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Retinal Detachment Surgery

Second Edition

With 74 Figures

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Preface to the Second Edition

Since the first edition of this book there have been substantial improvements in the treatment of retinal detachment. *Firstly*, advances in the use of pars plana vitrectomy have not only made it possible to treat previously hopeless cases but also, and this is of more importance, provided a much safer and easier form of treatment in cases which previously had a poor outcome. In addition the technique has added to our knowledge and understanding of vitreo-retinal relationships, especially of tractional systems within the eye. Although, therefore, this book is not about pars plana vitrectomy, it is clearly important for those engaged in retinal surgery to know the place of vitrectomy in the management of retinal detachment. Indeed, vitrectomy may be the primary surgical method of choice and should not be regarded as a procedure to be reserved for cases in which other conventional detachment techniques have failed. *Secondly*, and mainly stimulated by vitreous surgery, there has been a renewal of interest in the use of intraocular gases. Both expanding and non-expanding gases have been found to be of value and are being used with increasing frequency in the management of both simple and complicated cases. Much remains to be learnt in the two aforementioned areas, and no doubt considerable progress will be made over the next few years.

In spite of these obvious advances, there are still numerous gaps in our knowledge; for example we know too little of the mechanisms of production of retinal detachment and of the processes contributing to its main precursor, posterior vitreous detachment. We are also still ignorant of many of the factors involved in the production and progression of periretinal membrane formation in the eye once retinal detachment has occurred.

Once again, I have tried to keep the text of this book simple, in the hope that the reader will concentrate on the fundamental objectives of retinal surgery, namely closing retinal breaks and relieving tractional systems where appropriate. The ability to detect and close retinal breaks is one of the oldest requirements of retinal surgery; however, inability to do so still remains by far the most important cause of failure. It should be remembered that the great majority of cases which end up as difficult problems, started as simple ones.

Thanks to the consummate skill and artistry of Mr. Terry Tarrant, with whom once again it has been a pleasure to work, a substantial number of diagrams have been added or revised, and the audiovisual department of St. Thomas's Hospital has also provided additional material. I am also grateful to Miss Marie Restori for providing Fig. 1.16, to Dr. Glyn Lloyd for Fig. 1.18 and to Mr. T. J. ffytche for Fig. 5.3. I am indebted to the secretarial assistance provided by Miss Debbie Clutterbuck and Miss Hazel Hollands.

London, December 1987 A.H. Chignell

Preface to the First Edition

This short book is an account of an approach to retinal detachment surgery. I hope it will be of use to all those dealing with the detached retina, although it has been written mainly for the training ophthalmologist, who, becoming familiar with the methods of examination, is faced with a bewildering array of methods of treating the detached retina. The object of surgery is to produce the desired result in the least traumatic way possible and this involves correct interpretation of how the detached retina is likely to respond to the operation that is planned. I have therefore concentrated on the aspects of clinical examination that have a direct bearing on the planning of the type of operation to be performed. I have not attempted to deal with all the different surgical techniques currently practised, but have described only those that I believe represent the simplest, safest, and most effective methods. I have drawn widely on standard techniques; thus, for examination, Schepens' indirect ophthalmoscopy with scleral depression, Lincoff's use of cryotherapy and his modification of Custodis' non-drainage techniques at operation and Rosengren's use of intraocular air. Because this book is not intended for the retinal surgical expert I have not dealt in great depth with rare cases, e.g. macular holes, or other conditions that are exceptionally difficult to treat (massive periretinal proliferation). The surgical management of these types of case is likely to be an area of continual change, and the role of the various advancing techniques (e.g. vitrectomy) one for further assessment.

In the preparation of the book I have been much helped by a number of people. The illustrations have been expertly and painstakingly prepared by Mr Terry Tarrant of the Audio Visual Department of the Institute of Ophthamology. Additional photographic work has also been done by Mr Rolph Sennhenn and Miss Jan Shugg, of the Eye Department of St Thomas' Hospital. Mrs Margaret Grice has done the greater part of the secretarial work, a feat performed with much good humour and tolerance, and Miss Sue Patterson has given additional help in the later stages. My colleague, Mr Martin Crick, FRCS, kindly read the manuscript and made many useful suggestions.

I am grateful to Mr Jack Kanski, FRCS, for permission to use slightly modified versions of Figures 2.6 and 2.7, and also to Mr Tim ffytche, FRCS, for Figure 5.5. The colour frontispiece was made possible by kind donations from Keeler Instruments Ltd and Davis & Geck.

I am particularly indebted to the past and present junior ophthalmic staff of St Thomas' Hospital, London, with whom I work, as it is their constant enquiry and challenge of traditional practice that prevents a static approach to the clinical problems we share, problems that, if solved, offer as their reward the restoration of vision.

In conclusion, I am grateful to my Publisher for being so patient with me in the preparation of the manuscript.

London, October 1979 A.H. Chignell

Contents

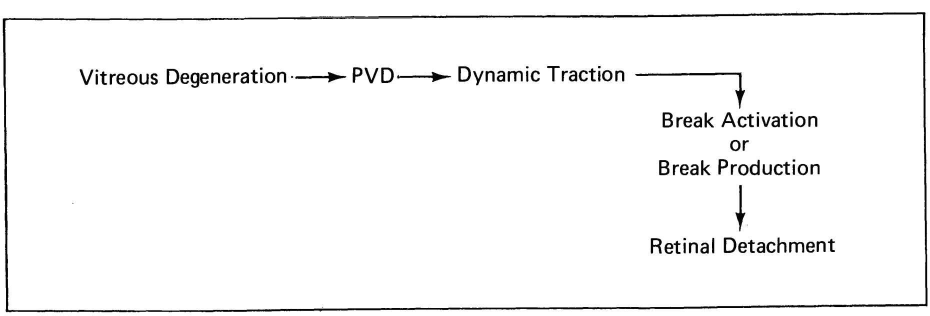
1 Pathogenesis, Predisposing Factors, Presentation and Methods of Examination

Definition

Retinal detachment is the result of fluid accumulating between the photoreceptor and pigment epithelial cells of the retina; in rhegmatogenous retinal detachment the fluid accumulates after a break has formed in the retina.

Pathogenesis

Vitreous degeneration leading to posterior vitreous detachment (PVD) is almost invariably the first step in the sequence of events leading to retinal detachment. Vitreous detachment itself results in traction on the underlying retina which either causes retinal break formation or activates a pre-existing break. Fluid from the vitreal compartment enters the subretinal space via the retinal break and produces retinal detachment.



The various factors involved in the production of retinal detachment will now be considered in more detail.

The Vitreous

In the emmetropic young adult eye the vitreous occupies a volume of approximately 4 ml. The volume varies with the size of the globe and is greatly increased in high myopia. The major constituents of vitreous are water, collagen, hyaluronic acid and soluble proteins. It is the interaction of the double helices of hyaluronic acid with the collagen fibrils that gives the vitreous its gel structure [1]. Pathological states of the vitreous such as cellular infiltration, haemorrhage, ageing, myopia, YAG laser disruption and aphakia tend to eliminate this co-operative interaction and convert the vitreous gel into a more liquid state, often with some loss of complete optical clarity.

The normal vitreous is closely applied to the inner layers of the retina and is continuous with the internal limiting membrane. It is particularly firmly attached to the retina around the disc [2], at the macula [3, 4] to superficial retinal vessels [5], and at the vitreous base, an area that extends for approximately 1–2 mm on either side of the ora serrata; thus it is firmly attached to the retina posteriorly and to the pars plana anteriorly. The posterior part of the vitreous base is of particular importance, for it is here that traction is exerted if a detached posterior vitreous swings freely at this point of anchorage.

Vitreous Detachment

If vitreous separates from the retina this separation almost invariably starts in the superior and posterior parts of the globe and spreads forwards (Fig. 1.1). As separation continues, the vitreous may remain adherent only to particularly firm points of attachment (e.g. the disc) and the vitreous detachment is termed incomplete. If the vitreous detachment is complete, the vitreous will have moved forwards from the whole retinal surface, remaining attached only at the vitreous base. Separation from the disc produces a circular opacity in the posterior hyaloid face (Weiss' ring). Saccadic and other eye movements will result in continual rotational movement of the gel, which swings from and pulls upon its point of anchorage. Although the link between vitreous detachment and retinal detachment is clear, the mechanism of production and progression of posterior vitreous detachment is poorly understood. Fortunately, only a small proportion of patients who develop posterior vitreous detachment progress to retinal break formation and retinal detachment.

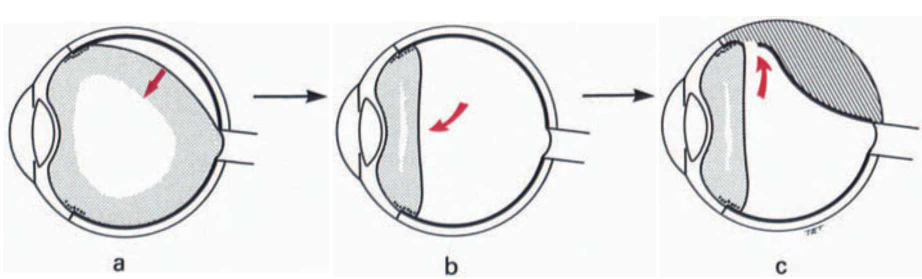


Fig. 1.1. **a** A posterior vitreous detachment is developing and has become complete in **b**. This has caused the production of a retinal tear in **c**. Retrovitreal fluid has entered the subretinal space to create rhegmatogenous retinal detachment.

Consistency of the Vitreous

The more fluid that the vitreous becomes in pathological states, the less will be the resistance to its passage through a retinal break. Loss of hyaluronic acid from the vitreous contributes to this lowering of resistance [6].

Retinal Breaks

A retinal break results from the interplay of two factors: vitreous traction and underlying retinal weakness. Each factor plays a varying role in the production of different types of retinal break; for example, retinal tears (with a horseshoe-shaped configuration) are produced as a consequence of posterior vitreous detachment and there is a strong focal vitreo-retinal tractional element, whereas vitreo-retinal traction plays much less a part in the production of small round retinal breaks (retinal holes), when, it seems, the retina itself is primarily at fault. Often there may be a combination of factors, a tractional state being associated with an underlying retinal weakness, e.g. retinal tears forming in areas of lattice degeneration, or vitreo-retinal traction causing retinal detachment from an area of lattice degeneration in which there is already round hole formation.

Retinal Detachment

Normal Intraretinal Apposition

Although not clearly yet understood, forces that tend to keep the retinal layers in apposition include a high choroidal osmotic pressure, hydrostatic forces and an active solute linked transport system activated by the retinal pigment epithelium [7]. These forces may be augmented by the potential binding effect of the two layers of the retina by the intercellular mucopolysaccharide layer [8]. The efficiency of these mechanisms in providing adhesion is shown by the fact that post-mortem [9] and clinical studies [10] have demonstrated that the majority of retinal breaks do not progress to retinal detachment. The occurrence of detachment indicates that the posterior movement of fluid across pigment epithelium has been exceeded by the rate of recruitment of fluid from the vitreous cavity [11]. The more pronounced the vitreous traction, the greater will be the chance of a breakdown of the adhesive forces; thus, retinal tears are more likely to proceed to retinal detachment than are retinal holes [12]. Also, large breaks offering easy access of retrohyaloid fluid to the subretinal space are more likely to lead to detachment than smaller ones.

Formation and Spread of Subretinal Fluid

As subretinal fluid accumulates, the detaching retina is pushed inwards towards the vitreous cavity and in the process its contour assumes a convex configuration towards the vitreous. This is in contrast to the concave contour that is seen when a traction retinal detachment is present (Fig. 1.7).

Rate of Spread

Position of Break in the Retina. Due to the influence of gravity, subretinal fluid will accumulate quickly if the break is in the upper half of the retina, whereas with inferior breaks subretinal fluid accumulation is slower.

Size of the Break. Retinal detachments with large breaks tend to extend more rapidly than those with small ones.

Adhesion Between Pigment Epithelium and Neuro-epithelium. If this is deficient, resulting in a less effective pigment epithelium pump, as suggested in aphakia, subretinal fluid will accumulate more rapidly.

State and Position of the Vitreous. If the vitreous gel is of apparently normal consistency, e.g. in a young subject with a traumatic retinal detachment, and is undetached, then the rate of progression of retinal detachment will be slower than if the gel is degenerate (e.g. in myopia) and extensive posterior vitreous detachment is seen.

When there is superior retinal detachment and a very degenerate gel, progression of detachment is rapid, there being no resistance to the downward descent of the retina from vitreous gel. The normally more closer apposition of vitreous to inferior retina may contribute to the tendency of such detachments to spread slowly.

Anatomical Direction of Spread

Subretinal fluid accumulating around the retinal break will spread first from the break to the ora serrata; its subsequent spread will be influenced by the position of the break in the retina and by any obstructions in the natural pathway of the spread, e.g. areas of choroido-retinal adhesion (e.g. from previous cryopexy).

Knowledge of the way in which subretinal fluid spreads is of great value clinically because it enables the site of a break to be accurately forecast even when, on examination of the retina, the offending break is difficult to find [13]. Subsequent treatment of the retinal detachment is thus made much easier. Similarly, when a break is found, and the distribution of the subretinal fluid from it is not as expected, further careful search is indicated to discover the whereabouts of a further break.

Superior Temporal and Superior Nasal Detachments

As the detachment becomes more extensive, the fluid front descends on the same side as the retinal break towards the disc. It will then swing below the disc and, with progressive accumulation, which often results in inferior bullae, will rise up again on the other side of the retina (Fig. 1.2). It will, however, assume an upper

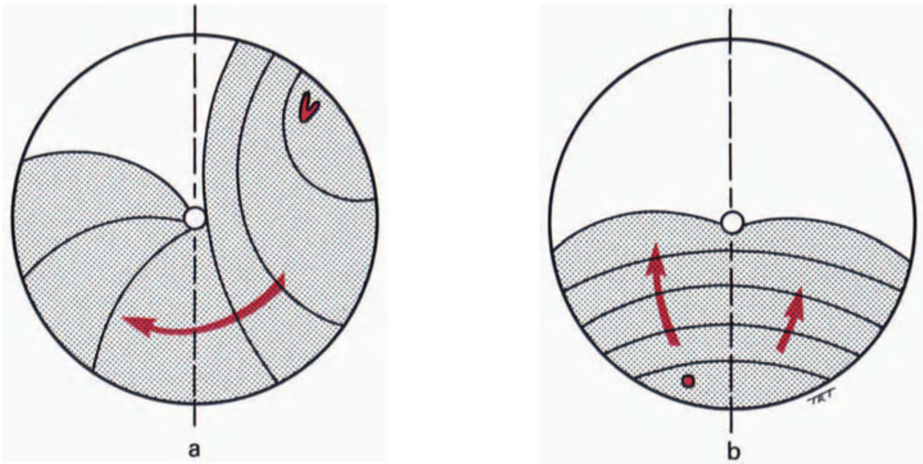


Fig. 1.2. **a** Progressive accumulation of subretinal fluid from a break in the upper retina but not close to the mid-line. **b** Accumulation of subretinal fluid from an inferior break.

level lower than that of the side from which it began. The retina will detach above the level of the retinal break on the same side to a certain extent, but this detachment level will not cross the mid-line, assuming the disc is centrally placed.

Superior Mid-line Breaks

Subretinal fluid from breaks situated very near the mid-line (i.e. directly above the disc) will spread down rapidly and symmetrically on each side of the disc. If the break is slightly to one side of the disc, the fluid front will be more prominent on the side coincidental with the retinal break. If the break is situated in a particularly posterior position, the tendency for fluid to cross the mid-line and descend on either side of the disc is rather greater, and thus the contour edges will be of less localising value; however, these breaks are usually easily seen.

Inferior Detachments

Subretinal fluid extension will produce a detachment that rises slowly from below (Fig. 1.2). Such detachments are never bullous. If the break is situated exactly below the optic disc, fluid will rise equally on each side of the disc, but if it is sited in either the temporal or the nasal half of the retina, fluid will rise high on the side on which the break is located. Inferior breaks rarely result in total detachment.

Total Detachments

The majority of fresh total detachments arise from breaks situated close to the mid-line in the superior position of the retina.

Natural History

Untreated, retinal detachment usually progresses until it is total. The retina and vitreous will gradually be infiltrated by the growth of periretinal fibrous-like membranes and the detached retina itself will become thin and atrophic. In the anterior segment uveitis and cataract formation may develop. Eventually the eye will tend to become phthisical, although glaucoma may also occur. This chain of events is accelerated in cases that have been unsuccessfully treated. Untreated subtotal detachments that do not become complicated by proliferative vitreoretinopathy may remain static for years, walled off by demarcation lines, and even spontaneous reattachment of the retina may occur, although it is rare.

Predisposing Factors

Retinal detachment has a strong bilateral tendency (19% of a non-traumatic group) [14] and is associated with a variety of predisposing factors. These factors result in the final common pathway of vitreo-retinal traction and retinal weakness. Retinal weakness may be caused by various retinal degenerations, such as lattice degeneration, or may be less obvious clinically. Vitreo-retinal traction is consequent to posterior vitreous detachment, and therefore any condition leading to posterior vitreous detachment may predispose the eye to retinal detachment. Vitreo-retinal traction may also be produced as a result of fibrotic changes in areas of preretinal neovascularisation (e.g. diabetes and HbSc disease) or fibrovascular ingrowth following perforating injury. These areas of fibrovascular proliferation undergo contraction and result firstly in traction retinal detachments, which may be further complicated by the production of break formation, adding a rhegmatogenous element to the detachment. The following conditions predispose an eye to retinal detachment:

Myopia

Myopia predisposes an eye to retinal detachment mainly because of degenerative changes in the vitreous itself, and posterior vitreous detachment. It has also been found that the peripheral degenerative changes of lattice, pigmentary and paving stone degenerations, and white without pressure are more likely to be found in myopic eyes [15], possibly indicating intrinsic weakness of the peripheral retina in myopia and increasing vulnerability to vitreo-retinal traction. It has been estimated that retinal detachment occurs eight times more frequently in myopes than in the normal population [16], and the higher the degree of myopia, the greater the risk of detachment [17].

High myopia with retinal detachment is more common in the male population than in the female, a tendency that is not found with the lower levels of myopia [14]. In myopic retinal detachments, round breaks are more often encountered than in non-myopic cases. The tendency of the round break to produce detachment suggests that in myopia a less effective intraretinal adhesive mechanism may be present.

Aphakia

Retinal detachments were estimated to have occurred in approximately 2% of patients rendered aphakic by the intracapsular technique [18]. This incidence was higher if there were other high-risk factors such as pre-existing myopia [19] or pre-existing retinal degenerative change (such as lattice degeneration [20]). It was also well known, and has recently been confirmed, that those patients suffering vitreous complications in the management of cataract surgery were particularly likely to develop retinal detachment [21]. These high-risk cases offset the still very low incidence of aphakic retinal detachment following uncomplicated intracapsular surgery in eyes that were previously emmetropic [22]. The mechanism of aphakic retinal detachment following intracapsular extraction is probably related to the movement of the vitreous gel that occurs to occupy the space previously filled by the crystalline lens. This forward movement will inevitably be

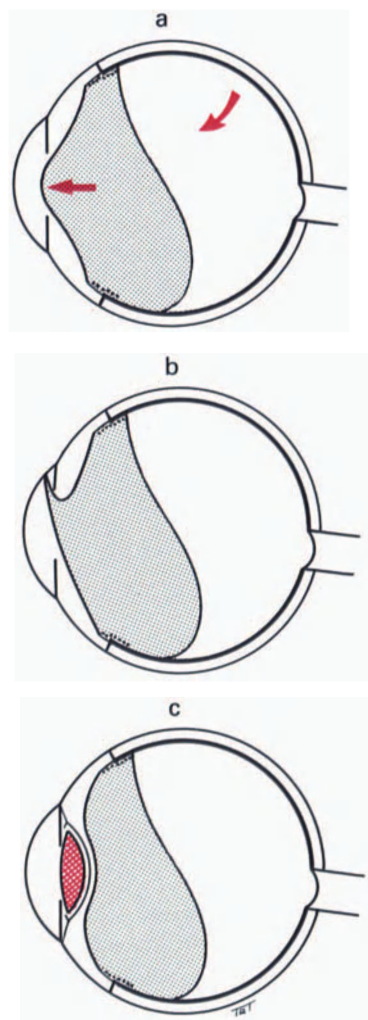


Fig. 1.3. **a** Position of the gel after posterior vitreous detachment in intracapsular aphakia. The gel has moved forward to occupy the space previously filled by the lens. **b** Anterior tethering of gel following vitreous incarceration into a cataract section. Altered dynamic vitreo-retinal traction increases risk of break formation. **c** After extracapsular extraction and intraocular lens implantation there is little movement of gel towards the anterior segment.

accompanied by a high incidence of posterior vitreous detachment, and vitreo-retinal tractional forces are accentuated by the increased volume of the vitreous cavity following extraction and a subsequent increase in capacity for excursion of the gel when it moves. Vitreous loss at the time of cataract surgery, particularly if complicated by incarceration of gel into the cataract section, may induce its effects on the incidence of aphakic retinal detachment by again altering the nature of the posterior vitreous detachment. Anterior incarceration of gel may result in increased traction at the posterior border of the vitreous base (Fig. 1.3). If vitreous incarceration is very substantial then direct vitreo-retinal traction forces may be exerted on inferior retina.

In recent years there has been a pronounced move toward the reintroduction of extracapsular cataract extraction. The preservation of the posterior capsule (and not subsequently accompanied by large capsulotomies, as used to be the case), with or without the insertion of an intraocular lens implant, prevents gel movement and reduces the risk of detachment [23–25]. Subsequent capsulotomy increases the risk of detachment [25]. The difference in the incidence of aphakic retinal detachment following the use of various types of intraocular lens [26] may depend more on whether the procedure was extracapsular or not than on any intrinsic influence of the lens itself.

Retinal Degeneration

Some retinal degenerations, for example, lattice or snail track degeneration, have a particular predilection to retinal break formation and subsequent retinal detachment. These degenerations may result in reduced intraretinal adhesion and subsequent vulnerability of these lesions to vitreo-retinal traction (much more pronounced in lattice than in snail track degeneration).

Trauma

Retinal detachment may follow either contusive or penetrating trauma, and although it is convenient to consider the clinical pictures separately, in severe injuries mixed clinical pictures are found.

Contusive Injuries

In contusive injuries the globe is temporarily deformed at the moment of impact. Although the walls of the globe are capable of such movement, the inelastic gel is not. On compression, therefore, the walls of the eye tend to move away from the vitreous base (Fig. 1.4) and this movement results in the typical retinal break characteristic of trauma, i.e. retinal dialysis. The dialysis pathognomonic of ocular contusion is found in the upper nasal quadrant of the retina [27] and the break is always formed at the time of the injury and not as a late occurrence [28]. The role of trauma (if any) in the production of dialysis found in the lower temporal quadrant is much less clear. In contusive injuries, sudden movement of the gel in the region of its firmly attached base may result in avulsion of the vitreous base (Fig. 1.5) and can also, though less commonly, produce slit-like

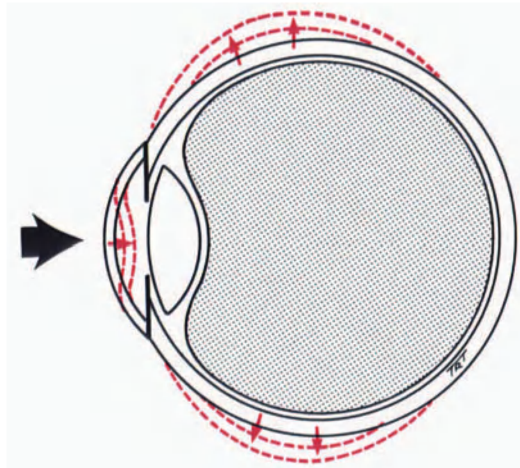


Fig. 1.4. After blunt trauma to the anterior segment the eye is deformed (*dotted line*). The inelastic vitreous base may cause retinal dialysis.

breaks in the pars plana. Acute posterior vitreous detachment resulting in macular breaks or irregular tears along blood vessels at the posterior pole occur immediately; breaks in the equatorial region can appear later as delayed posterior vitreous detachment occurs.

In a study of retinal detachment associated with ocular contusion, retinal detachment developed soon after the injury – in 80% of cases within 2 years [29]. Certain occupations and sports carry some risk. Injury occurs directly in boxing, and less directly in various games such as squash rackets, where the players may be struck by the ball or the racket [30]. Retinal detachment may also occur as part of the battered baby syndrome [31].

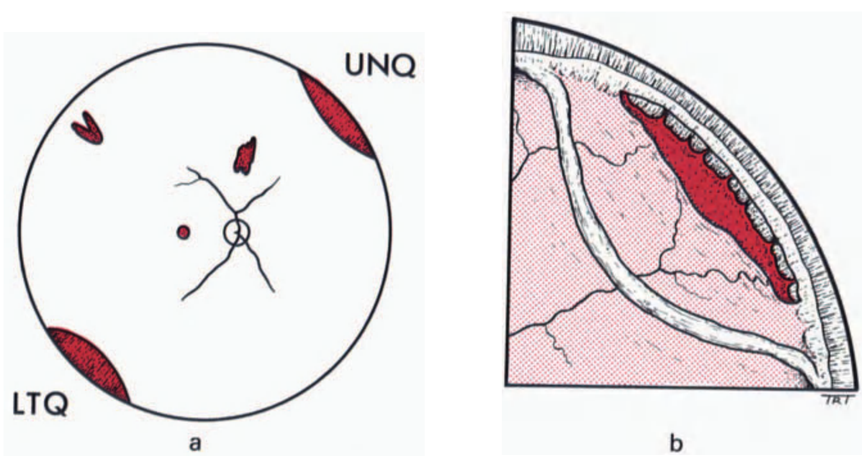


Fig. 1.5. **a** The types of break that may be produced by trauma. There are dialyses in the upper nasal quadrant (*UNQ*) and lower temporal quadrant (*LTQ*); macular or irregular breaks in the posterior segment or equatorial retinal tears follow posterior vitreous detachment. **b** Avulsion of the vitreous base with its typical bucket handle appearance and retinal dialysis.

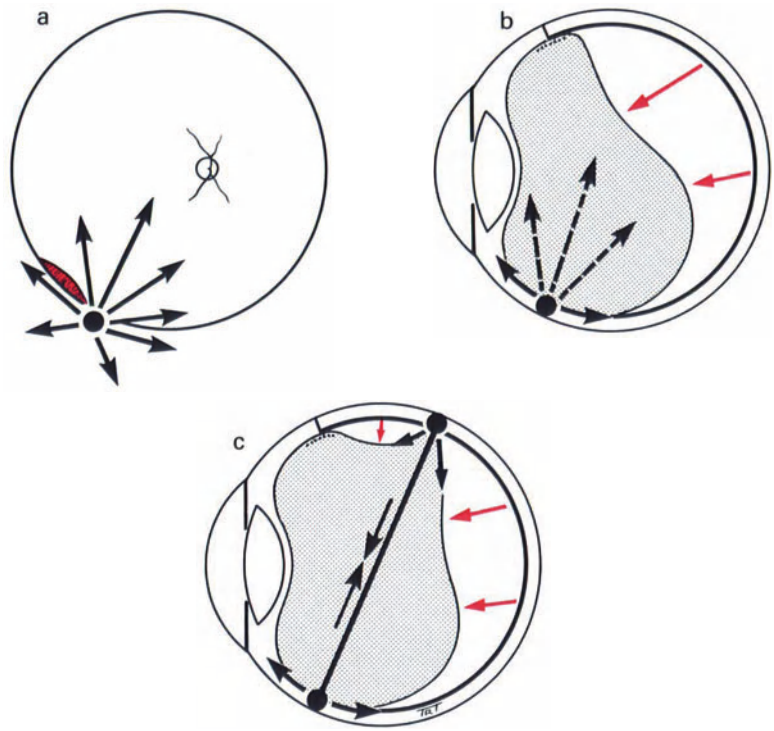


Fig. 1.6. **a** Tractional systems that may develop following a perforating injury in the pars plana area. Trans-gel and tangential retinal forces are established (*heavy arrows*). **b** Sequential posterior vitreous detachment (with tendency to relieve trans-gel traction). **c** Trans-vitreal traction produced as a result of pars plana perforation and connecting to a posteriorly placed inpact site; there is limited posterior vitreous detachment.

Perforating Injuries

Corneal lacerations do not result in retinal detachment unless the injury is complicated by involvement of the posterior segment either directly (e.g. intraocular foreign body reaching the posterior segment via an anterior perforation site) or indirectly as a result of surgical treatment (e.g. following lens extraction).

In scleral lacerations with direct retinal damage and vitreous loss, retinal breaks, although not usually found at the actual site of entry, may occur in neighbouring retina or pars plana [32]. Breaks may also be produced by posterior vitreous detachment occurring subsequent to the injury (Fig. 1.6). The main complicating feature of posterior segment injuries is fibrocellular ingrowth from the scleral wound. This proliferation, starting early after injury and becoming well established 1–2 weeks from the time of perforation [33], is particularly encouraged by poor wound healing and blood and inflammatory cells in the vitreous gel and is further enhanced by the presence of an intraocular foreign body or of infection. This fibrocellular ingrowth, which may be vascular, causes its effect by subsequent contraction and marked vitreo-retinal traction. The anterior membranes may involve basal gel establishing extensive tangential

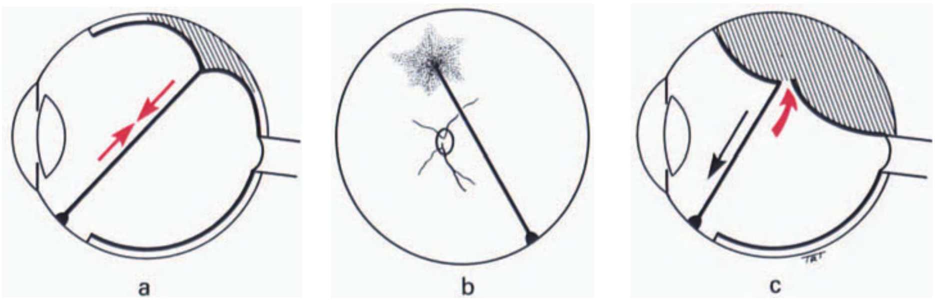


Fig. 1.7. **a** Trans-vitreal traction from a perforation site has led to a traction retinal detachment. **b** The detachment is concave towards the vitreous cavity and the edges of the detachment convex towards the focal point of vitreo-retinal traction. **c** Traction has produced a full thickness retinal break, allowing a rhegmatogenous element to be superimposed upon the tractional detachment.

traction in the peripheral retina and pars plana. This sequence of events, if uninterrupted by surgical intervention, may promote retinal detachment situations that are exceedingly difficult to treat successfully. Retinal detachment will usually occur within months of a perforating injury.

Surgical trauma may also occur as a result of inadvertent perforation of the globe during squint surgery [34], and this may lead to retinal detachment many years later [35].

The role of less obvious trauma in the production of retinal detachment is hard to assess. It is probable that trauma is not a significant factor in the great majority of detachments [36].

Traction Retinal Detachment

The natural history of neovascularisation arising from retinal vessels is one of eventual infiltration with fibrous tissue. If the vascular complex has assumed the shape of large fronds, the resulting complex may be very extensive. The complex, adherent to a retracting posterior hyaloid face, may result in traction retinal detachment. This may occur in any disease characterised by the formation of retinal new vessels, e.g. diabetes, HbSc disease, venous occlusion, Eales disease or the retinopathy of prematurity. Traction retinal detachment characterised by a contour that is both convex towards the centre of the complex and concave towards the vitreous cavity may develop a rhegmatogenous element if a full thickness retinal break occurs (Fig. 1.7).

