experience, has worked reasonably well in a high percentage of cases, especially if the radiologist and his staff have been in the habit of dealing with a large number. It has been and still is of great value, but we believe it is not accurate enough when dealing with intra-ocular F.B.'s of low magnetic quality, or non-magnetic F.B.'s. It depends on measurements compared with those of a standard size eye, and though the picture with movement shows whether the F.B. is within or outside the globe (except those situated in Tenon's capsule or an ocular muscle), it does not give an accurate measurement of the distance from the limbus to the incision point on the sclera. It is possible for there to be a very large error in this respect, the importance of which will be revealed in the sections on magnet and diathermy to follow. Even with

a full set of rings it is sometimes impossible to get a perfect fit at the limbus and the mere fact of stitching a ring into position is sometimes interpreted by the nervous patient as an operation and enough to upset him and make the X-ray examination more difficult. Finally, it is sometimes necessary to make several exposures before a true lateral and true postero-anterior view are obtained and the error of rotation of the globe creeps into the picture with movement.

For these reasons we consider that localisation up to now has not been entirely satisfactory, and we submit for consideration

the following method. We believe this method gives the exact position of the F.B. in the particular globe to be operated upon, and also the exact position on the sclera where the incision must be made to be in the closest proximity to the F.B. These measurements produce the optimum conditions for a successful extraction.

There is no need to describe the apparatus in detail as the photographs are self-explanatory. The main principles are as follows:—

(1) A head rest with clamping devices attached, to attain complete immobilisation of the head.

(2) Attached to the forehead cross bar is a small unit designed to work to fine adjustment and carrying the indicators L and F (Fig. 1) which can be moved laterally, up and down, and to and

from the eye. These indicators are partly of radio-opaque and partly of non radio-opaque materials.

(3) X-ray cassette holders, and perimeter with spot light.

What follows immediately is purely technical, but is of necessity inserted to explain the geometry of the calculations for those who may be interested. The practical application follows later.

To localise the intra-ocular F.B. and the incision point on the sclera nearest the F.B., one lateral with movements and one postero-anterior X-ray pictures are necessary.

FIG. 1.

FIG. 2.

FIG. 3.

FIG. 4.

To find the diameter of the eye three lateral exposures are taken on the same film, first with the eye looking straight forward, secondly upwards, and thirdly downwards. For each exposure the indicator "L" is placed in contact with the cornea at the centre of the pupil and the scale attached to the indicator shows any magnification, so that true measurements in millimetres can be calculated (Fig. 2). The degrees of upward and downward movement need not, of course, be the same.

The eye has to be assumed to be a sphere tilted between the three exposures about its dead centre and a fixed centre is defined when the head is in a fixed position. The points A, A1, and A2 being given on the films by the indicator, the centre "O" and the radius "R" of the sphere can be easily found according to the laws of elementary geometry (Fig. 3). The centre "O" is at the intersection of perpendiculars dropped from the midpoints of A.A1, and A.A2, and the radius is calculated from the formula.

$$R = \frac{S^2 + 4h^2}{8h}$$

Where "s" is the distance A1 A2 and "h" is the distance AC (Fig. 3), but practically it is enough to measure from centre "O" to A, A1 or A2. The distance "a" of the F.B. from the equatorial plane "E" can now be found (Fig. 3). The distance "b" of the F.B. from axis of the eye and the meridian in which it lies is found from the postero-anterior picture (Fig. 4). This picture is taken with the eye looking straight forward and the indicator "F" in contact with the cornea at the centre of the pupil. The film shows point "A" indicating the axis of the eye, a line at 12 o'clock to give the orientation and a scale from which true measurements in millimetres can be calculated.

To find the distance "y" between the point "P" (on the

surface of the sclera and nearest to the F.B.) and the centre of the cornea "A" as well as the distance "z" of the F.B. from the incision point, we imagine a section of the eye containing the optical axis and the F.B., therefore including "P" and a

FIG. 5.

FIG. 6.

meridian "M" which crosses the equatorial line at "T" (1 hr. 15 min. Fig. 4) and naturally the pole (centre "A" of the cornea—Fig. 5).

