Affections of the Eye

due to

Injury by blunt objects.

A Thesis for the Degree of M.D.,

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By

Arthur J. Ballantyne, M.B., Ch.B. (Glasgow)

ProQuest LLC.
789 East Eisenhower Parkway
P.O. Box 1346
Ann Arbor, MI 48106 – 1346

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Injuries of the Eye by Blunt Objects.

The immediate and remote effects of concussions or contusions of the eyeball are of considerable interest, both to the general practitioner and to the ophthalmologist; to the former because a knowledge of them may enable him to adopt proper lines of treatment in apparently trifling cases of injury to the eye, and save him from the mistake of offering a false, and especially too favourable prognosis; and to the latter because he may be called upon at any time as an expert, to forecast the probable course of the affection especially in cases where the question of compensation has arisen.

Since the introduction of recent legislation on the subject of compensation to workmen, injuries of all kinds to the eye have become of increased importance, and difficult questions of prognosis frequently arise. This is particularly so in the case of those degenerative changes which occur in the optic nerve, choroid, and retina as a result of blows of various kinds, a class of cases which will be referred to in more detail later.

The concussion injuries of the eye have not received much systematic study in this country. Special paragraphs were devoted to them in the text books of

MacKenzie, (1854) Cooper (1859) and Lawson (1867) but as MacKenzie wrote for the most part before the introduction of the ophthalmoscope, and the two latter wrote only a short time after the introduction of the instrument, the material supplied by those excellent clinicians loses much of its value for us.

English writers for the most part have not devoted much attention to the question of the physical and mechanical factors which determine the occurrence of the different lesions. This subject, on the other hand, has received considerable attention from Continental authorities, while many of these have conducted experiments on enucleated human eyes or on the eyes of living animals, in order to determine the conditions essential to the production of the various lesions. This is still the part of the subject on which there is the greatest difference of opinion, and much investigation is still required before a number of the lesions receive a satisfactory physical explanation.

One is struck at the outset by the very large number of different pathological conditions produced in the eye by the impact of blunt objects. This is especially remarkable when one considers the small size of the eyeball and the perfection of its natural means of protection. As a rule somewhat less than half of its entire surface is exposed, and in most cases this

is so well protected by the surrounding bony margin of the orbit and by the nose that the total extent of surface available for impact of a blunt object must be very small. As the eyeball however has a very free range of movement and is an elastic structure, and not a rigid immovable one, a large number of new factors are introduced which must be considered in dealing with the mechanical conditions necessary to the production of individual pathological conditions. One must also take into account the presence of an elastic support in the form of the orbital fat which serves further to complicate matters. Another fact which adds to the difficulty of obtaining a scientifically complete understanding of the individual case, is the impossibility in almost all cases of obtaining from the patient a clear account of the circumstances attending the accident, for example, the nature of the injuring object, and the direction, force and point of impact of the blow.

In investigating a case in which there is a complaint of defect of vision following an injury by a blunt object, we are met by the difficulty that we may be dealing with an eye which was already blind or amblyopic before the injury, the attention of the patient having only been directed by the injury to the defect. It is remarkable how some patients will go about their duties for years, quite unconscious of the fact that one eye is amblyopic or

blind, until some accident which throws the sound eye out of gear for the time being, forces the fact upon their attention. This is especially apt to be the case, of course, with eyes which are congenitally amblyopic, in which cases, the limitation of the field of binocular vision which might otherwise attract notice, is not observed.

There must always remain then, an element of doubt as to the causal relation between a given injury and a visual defect, so long as the patient is unable to testify that the eyes have been separately found to have good visual acuity shortly before the accident.

When, after an accident of the kind now under consideration, the fundus of the eye is found to present pathological changes of the choroid and retina, especially of the macula region, care should be taken to determine whether such changes might not be due to constitutional disease (albuminuria, syphilis etc.) senility, or progressive myopia, the latter of which especially is frequently associated with macular changes which are quite indistinguishable from some of those following injury. The following case illustrates the difficulty of diagnosis in such cases:-

Case 1.

The patient, a man aged 28 was struck twice during the week preceding his first visit, on the left eye with a piece of metal.

He complained of dimness of vision in the left eye, and V.A. was found to be 12/200. V.A. of R. was 20/50. On ophthalmoscopic examination Right fundus was normal while Left fundus presented in the macula region the appearance shown in Fig. 23, viz. that of a number of bright yellowish-white spots on a deeply pigmented background. The field of vision (fig b) showed both absolute and relative central scotoma and some contraction of the periphery of the field. There was no history of any previous injury, and so far as patient was aware both eyes were always perfectly normal before the accidents referred to. The condition was diagnosed as of traumatic origin. Improvement occurred in the V.A. and ophthalmoscopic appearance during the next fortnight until vision of both eyes was practically normal. Two months later, however, patient returned with great reduction of vision in left eye again, an absolute central scotoma in the visual field and some spots in the macula region. Five days later the right eye also became affected, without any history of injury, and its condition became as bad as that of the left, vision being reduced in both to the counting of fingers at 12 inches. By the ophthalmoscope a few spots about the macula were found in the eye. Also, inquiries discovered that he had had Gonorrhœa and possibly Syphilis a year before. It is therefore not improbable that the case was one of disseminated Choroiditis in an early exudative stage. Improvement ultimately took place under treatment with

X Antiskecific drugs.

Other pathological conditions besides macular changes may simulate closely those produced by trauma, amongst those being cataract, intraocular haemorrhage, separation of the retina and optic neuritis and atrophy.

Still more perplexing will be those cases in which on account of preceding inflammation, or other disease process, the eye has been so damaged, that an otherwise trifling blow has sufficed to cause serious mischief, and an opinion is required as to how far the injury and how far the disease was responsible for the condition.

All these points are of special importance in connection with the assessment of damages and compensation, and they demand great care in the investigation of all points relating to the individual case. A few cases occur in which, after excluding the possibility of preexisting amblyopia and attempts at malingering, one is forced to conclude that there is a visual defect, the effect of injury, though no change of any sort can be discovered in any part of the eye. It is in just such cases that a careless examination might lead one to the opinion that the patient was exaggerating or deceiving.

When a case of visual defect suspected to be of traumatic origin comes up for investigation, and no obvious lesions exist to account for the defect, no available means should be neglected of obtaining information with regard to the state of all

parts of the visual apparatus. The perimeter is of some importance in this respect, as, in one or two cases to be mentioned later, the central vision may be perfect, the patient being able to read the smallest distance and near types without difficulty, and yet he complains of a dimness of vision which, on perimetric examination, is found to be associated with either a peripheral contraction of the visual field, or scotomata of greater or less extent, which constitute without doubt a very real defect. In some cases it may even be necessary to investigate the colour sense, cases having been reported in which trauma was responsible for colour defects of various kinds.

Taking up in the first place the consideration of the fundamental forms of lesions produced by concussion or contusion, it will be found that in the eye as elsewhere these effects can be roughly classed in three divisions according as they consist of (1) those finer molecular changes which manifest themselves in vaso-motor disturbances at the seat of injury, or in paresis or spasm of muscles. (2) Tissue changes still invisible to the naked eye but possibly visible to the microscope and of such magnitude as to be associated with rupture of fine blood-vessels and consequent haemorrhage. (3) Gross changes which may be classed as losses of continuity or contiguity.

To the first of these classes belong changes in the vascular system of the eye;

congestion of the optic disc, dilatation and contraction of retinal blood-vessels, oedema of the retina, and turbidity of the media due to abnormal transudation of fluids; and also traumatic miosis and mydriasis, and paralysis and spasm of accommodation, the latter of which may be or may not be secondary to vascular disturbances. To this class also must be referred those unknown changes which give rise to visual disturbances of a subjective nature, and such as are associated with subsequent retinal and choroidal degeneration, or with no visible lesion at all. The conditions present in this class are present in all cases of concussion, as has been shown both clinically and histologically, but it is probable that where these are the only conditions present, the functional disturbances are in most cases of a transient nature and are of good prognosis, although where congestion and oedema have been severe, permanent effects are apt to be left behind.

Numerous experiments have been conducted for the artificial production of ocular lesions which could afterwards be subjected to histological examination. In all cases where a moderate degree of force is used, the first effect produced is a passing ischaemia of the retina with contraction of the retinal vessels. This soon gives place to a wide dilatation of the same vessels, and those of the choroid, ciliary body, and iris. The

retina assumes a milky-white opacity from being permeated with an exudate or transudate from the choroidal vessels due to their paralytic dilatation. At the same time there is a transudation from the vessels of the iris and ciliary body into the anterior chamber, and the congested, oedematous condition of the iris, and ciliary body and muscle, is associated with contraction of the pupil and spasm of accommodation.

These conditions as a rule pass off entirely in the course of a few hours, or at most days, leaving the eyes without any visible lesion. It is pointed out by Berlin that the contracted pupil above referred to, is with difficulty dilated with Atropine, a fact which supports the view that the contraction of the pupil is the consequence of the hyperaemia of the iris which has been observed histologically in such cases.

To the second class of injuries belong all haemorrhagic conditions produced by blunt force acting on the eye, whether the haemorrhages are confined to the neighbourhood of the vessels in the ocular tunics or reach the refractive media. Although certain conditions, such as the form of retinal oedema described by Berlin, may belong either to the first or second class according to the theory which is assumed as to their origin, still there is a fairly well marked line of distinction between the two classes, inasmuch as the effusion of blood presupposes a somewhat

severe injury, and the mere fact of the presence of blood outside of the vessels, diminishes in many cases the chance of ultimate recovery of perfect sight, and in some conditions to be referred to later may give rise to further serious mischief. It must be stated however, that where the haemorrhage has taken place into the Anterior Chamber, the haemorrhage in itself is of little moment, as the blood is absorbed in a remarkable manner even within a few hours of the injury with apparently no evil results. As regards the sources of blood, it may be effused from practically any of the tissues of the eyeball, such as the retinal and choroidal vessels, the vessels of the iris and ciliary body, and the Canal of Schlemm.

The third class of injuries includes all the more severe ones, which consist anatomically of visible loss of continuity or of contiguity. Practically all the coats of the eyeball may suffer rupture from concussion, the various parts of the uveal tract being particularly prone to this form of injury. Ruptures of the retina are much less frequently observed. Under losses of contiguity are included such injuries as separation of the retina, choroid or ciliary body, and alterations in position of the iris and lens.

The term "Concussion Injuries" is thus seen to include lesions of all degrees of severity, from a mere vasomotor disturbance of a transient nature, to the most

severe injuries such as rupture of some or all of the coats of the eyeball.

The lesions under consideration may be caused by an infinite variety of objects, and in an endless number of ways, in fact by anything which produces a concussion or jarring of the eye, as distinguished from the cutting injuries produced by sharp objects. The injuring object may even be such as would at another time produce a penetrating wound, but, on account of the obliquity of its direction, the interposition of the lids, or its interception by the protective surroundings of the eyeball, has been unable to do so.

Injuries of this description bear a variable proportion to injuries of the eye as a whole, which has been estimated by various authors investigating large numbers of cases at from 10% to 20%. In contra-distinction to penetrating wounds of the eyeball which occur mainly in the mechanical trades, these are very much more common in domestic life, as will appear from the following list of some of the most common means of injury:- Blows from fists, sticks, pokers, shafts of hammers, spades, hoes and rakes; footballs, cricket balls, snowballs; hockey sticks, cricket bats; buckles, stones, corks and metal tops of aërated water bottles. The majority of cases result from a blow or stroke with a fist, stick, etc. Next in order of frequency come those which result from small blunt objects flying with some speed against the eye, such as stones,

corks from soda water bottles and chips of wood; and lastly, the least common class includes cases of falls or knocks against projecting objects, striking the head against the ground, and even falls from a height on to the feet or back.

Before investigating the mechanical factors involved in the production of the class of injuries with which we are dealing, let us first take account of the means adopted by nature for the protection of the eyeball from injury. The eyeball is so placed as to be secure from injury over the greater part of its surface, by the bony walls of the orbit, especially by the projecting superciliary ridge, and to a less extent also by the bridge of the nose. Great individual differences exist in the relationship between the eyeball and its surroundings; in some, especially elderly persons, the eyeball is sunk in the orbit from absence of orbital fat, while in others it projects forwards prominently so that one can get the finger well up to the equator on all sides. As a general rule a little less than half of the eyeball is available for examination by the finger, and is therefore exposed also to injurious influences from without, and this extent is somewhat increased by the mobility of the eye. The most exposed portion of the eyeball is the lower and outer portion and the least exposed the inner portion. The eyelids exercise a certain protective influence, not so much on account of actual resistance

to force, as because they tend by the laxity of their integument to convert a direct into an oblique or glancing blow. The torsus may also tend to distribute the force of a blow from a small object over a larger surface. In the orbit itself the eye receives the support of the orbital fat, a highly elastic tissue which forms a cushion, against which the eyeball must be driven. It has been a matter of dispute whether there occurs at the time of a blow a reflex rotation of the eyeball upwards and inwards behind the upper lid, but it is highly probable that, at least in some cases, such a motion does take place. At every normal closure of the lids there is a rotation of the eyeball upwards and inwards; again rupture of the sclera, which is generally supposed to be brought about by pressure of the eyeball against the trochlea, occurs as a rule at a place which is not in contact with the trochlea except where the eyeball rotates inwards and upwards; and lastly in a case which came under my notice, a puncture and counter-puncture of the sclerotic by a sharp instrument, were both situated well behind the equator on the outer side of the eyeball, in such a position as to suggest that the eyeball must have rotated, inwards at least, to a considerable extent at the time of the blow. If then, as most authorities agree, such a movement does occur, a direct blow acting from in front of the eye, will strike, not the centre of the cornea, but probably a point

about the lower-outer corneal margin, which must be borne in mind in investigating any such case. Other movements of a reflex nature are supposed to occur in the intrinsic muscles of the eye at the time of a blow. These may be referred to later.

For the purpose of our inquiry the eyeball should be looked upon as an elastic envelope tensely filled with fluid, this conception being somewhat modified in certain cases by the differences in surface curvature, variation in consistency of the different contents, etc.

The effect of constant pressure or a sudden application of force to a point on the surface of such a sphere, is to cause an equal pressure to be exercised on every part of the internal surface. If, as in the case of the eyeball, the sphere is supported at the point opposite to the point of impact, the result is that there is a tendency to stretching of the wall in the direction of the equator which lies at right angles to the line joining the point of impact and point of support (equator of expansion), and should this stretching be carried to the extent of rupture, the rupture will be so situated as to lie in a "meridian of expansion" with its centre in the "Equator of expansion". (fig 1) These facts come into play in explanation of the occurrence of indirect rupture of the sclerotic, but injuries of the uveal tract, lens, etc. present more complicated problems. Some have tried to compare

the indirect injuries to fracture of the skull from contrecoup, but there is not much satisfaction to be got from such a comparison. In the first place the consistency of the two objects differs greatly, and again the eyeball is supported at the surface opposite to the point of impact, while the skull in fracture by contrecoup is not so supported.

A heavy crushing blow then, applied to a considerable extent of the exposed surface of the eyeball, will drive the whole eyeball backwards, compressing the supporting cushion of orbital fat against the bony wall at the back of the orbit. The force may be sufficient to produce actual fracture of the orbital bones, but in any case there is, besides the displacement of the eyeball, a displacement of the ocular contents. The intraocular pressure is equally distributed to all points on the internal surface of the globe and there is thus an equal tendency to expansion at all unsupported points. In this way rupture of the globe may be brought about. Short of rupture of the whole thickness of the wall, the choroidal coat, being the least elastic, may give way. The position of these ruptures is of course influenced by the position of the eyeball at the time of the injury, and the area of the surface involved in the blow.

If now the force, though considerable, is produced by a comparatively small object, further factors are brought into play, which

affect the anterior segment of the ball. The tendency of the force, which is evenly distributed over the internal surface of the coats of the eyeball, is to smooth out all irregularities of surface and curvature and so convert - not the external surface as it is sometimes put, but the internal surface into that of a true sphere. The surface in question is made up of two main sections, viz. the cornea and the sclerotic, each having its own curvature, and forming at their junction a projecting ridge corresponding to the sulcus on the external aspect. The tendency then of the increased intraocular pressure is to increase the circumference of this ring. This in its turn puts the zonular ligament of the lens on the stretch and stretches also the iris at its attachment to the ciliary body. These facts no doubt play a part in the production of such injuries as luxation and subluxation of the lens, iridodialysis etc.

But the injuries of the anterior segment of the eyeball are perhaps most of all produced by the action of small flying objects, which impart a smart, stinging blow to the eye especially on the cornea or near its margin. Such objects are buttons, corks or twigs of trees. In these cases we have not merely to deal with increase of the intraocular pressure of the eyeball as a whole or displacement of the ocular contents as a whole. The presence of a diaphragm, composed of the hyaloid membrane, lens, zonular ligament and iris, dividing

the eyeball into two parts, the one being filled with viscid and the other with aqueous contents, now comes into play, and where the blow is of the nature indicated above, namely sharp, quick, and not of a crushing or lasting nature, we may, as it were, leave the posterior or vitreous chamber out of account and consider only the anterior segment. This for the purpose in view may be looked upon as a closed vessel, containing a fluid which is practically water, and having walls which offer varying degrees of resistance to the pressure of the contents. As before stated, where a force acts upon the outside of such a vessel so as to increase its internal tension, there is an equal distribution of pressure at all points on its internal surface. Therefore if a blow of the kind indicated strikes some part of the cornea, the aqueous suffers displacement and exerts its pressure equally over the posterior surface of the cornea, and the anterior surface of the lens, iris and zonula. From its nature the cornea scarcely yields to such pressure and so the increase of tension acts mainly on the lens, iris and zonula. The lens lying in its fossa is supported by the vitreous humour. The iris over a considerable extent is supported by the anterior surface of the lens, while the rest of its posterior surface lies partly on the fibres of the zonular ligament, and is partly unsupported, having aqueous humour

both before and behind it. In a sense then the posterior wall of the vessel we are considering is formed, not by the lens and iris, but by the lens and hyaloid membrane supported by vitreous, but owing to the intimate contact between the iris and the lens there is no free escape of aqueous from the anterior to the posterior chamber at the moment of a blow, and so the iris has to withstand the pressure of the aqueous with the slight support afforded at its periphery by the aqueous of the posterior chamber and by the fibres of the zonula. This peripheral part of the iris then is seen to be the weakest portion of the wall of the vessel formed by the anterior chamber. (fig 3)

Given a short blow acting on or about the centre of the cornea, the peripheral part of the iris will yield to the pressure of the displaced aqueous, and at the same time there will be, from the flattening of the cornea, a tendency to expansion of the ring of insertion of the iris. Should the pupil have been contracted at the time of the accident, the probable result of such a blow would be a detachment of the iris at its extreme periphery from its insertion into the ciliary body (Iridodialysis). On the other hand such a condition as a special elasticity of the iris itself or special delicacy of the zonule of Zinn, would lead to a rupture of some fibres of the latter by the backwardly

displaced iris. Here we would have subluxation of the lens with tremulousness of the iris, from loss of its accustomed support at the place where the Zonule had given way. Just as the Iridodialysis might be of very small or of great extent, so there might be only a limited rupture of the Zonule, or such an extensive rupture as to free the lens over the greater part of its circumference, and so cause Luxation or Dislocation of the lens.

Supposing the pupil now in such a case to have been dilated instead of contracted, the blow might suffice, after rupturing some fibres of the Zonule, to drive the pupillary margin of the iris round behind the lens. (Retroflexion of the Iris, Fig. 2.) This may be partial, in which case it resembles a colobома of the iris; or total, when it resembles, and is usually with difficulty distinguished from, absence of the iris (Aniridia). Such a complete retroflexion of the iris, where it seems to fall back and lie upon the ciliary body out of sight, is a rare occurrence. More commonly when the margin of the iris has been driven behind the lens, the pupil immediately contracts, when, if the displacement is partial the pupil embraces the partially dislocated lens, or if the whole margin of the iris is driven back, the iris comes to lie entirely behind the lens and we have dislocation of the lens into the anterior

chamber.

Another iris injury - Rupture of the Sphincter Iridis - is less easy to understand, as the marginal portion of the iris is supported by the lens, and therefore as a rule escapes injury. Probably where this injury occurs, the blow has struck the cornea obliquely or in such a manner as to cause a flattening or oval deformity of the corneo-scleral ring. This with a contracted pupil might produce such a degree of stretching as to rupture the sphincter.

Other lesions occurring under similar circumstances can be explained on the principles already laid down. For example, the Rupture of the Canal of Schlemm, which is an occasional source of bleeding into the anterior chamber, is easily understood when we remember the intimate connection of the origin of the iris with the inner wall of the canal, and the delicacy of that wall, which is composed of the fibres of the Ligamentum pectinatum iridis.

It is possible for us thus to form theories to account for the different lesions met with, and in some cases we can be fairly certain of the manner in which these accidents are brought about, but our theories are apt to be upset at any time by the occurrence of cases which do not seem to conform to our explanations. In fact, it is impossible to make any hard and fast mechanical laws serve to explain the various lesions, and it is

doubtful whether it would even be possible, given the particulars as to the nature, size and weight of the injuring object, the force of its impact, the point struck, and other details, to predicate with certainty what sort of lesion would result.

The natural variability in the tissues of different individuals, the disproportionate resistance to injury of the different parts even within the limits of the normal, and the effects of age, general and local disease etc., are all factors the value of which it is difficult or impossible to estimate. A stroke which in one patient is sufficient to produce the most complicated and serious internal lesions, in another may give rise only to some temporary pain and discomfort or perhaps general congestion of the tissues.

Certain conditions however, have a recognised effect in increasing or diminishing the resistance of the whole eye or of certain parts to injury. In this respect age plays an important part as it does in other parts of the body. All tissues are less elastic and therefore yield more readily to slight injuries. Hence a very slight cause may be sufficient in an elderly person to produce rupture of the ligament of the lens with dislocation. Again the general sclerosis of the vascular tissues which accompanies advancing age, predisposes to rupture of vessels in the choroid, iris and elsewhere. Sex cannot be said to exercise any influence on the question except

in so far as the duties of the male sex expose its members more frequently to accidents of all kinds. The greatest importance attaches to previous injuries or attacks of disease in the injured eye. For example, the presence of a scar from an old injury is always a source of danger, and a moderate amount of force may be sufficient to rupture an eyeball at the seat of such a scar. Again an eye which has once been the seat of iritis, choroiditis, or other inflammatory condition is always predisposed to a recurrence from a slight trauma, and its tissues are so weakened that they may give way on slight provocation. Haemorrhagic lesions are especially frequent in eyes so affected. Even such a slight cause as rubbing the eye with the hand may fill the anterior chamber with blood, when the iris has been inflamed for some time or has been affected with repeated attacks of iritis. Abnormal elevation or diminution of intraocular tension predispose to traumatic affections. The former predisposes to such injuries as rupture of the globe or of the choroid alone, and lesions of the iris; while the latter is more often associated with dislocations of the lens and separation of the retina. One of the conditions which is most favourable to the occurrence of traumatic affections is the presence of high Myopia. In addition to the size and prominence of the highly myopic eye, such an eye is at all

times unhealthy, especially when the myopia is of an actively progressive type, showing a very low power of resistance in the tissues. Many lesions occur with great readiness in such an eye, the most frequent being dislocation and subluxation of the lens, and separation of the retina. Occasionally diagnosis presents difficulties in myopic eyes owing to the strong resemblance between the choroidal and retinal changes which occur in progressive myopia, and those degenerative changes which are sometimes consequent on injury. It is not unlikely that in some cases a trauma hastens the onset of these degenerative changes in an eye which is otherwise disposed to them.