Rhegmatogenous Retinal Detachment

Classical Symptoms

The classical history is that of the premonitory symptoms of flashes of light caused by vitreous traction on the retina as the posterior vitreous detaches, floaters due to vitreous haemorrhage resulting from retinal break formation, and subsequent onset of a field defect caused by detaching retina. The timing and presence of all three symptoms is variable, and only approximately 50% of patients suffering from retinal detachment have premonitory symptoms [37]. Flashes of light are usually experienced in the temporal field of vision and they have no localising value as to the site of the retinal break or of vitreous traction; usually they last for a few seconds and may be experienced several times a day for several days [38]. Floaters generally appear several days after the onset of the flashes of light. The symptoms created by vitreous haemorrhage depend upon its severity and vary from a slight shower of black spots (the patient often noticing the blood in the detached vitreous as a moving lace-like curtain) to extensive loss of vision. The vitreous haemorrhage is usually a single event, although occasionally, if a retinal vessel is partially avulsed and lies free of the retinal surface, haemorrhages may be multiple and repeated over months or years [39]. Floating spots may also be noticed by the patient who is suffering a simple posterior vitreous detachment, rather than one complicated by retinal break or vitreous haemorrhage. Usually floaters noticed after posterior vitreous detachment alone are less dramatic than those associated with vitreous haemorrhage after break formation. However, posterior vitreous detachment even without the formation of retinal breaks may in its own right produce haemorrhage from superficial retinal blood vessels. The haemorrhages occurring with posterior vitreous detachment are usually small and punctate on the retinal surface, but occasionally extensive haemorrhage around the disc can be seen [40]. This blood may be found in the retrovitreal and intravitreal compartments or both (Fig. 2.6). When posterior vitreous detachment occurs in association with vitreous haemorrhage it should always be assumed that there is a retinal break [41]. In a survey of patients with posterior vitreous detachment who presented with flashes and floaters it was found that only 10%–15% had retinal breaks [42].

If a retinal break is to progress to retinal detachment, the detachment occurs within a few days or weeks of the formation of the break. It is exceptional for this interval to be months or years.

A field defect develops when the retinal detachment extends posterior to the equator, and therefore it may be quite extensive before such a defect is noticed. Usually the field defect is dense, but it may be much less so if the detachment is shallow. A field defect can be of localising value in indicating the starting point of the retinal detachment; for example, an inferior nasal field defect will indicate a superior temporal detachment and an infero-temporal defect will indicate a superior nasal detachment. Superior defects, however, are of less localising value because a large inferior retinal detachment may be produced as a result of either an inferior break with fluid ascending from below or a superior break resulting in subretinal fluid tracking inferiorly, leaving superior retina attached. In superior detachments the inferior field defect extends rapidly. Central vision will be lost when the macula detaches, and the detachment will rapidly extend to affect all quadrants. The inferior field defect of superior detachment is usually noticed early. Superior field defects, however, are seldom noticed for weeks and months even in spite of macular detachment. The defect is itself unlikely to extend much above the macula because inferior half retinal detachments rarely progress far above the mid-line.

The field defect itself is sometimes of variable quality. Thus, a detachment that involves the upper half of the retina and produces an inferior defect may be noticeable in the evening, whereas during the night, if the patient lies in a horizontal position, which brings the break into a dependent position, there may be redistribution of subretinal fluid into the vitreous cavity via the retinal break with resultant progressive flattening of the retina. Thus, in the morning the field defect may have disappeared entirely, only to reappear again as the day progresses. Such a field defect may lead to diagnostic confusion, the patient being labelled as hysterical, particularly if a careful fundal examination is not made at the appropriate time of the day. In these cases if the macula is affected, there may also be fluctuation in central vision or production of the macular symptoms of micropsia and metamorphosia, again with better vision and absence of symptoms in the morning and worsening as the day progresses. These symptoms highlight the need, when the macula is found to be abnormal, to examine the periphery of the retina in exactly the same way as the periphery is examined for vascular abnormalities when macular exudates are found.

When listening to the history given by a patient it is essential that the examiner asks specifically about trauma. In most recent injuries, whether penetrating or contusive, the traumatic event will be obvious. In older injuries, however, the association between previous injury and the present ocular problem may not be obvious to the patient, and the history of trauma will only emerge on direct questioning. Inquiry into the patient's occupation or leisure habits is particularly important. When an intraocular foreign body is suspected, a careful history at the time of the examination in relationship to trauma is important (e.g. revealing the use of a hammer and chisel) not only to institute correct treatment but also from a medico-legal point of view.

Other Symptoms

In some cases of retinal detachment the classical symptoms do not occur, and the detachment is identified in other ways. Thus visual acuity may be found to be reduced either by the patient or during an incidental ophthalmological examination.

Reduced Visual Acuity

Reduction of visual acuity as the only sign of retinal detachment arises in the following ways:

Inferior Retinal Breaks. Retinal detachments associated with inferior breaks (e.g. retinal dialysis) have an insidious course; premonitory symptoms rarely occur, the associated superior field defect is rarely noticed, and detachments progress slowly until the macula is detached (84% of patients with retinal dialysis presented with a detached macula, compared with approximately 70% of patients with other types of retinal break [43]).

Aphakic Detachment. If retinal detachment occurs rapidly after cataract extraction, the detachment will be detected only when ophthalmoscopy of the posterior segment has been performed after surgery; this is because the patient will have had little chance to appreciate improved vision following extraction unless an intraocular implant has been used.

Breaks at the Posterior Pole. Retinal detachment associated with breaks arising from the posterior pole (e.g. a macular break) present as a central defect and reduced central vision even if the visual acuity has already been depressed by previous macular degenerative change.

Vitreous Haemorrhage

Severe vitreous haemorrhage associated with retinal break formation may depress central vision even if retinal detachment is slight.

Inflammation

Uveitis. The presenting feature of the retinal detachment may be anterior uveitis (secondary to the detachment) and reduced cental vision. Flare and cells, often with fibrinous exudate, may be found in the anterior chamber, and posterior synechiae form. White cells are seen in the retrolental space. Thus, rhegmatogenous retinal detachment should be excluded in all patients in whom uveitis has been diagnosed. Conversely, uveitis itself, by inducing secondary changes in the vitreous body, may precipitate posterior vitreous detachment and consequent rhegmatogenous retinal detachment. Thus, a detachment found in association with uveitis should not be assumed to be exudative and non-rhegmatogenous in origin.

Retinitis. Inflammation in the retina may be associated with acute retinal necrosis, break formation and rhegmatogenous retinal detachment.

Asymptomatic Detachments

Asymptomatic detachments without depression of central vision are usually detected during routine ophthalmoscopy on patients in whom the examiner has a high index of suspicion of retinal detachment, as, for example, in the other eye of a patient with retinal detachment or following trauma.

Techniques of Examination

A general ocular examination of both eyes is made with the object of excluding coexisting ocular disease before attention is turned specifically to the posterior segment. In a patient with extensive retinal detachment involving the macula, not only will there be profound reduction of central vision but the patient will be unable to project light accurately except in the field of vision corresponding to attached retina. The affected eye with extensive detachment will show a relative

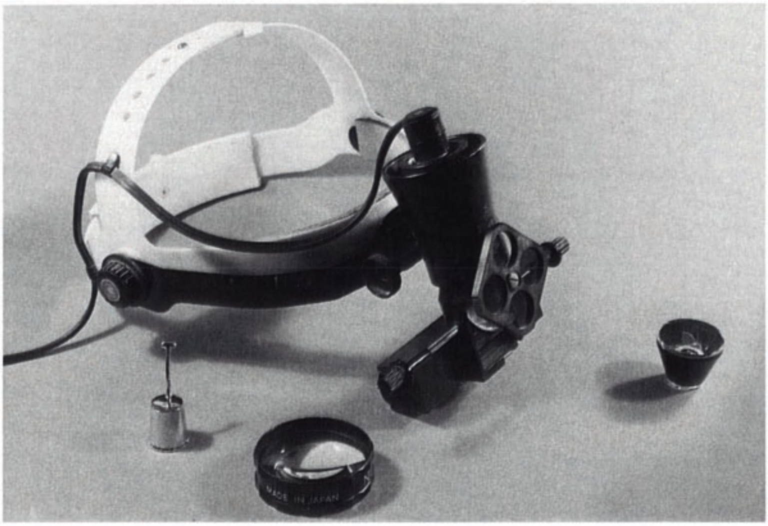


Fig. 1.8. The tools of the trade. The indirect ophthalmoscope and scleral depressor with condensing lens and a three-mirror contact lens.

afferent pupillary defect. These two signs are of particular value to the examiner when the view of the underlying retina is obscured by opacities in the media and detachment is unsuspected.

The main instruments for examining the retina are the indirect ophthalmoscope combined with scleral depression, popularised by Schepens [44], and the three-mirror contact lens (Fig. 1.8). The methods of usage and importance of these instruments have been so well documented that it is necessary here to comment on them only briefly. Whatever surgical methods are going to be used to cure the retinal detachment, it is agreed by all surgeons that complete mastery of the techniques of examination is essential before modern retinal surgery can be successfully and consistently performed. Indirect ophthalmoscopy combined with scleral depression and examination by three-mirror gonioscopy are complementary forms of examination and are not mutually exclusive. The ophthalmoscope is mainly useful for examining the retina itself while the three-mirror gonioscope is used to examine (a) the angle of the anterior segment, the mid and posterior portions of the vitreous body with particular reference to points of attachment of the vitreous to the underlying retina and (b) the movement of the vitreous. The magnified view provided by the gonioscope is of great help in checking the indirect ophthalmoscopic findings and in finding small breaks. In all cases of retinal detachment, ophthalmoscopy and three-mirror gonioscopy should be carried out on both eyes in the preoperative examination.

Indirect Ophthalmoscopy and Scleral Depression

For indirect ophthalmoscopy the examination must be thorough and unhurried, with the patient lying comfortably on a couch in a darkened room, under full mydriasis of the pupils (phenylephrine 10% and tropicamide 1%).

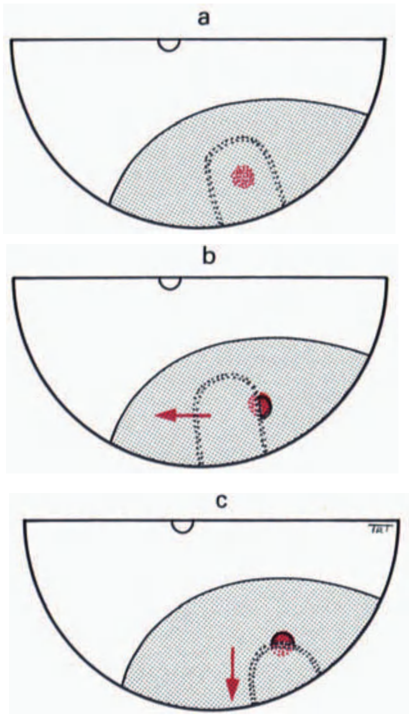


Fig. 1.9. The scleral depressor does not greatly improve the visualisation of a suspected retinal break when situated directly under it, as in **a**. Lateral or posterior depressor movement, as in **b** and **c**, allows visualisation of the edge of the retinal break.

The indirect ophthalmoscope provides a stereoscopic view of the fundus with low magnification enabling a good overall view of the retina to be obtained. The relatively high light source used will make a view of the retina possible even if there are relatively severe opacities in the media such as cataract and vitreous haemorrhage. Indentation of the walls of the eye as far back as the equator by scleral depression makes it possible to see otherwise hidden areas of peripheral retina. The scleral depressor also adds a dynamic dimension to the examination; small movements improve stereopsis and alter light reflection patterns, which is particularly useful for revealing small breaks and identifying points of vitreoretinal traction (Fig. 1.9). In the great majority of cases the scleral depressor is used over the lids and it is seldom necessary to indent directly over the anaesthetised conjunctiva. In most patients scleral depression is performed without difficulty, although enophthalmic eyes are technically more difficult to examine. On occasions, however, it proves extremely unsatisfactory; this is particularly so in patients who have undergone recent surgery and in whom the eye is photophobic and lacrimation, excessive. Nervous patients may be also intolerant of the procedure. High levels of illumination should be avoided. A higher light source will tend not only to aggravate the patient but also to bleach details of the retina. A very bright light source is only useful when there are severe opacities of the media.

Ambidexterity with lens and scleral depressor must be mastered in order to examine all retinal details. Thus, when examining the upper nasal quadrant of the right eye from the patient's right-hand side, or the upper temporal quadrant of the left eye from the same side, the examiner uses the scleral depressor on the left hand while holding the condensing lens in the right (Fig. 1.10). The converse arrangement of lens and depressor is used for examining the upper nasal quadrant of the left eye and the upper temporal quadrant of the right when examining the patient from the left-hand side (Fig. 1.11). The inferior and superior portions of the retina are examined from above and below respectively and from the same side as the eye concerned, with the examiner's head tilted accordingly (Fig. 1.12). The patient is asked to move his eyes away from the examiner towards the quadrant of the eye that is being examined. It is important, however, for this movement not to be too extreme. If it is excessive the examiner will have great difficulty in seeing retinal details through the pupillary plane (Fig. 1.13).

A variety of aspheric condensing lenses are used. The 20 dioptre lens (Fig. 1.14) is by far the most useful for general purpose examinations, be they preoperatively or in the theatre. The 30 dioptre lens with its larger field but less magnification is helpful when the retina is being examined through a small pupil.

It hardly needs to be stressed that all examinations should be performed with gentleness. Force is never necessary, and if used will only result in a protesting and uncomfortable patient. In some apprehensive patients the examination may have to be performed several times over short periods so that the patient's

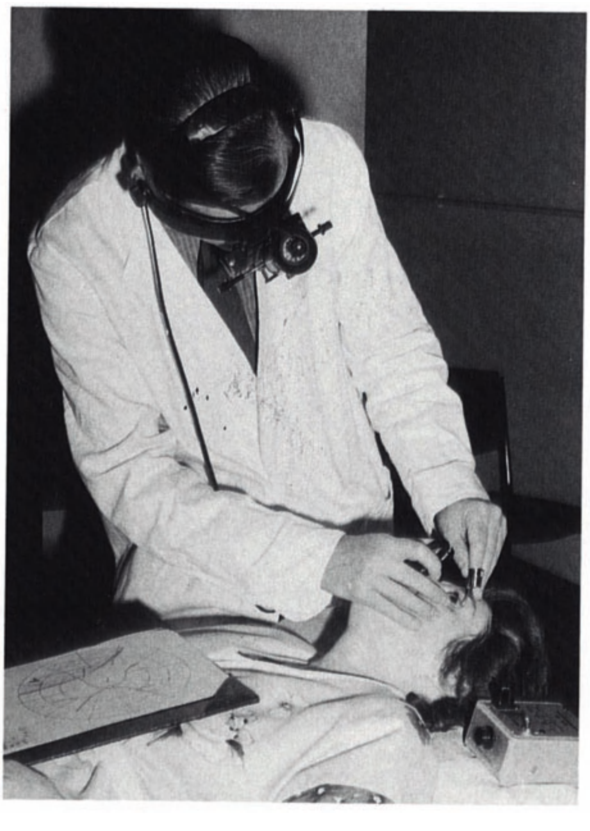


Fig. 1.10. When examining the upper temporal quadrant of the left eye from the patient's right-hand side, the scleral depressor is used on the examiner's left index finger and the condensing lens is held in the right hand.

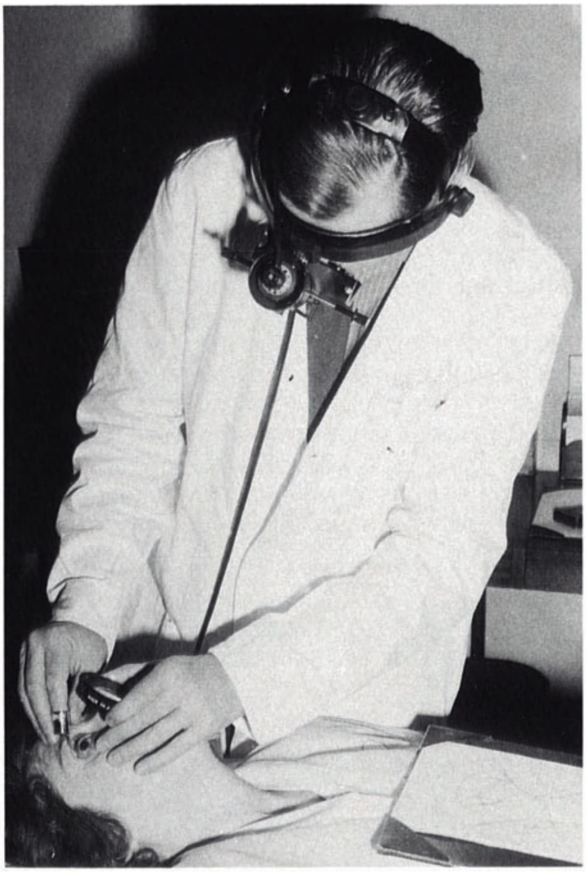


Fig. 1.11. The converse arrangement is used when examining the upper temporal quadrant of the right eye from the patient's left-hand side, i.e. the scleral depressor is used on the right index finger and the condensing lens is held in the left hand.

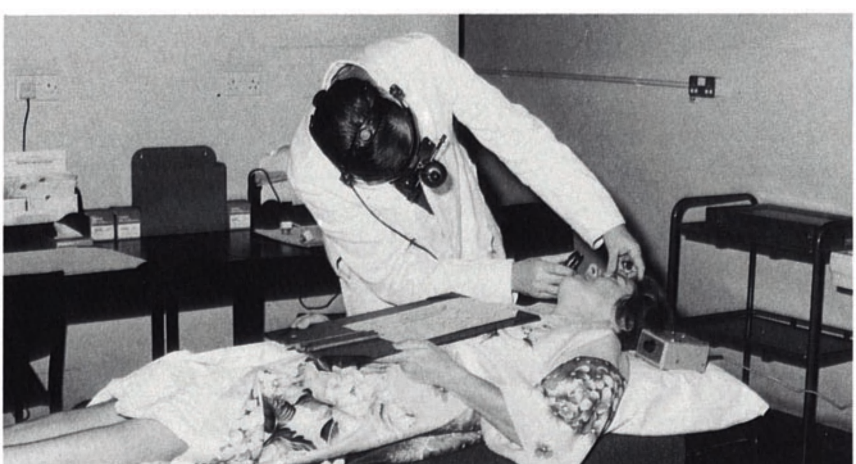
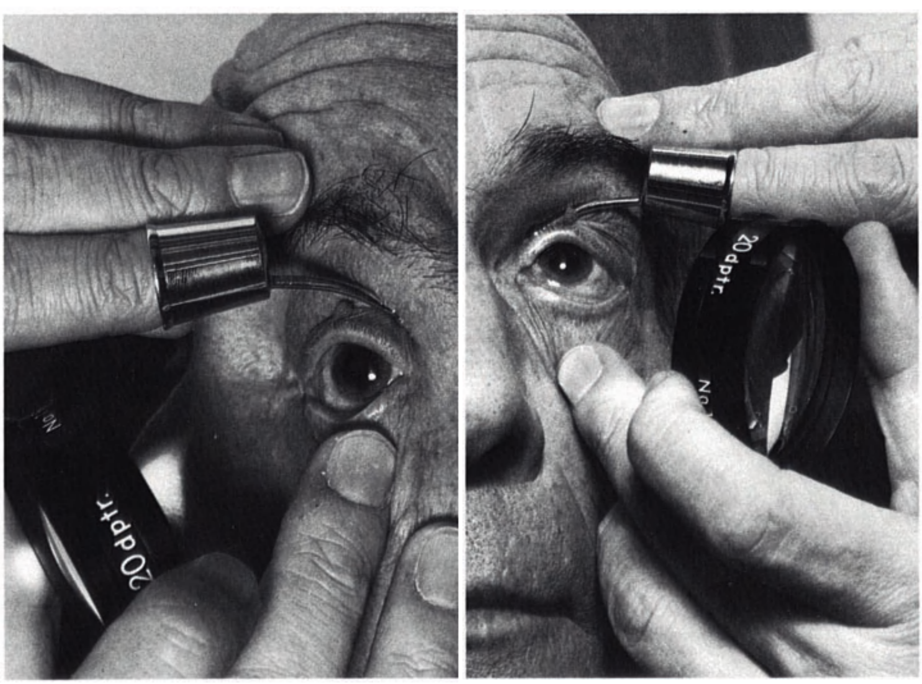


Fig. 1.12. The examiner's head is tilted to examine the upper part of the retina.

Fig. 1.13. While examining the upper part of a retina it is essential for the elevation of the eye to be moderate. Over-elevation will prevent the scleral depressor from being placed in position and also reduce the observer's window through an oblique pupil.



a b

Fig. 1.14a,b. As well as indenting, the scleral depressor acts as a retractor of the lid over which it is applied, as does the middle finger of the hand holding the condensing (20 dioptre) lens.

confidence in the examiner is built up. After several sessions the patient, who may initially have been a most difficult subject, will often tolerate the procedure well and allow an adequate examination to be made. There are special situations when scleral depression has to be performed with great care, e.g. in patients with recent vitreous haemorrhage and patients in whom unstable iris clip lenses are present. In the former, further vitreous haemorrhages may be precipitated and in the latter dislocation of the intraocular lens can occur.

Examining Children

In the rare cases when retinal detachment occurs in very young children, the examination poses particular problems. The child may be uncooperative and is usually apprehensive. This apprehension may be partially relieved by the presence of a calm parent. In these conditions the examination must not be allowed to take too long and the subject's confidence in the examiner must be built up slowly. Usually with patience it is possible to examine the retina in detail. Only the very gentlest scleral depression should be practised on children; indeed, often it is not possible to do so at all. In many cases it is only possible to make a general examination of the fundus and a detailed examination has to be deferred until the patient is anaesthetised at the time of surgery. Indirect ophthalmoscopic examination can then be made with scleral depression and a fundal chart completed in the operating room before surgery is started.

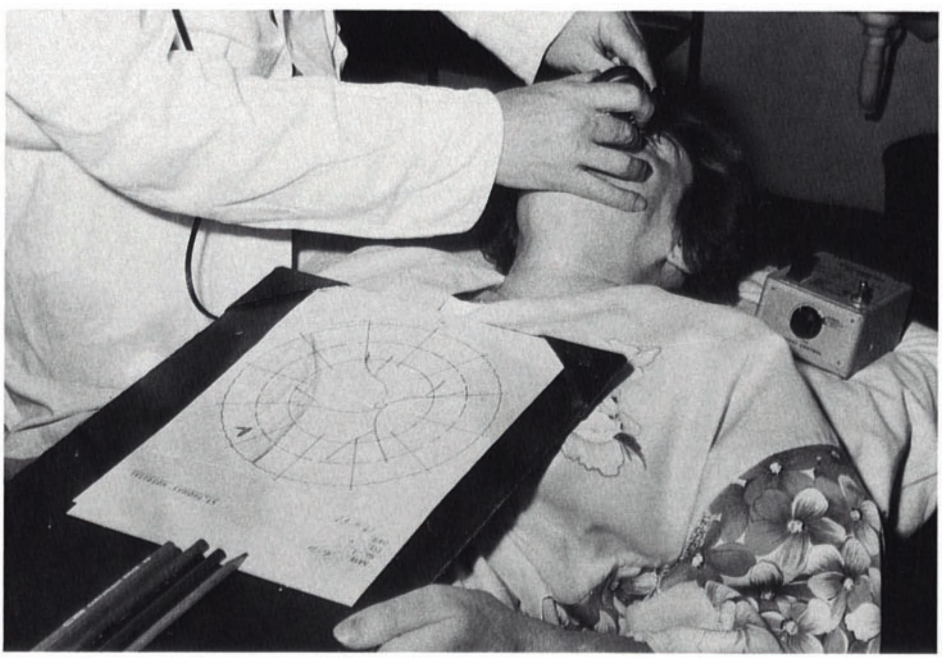


Fig. 1.15. The inverted retinal chart is placed on the supine patient to allow the retinal diagram to be made.

Retinal Charts

Retinal drawings are prepared of both eyes prior to surgery; the time spent by the surgeon in completely familiarising himself with the retina on which he is going to operate will result in much saving of time during the operation itself, mainly by making it easier for him to identify breaks and other landmarks rapidly. The assessment of the findings of indirect ophthalmoscopy are often confusing to the beginner, the view of the retina being vertically inverted and laterally reversed by the indirect ophthalmoscope. This preoperative difficulty is overcome by placing the retinal chart on the patient in the upside down position during the examination (Fig. 1.15). Thus, when the patient looks down with the surgeon standing above, details of the inferior retina will be indicated on the part of the chart nearest the surgeon (and this will correspond to inferior retina in the transposed retinal chart). As the surgeon progressively moves round the eye, further details of the retina will similarly be added to the chart.

When the retinal detachment has been accurately charted it should be possible to form a clear-cut idea of what needs to be done at surgery. If there is a period of bed-rest before operation, it will be necessary to re-examine the retina before surgery because if subretinal fluid has been redistributed by bed-rest, the appearance of the retinal detachment may have changed dramatically and the surgeon will need to familiarise himself with the new conditions prior to operation.

Direct Ophthalmoscopy

Direct ophthalmoscopy is of little use in examining the detached retina but on occasions may be of help in patients with small pupils. It should, however, be used to examine the optic disc.

Visual Fields

Visual fields have little part to play in the diagnosis of retinal detachment or in subsequent management other than to confirm the patient's objective impression of improvement and to record such improvement. The peripheral field will only start to become affected when the detachment has extended posterior to the equator.

Other Investigations

The following investigations are not routinely performed in the examination of a patient with retinal detachment but are of value in special situations.

Ultrasonography

Ultrasonography, particularly in the form of a B-scan, is of value in eliciting not only the presence and extent of retinal detachment when there is severe opacity in

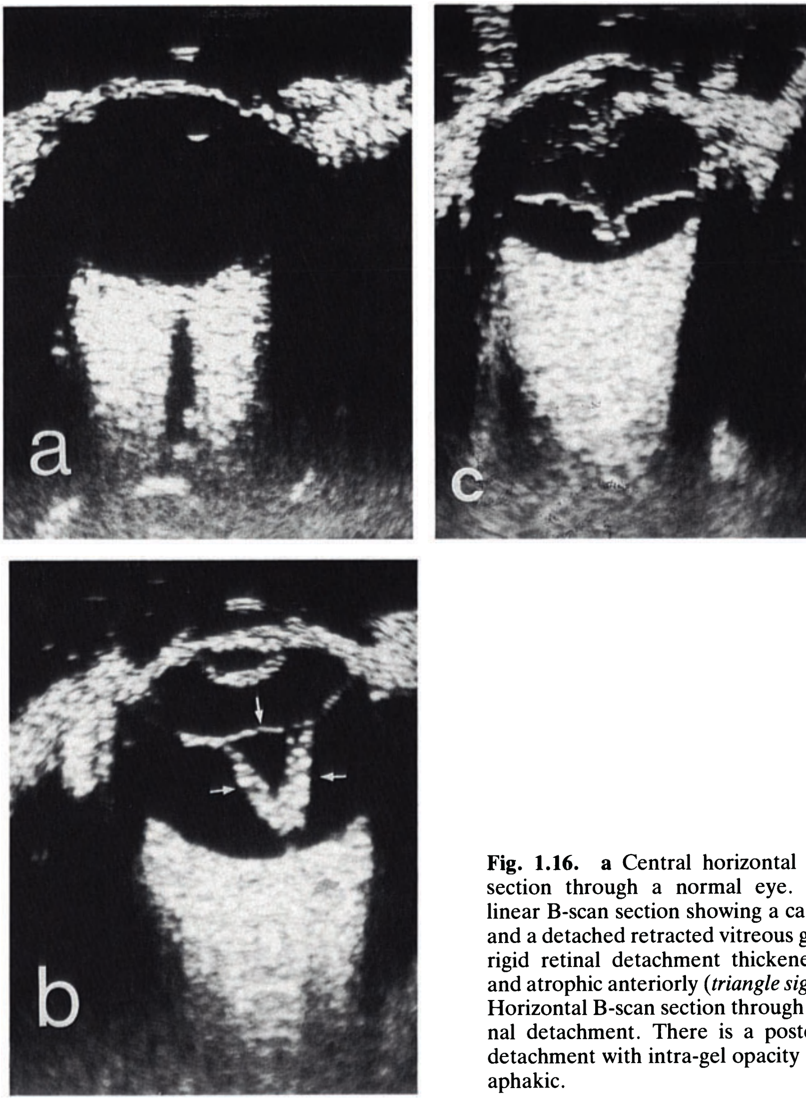


Fig. 1.16. **a** Central horizontal linear B-scan section through a normal eye. **b** Horizontal linear B-scan section showing a cataractous lens and a detached retracted vitreous gel with a total rigid retinal detachment thickened posteriorly and atrophic anteriorly (*triangle sign-arrowed*). **c** Horizontal B-scan section through a mobile retinal detachment. There is a posterior vitreous detachment with intra-gel opacity and the eye is aphakic.

the media but also the character of the detached retina [45] (Fig. 1.16). It may also provide other valuable information about the general state of the eye, e.g. the presence of intraocular foreign bodies. Ultrasonography is an essential prerequisite when pars plana vitrectomy is being considered in patients in whom it is not possible to see the retina due to opacities in the media.

X-rays

A plain X-ray of the eye may be helpful in excluding the presence of a metallic intraocular foreign body (Fig. 1.17). Patients presenting with retinal detachment

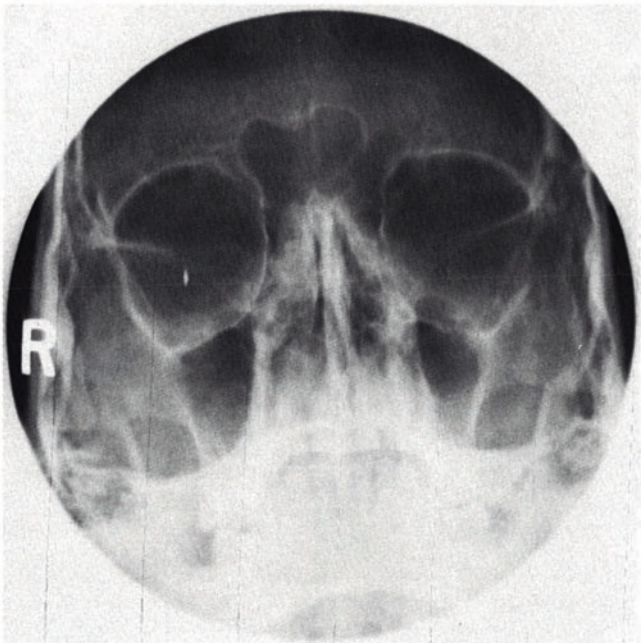


Fig. 1.17. A large radio-opaque foreign body is present on an anteroposterior view of the right orbit.

when the media are opaque and in whom there is a suggestive history of penetrating injury should make the surgeon suspicious of the presence of an intraocular foreign body.

CT Scanning

A CT scan is useful in helping to decide whether a foreign body is truly intraocular or not (Fig. 1.18).

Fig. 1.18. A CT scan shows the presence of a metallic foreign body attached to but not within the medial and posterior wall of the right eye.

Fluorescein Angiography

Fluorescein angiography is of value when considering the possibility of malignant melanoma and other diseases that may cause non-rhegmatogenous retinal detachment [46] (e.g. Harada's disease, posterior scleritis).

Transillumination

Transillumination is of value in distinguishing between a rhegmatogenous and a solid non-rhegmatogenous retinal detachment. In most cases, however, the presence of a solid tumour is obvious on indirect ophthalmoscopy.