Fig. 6 shows how the distances of "y" and "z" can be found graphically from the postero-anterior view and that lateral view with the eye looking straight forward, both being drawn on the same scale (if necessary enlarged or reduced). The distance "y" and "z" should be calculated as follows, using "r" the distance between the F.B. and the centre "O."

$$r = \sqrt{a^2 + b^2}$$

$$y = \sqrt{R + \frac{aR}{r}}^2 + \left(b \frac{R}{r}\right)^2 = \frac{R}{r} \sqrt{(r + a)^2 + b^2}$$

$$z = R - r = R - \sqrt{x^2 + b^2}$$

R=Radius of the eye (Fig. 3).

r=Distance of F.B. from the centre "O" (Fig. 6 III).

a=Distance of F.B. from the equatorial plane "E" (Fig. 3).

b=Distance of F.B. from the optical axis (Fig. 4).

z=Distance of F.B. from the sclera, i.e., "P" (Fig. 6 III).

y=Distance of incision point "P" from centre of the cornea (Fig. 6 III).

1. Lateral view looking straight forward.
2. Postero-anterior view (perpendicular to equatorial plane "E" (II-II)).

3. The contents of the eye seen in the direction of the arrow, representing a section perpendicular to the plane (III-III) which contains the optical axis and the F.B.

Now all the foregoing is purely technical, and what the Ophthalmologist wants, providing he is satisfied that the scientific explanation is correct, is the practical application in as simple a form as possible.

Perhaps the best way is to tackle the X-ray films first. The lateral view shows the indicator "L" and the millimetre scale in three positions, the point of the indicator we know being in contact with the centre of the cornea at each exposure and also it shows the shadow of the F.B. in three positions.

Join by lines on the actual film the end of the indicator in its three positions in contact with the cornea. (A with the eye looking straight forward, A1 with the eye looking up, and A2 with the eye looking down.) Bisect those lines (A1A and A2A) by perpendiculars which will intersect at the exact centre of the eye "O." Draw a circle with centre "O" and radius OA. This circle will naturally pass through A1 and A2 and is the circumference of the eye.

From this you get "R" (the radius of the eye) and the distance "a" of the F.B., in front of or behind the equatorial plane (Fig. 7—F.B. behind the equatorial plane). The F.B. shadow taken is, of course, the one shown when the eye is looking straight forward. Reduce these two measurements "R" and "a" to actual millimetres by comparing any magnification or otherwise with the set scale, also shown on the film.

Now take the postero-anterior view and on this film will appear the central mark of the indicator "F" at "A," a marker at the 12 o'clock meridian for orientation and the shadow of the F.B. Join the 12 o'clock indicator and "A." Describe a circle of any

FIG. 7.

FIG. 8.

radius with a centre at "A." Join this centre "A" with the shadow of the F.B. and prolong to the circumference of the circle. The crossing point of this line and the circumference of the circle gives the exact meridian in terms of a clock face in which the F.B. lies (Fig. 8).

Measure the distance from "A" to the F.B., this will be called "b," and reduce to actual millimetres. This measurement together with the meridian in which the F.B. lies is all one requires from this X-ray film. So that to sum up, from the two X-ray films one can obtain:—

1. Radius of the globe.
2. Distance "a" of F.B. in front of or behind the equatorial plane.
3. Meridian in which F.B. lies from the centre of the eye.
4. Distance "b" from the centre of the eye.

N.B.—All these measurements are of the actual eye, as opposed to other methods which presume a standard eye of 12 mm. radius.

These measurements have been reduced to actual millimetres after allowing for magnification by reference to the scale attached to each indicator.

Now for the plotting. It is easier to work to a large scale and therefore we suggest doubling the measurements already ascertained and dividing the final results by 2. For this reason when distances are referred to, it will be understood they are doubled before plotting (Fig. 9). On a piece of paper describe a circle of radius "R" and "AO" the centre. Mark the 12 o'clock meridian. Along the circumference mark the meridian in terms of the clock face in which the F.B. lies (in the diagram 1 hr. 15 min.), and join this point with centre AO. From the centre AO along the meridian line in which the F.B. lies, measure the distance "b" and mark F.B. From AO and F.B. draw perpendiculars from the meridian line.

FIG. 9.

On the perpendicular from AO describe another circle of "R" radius sufficiently far distant from the first not to overlap. Let the centre of this circle be "O1." Where this circle cuts the perpendicular AO-O1 will be the centre of the cornea "C." Measure from O1 the distance "a" and call it "D." From "D" draw a perpendicular. Where this cuts the perpendicular already drawn from F.B. (in the first circle) is the real position of the F.B. in the eye. Call it F.B.1. Join O1, and F.B.1, and prolong to the circumference of the circle. There you get a point. Call it "P." Distance "P" F.B.1 equals nearest distance of the F.B. to sclera ("Z"). PC equals distance from the centre of pupil to incision point on the sclera ("y"). To get the distance of "P" from the limbus, deduct the radius of the cornea from PC ("y").