The same conditions which predispose to the occurrence of traumatic affections also influence the prognosis in many cases. For example in old age, the circulation of blood and lymph in the eye is not so active as in youth, and hence exudates and haemorrhagic effusions are only slowly, if at all absorbed. Thus, while in youth an extreme degree of vitreous haemorrhage may in the course of three or four weeks almost entirely clear up with resulting good vision, the same lesion in old age has a much less favourable prognosis, and extensive traces of the effused blood are sure to remain permanently in a degenerated vitreous. Similarly with other lesions, the recuperative power in old age is low, and the same lesion has always a rather worse prognosis in old age than in early life.

Passing now to a consideration of the special lesions of different regions, we find that the injuries of the Cornea and Sclera which come within the scope of this paper are few in number.

The most common affection of the cornea following injury by a blunt object is a delicate opacity which on careful examination is found to be made up of numerous fine striae in the deeper parts of the cornea. Some authorities regard this as being due to a wrinkling of Descemet's membrane, others as the result of a small rupture of Descemet's membrane with percolation of aqueous humour between the layers of the corneal tissue. Another view is more probably correct, viz. that there is a mechanical opening up of the normally existing interlamellar spaces, which gives rise to increased reflexion of light and hence an opaque appearance; just as it is claimed that a transient opacity of the lens occurs without rupture of its capsule, from a disturbance of the normal relations between the lens fibres and the contents of the interfibrillary spaces. Dr. H. Wintersteiner (Archives für Ophthalmologie, Vol. 40) in dealing with cases of indirect rupture of the sclerotic, describes also this diffuse striate opacity of the cornea. Microscopically he found, in one case, only wrinkling of Descemet's membrane and neither cellular infiltration nor widening of the tissue spaces. In another case he found widening of the interlamellar spaces only, and in another widening

of the spaces and cellular infiltration. The latter phenomenon - cellular infiltration - cannot be looked upon as a constant phenomenon in stricte opacity of the cornea, which as a rule appears immediately after the injury and slowly disappears. It always passes off in the course of a few hours or days. It seems to be identical with the somewhat similar opacity of the cornea which follows on the operation for extraction of Cataract, when a good deal of friction has been exercised on the cornea in delivering the lens or the soft cortical remains.

In some cases of injury by blunt objects, blood colouring matter is observed in the form of pigmented crystals and granules between the layers of the cornea. Various explanations have been given to account for this phenomenon. It may be that blood finds its way into the layers of the cornea from the anterior chamber through a rupture of the posterior elastic lamina. According to Treacher Collins however (Researches into Anatomy and Pathology of the Eye 1896) the blood pigment, in the form of Haemoglobin, diffuses through the posterior elastic lamina from the Anterior Chamber, and there becoming transformed into a substance insoluble in the fluids of the corneal tissue, is deposited in the form of Haematoidin crystals in the corneal tissue spaces. That the brightly refracting granules and crystals are

Haematoidin, Treacher Collins assumes for the reason that the crystals, like those of Haematoidin are of varying sizes, and correspond with Haematoidin in solubility, spectroscopic and chemical reactions. Figure 9 is taken from a section of a cornea showing this phenomenon. It will be seen that there are scattered throughout the section, numerous highly refracting granules of varying size, and of irregular polyhedral form. These cannot be seen to bear any definite relationship to the lamellae and interlamellar spaces of the cornea. They are not found in the elastic laminae - Bowman's and Descemet's membranes - nor are they found in the epithelial layer. It will be seen that the number of granules is much smaller in the anterior half of the cornea than in the posterior half, and that they are absent or almost so, from the few layers immediately in front of Descemet's membrane. On the other hand the average size of the granules is greater in the anterior layers than in the posterior layers and in the centre than at the periphery of the stained area. The condition is one which is not always easy to diagnose and, as Treacher Collins remarks, when the area of staining is surrounded by a slight band of clear cornea the appearance may very closely resemble that of an amber coloured lens dislocated into the anterior chamber. Resorption of the pigment granules is a very slow process, which is only to be expected considering

that Haematoidin is so insoluble in the corneal fluids. In a case which Collins watched throughout its whole course, the staining of the cornea had only entirely disappeared in a period of two years and three months. In all cases the staining clears away first from the periphery and thereafter the clearing process gradually progresses towards the centre. Collins is of the opinion that the granules are carried off by means of migratory leucocytes. He does not mention that he has any microscopical evidence that this occurs, and certainly the statement is not borne out by sections which I have examined; no migratory cells with granules in their interior being found at the periphery of the stained area, as one would expect to find if such were the case. On the other hand the much smaller size of the granules at the periphery would seem to point to an actual slow solution of the deposit. The straight tubes of Bowman are also seen well marked out, being filled with closely packed granules. Whether this represents a mode of escape by means of lymph channels or not, I am not prepared to say, but it is at least suggestive of such a process.

Rupture of the Cornea from a concussion or contusion is one of the rarities amongst the injuries of the eye. It occurs as a rule more readily in young people than in the old and no satisfactory explanation of its occurrence can be given. Possibly it has the same physical cause as rupture

of the sclera, and occurs instead of the latter, when the sclera is so supported through its whole extent that rupture is impossible.

Rupture of the sclera itself is a much more frequently observed injury, and has been the subject of much speculation and discussion from the middle of the 19th century onwards. The following case observed in the Glasgow Eye Infirmary presented the injury in its typical form and therefore forms a suitable introduction to the subject.

Case 2.

C carter aged 28 was first seen nine days after an injury to the Right eye by striking it against a corner of his cart. The eye must have been struck through the closed lids, as both lids were so swollen that the eye could not be opened. On examining the eye there was found to be whitish opacity of the right cornea, over a limited area. The iris presented a coloboma at the upper and inner part, only a narrow strip being visible elsewhere. There was a good deal of blood in the anterior chamber. Above the cornea there was an elongated swelling of the ball about ½ centimetre wide and 2 centimetres long, and lying parallel to, and about ½ centimetre from, the upper corneal margin. This swelling was more prominent at its inner extremity than elsewhere. The whole

conjunctiva was of a dusky red colour from extravasated blood. Fundus not illuminable. Tension very low. Catoptric tests showed lens was absent from its normal situation. In the course of a few days the swelling referred to subsided, and a large rupture of the sclerotic was seen in the corresponding position, the conjunctiva over it being intact. The rounded larger portion of the swelling no doubt represented the lens, which had escaped from the eye at the time of the accident, and lying below the conjunctiva was gradually absorbed. Gradual shrivelling of the ruptured eyeball occurred and enucleation was performed. There was found to be a rupture in the usual situation, that is about 2 m. m. behind the apparent corneo-scleral junction, into which iris, and ciliary body had prolapsed. All trace of the lens was lost. Here, as in the majority of cases, the injury was inflicted by an object of some size coming with considerable force against the eyeball with closed lids. The severity of the blow is indicated by the great swelling of the lids, the chemosis, and the damage to the interior of the eye, the retina in this case being totally separated and the eye almost filled with blood. The condition is difficult in most cases to diagnose until rest and suitable applications have reduced the swelling and congestion of the surrounding parts. Once a view of the eyeball can be clearly obtained, however,

the diagnosis is usually a simple one. When the lens has not escaped so as to lie under the intact conjunctiva and conceal the rupture, the ragged wound can usually be distinguished shining through its conjunctival covering, and presenting in many cases a considerable uveal prolapse. The iris and lens seldom remain intact where such a severe injury is in question. In the first place the iris is usually separated from its ciliary attachment at the part corresponding to the situation of the rupture. It may suffer no further injury, but usually the detached portion prolapses between the lips of the wound, and in other cases the whole iris may be torn away from its ciliary attachment and be caught in the wound or escape entirely from the eye. Though it is a very rare occurrence the lens may remain in situ even after an injury severe enough to rupture the sclera and detach the iris. Such a case is represented in figure 10 where the cicatrix of the wound has become ectatic. In most cases however, the lens becomes more or less completely detached from its suspensory ligament, when it may be dislocated either backwards into the vitreous, towards the site of the wound, out of the eye and under the conjunctiva, or away from the eye altogether. The course taken by the lens when it leaves the eye, appears to lie between the ciliary body and the iris, that is through the gap formed by the separation of the iris from its ciliary attachment, but that the lens itself does not

cause this separation, can be seen from cases like that presented in Figure 10 in which iridodialysis has occurred without displacement of the lens.

Naturally the prognosis of such a severe injury is in all respects bad. This is the most severe traumatism to which the eyeball is subject and with very few exceptions the injury to the internal structures of the eye is such that sight is much reduced or altogether lost. Further, where there is such an extensive breach of surface septic processes are apt to gain a footing, and even when a fair healing of the wound has taken place, the almost invariable consequence is a slow shriveling of the eyeball. A curious exception to this bad prognosis is offered by the case mentioned by Fuchs (Text Book of Ophthalmology) of a farmer who had been gored first in one eye and years later in the other by a cow's horn, and at the time of examination presented in each eye the cicatrix of a scleral rupture, the lens being absent in each eye, but the fundi normal, so that vision was very serviceable with cataract glasses.

The form of scleral rupture under consideration here is, of course, the form known as indirect rupture, the one essential feature of which is, that it occurs at some part of the ball other than the part struck by the injuring object. Although the injury has been a comparatively well observed one, attempts to explain its origin have led to much discussion and

theorising. The two main questions which have had to be answered are:- (1) How is the rupture brought about? and (2) What determines the position of the rupture?

As regards the first of these questions there is a general consensus of opinion that the coats of the eyeball rupture from within outwards, and therefore that the essential factor in the production of the rupture is the increase of intraocular tension working from within. With regard to the second point however, differences exist, and different authorities attribute the choice of position to the pressure of the eyeball against projecting ridges of bone (trochlea etc.) to thinness and delicacy of the wall at certain parts, and to want of outside support to the wall at the injured part. Owing to the severity of the blow required to produce a rupture of the normal eyeball, and the consequent swelling of the lids and conjunctiva, it is usually extremely difficult in the first place to make out any mechanical data at all, beyond the nature and size of the injuring object. This is usually a hard rounded object of some size as compared with the eyeball, and it may be supposed generally, that the blow has been a severe and crushing one rather than a smart stinging blow, such as would serve to bring about some of the minor injuries to be hereafter mentioned. In the great majority of cases the rupture is above a line drawn horizontally across the ball through the lower edge of the pupil,

the favourite position of all being the upper and inner part, the wound lying parallel to the corneal margin and 2 or 3 m.m. removed from it, that is just in front of the insertions of the recti muscles.

Since the earliest attempts to explain the mechanism of this injury, it has been assumed that the part of the eyeball usually struck is the lower and outer part, this idea being supported by the fact that here the eyeball is most exposed to such shocks by large and blunt objects. Thus Zander and Geissler (1864) offered the simple statement that the eyeball was driven upwards and inwards against the sharp margin of the orbit which was the proximate cause of the rupture. Manz on the other hand (1865) considered that all parts supported either by the injuring object, or by the wall of the orbit, Tenon's Capsule etc., escaped rupture, while the latter tended to occur at the unsupported part, the cornea being excluded by its special powers of resistance. Allowing for a rotation of the eyeball upwards and inwards at the time of the blow, he limited the unsupported zone to the part between the margin of the orbit and the upper and inner border of the cornea, the increased intraocular pressure being sufficient to produce rupture at that part. Von Arlt (1874) propounded the theory that the ball, being compressed in the direction of the force, expands in a circle at right angles to that direction, the natural consequence when the tension has reached a maximum, being a rupture of

the wall at right angles to this equator of expansion. Assuming then that the blow comes from outside and below, and that the eye is rotated upwards and inwards, the equator of expansion will be in a more or less antero-posterior plane, and the meridian of expansion in which rupture ought to occur will pass through the cornea. It must be supposed, however, that on account of the special resistance of the cornea, the rupture avoids the cornea and occurs in the nearest part of the sclerotic, i.e. parallel to the corneal margin. Other theories have been proposed, some seeking to introduce the influence of the aqueous humour or the lens in the production of the rupture, while others compare the lesion to fracture of the skull by contrecoup. These theories scarcely require consideration. From the nature of the injury it is evident that no theory is of any value which does not consider the eyeball as a whole, and neither the aqueous nor the lens can play any important part in its production. Nor is the contrecoup theory any more satisfactory, as the eyeball is supported on all sides and is soft in consistency, while the consistency of the skull is entirely different and it is quite unsupported except at the point of contact with the injuring object and its attachment to the spinal column.

Müller, who in recent years has given most attention to this subject, ("Kupt. der Corneoscleral Kapsel durch stumpfe Verletzung" 1895) has put forward some views

which run counter to a number of hitherto accepted theories. For example, in the matter of the point of impact, he entirely disagrees with the accepted notion that this is usually the lower and outer part of the eyeball, and brings forward statistics to support this point. He concludes from his own cases that the usual points of impact are upwards and outwards, upwards, and inwards, and that the rupture commences not 180° from (that is opposite) the point of impact, but 90° from that point. Further he denies all reflex movements of the eye or eyelids at the time of the blow. The injuries to which he attributes rupture of the globe are blows with objects which strike the eye somewhat obliquely, and gliding over the surface of the ball are driven between the eyeball and the wall of the orbit, and this, he says, occurs mainly between the eye and the upper orbital margin.

The main factor in the production of rupture of the sclera is the rise of intra-ocular pressure brought about by the blow, and this acts in the following way:- The wall of the eye is made up of segments of two spheres of different radii - the cornea and sclera. According to the laws of hydrostatics the consequence of an increase of pressure in a closed vessel of this kind is an attempt to transform the wall into a perfect sphere. Hence in the eye there is an attempt to flatten out the angle formed between the cornea and sclera, and therefore a tendency to rupture in that

line. This tendency is further increased by the delicacy of the wall due to the presence of the Canal of Schlemm along the same line. These two facts explain the frequent occurrence of indirect rupture of the sclera in some part of a circle concentric with the corneal margin and about 2 m.m. removed from it. As regards the preference of ruptures for the upper and inner part of the globe, Müller allows the influence of the trochlea, whose pressure on the part already predisposed to rupture makes this its starting point. He also further introduces a mechanical principle similar to that brought forward by Von Arlt, namely, that when a ball is compressed between two points, rupture tends to occur at a point midway between these two points, that is, in a meridian of expansion with its centre in the equator of expansion (see Fig. 1.) and he showed experimentally that when the meridian of choice passes through the cornea, the rupture avoids the cornea and passes round about it, selecting naturally that position which is most predisposed to rupture, viz., the zone corresponding to the corneo-scleral sulcus and Canal of Schlemm.

These theories are consistent with each other, and are also consistent with the belief expressed by Müller that the favourite point of impact is not outside and below, but somewhere below the upper orbital wall. But the latter statement

is hardly to be accepted on the strength of the few cases on which Müller was able to base it. In this connection it is instructive to consider the following analysis of cases of scleral rupture recorded in the books of the Glasgow Eye Infirmary. Out of 38 unselected cases occurring in the last ten years, all of which were subjected to pathological examination, 32 were upper, upper and inner, or upper and outer; 2 inner; 1 lower and inner; 1 lower and outer; 1 outer, and 1 unstated. Of the 32 mentioned as occurring above the horizontal meridian, indications of the probable point of impact were present in 9, in the form of cuts or bruises of the surrounding parts. In 2 these were on the lower lid or cheek, in 2 on the upper lid or eyebrow, and in 5 on both eyelids.

These figures do not indicate that the upper part of the globe is the most frequent point of impact, in fact they favour no one point more than another. The same idea is borne out by considering the nature of the blows which led to the ruptures.

If we examine the 32 ruptures of the upper half of the ball we find that 12 were caused by the fist or back of the hand, 1 by the elbow, 2 by the booted foot, 1 by a rubber ball, 2 by falls against a chair or fender, and the others where the cause was stated, mainly by blows with sticks or handles of tools. The suggestion borne by these facts is, that the injuring

objects were in very few cases such as would glide into the orbit, between its wall and the eyeball as Müller has indicated; in most cases indeed the object would be of such a size that it would be in contact with the whole of the exposed portion of the globe, while the projection of the nose and of the upper orbital margin would tend to direct the force upwards and inwards.

Whether this be so or not it seems to me that, given a blow which compresses the globe against the orbit more or less equally all round, and still more if it is driven upwards and inwards; the predisposition to rupture caused by the anatomical facts before mentioned and by the presence of the trochlea, would in the majority of cases determine a rupture of the globe at the upper and inner part, parallel to and a short distance removed from the apparent corneo-scleral junction. The ultimate position of the rupture will of course vary according to the direction or directions in which the rupture extends from its starting point. In the rare cases in which the rupture is situated below the horizontal meridian it is probable that the blow has driven the eyeball downwards so that the action of the trochlea did not come into play.

Probably the Iris is more frequently affected by concussion of the eye than any other part, except perhaps the zonule or suspensory apparatus of the lens, and its lesions assume a large variety of forms.

As before stated the concussion injuries of the iris are mainly the result of sharp sudden blows from small flying or stringing objects, such as rounded chips of metal or wood stringing from a lathe or while chopping wood, and corks or metal tops of aërated water bottles. These may give a direct or a glancing blow, but in all cases they are such as act on the surface of the eyeball instantaneously and so do not necessarily affect the eyeball as a whole. Their effects are produced by the widening of the corneoscleral ring from flattening of the cornea, combined with the action of the displaced aqueous humour on the walls of the anterior chamber. As an injury of the first degree may be instanced the condition of ~~fixity of~~ the pupil under light and other stimuli, which is present in a large percentage of concussions of the eye. This is usually associated with a certain degree of traumatic mydriasis but may also, though more rarely, be associated with miosis.

In traumatic mydriasis we are probably dealing with a paresis of the nerve fibres which are concerned in the contraction of the sphincter iridis, the paresis being the effect of direct concussion of the nerve fibres. The mechanism, however, is very doubtful and there are other possibilities e.g. stretching or tearing of twigs of the ciliary nerves or compression of the same by extravasated blood. Again the dilatation may in some cases be partly or wholly due to stimulation of the sympathetic (dilator) fibres, e.g. in cases where there is mydriasis with a

pupil still reacting to light.
Traumatic mydriasis is usually, though not always, associated with fixity of the pupil, and rarely amounts to maximal dilatation of the pupil, so that atropine can always produce an increase of the dilatation. Furthermore the dilatation of the pupil is seldom regular and in these two respects it differs from Atropine mydriasis, which is very apt to be present in injured eyes by the time that they are seen by the oculist, the patient having treated himself at home with some variety of eye ointment containing atropine. The irregularity of the pupil may assume a vertical egg-shape or pear-shape or that of a transverse oval, and this irregularity is not at first entirely obliterated by the action of Atropine. Through time, however, the pupil usually assumes its normal shape, although in some cases both the mydriasis and the irregularity may be permanent. According to Gruening (Norris and Oliver's Text Book) one should always assume the presence of radiating lacerations of the border of the iris as the cause of irregular mydriasis, but I have been quite unable, with most careful examination, to find this cause in cases which have come under my notice. In addition to the mydriasis there is generally a certain amount of paralysis of accommodation which is also a result of direct injury to the ciliary branches of the 3rd nerve. On the other hand

instead of paralysis there may be spasm of accommodation giving rise to a temporary myopia. That this myopia may be of long duration is shown by a case cited by Von Grolman (quoted in Nagel-Michel Jahresbericht 1896) of accommodation spasm with myopia of 3 D of one and a half years duration. As a rule however, like other functional disturbances of the iris and ciliary muscle, it is a phenomenon of short duration.

Traumatic miosis, usually with spasm of accommodation, unlike traumatic mydriasis, appears to be in many cases a vaso-motor phenomenon, the immediate cause of which is congestion of the vessels of the iris and ciliary body with possibly the additional effect of irritation of the ciliary branches of the third nerve. It is a part of the clinical picture following concussion of the eye, in which there is congestion of all parts, from the conjunctiva to the optic disc, associated with a certain amount of pain and photophobia. In accordance with the congestive nature of the miosis the pupil responds feebly to atropine, but under the influence of rest to the eye this condition shortly passes off, leaving the eye apparently normal.

As in traumatic mydriasis so in traumatic miosis, the pupil is almost always somewhat irregular in shape, the form being oval, flattened or pear-shaped. Of the pear-shaped pupil several good instances have come under my notice. In

these cases it is difficult to say whether one is dealing with a mydriasis affecting only a small segment of the iris or with a miosis affecting the iris all but the small segment in question. Possibly a combination of these two phenomena may be present in some cases, the dip in the pupillary margin being of the nature of a local mydriasis due to stimulation of the nerve supply to the dilator fibres of that segment, while the remainder of the pupillary border is contracted from stimulation of the sphincter fibres or purely from congestion of the iris. Such cases are almost invariably affected with a certain degree of hyphaema the source of which is not evident. Figure II represents the progress of a typical case.

Case 3. The patient, a boy aged 11., was struck three hours before examination, with a stone. There was no wound of any kind. The anterior chamber was about half full of diffused fluid blood, which had commenced to settle down to the lower angle. The pupil was if anything contracted and could not be clearly seen through the turbid aqueous, but showed a condition below suggestive of a rupture of its border. Tension normal. No tenderness. The following day the blood had so far subsided as to give a clear view of the pupil. This showed an enlargement below but no rupture of its border. The following day the blood was largely absorbed and the pupil returning to its round shape. Reaction of

the pupil to light very tardy.

By the fourth day after the accident all signs of blood had disappeared and the pupil was perfectly normal in shape, though its reaction to light was still sluggish. No sign of injury to any part of the iris could be detected.