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2 Preoperative Examination

The initial examination is that of the anterior segment, which is conducted at the slit lamp; this is followed by examination of the posterior segment by indirect ophthalmoscopy and scleral depression. The patient is then returned to the slit lamp for three-mirror examination.

Initial Slit-Lamp Examination

The examination of the cornea, anterior chamber, lens iris diaphragm, retrolental space and anterior vitreous is made.

Cornea

Corneal opacities may interfere with the view of the fundus but it is unusual for opacities to be of such severity that they seriously obstruct the fundal examination. It is therefore rare for any preliminary corneal grafting procedure to be necessary prior to retinal surgery. Peripheral retina can usually be seen adequately even if there are central corneal opacities, although central retina may be poorly seen. Nevertheless, a dense peripheral opacity may make observation of the peripheral retina difficult. Corneal sutures following recent repair, for example, a corneal perforating injury may impair the view and produce annoying distortion of the retinal image.

Although the risk of retinal detachment is not increased following phakic corneal grafting, it may be after aphakic grafts, particularly if there has been vitreous manipulation [1].

Anterior Chamber

Intraocular Pressure

The intraocular pressure is recorded and although raised intraocular pressure may be found in an eye with retinal detachment, the pressure is in fact usually lower. This hypotony is probably related to the posterior movement of fluid from the eye across the retinal pigment epithelium via the retinal break and reduction of aqueous secretion may also play a part [2]. Raised intraocular pressure [3, 4] either indicates glaucoma of an underlying nature (e.g. chronic simple glaucoma or aphakic glaucoma) or is a consequence of the detachment itself, in which case it is usually secondary to anterior uveitis. Reduced pressure may occur in eyes that have underlying chronic simple glaucoma, and it is therefore important to watch the intraocular pressure after reattachment has been achieved. Preoperative rise of intraocular pressure secondary to uveitis resolves spontaneously after the retina has been reattached.

Uveitis

Anterior uveitis may be found in association with retinal detachment and is of two main types:

1. Uveitis secondary to retinal detachment is the more commonly encountered type, and although usually associated with a long-standing retinal detachment, it may occur after the detachment has been present only for a few days. It is not known why some cases of detachment excite such a marked inflammatory response which may involve the formation of posterior synechiae and secondary glaucoma. In addition to flare and cells in the anterior chamber, there is cellular infiltration of the anterior vitreous, and if this is severe it may mask the underlying detachment – one reason why all patients with anterior uveitis must have a careful fundal examination.

2. Retinal detachment may be secondary to an underlying uveitis or other inflammatory problems of the posterior segment. The retinal detachments encountered are of two main types:
a) *Rhegmatogenous*. In these cases the usual mechanism of production of the retinal detachment is inflammatory changes in the vitreous cavity inducing posterior vitreous detachment and subsequent retinal breaks. In exceptional circumstances such as acute retinal necrosis, large retinal breaks may appear in the retina prior to significant posterior vitreous detachment.
b) *Non-rhegmatogenous*. These detachments, in which retinal breaks are not present, may be either bullous or small and relatively insignificant. The former detachments are usually found in the inferior fundus (e.g. in the Harada-like syndromes and posterior scleritis) while the latter are found in the inferior periphery of the retina in some cases of generalised uveitis of a non-specific type [5].

The depth of the anterior chamber is noted and will be assessed with the examination of the angle conducted during the three-mirror examination.

Iris

If pupillary dilatation is not achieved to the level of approximately 3–4 mm then difficulty will be found in examining details of the fundus peripheral to the equator. The cause of the failure of pupil dilatation may be physiological, e.g. in

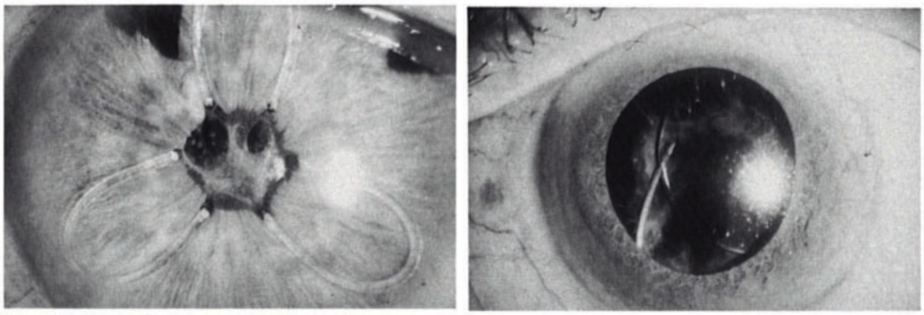


Fig. 2.1. **a** An iris-suspended intraocular lens with a small fixed pupil. **b** A subluxated posterior chamber lens with thickening of the posterior capsule.

heavily melanotic irides, or one of a variety of pathological states, such as diabetes, intracapsular aphakia (particularly if the cataract surgery has been complicated by vitreous loss), iris clip intraocular lenses (Fig. 2.1a) (particularly if unstable) and Marfan's syndrome, or miotics for the treatment of glaucoma. Iris atrophy may be found but its significance is difficult to interpret, particularly if the eye has been subjected to previous retinal or anterior segment surgery. If, however, extensive segmental iris atrophy is found following previous retinal detachment surgery, the examiner is warned about the risk of additional ischaemia if further buckling procedures are required.

Lens

Position of Lens, Pseudophakia and Lens Capsule

If the crystalline lens is subluxated or even dislocated, as may be found in Marfan's syndrome or following trauma, accurate observation of the peripheral fundus (Fig. 2.1b) is difficult. The presence of intraocular lenses inserted during cataract surgery may make examination of the retina more difficult, not only because of poor pupillary dilatation but also because these lenses cause distortion of the retinal view and annoying reflexes from the surface of the lens [6]. The view through currently used anterior chamber and posterior chamber lenses is usually good. The most difficult lenses are those attached to the iris with the inability to effect good pupillary dilatation. If the extracapsular method of cataract surgery has been used, peripheral thickening of the capsule can cause great difficulty in observation of the peripheral fundus. This difficulty is compounded if removal of lens material has been incomplete at the time of extraction.

Lens Opacities

Peripheral cortical opacities are frequent causes of difficulty in examining the fundus. On occasion it may be possible to obtain only a hazy view, but usually the

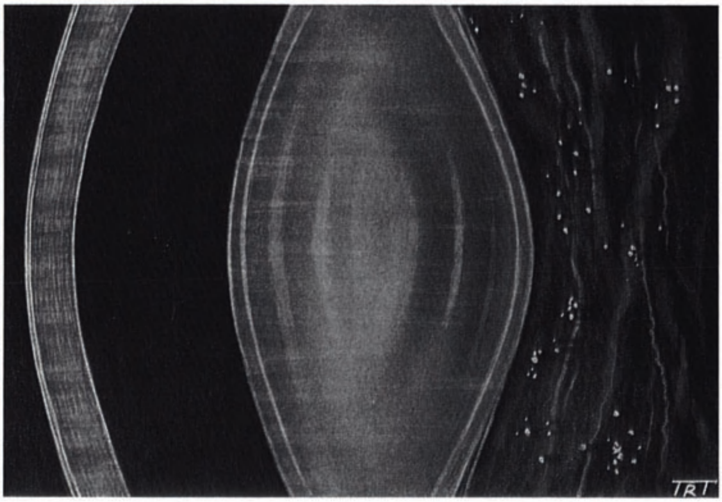


Fig. 2.2. Pigment granules in the retrolental space and anterior vitreous.

observer will find that with good pupillary dilatation and by varying his position and line of observation most fundal details will be revealed through chinks in the lens striae.

Retrolental Space

Pigment

The retrolental space will usually be found to contain pigment granules (Fig. 2.2) (tobacco dusting) when a retinal detachment is present [7, 8]. Exceptions to this may be long-standing retinal detachments, such as are found in cases of retinal dialysis, or detachments that have complicated retinoschisis. This type of pigmentation in the retrolental space is of no particular significance, although the mechanism by which the pigment achieves this position is not clearly understood. Presumably it is derived from pigment epithelium and traverses the vitreous cavity via the retinal breaks.

Red Cells

Red cells in the retrolental space and anterior vitreous are found when there has been extensive vitreous haemorrhage. In particularly severe cases, pooling of blood in a hyphaema-like arrangement is found in the lower part of the lens on its posterior surface, a configuration produced by the attachment of vitreous gel to the back of the lens.

White Cells

White cells may be found in the retrolental space or anterior vitreous. The accumulation of inflammatory cells in the vitreous may contribute both to vitreous degeneration and to collapse [9]. It may also enhance the production and formation of periretinal membranes.

Anterior Vitreous

Although examination of the middle and posterior parts of the vitreous cavity is best performed with a three-mirror contact lens, the anterior third of the vitreous gel can be examined at this stage and much useful information obtained about the state of the vitreous as a whole. Normal vitreous gel appears to have a delicate ribbon-like structure, a characteristic feature being its vigorous mobility, which is easily seen. When the vitreous degenerates, this ribbon-like structure is lost and the vitreous substance has a more fibrillary appearance and is less compact in structure. If posterior vitreous detachment has been extensive, the posterior hyaloid face may be easily seen. Detachment of the vitreous from the lens itself is unusual and is of no particular significance to the retinal surgeon.

When fibrous-like membranes start to form in relation to a retinal detachment, the vitreous is also involved in the process. When this happens, its normal gel-like structure collapses, as does its normal mobility, and the vitreous itself becomes extensively infiltrated by fibrotic strands. These strands are semi-translucent and usually extensively infiltrated with pigment (pigment epithelial macrophages and other fibrocytes); they are often arranged in large clumps in the vitreous cavity and sometimes in a string-like fashion. This infiltration causes obvious immobility of the gel.

Indirect Ophthalmoscopy of the Posterior Segment

The examiner must be familiar with the normal anatomical variations in the fundal appearances so that both harmless and potentially dangerous features can be recognised. The normally occurring anatomical landmarks also serve to orientate the surgeon, particularly to the position of retinal breaks, which will help him when he comes to place buckles at the time of surgery.

Anatomical Landmarks

The distance from the ora serrata to the limbus is approximately 6 mm, slightly more than this on the temporal side and slightly less nasally [10]. Externally this corresponds to the level of insertion of the rectus muscles. The internal attachment of the vitreous base straddles the ora serrata, extending approximately 1 mm on either side of it. These measurements are important because an injection into the vitreous cavity should be made 4–5 mm back from the limbus, so that pars plana is perforated anterior to the ora serrata. The equator of the retina is approximately 6 mm further posterior to the ora serrata (i.e. 12 mm from the limbus) and externally the equator is marked as being just in front of the scleral exit to the vortex veins. Internally the equator is recognised as being situated at the site of the horizontal part of the vortex veins, prior to their entering the ampulla of the veins (Fig. 2.8).

Intraocular Vessels

Long Ciliary Arteries

The long ciliary vessels which always accompany the long ciliary nerves are found in two bundles (Fig. 2.8). They are remarkably constant in their position and are found in the horizontal meridian of each eye. Each bundle emerges at the mid-point between the optic disc and the equator and is usually readily seen on fundoscopy because of the increased pigmentation on the sides of the bundles as they run forward. They are useful because they divide the retina into upper and lower parts and help surgical orientation. They should be avoided when the surgeon is working in the region of the horizontal rectus muscle, as they may be damaged when buckling sutures are placed or when subretinal fluid is being drained. In practice, damage to these structures seems rare.

Short Ciliary Arteries

These arteries are more irregular and variable in appearance than long ciliary arteries and are quite often not seen. They are usually situated around the vertical meridian. The short ciliary nerves, which are seen as whitish marks on the fundus, are often not accompanied by the arteries, which are much more difficult to see. These vessels are not of much significance to the surgeon.

Vortex Veins

The vortex veins vary considerably in number and are readily seen on fundoscopy in the lightly pigmented subject. On ophthalmoscopy there is great anatomical variation in the way the veins enter their ampullae. The vortex veins are found in greatest number in the nasal quadrant, the upper half being favoured more than the lower. The upper temporal quadrant, which is the commonest quadrant for the surgeon to be operating upon, has only one vortex vein. Externally this is closely related to the tendon of the superior oblique muscle. The establishment of the site of the vortex veins (usually determined at the time of surgery because retinal detachment obscures them on preoperative fundal examination) is important, for if they are situated near retinal breaks they may be damaged during buckling or cryotherapy, and they may also be damaged if sited near the position where subretinal fluid is to be drained. Damage to veins can cause choroidal haemorrhage during surgery and this is still the most feared operative complication.

Peripheral Retina

The peripheral retina includes the ora serrata and the retina between the ora and the equator. As the majority of retinal breaks and degenerations are found in this part of the retina, it is of particular importance to the retinal surgeon and demands painstaking observation and experience in interpretation.

Ora Serrata

The ora serrata (the junction between the retina and the ciliary body) is most easily seen in the aphakic patient. For this there must be no significant opacities in the media and good pupillary dilatation. In all cases skilled scleral depression is invariably required to define the details of the area clearly. The dentate processes that make up the ora serrata are most prominent on the nasal side; on the temporal aspect they have a rather flat, inconspicuous appearance, particularly in the lower temporal quadrant. The processes show considerable individual variation and are less obvious in children. Although a detailed drawing of the ora serrata is not necessary, it is important to be aware of local anatomical variations so that physical signs are not misinterpreted. It is easy to treat harmless conditions. The following important variations in the ora serrata may be found [11] (Fig. 2.3):

1. A giant tooth extending almost to the ciliary process.
2. An enclosed oral bay formed by joined processes. This may be mistaken for a peripheral retinal break.
3. Meridional folds are posterior and upward projections of full thickness retina. These may occasionally be associated with small round retinal breaks at the posterior aspect of the fold. A meridional complex is defined as an alignment of a meridional fold and a ciliary process in the same meridian.
4. Granular tissue (tags) consists of small whitish opacities of various shapes and sizes, probably derived from the retina itself. Such opacities are often found in the postoral region, particularly on the nasal side either on the surface of the retina itself or in the vitreous. They may be mistaken for small peripheral

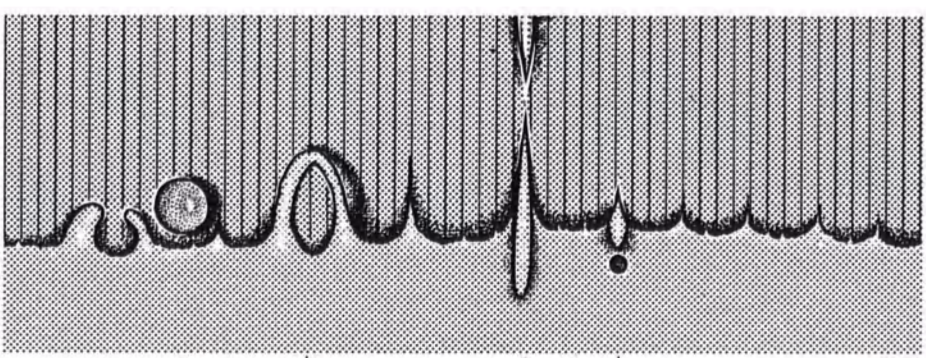


Fig. 2.3. **a** Pars plana cyst. **b** An enclosed oral bay. **c** A meridional complex. **d** A meridional fold adjacent to a small retinal break.

opercula; however, their small size, their peripheral distribution and their multiplicity are distinguishing features.

Pars Plana

The pars plana part of the ciliary body which extends 2–6 mm from the limbus is usually flat and featureless. However, small pars plana cysts may be found and are quite commonly found in the ageing eye [12]. The cysts are similar to the Blessig-Iwanoff cystoid spaces of the peripheral retina.

In the observation and charting of the findings of the posterior segment it is stressed that all the observations are to enable a correct choice of operation to be made. This involves:

1. Consideration of whether the case will respond to "conventional" retinal detachment surgery or whether vitrectomy is necessary.
2. Evaluation of the following main points in the event of conventional retinal surgery being indicated:
   a) What type of buckle is to be used?
   b) Does subretinal fluid have to be drained?
   c) Are any other procedures (e.g. vitreous injections) necessary?

In assessing a retinal detachment prior to conventional surgery the following aspects of the examination are of particular importance:

1. The character of the retinal breaks (if found)
2. The depth and site of subretinal fluid
3. Evaluation of the traction systems involved

Details of Retinal Detachment

Macular Involvement

Marked reduction in central vision gives the most important clue as to the likelihood of detachment of the macula, although on occasions reduction of central vision may be caused by an overhanging bullous retinal detachment even if the macula itself is not detached. Vitreous haemorrhage may also mask an underlying normal macula. It is essential to know whether the macula is detached or not for two main reasons:

1. To determine the urgency of the operative procedure. If the macula is not detached, surgery should be performed as soon as is reasonably possible to prevent extension of the detachment into the macular region and depression of central vision.
2. So that the patient can be warned of the uncertainty of the return of central vision if the macula has indeed been detached.

The Contour

It has already been seen that the spread of subretinal fluid from a retinal break occurs in a predictable way and this, in turn, means that the contour of the retinal detachment – the line representing the junction between the attached and detached retina – will indicate the way subretinal fluid has accumulated and thus point to the site of the primary retinal break. If, on completion of the retinal drawing, the retinal contours and distribution of subretinal fluid cannot be explained on the basis of the retinal break found, then it is almost certain that a further break has been missed. In cases in which it is not possible to find a break, an operation may be planned on the presumed site of the break, obviating the need for unnecessarily extensive buckling surgery.

Retinal Breaks

The description of a retinal break can be varied to describe its shape, e.g. round, its position in the retina, e.g. macula, or even its size, e.g. giant. The site, size and shape of all retinal breaks are carefully indicated on the retinal chart.

The observations concerning retinal breaks are essential to ensure rapid and accurate localisation of the breaks at surgery, and for the correct preoperative selection of the type and size of buckle. Holes and tears are by far the most commonly encountered retinal breaks [13]. In one series round holes were found most frequently on the temporal side, and in myopic patients the upper temporal quadrant was preferred whereas in non-myopic patients the lower temporal quadrant was the commoner site. The upper temporal quadrant was the most favoured site of tears in both the myopic and the non-myopic groups. It can be seen, therefore, that the upper temporal quadrant is of the greatest importance to the retinal surgeon and the one in which he will be performing his buckling procedures most often.

In approximately 60% of cases, more than one break is found in the detached retina [14]. Of the cases in which multiple breaks are found, the majority (64%) have the breaks in close proximity to each other and not separated by more than one quadrant of detached retina. This again is of value in deciding where the buckle should be placed, if opacities in the media are obscuring part of the view of the retinal detachment.

Retinal dialysis accounts for approximately 10% of most detachment series and giant tears and macular holes for 1%–2% each.

The charting of the position of the retinal breaks is made with reference to convenient anatomical landmarks; thus the relationship of the long ciliary bundles will indicate whether the breaks are in the upper or the lower half of the retina, and further orientation is achieved by dividing the retina into temporal and nasal halves by means of an imaginary line drawn vertically through the disc. The posterior extremity of breaks is estimated by noting their relationship to vortex veins if they can be seen. The relationship of a retinal break to local retinal landmarks in the detached retina is assessed when possible; for example, neighbouring retinal blood vessels are traced as they run peripherally until the break is reached, or the proximity of local retinal degenerations, e.g. lattice degeneration, is observed. It should be noted that the position of the posterior limit of the retinal break is always difficult to estimate when there is deep subretinal fluid.

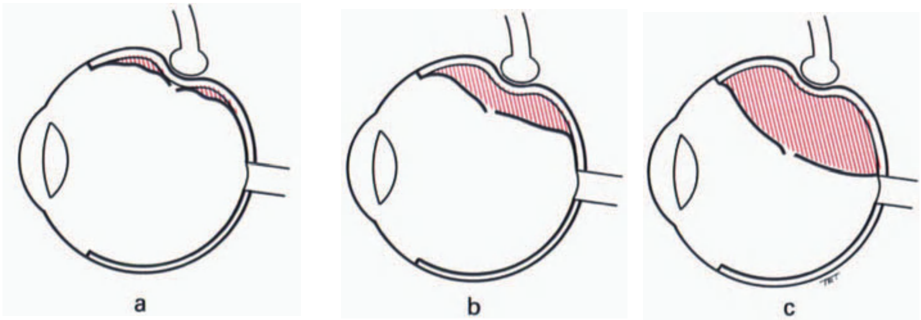


Fig. 2.4. **a** Scleral depression underneath a retinal break resulting in closure of the break. **b** There is subretinal fluid between break and depressor. **c** The fluid between break and depressor is deep.

The size of the retinal break must be estimated so that the correct choice of buckle can be made. The tip of the scleral depressor is approximately 5 mm in width; thus the size of the break can be estimated provided the retinal break can be approximated to the pigment epithelium when the eye is being depressed. Difficulty in estimating size is encountered when subretinal fluid is deep, in which case approximation of pigment epithelium to the detached retina is impossible (Fig. 2.4). The actual extent of a large break will be checked at the time of surgery, when its extremities are accurately localised. The shape of the retinal break is important not only because of the various problems in buckling that different shapes pose, but also because the shape may be distorted by the presence of periretinal membranes. The presence of such membranes may alter the decisions as to drainage of subretinal fluid and the necessity of vitreous injections.

Pigmentation

Not infrequently, pigmentation may be found in relationship to a retinal break, particularly at its posterior margin. Pigmentation usually indicates that the break has been there for a long time. Pigmentation around a break does not mean that the break has been rendered secure and free from the risk of subsequent detachment.

Although holes and tears show considerable morphological difference, they do not, in general, influence the choice of method of operation to be performed, although they do pose questions as to how best they are to be sealed. Round holes are smaller and often multiple and, unless accompanied by areas of local retinal degeneration (lattice degeneration), are associated with general rather than focal vitreous traction in their vicinity. Consequently detachments characterised by round holes are less likely to have a preoperative vitreous haemorrhage or premonitory symptoms than those in which retinal tears are found. When a retinal hole is formed there may or may not be an operculum. If there is one, it is usually found detached from the retina, lying on the posterior hyaloid face at a variable distance from the break itself, sometimes so close as to make detection of the underlying break difficult and sometimes separated by quite a wide space. On many occasions no operculum is present, the hole itself having been produced as a result of atrophic changes in the retina. When a retinal tear is present, vitreoretinal traction is active on the anterior aspect of the break.

Subretinal Fluid

Depth

The depth of subretinal fluid between the retinal break and the underlying pigment epithelium is of particular importance. Its depth in other sites is less important unless, for example, the detached retina overhangs and obscures the disc or makes observation of retinal breaks more difficult. The depth of the fluid can be estimated when scleral depression is performed during the preoperative examination: the hole may be closed easily by gentle indentation, or it may be closed only by firm indentation, or it may be impossible to close it at all (Fig. 2.4). On the basis of this information a decision will be made as to whether or not subretinal fluid needs to be drained at the time of surgery. In most cases when deep subretinal fluid is present, drainage will be required as otherwise it would not be possible to localise accurately the break at the time of surgery. Large breaks on high balloons make localisation very difficult whereas with small breaks and little subretinal fluid, localisation is simple. At the time of surgery highly elevated breaks cause difficulty in visualising the cryotherapy reaction, with consequent risk of over-freezing. A period of bed-rest may be advised prior to surgery to encourage approximation of the break to the pigment epithelium by redistribution of subretinal fluid, and this may greatly facilitate localisation and cryotherapy at the time of surgery.

Shift of Fluid

Rapidly shifting subretinal fluid in the inferior retina is a characteristic of non-rhegmatogenous retinal detachment. Shifting fluid, however, is sometimes seen in rhegmatogenous detachment, particularly in aphakia and when retinal breaks are small [15]. In these cases tilting of the patient's head towards the side of the suspected break may persuade inferior fluid to track upwards and push the break into view (Fig. 2.5).

Mobility of the Detached Retina

In fresh retinal detachment a characteristic undulating movement of the detached retina is seen. The mobility of detached retina is best assessed when it is examined by indirect ophthalmoscopy both preoperatively and at the time of operation. Two main factors affect the mobility of the detached retina:

1. *Depth of subretinal fluid*. If subretinal fluid is shallow there is little scope for actual movement of the detached retina, which may appear to be relatively immobile.

2. *Presence of periretinal membranes*. These membranes (see later) can convert the detached retina to a more rigid structure which creates problems in deciding (a) whether or not a non-drainage operation can be performed [16], (b) if

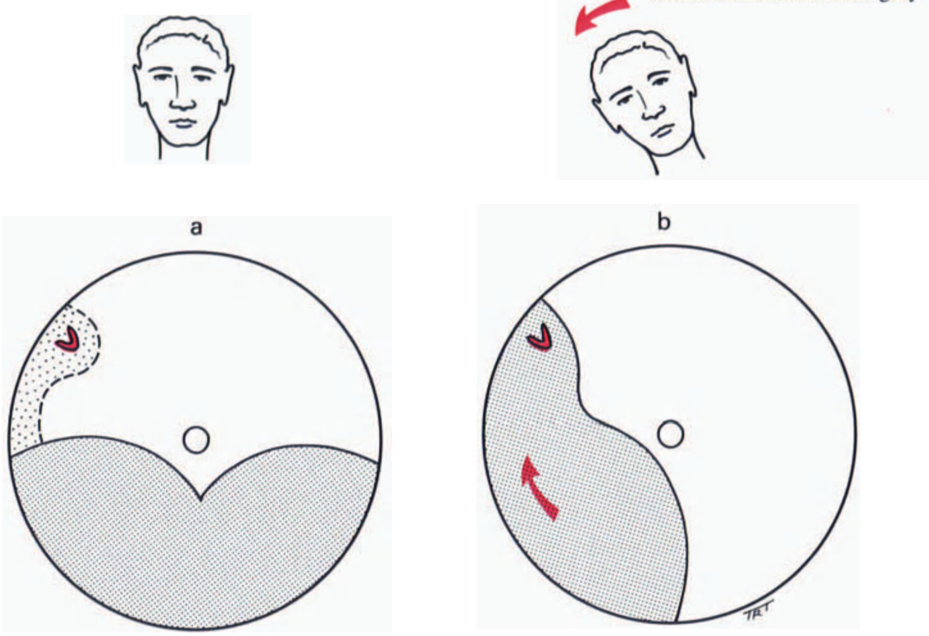


Fig. 2.5. **a** A retinal break in the upper temporal quadrant has produced subretinal fluid which is mainly inferior in distribution. **b** Tilting of the patient's head towards the side of the break has resulted in marked shift of inferior subretinal fluid towards the break.

drainage is performed, whether an intravitreal injection of gas will be necessary, and (c) whether or not pars plana vitrectomy is necessary in severe cases. In cases of relatively early membrane formation, it is the retina in the immediate vicinity of the retinal break that is of particular importance because it is at this point that the buckle will be raised.

Haemorrhage

Retina

Small round haemorrhages are often found in the vicinity of retinal breaks in fresh cases of retinal detachment. They are probably produced as a result of posterior vitreous detachment. They are more often associated with retinal tears than with retinal holes and may be found on the operculum itself or on the posterior aspect of the break. Their presence may serve as a signpost and often aids in the detection of a particularly small break. Similar haemorrhages are also found in long-standing retinal detachments, in which case they are often widely though thinly scattered throughout the periphery of the detached retina.

Vitreous

Some degree of vitreous haemorrhage is a common finding in cases of retinal

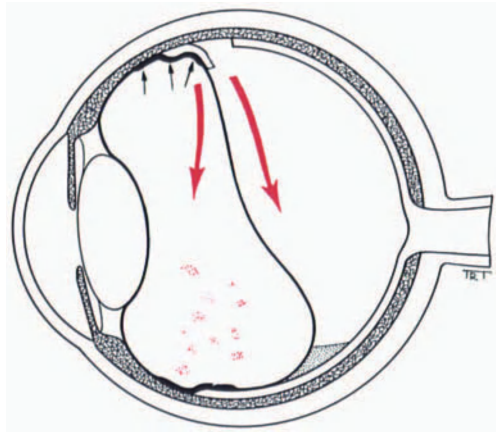


Fig. 2.6. Haemorrhage from a retinal break passes either into the vitreous cavity or into the retro-gel space (*large arrows*). The firm attachment of the vitreous base to ora serrata, peripheral retina and the anterior aspect of a tear is shown (*small arrows*).

detachment and is associated with a rupture of a retinal blood vessel during the development of a retinal break (Fig. 2.6) or as the result of trauma. In most cases the haemorrhage is not severe enough to interfere seriously with the observation of the retina, nor, if small, does it usually influence the operative technique or choice of operation. Occasionally, however, a haemorrhage will be severe enough to prevent any examination of the fundus at all. Haemorrhage occurs most frequently from an upper half retinal tear and either descends by gravity down the back of the detached posterior hyaloid face or passes into the vitreous gel itself. The behaviour and spread of vitreous haemorrhage following clotting and lysis depends mainly on the extent of the haemorrhage and the state of the underlying vitreous and its attachments. Retrovitreal haemorrhage may be found in the inferior retina, piled up on the back of the posterior hyaloid face, at whatever level the detachment of this face has reached. In degenerate myopic vitreous, haemorrhage usually settles rapidly. Conversely, in traumatic detachments where the eye has more normal gel, large intravitreal and preretinal collections of blood may be found and may take weeks or months to settle. In aphakia, blood may pass forward into the anterior chamber, to cause a hyphaema with subsequent more rapid clearing. Blood in the vitreous cavity is metabolised slowly, and evidence of old haemorrhage is provided by the presence of a whitish coagulum that is found in the inferior vitreous in modest cases or even scattered throughout the vitreous cavity in severe cases, obscuring the view of the underlying retina. The presence of vitreous haemorrhage is of importance for several reasons:

1. An inadequate view of the fundus may be produced. In these cases a period of bed-rest in the upright position with padding of the eyes is advised to encourage the vitreous to clear and enable detection of the underlying break where possible.

2. Recent and extensive vitreous haemorrhage make it unwise for anything but the most gentle scleral depression in the vicinity of the break, for fear of precipitating further haemorrhage. This applies both to the preoperative examination and to the manipulation of the cryoprobe at the time of operation.