The distance "a" has to be measured either in front of or behind O1 according to whether the F.B. lies anteriorly or posteriorly to the equatorial plane "E," which will be determined from the lateral X-ray film.

If the localisation shows the F.B. to be in a position where

First, in addition to surface anaesthesia a retrobulbar injection of novutox 2 per cent., to which has been added an extra few minims of adrenalin should be given with the object of lowering intra-ocular pressure as well as the anaesthetic effect. Secondly, a facial nerve block at the angle of the jaw or local infiltration of the orbicularis at the external canthus. Subconjunctival and sub-Tenon injections, in our opinion, should not be given as they tend to complicate future procedure by disturbing anatomical relationships, increase haemorrhage and add to the difficulty in preparing a completely dry and bloodless field of operation, a point so important in the proper use of diathermy.

After insertion of the speculum and just prior to the conjunctival incision extra surface anaesthesia may be obtained if necessary

Fig. 11.

by holding a pledget of cotton wool soaked in 5 per cent. cocaine with adrenalin on that part of the conjunctiva about to be incised.

As regards the type of speculum to be used, one relieving the globe of all pressure is the best, such as the Arruga, but a much simpler and lighter one is the Oláh (Fig. 11).

Hereafter the operative technique resembles to some extent that already described by Stallard, but of necessity, modified to suit the new localisation with an alteration in the area of diathermy application and a different scleral stitch, the importance of which will become apparent when we come to the actual use of the magnet. We feel therefore that it will not be out of place to spend a moment or two in describing the various stages in some detail.

Mark the meridian on the actual limbus and "o'clock" exactly opposite, *e.g.*, 3 and 9, 5 and 11, 8 and 2, using dividers and a marking needle. Insert a fine silk suture at the mark on the limbus exactly opposite to the already marked meridian (Fig. 12). Tie,

leaving one end about $3\frac{1}{2}$ cms. long. This suture should be greased with sterile vaseline to prevent damage to the corneal epithelium later.

Insert a silk suture in the form of a mattress suture by taking a good bite of conjunctiva, episcleral tissue and if possible the

FIG. 12.

FIG. 13.

sclera about 3 mms. from the limbus, and with one arm on either side of the point marking the line of the meridian in which the F.B. lies (Fig. 13).

This holding suture can be clamped by artery forceps to the head towels, as the traction upon it may need to be varied from

time to time, thus altering the degree of rotation of the globe until the moment arrives to incise the sclera, when it should be used to bring that area of the sclera to be incised as near pointing vertically upwards as possible.

Dissection of conjunctival flap.

It is a mistake to attempt the operation through a small incision, as room is required for manoeuvre and for marking out accurately the required place and size of the scleral incision. Through all the tissues down to the sclera cut a flap, the apex of which points towards the limbus, the base at least 10 mms. broad, and the long axis roughly in the line of the meridian in which the F.B. lies. The apex should be at least 4-5 mms. nearer the limbus than the anterior end of the proposed scleral incision (if possible), and the base should be a few mms. behind the posterior end of the proposed scleral incision. Reflect back together with Tenon's capsule and episclera. Fix the flap with two or three holding sutures clamped to the head towels with artery forceps. Dry the whole field thoroughly, stopping all bleeding points by actual cautery, and see that the bare sclera is exposed without any tags of episcleral tissue adhering to it, that might interfere with a proper application of the diathermy.

Draw the fine silk suture inserted at the time of marking the meridian, taut across the cornea passing exactly over the marked meridian and held in close apposition to the sclera. The assistant now marks on the sclera with dividers and marking needle a point

FIG. 14.

at the already known distance between the limbus and the nearest point on the sclera to the F.B. in the line of the silk suture still held in position, he makes two marks each equidistant anteriorly and posteriorly from the first mark, to show the size of the proposed scleral incision (Fig. 14). This will depend on the size and the shape of the F.B., and also the depth at which it lies in the vitreous. (The deeper the F.B. lies, the larger the scleral incision required—see magnetic principles.) The fine silk suture can now be removed.

Diathermy.