According to Dr. E. Fraun (Verletzungen des Auges 1899) the symptoms of photophobia, lacrymation and hyperaemia of the iris, rigid small pupil and spasm of accommodation, consequent on a severe blow, may also be accompanied by exudation into the vitreous and anterior chamber, and may even go so far as to pass into Iridocyclitis and atrophy of the eyeball; but such a consequence must be a very rare one in simple concussion of the eyeball however severe. Cases frequently come under observation in which, even after penetration of a foreign body, the conjunctival wound is so small as to be invisible or easily masked by the slight local hyperaemia, and it is highly probable that where iridocyclitis has appeared to follow a pure concussion, there has in reality been such a penetrating wound providing a source of infection.

Passing now from these lesions of the first degree, we come to the most numerous class in the whole range of concussion injuries of the eye, namely those of the third degree in which there are lacerations or displacements of the tissues with, in almost all cases extravasation of blood in sufficient quantity to be visible to the naked eye. These lesions

are of importance not only on account of their frequency but also because of the serious defects of vision which may attend them.

Perhaps the most common of these injuries is Iridodialysis which is illustrated in the following cases:-

Case 4. J. Mc D. Miner, aet 50, was struck on the Right eye with a stone while blasting, two days before admission to the Glasgow Eye Infirmary. There were one or two wounds of the eyebrow and outer end of the upper lid and chemosis of the ocular conjunctiva. Anterior Chamber was full of blood. Striate opacity of cornea at outer part. No fundus reflex obtained. In about a week when the blood clot in the anterior chamber had been sufficiently removed there was seen to be a detachment at the upper and outer side and a rupture of the sphincter of the iris of moderate size outwards and slightly downwards. There were also some smaller lacerations of the edge of the iris in the same region. There was still a little blood clot at the seat of injury when he was dismissed 16 days after the accident (see fig. 12)

Case 5. M. G., aet 50, was admitted the day following an injury to his left eye by a block of wood about the size of a cotton reel. Vision was very much reduced in the injured eye. The point of injury was indicated by a redness of the outer end of the upper lid. There was a small blood clot

in the lower angle of the anterior chamber. The pupil was small but responded to light. Shape slightly irregular. Under Homatropine it dilated slowly but not at its upper and outer part which remained fixed and with a flattened shape. No separation or rupture of the iris could be detected. The blood had completely disappeared in four days (see fig. 13). The latter case was diagnosed iridodialysis in spite of the fact that no lesion could be seen, firstly on account of the peculiar form of the pupil, and secondly because of the coagulated condition of the blood which will be referred to again. When there is iridodialysis the pupil always takes a peculiar form being flattened on the side corresponding to the part separated, and when the iridodialysis is so small as to be invisible from in front, being hidden by the opaque rim of the cornea, the deformity of the pupil is still present as in Case 5. Where the dialysis is of greater size the gap forms a secondary pupil which can be illuminated by the ophthalmoscope.

In the two cases described above as in most cases of iridodialysis, the iris has been detached from its ciliary insertion at a point corresponding to the position of the wound or bruising of the lid. In a few cases the detachment occurs at the diametrically opposite point of the circle of insertion. The detachment in all cases occurs close up to the ciliary body, so that in cases which have been submitted to microscopic examination no trace of the iris remains adherent to the ciliary body. The iris does not give way at its least

supported part but at its weakest part, that is at its insertion. A blow striking the eye at or near the limbus corneae would seem to be necessary for the production of this injury and can usually be reasonably assumed to have occurred. This fact is demonstrated in the cases quoted by the position of the other injuries relatively to the seat of detachment. In these two cases as in others however, the statement that the Iridodialysis occurs at the point struck, to be true must assume that the eye at the time of the injury was in its normal position with the cornea directed straight forward. As was mentioned elsewhere however, there is reason to believe that, in many cases at least, the eye makes a movement of rotation upwards and inwards along with the automatic closure of the lids at the moment of receiving a blow. If this be so, the blow striking the upper lid in the position noted in these two cases, viz., at the outer end, would strike the eye not at the upper-outer part of the corneo-scleral ring (the point of detachment) but at the lower-outer part of the ring i.e. at a point 90° removed from the point of detachment. It seems to me also that this assumption offers a better explanation of the mechanics of the injury than can be given if we assume that the tear occurs at the exact spot struck by the impinging body. The original theory of the mechanism of this injury as propounded by Von Arlt assumed that the blow struck somewhere near the centre of the cornea, that the cornea was flattened, and that consequently the ring of insertion of the

iris was widened, and the iris, being unable to accommodate itself to the expansion of the circle, gave way at some part of its insertion. Förster (Ophthalmological Congress of Heidelberg 1887, quoted by Fraun) introduced the proposition that the aqueous played an important part in the causation of the lesion, for along with the flattening of the cornea there is a backward displacement of the aqueous which expends its force mainly upon the unsupported portion of the iris behind, and therefore directly increases the tendency for the iris to be torn from its insertion. These authors seemed to assume that in Iridodialysis the blow compressed the eye directly from before backwards, and the same idea is borne out in Fraun, when he says that blows acting directly from before backwards produce only Iridodialysis and other injuries of the internal tunics, whereas when the force acts in a lateral direction rupture of the sclera occurs. Müller was the first to notice that this lesion often followed a blow on the limbus, and he attributed the injury to stretching of the ring of insertion of the iris combined with a sudden and strong contraction of both the sphincter and dilator pupillae. This hypothetical contraction of the sphincter and dilator would certainly be an important factor in the production of an Iridodialysis, but why the rupture should occur at the point of application of the blow does not seem clear. If a force is applied to some point on the corneoscleral margin or circle

of insertion of the iris (A in Fig. 5), while there is at the same time a spasmodic contraction of the sphincter and dilator pupillae, it stands to reason that as the expansion of the circle takes place in the direction B B' while the pupil tends always to retain its circular form in virtue of the action of the sphincter, the greatest strain is put upon the iris in the direction of the arrows in the figure, and therefore the most likely point for detachment is at B or B'. Further, if we take into account the action of the aqueous humour, it is evident that the action of the retreating aqueous will be as great at the points B and B' as at A. This explanation further, would be quite consistent with the occurrence of a double Iridodialysis and such a thing has been recorded. The same factors would serve to bring about the detachment of the iris at both sides B and B'. Another point in favour of this view of Iridodialysis is that it brings it into line with what is known to occur in rupture of the globe. Researches have shown that when rupture of the globe occurs as a result of a blunt blow, the rupture occurs not at a point diametrically opposite to the point of impact (i.e. 180° removed from it) but with its centre as nearly as possible 90° from the point of impact, the rupture always tending to lie in a meridian of expansion with its centre in the equator of expansion (Müller).

Now in many cases of rupture of the globe where the iris has not been completely torn away, there is an Iridodialysis at a point corresponding to the seat of rupture, in fact the greater number of reported cases of Iridodialysis are cases of this sort, in association with scleral rupture (compare Fig. 10). Scleral rupture however, is a lesion produced by a severe crushing blow in virtue of an elevation of intraocular pressure, not as in the case of simple Iridodialysis, by a sharp sudden blow with a small object affecting only the anterior segment of the eye. It is evident then, that Iridodialysis can be brought about in two ways, either (1) by such injuries as lead to rupture of the globe or (2) by the mechanism already explained, which attributes its occurrence to flattening of the cornea, expansion of the circle of insertion of the iris, and backward pressure of the iris by the displaced aqueous. Common to these two supposed modes of occurrence is the expansion of the circle of insertion, which therefore is probably the essential factor in the production of the lesion. In most cases which I have observed it seemed likely that the blow had acted on the eye at or near the limbus corneae, and at a point 90° removed from the situation of the lesion. I am therefore disposed to think that the part played by the aqueous is only of minor importance, the main factors as explained above and illustrated in Figure 5, being

flattening and expansion of the circle of insertion of the iris, with probably at the same time contraction of the sphincter pupillae.

Iridodialysis itself, even when of some extent, may cause little disturbance of vision beyond the dazzling due to admission of excess of light through the second pupil; and the severe haemorrhage into the anterior chamber, which always occurs, will as a rule be completely absorbed within a week or two; but, as with other iris injuries, the prognosis must always be reserved until it is possible to exclude all injury to the lens and also the possibility of vitreous haemorrhage.

When any or all of these complications are present, vision may be of course reduced to a minimum. As a rule however, it may be said that the prognosis of Iridodialysis uncomplicated by rupture of the tunics of the eyeball, is favourable, and may be followed by a satisfactory restoration of vision. Dr. W. Wintersteiner (Archiv. f. Ophthalmologie, Vol. 40) in reviewing a number of cases of Iridodialysis, raises the question, why there should always be haemorrhage in a case of separation of the iris from its ciliary attachment, while in a normal iridectomy of similar extent there should practically never be any bleeding. From microscopical examination of the cases which came under his observation he found a rupture of the inner wall of Schlemm's Canal to be present. He

states it as his opinion that this is the main source of the haemorrhage, another factor being that the iris is torn across where the larger vessels enter it after leaving the circulus arteriosus iridis major. He explains that in iridectomy the crushing action of the scissors is sufficient to obliterate the lumen of those vessels and prevent haemorrhage. It must be noted however, that the cases examined by Wintersteiner were cases of Iridodialysis occurring along with rupture of the globe, which may affect the validity of his explanation for other cases. Schäfer (Archiv. f. Ophthalmologie, Vol. 29) laid some stress upon the fact that in traumatic Iridodialysis the blow on the eye led to a paralysis of the vaso-motor nerves of the vessels, a fact favourable to the occurrence of haemorrhage.

After detachment the iris rarely unites to its old insertion and Wintersteiner explains this on two grounds, (1) that the torn edge of the iris becomes rapidly covered in with epithelium proliferating from the posterior and anterior surfaces and (2) that the torn edge becomes adherent to the anterior capsule of the lens, or when that is absent, to the hyaloid membrane by means of a new formed tissue. One may suppose also that the natural elasticity of the iris will tend to keep its torn edge from returning to its original position.

It may be appropriate to bring forward in connection with Iridodialysis, these cases in which the only visible sign of injury is an extravasation of blood into the anterior chamber, the pathological

condition being a Rupture of Schlemm's Canal. Czermak, whose articles on this subject are the most authoritative description of the injury, gives it as his opinion that Rupture of Schlemm's Canal should be looked upon as an incomplete rupture of the ball. When it is borne in mind that the main factor in the production of indirect, as opposed to direct rupture of the ball, is that the rupture is brought about by the contents of the eyeball acting from within outwards (not by the injuring body directly) and that, as Müller has shown, the rupture is most liable to occur at the site of the Canal of Schlemm because here the wall is particularly delicate, it will be conceded that this opinion is a most reasonable one. Given a force acting on the eyeball as a whole in such a way as to increase the general intraocular tension, and a force which under the existing circumstances would be liable to cause a rupture of the globe, the first step in the production of that injury would be a rupture of the innermost layer of the wall of the eyeball on the line of the Canal of Schlemm, i.e. of the ligamentum pectinatum which forms the inner wall of the Canal. If the action of the force stops there, the result will be an opening up of this space with no external appearance of injury beyond the presence of blood in the anterior chamber. In the article on Iridodialysis by Wintersteiner already referred to, which described cases of indirect rupture of the ball with Iridodialysis, it was shown that on examining

the eyes after enucleation there was found to be a rupture of the inner wall of the Canal of Schlemm, continuous with, and of greater linear extent than, the complete rupture of the wall. This fact directly supports the above view that the rupture of Schlemm's Canal is merely a first step in the development of a complete rupture of the tunics of the eyeball, and may therefore be classed as an incomplete rupture. But there is another way in which a rupture of the ligamentum pectinatum may be supposed to take place. As stated in speaking of Iridodialysis, there seems to be reason for the belief that that lesion may be brought about (1) As part of the more serious injury of rupture of the globe, by a force acting behind the level of the iris, or at any rate a force of such magnitude as to act on the contents of the eyeball as a whole, and by increasing the intraocular tension tend to the production of complete rupture, or (2) by a force of a different kind acting more directly from in front on the anterior segment of the eye, sudden and sharp in its onset and bringing into play both expansion of the ciliary ring and backward displacement of the iris by the aqueous humour. Now rupture of Schlemm's Canal in Czermak's sense would be an early step in the production of the first form of injury, but it seems to me that if Iridodialysis can be brought about in the second way (and this is assumed by all authorities) such a mechanism may be made

to explain certain cases of Rupture of Schlemm's Canal also; for any strain put upon the attachment of the iris to the ciliary body, must necessarily put a strain also upon the fibres of the ligamentum pectinatum which are so intimately connected with the iris at the angle of the anterior chamber. Thus in any given case a slightly greater strength of the iris attachment or a slightly less resistance of the fibres of the ligamentum pectinatum might allow a rupture of the latter to occur without the former giving way, and in this way Schlemm's Canal would be opened into and its contents allowed to escape into the anterior chamber. The following are the details of a case which I take to be one of Rupture of Schlemm's Canal:-

Case b. A man aged 20 received a blow on the left eye with the handle of a shovel, which apparently struck the outside of the eye and bruised the surrounding skin of the eyebrow and cheek. He was seen on the following day when the iris was found to be tremulous, slightly stained brown and the pupil of normal size and shape and reacting normally. No external wound of any sort. The aqueous humour was turbid and at the inner angle of the anterior chamber was a clot of blood, whose peculiar position was probably due to the fact, that the patient went home and lay down on the right side immediately after the injury (Fig 14). The following day (i.e. two days after the injury) patient

complained that during the night he had felt a smarting pain in the eye. On examination it was found to be acutely tender, and the anterior chamber was quite full of blood. (Fig. 15). After another day's interval there was another recurrence of the bleeding, and then the anterior chamber proceeded to clear and was free from all trace of haemorrhage in about a week. Fourteen days after the accident, the anterior chamber being perfectly clear and the eye apparently quite well, an interesting phenomenon was observed. While the eye was being examined, a fine stream of bright red blood was seen to issue from the angle of the anterior chamber at the upper and inner part and form a small deposit of blood at the lower angle. The point from which this took place I assume to have been the source of the original haemorrhage. No rupture or detachment of the iris at any point could be made out, and vision was perfectly restored. All the other possible sources of haemorrhage having been excluded in this case, we must assume that the bleeding proceeded from Schlemm's Canal, and from the nature of the injuring object and the signs of a very severe blow it is highly probable that the rupture took place in the first of the two ways referred to above i.e. that it was of the nature of an incomplete scleral rupture. It is of interest to note that Czermak says that we cannot be so certain of rupture of Schlemm's Canal if the blood is at the bottom of the anterior chamber as if

it is at some other part of the angle, as was the case with the above case. Another point of interest was the recurrence of the haemorrhage which is a condition not often noticed. It was present however, in a case quoted by Williams (Klin. Monatsbl. f. Augenheilk, 1873) and diagnosed by him as one of rupture of Schlemm's Canal. The question of the possibility of blood coming from Schlemm's Canal scarcely requires to be discussed. For many years opinions differed as to the exact anatomical nature of that Canal, and some denied entirely the venous nature of its contents; but the latest researches of Schwalbe, Leber, Waldeyer and Guttmann, point to the probability, almost to the certainty that the Canal of Schlemm is a venous sinus, in communication more or less freely with the scleral veins, and indirectly with the anterior chamber through the Spaces of Fontana. (Norris and Oliver)

Two other injuries may be mentioned here, which, though they do not properly belong to the iris, are yet closely associated in their etiology with those which we have been considering, and serve to throw some light on their occurrence. Both of these lesions were described and pictured first by Dr. Treacher Collins, and the following

description of them is taken from his "Researches on the Anatomy and Pathology of the eye."

Passing from the description of iridodialysis as a result of concussion of the anterior part of the eye he says:- "In other cases instead of the iris tearing away from the ciliary body, those fibres of the ligamentum pectinatum which curve round the angle of the chamber and go to the root of the iris, give way, and the ciliary muscle becomes split, so that the angle of the anterior chamber is prolonged outwards; a wide gap being left between the circular and longitudinal muscle fibres." This condition is diagrammatically represented in Fig. 4. With regard to the other form of injury which was produced in a boy by the stick of a rocket, he says:-

"I found that not only had those fibres of the ligamentum pectinatum which go to the root of the iris been torn through, but also those which give origin to the ciliary muscle, and that the whole ciliary body had become separated from the sclerotic and displaced to one side."

The clinical aspect of the latter case was one of complete disappearance of the iris at the upper part, (that is, at the part where the ciliary body was detached),

from displacement backwards of the ciliary body and iris. This lesion was found to be present in the case presently to be described under the head of rupture of the iris, (Case 8) The whole ciliary body at one point was thus detached from its normal position and having slid backwards over the sclerotic had assumed a new attachment. A point of some interest to us, is brought out by one of the cases of splitting of the ciliary body described by Treacher Collins. In it there was at one side an Iridodialysis, while at the opposite side the fibres of the ligamentum pectinatum (pillars of the iris) had been torn through and the ciliary body split between the circular and longitudinal muscle fibres. This case demonstrates, that the same sort of injury and a somewhat similar mechanism sufficed for the production of the two lesions i.e. the widening of the circle of insertion of the iris, combined with displacement of the aqueous humour.

These four injuries then - Iridodialysis, rupture of the inner wall of Schlemm's Canal, splitting of the ciliary body, and separation of the ciliary body from the sclerotic are closely associated and may be classed together as being brought about by the one set of physical conditions; and we may contrast with them that form of Iridodialysis and of Rupture of Schlemm's Canal which may be supposed to be the early steps in the production of rupture of the eyeball, being brought about by increase of general intraocular pressure and expansion of the corneoscleral ring, without participation of the

displaced aqueous humour.

Traumatic Aniridia, or total separation of the iris from its ciliary attachment, is a much rarer condition pathologically than clinical records would suggest, as Winter-steiner has shown; for in many cases in which there appeared during life to be total absence of the iris, the iris was found on examination of the enucleated eye to be still attached at some point or other. Still a total separation of the iris does occur, though it is most commonly associated with rupture of the ball, and only rarely occurs as the only visible result of a concussion. In the latter case of course, its mechanism is simply that of simple Iridodialysis carried to an extreme, while in the former the separation occurs, first as an Iridod-ialysis at the point of rupture of the ball, and the remainder of the iris is torn away by the rush of aqueous and vitreous and displacement of the lens. When there has been rupture of the globe, the iris usually escapes from the eye entirely along with the lens and other contents, or it may be found nipped between the lips of the scleral wound, but it is found in other cases lying at the bottom of the anterior chamber rolled up into a little grey shrivelled ball which is afterwards absorbed.

One of the results of concussion which is apt to be confounded with the preceding is total retroflexion of the iris, a condition first mentioned by J. A. Schmidt in 1804. A partial retroflexion gives the appearance of a coloboma of the iris, which might be mistaken for rupture of the iris, congenital

coloboma, or the result of an iridectomy. The mechanism of this injury was shortly considered in the earlier part of this paper dealing with injuries in general. The result of a sudden smart blow acting on the anterior part of the eye is to cause a sudden backward rush of the aqueous humour, which expends its force upon the lens and iris which form the posterior wall of the anterior chamber. The least supported portion of this posterior wall being that part of the iris near its insertion, which has behind it only a few fibres of the Zonula, the effect of the force is to drive this portion backwards in the form of a sac or gutter running between the lens and ciliary body. (fig 2) If now we assume that the pupil is of medium size or somewhat dilated it is easy to understand that the force of the displaced aqueous may be sufficient to rupture a few of the fibres of the Zonula and invert the edge of the iris completely behind the lens. The iris thus comes to lie backwards against the ciliary processes, and when examined with the ophthalmoscope no ciliary processes are to be seen. After the iris has been displaced backwards, and if the Zonula has been completely ruptured, the pupil may again suddenly contract behind the lens so that the lens comes to lie in front of the plane of the iris, and we have thus a total dislocation of the lens into the anterior chamber. In other cases the force of the blow seems to be expended mainly on one part of the iris and, this part being driven back in the manner described, the corresponding edge of

the lens tilts forwards in front of the iris while the rest of the iris remains in its normal relation to the lens, which is then grasped in an oblique position by the pupillary border of the iris, and there is produced the condition of partial dislocation of the lens into the anterior chamber. It might be supposed that total aniridia would be easily diagnosed from retroflexion of the iris, by the fact that in the former the ciliary processes remain in sight, while in the latter they are covered by the iris. This is not quite true however, for in many cases of aniridia the ciliary processes are quite invisible. Some have attributed this to separation of the ciliary body along with the iris, but Wintersteiner in the article referred to, showed that in the cases submitted by him to microscopic examination there was, along with the aniridia a rupture of the fibres of the ligamentum pectinatum, the torn fibres of which united shortly after the injury with the stump of the ciliary body where the iris was inserted, and these two growing together the ciliary body became flattened out in such a way as to be quite invisible in front.

The pupillary border of the iris is also liable to injury, which appears in the form of smaller or larger ruptures running in a radial direction from the pupillary border outwards. These may be no more than a slight laceration of the pigmentary border without involvement of the sphincter iridis, they may pass through the substance of the sphincter, or they may even be so

extensive as to reach quite up to the ciliary attachment of the iris (Total rupture or Rhexis iridis). The smaller ruptures as a rule are multiple whereas the more severe are usually single and are very apt to be associated with other lesions e. g. dislocation of the lens, vitreous haemorrhage and rupture of the choroid. These injuries in their etiology resemble those which have just been described, that is they are brought about by the impact of sharp sudden blows not necessarily of very great weight. As regards the mechanism, the same data which explained separation of the iris from its ciliary attachment seem sufficient to explain this form of injury also. We must assume however, that in the cases where this lesion occurs in preference to Iridodialysis there has been such a disproportion between the strength of the circular fibres of the iris and the ciliary attachment, that the former gives way before the elasticity of the latter has been exhausted. If we recall the state of affairs as described under the head of Iridodialysis, we can see in what way rupture of the iris border is brought about. As explained then the depression of the cornea causes a backward rush of aqueous which tends to drive the unsupported segment of the iris backwards and stretch the pupillary border over the anterior surface of the undisplaced lens, (fig 2) while at the same time (supposing the blow to strike the cornea from the side marked A fig. 5) there is a general expansion of

the corneo+scleral ring, and a special tendency to elongation of the circle in the direction E - E′ at right angles to the direction of the force. This puts a special strain upon the radial fibres of the iris in the direction E - E′, with, in most cases, the resulting separation of the iris from its ciliary attachment at E or E′ (i.e. 90° removed in one or other direction from the point of impact.) If now, instead of the radial fibres giving way at their insertion, the circular fibres give way, they will tend specially to tear opposite the points A and A′, that is, near to, or at a point 180° removed from, the point of impact, and 90° from the seat of election for Iridodialysis. This corresponds closely to what actually happens when both Iridodialysis and rupture of the Sphincter are observed together, as will be seen from the case illustrated in Fig. 12 and described under Iridodialysis (Case 4). Similarly in a case reported by Blumenstock in 1871 and quoted by Franke (Arch. f. Ophthalmologie, Vol. 32) there was Iridodialysis at the lower and outer side, with several ruptures of the edge of the iris at the upper and outer part with a wound of the supraorbital region, which suggests that the blow may have struck the cornea about the region of the iris ruptures above and outside; and in another case described by Franke (Arch. f. Ophth. Vol. 33) there was Iridodialysis of ¼ or ⅕ of the circumference with a rupture of the edge of the iris at each end of it. As examples of this injury the following two cases may be quoted:-

Case 7. A man aged 43 was first seen five days after receiving an injury to his right eye by a brass stud out of a driving belt. Increasing dimness of vision caused him to seek advise. No external wound of any kind could be discovered. The iris presented a single rupture of moderate degree at the lower and inner part as shown in Fig. 16. There was moderate mydriasis. Four or five days later the lens was observed to be gradually becoming cataractous.