3. Extensive vitreous haemorrhage may result in secondary uveitis or glaucoma.

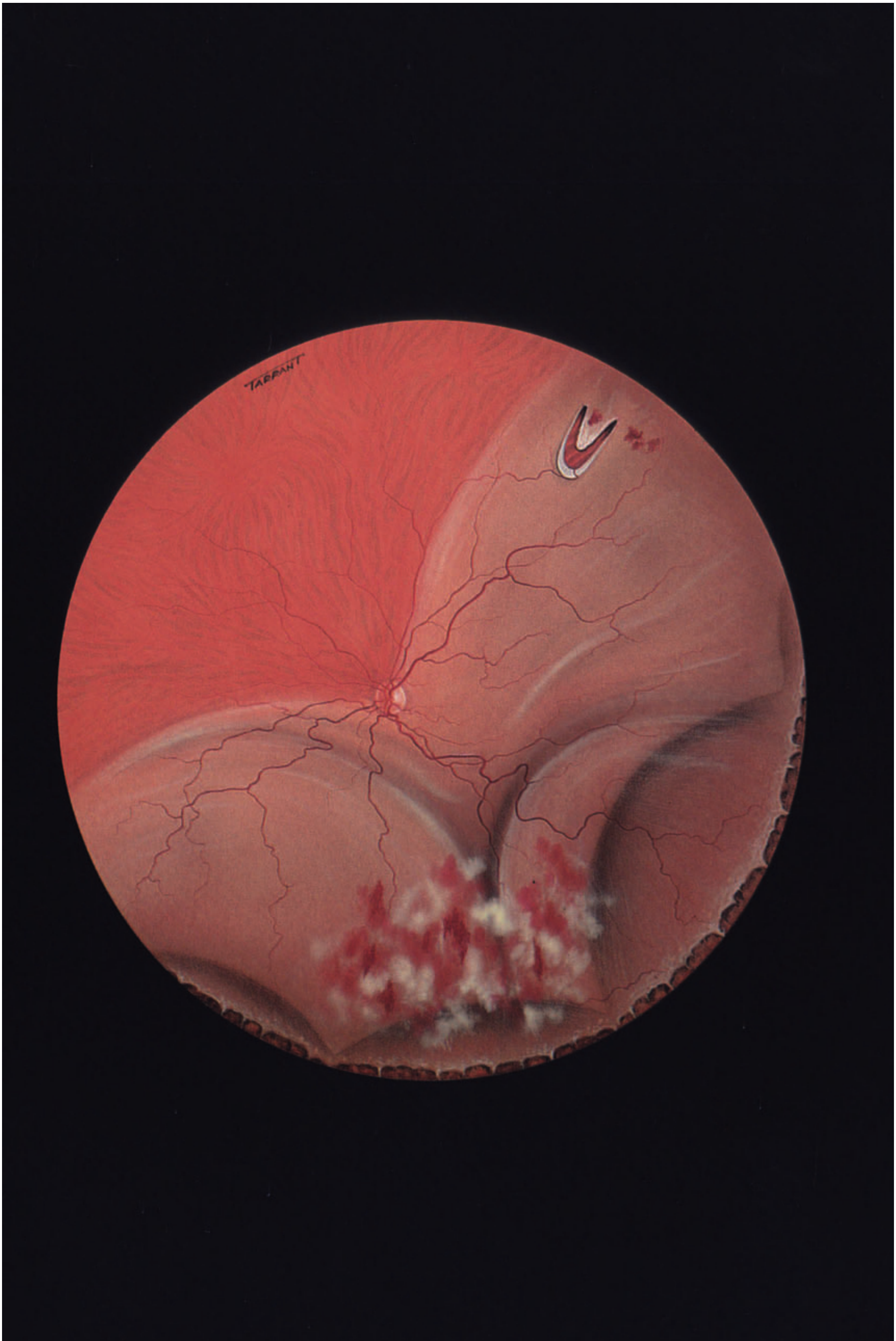
4. The effect of vitreous haemorrhage on retinal detachment. Iron released into the eye as a result of vitreous haemorrhage does not apparently have any toxic effect on the underlying retina [17], but the presence of blood in the vitreous cavity encourages the growth of fibrocellular membranes in the presence of retinal detachment. Normal constituents of blood (e.g. fibronectin) have a chemo-attractive effect on cells producing membranes [18], an effect which is enhanced by the inflammatory response excited by the presence of blood in the eye. Clinical experience shows that vitreous haemorrhage predisposes an eye with retinal detachment to membrane formation [19, 20]. The presence of a substantial element of vitreous haemorrhage in a case of retinal detachment should warn against the likelihood of a more pronounced tendency to proliferative vitreo-retinopathy.

Choroidal Detachment

Serous choroidal detachments are occasionally found preoperatively in eyes with retinal detachments (4.5% in one series) [21]. They are recognised by their characteristic dark rounded outlines seen through the retinal detachment and occur more often in eyes that have had a failed operation [22] (Fig. 2.7). They may be localised or annular in extent and are identical in appearance to the choroidal detachments seen following cataract or glaucoma surgery. The detachments themselves often extend into the vicinity of the ciliary body but their posterior extension is limited by the scleral exit of the vortex veins. The development of preoperative choroidal detachment is probably related to hypotony resulting from the sudden onset of retinal detachment. Their importance when found in the vicinity of the retinal break is that it will be impossible to apply cryotherapy through the sclera at the affected site, as choroidal and pigment epithelium are separated and no reaction will appear. In primary retinal detachments, choroidal detachments do not usually disappear before surgery. In reoperations where serous choroidal detachments are present as a result of a previous procedure, a period of time (1–2 weeks) should be allowed to elapse before reoperation if possible, so as to try to give the choroidal detachments a chance to reabsorb prior to further surgery. If choroidal detachment is situated somewhere other than in close proximity to the break, there is no particular advantage in delaying surgery, because choice and method of operation will not be influenced by the presence of the choroidal detachment, which will spontaneously disappear in the postoperative period as the retina becomes reattached. Choroidal detachment is an unwelcome sight as it tends to promote proliferative vitreo-retinopathy and this may be related in part to inflammation secondary to the detachment.

Haemorrhagic detachment of the choroid may be seen in failed cases after previous surgery. Reoperation should be delayed as long as possible to encourage absorption of blood.

Fig. 2.7. A subtotal retinal detachment. There is choroidal detachment in the lower half of the retina which has pushed the ora serrata into view. The fresh and altered blood of vitreous haemorrhage from a superior break is seen in the inferior vitreous.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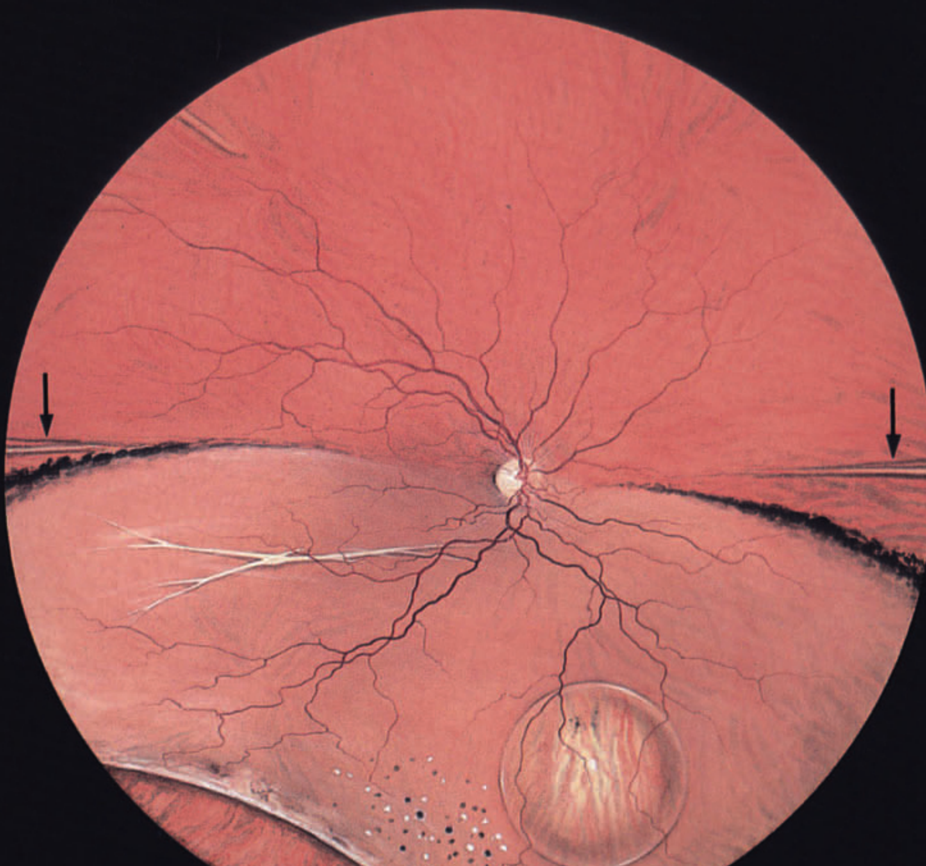
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Signs of Long-standing Detachment

It is useful to judge approximately how long the retinal detachment has existed. This is of value in medicolegal cases, when injury that may in fact have preceded the traumatic incident may be incorrectly considered to have caused retinal detachment. Also, if the macula has become detached and central vision reduced, a cautious prognosis regarding the likelihood of recovery of central vision should be given, since one of the most important factors governing recovery of central vision is the length of time that the macula has been detached. In some cases it may not be worthwhile operating at all.

In long-standing retinal detachment, the retina becomes increasingly transparent due to the loss of the outer segments of the photoreceptors and develops a cystic appearance. The cystic spaces which develop in the outer plexiform layer of the retina may become enormously enlarged and give the appearance of secondary intraretinal cysts (Fig. 2.8) [23]. From the time of onset of detachment, these cysts usually take at least a year to develop and, although of striking ophthalmological appearance, do not pose any particular problems to the surgeon, disappearing spontaneously in the postoperative period when the retinal break has been closed. Retinal vessels may develop telangiectatic-like formations or tuft-like projections.

Another characteristic feature of long-standing retinal detachment is the appearance of black-pigmented demarcation lines (high-water marks) which form in flat retina in front of the advancing wall of subretinal fluid. Sequential levels of water marks may be found if there has been a slow advance of the detachment edge; these findings show that demarcation lines themselves do not offer complete protection against further separation of retina but may contribute to somewhat slower progression. Conversely, detachment may have apparently retreated from a previous high-water mark. The degree of pigmentation of the lines varies and there is often an associated whitish appearance.

In long-standing cases, an interlacing network of retroretinal white lines can be seen. These formations [24] are relatively benign and in their simpler forms only cause some immobility and splinting of the retina. Rarely in advanced cases, they may contribute to the picture of advanced periretinal membrane formation, particularly when adopting a purse-string like formation in detached retina around the optic disc.

Previous Surgery

Cases subsequent to previous surgery are usually more difficult to examine and interpret. The presence of an encircling element will limit the posterior extension of the scleral depressor and greater reliance will be placed on the three-mirror examination for the detection of the retinal breaks. Scleral depression itself will

Fig. 2.8. A long-standing retinal detachment due to an inferotemporal dialysis has resulted in high-water mark formation. A large intraretinal cyst is seen. Retroretinal strands are seen on the back of the detached retina and the long ciliary bundles (*arrows*) are seen in the horizontal meridian. Characteristic dot-like opacities are seen in the vicinity of the dialysis in the inferior vitreous.

often be less well tolerated, particularly if the eye is still tender and photophobic from recent surgery.

The vitreous may be hazy, and previous surgery will have resulted in choroido-retinal scarring, making retinal breaks more difficult to detect against the white background. The retina itself may be detached up to the edges of the cryopexy lesion, while the treated area itself remains flat (occasionally the scar itself is the only flat part of a totally detached retina). The presence of treated areas with adhesion of overlying neuro-epithelium may cause obstruction to the natural spread of subretinal fluid, with resulting distortion of the retinal contours. This makes estimation of the site of an undetected retinal break less reliable in these cases.

Previous Buckles

Indentation from previous buckles will usually be obvious. If it is excessive or the underlying sclera unusually weak, there may have been erosion of the explant, particularly if the previous surgery took place several years before. The explant, or one of its attendant sutures, may have come to lie under the retina but occasionally may have gained the vitreous cavity itself. If there is erosion, great care is necessary in approaching such an explant at the time of operation, as its manipulation may result in perforation of the globe or in severe intraocular haemorrhage.

Evidence of Previous Complications

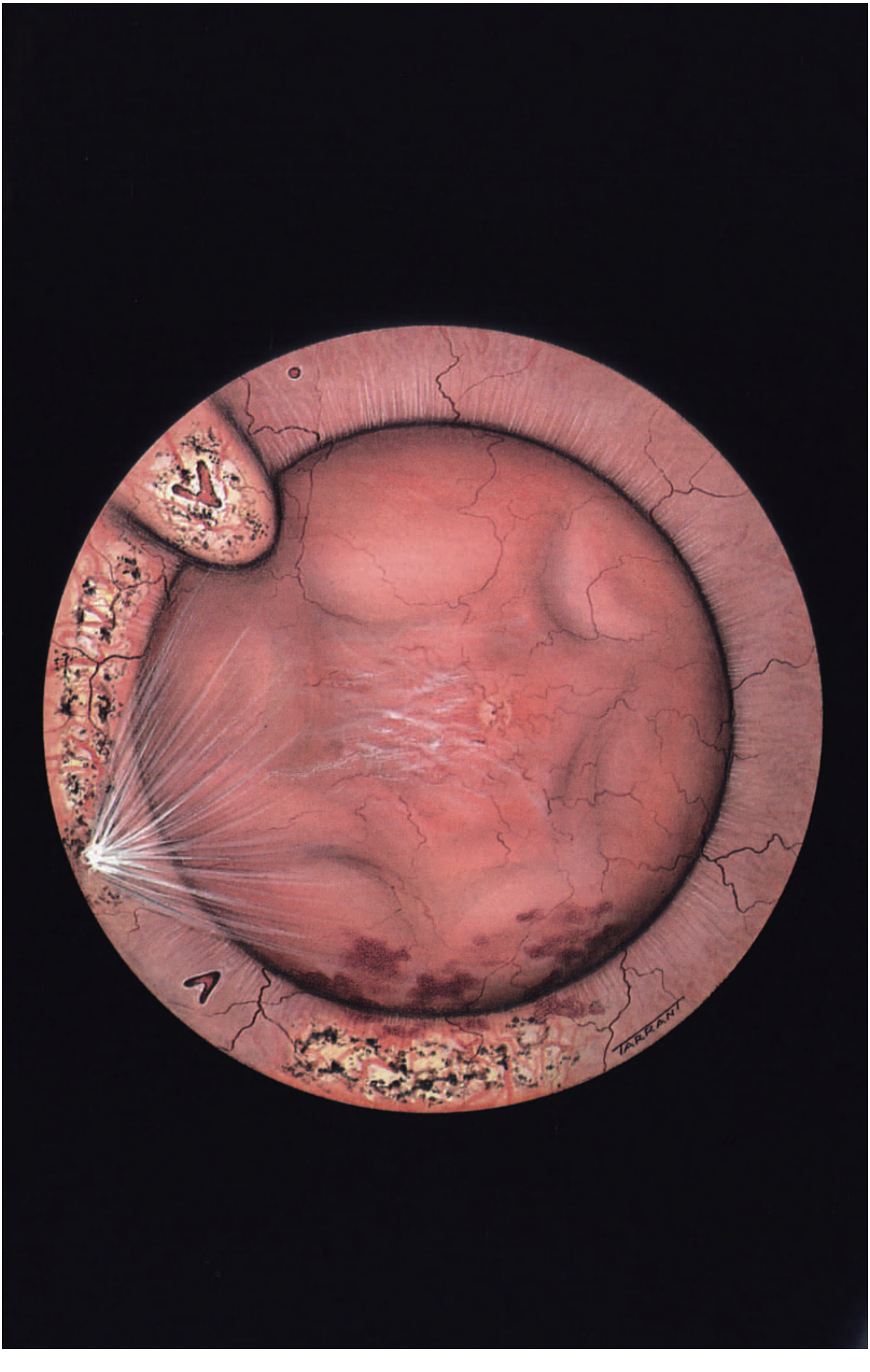
Haemorrhages, either vitreous, subretinal or choroidal, will usually be obvious. If choroidal, they have a somewhat blackish appearance, as they are seen through detached retina. In the subretinal space the haemorrhage is usually less dark. Incarceration of the retina and vitreous into a previous site for subretinal drainage results in a characteristic stellate puckering effect at the site of the incarceration with traction lines into the vitreous cavity (Fig. 2.9).

After examination of detached retina itself, the examiner's attention will pass to the subject of degenerate areas in flat retina.

Peripheral Retinal Degenerations

The presence of peripheral retinal degeneration is important when flat retina is being examined, either in the eye that contains the detachment (if flat retina is present) or in the other eye. The object of noting these degenerative changes is to detect those that will predispose to subsequent retinal detachment. Following these observations it is then to be decided whether such lesions require prophylactic treatment.

Fig. 2.9. A failed case. An encirclement has failed to buckle anterior breaks in the supero- and inferotemporal retina. A radial buckle has closed a break in the upper temporal quadrant. Incarceration of vitreous into a subretinal fluid drainage site is seen in the lower temporal quadrant. The retina is still almost completely detached.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These lesions may belong to one of two main groups. The degeneration may be either benign and will not lead to detachment or one that will predispose the retina to break formation and the risk of detachment.

Benign Peripheral Lesions (Fig. 2.10)

All benign peripheral lesions are found in the equatorial and pre-equatorial regions of the retina, extending forward in some cases to the ora serrata. In these conditions there is no associated overlying vitreous abnormality, which probably contributes to the benign way in which these lesions behave.

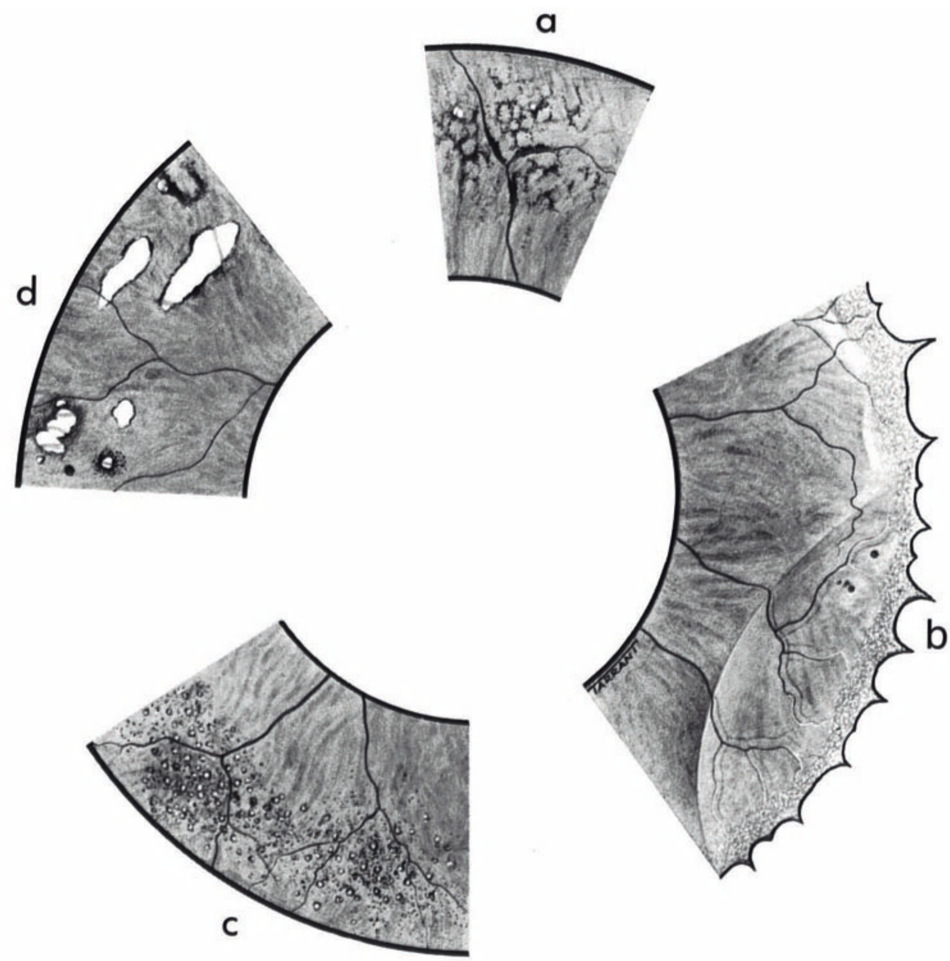


Fig. 2.10. **a** Non-specific pigmentary degeneration. **b** Cystoid degeneration and retinoschisis. **c** Cobble-stone degeneration. **d** Paving-stone degeneration.

Choroido-retinal Degeneration (Fig. 2.10a)

Choroido-retinal degeneration is found in the retina immediately adjacent to the ora serrata and varies in severity according to its appearance. In its mild form, the only detectable change is a whitish-grey appearance on the surface of the retina, with some degree of mottling and accentuation of pigmentation. If slightly more marked, the peripheral retina assumes a more opalescent appearance with an increase in the pigmentary disturbance. When the degenerative changes are even more pronounced, peripheral terminal arterioles are sometimes seen to be whitened and there is quite marked hyperpigmentation of peripheral retina. If there is choroido-retinal degeneration in the equatorial region, it takes the form either of a series of round elevated lesions with hyperpigmented borders (cobblestone degeneration) (Fig. 2.10c) or of a honeycombed area of pigmentation with the pigment tending to collect along the retinal blood vessels in a fine lace-like manner (Fig. 2.10a). The various types of choroido-retinal degeneration are harmless, widespread and non-progressive conditions found in large numbers of eyes.

Choroido-retinal Atrophy (Paving-stone Degeneration)

Choroido-retinal atrophy is found in the equatorial and pre-equatorial regions (Fig. 2.10d). It is characterised by the appearance of punched-out areas of retina with hyper-pigmented borders [25]. The lesioins are usually linear in configuration, and the centre of the affected area varies in colour according to the degree of atrophy present. In extreme cases the whole choroid appears to be deficient, leaving only bare sclera visible at the bottom of the lesion, but in most cases larger choroidal blood vessels can be seen traversing the white area. The overlying retina, however, with the exception of the pigment epithelium, which is absent, is found to be normal. It is not unusual to find extensive confluent lesions which may, on occasion, extend through 360° of the peripheral retina, and which are usually bilateral; the lower half of the retina is somewhat favoured. There is usually normal retina between the lesions and the ora serrata but the lesions, although in themselves harmless and not leading to retinal break formation, may, if extensive, make detection of small breaks more difficult if retinal detachment is present. Detached retina, if present, will always be adherent to the edge of the paving-stone areas.

Snowflake Degeneration

Snowflake degeneration consists of scattered yellowish dots, often multiple and close together in the postoral and equatorial region of the retina.

Cystoid Degeneration

Cystoid degeneration begins in the outer molecular layer of the retina and results in the formation of cystic spaces in the neuro-epithelium (Fig. 2.10b). When these cavities coalesce and enlarge so that actual elevation of the retina can be observed, the term "retinoschisis" is used. In its mildest form, cystoid degeneration is found immediately posterior to the ora serrata, the lower temporal being the most favoured quadrant. Pink-red vesicles on a whitish-grey background give the retina an opalescent appearance, and on scleral depression the affected tissue assumes the appearance of fine frog-spawn. Occasionally the cystic cavities may rupture to produce small excavations mimicking retinal holes. Cystoid degeneration is commonly found in eyes that show other forms of degenerative change. If extensive, cystoid degeneration may extend towards but not posterior to the equator.

Pigment Clumping

A localised area of pigment clumping in the peripheral fundus is frequently seen, the clumps usually being distributed between the ora serrata and equator. The clumps are of no particular significance and are more often found in myopia.

White With and Without Pressure

White with and white without pressure (Fig. 2.11a) are seen in flat retina with or without scleral depression respectively and it is likely that white without pressure is simply an exaggeration of white with pressure. The condition is to be distinguished from the normal blanching of the choroid that comes about with scleral depression and which, accordingly, moves as the scleral depressor alters its position. In both white with and white without pressure, geographical areas which as a rule have a linear configuration are found in the periphery of the fundus. Occasionally, however, these areas remarkably extend posteriorly as far as the equator and even beyond. The more linear edge of the area is on the ora serrata side of the lesion and the geographical shapes of the more central area vary considerably.

When present, the changes are extensive and the upper temporal quadrant is favoured. The exact significance of the findings has not been clearly established. Certainly, the appearance is rarely seen in normal eyes but it is often found in association with changes such as cystoid degeneration and lattice degeneration [26]. In both white with and white without pressure, vitreo-retinal adhesions have been described [27, 28]. Occasionally, the configuration of these lesions has been seen to change [29]. These areas, however, have not themselves been shown to progress to vitreo-retinal degeneration of a more serious nature or to break formation and may therefore be regarded as ophthalmoscopic curiosities rather than areas of much significance.

Retinal Erosions

Retinal erosions are oval-shaped excavated areas situated within the vitreous base (Fig. 2.11d). The margins of such areas may appear to be slightly elevated and the base of the erosion cratered in appearance. Small whitish tags of vitreous, often exactly similar to those overlying areas of classical lattice degeneration, are seen in most cases. There is no evidence that these areas are associated with retinal break formation and retinal detachment, but they are often seen in eyes that contain lattice degeneration.

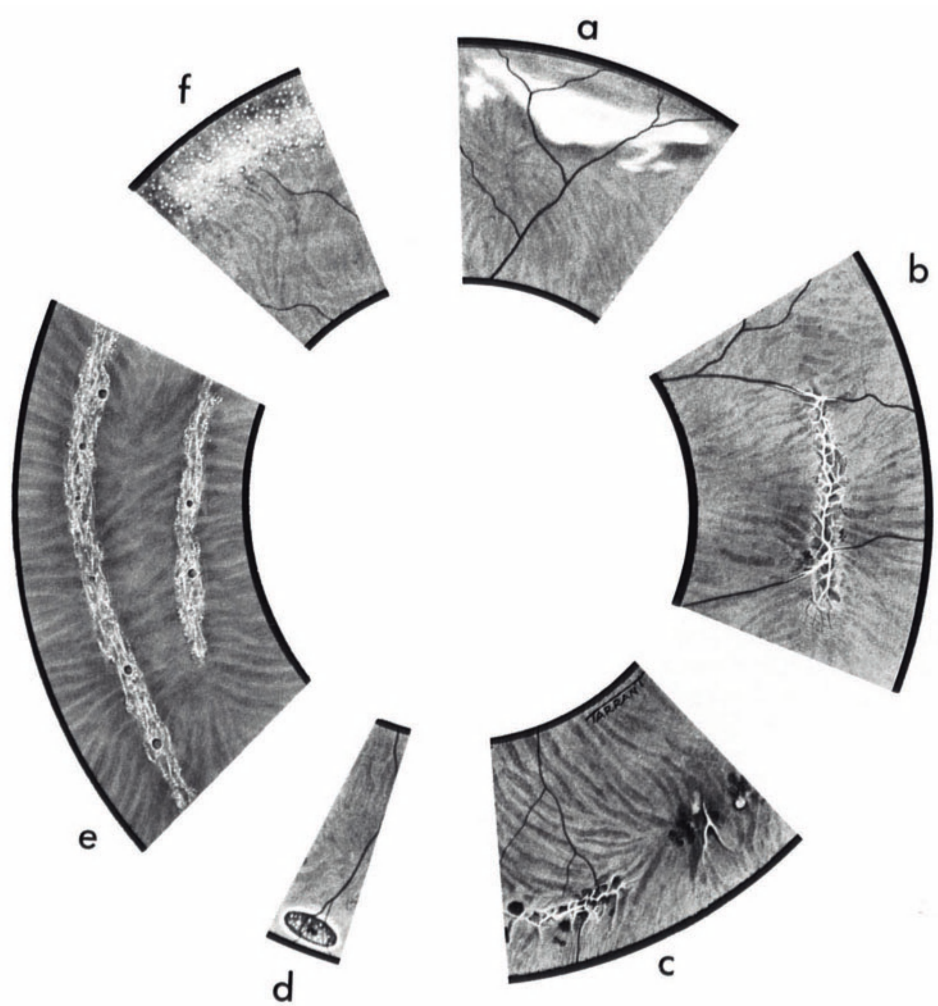


Fig. 2.11a–f. Peripheral retinal lesions. **a** White without pressure. **b** Non-pigmented lattice degeneration. **c** Pigmented lattice degeneration. **d** Retinal erosion. **e** Snail-track degeneration. **f** Snowflake degeneration.

Lesions That May Predispose to Retinal Detachment

Lattice Degeneration

Lattice degeneration has been described clinically and histopathologically since the earliest days of successful retinal detachment surgery [30–36]. In its typical form, lattice degeneration consists of a sharply demarcated, circumferentially orientated lesion usually located at the equator or in a pre-equatorial region (Fig. 2.11b,c).

The fine white lines of a lattice degenerative lesion are continuous with the retinal blood vessels and, indeed, the blood vessels may on occasion be found emerging apparently quite normal in appearance on the anterior side of the lesion. Pathologically the fine white lines consist of hyalinisation of the retinal blood vessels; there is thinning of the underlying neuro-epithelium although the choriocapillaris is itself relatively unaffected.

Vitreous abnormalities overlying the lesion are frequent. Vitreous adheres firmly in a strand-like manner to the area of degeneration interspersed with areas of liquefaction.

A high incidence (6%) of lattice degeneration in autopsy eyes has been reported in otherwise normal fundi [37], indicating that most cases of lattice degeneration do not progress to retinal detachment; this risk is, however, increased if there is also myopia [38], in which there is a higher incidence of lattice degeneration. It has been noted that the progression of lattice-like lesions is extremely slow [39]. The areas may be multiple and at different levels and the upper temporal quadrant is the most favoured. Bilateral lesions are found in about 50% of cases. Typically, the lesions may be found in the second decade. They evolve slowly, although the usual time of presentation is not until the fourth or fifth decade during an ophthalmic examination. Rapid progression and appearance of new lesions is rare but is occasionally seen [40]. Associated clinical appearances may be a retina with a thinned and shaggy appearance, yellow dots may be found in the vicinity of the lattice lesions and a pigment epithelium that varies in response from complete absence of pigment to extensive clumping. Retinal breaks with risk of detachment are the most significant additional clinical features of lattice degeneration. They may be:

1. Round, in which case they tend to favour the ends of the lattice lesion if it is a long lesion, and are found in among the fine white lines.
2. Tears which are produced by posterior vitreous detachment and adhesion of gel to the posterior aspect of the lattice lesion. When the break is formed the lattice lesions are detected in the operculum itself.
3. Giant breaks which, exceptionally, arise from the posterior edge of a long section of lattice degenerative change.

Snail-Track Degeneration

Snail-track degeneration is so named because the lesions consist of bands of sharply demarcated areas that resemble the trail made by a snail and have a glistening frost-like appearance (Fig. 2.11e). The degenerative areas are found in the equatorial region of the retina, and the upper temporal quadrant is preferred. There are overlying vitreous abnormalities consisting of liquefaction but marked vitreous traction is seldom if ever in evidence. These lesions have a pronounced predisposition to form retinal breaks which are characteristic, rather large, round holes; horseshoe-shaped tears are never seen, suggesting that posterior vitreous detachment, when it occurs, will not be impeded by firm adhesion and tear formation. Myopia is often associated with these lesions and there is a strong tendency to retinal detachment [41]. This condition bears some similarity to lattice degeneration and, indeed, it may be that it is just a variation of it; nevertheless, there are some striking differences. White lines are not seen in association with snail-track degeneration and the two types of degeneration are not found together.

Although snail-track degeneration is considerably rarer than the lattice type, and most of the reported series are small, eyes in which there is snail-track degeneration appear to have a considerably greater risk of retinal detachment than those with lattice degeneration.

Cystic Retinal Tufts

These are relatively insignificant small elevations in the postoral region of the retina. In the event of posterior vitreous detachment, traction tears may arise at the posterior aspects of such tufts [42].

Retinoschisis

Retinoschisis may be classified as senile, juvenile or secondary.

Senile

Senile retinoschisis originates from peripheral cystoid degeneration of the retina (Fig. 2.10b). The cystoid cavities become confluent in the outer plexiform layer; the retinoschisis thus formed progresses by extending in a posterior direction through the layers of the neuro-epithelium. The condition is usually bilateral, occurs more often in hypermetropic eyes, and the lower temporal quadrant of the eye is the most favoured [43]. In its most obvious form, retinoschisis reveals itself as a smooth dome-like elevation with an absence of retinal folding, but this cystic type appearance can be much less obvious. It is customary to describe the innermost layer of the schisis (i.e. that nearest the vitreous) as the inner leaf and the other layer as the outer leaf. In some cases one or two cyst-like elevations are seen and these are usually continuous with a less elevated zone extending around the periphery of the fundus and confluent with obvious peripheral cystoid degeneration. Other clinical features of retinoschisis [44] are as follows:

1. Yellow-white dots are scattered on the inner surface of the schisis cavity, apparently lying at the level of the internal limiting membrane. These dots are

not in themselves specific and may be found in other conditions, e.g. lattice degeneration, or even when the rest of the retina is apparently normal.
2. The inner leaf of the schisis has a beaten metal appearance which is best seen on slit-lamp examination and retro-illumination.
3. There may be sheathing or obliteration of peripheral retinal vessels. The white lines found correspond to the retinal blood vessels and they are mainly on the venous side of the circulation.
4. Retinal breaks are infrequent but may be found in the outer of inner leaf of the schisis and occasionally both. Breaks in the inner leaf are always round, whereas those in the outer leaf, which are difficult to detect, particularly at their posterior borders, often have a scalloped appearance, the edges of which are rolled. These breaks are usually irregular in shape.
5. Pigment demarcation lines are not seen in the simple form of schisis unless retinal detachment intervenes.
6. Scleral depression over the outer leaf of the schisis will make the depressed area appear white, as it does in normal retina: a whiteness that is not seen in cases of retinal detachment.
7. If retinoschisis extends posterior to the equator, an absolute field defect corresponding to the area of the schisis is found.
8. Vitreous or retinal haemorrhage is rare.