Two mm. lateral to each marked point on the sclera and on both sides, surface diathermy is applied (Fig. 15) approximately 100 mps. for 2 seconds (see explanation in diathermy principles). The result should be a coagulation showing bluish-grey like parchment.

FIG. 15

FIG. 16.

To prevent overheating cool with distilled water (a bad conductor), after three applications.

It should be noted that the power in every diathermy machine is variable during operation, so that the amperemeter and result

of coagulation on the sclera must be watched—Fig. 16 shows diathermy points, insulated flush to the end of the metal core which is 1 mm. in diameter.

Scleral incision.

With a Tooke's corneal splitter incise the sclera to a depth of $\frac{3}{4}$ of mm. along the line of the previously marked three points. Take two double-threaded 6/0 catgut sutures on small needles and insert through the lips of the scleral wound from within outwards, spacing evenly and leaving a large intermediate loop on each (the Mersature eyeless are best). These will be referred to as the omega stitches (Fig. 17).

FIG. 17.

With the Tooke's corneal splitter complete the division of the sclera down to the choroid. The assistant takes between the thumb and forefinger of one hand the free ends and corresponding sides of the loops and with the other hand in the same way the other free ends and corresponding sides of the loops, applying gentle traction in an upward and outward direction from the line of the scleral incision (Fig. 18); with a narrow Graefe knife, blade upwards cut the choroid in the same way as an incision for corneal section. The omega stitches must not be released by the assistant until they are required for closing the scleral wound. See that all magnetic instruments are removed.

Place the magnet in position and by foot switch give interrupted applications of two seconds duration at two second intervals. If the F.B. is not extracted after about fifty applications, it is useless to go on (see magnetic principles).

FIG. 18.

Now the assistant hands over one of the omega stitches, and both surgeon and assistant together release the loops, at the same time drawing the free ends apart thus converting each omega stitch into a normal suture. Both sutures are tied at the same time, one by the surgeon, and one by the assistant in a surgical knot, and the ends not cut too short.

Replace the conjunctival flap, having removed its holding sutures and sew into position with a continuous silk suture without knots and leaving a few mms. of free end at the limits of the wound. Remove the final holding suture. Dressings will be according to individual choice, but both eyes should be bandaged and nursing for the first ten days should be as for retinal detachment.

If a muscle has to be divided a "W" stitch is used. This consists of silk threaded through three needles, one at either end, and one at the middle. The middle needle is passed through the

FIG. 19.

centre of the muscle and the needles at each end, 1 mm. internal to the edges (Fig. 19).

Principles of diathermy.

The decision to be made is, what strength of current and what time of application has to be used to avoid complications and at the same time give the required result. That required result has only to be a circumscribed adhesive choroido-retinitis which will lead to adhesion between retina, choroid remains and sclera. For this reason it is not necessary to "cook" a large part of the globe, a process which, as will be explained later, in addition to producing a sero-fibrinous choroido-retinitis, results in opacities and traction bands in the vitreous and coagulation around the metallic F.B., liable to lead to secondary detachment of the retina.

Let us consider the electrical facts resulting from application of a diathermy current (high frequency) to the surface of the sclera. When the electrode is placed in contact with the surface of the sclera and the current is switched on, because the eye is not one even resistance but a combination of multiple unequal resistances, the current will flow according to the law of Kirchhof.

The sclera offers to the current a bigger resistance than other parts of the eye so that the thermal effect will be greater here than elsewhere in the eye (according to the well known laws of repartition of energy in a conductor composed of materials of differing resistances).

Applying the law of Joule ($I^2 \times rt = KH$). Where I = current in amps, r = resistance in ohms, t = time, H = produced calories, K = constant, we find that by doubling the current the same thermal effect in calories is produced in one quarter of the time. Using therefore a stronger current we get a more complete coagulation in a shorter time than by using a weaker current. This coagulation increases the resistance of the sclera to heat conduction. A condition which is required.

By using high frequency current there will be built up in the vitreous a di-electrical field, whereas in the F.B. (metal and a good conductor), there will not occur a di-electrical field and for this reason the greater part of the electrical energy will be concentrated in the metallic F.B., resulting in the production of heat and consequent coagulation around it.

If a body of higher temperature is placed in contact with a body of lower temperature, following the physical law that the temperature tends to equalise, heat will increasingly penetrate the body of lower temperature, but this requires time. In practice that part of the heat which in the process of dissipation tends to penetrate the eye is what we wish to avoid. As the coagulated sclera is a dehydrated tissue it is more heat resistant than the air and surrounding normal tissue.