Case 8. This patient aged 24 was struck with the free end of a broken driving belt half an hour before examination. There was a deep cut on the upper lid but no wound of the eyeball. The pupil was widely dilated and showed a rupture of the sphincter iridis at the lower inner part opposite to the position of the cut in the lid. Striate opacity developed in the cornea. In spite of instillations of eserine the pupil became wider rather than narrower until the iris was only seen with difficulty as a very narrow band. Three weeks after the injury the iris was gradually coming into sight again but still remained very narrow. Four months later the eye was removed on account of pain and the danger to the other eye, and on microscopical examination the cause of the retraction of the iris was revealed in a separation and backward displacement of the ciliary body, which had formed a new attachment to the sclerotic. In both of these cases the fundus was very much obscured

at first by the presence of blood in the vitreous. Figure 18 also illustrates a complete rupture of the iris. In both of the cases above described the injuring force was of the kind already mentioned i.e. a swiftly flying object impinging suddenly against the eye. In Case 8 the wound of the upper lid indicated fairly well the seat of the injury which is apparently diametrically opposite to the seat of rupture, while in Case 7 so long a time had elapsed between the accident and his first presenting himself that it was impossible to say which part of the eye or lids had received the blow. It will be noticed that in both cases there was a certain degree of mydriasis very moderate in Case 7 and extreme in Case 8, but in both giving practically no reaction to Eserine. The question of the size of the pupil has been a disputed one in cases of ruptures of the iris. Some authors held on the strength of their own cases that a wide dilatation of the pupil was a necessary accompaniment of rupture of the sphincter, in fact Ivert (quoted by Franke loc. cit) held that mydriasis following blows on the eye was pathognomonic of such ruptures, which must be present though not evident at the time of examination. Such a phenomenon has not been the rule with other observers. In one of the cases described by Franke there were multiple ruptures affecting mainly the nasal half of the iris. After the effects of atropine passed off the

pupil assumed the same size as the other with reaction to light and in convergence, though these were slightly deficient in the half affected by the ruptures. In other cases observed by myself a very moderate degree of mydriasis has been the rule, that of Case 8 above being the only one of five or six in which there was such an extreme mydriasis, and, as was seen, there was another cause for that in addition to the rupture. It is extremely probable that the explanation of Wecker was right (Graefe-Saemish Handbuch 1876), and that the dilatation of the pupil when present, is a separate effect of the concussion, and should be looked upon as a paralytic mydriasis or one due to stimulation of the dilator fibres by concussion. A priori one would scarcely expect that a rupture of the sphincter would give rise to a wide dilatation of the pupil, when it is remembered that even with the wide coloboma produced by an iridectomy such a phenomenon does not occur. Rupture of the border of the iris is easily distinguished from all other colobomata of the iris by (1) its shape, which is usually definitely triangular, (2) the hiatus in the pigmentary border of the iris, (3) the direction of the markings of the iris which no longer run across the width of the iris but run parallel to the margin of the gap. Like other injuries to the iris it cannot be properly diagnosed until the clearing up of the hyphaema which invariably accompanies it. When the state of affairs becomes visible the extreme simplicity of

the lesion would be apt to lead one to give a very favourable prognosis, but no prognosis should be given until some time has elapsed after the injury, as this lesion when of any extent is especially prone to be associated with lesions of other parts. Intraocular haemorrhage is not likely to be overlooked on account of the great visual disturbance which it causes. A very common and at the same time very annoying complication of rupture of the iris is cataract. As was shown by the first of the two cases quoted above, (Fig 1b) this may come on after the lapse of some days and even then it is only noticeable on ophthalmoscopic examination. The occurrence of this complication still further diminishes our power of giving a prognosis, as the presence of the cataract may hide still further complications, in the shape of changes in the fundus of the eye. When the lens has become cataractous in such a case the probability is that there has been, along with the rupture of the iris border, a simultaneous rupture of the anterior capsule of the lens, allowing of the imbibition of aqueous which gives rise to a gradually increasing opacity. The lens as well as being wounded in this way, may be rendered loose and freely movable by rupture of some of the fibres of the Zonule of Zinn. When there has been a considerable degree of haemorrhage into the vitreous chamber, the vision is for a time at least, greatly reduced by the presence in the vitreous of large dark

flakes which, as the vitreous assumes a more fluid consistency, float about across the field of vision. This may not affect the ultimate prognosis of the injury if the patient be still young, for the flakes will absorb in the course of a few weeks, leaving no trace to disturb the vision. Other recognised complications of rupture of the iris which must be considered in their turn are separation of the retina and rupture of the choroid, the latter being especially apt to occur.

The following case is an example of a condition which, to judge by the number of reported cases must be of extreme rarity, and known as Dehiscence of the Iris.

Case 9. (See Fig. 17) The patient, a boy aged 13, was struck a severe blow on the left eye with a cricket bat three days before admission to Hospital. There was a good deal of ecchymosis of the lids and conjunctival congestion. Aqueous humour was slightly turbid so that the details of the iris were hazy, and there were a few traces of blood still in the anterior chamber. The pupil was of peculiar shape, being flattened on its lower outer aspect, and at this part there was a radiating fissure in the iris separated from the pupil by a bridge of iris tissue, but reaching as far outwards as the periphery where it was continuous with a small Iridodialysis. There were several small lacerations of the pigment border of the pupil also visible. Under atropine the pupil dilated and under

eserine it contracted but the fissure retained its size and shape. When in the course of a few days the vitreous had cleared somewhat, the red fundus reflex could be obtained through the fissure at the periphery.

We were here dealing with a gap in the substance of the iris between its border and its ciliary attachment, the fissure being separated from the pupil by a narrow band of iris tissue probably including the sphincter. It was continuous at its ciliary extremity with a small Iridodialysis which caused the fissure to have the form of a triangle with its base outwards. Without a separation of the periphery of the iris from its ciliary attachment to some extent, it would be impossible for such a fissure to have a trianaular form and therefore I assume that the same combination of lesions must have been present in the case quoted in the Nagel-Michel Jahresbericht for 1899, in which a boy who had received a blow on the eye with a stick, presented in the injured eye a triangular hole in the iris separoted from the pupil by a narrow band. In such cases it might be assumed that, starting with an Iridodialysis the tear ran up between the radial fibres to produce the radial fissure, but in other reported cases the iris was the seat of more or less numerous fissures which did not reach the ciliary border of the iris. These may be caused by an unusually delicate constitution of the iris stroma enabling the displaced aqueous to force its way between the radial fibres,

and this seems to me a more reasonable explanation than that of Praun (op. cit.), who assumes that the iris is compressed between the depressed cornea and the anterior surface of the lens, and so gives way as one can rupture the delicate skin of some fruits by crushing it between the finger and a hard surface. A still more rare condition is that described by Westphal and referred to in the Nagel-Michel Jahresbericht 1896. Here there were as a result of a severe blow on the eye, a large number of small holes in the iris such as might have been made with a pin, which disappeared under eserine to reappear when its effect passed off. These apertures certainly could not have been caused by direct injury, and it seems highly probable that they were caused by the forcing of the aqueous through between the fibres of the iris at the time of the accident.

Hyphaema, or blood in the anterior chamber is a symptom of some interest in connection especially with the injuries we have just been considering. In most works on injuries of the eye it receives little more than mention, but it may be found to be of some service to us in diagnosing the nature of the lesion which is present.

Blood is often found in the anterior chamber as a consequence of a sharp blow on the eye without external wound and with no visible injury to the iris or other internal parts. It is in these cases that the difficulty arises of determining the source of the haemorrhage. Where a gross

lesion such as a rupture of the iris or an Iridodialysis exists, there is of course no difficulty, though we may have to await the partial or total absorption of the blood before a diagnosis can be arrived at. Setting aside then Iridodialysis, aniridia and the various gross and visible ruptures of the iris, the only other known causes of hyphaema are bleeding from individual vessels of the iris, bleeding from a rupture of Schlemm's Canal, and bleeding from ruptured vessels of the choroid and ciliary body. We suspect the last two forms of injury when, after the blood in the anterior chamber has been so far absorbed that we can get a clear view of the pupil, the fundus reflex is abolished by the presence of blood behind the iris, or the remains of blood are seen in the vitreous in the form of actual clots or floating opacities of irregular form. Where such posterior effusions of blood are present we can be sure that injuries of the choroid or ciliary body at least are present whatever else there may be in addition. Blood passes more or less readily from behind the iris into the anterior chamber, but seldom finds its way in the opposite direction. Where then a moderate degree of hyphaema has been present, which, when it clears up, reveals no sign of gross lesions of the iris and no blood in the posterior chambers of the eye, the causal lesion reduces itself to one of two things, either rupture of the Canal of Schlemm or rupture of some vessels on or near the surface of the iris. But it seems to me that another point of diagnostic

importance is the condition of the effused blood, a point which may be stated briefly as follows:- (1) When the effused blood is in the form of an actual coagulum, especially if it is seen in some part of the chamber other than the lower angle, there has been a breach of surface in the form of Iridodialysis, rupture of the iris etc., (2) When the blood is in a fluid state it has been effused from a small rupture of a blood vessel of the iris or, if from a rupture of the tissues, has not been allowed to accumulate round the point where the breach of surface occurred.

Let us here digress somewhat for the purpose of bringing forward a few facts in support of the above statements. When blood is effused into water (the aqueous humour may be considered for the purpose to be simply water) the red corpuscles shortly imbibe water, swell up, and discharge their haemoglobin into the fluid. If a very minute quantity of freshly drawn blood be mixed on a glass slide with a proportionately large quantity of water, it will be seen that within a few minutes not a whole red corpuscle remains. If the quantity of blood be made greater in proportion to the quantity of water, numerous unbroken red corpuscles will be found after a considerable lapse of time, the breaking up of a certain number of the red corpuscles having perhaps raised the specific gravity or altered the constitution of the fluid in such a way, that a number of the corpuscles are allowed to

remain intact. It is easy to understand therefore that when the quantity of blood effused into the anterior chamber is very small, the corpuscles break up, the colouring matter is seen diffused through the aqueous, and in a remarkably short time disappears entirely having passed away in the ordinary course of the circulation of the aqueous humour. Where the blood is in somewhat greater quantity, a large number of red corpuscles sink to the bottom of the anterior chamber by force of gravity forming a distinct deposit there, and from there gradually pass off either whole through the spaces of Fontana or after breaking up gradually and being carried off as before.

The laws of coagulation and the physico-chemical processes involved are still to a great extent undetermined, but certain well known facts have a bearing on the subject before us. Blood enclosed in a ligatured segment of a blood vessel and removed from the body will remain fluid for a considerable length of time. Blood normally remains fluid while circulating in the living blood vessels, but alterations of the interior of the blood-vessels by inflammatory processes or by trauma, will lead to the formation of a clot in spite of the constant flow of the blood stream over the affected area, a fact which has been made use of in the treatment of aneurysm by irritation of the internal lining of the sac, so as to encourage the formation of a firm clot. This brings us to the explanation of the first of the above statements, namely that

when the blood in the anterior chamber is in the form of a clot there has been a gross lesion of the iris or some other structure lining the anterior chamber and coming in contact with the effused blood. Further, the statement is borne out by a large number of cases, two of which have already been described under the head of Iridodialysis (Cases 4 and 5) one under Rupture of the iris (Case 8) and one under rupture of Schlemm's Canal (Case 6). In these as in all other cases in which the blood in the anterior chamber was coagulated there was a definite rupture of some of the structures composing the wall of the anterior chamber. Further, in all except one, namely Case 5, the clot was, at the time of examination, in contact with the breach of surface referred to. In Case 5 it will be remembered, an Iridodialysis of small size was diagnosed on account of the shape of the pupil combined with the presence of blood in the anterior chamber. Possibly the clot in this case was a loosely formed one (the whole of the blood disappeared in 4 days) and the connecting strands between the point of injury and the blood at the bottom of the anterior chamber had been already dissolved before he came under observation. As bearing further upon this point it will be remembered that it is the regular rule, when blood is effused into the anterior chamber from the performance of an iridectomy or extraction, or even from wounding of the iris during a needling operation or from

division of synechiae; that the blood assumes the coagulated form, lying in contact with the torn part of the iris. With the exception of Case 5 above referred to, the only other case in which in the absence of a visible wound of the iris, I have seen a blood clot form in the anterior chamber, was that of the man (Case 6) in which rupture of Schlemm's Canal was diagnosed. In this case the clot occupied the anomalous position shown in figure 14, being placed vertically in the inner angle of the anterior chamber. According to the patient's own statement, when he had recovered from the shock of the blow he went home and lay down on his right side, that being the side away from his wounded eye. The blood then, issuing in some quantity from the angle of the anterior chamber at a point corresponding to the situation of the blood clot, collected there, and being in contact with the ruptured part proceeded to coagulate. It is conceivable that if the patient had remained on his feet the blood would have accumulated at the lower angle and remained in a fluid state. Bleeding which occurs from vessels on the surface of the iris is of very moderate amount. Moreover the point of escape of the blood probably does not close entirely by a process of thrombosis but largely by retraction of the ruptured vessel. There is thus no encouragement for the blood, which falls by force of gravity to the bottom of the anterior chamber, to form a clot. The behaviour of the blood

under the two conditions is totally different. When the blood remains fluid, even when it seems to fill the whole of the anterior chamber, it is absorbed or carried off with remarkable rapidity, a hyphaema of ½ or ⅓ of the anterior chamber disappearing entirely in three or four days. Coagulated blood on the other hand requires time for its maceration and absorption, and even small coagula may persist for a matter of weeks. Blood clots in the anterior chamber assume various forms, being seen as shreds, webs, or masses of irregular shape. Fluid blood on the other hand settles down by the force of gravity to the most dependent part of the anterior chamber, alters its position with changes in position of the patient's head, and always preserves a horizontal upper border. The blood, at first of a bright red colour, gradually assumes a chocolate tint and finally becomes somewhat purplish. When much blood has been effused the tissues of the iris become stained of a yellowish or greenish tinge which may persist for many weeks after the blood has gone.

Closely associated with the subjects of injuries of the iris and hyphaema are the injuries of the Lens and its suspensory apparatus which may be here enumerated before taking up the other lesions of the uveal tract. Lenticular opacities are naturally less frequent in cases of pure concussion injury, than in those where a penetrating instrument has caused a direct

wound of the lens itself, and moreover, in concussion injuries, traumatic cataract is rarely observed except where there is also a rupture of the iris, iridodialysis or rupture of the zonula, showing that there has been a severe sudden blow which, by the flattening of the cornea and expansion of the ciliary ring, has put a considerable degree of strain on the elastic structures in that neighbourhood. The question has been frequently raised as to whether it is possible for jolting of the body from a fall on the feet, jarring of the spine, or concussion of the head, to produce a traumatic cataract. It is impossible in such cases to positively prove or positively deny the influence of the given injury, but one would scarcely expect that such remote injuries could produce a true traumatic cataract such as is usually only found as a result of a severe direct blow. At the same time some support is lent to the view that such an occurrence can take place, by the discovery in a hanged criminal of cataract in both eyes with transverse rupture of the anterior capsule, and the production of the same condition by hanging in dogs (Norris and Oliver). The only cases of the kind which have come under my notice showed a complete cataract in one eye said to be due to a blow on the forehead or side of head. The point of injury in these cases was indicated by the presence of a large scar, but there was no proof that the eye did not receive some sort of direct injury at the same time.

Concussion cataracts may be divided into those with, and those without rupture of the lens capsule, for though as Collins says, no case of complete traumatic cataract has been recorded in which microscopically the capsule was found intact, still it is undoubted that certain lenticular opacities do form as a result of concussion without rupture of the capsule. Where no lesion of the lens capsule has occurred, it is probable that the opacity is due to a change in the relation between the lens fibres and their fluid surroundings, as in the case of the transient opacity of the cornea following concussion. The fact that this form of cataract most frequently appears as an anterior or posterior polar star corresponding to the normally existing lines of cleavage in the lens, is in favour of this view. Possibly the normal tissue fluids of the lens are driven by the concussion of the eye, out of their normal channels, thus widening the normal spaces or producing such where none normally exist. It is conceivable that such a phenomenon could be brought about by the jolting of the eye conveyed from a blow on the head or fall on some remote part of the body, but probably in most cases it is caused by the alteration in the shape of the lens which will be produced by direct blows on the eye. Bäck, in his experimental observations on contusions of the eye (Archiv. f. Ophthalm. Vol. 47) showed that a blow on the cornea may produce a sort of opacity

in the form of forked lines in the posterior or anterior layers of the lens without any lesion of the capsule being found microscopically. This form of opacity when produced experimentally in animals by Bäck, disappeared within an hour or two. Similar opacities have been observed clinically disappearing within a few hours; but, on the other hand, opacities of a more or less dense and extensive kind have been observed, which had a duration of days or weeks. Rupture of the lens capsule, when it occurs, may affect any meridian or any part of the capsule, the equatorial region being perhaps most commonly affected. Collins (loc. cit.) has described and figured a case in which there was rupture of the posterior lens capsule.

The pathology of this form of traumatic cataract is well known. The slightest breach in the capsule of the lens allows of imbibition of aqueous or vitreous by the lens, the result being a more or less rapid swelling up of the crystalline with a corresponding opacity of its substance. The process indeed is perfectly similar to that which is brought about deliberately in the operation of discission of the lens. If the rent in the capsule be of large size the lens rapidly becomes opaque and swells up, portions of the soft opaque material being extruded through the opening into the aqueous, where they are gradually absorbed. In this way a traumatic cataract may go on to a spontaneous cure, but in most cases this

favourable issue does not come about spontaneously. The opening in the capsule, being small, heals up after a certain limited amount of imbibition has taken place. The opacity produced first at the point of injury may now remain strictly localised to that spot, or may gradually spread inside the restored capsule even to the stage of complete cataract. The mechanism of the injury would appear to be, that the flattening of the cornea and expansion of the ciliary ring put a severe strain upon the suspensory ligament of the lens at the same time as they stretch the fibres of the iris. In most cases under the circumstances the fibres of the zonule give way at some point or other but probably from a delicacy of the lens capsule or greater strength than usual of the zonular fibres the former gives way. Where there is extensive rupture of the zonula of course it is easy to understand how a cataract of this description can occur, the connection between the zonule and the lens capsule is so intimate. As a matter of clinical experience a large number of dislocated or partially dislocated lenses are or become cataractous. It is rather an exceptional thing for a dislocated lens or even a subluxated one to remain perfectly transparent for any length of time. It is conceivable that in an otherwise healthy eye a rupture of a large part of the zonule could occur without any change of position on the part of the lens but as a rule one of the results of such an injury

is a fluid degeneration of the vitreous humour and softening of the eye, whereby the lens, relieved of its means of support, moves about as it were, within the limits of the tether formed by the remaining zonular fibres. The displacement of the lens in such a case is of two kinds, namely, a lateral displacement away from the position of the rupture and a rotation round its own equatorial axis. With a fairly free separation of the lens from its supporting ligament and a fluid state of the vitreous, the lens is seen to bob about within certain limits behind the iris, with usually a constant displacement away from the side at which the separation has been most free. At the same time there is usually a marked tremulousness of the iris from loss of its normal support in the shape of the lens and its zonular ligament, the tremulousness in moderate cases being confined to the locality of the ruptured zonula.

The following case presented a fairly extensive rupture of zonular fibres with subluxation of a cataractous lens and fluidity of the vitreous.

Case 10. The patient, a miner aged 23, was injured on the left eye by a piece of road metal. No external injury of the eye was found. There was complete radial rupture of the iris upwards and outwards and several small lacerations at the pupillary border. The lens was cataractous. The zonule was apparently broken all round except at the upper outer quadrant, so that the lens was dislocated and

tilted backwards and outwards. It was also freely moveable. (Fig. 18).

Along with these subluxations of the lens should be classed also those cases in which the lens is rotated on a vertical axis and partially dislocated into the anterior chamber. The mechanism of the production of this injury has been already described.

When there has been complete rupture of the zonula the lens loses all support and, if the vitreous is in a fluid condition, is free to move about in all directions, controlled only by its obedience to the law of gravity. Such a completely detached lens falls back as a rule into the vitreous chamber, where it sinks to the lowest part of the vitreous, and is seen there by the ophthalmoscope as a dark spherical mass which floats up into the line of vision when the patient alternately rotates the eye up and down. The lens often becomes opaque but may remain for a considerable number of years unaltered, and in spite of the freedom of its movements may give rise to no irritation or inflammatory reaction. Unfortunately however, a more unfavourable result may be brought about in the form of Cyclitis, high tension, or atrophy of the eyeball. In other cases the lens is completely separated from its attachments and comes forward into the anterior chamber. This condition invariably leads to a great deal of inflammatory reaction with possibly a true iridocyclitis and in many cases a glaucomatous rise of tension. The following is an illustrative case.

Case 11. The patient was a woman aged 58. The left eye had received two injuries, one 14 years and the other 5 years before admission. The eye had only been acutely painful for seven weeks. As shown in Fig. 19 there was a dislocation of the lens into the anterior chamber, only a narrow border of the iris being visible above and to the inner side. The eye was the seat of severe congestion and was tender to the touch and hot and painful at all times. Tension was slightly elevated. The lens itself was cataractous.

Occasionally the lens may move about under the influence of gravity from the vitreous into the anterior chamber and vice versa, and one or two cases have been put on record in which the patient could at will replace the lens in its normal situation at the pupil by placing the head in a certain drooping position, and so have good vision until the head was shifted.

A lens dislocated into the anterior chamber may have escaped entirely from its capsule leaving the latter in its former position, or it may remain enclosed in its capsule. In the latter case it may remain clear and transparent but more often such dislocated lenses become gradually cataractous, if not cataractous before dislocation. It may even undergo a calcareous change and has been known to become fluid inside its intact capsule and float in the aqueous humour in that condition. All these alterations in position of the lens from rupture of the zonular fibres

are especially prone to occur in highly myopic eyes, in which, in addition to the delicate state of the tissues of the eyes generally, there is often a special weakness of these fibres. The diagnosis of the different forms of luxation and subluxation, of course, present no special difficulty except in the case of a transparent lens recently dislocated into the anterior chamber, which may be difficult to recognise. In other cases the catoptric tests for the presence of the lens, the examination with the ophthalmoscope and subjective symptoms such as loss of power of accommodation etc. will serve to demonstrate the state of affairs.