Senile retinoschisis is either static or progresses very slowly [45] and cases in which the schisis has extended into the posterior pole are extremely rare.

The great majority of patients with retinoschisis have no symptoms and suffer no visual loss. The condition requires no treatment other than periodic observation. Retinoschisis may occasionally be complicated by retinal detachment. This problem will be considered later, under the differential diagnosis of retinal detachment.

Juvenile

In the juvenile variation of retinoschisis the retina splits at the nerve fibre layer. The condition is rarely seen [46]. It is inherited as a sex-linked recessive disease affecting males, or, less commonly, as an autosomal recessive disorder. It is found in infants and children and together with Favre's disease (retinoschisis and tapeto-retinal dystrophy inherited as an autosomal recessive disorder) and Wagner's diseases (pigmentary retinopathy, cataract and vitreous degeneration inherited as an autosomal dominant disorder) constitutes one of the vitreo-retinal dystrophies. In juvenile retinoschisis degenerative changes are found in both vitreous and retina, and the condition may be complicated by retinal detachment.

The age of onset of this condition is usually less than 20 years and the retina has something of the appearance of a Swiss cheese. Early in the disease, changes of retinoschisis are present at the macula as well, but they disappear in later life. Treatment of the congenital form of retinoschisis is conservative; photocoagulation may in fact precipitate retinal detachment [47]. If retinal detachment supervenes in cases of congenital schisis the prognosis for surgery is poor.

Secondary

It is difficult and unimportant to distinguish secondary retinoschisis from traction retinal detachment, and the former is found in conditions where there is, in any case, marked traction on the retina from vitreous strands, e.g. where retinitis proliferans exists. The features of this kind of schisis are as follows:

1. Spread is slow with little evidence of progression.
2. Water marks do not occur (unlike with traction retinal detachments).
3. Breaks may form along retinal blood vessels in the inner leaf but they do not result in rhegmatogenous detachment. This again is a distinguishing feature between secondary schisis and traction retinal detachment.
4. The contour at the edge of the schisis, where it meets normal retina, is convex towards the centre of the schisis, as in traction retinal detachment.

No treatment is required for secondary retinoschisis.

Other Fundal Details

Disc

To see the disc is important because, if it is hidden, e.g. due to opacities in the media or overhanging retinal detachment itself, the non-drainage operation may be impossible since it is essential to observe the patency of the arterial supply to the retina during surgery. The presence of glaucomatous cupping is also noted.

Pars Plana

Details of the pars plana can be detected with scleral indentation and clear media if good mydriasis has been achieved. This is very simple in cases of aphakic detachment when the periphery of the crystalline lens does not interfere with the view. Harmless local anomalies such as small pars plana cysts are often found and occasionally these cysts may be very large [48]. A thin white line running concentric and anterior to the ora serrata can usually be seen and indicates the anterior part of the vitreous base. Retinal detachment itself can extend into the pars plana, particularly in some cases of aphakic detachment [49]. Occasionally, also, small slit-like breaks may be detected in the pars plana in traumatic retinal detachment, but pars plana breaks are exceptionally uncommon [50] and rarely a cause of failure in retinal detachment surgery.

Following the preliminary charting of the fundi of both eyes, the three-mirror examination (using 1% methyl cellulose) in the contact lens is performed. This examination should not be carried out on the day of operation as prolonged examination may result in some loss of transparency of the cornea.

Three-Mirror Examination

Angle of Anterior Chamber

The width of the angle should be assessed. If the angle is shallow then there is a risk of angle closure in the postoperative period. Angle recession following trauma may indicate that the aqueous outflow from such an eye is impaired, and detachments following trauma have a greater tendency to postoperative glaucoma. If non-drainage surgery is to be performed, impairment of outflow will result in reluctance of the eye to soften following the tightening of the buckle sutures and raising of the itraocular pressure. Multiple peripheral anterior synechiae in an aphakic eye will likewise indicate risk of embarrassed outflow. Adhesion of vitreous to the cataract section in an aphakic eye indicates a vitreous complication during surgery.

Vitreous

Having assessed the angle, the next step is to examine the vitreous cavity. When a clinical examination of the vitreous is conducted it must be borne in mind that the observations that are important are those that will affect the choice of operation. For this reason examination of the vitreous may not greatly help in the choice of operation in "simple cases", and drawings of the state of the liquefaction of the vitreous and a detailed assessment of its attachment will not be a profitable preoperative manoeuvre. In complicated cases, however, and this almost invariably means the presence of periretinal membranes, examination of the vitreous and its relationship to the retina in order to appreciate the tractional forces at play is an essential prerequisite for correct interpretation of the case [51, 52].

Degeneration

In the majority of cases, by the time a patient develops a retinal detachment, degenerate changes in the vitreous body are found to a lesser or greater degree. In its simplest form there may be liquefaction and the formation of cavities (lacunae) within the vitreous body. This is followed by posterior vitreous detachment. Occasionally these spaces become large and it is then difficult to tell whether in fact the posterior hyaloid is detached from the retina itself or whether a thin layer of cortical gel remains to lie in contact with the surface of the retina. Often, a combination of circumstances is present.

Detachment

Posterior vitreous detachment is an almost invariable finding in cases of retinal detachment except following trauma and retinal dialysis, when it is sometimes absent. A total posterior vitreous detachment, when the posterior hyaloid face lies in the anterior third of the vitreous cavity, can be detected by simple slit-lamp examination of the anterior gel. When, however, a partial posterior vitreous detachment is present in which the vitreous is still attached to the posterior pole of the eye and inferior half of the retina, the posterior hyaloid can be seen only by the use of the three-mirror contact lens. By studying a point on the posterior aspect of the vitreous gel (providing the latter has in fact become detached from the retina), the patient is asked to look first up and then down and then back to the central straight ahead point. Upon such movement the gel will be set in motion and will flow up and down in a curtain-like movement (the ascension phenomenon). When this movement is initiated the separated posterior hyaloid membrane can be seen as the most posterior part of the moving gel. Behind this membrane is the optically empty retrohyaloid space. Holes in the posterior hyaloid can usually be detected, especially where the hyaloid membrane has become detached from the optic disc. The detection of lacunae and the distinction between partial and total vitreous detachment will not influence the type of procedure to be used. However, evidence of proliferative vitreo-retinopathy (see p. 53) certainly does, and must be carefully noted.

An anterior detachment of the vitreous from the lens is rare and is of no significance. Similarly, detachment of the vitreous base is unusual and is only seen in traumatic cases, when there is avulsion of the vitreous base, which, with adherent non-pigmented epithelium of the pars plana, can be seen festooned in the vitreous cavity in a characteristic frill-like fashion [53] (Fig. 1.3).

Retinal Details and Vitreo-retinal Relationships

Retinal breaks seen on indirect ophthalmoscopy and scleral depression can be confirmed with the three-mirror examination. Occasionally, this examination will reveal breaks not seen previously with the indirect ophthalmoscope and this is particularly so when scleral depression is unsatisfactory, for example, in cases for reoperation or when very posterior breaks are present. To the inexperienced ophthalmologist the magnified view that the three-mirror examination allows will be particularly helpful, but as greater experience and expertise are attained with indirect ophthalmoscopy and scleral depression, less dependence on the three-mirror examination will be needed to confirm the fundal findings.

Traction on the Retina

The type of traction present in any given case of retinal detachment is deduced from the examination. Traction acting on the retina may be described as either dynamic or static in nature.

Dynamic Traction

Dynamic traction is a vitreo-retinal pulling force exerted on the retina when the vitreous moves, and is a consequence of posterior vitreous detachment [54]. This force may be exerted over quite a wide area, particularly at the posterior border of the vitreous base and areas to which the posterior hyaloid remains firmly adherent; thus vitreo-retinal attachment is always encountered over the whole length of an extensive area of lattice degeneration in the equatorial retina. Occasionally, however, points of vitreo-retinal traction may be very narrow, e.g. when the detaching vitreous remains attached to posterior points in the retina.

When a retinal tear is examined, an intermittent pulling movement of the operculum will be seen when the gel is set in motion due to the attachment of the posterior hyaloid to the anterior aspect of the break.

The importance of dynamic traction is that the cure of the detachment depends only on closing and sealing the retinal break—permanent relief of this type of traction is not necessary.

Static Traction

Static traction is defined as a pulling force exerted on the retina which, unlike dynamic traction, is continuous rather than intermittent. In the most commonly encountered static tractional states, the forces exerted are tangential to the retinal surfaces (particularly the preretinal surface when preretinal membranes contract). Sometimes the pulling force is vitreo-retinal in nature, e.g. focal traction resulting from the track of a foreign body as it traverses the vitreous cavity before impaction into the retina or, for example, a more widespread vitreo-retinal tractional force from a thickened and contracting posterior hyaloid face. Thus, the directional pull of tractional forces varies with the different clinical pictures encountered and mixed patterns are often seen. Depending on its position and severity, static traction may need to be relieved at the time of surgery. This may be achieved by buckling procedures or, in severe cases, with direct surgical relief by dissection of membranes at pars plana vitrectomy.

The overall problem of traction leads to a consideration of the membranes responsible for the establishment of tractional systems.

Retinal and Vitreous Membranes (Proliferative Vitreo-retinopathy)

On examining a case of retinal detachment, cellular avascular membranes may be found on the inner and outer surface of the detached retina and also within the vitreous cavity itself. Some degree of membrane formation has been found to occur in approximately 30% of a retinal detachment series [16]. Proliferative vitreo-retinopathy is the commonest reason for eventual failure in retinal detachment surgery [20, 55, 56], although many of the eventual failures start as more simple cases uncomplicated by proliferative vitreo-retinopathy. This cellular proliferation is followed by subsequent membrane contraction and it is this contraction that results in difficulty in reattaching the neuro-epithelium to the underlying pigment epithelium. This difficulty is caused either by preventing closure of the retinal breaks or by actually pulling the retina away from pigment epithelium. A variety of cells [57] have been found to contribute to the process of proliferative vitreo-retinopathy, and it seems that the predominant cell types will vary from one clinical situation to another. The pigment epithelial cell [58, 59] is capable of undergoing metaplastic activity and of contributing to the production of membranes. A similar capacity is also found in the glial cell of the retina and this cell is considered to be particularly likely to contribute to the formation of simple preretinal membranes [60–62]. Adventitial cells are contributory in those detachments associated with retinal neovascularisation and choroidal and epis-

Fig. 2.12. **a** A retinal detachment showing substantial preretinal membrane formation taking the form of star-shaped folds. There is tortuosity of retinal vessels in the folds and elongation of nearby retinal breaks. Clumps of pigment are present. **b** Total retinal detachment is present with a retinal break in the upper temporal quadrant. There is extensive periretinal membrane formation which has resulted in multiple tight retinal folds in inferior retina. Contraction of the posterior hyaloid face elevates equatorial retina. Tangential preretinal contraction at the vitreous base produces a purse-string effect and also tends to drag the ora serrata posteriorly. **c** A more advanced example of proliferative vitreo-retinopathy. Extensive posterior preretinal membrane formation has resulted in tunnelling of posterior retina towards the disc and extensive posterior retinal folding. Posterior subretinal membrane produces a purse-string effect around the disc. **d** Extensive posterior preretinal membrane in the macular region.

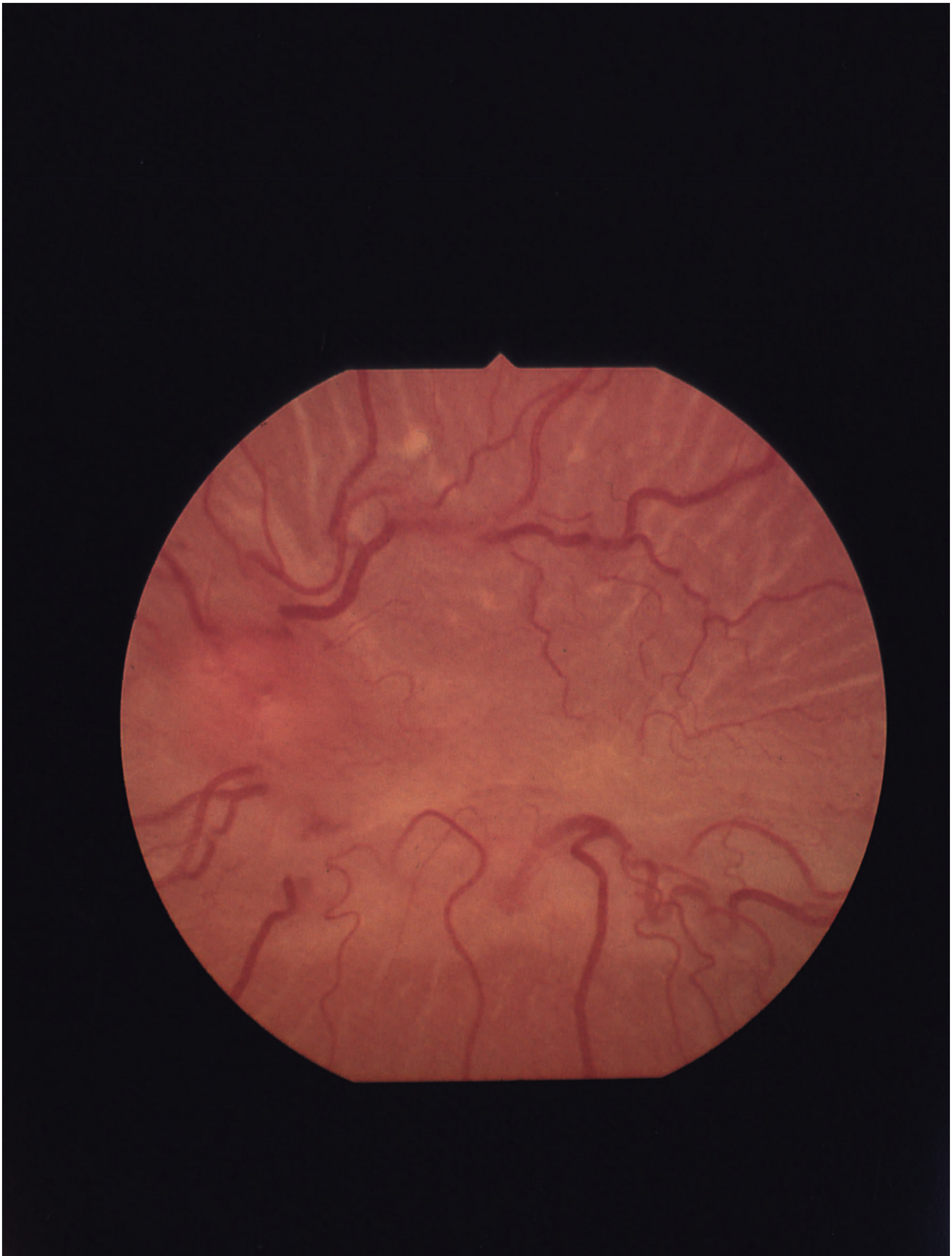
cleral connective tissue in retinal detachments associated with posterior perforating injuries. In cases where the cellular membranes have been examined subsequent to removal from the eye it has not been found possible to identify clearly the origin of some of the fibrocytes present. The contraction of these membranes, once formed, is due to the presence of intracytoplasmic contractile filaments [63, 64]. With progressive ageing of the membranes, collagen is deposited but the degree of collagen present in the membrane is not related to the clinical appearance of opacification although membranes themselves do tend to become more opaque as they mature [64]. The actual stimulus to the production of these membranes is not clearly understood but the detached retina itself is certainly one. Extracellular materials (such as fibronectin, which is a glycoprotein normally present in serum but also secreted by fibroblasts) play a part in the production of these membranes by encouraging fibroblastic activity; thus inflammation or haemorrhage in the vitreous cavity increases the membranous response.

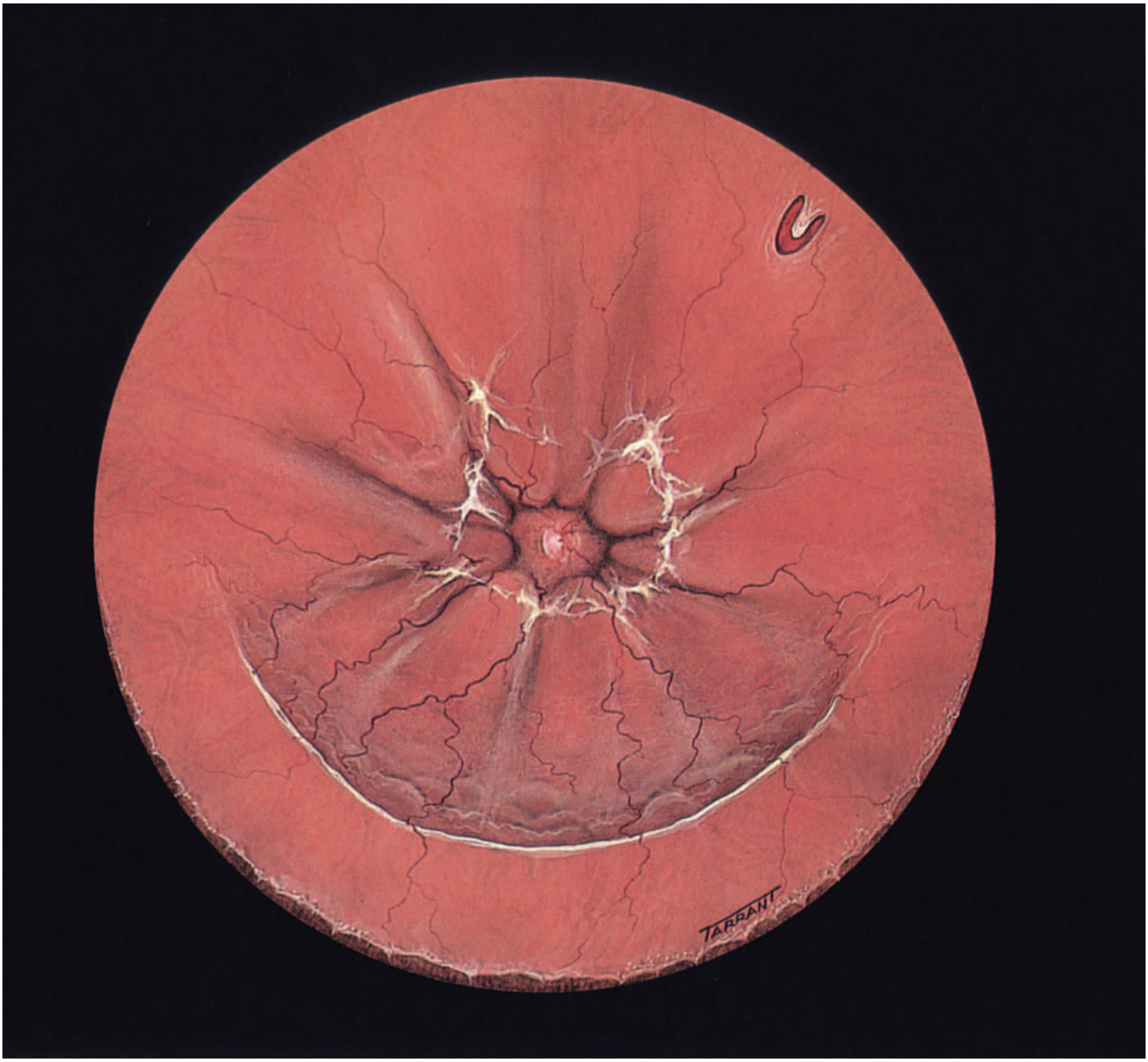
Certain other clinical features concerning the onset of membranes are recognised. The risk of membrane formation increases with the length of time of the detachment, in certain types of detachment (such as those associated with giant tears or penetrating injuries of the posterior segment) and in those detachments that have failed to respond to surgical treatment, particularly if the failed treatment has been complicated by, for example, haemorrhage, retinal incarceration or vitreous loss [20]. In these cases cryotherapy, if excessive, may contribute to the membranous response [65] by virtue of its disruptive effect on pigment epithelium and its tendency to produce inflammation and an exudative type of intraocular response to its application.

Site of Membranes

The way in which membranes are distributed in a detached retina varies considerably from one case to another. In general, the inferior retina is much more often affected than the superior retina. The anteroposterior distribution of membranes is much more variable; thus they may be confined to the posterior pole of the eye only or mainly affect equatorial or anterior retina and basal gel. In advanced cases, mixed pictures are usually encountered. The distribution of these membranes is of importance when relief of these membranes is being attempted

Opposite: Fig. 2.12a ▶





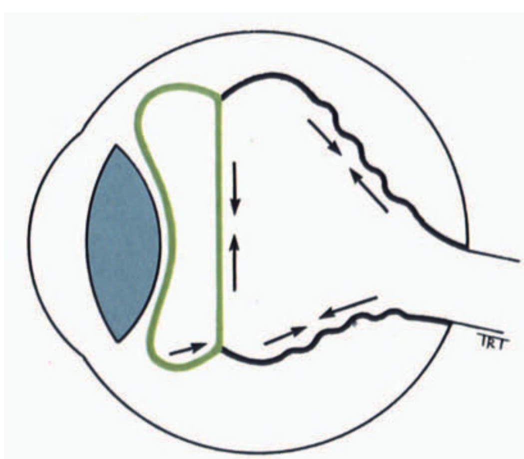
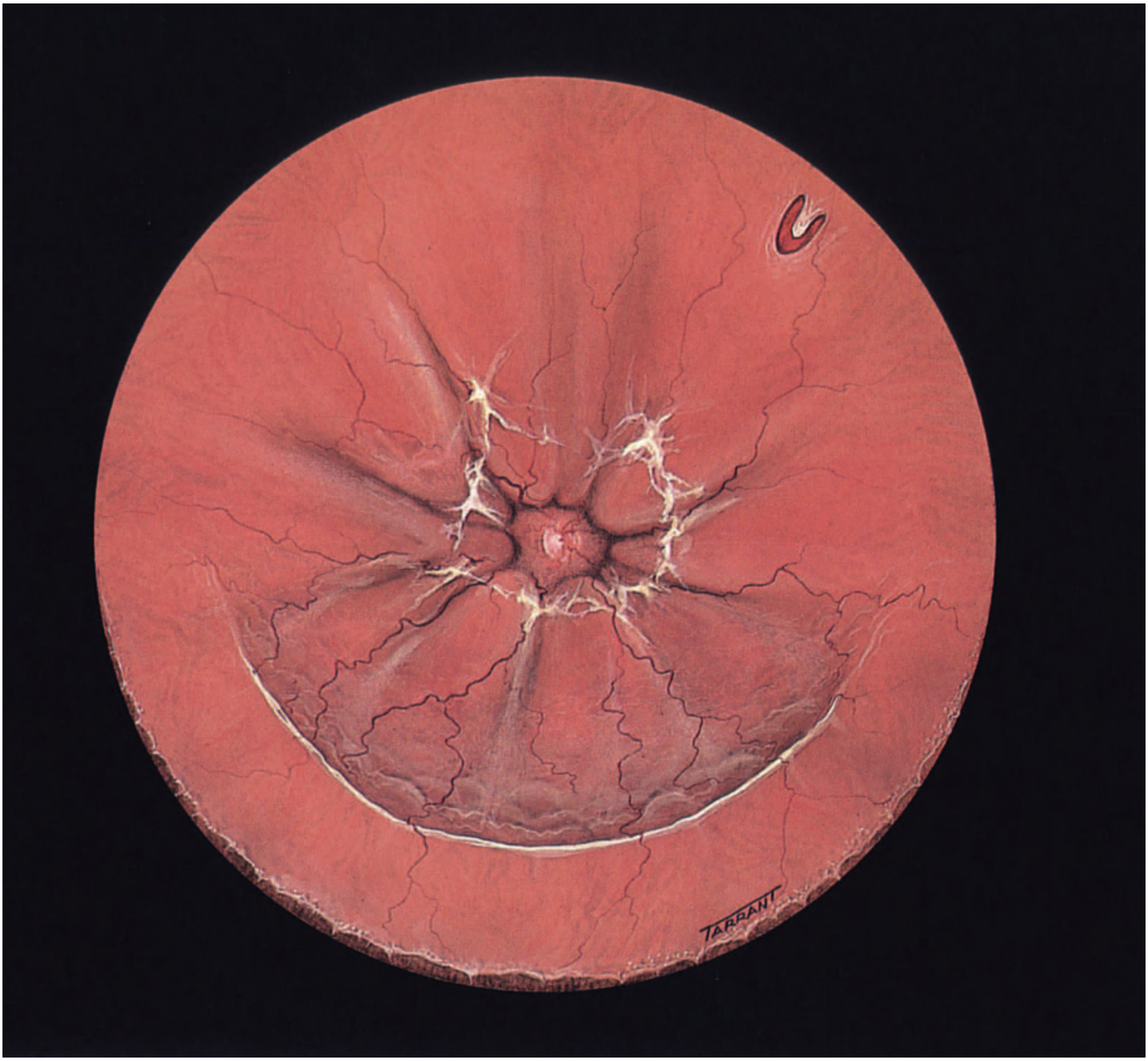


Fig. 2.12b



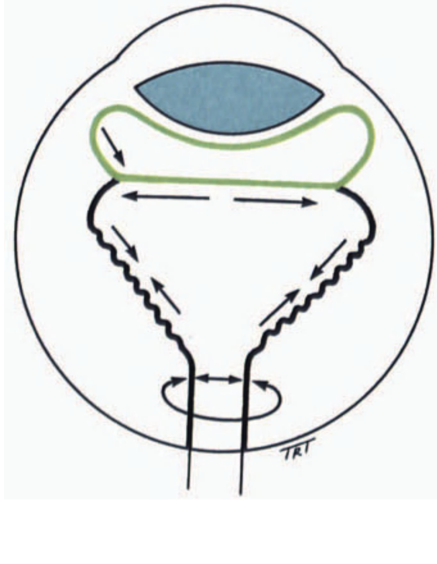
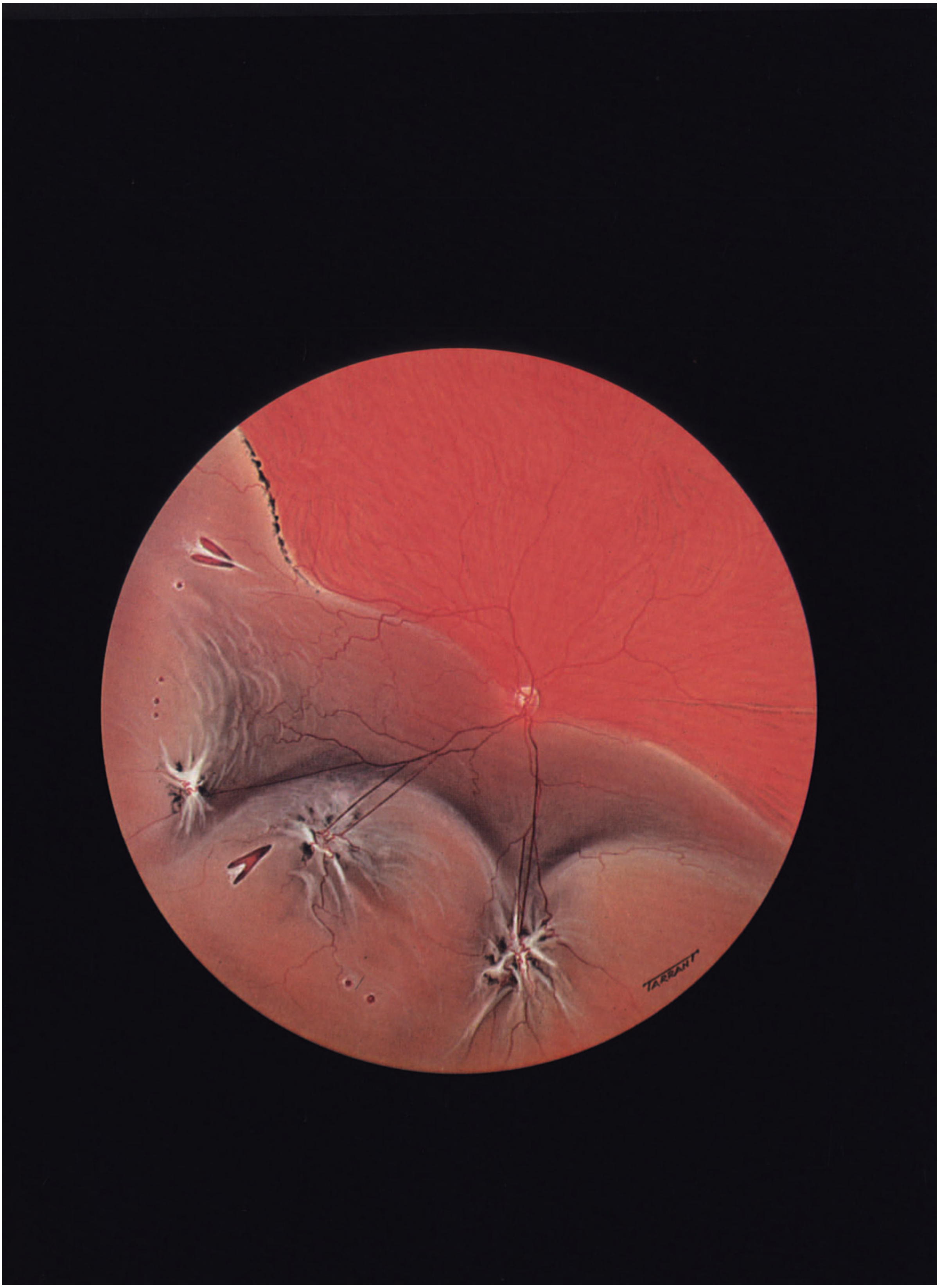


Fig. 2.12c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during vitrectomy. Inferior membranes are easier to dissect than superior ones and posterior membranes are much easier to deal with than those in the anterior retina.

Effects of Membranes

Preretinal Membranes (Fig. 2.12). Early evidence of contracting preretinal membrane is provided by distortion of neighbouring blood vessels or of retinal breaks. The simplest example of preretinal membrane formation is seen in the macular region, where it is known as macular pucker (Fig. 5.5). In this situation, the mechanism of production is probably through glial cells gaining access to the preretinal space via breaks in the internal limiting membrane which are produced by a detaching posterior hyaloid face. Initially there is loss of the normal macular reflex and wrinkling of the internal limiting membrane (cellophaning). A more peripheral example of early preretinal membrane is the backward rolling of the posterior edge of a retinal break, and these early changes may indicate membrane formation before the membrane can be actually seen. Breaks become distorted and immobile and this may cause difficulty in localisation and closure at surgery. As membranes develop, they become more opaque and are seen on the surface of the retina. Progressive contraction throws the underlying retina to which the membrane is attached into folds and the folded retina becomes oedematous and immobile. If membrane formation is extensive, retinal folding is widespread and rather non-specific in appearance (Fig. 2.12b). If contraction is localised to a small epicentre, star-shaped retinal folds are produced. Initially the membrane is semi-transparent and weak, involving only the superficial part of the detached retina, and the folds themselves are of only partial thickness. At this stage there is little evidence of increased pigmentation. However, as the membrane increases in density, full thickness folds are produced and these folds are usually associated with some degree of pigmentation. Clumps of pigment are found lying in close relationship to the folds, either on the retinal surface or immediately overlying them in the vitreous cavity. After further contraction, retinal blood vessels become buried into the folds, and the whole fibrovascular complex has a knotted appearance.