By applying the diathermy electrode for 6 secs., the produced heat has a greater opportunity of penetrating into the vitreous than if the electrode is applied for one or two seconds only, and this is not proportional to the degree of produced heat. As an example, if we touch the skin for a fraction of a second with white hot metal (approx. 1,000 degrees), a severe but superficial burn will result. Whereas by touching the skin with dull red hot metal (approx. 500 degrees), for a second or longer, the result will be a deep necrosis.

The conclusions to be drawn from this are by using a smaller current for a longer time there could be produced a sero-fibrinous choroiditis with attendant vitreous opacities from the deep coagulation of the tissues and into the vitreous. By a longer application of the current the heat produced will have a greater opportunity of penetrating deeper into the globe and could also be the cause in bigger or smaller degree of vitreous opacities. (We must think always in terms of a circumscribed, sterile, inflammatory process and not in terms of a spreading bacterial or toxic one, *i.e.*, the changes remain practically localised to that degree and area which we have affected by the diathermy.) Too high a strength of current will produce burning which is in every way undesirable.

Most diathermy apparatus in use depends on the high frequency current being produced by spark gap electrodes. The greater the distance between the spark gap electrodes the longer the spark. The shorter spark gives higher frequency and lower voltage, a longer spark will give higher voltage and lower frequency. These two factors, frequency and voltage, determine the kind of coagulation. The optimum length of spark cannot be given dogmatically for every apparatus and must be ascertained empirically for each individual one. The best way of doing this is by the use of a pig's eye and needle electrode. Apply the needle electrode to the cornea of the pig's eye and turn on the current (40 mps.). The needle should penetrate without any force being necessary and after one second when it is removed (the current having first been switched off), an area of 2 mm. in diameter around the needle puncture through the cornea should be white without any blisters. If the spark gap is too long an area of brownish coagulate will show around the needle puncture and will be smaller than 2 mm. in diameter. The cornea will be burnt around the needle puncture and further coagulation prevented from spreading. Instead the corneal tissue may be even heaped up around the needle puncture due to sparking at the needle point and blisters may be apparent. If the spark is too short, a very small white area around the needle puncture will result.

To obtain the proper spark gap, a current kept steady at 40 mps. should be employed, and the spark gap regulator adjusted

until the optimum coagulation is obtained. The spark gap should be checked at fairly frequent intervals for each individual machine and always before use if it has been out of commission for some time.

The above is only for obtaining the requisite spark gap for any form of coagulation and the spark gap has to remain constant for whatever power in amps. it is intended to use.

After setting the spark gap, a further trial for surface coagulation can be made if desired on a pig's sclera, if possible. The result should be a bluish-grey area like parchment as already mentioned in the section on operative procedure.

Principles of magnetism.

The magnets most commonly in use are Giant Magnets, either of the Haab-type or the Mellinger. The former is directly magnetised by the electrical winding around it, and the latter works indirectly through a bar of soft iron which, placed in the magnetic field, becomes magnetised.

For the posterior route extraction of intra-ocular F.B.'s the Mellinger is the more handy, but the Haab has the more powerful pull.

The governing factors as regards the success of extracting a magnetic F.B. from the eye are :—

1. The distance of the magnet from the F.B.
2. The power of the magnet.
3. The magnetic quality and size of the F.B.

Because of the low magnetic quality of the alloys which form such a high percentage of intra-ocular F.B.'s in this war, it is essential to use a powerful magnet and apply it as near as possible to the F.B.

The loss of magnetic power by increasing the distance from magnet to body, practically is equal to the cube of that distance. So if the pulling power of a magnet at 1 mm. distance is say 1 gram., then by increasing the distance to 2 mms. the pulling power becomes only $\frac{1}{8}$ of a gram., at 3 mms. $\frac{1}{27}$ gram., at 4 mms. $\frac{1}{64}$ gram., and so on. Nearer than 1 mm. the pulling power increases out of all proportion up to actual contact. The reason for this is that the body comes only into the small central core of the magnetic field, extremely limited, the rest of the magnetic field being lost (Fig. 20). The larger the body the more magnetic lines will reach it, and the stronger will be the pull (Fig. 21).

Up to date the power of only one pole of a magnet is used and possibly if both poles could be used the pulling power would be much increased because of the increased density of the magnetic field, but there are difficulties in constructing a bi-polar magnet for use in eye work (Fig. 22).