Returning to the uvea let us now take up the different forms of concussion injury to which the Choroid is liable. A consideration of the anatomical relations of the choroid will help to give us some idea of the form which these injuries are apt to assume. Supported as it is between the retina and vitreous on the one hand, and the sclerotic and orbital tissues on the other, one would not expect to find it a frequent seat of injuries from indirect force, but the peculiar brittleness of such a delicate vascular tissue predisposes it to gross lesions which are not so liable to affect the highly elastic retina. Further the manner in which the choroid is bound down to the sclera at the circumference of the optic nerve entrance, at the point of exit of the venae vorticosae and at its anterior or ciliary border, favours the production of these lesions.

Being free from those finer perceptive elements which are present in the retina and which are liable to be disorganised, temporarily at least, by even slight concussions, it does not suffer except under more severe blows, when it may be the seat of lesions of considerable extent and of a more or less permanent character.

As it is a highly vascular tissue composed partly of the finest capillary vessels, partly of those of greater calibre, it is natural that its lesions should be accompanied in most cases by pretty extensive haemorrhages, which interfere with vision for the time being and ultimately lead to permanent defects of sight by the production of secondary changes. The connection between choroid and retina being so intimate, a lesion which is in the first place choroidal, sooner or later affects the retina also. Clinically it is often difficult to say how much of a lesion is choroidal and how much retinal.

Choroidal haemorrhage in its simplest form occurring from rupture of a few choroidal vessels is not a common occurrence. If the haemorrhage is in considerable quantity it may pass backwards between the choroid and sclera elevating the former, or between the choroid and retina with separation of the latter.

Without rupture of the retina either simultaneously or at a later period the blood cannot escape into the vitreous chamber, but having once made its way through the retina it may lodge in the

vitreous chamber or even pass through the pupil into the anterior chamber. When the haemorrhage has produced elevation of the retina the latter has a dull brownish colour, probably at first veiled with a greyish opacity from oedema. That the haemorrhage is not from the retina can be diagnosed by the fact that it bears no relation to any of the retinal vessels, and these pass over the elevated portion intact. Haemorrhagic elevation of the choroid is one of the rarest of clinical phenomena, and can only be diagnosed from separation of the retina by the recognition of branchings of choroidal vessels in addition to the retinal vessels, coursing over the elevated area.

Small haemorrhages in the choroid may through time be absorbed and leave behind them no ill effects. Often, however, they give place to white patches of choroidal atrophy with pigmentary accumulations similar to those met with in some forms of Choroiditis. In other cases atrophic and pigmentary changes occur in the choroid as a sequence of injury by a blunt object quite apart from the occurrence of haemorrhage. In many of those cases the changes have been attributed to rupture of some of the posterior ciliary arteries, and this diagnosis seems to be justified, by the fact that similar appearances have been produced by experimental division of the ciliary vessels. For example Hertel of Jena, (Bericht über Ophthalm. Congress, Heidelberg, 1893) showed that when the ciliary vessels round the entrance of the optic nerve had been

divided, retinal opacities were produced close to the disc, which afterwards gave place to chorio-retinitic spotting of the fundus.

Commoner than either of these affections which have just been described is indirect rupture of the choroid a lesion which, like indirect rupture of the sclera, is rather difficult to explain satisfactorily and has been the subject of much discussion within the last forty or fifty years. In its typical form it consists of a tear through the whole thickness of the choroid, and of such magnitude as to be easily distinguished by Ophthalmoscopic examination, the sclera always remaining intact, and the retina at the corresponding site being very rarely involved in the lesion. At first, as one would expect, the injury is accompanied by profuse choroidal haemorrhage which may for a time obscure the rupture, though this is usually visible within a day or two of its occurrence as a yellowish curved band situated between the macula and optic nerve entrance, and concave towards the latter. That it is a choroidal lesion is shown by the fact that the retinal vessels maintain their course over the affected spot quite uninterrupted and this is still more easily made out when, in the course of time, the haemorrhage clears up and leaves the rupture standing out clearly as a sharply defined crescentic band with pigmented margins and of bright whitish colour from the exposure of the sclerotic behind the rupture. Although this description is true for the great majority

of cases, varieties in form and position occasionally occur. Thus, instead of being situated between papilla and macula, the rupture may lie to the nasal side of the former, though still with its concavity towards it, or it may even have a horizontal course between papilla and macula, or a vertical direction from the papilla upwards or downwards. Another variation from the usual form is a breaking up or bifurcation of the extremities of the rupture so that it loses its typical crescent-moon form. Though this lesion is usually single, multiple ruptures are occasionally observed. In such cases the smaller ruptures are usually situated nearer the papilla. A case pictured by Haab (Atlas für Ophthalmoscopie) however, shows small ruptures further removed from the papilla than the larger one.

A prognosis in cases of Choroidal rupture can only be ventured when one has decided on the probability of good absorption of the effused blood. Where other lesions are absent e.g. rupture of the iris, or subluxation of the lens, and the blood effused from the ruptured choroid shows signs of rapid absorption, while the rupture, from its position and size, does not directly involve the macula, there is a fair prospect for the vision. Vision is always defective in the retinal segment corresponding to the choroidal rupture but, as this does not form a positive scotoma, the disturbance of vision is not great if the macular region is not involved. If there has been an

escape of blood through the retina into the vitreous chamber, the presence of opacities in the vitreous after recovery will considerably diminish the acuity of vision, while in any case the simultaneous rupture of the retina is a severe complication as it leads to progressive degenerative changes in the retina. The most favourable prognosis can be given in uncomplicated cases with one or more small ruptures which avoid the macula region. After clearing up of blood clot, a complete restoration of vision may come about from healing of the tears provided that no retinal disturbance is caused by cicatricial contraction. Figure 20 illustrates a case with two well marked choroidal ruptures, the history of which is as follows:-

Case 12. A boy aged 14 was struck on the left eye with a lump of hard clay thrown by another boy. A week after the injury there was found to be mydriasis of an extreme degree the pupillary border above having a flattened form. The iris was of a yellowish green colour, but there was no blood visible in the anterior chamber. The vitreous however, was apparently the seat of considerable haemorrhage which formed numerous floating opacities and also imparted to it a general haze which made it impossible to get a view of the fundus. A solid looking mass was seen both by oblique illumination and by ophthalmoscope, bobbing up behind the lens on movements of the eye. This had a pale

reddish colour and was probably blood clot. Tension tended to be high. Four weeks after the injury the vitreous had cleared sufficiently to give a clear view of the fundus, which presented two crescentic ruptures of the choroid of about equal size, both below and somewhat outside of the disc and concentric with it. The fundus in the region round the upper part of the disc was the seat of diffuse mottling with black pigment. This appeared to be at least partly retinal, as it here and there covered the retinal vessels. The field of vision showed a general constriction at the periphery, most marked above. (fig. 7) It was a fortnight later before the pupil returned to its normal shape and responded to repeated instillations of eserine.

The explanation of the mechanism of indirect choroidal rupture presents many difficulties especially in view of the variations in form and position which have been mentioned, and indeed no theory has been formulated which will satisfactorily explain all cases.

A paper by Dr. H. Hughes of Hamburg (Archiv. f. Ophthalm. Vol. 33) gives a review of the various theories which have been brought forward from time to time and adds another to the already large number.

Von Zeidlitz of Kiel (1873) attributed the rupture to a compression wave communicated from the point of impact, which he said reached the opposite end of the diameter of compression before it reached the other parts. This theory is quite

opposed to the laws of hydrostatics, the internal pressure produced by a blow being communicated equally and at the same instant to all points on the wall.

Knapp (1870) and Gub (1871) likened the injury to fracture of the skull by contrecoup, a fallacy which has been dealt with in connection with the subject of scleral rupture.

Becker (1878) thought that the optic nerve, when the eyeball was driven back into the orbit, did not yield like the orbital fat, and so was depressed into the back of the eyeball and produced rupture of the choroid by stretching; but probably no such action of the optic nerve occurs whereby it would assume the role of the injuring body, for the consistency of the optic nerve is not greatly different from that of the cushion of orbital tissue behind the eyeball, and its twisted course will prevent its being driven against the posterior wall of the eyeball with enough force to overcome the equal distribution of intraocular pressure.

Laemish tried to explain matters by the statement that the choroid was more stretched by the rise of intraocular pressure, at the posterior pole than elsewhere, on account of its attachment here to the sclera by means of the posterior ciliary arteries.

Von Arlt introduced a more valid explanation by showing that the same physical conditions could act here as in the case of rupture of the sclerotic. Increase of intraocular tension gives rise

to stretching of the choroid and other coats which is greatest in the "equator of expansion" (see fig. 1.) The choroid is particularly firmly attached to the sclerotic round the optic nerve entrance where the posterior ciliary arteries enter it, at or near the equator where the venae vorticosae leave it, and at the anterior extremity of the choroid where it passes into the ciliary body and receives the anterior ciliary arteries. If the choroid and sclerotic were equally capable of extension, even these facts would not allow of rupture of the choroid occurring without a corresponding lesion of the sclerotic; but the choroid being of a more fragile consistency, the natural consequence of the stretching produced by rise of intraocular pressure is a rupture of this coat at some point between the lines of attachment, and at right angles to the shortest distance between them.

Berlin's view (1873) was that the posterior choroidal rupture was of the nature of a direct injury to the choroid from behind by return shock, from the compression of the elastic orbital contents against the bony wall of the orbit, a view which can hardly be supported by any known physical law.

The contraction of the ciliary muscle mentioned by Hülse (1878) may possibly occur at the time of a blow, but it is doubtful if its influence would even assist in the production of the rupture of the choroid in the typical position between macula and optic disc.

Franke (Arch. f. Ophthalm. Vol. 30) again tried to show the importance of the optic nerve. In his opinion the return pressure on the eye, produced by elasticity of the compressed orbital cushion, failed at the optic nerve entrance, and in this way choroidal rupture could be produced virtually as a direct injury from behind, by the return shock producing a severe stretching of the choroid. This view seems to be as little supported by fact as that of Becker which assumed an excessive rigidity of the optic nerve. It seems reasonable to suppose that the support afforded to the posterior part of the eyeball is equal at all points, or at least not sufficiently varied to account for the production of such an injury as rupture of the choroid.

Hughes himself (loc. cit.) ascribes an important role to rotation of the eyeball and torsion of the optic nerve. Assuming that rupture of the choroid occurs in cases where the blow has struck the ball in a somewhat tangential direction, so as to produce extreme rotation of the ball, but not necessarily any great rise in intra-ocular tension; he attributes the actual rupture of the choroid to the rotating ball being brought to a sudden halt by the check action of the optic nerve. This he says, from the intimate attachment at the optic nerve entrance, tends to tear the choroid at the opposite side from that towards which the eye was being rotated when the pull of the nerve came into play.

Thus, supposing a blow to come from the outer side, the ball would be rotated inwards towards the nose. Suddenly it would be brought to a halt by the action of the optic nerve, which would drag on the choroid of the outer half of the ball, whereby rupture of the choroid would occur at the usual situation, to the outer side of the disc. Ruptures lying to the nasal side of the disc and in other exceptional positions could be explained similarly by the action of a blow which rotated the eyeball in some other direction— outwards, upwards or downwards. This seems at first a somewhat reasonable theory especially as it would help to explain the occurrence of ruptures in unusual situations, but several facts tell against it. In the first place, with regard to the nature of the injuries which lead to choroidal rubture, it is seen that this theory of Hughes' assumes a glancing blow rotating the eye while causing comparatively little rise of tension. According to the statements of Müller, on the other hand, choroidal rupture is specially prone to occur where the eye is subjected to a severe blow coming from in front without rotation of the eye. Moreover, those authorities who have succeeded in producing choroidal rupture experimentally in animals have made no mention of this factor of rotation, but attribute the ruptures to severe sudden blows on the front of the eye. On the whole the explanation of Von Arlt seems to represent the facts most accurately without the introduction of any unknown or imaginary

factors. Undoubtedly the production of choroidal rupture requires a considerable exercise of force, and that of a kind which produces compression of the ball with corresponding stretching of its coats from displacement of the contents. If now we assume that at the time of injury, the eye is rotated inwards and upwards and the blow comes from below and outside, the macula region approaches to the equator of expansion. The result would be a rupture of the less expansile choroid, whose position is determined by the anatomical arrangements previously mentioned. It must be confessed that Von Arlt's theory is not applicable to ruptures at the nasal side of the nerve and in other unusual positions, but in such cases it may be sufficient to assume a blow coming from the nasal side, from above, or from below as the case may be. The theory does not exclude the possibility of a rotation of the globe by the injuring body, but it does not assume that the optic nerve plays any important part in the mechanism.

Haemorrhage into the vitreous is a symptom sometimes associated with rupture of the choroid when there has been a simultaneous rupture of the retina or injury to the ciliary body. The importance of this symptom in view of the prognosis of concussion injuries is very considerable, as an otherwise good recovery, especially in an old person, may be quite nullified by the presence of blood or its remains in the vitreous. When the patient is young

and of good constitution a total absorption of even an extensive vitreous haemorrhage may be looked for in the course of three or four weeks, but in elderly patients such a favourable issue is the exception rather than the rule. Haemorrhage into the vitreous gives rise in a very short time to a fluid degeneration of the medium, so that the remains of the effused blood, which take the form of flakes and masses of irregular shape, float freely about with the slightest movement of the affected eye. In this way even a few small streaks floating freely in the vitreous and occasionally passing across the line of vision may cause endless annoyance, if they do not render the patient useless for any form of skilled labour. When vitreous haemorrhage is very severe, one of its consequences is often an extremely irritable state of the other eye, with photophobia and lacrymation apparently of a sympathetic nature.

A more serious effect still, though fortunately not very common, is the development in the injured eye of glaucomatous symptoms which, along with the sympathetic irritation of the other, will necessitate the removal of the eye.

Rupture of the retina being a rare occurrence, and separation of the retina by concussion being by no means common, the concussion injuries of the Retina are mainly of the first and second degrees, namely, serous effusions and rupture of vessels.

The most simple retinal affection known to follow a blow on the eyeball is oedema,

a lesion which assumes several different forms. It may almost be said that a certain degree of retinal oedema results from every severe blow on the eye. Frequently of course the presence of gross lesions of the other parts conceals or lessens the importance of this retinal condition but ophthalmoscopic examination of almost any eye within a few hours of a severe concussion will detect a general haziness of the retina which may be looked upon as the natural consequence of the congested state of the retinal vessels, which is an almost constant phenomenon in such injuries. Such a slight oedema may be compared with the phenomenon of fulness and swelling which results from a concussion in any other part of the body, and is naturally of very short duration.

The effusion takes place from the congested retinal vessels and is situated in the anterior layers of the retina. Experimental investigations such as those of Eäck (Archiv. f. Ophth. Vol. 47) show that after a blow on the front of the eye, the first phenomenon observed in the fundus is a momentary narrowing of the retinal vessels giving place in a few minutes to a dilatation of these vessels, and the formation, as observed microscopically, of a finely granular exudate between the retina and the choroid, supposed to be a paralytic exudate from the vessels of the choroid.

The form of retinal oedema which has received most attention is that known as Berlin's oedema or Commotio Retinae. The

term Commotio Retinae in preophthalmoscopic days was applied to those obscure cases of blindness which followed blows on the eye or its neighbourhood, with no visible lesion to account for the defect. Through time many of those cases were cleared up by the observation of fundus changes such as optic atrophy, macular changes etc. and Berlin in 1873 applied the old term Commotio Retinae to a class of cases in which visual defect could be attributed to a retinal oedema of peculiar form which had been observed by him. In these cases there is noticed within an hour or two of the injury, (which is usually a blow with a stick, stone, snowball, or some similar object) a diffuse milkwhite opacity of the retina in and round about the macula region. There is also a similar area in the anterior part of the retina corresponding nearly to the position of the blow, but this cannot be seen in its whole extent. The opacity is distinguished from a recent separation of the retina by the colour, which is of a dead milky white, by its diffuse undefined margin, and by the fact that there is no alteration of level or change in the course of the vessels. The retinal vessels pass over it unaltered. Sight is at first considerably reduced, both central and peripheral defects of the visual field being present. Light sense is also defective. In the course of a few days however, the ophthalmoscopic changes disappear, seldom continuing more than a

week, and with them the visual defects clear up also. Berlin satisfied himself by producing a similar condition experimentally in dogs, that the pathological condition was a haemorrhage between the choroid and sclera, from which the overlying retina imbibed fluid. This view has been subjected to a considerable amount of criticism and is not now generally held. Fraun (Op. cit.) objects to it on the following grounds. (1) The oedema disappears more quickly than haemorrhage could be expected to be absorbed. (2) It is never associated with haemorrhage on the anterior surface of the choroid as one would expect to find, at least occasionally, if it were due to haemorrhage from choroidal vessels. (3) Retinal oedema is not seen in cases of rupture of the choroid where all the conditions as regards haemorrhage are present. (4) Elevation of the choroid does not occur as one would expect to see if there were haemorrhage behind the choroid. (5) It is never followed by choroiditic changes.

Some writers e.g. Ostwalt and Kaab have described this form of oedema as forming first in the course of the retinal vessels, thus suggesting that the transudation of fluid is chiefly from them; but, as Fraun remarks, this cannot be true of Berlin's oedema, as vessels are very scarce in the macular portion of the retina, while at the same place the choriocapillaris is peculiarly rich. As the macula is the favourite seat of the oedema

this suggests that the oedema is due to a transudation from the choroidal vessels, which takes place from increased permeability of the vessel walls.

Denig (New York 1896) conducted a series of experiments on animals, and agreed with previous writers as to the retinal vessels being first narrowed and later dilated, while the onset of the milky-white retinal opacity occurred about fifteen minutes after the blow. The haemorrhage between choroid and sclera which Berlin had observed, and to which he attributed the retinal opacity, was declared by Denig to be an occidental phenomenon due to too great strength of the blow, and not a necessary accompaniment of the oedema, and he also observed that when it was present the oedema had a bluish darker colour. He described the appearance of Berlin's oedema as being like a fine white network ramifying behind the vitreous and lying on the retina. Microscopically the meshwork resolved itself into a series of fine, highly refracting spots, covered by the membrana limitans, and with a higher power examination he came to the conclusion that these spots represented the stigmata between the ends of Müller's fibres, which had been expanded, by the vitreous having been driven between the fibres into the nerve fibre layer of the retina. At the same time he described, though he did not lay great stress upon, the paralytic exudate from the choroidal vessels lying between the retina and choroid and partly imbibed by the former. A further series of experiments was conducted by Eäck (loc. cit.) who produced various lesions

by means of a spring apparatus by which he was able to regulate the force of the blow used. He was able to produce a retinal oedema corresponding in ophthalmoscopic appearance to that described by Berlin, and tried to determine the tissue changes underlying it by microscopical examination of the injured eye, as well as of the uninjured one for control purposes. His cases like those of other observers showed the momentary constriction followed by dilatation of the retinal vessels, the same phenomenon being observed in the iris.

About ¾ hour from the time of the injury, the milk-white opacity of the retina appeared, reaching its maximum in about 2 hours, and disappearing entirely in about 40 hours. At the same time an exudate of finely granular and fibrillary form was given off into the anterior chamber, apparently from the iris vessels during their stage of paralytic dilatation. The only change which he found to account for the retinal oedema was a similar exudate between the choroid and retina, which he declares to be derived from the choroidal vessels and strictly analogous to the effusion into the anterior chamber from the iris. This he confirmed by reactions with staining fluids. He found none of the subchoroidal haemorrhages mentioned by Berlin. Bäck also observed the changes in the inner layers of the retina described by Denig, but considered that they were minute plications of the retina produced during preparation, and declared that he had found them also in the uninjured eyes. His objection to Denig's

theory about the driving in of the vitreous between the ends of Müller's fibres, is that such an occurrence would produce its appearances instantaneously, whereas the retinal opacity forms gradually after the injury. Denig in reply denies that the appearances in the inner retinal layers are artefacts, and adheres to his view that they are due to driving in of the vitreous or its fluid portion between the bases of Müller's fibres. Be that as it may, it seems very improbable that these appearances form an essential part of the condition known as Commotio retinæ, since that lesion is one which appears gradually, increasing during a matter of hours both in extent and in distinctness, and as slowly disappearing. It is only to be expected, as Bäck observed, that changes due to the opening up of the stomata in the limitans interna by the force of the vitreous, would be of sudden onset and would not progressively increase after the cause had ceased to act. Moreover the presence of the aforementioned exudate in front of the choroid may be supposed quite sufficient to explain the appearances observed, namely obscuration of the red choroidal reflex at the affected part.

The case illustrated in Fig. 21 was one of retinal oedema of an unusual form.

Case 13. The patient - a boy aged 17 - was struck on the left eye by the butt end of a billiard cue ten days before the drawing was made. Immediately after the injury and for a day or two, vision was reduced to counting fingers close to the eye. When the picture was made, vision in the injured eye was

20/200. By that time no sign of external injury could be detected. The appearance of the fundus was that of a series of pale greyish-white rays, in width about the same as a choroidal vessel as seen in a tessellated fundus, and radiating from the macula upwards, outwards, and downwards, while those between the macula and the disc ran parallel to the latter.* Although the optic disc was slightly congested, and the vessels passing from it had a somewhat tortuous course, these rays had not the appearance of retinal plications, being apparently quite flat with retinal vessels passing over them unaltered in their course. The whole retina was somewhat hazy in appearance. There was no relative alteration of the field of vision as compared with that of the other eye.

In the course of a few weeks the appearances described had mostly gone and vision was almost normal.

Such unusual forms of oedema have been mentioned from time to time, but one cannot explain why the effusion should have assumed the pattern shown, on the basis of the microscopic anatomy of the parts. The above patient was not seen until ten days after the injury so that it is possible that the fundus may at first have presented the typical picture of Berlin's oedema.

Cases have also occasionally been described in which a projection of the macula, apparently due to oedema, was found after injury. This is not often observed ophthalmoscopically but Dr. Leslie Buchanan

* If a series of lines were drawn crossing at right angles the optic nerve fibres as they pass towards and round the macula, these lines would give a pattern similar to that in Fig. 21.

(Ophthalmic review Ap. 1898) has examined microscopically the retince of a number of cases, finding in the simplest forms a single prominence in the macula region in place of the normal depression, while in the more severe cases the retina in the macula region and between it and the disc, was thrown into ridges and folds, which he concludes are brought about by oedema and congestion of the retina. It is doubtful however, how far such changes could be produced by blows with blunt objects, as the cases in which they were observed microscopically all suffered from penetrating wounds.