Subretinal Membrane. Subretinal membrane may be difficult to see if the retina is thickened or oedematous, or easy to see if thinning of the retina has occurred in long-standing detachment. Two forms of subretinal membrane may be encountered:

1. Yellowish-white retinal strands, particularly in association with long-standing retinal detachment (Fig. 2.8). These strands are usually easy to see due to thinning of the overlying neuro-epithelium that occurs with age of detachment [66]. They are often widely distributed in a strut-like configuration on the posterior retinal surface with numerous interconnecting branches. These strands may cause immobility and elevation of the overlying retina, but they usually behave in a benign way. They are seldom associated with substantial preretinal fibrosis and have little tendency to progress.

◀ *Opposite: Fig. 2.12d*

2. Purse-string arrangements of retroretinal membranes contracting in the peripapillary region. These structures can contribute to the appearances of end-stage proliferative vitreo-retinopathy. They are difficult to identify prior to vitreous surgery but may be encountered after vitreous opacities and preretinal membranes have been removed from the surface of the retina.

Vitreo-retinal Membranes. Fibrocellular membranes occurring within the vitreous cavity can occur either before retinal detachment appears (for example, following a perforating injury) or after retinal detachment has occurred, as part of the general proliferative response. In the latter case, while helping to perpetuate the detachment and frustrate surgical attempts at reattachment, they are not responsible for its production. In ordinary primary rhegmatogenous retinal detachment, membranes within the vitreous cavity take the form of clumps or strand-like arrangements of pigment throughout the vitreous body, which itself becomes progressively more collapsed and immobile, losing its normal structure completely. The detached posterior hyaloid, a normally thin membrane, becomes converted into a thick and rigid structure, the contraction of which results in drawing inwards of equatorial retina (provided the vitreous has detached as far as the equator) towards the centre of the vitreous cavity (Fig. 2.12c). This elevation will tend to pull the ora serrata into view. As well as vitreo-retinal traction, membranous infiltration of the vitreous base produces a purse-string like tangential traction on the posterior border of the vitreous base. This type of contraction is particularly difficult to relieve.

If membranes are situated within the vitreous base and pars plana area, anterior retina may be drawn forward towards the pars plana – anterior loop traction [67]. This type of traction is seldom seen in retinal detachment prior to vitrectomy.

Progression of Membranes

The rate of progression of membranes is extremely variable and poorly understood. Occasionally, progression is rapid, but sometimes membranes are extraordinarily reluctant to form. In some cases (e.g. the retroretinal strands found in long-standing detachment) progression is slow or even static. When preretinal membrane formation is present, however, remorseless progression over weeks and months is the general rule. The eye progresses to total detachment and end-stage proliferative vitreo-retinopathy is present with the retina becoming shortened and board-like.

Classification

Proliferative vitreo-retinopathy is now by far the commonest eventual cause of failed retinal detachment surgery. It should be remembered, however, that many of these cases started their detachment life as being uncomplicated by membrane formation, the latter developing after surgery failed to close the retinal break(s). Confusion exists as to the best methods of treating detachments complicated by proliferative vitreo-retinopathy, and this confusion to some extent reflects difficulties in terminology of extent, distribution and severity of the proliferative process. This has made surgical series extremely difficult to compare and has led to the introduction of various classifications to aid description of surgical results. The present classification introduced by the Retinal Society in the USA [68] is at least a step in the right direction in enabling communication in the literature. There are problems, however, in such a classification, and it will almost certainly be subjected to various amendments in due course. For example, localised peripheral anterior traction (e.g. following a perforating injury) may prove very difficult to relieve, with difficulty in achieving reattachment, whereas extensive posterior membranes, while resulting in an advanced picture clinically, may be relatively easy to dissect with a good chance of surgical success.

Classification

A – Vitreous haze, vitreous pigment clumps
B – Inner retinal surface wrinkling, rolled edge of break, vessel tortuosity, retinal stiffness
C – Full thickness fixed retinal folds
C1 – One quadrant
C2 – Two quadrants
C3 – Three quadrants
D – Fixed folds in four quadrants
D1 – Wide funnel towards disc
D2 – Narrow funnel towards disc
D3 – Fixed funnel – disc not seen

Characteristics of Various Types of Retinal Detachment

Aphakic Detachment

1. *Following Intracapsular Extraction.* These types of aphakic detachment, the majority of which come on within one year of cataract surgery, have a variety of features that tend to distinguish them from their phakic counterparts. Retinal tears are much less commonly found, round holes being more often encountered. Retinal breaks are more likely to be multiple and occasionally they are widely separated in detached retina. For many years, the presence of multiple small breaks in the postoral region of the retina was considered the characteristic feature of aphakic retinal detachment [69]. However, in a recent series of aphakic retinal detachments there were few cases characterised by multiple small breaks in separate quadrants of the retina. In this series, though, the incidence of vitreous loss at cataract surgery was high (40% of cases [70]). In vitreous loss cases the detachment appears significantly earlier (within 3 months) and also tends to develop periretinal membranes more quickly than those cases following uncomplicated cataract surgery. In aphakic detachments, retinal breaks are usually difficult to find, a difficulty that is compounded by poor pupillary dilatation and by capsular lenticular remnants obscuring details of the peripheral fundus. These detachments tend to progress more rapidly to periretinal mem-

brane formation [70, 71] and this is particularly likely to occur if the cataract surgery has been complicated by poorly managed vitreous loss with incarceration of vitreous into the cataract extraction, or by extensive haemorrhage. There is a higher incidence of inferior detachment in aphakic cases and a greater tendency for the detachment to become total [72]. The ability of the retina to detach when there are small round breaks, the general absence of high-water marks in these cases and the tendency to rapid progression to total detachment have been interpreted as indicative of poor adhesion between receptor layers of the retina and pigment epithelium, allowing an easy stripping off of the receptor layer when detachment begins [71]. This weakness may have been induced by the actual removal of the cataract itself, possibly by disruption of the zonular fibres and their attachment to peripheral retina. Due to difficulty in detection of retinal breaks and also to the tendency to more rapid onset of proliferative vitreo-retinopathy, some series [20] reported a lower incidence of success of conventional retinal surgery in the management of this type of aphakic retinal detachment.

2. *Following Extracapsular Cataract Surgery.* The incidence of aphakic detachment has become much lower following the introduction of extracapsular techniques, with or without the inclusion of intraocular lenses [73–75]. In spite of this reduced incidence, if retinal detachment does occur, then it poses particular problems to the surgeon. Observation of the detachment is usually difficult if there are opacities of the posterior capsule or if there are extensive synechiae between iris and posterior capsule. Synechiae are less likely to form if a posterior chamber intraocular lens has been used, but difficulties can be encountered in addition to reflexes from the surface of the lens [6]. The lens itself may be unstable, particularly if iris supported, making preoperative examination hazardous, with a tendency for lens dislocation. Haemorrhage from the iris may occur with anterior chamber lenses. If detachment is to occur after extracapsular surgery, in the majority of cases this occurs within a year of surgery. The breaks are more difficult to detect [76] and are very much more suggestive of an ordinary phakic type of retinal detachment, with no unusual tendency to multiplicity or widespread distribution. The incidence of proliferative vitreo-retinopathy does not appear to vary from an ordinary phakic detachment [77]. The response to surgery of these detachments to conventional buckling techniques appears excellent [78]. The incidence of aphakic detachment following extracapsular surgery seems to rise somewhat after capsulotomy has been performed [75], although there is no evidence to suggest that use of the YAG method to perform the capsulotomy has any undue influence on the production of retinal detachment [79].

3. *Following Congenital Cataract Surgery.* The detachment occurring following this form of surgery tend to appear many years after cataract surgery. This delay is presumably consequent to an eventual vitreous detachment.

Dislocated or Subluxated Lenses

Retinal detachments may occur in cases in which there are either dislocated or subluxated lenses [e.g. Marfan's syndrome). The main difficulty then encountered is visualisation of the underlying detached retina; this is because of distortion of reflexes due to the presence of the subluxated crystalline lens, and the problem is particularly severe if that lens has become cataractous. In Marfan's syndrome it is usually especially hard to detect retinal breaks as there is often difficulty in dilatation of the pupil.

Retinal Dialysis

Retinal dialysis is the term applied to retinal breaks at the ora serrata (Fig. 2.8), but it is more accurately a separation of sensory retina from the pigmented epithelium of the pars plana. The commonest site for the presence of a spontaneous retinal dialysis is the lower temporal quadrant [80]. Usually the break involves several serrations of the ora to result in a large dehiscence (a segment of about 1 clock hour). However, in contusive injuries the dialysis is found in the upper nasal quadrant in a surprisingly high proportion of cases [81], and the finding of a dialysis in this site is pathognomic of trauma to the eye [82]. Retinal dialysis may also be found following perforating injuries or pars plana vitrectomy, in the latter case as a result of instrumentation in the vicinity of the vitreous base. Usually the vitreous base remains intact and its posterior limit is firmly adherent to the edge of the dialysis, an attachment which results in splinting and some degree of immobility of the dialysis edge, particularly in large and long-standing breaks. Posterior vitreous detachment is rare and is generally found only if there has been extensive vitreous haemorrhage consequent to injury.

The relationship between trauma and retinal dialysis is not fully understood [83]. Experimentally it has been shown that a stretching force on the relatively immobile vitreous base, as a result of contusion injury, may result in dialysis [53]. However, it has never been fully explained why the lower temporal quadrant of the retina has been found to be very vulnerable to this form of retinal break; certainly the role of trauma in the production of lower temporal dialysis is much less well established. Indeed, in approximately 5% of cases the condition is found to be bilateral, suggesting an underlying weakness of the ora serrata.

In the cases of inferior dialysis, accumulation of subretinal fluid is insidious so that in the majority (85%) the macula is detached by the time the patient presents [81]. A superior field defect is seldom noticed and the detachments are usually asymptomatic, presenting only when visual acuity is noticed to be reduced or discovered in the course of a fundal examination. In the majority of cases (over 90%) the eyes are emmetropic.

As would be expected in cases involving trauma, the condition favours young men. Trauma is by far the commonest cause of detachment in children and young adults, and approximately half the cases arise in patients under the age of 20.

The presence of dialysis is often signposted by characteristic whitish opacities and pigment collection in the vitrous, overlying its attachment to the dialysis edge. When the retinal dialysis is fresh, the actual dehiscence may be slit-like and is difficult to detect in the peripheral retina, a problem that underlines the need for careful scleral depression. This must be gentle because firm pressure will actually close the dialysis and render it invisible to the casual observer. No other type of retinal break is more testing to the capacity of the surgeon to examine the peripheral retina correctly. Multiple dialysis are sometimes found; they are generally situated in the same quadrant of the retina, separated by small bridges of intact retinal tissue; and it is rare for them to be widely separated. Retinal dialyses extending for more than a quadrant are classified as giant dialyses and are exceptionally rare. With the passage of time, particularly if the dialysis is large, the posterior edge becomes retracted, giving the dialysis its characteristic semilunar appearance, and other features of long-standing detachment appear, with the formation of demarcation lines and secondary intraretinal cysts [23] (Fig. 2.8).

It is most unusual for detachment associated with inferior dialysis to become total unless complicated by a substantial degree of proliferative vitreo-retinopathy. The more normal vitreous and only slight tendency to proliferative vitreoretinopathy in the typical emmetropic eye contribute to an exceptionally good surgical prognosis for anatomical reattachment of the retina [83]. However, the recovery of central vision in these cases is much less satisfactory owing to the usual finding of long-standing detachment of the macula.

Children

Trauma, either penetrative or contusive, is the most important factor in the production of retinal detachment in children [84] and the commonest individual type of retinal break is the dialysis. High myopia in children, particularly if associated with other congenital abnormalities (such as Stickler's syndrome [85]), may be associated with giant break formation. Other unusual causes of detachment in younger children include the retinopathy of prematurity [86] and rare congenital anomalies such as posterior hyperplastic primary vitreous [87] and optic disc anomalies [88].

Giant Retinal Breaks

Giant retinal breaks are defined as those that are 90° or more of the retinal circumference. They pose particularly difficult management problems. Most cases arise spontaneously, although they can occur following trauma (penetrating or contusive) or vitreous manipulation at surgery [89]. Giant breaks occur quickly and it is exceptional to observe extension of a giant break once it is formed. The reason for and methods of production of this type of retinal break are not understood. It is not clear why a posterior vitreous detachment will produce a single retinal tear or a series thereof in one eye but a giant break in another. Fortunately giant breaks are rare. They are sometimes associated with congenital abormalities (such as Stickler's syndrome) and have also been found in association with coloboma of the lens [90]. The average age in this group of patients is lower than that in the detachment population as a whole, and the male sex is favoured. There is a tendency toward a higher incidence of myopia [91], and the breaks themselves arise in the pre-equatorial region of the retina that in most cases has no sign of underlying weakness [92]. On occasions, lattice degeneration is found, as are areas of white without pressure in both the affected and the fellow eye. In non-traumatic cases there is particular risk to the other eye, examination of which usually reveals no obvious detectable abnormality. This high incidence

Fig. 2.13. A giant tear of the temporal retina in a highly myopic eye. The retina has flapped over but has not become fixed. The anterior part of the tear is elevated and drawn into the vitreous cavity by extensive vitreo-retinal traction. There is a small associated U-shaped tear.

of bilaterality (approximately 50%) is important when prophylaxis to the second eye is being considered.

When a giant break is produced, a complete posterior vitreous detachment is surprisingly unusual but there is strong attachment of the vitreous to a rigid anterior edge of the break, which is considerably elevated into the vitreous cavity. The posterior flap of the giant break therefore tends to hinge on a line joining its two extremities (which may have deep posterior extensions) and is unsupported by vitreous gel. The movement of this flap is variable (Fig. 2.13); if the break is very extensive, the detached retina will tend to flap like a sail in the vitreous cavity. Initially the flap will tend to stay almost in situ, but later there is a tendency for the retina to hinge back over, so that the back of the neuro-epithelial layer is viewed on ophthalmoscopy. The movement of the posterior flap may produce the unusual symptom of a dense moving curtain passing in front of the eye as it flaps over the macula. The posterior movement of the flap will be reduced as it becomes immobilised owing to the formation and contraction of periretinal membrane. Eventually the flap will roll up and become fixed in a retroverted position and incorporated into dense preretinal fibrous tissue. In the early stages of giant break formation there is often little subretinal fluid, but with progression the retina becomes totally detached. Small retinal tears are often found in association with giant breaks and are invariably situated in the same circumferential level of the retina. The very substantial exposure of pigment epithelium to the vitreous cavity in giant breaks is one of the reasons why these cases fare so badly by rapid progression to proliferative vitreo-retinopathy.

Macular Breaks

Macular breaks are unusual and are often difficult to detect on examination unless borne in mind. Slit-lamp biomicroscopy is necessary to find the breaks, which are often poorly contrasted with the white of underlying choroido-retinal atrophy. Macular breaks may be found in association with retinal detachments in the following ways (Fig. 2.14):

1. The macular break is actually responsible for the production of the retinal detachment (Figs. 2.14, 2.15a). In these cases (which are rare, accounting for approximately 1% of retinal detachment cases encountered), the macular breaks occur as a result of round hole formation in highly myopic eyes, usually with

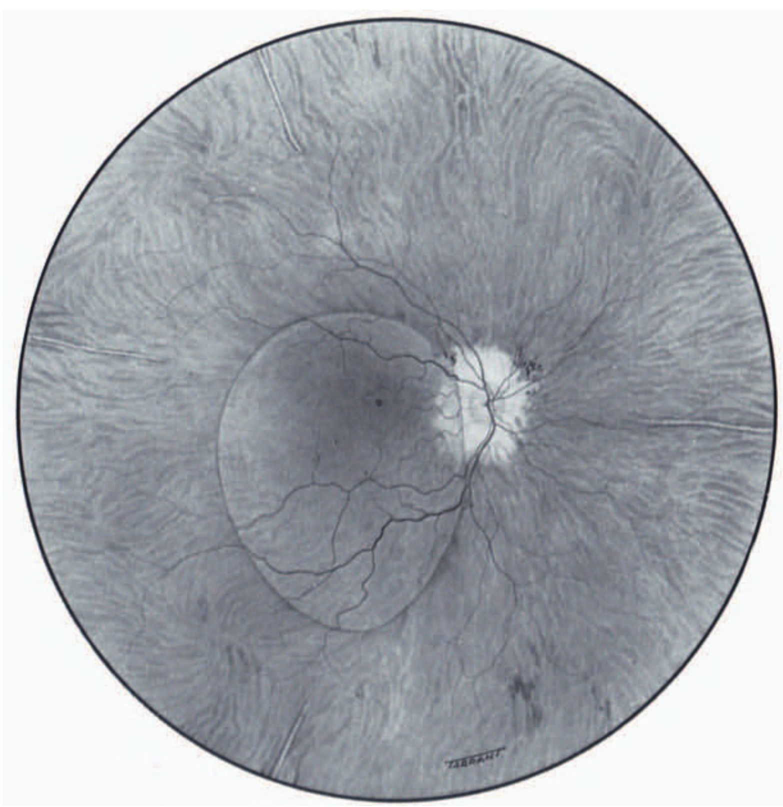

Fig. 2.14. A macular break has caused a retinal detachment in a highly myopic eye.

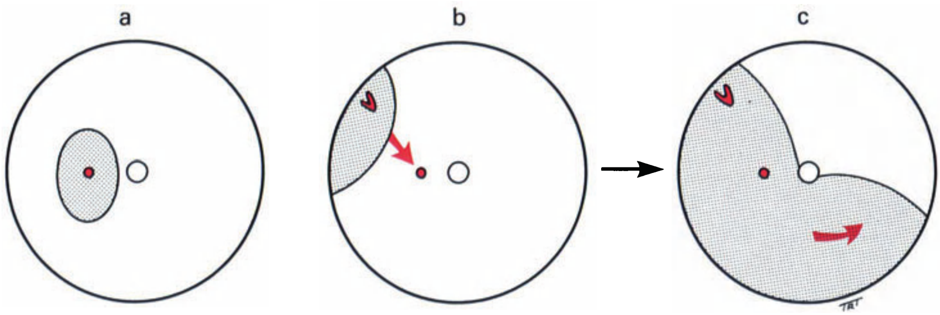

Fig. 2.15a–c. Retinal detachments associated with macular breaks. **a** A macular break causes the retinal detachment. **b** Peripheral retinal detachment extends towards the macula, where it causes a secondary retinal break. **c** Retinal detachment becomes more extensive.

associated posterior staphyloma. It is exceptional for ordinary senile macular holes of a degenerative nature to progress to retinal detachment [93]. Focal vitreous traction (such as is responsible for equatorial retinal breaks) is rarely seen in macular break formation, although at the time of vitrectomy, loose vitreous detachments to the macular area are often found. Horse-shoe-shaped breaks are exceptionally unusual in the macular region [94].

2. Macular breaks may form as a secondary phenomenon to the advancing wall of subretinal fluid, arriving at the macula from a peripheral retinal break (Fig. 2.15b). In these cases, the patients are not necessarily highly myopic and peripheral retinal breaks are found. This situation accounts for the majority of macular breaks encountered.

3. A macular break is found and the retinal detachment extends to the periphery. In these cases it is very difficult to know whether the macular break has been the primary aetiological factor in the production of the detachment or whether (as is much more likely) it has arisen secondary to an unseen peripheral break.

Retinoschisis Complicated by Detachment

Cases of retinoschisis complicated by detachment are rare, since retinoschisis is typically non-progressive and rarely lead to rhegmatogenous retinal detachment. When retinal detachment does ensue, large outer leaf breaks which are oval or kidney-shaped, with a rather rolled, ill-defined posterior border, are seen (Fig. 2.16). Inner leaf breaks are difficut to detect and only found in approximately 40% of cases [95]. The combination of retinal detachment and retinoschisis makes it difficult to determine the exact extent of the pre-existing schisis. In the majority of cases, a combination of typical appearances of retinoschisis and the added appearance of fresh rhegmatogenous detachment arising usually from one border of the schisis (often its posterior aspect) is seen. In exceptional circumstances, giant breaks in the outer leaf of the schisis may be seen. Signs of retinoschisis are usually found in the other eye.

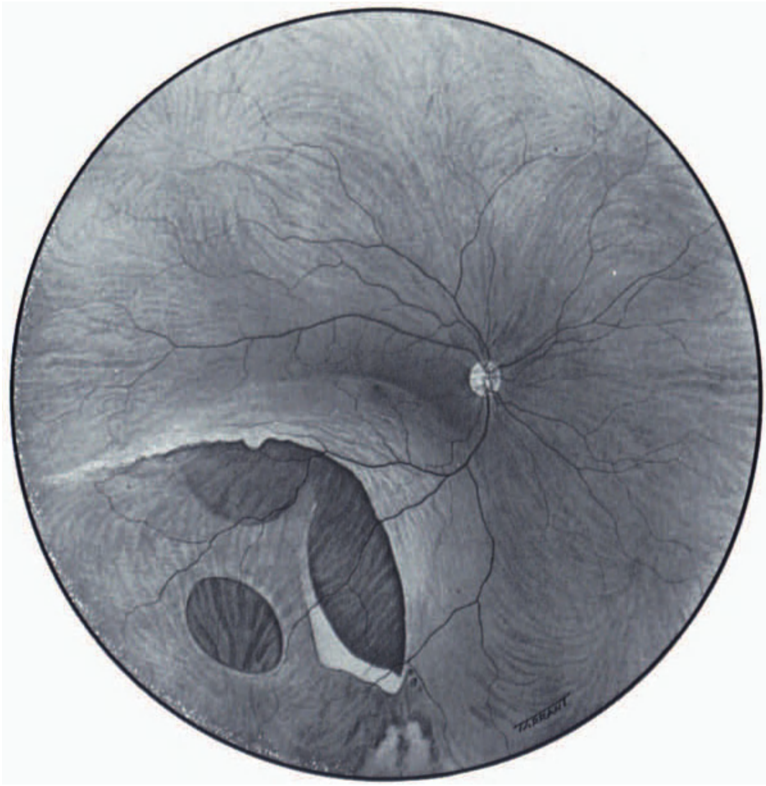

Fig. 2.16. Retinoschisis complicated by retinal detachment. A large round break can be seen in the inner leaf of the schisis and an even bigger kidney-shaped break with a rolled anterior edge is present in the outer leaf.

Uveal Colobomas

Retinal detachment is sometimes seen in uveal colobomas (Fig. 2.17) and may be of two main types:

1. The detachment arises from breaks quite separate from the coloboma itself, in which event the detachment can be managed and assessed without regard to the coloboma itself.
2. The break cannot be seen and is presumed to be related to the edge of the coloboma. These cases are difficult to treat and carry a much worse prognosis.

Differential Diagnosis of Rhegmatogenous Retinal Detachment

There is usually no difficulty in the diagnosis of rhegmatogenous retinal detachment, with its typical appearance of undulating folds of the retina, loss of

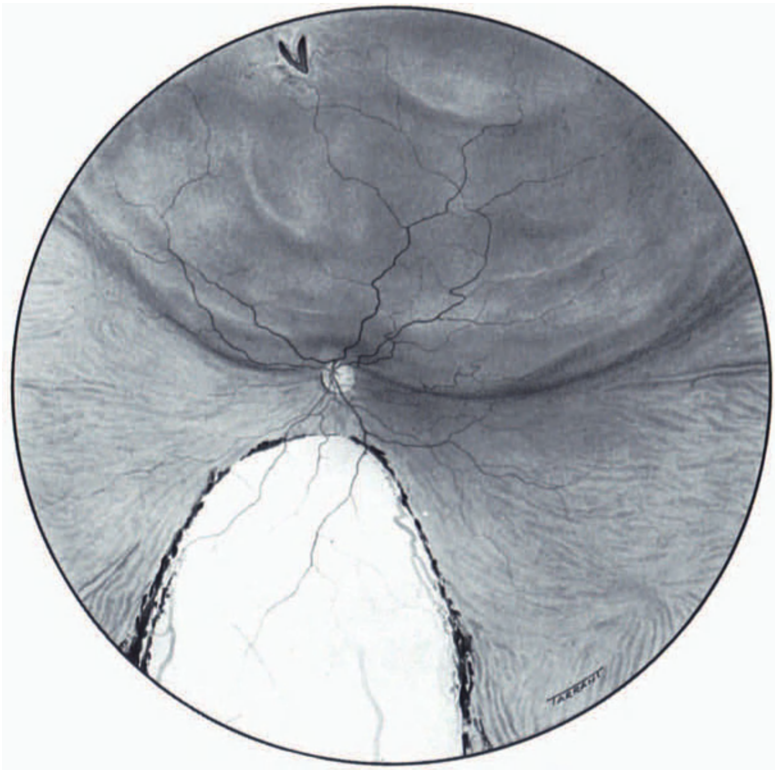

Fig. 2.17. An upper-half retinal detachment is quite separate from a large inferior coloboma.

the normal underlying choroidal reflex, darkening of the retinal vessels and the presence of retinal breaks. The detection of full-thickness retinal breaks virtually eliminates non-rhegmatogenous detachments, and the clinical features distinguishing traction retinal detachment from rhegmatogenous retinal detachments have already been outlined (see p. 11). The main difficulty in diagnosis arises when it is not possible to find retinal breaks, in which event it may be hard to distinguish retinoschisis from long-standing retinal detachment and rhegmatogenous from non-rhegmatogenous detachments.

Retinoschisis and Retinal Detachment

It is important to distinguish retinoschisis from retinal detachment as in retinoschisis the management is conservative due to the non-progressive nature of the condition. In long-standing rhegmatogenous detachment, the retinal texture tends to resemble retinoschisis, becoming thin and atrophic, and loses the classical appearance of the freshly detached retina. After the failure to detect breaks the main practical points of distinction are:

1. In retinoschisis demarcation lines and secondary intraretinal cysts are not found.

2. Scleral depression over the outer layer of the retinoschisis will produce a blanching effect not seen in retinal detachment.
3. Retinoschisis tends to be a bilateral condition and is usually asymptomatic, with no premonitory signs or loss of vision.

Non-rhegmatogenous and Rhegmatogenous Retinal Detachment

There is usually very little difficulty in distinguishing exudative from rhegmatogenous detachments. In some cases, the exudative detachment is associated with extraocular disease (e.g. hypertension), in which event a general examination of the patient will reveal the underlying problem and the ocular examination will itself show retinopathy associated with symmetrical shifting bilateral inferior retinal detachment, without retinal breaks. If the exudative detachment is secondary to intraocular disease, indirect ophthalmoscopy aided by transillumination will nearly always reveal the true nature of the detachment, e.g. the exudative detachment associated with choroidal malignant melanoma, Leber's miliary aneurysms or von Hippel's retinal angiomatosis. Pain and redness of the eye may be a feature of some forms of inflammatory disease of the posterior segment (such as posterior scleritis) and in these cases in addition to the presence of non-rhegmatogenous detachments, an active uveitis is a helpful diagnostic pointer.

Harada's Disease and Similar Conditions

Vogt-Koyanagi-Harada's disease, originally described as two separate conditions [96, 97], has gradually become recognised as a single rather ill-defined entity of inflammation of retina and choroid, producing exudative retinal detachment, with three phases:

1. A meningo-encephalitic phase characterised by severe headache, meningeal symptoms and pleocytosis of the cerebro-spinal fluid.
2. An ocular phase manifested by bilateral uveitis and non-rhegmatogenous retinal detachment.
3. The appearance of cutaneous and auditory symptoms, the former consisting of vitiligo, alopecia and poliosis and the latter of dysacousia and deafness.

Considerable diversity in the clinical appearance of these diseases and in their intensity exists from one patient to another, and while the onset is usually dramatic, the subsequent course is extremely slow with a tendency to spontaneous remission within about a year. The disease has a tendency to affect middle-aged people of dark pigmentation, and while the ocular signs are usually bilateral, one eye is often affected at a different time from the other. In this condition, fluorescein angiography may be of diagnostic help, showing early masking and late leakage from pigment epithelium.

In general, any inferior retinal detachment in which a retinal break has not been found, subretinal fluid is found to shift markedly, and in which there is no other obvious intraocular cause of such a detachment (e.g. tumour), should arouse a high index of suspicion that a Harada-like condition is present. Signs of uveitis in the same or the other eye must be sought, and fluorescein angiography performed to help establish the diagnosis.

Uveal Effusion

The term "uveal effusion" was based on a description of cases [98] the cause of which was unknown and which had the following clinical features:

1. A tendency to affect middle-aged men
2. The clinical appearance of annular choroidal detachment, usually bilateral and involving the whole peripheral fundus
3. Non-rhegmatogenous retinal detachment, usually bilaterial with shifting subretinal fluid
4. Minimal or absent signs of uveitis

In some cases there was an associated elevation of cerebrospinal fluid pressure with an increase in protein content. The course of the disease was usually progressive and, again, one eye was affected at a different time from the other. These cases responded badly to any attempted retinal surgery.

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3 Preoperative Management and Operative Planning

Preoperative Management

In the preoperative discussion with the patient, the following points related to retinal detachment surgery should be borne in mind. Patients prefer optimism in their surgeon, but although restoration of lost peripheral vision can be guaranteed with successful reattachment of the retina, a cautious prognosis should be given regarding the likelihood of return of central vision if the macula has been detached. The patient should be warned that the other eye will also be subjected to a careful examination at the time of detachment surgery and prophylactic treatment carried out if indicated. This procedure may result in lid swelling, and although the eye will not be patched, the discomfort and swelling in what was to the patient a normal eye might otherwise cause alarm in the postoperative period. The knowledge that both eyes are not to be covered after operation will allay anxiety in patients, many of whom will fear waking after anaesthesia and being unable to see out of either eye.

The nature of any preoperative or postoperative posturing manoeuvres should be carefully explained since active co-operation is an intrinsic part of such manoeuvres. The surgeon should also attempt to assess whether or not the patient will be incapable, for either physical or mental reasons, of co-operating with such manoeuvres. If the case being dealt with is of unusual complexity, e.g. extensive periretinal membranes, or involves a risk of complications (e.g. cataract) and it is felt that further surgery is a possibility, then this should be mentioned so that no loss of confidence is experienced if reoperation does become necessary. Explanation should not be over-complicated.

Local antibiotics are given routinely for the eye to be operated upon.

Immobilisation of the Eye

Bed-rest for a period of 24–48 hours combined with padding of both eyes has been shown to reduce eye movements [1]. The reduction of eye movements may be a useful preoperative adjunct to retinal detachment surgery [2, 3] in that it reduces subretinal fluid. It is contra-indicated in patients with a history of thrombo-embolism, in whom deep vein thrombosis in the legs is a risk, and is avoided for the same reason in patients who are very old and in those likely to be emotionally disturbed and upset by having both eyes covered. In all cases in which the bed-rest is to be employed the patient should be permitted to visit the bathroom and allowed to sit up in bed without bandages for a short time to eat meals. Bed-rest may be of value in the following situations.

Vitreous Haemorrhage

Severe vitreous haemorrhage may completely obscure the view of the underlying retina [4]. The period of bed-rest varies with the severity of the haemorrhage and can be extended to 4 or 5 days to encourage the vitreous haemorrhage to settle on inferior retina, thus allowing at least a view of the upper part of the retina [5]; this is important as the upper retina is the most likely site of a retinal break. Blood will clear quicker from an aged or degenerate gel [6]. During the time of bed-rest the patient is encouraged to sit upright. B-scan ultrasonography should be performed to demonstrate whether or not retinal detachment is present. If detachment is found, urgent surgical intervention in the form of pars plana vitrectomy will be necessary. The presence of blood in the vitreous cavity will encourage the growth of periretinal membranes if retinal detachment is present. Untreated, such cases usually progress rapidly to advanced proliferative vitreo-retinopathy.