FIG. 20—distance factor.

FIG. 21—size factor.

FIG. 22.

The next question is one of points. If a Mellinger is used, a thin iron bar is easy to manipulate, but has a small capacity for saturation, and in consequence its pull is poor. But use of a thick iron bar has also its limitations depending upon the strength of the magnetic field, which can only saturate a certain size. The efficiency of the Haab also depends upon the choice of points. The strongest point is one with a blunt end and about as broad as it is long because the most powerful pull is exerted from the centre of the point where the density of the magnetic field is greatest. At the sides, the magnetic lines do not reach out towards the F.B. and so are wasted (Fig. 23). The point which is weakest is the long thin one because so much wasting of power takes place from the sides right up to the end.

FIG. 23.

A—effective magnetic power. B—wasted magnetic power.

The decision to be made is, can we come so much nearer to the F.B. with a long thin point than with the blunt one to make the use of the former worth while? As stated previously, the pulling power increases so vastly from 1 mm. up to actual contact that if by using a point even not thicker than say a blood needle we can actually contact the F.B. with it, then it will be better than using a blunt point (*e.g.*, if an F.B. is 4 mms. deep from the sclera and by using the long thin point we can come to within a half mm. of it, then we increase the pulling power by about 500 times or more). This applies to F.B.'s of low magnetic quality, as an iron or steel F.B. could be extracted even at 10 mms. distance by a Haab or Mellinger magnet. If a metallic F.B. of low magnetic quality is placed in a magnetic field, the magnetic quality will improve but only to a certain extent, saturation being reached very quickly. It is for this reason that numerous applications of the magnet are unnecessary, and, in addition heat is generated in the wiring and through this the pulling power of the magnet is decreased.

Non-magnetic F.B.'s.

To tackle a non-magnetic intra-ocular F.B. is always a big responsibility, especially if the vision of the eye has not been seriously impaired at the time of the penetration. It is a question of differentiating between those that will do harm if left and those that will remain inert.

The most chemically active are copper, lead, brass and zinc. The inert are, porcelain, glass, stone, aluminium, plastics, and wood. The chemically active almost invariably lead to loss of the eye unless extracted, and for this reason risks must be taken. The chemically inert, unless of large size, are better left alone. Even if they carried in infection at the time of penetration, their removal will not affect the end result. A skiagram helps in that, stone, wood, porcelain, aluminium and most types of glass are almost non-radio opaque, whereas lead, copper, brass and iron are densely radio-opaque. But not all radio-opaque F.B.'s are chemically active, *e.g.*, gold and silver.

The localisation of a non-magnetic F.B. is very important if possible, and the operative technique is that already described up to the use of the magnet. Thereafter there are two ways of proceeding with the extraction, direct and indirect.

1. In a darkened operating theatre the eye is transilluminated through the pupil with a Sacle lamp if possible, or other transilluminator, and the F.B. seen as a black or glittering point in the vitreous through the scleral incision, which has to be large, and more extensive diathermy is therefore needed.

2. Cases are recorded where the F.B. has been successfully extracted by observing it through the pupil with an ophthalmoscope and seizing it with forceps or snare inserted through a

FIG. 24a.

FIG. 24b.

scleral incision. With this method only monocular vision is possible with all its limitations, such as attempting to judge orientation, and considerable stirring up of the vitreous must occur in most cases. For this reason we believe the first method is the operation of choice.

For the extraction, the forceps illustrated is used (Fig. 24 a open; Fig. 24 b closed).

Summary

A new localiser and method of localisation of radio-opaque intra-ocular F.B.'s is described.

An improved operative technique is described in stages.

The problems of diathermy and magnetism are discussed and advice offered on how to regulate and use the diathermy apparatus to avoid complications.

A diagram of new forceps for extraction of non-magnetic F.B.'s is given.

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WAR SURGERY OF THE EYE IN FORWARD AREAS*

BY

Major E. C. ZORAB, R.A.M.C.

SURGEON TO A MOBILE OPHTHALMIC UNIT

In ophthalmic surgery, as in general surgery great advances have been made in the facilities which are available to a man wounded in battle.

Every eye injury comes under the care of what one may call an ophthalmic team, which consists of three parts, *viz.*,

(1) A Mobile Ophthalmic Unit.

(2) A Base Ophthalmic Wing.

(3) An Ophthalmic Department in United Kingdom, perhaps St. Dunstan's.

* Received for publication, April 30, 1945.