The only case of the kind known to me in which there was no penetrating wound, was one in which a dislocated cataractous lens was floating free in the vitreous and giving rise to much irritation. After enucleation the whole retina was found thickened by oedema while the macular region presented a marked elevation in place of the usual depression. The cause of the dislocation of the lens was a blow with a fist.

Cases have been occasionally reported in which the macula region was the seat of a perforation or hole in the retina, one such case being given by Noab in his Atlas. The retinal defect takes the form of a round, or sometimes oval, well defined hole, about half a disc diameter situated at the fovea, the surrounding retina being finely stippled with gleaming white specks.

A class of cases to which considerable importance attaches in view of claims for compensation after injury, is that which includes the so called Haab's Disease of the macula. This condition which is by no means a common one, was first described by Haab (1888) and a number of examples are depicted in his Atlas of Ophthalmoscopy. The essential nature of the condition is a degenerative change in the choroid or retina or both, especially in the region of the macula lutea, which has been shown to follow in some cases a concussion or contusion of the eye. Changes in all respects similar to them are seen also in eyes which are the seat of foreign bodies such as small chips of metal, in those subjected to long continued pressure by orbital tumours or aneurysms, and in those exposed to the direct action of the solar rays, for example, by looking at the sun without protecting glasses.

In most cases when a concussion injury has been responsible for the macular changes, the patient only presents himself on account of failing vision, some months or it may be years after the accident, and the mode of origin of the disease is quite unobserved. In a certain number however, (about half of the recorded cases) the condition has been observed to grow out of a condition of retinal oedema at the posterior pole, (Berlin's oedema.) When the presence of the latter lesion was first observed, it never lasted longer than eight days, and naturally if the cases were not seen until more than eight days had elapsed since the injury, the condition

of oedema was no longer present, although it may have preceded the macula changes as in the other cases. When such changes as are to be described, are noticed in the region of the macula, either during the clearing up of a Berlin's oedema, or some time after a concussion of the eye, the prognosis as regards vision is distinctly bad. Such an affection is seldom or never known to improve but tends on the contrary to increase, while its position renders the prospects of useful vision hopeless.

In the earlier stages the macula stands out distinctly as a round or oval dark patch without the normal reflex, and with a fine stippling or streaking in and around it. Through time dark pigment begins to accumulate in the macula region, which gradually increases in quantity, the intervening space assuming a greyish colour, which in the course of years becomes pure white from complete atrophy of the choroid. As regards the origin of these changes, it is known that haemorrhages of visible size in the macular part of the retina, sometimes leave after their absorption, yellowish and whitish spots which lead through time to pigmentary disturbances and degenerative choroidal changes in that region. It is assumed therefore that in a certain proportion of cases at least, this may be the mode of origin of the changes described, and that where the lesion has been seen to form itself as it were under cover of the oedematous condition already referred to, we must refer it to the occurrence of minute tears of the choroidal and retinal elements, with probably

extravasation of blood between these and in the posterior retinal layers. It must not be supposed however, that the pigment masses are of haematogenous origin, the blood even in haemorrhages of visible size being completely absorbed before any trace of pigmentary change appears. The lesion is partly a retinal one and partly choroidal. The retinal chanaes with the exception of the pigmentary change are of course, not visible to the naked eye. The marked alterations, in the form of white patches and masses of black pigment are mainly choroidal.

The difficulty in the diagnosis of Haab's disease lies in the fact already stated namely, that similar chanaes are observed as a result of pressure on the eye by a tumour or aneurysm, of presence of a foreign body in the eye, and of the direct action of the sun's rays. Besides, lesions of just the same nature are found apart from trauma of any kind in highly myopic eyes, as an accompaniment of old age and, (as was shown in Case 1) of incipient choroiditis probably of specific origin. Most of these can be more or less easily excluded, but the influences of old age and of specific disease are always difficult to eliminate. The fact of a variability in the position and extent of the lesion and in the visual disturbance, as illustrated in the above-mentioned case, might point to a non-traumatic origin. One would rather expect that in a traumatic lesion such as those described by Haab,

there would be progressive deterioration without rapid alterations of the visual acuity, or of the scotomata of the field of vision.

The two cases represented in figures 22 and 24 are considered to be examples of the disease which has just been described.

Case 14. (Fig. 22) Was a patient thirty one years of age, who was injured twenty years ago by a blow on the right eye by a goat's horn, from which injury he dates a considerable dimness of the vision of that eye. The horn seems to have caused a punctured wound of the skin of the upper lid without wounding the eyeball in any way. The eye is to outward appearance normal, but vision is as low as 20/200. The macula region has lost its reflex and is represented by an oval bright red patch with well defined margin. On and in the neighbourhood of this patch are a number of bright whitish spots as well as a larger white patch above and outside the macula. No pigmentary changes are present. The fundus is otherwise normal.

This patient was lost sight of so that the further progress of the case could not be observed, but in view of his statement that the eye had been defective since the time of the injury, and the fact that the ophthalmoscopic appearance had no resemblance to anything which might be congenital or the result of disease in childhood, it is probable that this represents a form of choroidal and retinal degeneration the

result of a severe blow.

Case 15. (fig. 24) This man aged thirty-three, complained of defect of sight in the right eye, gradually increasing. This defect he dated from a kick which he received from a horse's hoof five years before. As he was a gunner, and using his eyes separately for sighting work, he was in a position to discover any defect in the vision of either eye. With the right eye he could only count fingers at a foot or two, while the V.A. of the left was normal after correction of a minor degree of Hypermetropia. The fundus of the left was normal. In the right the macula region was the seat of an oval dark red patch, rather larger than the optic disc in which three large spots of black pigment were visible. Outside and below the above patch the fundus showed a mottled condition like that following choroidal inflammation. The disc itself was not quite normal, being pale and of that greyish colour slightly tinged with red, which is seen in optic nerve atrophy consequent on Choroiditis or Retinitis pigmentosa. The vessels however, were not narrower than normal.

The fact that the left fundus was quite normal and had never been defective at any time, told against the likelihood of the changes being of a specific nature. The most probable explanation of the appearances is that the retina after the injury was the seat of an oedema of the

Berlin type, which gave place to a slow degenerative process in the macula and neighbouring retina. Had the changes developed out of a large macular haemorrhage, a severe defect of vision would most certainly have been observed at the time, and this does not seem to have been the case. The condition of the optic nerve, which no doubt was somewhat atrophic, could be quite well considered as secondary to the retinal degeneration.

Haemorrhagic lesions of the retina are not a common occurrence after concussions. Rupture of the retina also is rare, being usually, when it does occur, a complication of choroidal rupture. Cases have been reported however, in which the retina alone was ruptured. The prognosis in such a case is always bad. Restoration of vision at the injured part cannot take place, and cicatricial processes tend to increase the scotoma, while it may go on to shrinking of the vitreous and separation of the retina.

Separation of the retina is not a very common result of contusion without rupture of the globe. Nevertheless a good number of cases have been recorded. The anatomical position of the retina is unfavourable to the production of a simple separation, on account of the support which it receives from the vitreous, so that in most cases where there has been a separation without previous effusion of blood from behind, one is disposed to assume a rupture of the retina, perhaps too small to be visible. The conditions necessary to the production

of a traumatic separation are found in highly myopic eyes which have posterior staphyloma, the tension being low from the diseased state of the vitreous, and the attachment of the retina lax. In such eyes a minor degree of shock is often sufficient to determine the occurrence of separation of the retina. When there has been rupture of an eyeball with escape of some of the contents, separation readily occurs, and when the rupture is in such a position as to be invisible it may be diagnosed by the extremely flaccid state of the ball. When separation has occurred without rupture of the ball, that is with conditions otherwise favourable to recovery, the prognosis is much better than in any other form of separation of the retina, indeed quite a few cases have been reported in which the retina returned to position and sometimes with partial restoration of function. Fig. 25 illustrates a case in which such a reattachment of a separated retina is believed to have occurred. The history is as follows:-

Case 15. The patient, a lad aged nineteen, was injured at the age of five, by a fall which appears to have resulted in a severe blow on the bridge of the nose and the surroundings of the left eye. The sight has been defective in that eye from the time of the injury, and has not altered perceptibly within the past four or five years. There was never any other injury so far as he could remember and there was no history of specific disease.

Vision is normal in the right eye but in left he can only count fingers at about 2 feet. The field of vision of the left eye shows a general peripheral constriction more marked above. (fig. 8)

The following is a description of the ophthalmoscopic appearance of the left fundus. (Compare Fig. 25) The disc is slightly congested and its margin somewhat hazy. The vessels are normal. Above the disc and between the superior nasal and temporal vessels the fundus is of the tessellated type. Two broad bands of greyish colour pass outwards from the neighbourhood of the disc, one outwards and upwards and the other inwards and upwards. These bands have no very well defined margins and appear to be only slightly pigmented. They extend into the furthest visible part of the periphery. Two other lines of a different kind commence near the disc and pass outwards with a perfectly straight course into the extreme periphery, the one passing inwards and slightly upwards and the other downwards and inwards. These latter lines have a bright glistening white appearance, are sharply defined and expand somewhat as they pass outwards. At some distance from the disc they present ampulliform dilatations. The streck which passes downwards and inwards seems to terminate in a profuse network of white lines at the extreme periphery of the fundus below. Three whitish or greyish patches of small size are situated as in the figure, one being almost in the macula. At all places

where those bands and patches bear any relation to the vessels, the latter cross the former without showing any alteration of their course. The fundus at all parts except the tessellated area above, is of a pale slightly opaque red colour like that of a moderately separated retina. The tessellated portion represents retina in its normal position and can be distinctly seen with a + 3D. lens. The separated part of the retina is represented by all not enclosed between the two curved greyish bands above. The level of this part of the retina rises from above downwards and from the centre towards the periphery. Thus in the macular region +6 or 7 D is required to focus details while the extreme periphery in the situation of the white fibrous network can be seen with +12 D.

Under observation of several months duration, no changes have been observed to occur in the ophthalmoscopic details.

Two cases similar to the above are reported in detail by Fraun (op. cit.). It would seem that a sero-fibrinous exudate lying behind the separated retina develops into white bands which attempt to draw the retina back into contact with the choroid, and appear in the form of white streaks of connective tissue lying under the separated retina.

The first of Fraun's cases was that of a woman aged thirty three, who had received an injury to her left eye seven months previously by a piece of wood. V. A. was reduced to seeing movements

of the hand. The ophthalmoscope showed an almost complete low separation of the retina. A small section above retained its normal position and passed away very smoothly into the elevated patch at either side, while the normal area was separated from the elevated portion at each side by a broad band of yellowish-white colour diverging from the disc towards the periphery. Besides these broad bands there were brilliant white sharply defined streaks, which passed out from the papilla towards the extreme periphery of the fundus. The portion of these streaks close to the disc and that at the extreme periphery, were extremely well marked, while the intermediate portion was seen to shine indistinctly through the incompletely applied retina. In the course of ten or twelve months of observation of this case, the complete attachment of the retina to these streaks of cement substance was seen to take place slowly from the periphery and from the disc towards the intermediate part. No accumulations of pigment accompanied those changes except here and there in the broad yellowish grey bands first mentioned, and no alterations in the course of the vessels were observed, showing that in this case as in our own the striae were entirely subretinal, and that the separation was quite a smooth one. This case is interesting from its striking resemblance to the case above described and illustrated in figure 25 ; and from the fact that the formation of the appearances described was watched from a comparatively

early stage, it can throw some light on the probable history of our own case. Braun's second case is almost identical but showed in addition the ampulliform expansions of the bright white streaks shown in Fig. 25.

We appear to be dealing in each of these three cases with a low separation of the retina, free from the folds usually seen in more pronounced separations. Organisation and contraction of the exudate lying between the retina and choroid, tend to produce a reapplication of the separated retina along certain lines. Following the principle illustrated in Symblepharon this process proceeds simultaneously from the parts where the separation is least marked, namely at the periphery and round the disc.

The streaks in the retina here described must not be mistaken for the striae of so called Retinitis proliferans, which are always prevascular and arise from haemorrhage between the retina and vitreous, while the above are retrovascular or subretinal and do not originate from extravasated blood; nor must they be confounded with the peri-vascular striae which are of inflammatory origin and have no connection with trauma.

The Optic Nerve though so well concealed and protected behind the eyeball, is also subject to injury by the action of blunt objects. Simple hyperaemia of the optic disc, like congestion of the retina is an almost constant effect of concussion, and

as one may suppose leaves no permanent ill effects. But the optic nerve may also be the seat of much more severe congestion presenting all the appearances of an acute optic neuritis, as in the following case which came under my notice.

Case 17. The cause of the lesion was a blow on the right eye with a stick or wire of an umbrella three weeks before. The patient was a little girl of nine years. On admission she was suffering from slight protrusion of the injured eye which had still some remains of sub-conjunctival haemorrhage round the cornea. No external sign of injury was visible. Tension normal. Pupil of normal size and shape and acting normally. There was slight swelling and drooping of the upper lid and some photophobia. The movements of the affected eye were limited in all directions. The ophthalmoscope revealed a severe congestion of the optic disc with vessels, especially the lower temporal vein, congested and tortuous. There was moderate swelling of the disc affecting all except part of the outer segment. All details of the fundus were somewhat hazy. There were a few streaks like fine plications of the retina radiating upwards and outwards from the disc. Vision apparently was not much altered. Nine days later there was a slight increase of the swelling of the upper lid and some serous chemosis of the ocular conjunctiva with lacrymation and slight increase of the proptosis. Temperature was normal. In another week all the symptoms were less marked and the swelling

of the disc giving place to simple congestion, with a slight recrudescence of the swelling of the lid a few days later. She was dismissed four weeks after admission with almost total absence of symptoms, and movements of the eye normal in all directions.

Whether there was any direct injury to the optic nerve in this case, or no, it is impossible to say but the absence of any sign of external wound makes it hardly likely. There seems to be no room for doubt that the essential lesion was a haemorrhagic one, the sub-conjunctival haemorrhage, the proptosis and swelling of the upper lid, the fixation of the eyeball, and the recurrence of the symptoms, all with normal temperature and absence of constitutional disturbance, pointing to this conclusion. The blood in all probability came from some of the muscular branches of the ophthalmic or other small orbital vessels (the nature of the ophthalmoscopic changes excluded the possibility of rupture of posterior ciliary vessels) and the congestion and swelling of the optic disc, with oedema of the retina would be brought about by pressure round the optic nerve by the extravasated blood. The case ran an entirely favourable course with apparently little or no injury to vision.

It is remarkable to what a dearee congestion of the optic disc or even optic neuritis, may develop without any defect of central vision, and it will sometimes be found that while patients complain of

defective vision, tests with the usual types give very good results. In these cases however, when the disc is congested, it will be found as a rule that the visual field is contracted.

Subjective sensations are not often complained of after blows on the eye, but a case of the kind came under my notice which should probably be classed along with injuries to the optic nerve.

Case 18. The patient aged thirty received a blow on the left eye with a rope's end, and thereafter was frequently troubled with brilliant flashes of light before that eye at the temporal side. Fundus was normal and vision was only slightly affected but the field of vision was considerably contracted. At first these sensations of light occurred almost continuously and on the slightest movement of the eyes or head. In the course of a few days however, they had subsided a great deal and only troubled him when stooping or straining. Three weeks after the accident the symptoms were much less felt, and the visual field had returned to almost normal dimensions, and in six or seven weeks time the patient was free from all disturbance.

From the nature of the subjective phenomenon, the exaggeration in the stooping posture, the contraction of the field of vision and the progress of the case, I should be inclined to put the whole thing down to a state of congestion in the optic nerve and possibly also the retina. No

separation of the retina at any part could be detected.

Atrophy of the optic nerve occasionally occurs as a result of concussion of the eye and the surrounding parts. On the strength of one or two reported cases Gowers (Medical Ophthalmoscopy) gives it as his opinion that slow simple optic atrophy may occur from a simple concussion of the optic nerve and retina. As a rule, however, a more severe injury is present to account for the atrophy. The most common cause in reported cases has been a fracture of the skull through the optic foramen with crushing of the optic nerve, which causes immediate loss of sight without fundus changes, and leads to simple optic atrophy which is just visible with the ophthalmoscope about 3 or 6 weeks after the accident. When the optic nerve has been torn or crushed at some point in front of the entrance of the central artery, ophthalmoscopic examination soon after the accident finds the same appearances as in embolism of the central artery of the retina. The atrophy in these cases is of the simple type, the nerve end being of a greyish colour sharply defined in outline, not filled in, and the vessels of normal size or slightly narrow.

Temporary defects of vision may be caused by haemorrhages into the sheath of the optic nerve, or outside the sheath from similar causes. The symptoms will vary according to the extent of the haemorrhage, its position and the rapidity

of its occurrence. A sudden haemorrhage occurring so as to compress the optic nerve anterior to the point of entrance of the central vessels is followed by a pallor of the disc and retina from compression of these vessels, while if the vessels are unaffected the optic disc may be unaltered but the visual acuity be greatly reduced from compression of the optic nerve and interruption of its conductivity. In other cases where the haemorrhage is in smaller amount, congestion of the nerve or even optic neuritis may be brought about with possibly little or no alteration of visual acuity. (Compare Case 17.)

The only conditions produced by blunt blows, which remain to be mentioned are the alterations of tension. Hypotony or reduction of tension is a common occurrence in a moderate degree, but occasionally is so marked as to suggest an actual rupture of the ball. Where this is the case it is hardly possible to positively exclude rupture, but if the fundus can be seen to be normal, and vision is not greatly affected, a simple traumatic reduction of tension is indicated.

Traumatic Glaucoma is sometimes observed especially in connection with luxation of the lens either into the anterior chamber or into the vitreous.

The question has been disputed whether Glaucoma could possibly follow a blow on the eyeball as a primary lesion. A.von Graefe (Arch. f. Ophth. Vol. 15) gave it as

his opinion that Glaucoma following such an injury was always of secondary type, and was probably brought about by rupture of the lens capsule with swelling of the lens, and this is the opinion which is still most generally held. Simple increase of tension does of course occur, but it is temporary like other minor results of concussion, and is not liable to go on to destruction of vision as is the case with a true Glaucoma. Another cause of secondary traumatic Glaucoma which has already been mentioned is the occurrence of haemorrhage into the vitreous chamber. It is supposed that in this case the increased viscosity of the fluids retards the normal circulation through the filtration angle, with increase of intra-ocular tension and ultimate loss of the eye.

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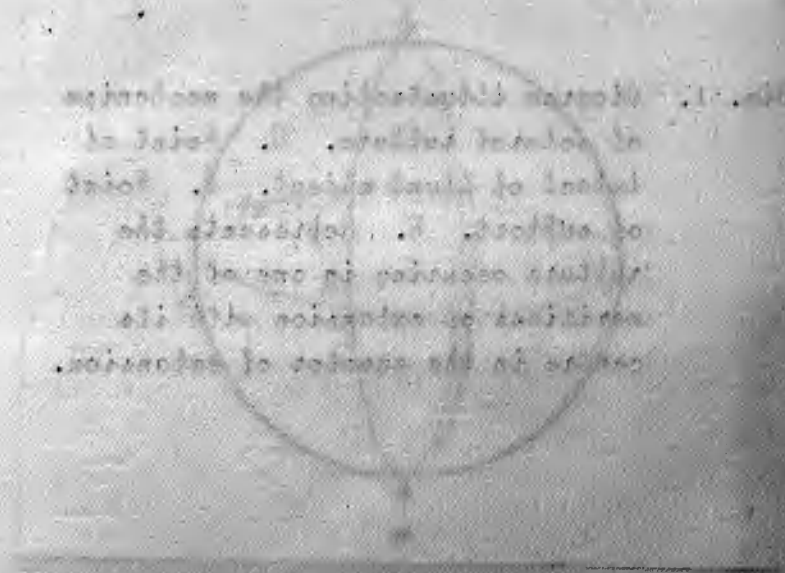


Fig. 1. Diagram illustrating the mechanism of scleral rupture. A. Point of impact of blunt object. B. Point of support. R. Represents the rupture occuring in one of the meridians of expansion with its centre in the equator of expansion.

Fig. 2. Diagram to represent retroflexion of the iris. On the left side the iris is seen driven back by the rush of aqueous humour. On the right side the fibres of the Zonule of Zinn have given way and the iris is reflected back upon the ciliary body.

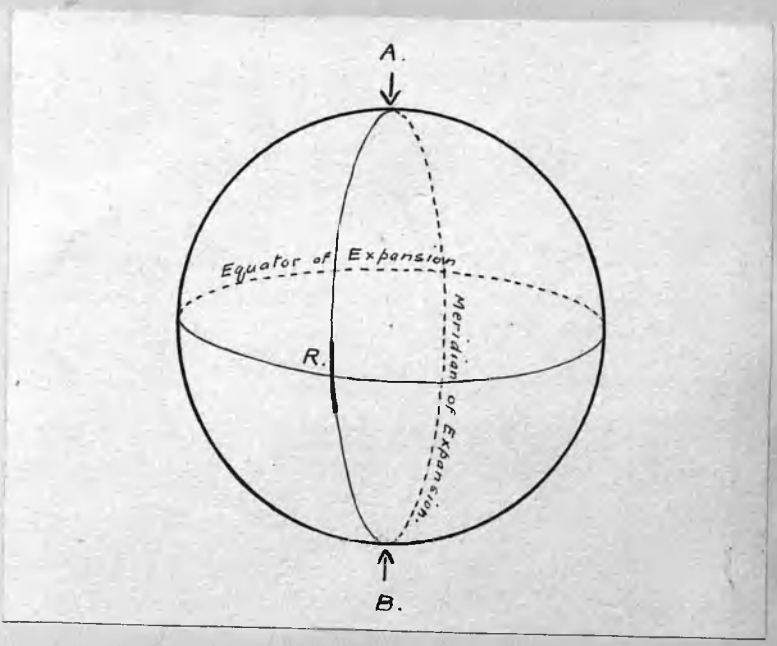


Fig. 1.