Reduction of Subretinal Fluid

The mechanism by which subretinal fluid may be reduced in quantity by bed-rest is probably a simple descent of the retina due to gravity and passage of the fluid from the subretinal to the retrovitreal space via the retinal break [7], provided the latter is placed in the most dependent position. This reduction of subretinal fluid may be useful:

1. To prevent detachment of the macula in cases of superior detachment prior to surgery.
2. To encourage approximation of the break to the underlying pigment epithelium. This will facilitate cryotherapy and localisation of the buckle at surgery.

In one study the use of bed-rest was found to be of value in only 25% of patients who had recent upper half detachments where the retina was still mobile [3]. In these cases the patient is placed as flat as can be tolerated, sometimes with the foot of the bed raised, and the head is inclined to keep the break dependent. In some cases the redistribution of subretinal fluid will be so great that it will convert a difficult bullous retinal detachment situation into a very simple small localised detachment.

Although bed-rest combined with patching of both eyes is the usual method of inducing immobilisation of the eyes, on some occasions a more complete immobilisation of the globe has been found to be of benefit and this has been achieved by the placement of a stitch through the inferior rectus and taping to the forehead [8]. This has been shown to have a profoundly beneficial effect on the reduction of subretinal fluid.

Medical Treatment

Uveitis

Treatment of preoperative anterior uveitis consists of vigorous pupillary dilatation to prevent or encourage breakdown of posterior synechiae and the administration of local steroids (dexamethasone 0.1% hourly). Systemic steroids are occasionally necessary, particularly if there is marked infiltration of the vitreous. A moderate degree of uveitis is seldom sufficient reason for postponing the operation as the view of the underlying retinal detachment will not be significantly reduced.

In cases of uveitis secondary to retinal detachment, surgical reattachment of the retina will result in rapid resolution of the uveitis.

Glaucoma

Small rises of intraocular pressure (up to 30 mmHg) may be treated by the administration of timolol 0.5% twice a day to the affected eye. If the intraocular pressure rise is more severe, then the administration of Diamox (250 mg four times a day) will be necessary to achieve control.

Removal of Infected Buckles

If it is apparent that an explant inserted at a previous surgical operation has become infected, the explant should be removed as a preliminary surgical step. If it is protruding through a dehiscence in the conjunctiva, it may be removed under local anaesthesia. If, however, the explant has led to considerable granuloma formation or is not visible, its presence being indicated by a mucopurulent discharge, then a general anaesthetic will usually be necessary: the removal of infected objects may be accompanied by some degree of haemorrhage and the need for a difficult dissection. Following removal of an infected implant it is advisable if possible to wait for a period of about 1 month before further definitive retinal detachment surgery is performed.

Selection of Operative Procedure

The examination will enable the surgeon to decide an operative plan. If a conventional retinal detachment operation is to be performed the facets of the operation for consideration are:

1. The method of adhesion
2. The scleral buckle
3. The drainage of subretinal fluid
4. Intravitreal injections

If conventional surgery is deemed not to be appropriate then the indications for vitrectomy have to be defined.

Methods of Adhesion

Cryotherapy has become the accepted method of achieving intraretinal adhesion [9], converting the treated retina into firm scars from which redetachment will not usually occur [10, 11]. The strength of the adhesion relies upon desmosomal detachments between the pigment epithelium and the Muller cells [12], and varies with the intensity of application of the cryotherapy and subsequent damage to the retina [13]. Heavy application (prolonged whitening of inner retina) will result in almost complete destruction of the cellular elements of the inner retina, and produce lesions of exceptional strength. The strength produced by the adhesive mechanism around the break will not only resist the effect of vitreoretinal traction but by sealing the retinal break will prevent retrovitreal fluid from gaining access to the subretinal space. Although never proven with certainty, it is suggested that it is necessary to include the detached retina itself to achieve effective subsequent adhesion [14], i.e freezing of the pigment epithelium alone will not produce a lesion of much intrinsic strength. Applied correctly at the time of conventional retinal detachment surgery, cryotherapy has been proven to be exceptionally safe and it has now replaced diathermy as the method of achieving adhesion [15]. Cryotherapy allows full thickness scleral buckling procedures to be used because it can be applied without damaging the underlying sclera. It may be applied trans-conjunctivally for prophylaxis or directly through the sclera at the time of surgery. It will not damage large vessels, e.g. the long ciliary vessels with risk of anterior segment ischaemia [16]. Cryotherapy will effect adhesion between the layers of the retina once they are opposed, but is in no way responsible for the process of reattachment, which is dependent solely on break closure and relief of traction [17].

The main practical disadvantage of cryotherapy is that it is sometimes difficult to see where the treatment has been applied, particularly when substantial areas of retina are to be treated. There is, therefore, a tendency for either gaps in treatment or over-treatment.

Experience with cryotherapy over more than 20 years has demonstrated that, used correctly, it is a safe and effective method of achieving intraretinal adhesion in retinal detachment surgery. Cryotherapy, however, breaks down the blood–retinal barrier and induces an exudative or inflammatory response within the eye [18, 19]. In difficult cases of retinal detachment, particularly where proliferative vitreo-retinopathy is already established, it is possible that the widespread and heavy application of cryotherapy may stimulate the growth and progression of periretinal membranes.

While cryotherapy is the accepted method of achieving retinal adhesion, there is still great variation in the methods and types of scleral buckling, in indications and technique for the drainage of subretinal fluid and in the use of intravitreal injections. In arriving at a decision regarding the latter three techniques an attempt must be made to select the least traumatic procedure that is consistent with a successful result, a principle that has been stressed for many years [20, 21]. In most cases the decision can be made prior to surgery and only occasionally has the surgeon to alter the preoperative plan in the light of operative findings.

Scleral Buckles

The main objective of scleral buckling is to close retinal breaks, and relief of vitreous traction is an important part of that process. Scleral indentation of the walls of the globe will reduce both dynamic and static vitreo-retinal traction, i.e. a pulling force towards the vitreous cavity. Therefore a buckle produced under a retinal break will serve to relieve the tractional forces active around the break. This will tend to allow the retina to settle back against the buckle. The closure of the break by the buckle will prevent subsequent recruitment of fluid from the vitreous cavity into the subretinal space via the retinal break. When static tractional systems exist that are tangential in their action rather than vitreo-retinal, it is doubtful whether indentation has any effect on relieving such traction. The degree of scleral indentation required (the height, width and length of the buckle) will vary from one clinical situation to the other. If, for example, there is substantial subretinal fluid between the pigment epithelium and the break, the height of the buckle will need to be greater than if the retinal break is very close to the pigment epithelium (unless approximation has been encouraged at operation by drainage of subretinal fluid with or without an injection of air into the vitreous cavity).

Full thickness scleral buckles are almost invariably preferred as cryotherapy obviates the need for partial thickness scleral beds required for diathermy. The main clinical decisions facing the surgeon when considering the buckling procedure is to decide:

1. The dimensions of the buckle, i.e. the height and extent (either local, encircling or mixed)
2. The materials to be used

Local Buckles

For retinal detachments characterised by the localisation of retinal breaks to less than approximately one quadrant of detached retina and without the presence of extensive proliferative vitreo-retinopathy, local scleral buckles are the method of choice and are thus suitable for the majority of fresh detachments encountered. These procedures need only be confined to the region of the retinal breaks and the buckles themselves do not necessarily have to be permanent. Progressive shallowing of the buckle raised by silastic sponge explant is usual, and even complete removal because of infection or extrusion seldom results in redetachment. Thus, dynamic traction needs only local relief and this does not necessarily have to be permanent. Reactivation of vitreous traction on shallowing of the buckle does not matter provided a firm intraretinal scar has been formed around the retinal break. Permanent relief of traction is necessary only if there is static vitreo-retinal traction which can produce a permanent and sometimes increasing tractional force on the retina.

Local procedures are particularly suitable when a non-drainage operation is being performed. The combination results in a minimal operative procedure with low risk of morbidity. When a local buckle is to be used there are two main points for consideration: the size of the buckle and the direction of the buckle.

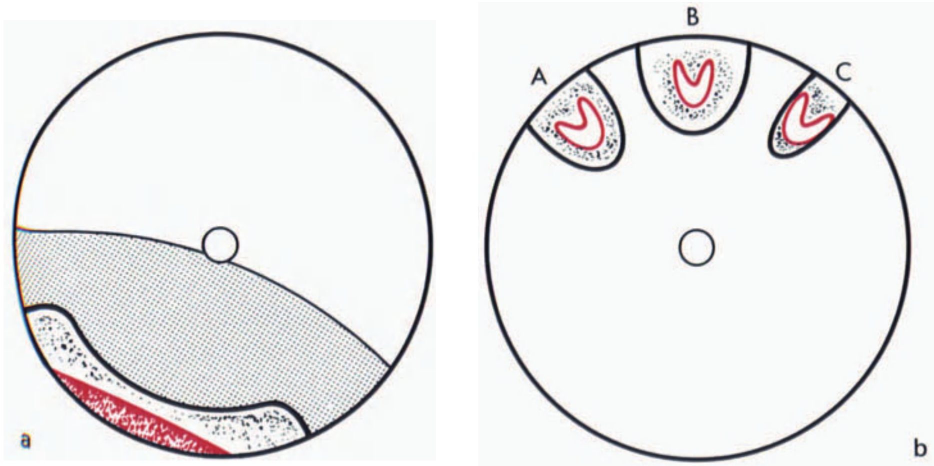

Fig. 3.1. **a** Use of a circumferential buckle to seal a dialysis. **b** *A*, The selection of a radial buckle of appropriate width and height to seal a horseshoe-shaped break. *B*, A buckle that is unnecessarily wide. *C*, A buckle that is too narrow and carries a risk of not sealing part of the break.

Size

It is usually possible to decide on the size and shape of the buckle for operation as a result of the preoperative examination. The width of the buckle is mainly determined by the size of the retinal break to be closed and by the distance separating multiple breaks if present. The buckle produced must be of sufficient width and height to leave a safety margin of approximately 1 mm of retina between the break and the edge of the buckle (Fig. 3.1). A greater margin of error must be allowed in a non-drainage operation if there is a substantial depth of subretinal fluid between the neuro-epithelium and the indent raised by the buckle, as in this situation it is often difficult to be accurate in the positioning of the buckle. This difficulty is particularly pronounced when trying to localise the posterior aspect of breaks, where subretinal fluid is deeper, with a resultant tendency to marked overestimation. The width of the buckle can be increased by increasing the diameter of the material used. If solid silicone rubber explants are being employed, then the maximum width that can be comfortably used is 9 mm (this is obtained by buckling a piece of 287 Band). The widest Silastic sponge explant that can be comfortably used is 7 mm in diameter. This can be increased by using explants placed side by side, but these should be avoided as they are awkward and cumbersome and cause much global distortion. The height of the buckle is determined by the distance by which the limbs of the scleral mattress sutures are separated and the amount by which the sutures are shortened when tied. The ease with which they are shortened depends on the intraocular pressure. If a non-drainage operation is being performed, intraocular pressure rises quickly as the sutures are tightened and considerable tension will need to be placed upon the sutures to achieve a satisfactory indent. When the eye is softened by drainage the same height of buckle can be achieved with sutures tied under much less tension.

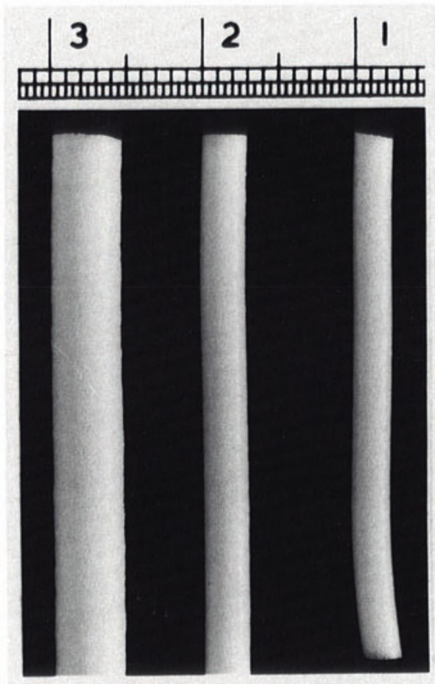

Fig. 3.2. Silastic sponge explants: 7.5 × 5.5 mm, 5 mm and 4 mm (scale in centimetres).

Materials

For local buckles Silastic sponge explants are available in various diameters (either 4 or 5 mm) (Fig. 3.2) as round sponges or as an oval sponge (5.5 mm × 7.5 mm). Silastic sponges are satisfactory for a variety of reasons:

1. The soft consistency of the sponge does not result in underlying scleral necrosis and only slight thinning of sclera is produced even when the deepest buckles are raised.
2. The sponges are relatively inert and are well tolerated by the eye.
3. The inherent elasticity of the sponges allows some expansion of the sponge to occur in the postoperative period of a non-drainage operation as the intraocular pressure returns to normal and this will result in some additional heightening of the buckle.

The main disadvantages of Silastic sponges are:

1. Infection.
2. Extrusion of the explant, which may occur at any time following surgery. Extrusion may result in bulky swelling underneath the conjunctiva, which can be felt and annoy a patient, or may present through a dehiscence in conjunctiva.
3. The height of the buckle decreases in the weeks and months following detachment surgery. This is of no disadvantage when dynamic traction systems are at play but may be a disadvantage if static traction is present on the retina, when a permanent buckle may be desirable.

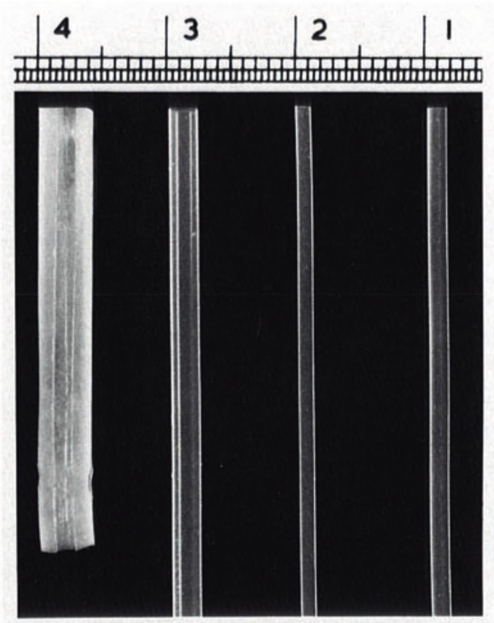

Fig. 3.3. Silicone rubber explants. *Left to right*: sizes 287, 20, 40 and 240 (scale in centimetres).

4. Silastic sponge excites a local inflammatory action and this, if related to extraocular muscles, may result in postoperative muscle imbalance. Silastic sponge is not advised as an encircling material.

Solid silicone rubber explants are available in various sizes (Fig. 3.3) and are useful for local indentation, either when combined with an encircling procedure (Fig. 3.4a) or in their own right. They cause less extraocular reaction than sponges and have less tendency to extrude [22].

When non-drainage retinal detachment operations are being performed, Silastic sponge is much easier to use than solid silicone. The latter will only produce shallow indentation owing to its inelasticity and can be used only in non-drainage detachment surgery when very shallow subretinal fluid is present between pigment epithelium and break.

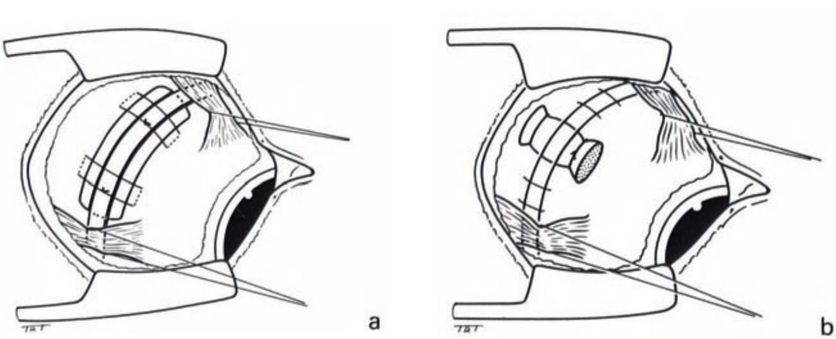

Fig. 3.4. **a** A silicone rubber encircling band has been locally enhanced by the use of an underlying tyre. **b** A combination of an encircling band and a radial Silastic sponge explant.

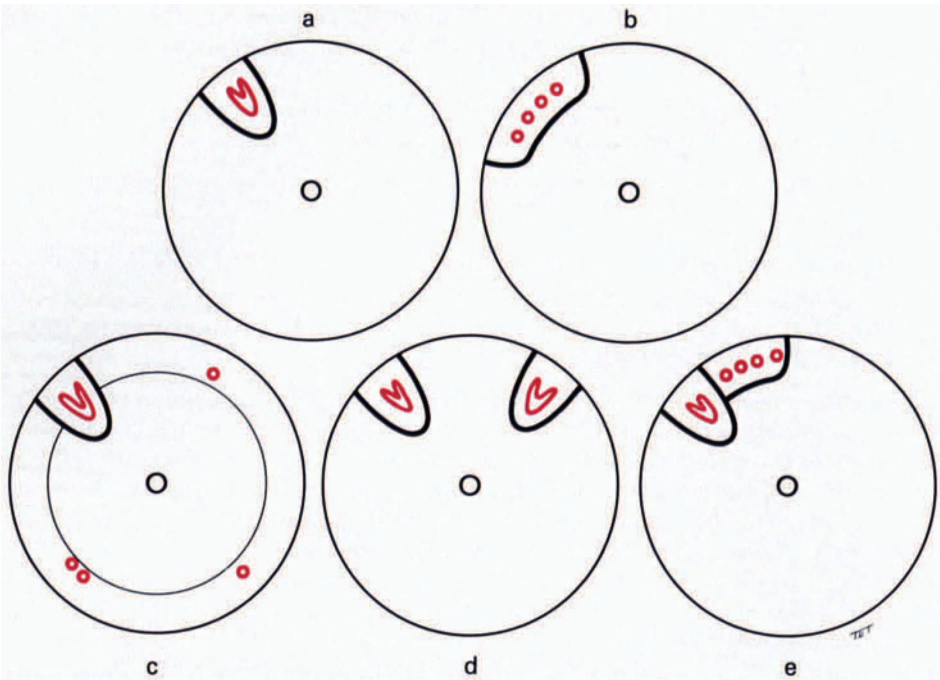

Fig. 3.5a–e. The management of different arrangements of retinal breaks. **a** A single tear treated by radial buckling. **b** A row of round holes treated by circumferential buckling. **c** Multiple retinal breaks treated by radial buckling of a tear and an encircling band to close small round holes in three separate quadrants. **d** Two separate breaks treated by separate radial buckles. **e** A tear in close proximity to a row of more anterior round holes treated by radial and circumferential buckles in closed apposition.

Direction

The direction of the local explant is either radial or circumferential in relationship to the limbus. Rarely, obliquely placed explants are used and sometimes the disposition and orientation of the retinal breaks necessitate the combination of circumferential and radial implants (Fig. 3.5). Selection of the direction of the explant to be used depends upon the type of retinal break and the relationship of one break to another. Radial buckles have as their main advantage the reduction of the risk of troublesome fish-mouthing of retinal breaks due to the formation of retinal folds [23]. In fish-mouthing, a fold of retina extends over the buckle from the detachment behind the indentation to a break, usually a tear at its anterior extremity (Figs. 5.9 and 5.10). Circumferential buckles tend to shorten a sector of buckled sclera with the result that redundant retina is thrown into folds [24]. These folds may appear de novo in the postoperative period but warning as to the likelihood of their appearance is given by the preoperative presence of any radial retinal folding in the vicinity of the retinal break. This problem is countered by the use of intravitreal gas (see later). Radial buckling is preferred in the following situations:

1. Retinal tears. Radial implants are particularly suitable for buckling this type of

retinal break, especially if the break is single. The buckle can close the break and by supporting the tear in its long axis relieve traction on its anterior aspect (Fig. 3.5).

2. When the preoperative presence of radial folds suggests the possibility of postoperative fish-mouthing.

Circumferential buckles are particularly indicated in the following circumstances:

1. Long retinal breaks (e.g. dialysis) (Fig. 3.1).
2. Multiple breaks close together (Fig. 3.5b).
3. When the position of retinal breaks is uncertain, necessitating the buckling of more than just small areas of retina (Fig. 3.9), particularly if proliferative vitreo-retinopathy is present.

While the selection of direction of the buckle and type of material to be used is important in some situations (for example, the use of radial Silastic sponge to seal a retinal tear in a non-drainage operation), in others, particularly when subretinal fluid is thin and breaks are small, the choice may not be of great importance as with any material and direction of explant, closure of breaks is easy and fold formation in the postoperative period extremely unlikely.

The Encirclement Procedure

The encirclement procedure became popular as it was considered desirable not only to seal the retinal break with a buckle but also to produce a 360° buckle that was permanent. In addition it enjoys popularity because the production of "a false ora serrata" theoretically guards against detachment at a later date, and will also have the advantage of buckling undetected retinal breaks.

In retinal detachments uncomplicated by periretinal membranes there is no evidence that a permanent 360° buckle is advantageous in the majority of clinical situations encountered. Encirclement to seal undetected retinal breaks is particularly favoured by the occasional retinal surgeon who may not have the time or expertise to detect retinal breaks with certainty either preoperatively or at the time of surgery. Even if breaks have been located, the confidence to place a local buckle with accuracy may be lacking. In spite of the fact that the encirclement procedure should not be used unnecessarily, it has a well established role to play, particularly in the management of more complex types of detachment.

Indications

Multiple Breaks. Even if multiple, the majority of retinal breaks occur reasonably close to each other and can therefore usually be treated by local buckles [25]. Sometimes, however, breaks are widely scattered, making local buckling awkward and impractical.

Uncertainty of the Position of Retinal Breaks. In the great majority of cases where retinal breaks are not detected and the retinal view is good, encircling will be advised. The only exceptions are cases where the extent of detachment is small and the majority of detached periphery can be covered by the buckle. In most other cases where breaks are not found encirclement will be performed with a view to closing the unseen retinal breaks with or without the addition of local buckles.

Proliferative Vitreo-retinopathy. Static retinal traction, particularly if transvitreal in nature, may best be treated by encirclement as in these cases it is useful to reduce the diameter of the globe in the plane of the encirclement, thereby relieving traction on the underlying retina. In tangential retinal traction the role of the encirclement is less certain.

Support of a Local Buckle. In some cases where a local buckle is being used, retention of the buckle is facilitated by the use of an encircling band. This is so when thin sclera is present, making local buckling sutures difficult to retain, or the local buckling process is to be very extensive and a wide silicone rubber gutter is to be used.

Materials

Silicone rubber bands in various sizes are used. The 20 (2 mm in diameter), 240 (2.5 mm in diameter), 40 (5 mm in diameter) and 287 (9 mm in diameter) bands are among the most useful sizes. The selection of the width of band will depend upon the type of problem to be solved; thus, for general supportive encircling procedures the 40 or 240 band is most convenient, whereas the 287 band is suitable if there are extensive and large breaks to be covered together with wide areas of vitreo-retinal traction to be relieved. In general, however, wide encircling buckles are not often employed for conventional retinal detachment surgery as they entail a higher risk of postoperative complications.

Combined Local and Encircling Buckles

In the majority of cases when encirclement is to be used, augmentation of the buckle either in height or width may be achieved with additional local buckles. For this purpose either underlying silicone rubber explants or Silastic sponge may be used (Figs. 3.4, 3.5). If only a small area of local augmentation is required (for example, under a single retinal tear), a radially placed Silastic sponge explant is positioned underneath the encircling band. If a more extensive area of buckling is required, for example, a quadrant of retina where several breaks are present, then an underlying silicone rubber gutter is suitable. The choice of the local underlying gutter will again depend upon the width of support required. For most purposes when a 20 band is being used an underlying silicone gutter of size 40 or size 287 is found to be most useful.

Complications

Complications of combined encircling and local buckles are related firstly to the nature of the material being used and secondly to the buckling process itself. The advantages and disadvantages of Silastic sponge have already been mentioned (p. 77). In general, complications following encirclement are greater than those following local explants [26]. Encirclement carries a higher incidence of anterior segment ischaemia of varying severity (an encircling procedure is particularly contra-indicated when reduction of perfusion of the anterior segment is hazardous, e.g. HbSc disease [27]), of glaucoma and of serous choroidal detachment. Encirclement may cause enophthalmos and create a cosmetic problem. Poor cosmesis may be of very great disadvantage to some patients. There is also the likelihood of more postoperative pain following an encirclement procedure, and although such pain usually lasts only a week or two, it may persist for many months. Most of the serious complications of the encircling procedure result from high, wide posterior buckles that are rarely necessary, and severe complications are rarely encountered if the height of the encircling buckle does not exceed approximately 2 mm. It is better to achieve a low encircling buckle augmented locally where necessary. In practice, however, and particularly if subretinal fluid is going to be drained from the eye (which it will be in the majority of encircling procedures), the actual height of the encircling buckle is sometimes difficult to determine with certainty.

In summary, the encircling procedure is more traumatic than local buckling procedures and is rarely indicated for the treatment of retinal detachment where breaks are confined to a single quadrant.

Non-drainage Operation

The non-drainage operation was introduced initially by Custodis [28] and was later modified and popularised by Lincoff [29]. At first highly controversial, this type of procedure has slowly gained general acceptance [30–34]. The stimulus to its introduction was that no matter how carefully the drainage of subretinal fluid from the eye is performed, this remains the least predictable step in retinal detachment surgery [35]. The most serious complication of subretinal fluid drainage is choroidal haemorrhage. Other complications such as retinal incarceration, vitreous loss, hypotony and intraocular infection are less common. As well as causing technical difficulties at the time of surgery, such as obscuring the view and making the closure of retinal breaks difficult, these serious complications may eventually contribute to failure by promoting proliferative vitreo-retinopathy [36]. It is therefore obvious that if this step can be eliminated the operation becomes much safer by turning it into a purely extraocular procedure.

The rationale of the non-drainage operation is that after accurate placement of a scleral buckle, resulting in closure of the retinal break either at the time of surgery or in the postoperative period (Fig. 3.6), subretinal fluid will be absorbed spontaneously, rendering it unnecessary to evacuate the fluid at operation. If the break can be closed at the time of surgery then there is cessation of fluid flow from the vitreal to the subretinal compartment and pigment epithelium will pump out subretinal fluid towards the sclera. It is unlikely that the detached retina itself plays any part in fluid absorption as it is not well equipped to absorb fluid [37]. One of the most remarkable features of the non-drainage operation is that it has not been found necessary in all cases to close the break at the time of operation provided the buckle has been accurately sited underneath the break and is of adequate dimensions. The break will gradually sink back against the buckle within a period of 24–48 hours to be followed by absorption of the remaining subretinal fluid. In these cases the initial movement of the detached retina towards the pigment epithelium in the early postoperative period is hard to explain. It is probable that relief of vitreous traction by raising the buckle is an

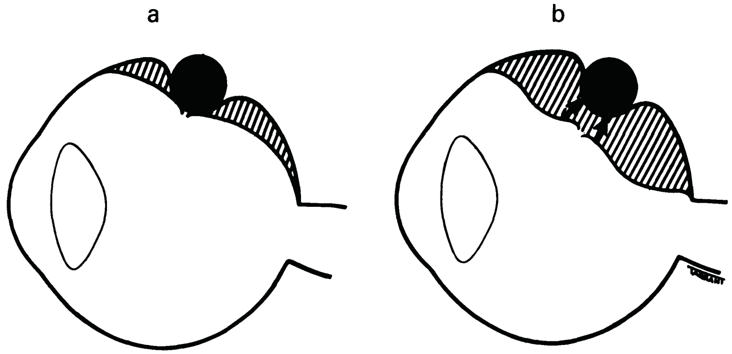

Fig. 3.6a,b. The non-drainage operation. **a** Retinal break closed by a buckle at the time of surgery. **b** The break has not been closed but can be expected to do so in the postoperative period provided the retina is mobile and the depth of intervening subretinal fluid is not too deep.

important factor and it has also been postulated that at least in some cases (when the break is anterior) cortical gel may be forced into contact with the break and prevent further recruitment of fluid from the vitreal space [37]. Cryotherapy does not influence the absorption of subretinal fluid in the postoperative period as patients treated with buckling without cryotherapy absorb fluid in an identical way [38, 39].

The main advantages of the non-drainage operation can be summarised as follows:

1. Serious intraocular complications are avoided.
2. The procedure involves minimal trauma, giving a very quiet postoperative eye.
3. The operation is fast.
4. In the event of reoperation the surgeon will return to an eye that has been little altered by the previous procedure.

Disadvantages of the non-drainage operation are as follows:

1. The eventual height of the buckle is difficult to anticipate, as a result of which buckles are often much higher than desirable, causing astigmatic errors [40].
2. If there is substantial fluid between break and pigment epithelium then the localisation of the retinal breaks is difficult and inaccuracies in the placement of the buckle may occur.

In summary, the non-drainage retinal detachment operation is suitable for a substantial range of simple retinal detachment cases when subretinal fluid under the break is not too deep, when the arrangement of the breaks is not too complex and when detached retina has not become infiltrated by extensive periretinal membranes. Cases for reoperation [41] and aphakia [34] are perfectly suitable for non-drainage procedures, provided the above criteria are followed. In most non-drainage operations, local buckling procedures will be favoured using Silastic sponge explants, but on some occasions encirclement may also be performed.

Indications for the Drainage of Subretinal Fluid

1. *To aid localisation.* Localisation of the buckle is difficult, particularly when there is a considerable depth of subretinal fluid between buckle and break and when breaks are large or multiple. In these cases, drainage of subretinal fluid, often combined with an injection of air into the vitreous cavity, is the best method to ensure accurate siting of breaks on buckles.

2. *Presence of periretinal membranes.* The presence of periretinal membranes, particularly if they are related to the retinal breaks, may necessitate the drainage of subretinal fluid for two reasons:

a) The membranes may result in relative immobility of the detached retina [42, 43]. The intrinsic success of the non-drainage operation when it is not possible to close the break at the time of retinal surgery is dependent upon the capacity of the detached neuro-epithelium to move back towards the scleral buckle. If this movement is prevented by immobility of detached retina, the retinal break will not close and the case will fail.

b) The need for internal tamponade. If local periretinal membranes are exerting tractional forces on the retinal break, it may be felt that in addition to the buckle, internal tamponade is also necessary to secure prolonged closure of the retinal break against the buckle. Drainage will have to be performed to allow the space for an intravitreal injection.

3. *Danger of high intraocular pressure.* While the buckle sutures are being tightened during a non-drainage operation, the intraocular pressure may rise to 60 mmHg or more. This pressure returns to normal in a healthy eye within about 15–20 min. However, there are occasions when it is impractical to raise the intraocular pressure to this extent:

a) Open angle glaucoma. The outflow channels may be unable to cope with the raised pressure and demand for increased aqueous outflow. The rise in pressure may therefore be unduly prolonged, which results not only in risk of ischaemia of the optic disc but also in a much longer operating time.

b) Rupture of an anterior segment wound. When cataract or corneal surgery has recently been performed the non-drainage operation must be executed with great caution as there is danger of rupture of the anterior segment wound. It may be safely performed approximately 3 weeks after a cataract operation. Drainage of the subretinal fluid will usually be indicated if detachment arises following corneal graft surgery, unless the latter has been performed several months prior to the contemplated detachment operation.

c) Unseen optic disc. A good view of the optic disc is essential to check the arterial patency, seen as arterial pulsation when the pressure rises. The view of the optic disc can be obscured by opacities in the media, or by an overhanging retinal detachment itself. If the disc cannot be seen, then subretinal fluid must be drained from the eye.

d) Ipsilateral poor ocular perfusion. This may result in closure of the central retinal artery as soon as there has been even the slightest rise in intraocular pressure, e.g. in central retinal artery disease, ipsilateral carotid artery disease or carotico-cavernous fistula. Similarly, hypotension as a result of anaesthesia may contribute to the reduction of perfusion of the globe. Early closure of the central retinal artery makes the non-drainage operation impossible.

e) Thin sclera. The tying of the buckle sutures in the non-drainage operation puts considerable tension on the adjacent sclera and when the latter is very thin, it may be quite impossible to get the sutures to hold. Drainage of subretinal fluid is then necessary to allow the buckle to be raised.