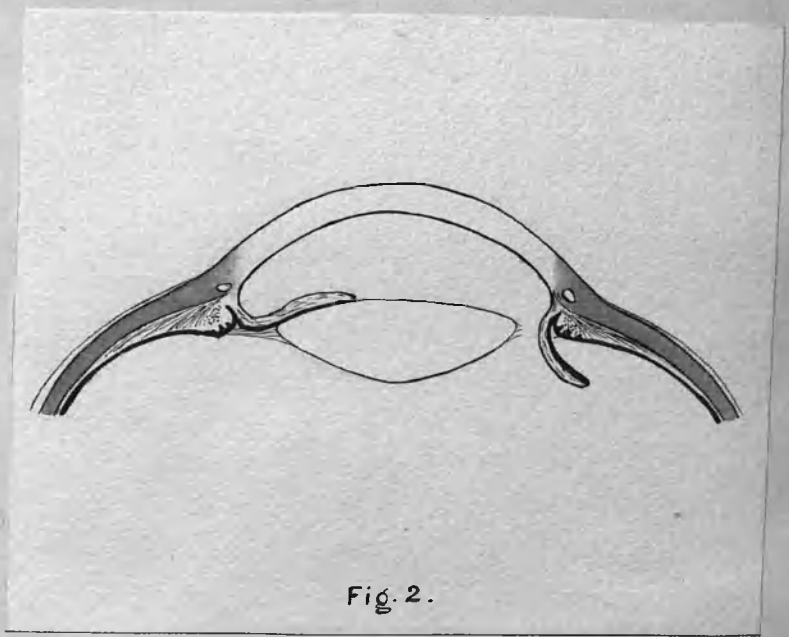


Fig. 2.

Fig. 3. Section of the anterior segment of the eyeball showing the relations of the parts. The most delicate portion of the iris is that just at its insertion into the ciliary body. The pupillary border is supported by the anterior surface of the lens. Between these two extremities the iris is unsupported and can be driven back against the Zonule of Zinn by the force of aqueous displaced backwards.

Fig. 4. Diagram representing splitting of the ciliary body from concussion. The fibres of the ligamentum pectinatum going to the root of the iris are ruptured, and a separation has occurred between the longitudinal and circular fibres of the ciliary muscle. The anterior chamber is thus deepened at its periphery.

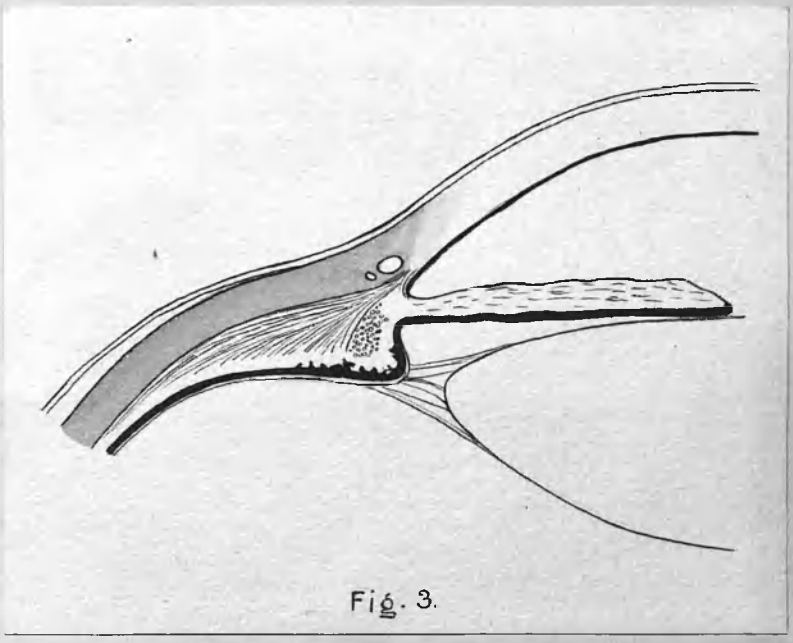


Fig. 3.

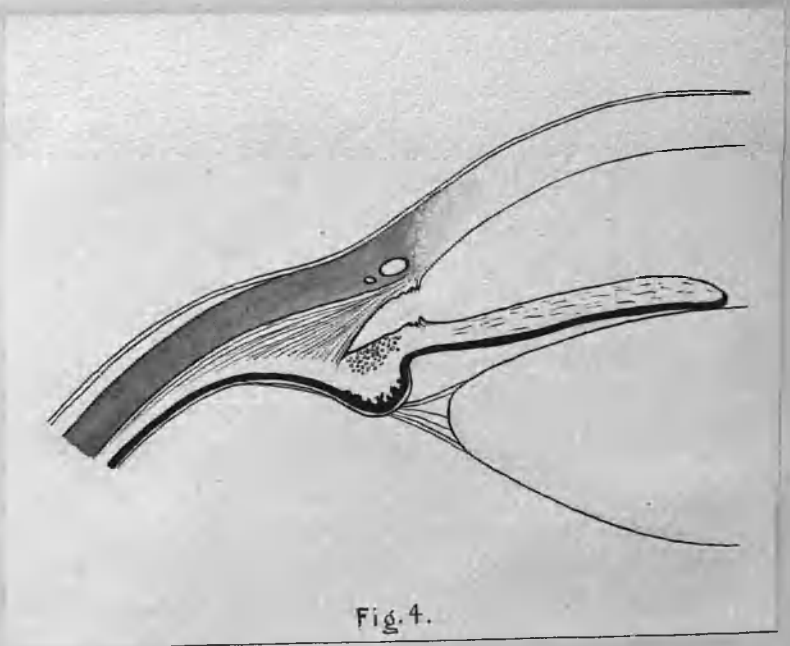


Fig. 4.

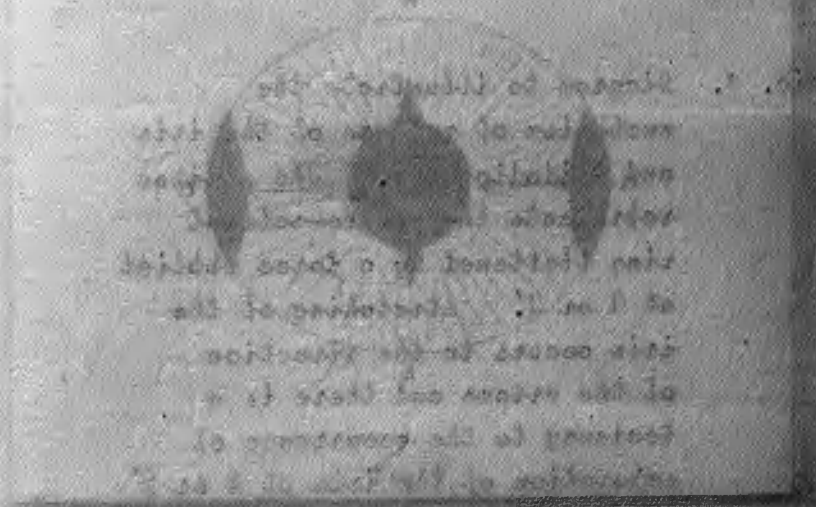


Fig. 5. Diagram to illustrate the mechanism of rupture of the iris and iridodialysis. The ellipse represents the corneo-scleral ring flattened by a force applied at A or A'. Stretching of the iris occurs in the direction of the arrows and there is a tendency to the occurrence of separation of the iris at E or E' and to the occurrence of rupture of the border of the iris opposite A or A'.

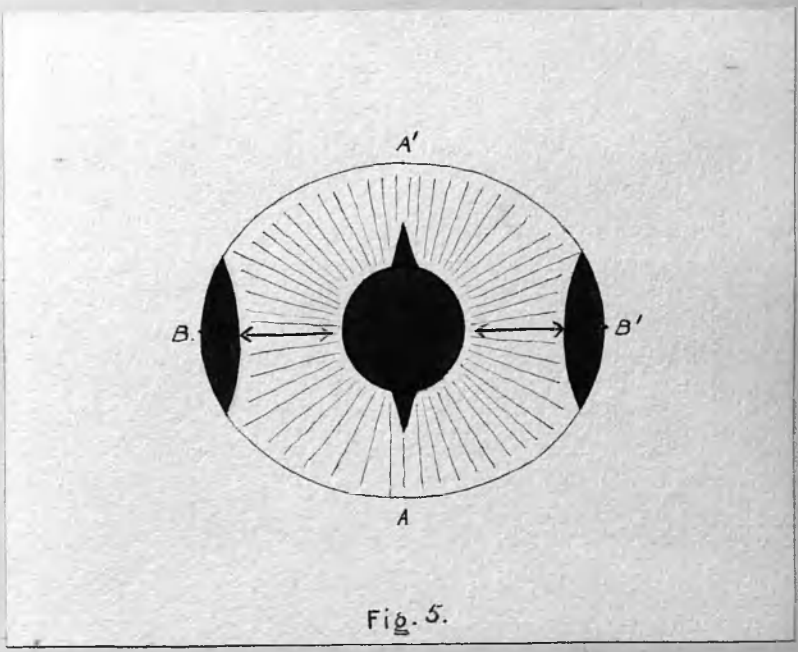


Fig. 5.

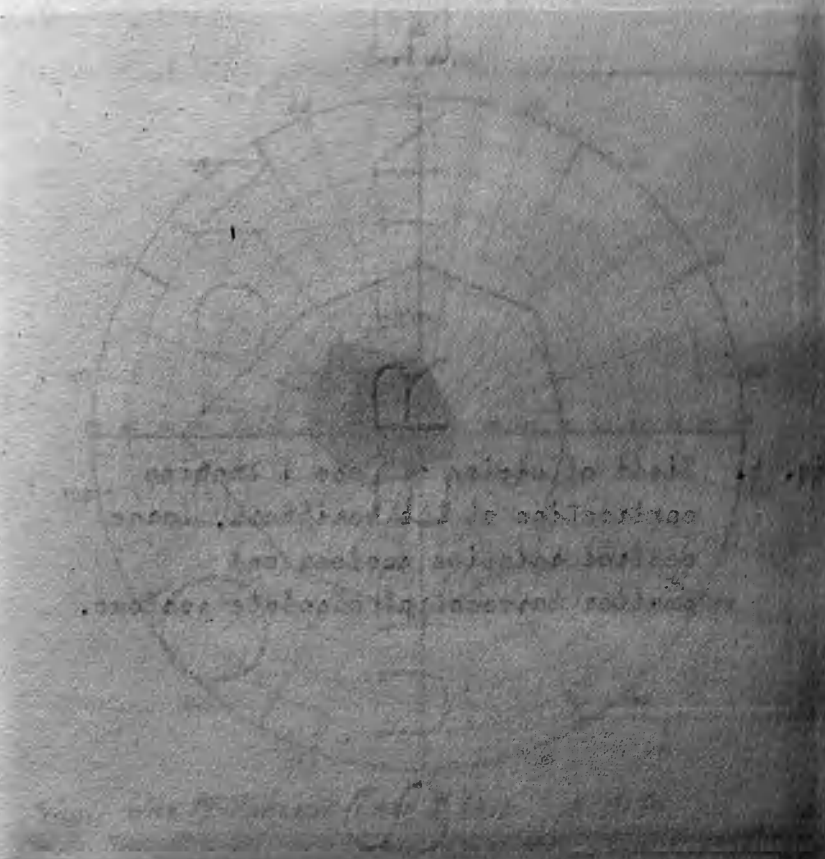
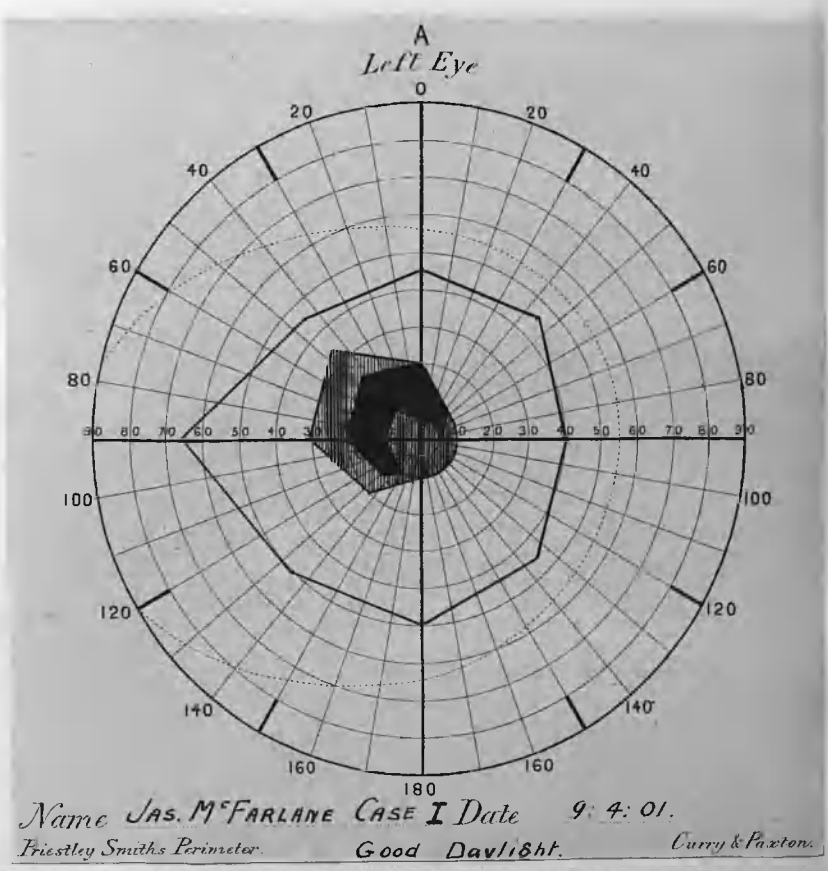


Fig. 6. Field of vision of Case 1 showing contraction at the periphery, large central relative scotoma and smaller paracentral absolute scotoma.


A
Left Eye
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Name Jas. McFarlane Case I Date 9: 4: 01.
Priestley Smiths Perimeter.
Good Daylight.
Curry & Paxton.

Fig. 6.

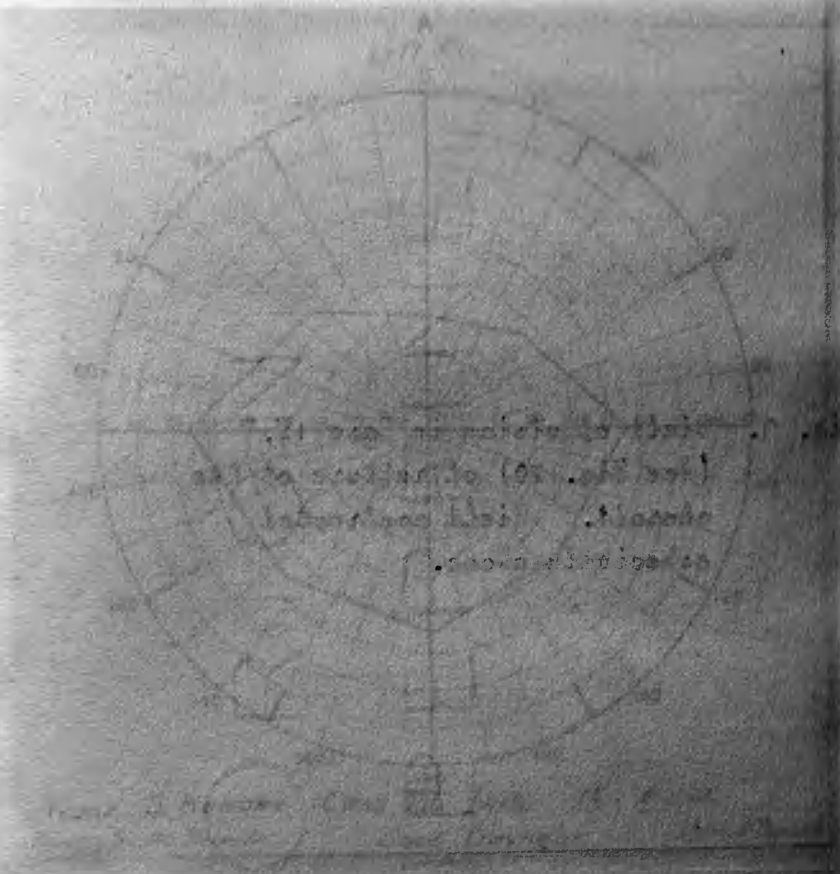
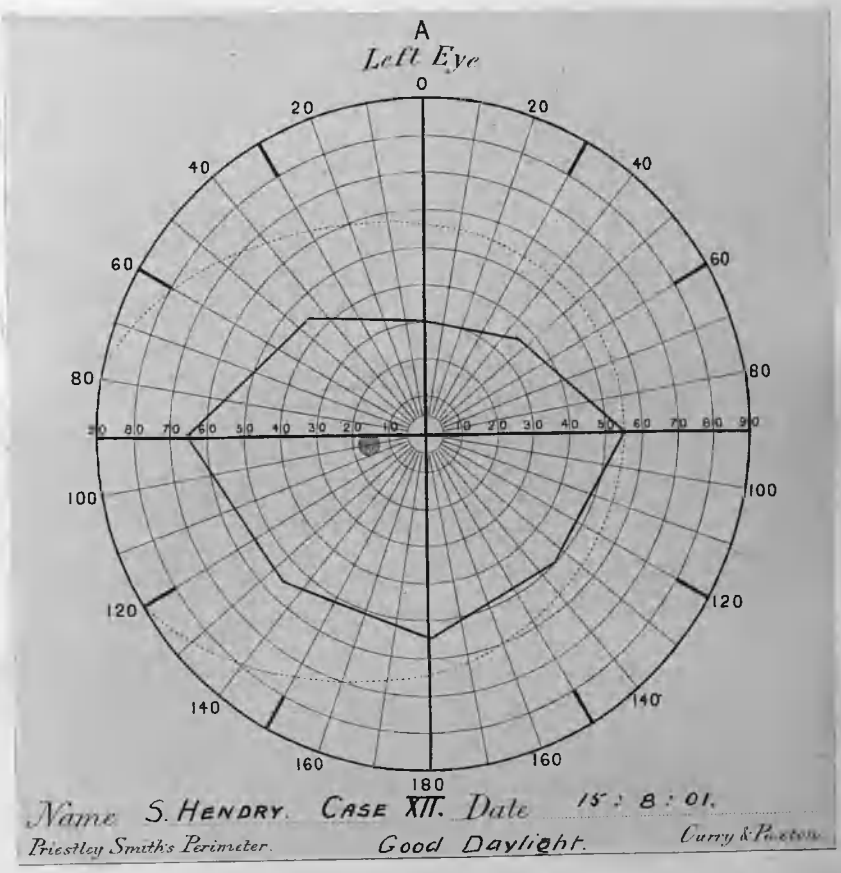


Fig. 7. Field of vision in Case 12, (see Fig. 20) of rupture of the choroid. Field contracted especially above.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Name S. HENDRY. CASE XII. Date 15 : 8 : 01.
Priestley Smith's Perimeter.
Good Daylight.
Curry & Paxton.

Fig. 7.

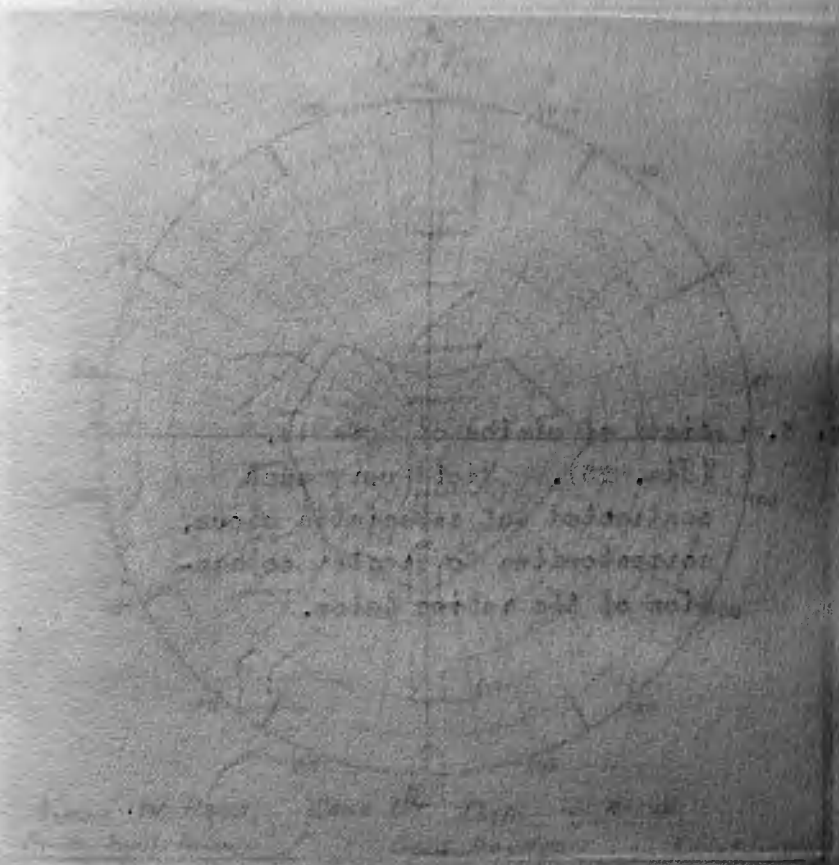
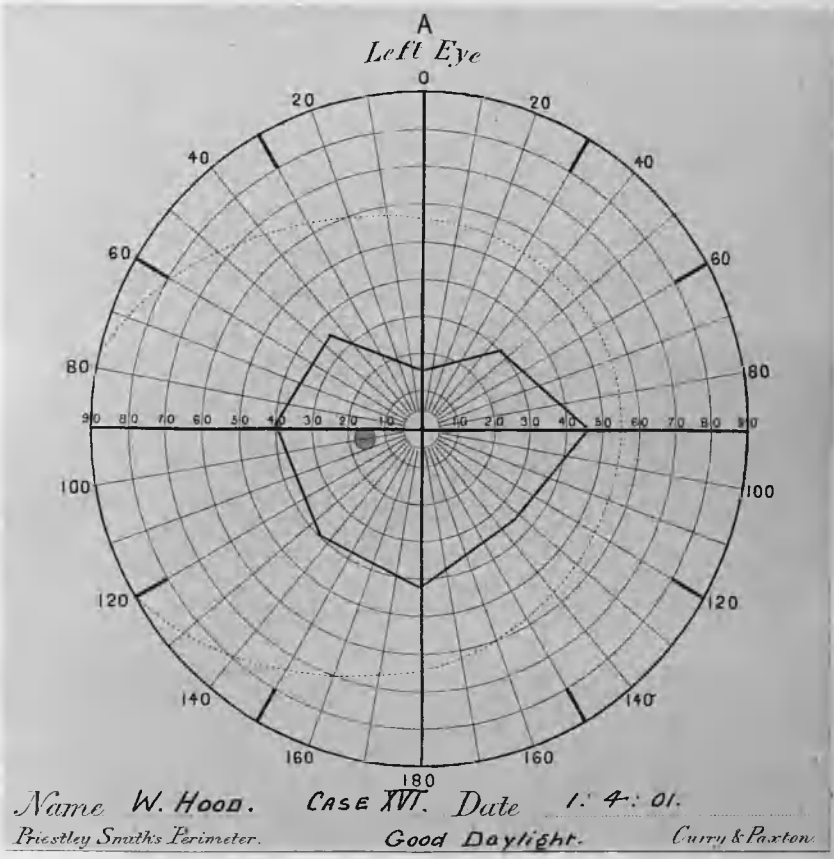


Fig. 8. Field of vision of Case 1b, (Fig. 25). Field very much contracted but especially above, corresponding to greater separation of the retina below.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Name W. Hood. Case XVI. Date 1. 4. 01.
Priestley Smith's Perimeter.
Good Daylight.
Curry & Paxton

Fig. 8.

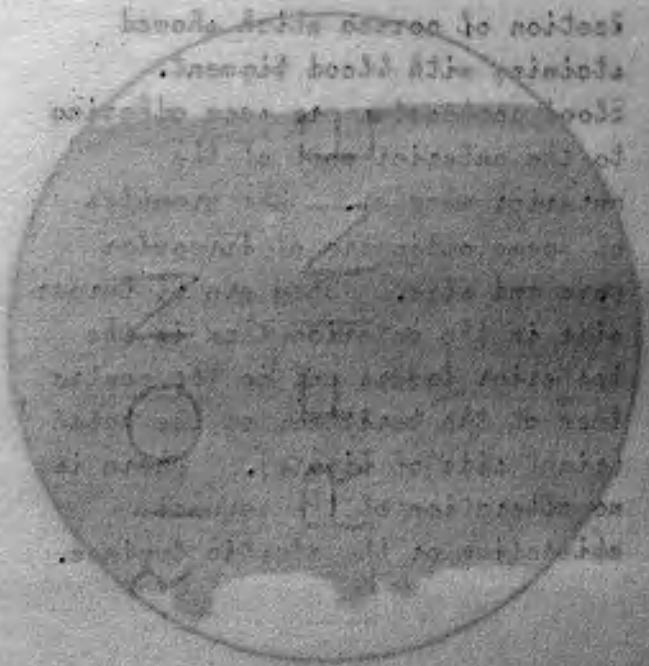


Fig. 9. Section of cornea which showed staining with blood pigment. Blood corpuscles are seen adhering to the anterior wall of the anterior chamber. The granules of Haematoidin are of irregular form and size. They are of larger size in the anterior than in the posterior layers and in the centre than at the periphery of the patch (right side of figure). There is no alteration of the corneal epithelium or the elastic laminae.

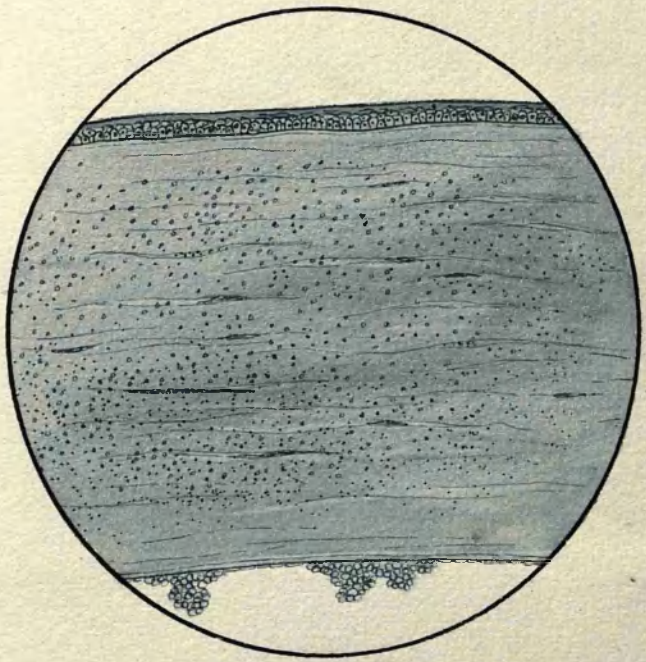
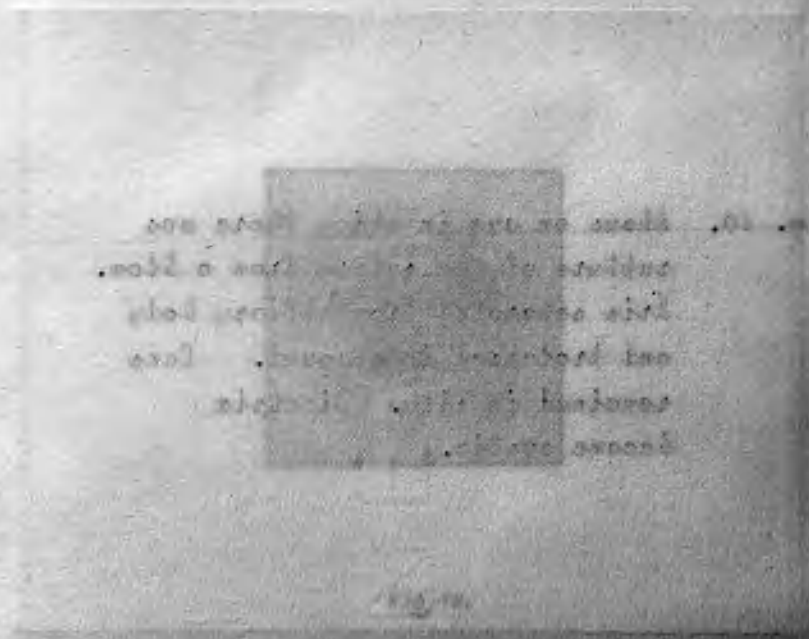


Fig. 9.



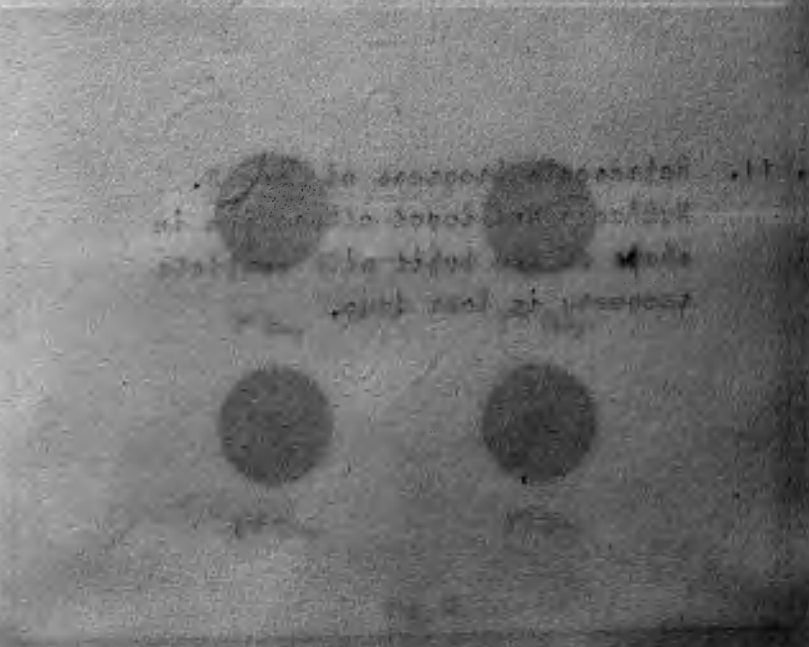


Fig. 10. Shows an eye in which there was rupture of the sclera from a blow. Iris separated from ciliary body and prolapsed into wound. Lens remained in situ. Cicatrix became cystic.

Fig. 11. Represents progress of Case 3. Hyphaema and local alteration in shape of the pupil with complete recovery in four days.

Fig. 10.

1st Day.

3rd Day.

2nd Day.

5th Day.

Fig. 11.

Fig. 12. External appearance of eye in Case 4. Iridodialysis at upper and outer side, Rupture of the iris border at lower and outer side. Blood clot lying on the injured iris.

Fig. 13. External appearance of eye in Case 5. Small blood clot at lower angle of anterior chamber. Pupil under the action of Atropine dilates downwards and inwards. Border remains flat at upper and outer side. Iridodialysis.

Fig. 12.

Fig. 13.

Fig. 14. Hyphaema (Case b) due to Rupture of wall of Schlemm's Canal by a blow. Appearance on day after injury.

Fig. 15. Same case as last with recurrence of haemorrhage on the following day. Anterior chamber full of blood.

Fig. 14.

Fig. 15.

Fig. 16. Rupture of border of iris, (Case 7) by a blow with a small blunt object. Triangular gap in border of iris with absence of pigment margin. Moderate mydriasis. Lens becoming opaque.

Fig. 17. Dehiscence of the iris (Case 9). Details of iris still indistinct from presence of blood in the aqueous.

Fig. 16.

Fig. 17.

Fig. 18. External appearance of Case 10. Complete rupture of the iris upwards and outwards. Lens cataractous and dislocated upwards and outwards. Most of the fibres of the Zonule ruptured.

Fig. 19. External appearance of Case 11. Total dislocation of a cataractous lens into the anterior chamber. Great irritability of the eye. High tension.

Fig. 18.

Fig. 19.

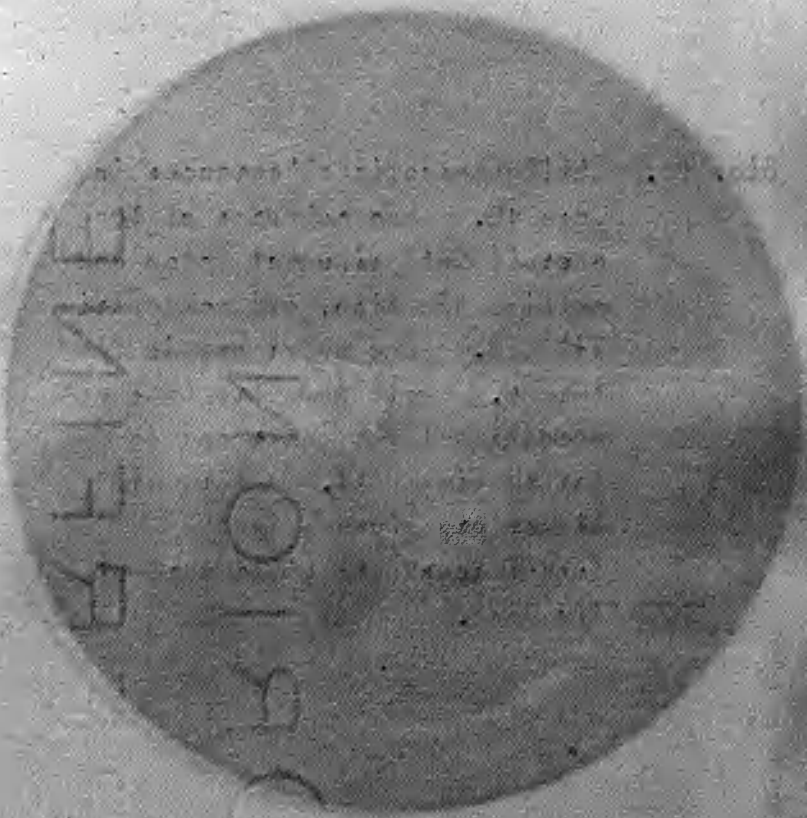


Fig. 20. Ophthalmoscopic appearances in Case 12. Two ruptures of the choroid both situated below and outside the disc, and concentric with it. The outer one is the larger. Both have pretty sharp margins and the inner one is partly pigmented. There are pigmentary changes in the fundus round the upper part of the disc.

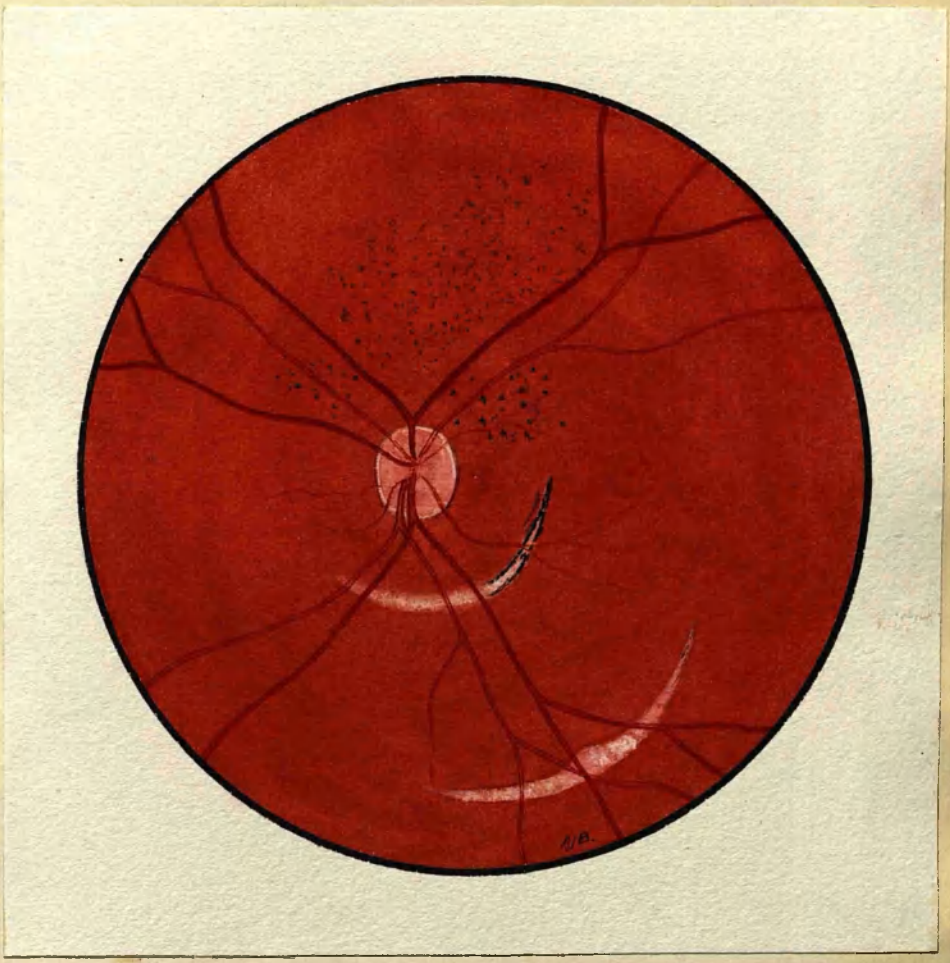


Fig. 20.

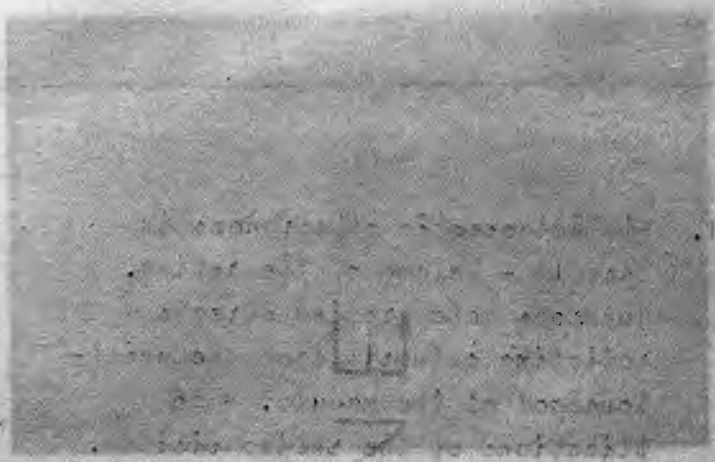


Fig. 21. Ophthalmoscopic appearances in Case 13 - Oedema of the retina. Numerous pale greyish streaks radiating outwards from the neighbourhood of the macula. No plications of the retina visible.

Fig. 22. Macular changes in case of concussion injury Case 14.

Fig. 23. Macular changes in Case 1. Mistaken for changes due to injury.

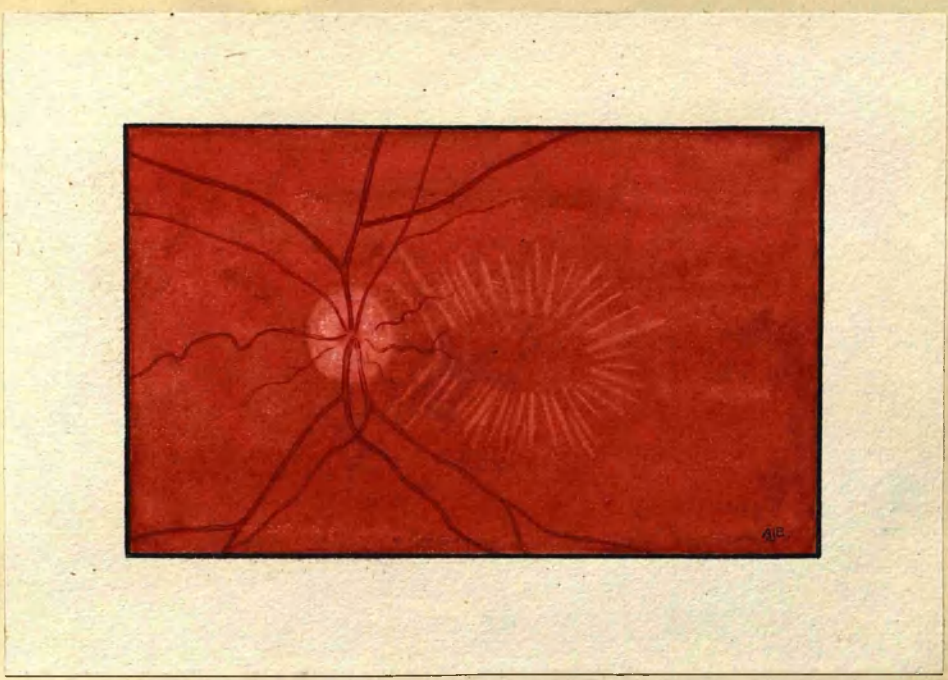


Fig. 21.

Fig. 22.

Fig. 23.

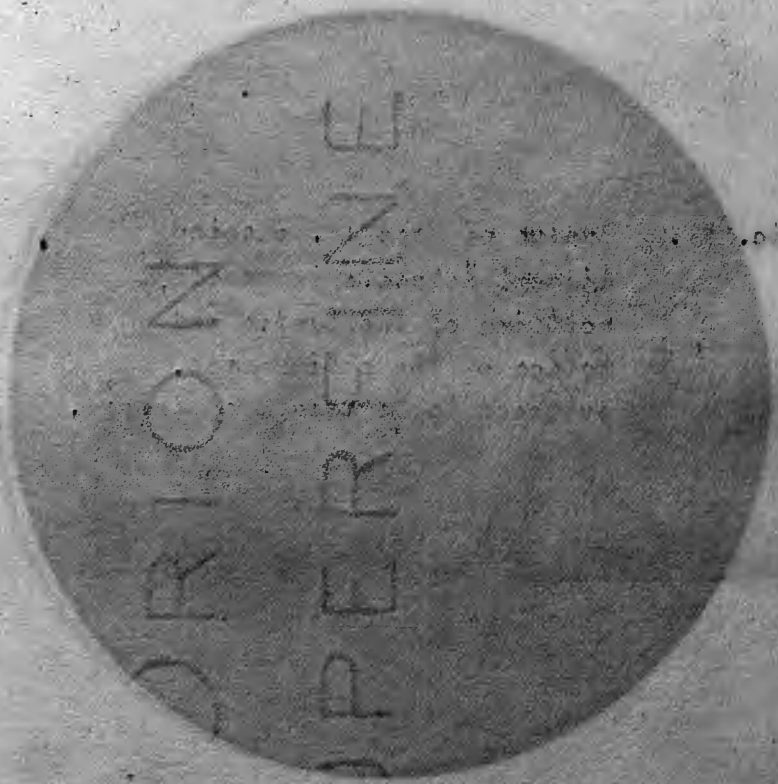


Fig. 24. Fundus of Case 15, showing pigment deposits in macula, , mottling of the fundus and pallor of the optic nerve, supposed to be result of injury.

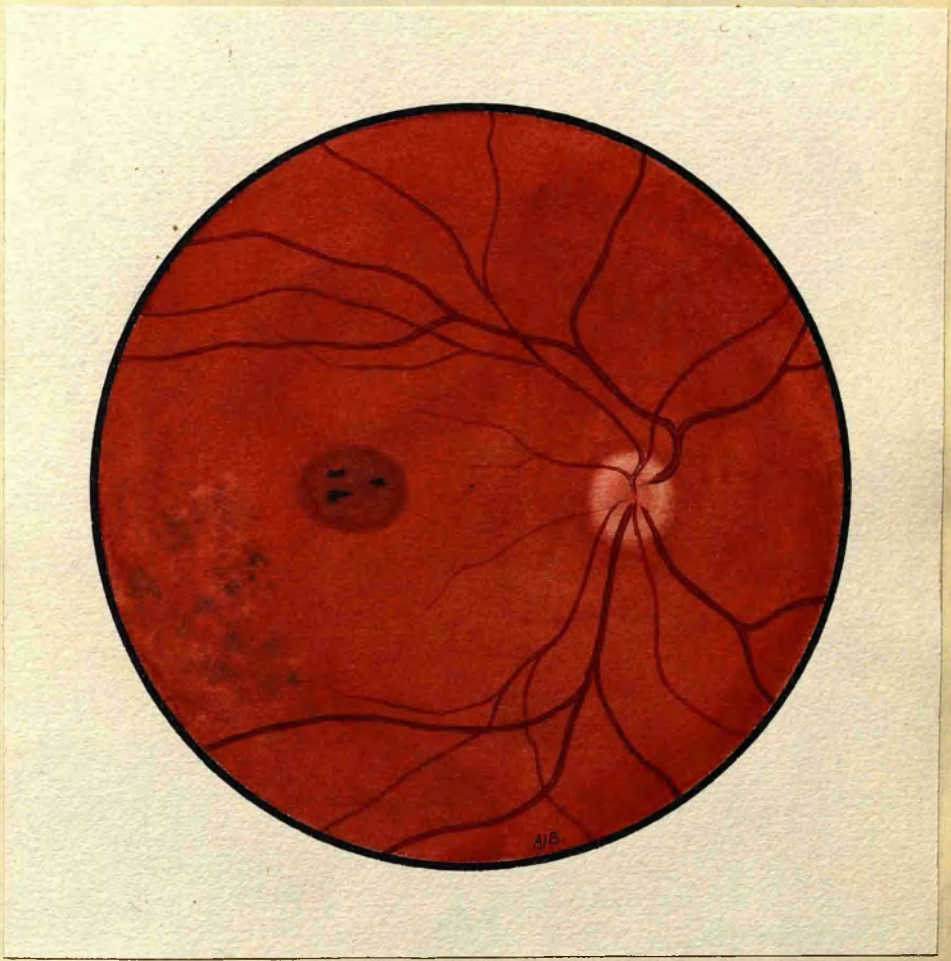


Fig. 24.

ORION
SUPERFINE

Fig. 25. Fundus of Case 16 showing appearances of reattachment of separated retina. For description of details see history of the Case.

Fig 25.