Intravitreal Injections

Gases

The practice of injecting air into the vitreous cavity has been used for many years [44] and the advantages of using an intraocular gas in the management of certain types of retinal detachment have been stressed [45, 46]. The physical qualities of gases when injected into the vitreous cavity may be of value to the retinal surgeon in the following ways:

1. *To manipulate retina.* As the injection proceeds and the volume of the gas bubble increases within the vitreous cavity, it will tend to push the detached retina back towards the neuro-epithelium. The gas bubble itself has a high surface tension and will not pass through retinal breaks into the subretinal space, i.e. the bubble of gas can be made to iron out the detached retina, against the natural concavity of the globe (Fig. 4.12). This technique is indicated when there is deep subretinal fluid between break and pigment epithelium.

2. *For internal tamponade.* The bubble produces internal closure (tamponade) of the retinal break, which will prevent recruitment of subretinal fluid from the vitreal compartment to the subretinal space. This tamponade of the retinal break is particularly useful when proliferative vitreo-retinopathy has created tractional systems active in the vicinity of the retinal break and prolonged break closure is necessary.

Both of these main effects can be used to a lesser or greater degree, depending on the clinical situation for which intravitreal gas is being used. Once the objective of the intraocular injection has been decided upon, the type of gas best suited to achieving that objective can be selected.

Deep Subretinal Fluid Without Significant Proliferative Vitreo-retinopathy

Air is the most convenient gas used for intravitreal injection in these cases (Fig. 3.7) [47, 48]. The main advantages of using air when there is deep subretinal fluid between the retinal break and the pigment epithelium are:

1. The approximation of pigment epithelium to the neuro-epithelium makes the application of cryotherapy much simpler and there is much less tendency to over-freeze.
2. The placement of the scleral buckle is likely to be much more accurate, and use of a buckle of unnecessary height or width is also avoided.
3. By ironing out detached retina prior to raising of the buckle, radial folds are avoided (Fig. 3.8).

Fig. 3.7. A bullous upper-half retinal detachment is present with two large retinal tears associated with lattice degeneration. There is deep subretinal fluid between breaks and pigment epithelium.

For these advantages to be utilised, prolonged action of the gas is not necessary because break tamponade is unnecessary, the break being closed by the buckle; for this reason air is the most suitable gas, usually disappearing within a few days (of a 1–2 ml injection) after surgery.

Gas Internal Tamponade in Conventional Retinal Detachment Surgery

The use of a gas to close retinal breaks was popularised by Rosengren [44] but gradually fell into disuse following the introduction of scleral buckles. In recent years, the value of internal tamponade of retinal breaks has been rediscovered; it is particularly favoured as part of pars plana vitrectomy but also has a role (as yet not fully defined) to play in the management of cases without vitrectomy. For

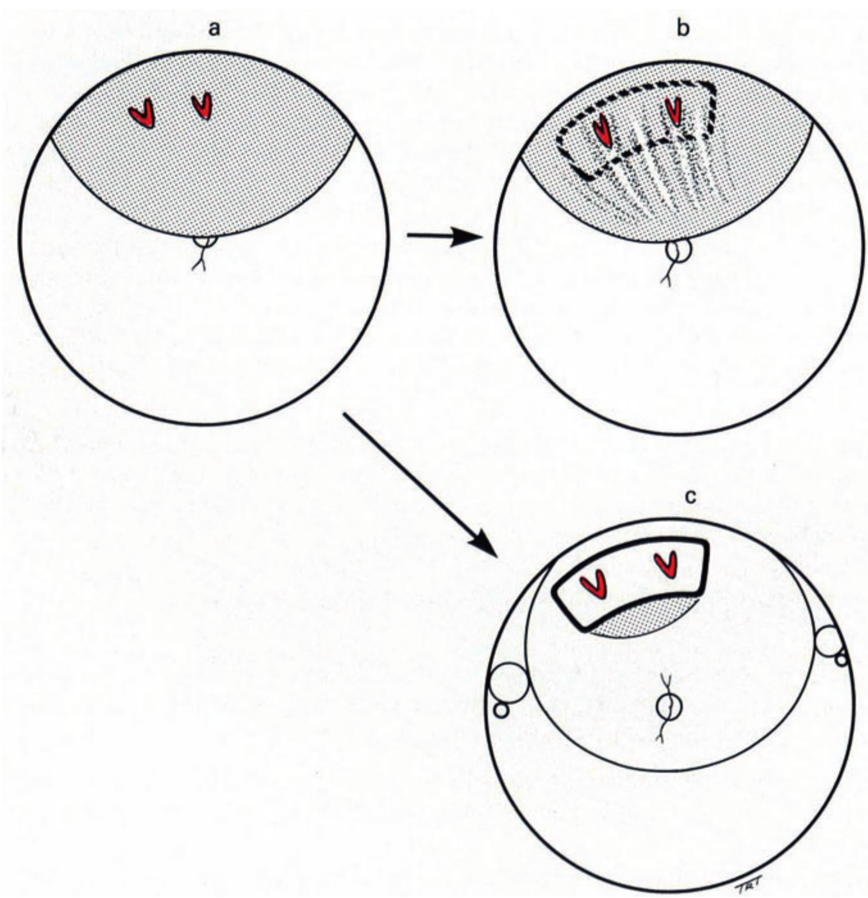

Fig. 3.8. **a** Bullous upper-half retinal detachment is present. **b** Drainage of subretinal fluid and tightening of a circumferential buckle results in multiple communicating radial folds. This situation can be obviated by the use of intraocular air consequent to the drainage of subretinal fluid, as seen in **c**.


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these purposes, expanding gases such as sulphur hexafluoride (SF6) or the perfluorohydrocarbons (Perfluoropropane C3H8 has been found most useful) can be used.

Detachment with Proliferative Vitreo-retinopathy. In cases of retinal detachment when proliferative vitreo-retinopathy is present but not extensive (less than C2 approximately), the tractional systems tend to reopen breaks in the postoperative period as well as making break closure more difficult with buckling alone. In these cases it is desirable to achieve not only closure of the break at the time of surgery but also to tamponade the break for long enough for the cryotherapy adhesion to be established (1–2 weeks). Most experience has been gained using SF6 [45]. This gas, when introduced into the eye, absorbs nitrogen from the blood so that the gas will in fact double its volume in the postoperative period of 24 h. If used undiluted in amounts of more than about 1 ml, expansion may raise the intraocular pressure to a dangerous level and threaten central retinal arterial patency. The volume of the gas that can be injected depends on the degree of softening of the eye that has occurred following drainage of subretinal fluid. If in fact only 1 ml of gas can be injected, then pure SF6 can be used. If, say, 2 ml can be injected, the mixture should consist of 1 ml of SF6 and 1 ml of air. In either case the intraocular bubble and has an effective life of at least 10 days.

Large or Giant Breaks. External buckles will not be sufficient to close large or giant breaks. These are best closed by internal tamponade. This is usually achieved with pars plana vitrectomy and tamponade, with either silicone oil for flapped over giant breaks or an air/SF6 mixture for less complicated break arrangements. These techniques have a high success rate, but particularly in the case of silicone oil are not without complications [49]. Recently some giant breaks have been treated successfully using perfluoropropane, which is a particularly insoluble gas [50, 51], with a simple retrovitreal injection [52]. This gas expands to four times its original volume over a period of 3–4 days and has a prolonged action of tamponade (1 ml lasts about 70 days). The advantages of perfluoropropane are that its slow expansion allows manipulation of a giant break and the small quantity required obviates the need for vitrectomy and drainage of subretinal fluid.

Detachments Without Proliferative Vitreo-retinopathy. The use of intravitreal expanding gas for the treatment of simple retinal detachment, characterised by the presence of breaks in the upper half of the retina, has recently been advocated [53]. An intravitreal injection with cryotherapy, but without buckling or drainage of subretinal fluid, is performed. Results of this procedure are interesting, but the technique is still being evaluated. In using gas bubbles to effect internal tamponade, the bubble must be in contact with the retinal break. Gas bubbles therefore are particularly effective in the tamponade of superior breaks but are much less useful when inferior breaks are to be closed.

Disadvantages of Gas Injections

The main disadvantages of gas injections are:

1. Complications may arise (see pp. 128 and 141).

2. Patients have to position their heads for some time in the postoperative period, so that the correct position of the bubble is achieved.

Intravitreal Saline

The injection of balanced salt solution into the vitreous during conventional retinal detachment surgery is sometimes necessary and is indicated in the following situations:

Aphakia. When intracapsular cataract surgery has been followed by aphakic detachment an intravitreal gas bubble tends to come forward through the pupil, into the anterior chamber. This will obscure the view of the posterior segment. The passage of an air bubble into the anterior chamber is inevitable if a preoperative examination has revealed that the anterior hyaloid face is broken and there is free communication from posterior to anterior chambers. In these situations it will be necessary to substitute the use of an air injection into the vitreous cavity by that of balanced salt. The disadvantage of a fluid injection is that it will tend to pass through the retinal break into the subretinal space and retina will not flatten completely. However, usually at least some movement of neuro-epithelium towards pigment epithelium can be achieved and accurate scleral buckling can still be attained.

Hypotony. Hypotony may occur during surgery, either as a result of excessive planned drainage of subretinal fluid or because of unplanned drainage of subretinal fluid with a scleral stitch. After tightening of the buckle sutures, the eye may still remain excessively soft following extensive drainage and there is a danger of choroidal haemorrhage. The temptation to restore intraocular pressure by further increasing the height of the buckle should be resisted as excessive tightening of a buckle procedure will result in gross over-indentation of the globe. Instead intraocular pressure should be restored with the use of an intravitreal air injection of saline or air.

Silicone Oil

The advent of vitreous surgery has meant that silicone oil is now never used in simple retinal detachment surgery but only on occasion during vitrectomy.

Conventional Surgery in Special Cases

Rhegmatogenous Detachment Without Apparent Breaks

In some cases of retinal detachment it may not be possible to find retinal breaks either at preoperative examination or during surgery. At surgery, previously unseen retinal breaks may be found on scleral depression, particularly if the preoperative examination was not well tolerated by the patient. Breaks may also be found when suspicious areas are treated with cryotherapy, and sometimes

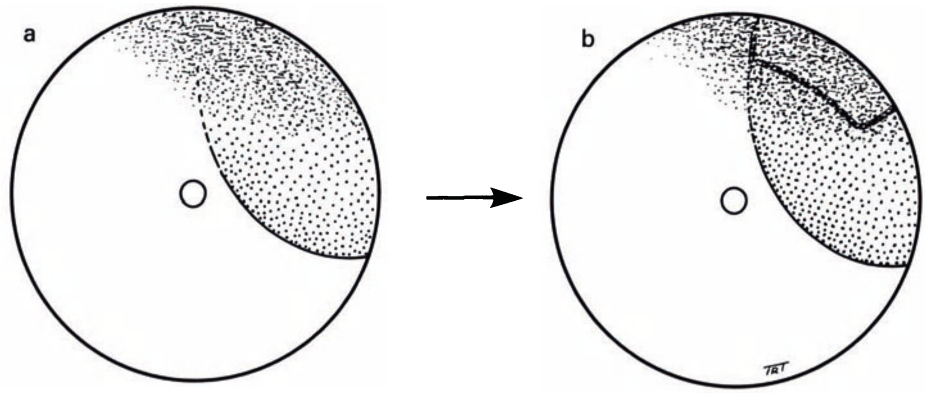

Fig. 3.9. A localised retinal detachment is present, the upper part of which is obscured by the presence of opacities in the media (**a**). The view of posterior retina is not obscured. A localised circumferential buckle is used to seal the unseen presumptive break (**b**).

unseen retinal breaks may come into view after subretinal fluid has been drained, particularly if the fluid is deep. If, however, breaks are still not demonstrated, a decision has to be made regarding the type of operation to be planned and this decision will depend upon the clarity of the ocular media.

1. *Clear Media.* If the view of the detached retina is completely (or nearly so) unimpeded by opacities in the ocular media, and a detailed examination of the retina has not revealed a retinal break, then it may reasonably be assumed that the break is small and is more than likely to be in the equatorial or pre-equatorial region of the retina [54, 55]. In these cases a conventional buckling procedure should be performed. If only a quadrant or so of retina is detached, then the whole quadrant can be buckled (Fig. 3.9). If the detachment is extensive, then an encircling procedure will be indicated (using a 40 band), accentuating the buckle (with 20 silicone rubber gutter) under suspicious areas of retina and at those sites where the distribution of subretinal fluid has indicated that the primary break is most likely to be situated [56]. Subretinal fluid will be drained if deep but not if shallow.

2. *Marked Opacities in the Media.* If there are marked opacities in the media or if the view of the retina is obscured by a poor view through the pupil, the treatment of choice is pars plana vitrectomy. Conventional buckling procedures have little chance of success when the view of the underlying retina is extremely poor. Vitrectomy offers the outstanding advantages that it not only clears the ocular media of the offending opacities but also may allow the identification of retinal breaks during the operative procedures and provides the surgeon with the chance to deal with unseen periretinal membranes at the time of the operation.

Retinoschisis Complicated by Retinal Detachment

If the schisis is entirely separate from the retinal detachment, the area of retinal detachment should be treated in the usual way and the schisis left completely alone. More usually, however, the retinal detachment has arisen from the schisis itself. These cases may lead to great difficulty in management. If outer leaf breaks are not too large (inner leaf breaks, if they can be detected, are usually in direct relationship to the outer leaf breaks), conventional retinal detachment surgery in the form of external scleral buckling of the outer leaf breaks and drainage of subretinal fluid with cryotherapy may be used. If, however, outer leaf breaks are large and therefore not amenable to local buckling procedures, pars plana vitrectomy should be performed. The primary objective of this procedure in these cases will be to provide space for intravitreal injection of an air/SF6 mixture to provide internal tamponade.

Retinal Detachment Complicated by Proliferative Vitreo-retinopathy

Tractional retinal detachment in which vitreo-retinal traction has resulted in tenting up of the retina at the point of vitreous attachment and in which there is no full thickness retinal break does not require treatment since tractional detachments of this type are usually static. If on the other hand a traction detachment is complicated by full thickness break formation with rhegmatogenous detachment occurring as a secondary event, or if a simple rhegmatogenous retinal detachment is complicated by periretinal membrane formation, then surgical treatment is necessary. Surgical treatment is the same in both cases, although the aetiology and anatomical questions posed are different. By whatever method contracting membranes have arrived within the eye, the guidelines for treatment depend upon the severity of the fibrotic process. If tractional retinal forces exerted by the membranes are not severe, i.e. the membranes are weak and usually in an early stage of their development (less than C1 on the American Society Classification), then closure of the breaks and flattening of detached retina will abolish the stimulus to membrane formation and prevent maturation of existing early membranes or formation of new ones. In these cases, conventional retinal detachment procedures should be used. However, in cases when the membranes are near the retinal break, it is wise to make sure that the break is closed at the time of surgery. This may or may not require drainage of subretinal fluid and injection of air. If there are poorly developed membranes elsewhere in the retina, they can be ignored and there is nothing to be gained by attempting to buckle them.

With increasing severity of the fibrotic process (up to C1–C2 of the Retinal Society Classification) conventional surgery will still be used [57] in preference to pars plana vitrectomy [58, 59] (providing there are no other reasons for vitrectomy, such as opacities in the media). In these cases, breaks must be closed at the time of surgery, usually using higher and broader buckles than in uncomplicated cases, and accessible membranes (they will be mainly equatorial) not related to breaks are best supported by an encircling element. Buckling of these membranes will not only tend to close any unseen breaks but also reduce the tendency of membranes (in spite of break closure) to prevent settling back of retina in their immediate vicinity. In spite of break closure, established membranes, if not supported, will result in residual traction detachment; this will tend to progress and eventually pull the previously sealed breaks from the buckles and cause complete redetachment.

If membrane formation is very extensive (more than C2 of the American Society Classification) conventional retinal detachment surgery will have little hope of success and pars plana vitrectomy is indicated, with its main objective of direct internal relief of tractional forces. Peeling and cutting of membranes [60], combined with endo-laser photocoagulation, gas [61] or silicone oil tamponade [62] and sometimes direct cutting of retina to relieve traction [63], are the main methods in current use to reattach these advanced fibrotic cases.

Indications for Vitrectomy

While conventional retinal detachment surgery will be the method of choice in the majority of patients, the availability of vitreous surgery has greatly increased the therapeutic options available to the surgeon. Vitrectomy may be indicated as the first procedure in a given instance and should not be regarded as a technique to be employed only after the failure of conventional surgery. It is important to select the operation that has the best chance of success with a single procedure [64], as with successive procedures the visual results get steadily worse. The indications for vitrectomy when the retina is detached are considered below.

Poor View of the Retina

If it is impossible for at least a reasonable view of the detached retina to be obtained, then vitrectomy is necessary. This will have the object of clearing the media and this will not only help the final visual result of the procedure but also provide a chance for breaks to be identified and membranes dissected if necessary. The advent of vitrectomy has greatly improved the prognosis in cases in which there is a very poor view of the detached retina (e.g. in aphakic retinal detachment following congenital cataract surgery [65]), which used to be treated by a hopeful encircling procedure placed in the equatorial region of the eye, combined with extensive cryotherapy and drainage of subretinal fluid. The results were not good.

The most usual obstructions to the view of the underlying retina are at the lens–iris diaphragm or within the vitreous cavity. Lens opacities themselves have to be severe to necessitate their removal via the pars plana or anterior segment as a prelude to vitrectomy and retinal detachment repair. More usual interference is provided either by the failure of the pupil to dilate (e.g. after complicated intracapsular or congenital cataract surgery or iris clip lenses) or by thickened capsular remnants following cataract surgery. The commonest opacity of the vitreous itself is that of vitreous haemorrhage. Other opacities in the vitreous such as infiltration by inflammatory cells are less common.

When the view of the posterior segment is particulary bad, B-scan ultrasonography is necessary to confirm the presence of retinal detachment, which may be clinically suspected by virtue of the presence of a relative afferent pupillary defect and an inability to project light accurately in all four quadrants. Pars plana vitrectomy should be carried out as soon as is reasonably possible after the diagnosis has been made.

Proliferative Vitreo-retinopathy

The growth of periretinal membranes may make conventional procedures unsatisfactory in the following circumstances:

1. *Macular pucker.* If retinal detachment is complicated by macular pucker, then the visual results of conventional surgery will be spoiled by the postoperative presence of the pucker, even if the retina is successfully reattached. Visual acuity will be low and distortion of the image very disturbing. In these cases, vitrectomy should be performed and the preretinal membrane peeled as the primary procedure, even if the retina elsewhere is not affected by membrane formation.

2. *Advanced proliferative vitreo-retinopathy*

a) When there is more than C2 of generalised membrane, or sometimes less if focal membrane is severe, e.g. at the pars plana in one quadrant following a perforating injury.
b) When there is rhegmatogenous detachment complicating traction detachment.

Difficult Breaks

Large or Giant Breaks. Although there is some potential for treatment of these cases with simple vitreal injection, while they are as yet uncomplicated by membranes, the majority need to be treated by vitrectomy and gas or silicone oil tamponade to relieve vitreo-retinal traction and to peel membranes that have formed. Gas or silicone oil tamponade will not be necessary for large or giant breaks in which there has been little displacement of the posterior flap, and these cases will still respond to conventional buckling. In more advanced cases the use of silicone oil combined with vitrectomy for internal relief of tractional systems is not only useful for prolonged postoperative tamponade but is an effective peroperative tool for achieving reattachment.

Retinoschisis. Vitrectomy is useful when outer leaf breaks are large.

Inaccessible Breaks. Breaks at the posterior part of the eye (e.g. macular or peripapillary breaks) are difficult to buckle, particularly as they are often associated with high myopia where the posterior part of the globe is thin and staphylomatous. Conventional external buckling in these cases was difficult and dangerous. Macular breaks, either primary or secondary, are best treated by internal gas tamponade. If they are secondary, peripheral breaks will also have to be sealed by buckling at the time of vitrectomy. Pars plana vitrectomy and gas tamponade has been found to be safe and simple in these cases [66, 67], although a simple injection of an expanding gas without vitrectomy has also been suggested [68, 69].

Multiple Large Breaks with Minimal Subretinal Fluid. In these cases conventional surgery is difficult, the small amount of subretinal fluid not allowing substantial external drainage and room for intraocular air injection. Vitrectomy provides the space for internal tamponade, as well as relieving vitreous traction on the breaks. In these cases superior breaks do not need to be buckled at all.

The use of pars plana vitrectomy for the treatment of patients with awkward breaks has represented one of the major advances in retinal detachment surgery and success rates with vitrectomy in these cases are now high, compared with the previous very poor results obtained with conventional detachment techniques.

Intraocular Foreign Bodies

When retinal detachment is combined with retention of an intraocular foreign body (IOFB), vitrectomy is indicated if removal of the IOFB is deemed necessary (e.g. the foreign body is metallic or intraocular infection is suspected). If IOFB removal is not necessary (e.g. retained glass), conventional detachment surgery may be sufficient to flatten the retina unless other features, such as proliferative vitreo-retinopathy, demand vitrectomy in their own right.

Choroidal Detachment

Eyes in which there is choroidal detachment are usually hypotonic and difficult to operate upon. If a choroidal detachment is small and unrelated to the retinal break, the choroidal detachment may be ignored and conventional buckling surgery performed.

However, if choroidal detachment is extensive and related to retinal breaks, conventional surgery is very difficult. Cryotherapy cannot be applied in a

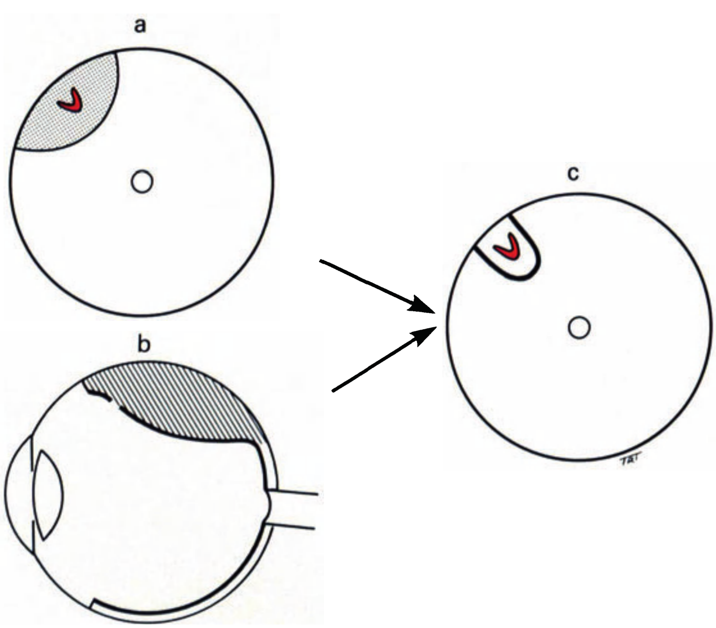

Fig. 3.10. *Example 1.* A single retinal tear is present in a retinal detachment (**a**) and there is only thin subretinal fluid between break and pigment epithelium (**b**). These cases can be treated with simple non-drainage retinal detachment surgery (**c**). A 5-mm radial sponge has been used.

satisfactory way, even if drainage of suprachoroidal fluid is performed. Pars plana vitrectomy allows drainage of suprachoroidal fluid and re-establishment of normal intraocular pressure facilitates break localisation and allows application of cryotherapy or endo-laser photocoagulation.

Combined Situations

In a proportion of cases vitrectomy is advised for a combination of reasons, e.g. a poor view of the retina plus proliferative vitreo-retinopathy.

Examples of suggested methods of treating different types of retinal detachment are shown in Figs. 3.10–3.15. A summary of the surgical approach to rhegmatogenous retinal detachment is shown in Fig. 3.16.

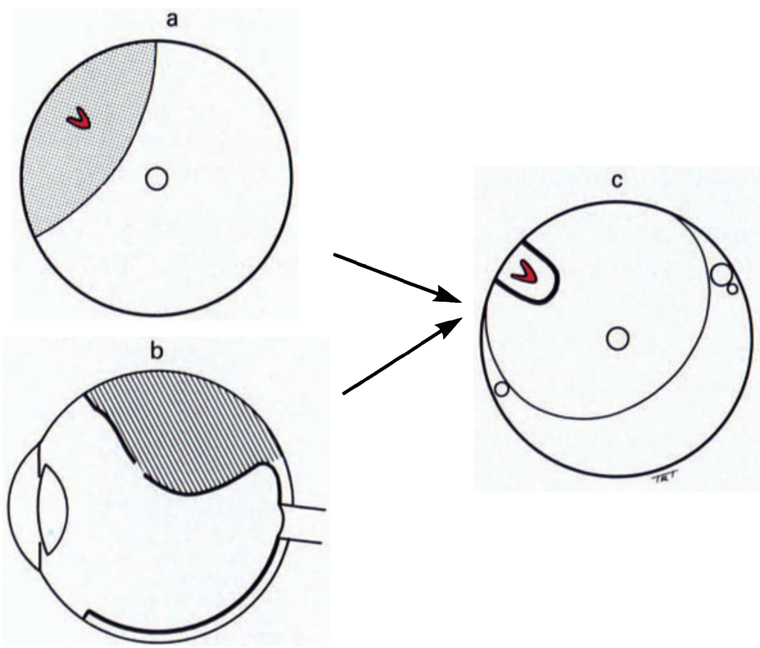

Fig. 3.11. *Example 2.* In this case the subretinal fluid between retinal break and pigment epithelium is deep (**a**, **b**). Drainage of subretinal fluid is followed by intravitreal injection of air, cryotherapy and buckling of the retinal break (**c**) with a radial sponge.

Fig. 3.13. *Example 4.* Retinal detachment is present with a substantial degree of preretinal membrane in the vicinity of the retinal breaks and in neighbouring retina (**a,b**). Although subretinal fluid may not be deep between break and pigment epithelium, retinal breaks must be closed at the time of surgery. A radial buckle is used (**c**) to close the upper tear (4-mm sponge). A circumferential explant (5-mm sponge) is used not only to seal the lower break but also to support equatorial membranes in which further breaks may be hidden. It will usually be necessary to drain subretinal fluid in these cases to ensure break closure. The surgical sequence is cryo, drain, buckle, gas.

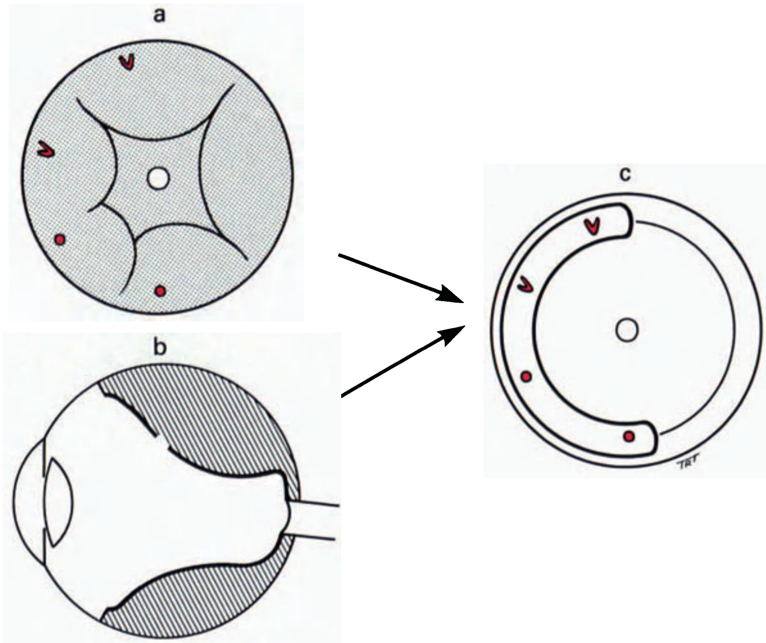

Fig. 3.12. *Example 3*. Total retinal detachment is present with multiple breaks (**a**). At least one of the breaks has substantial fluid between break and pigment epithelium (**b**). This case is treated with an encircling band (40 band) augmented with a silicone rubber tyre (20 gutter) under the breaks (**c**). Drainage of fluid will probably be necessary to aid localisation but intravitreal injection should only be performed if subretinal fluid is deep. The surgical sequence is cryo, drain, buckle (± gas).

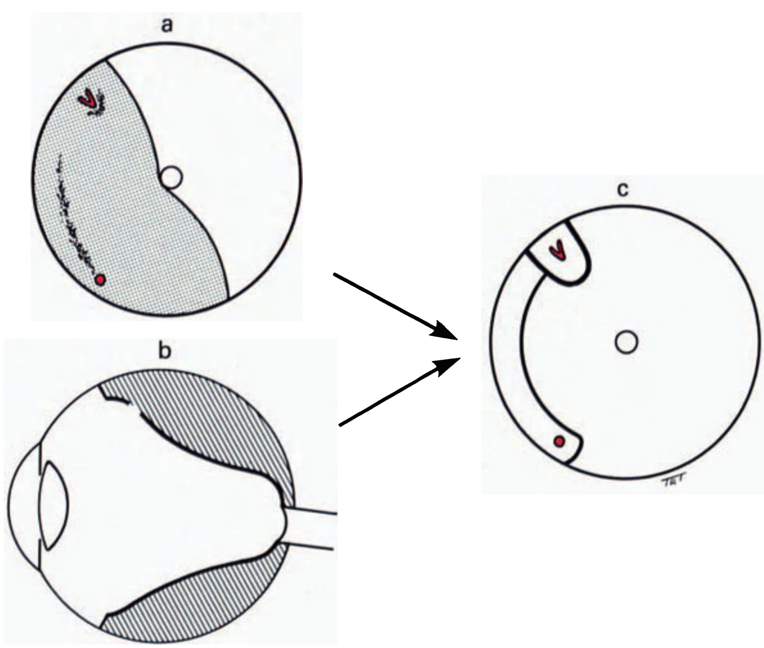

Fig. 3.13.

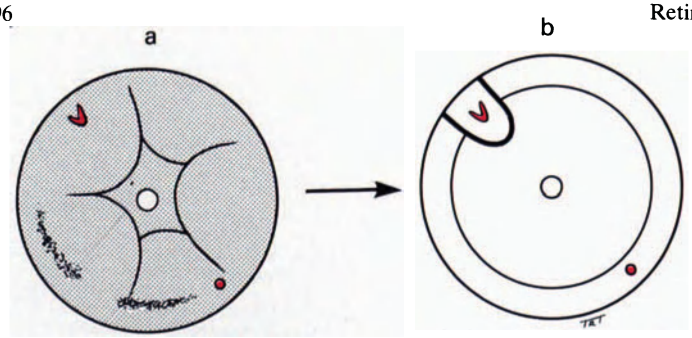

Fig. 3.14. *Example 5.* A total retinal detachment is present with multiple breaks and a substantial degree of peripheral preretinal membrane (**a**). An encirclement procedure is carried out augmented in the upper temporal quadrant by a radial sponge (**b**). Operative closure of breaks is necessary, requiring drainage of subretinal fluid and intravitreal SF6. If fluid depth is moderate the surgical sequence is cryo, drain, buckle, gas. If fluid is deep the sequence is drain, gas, cryo, buckle.

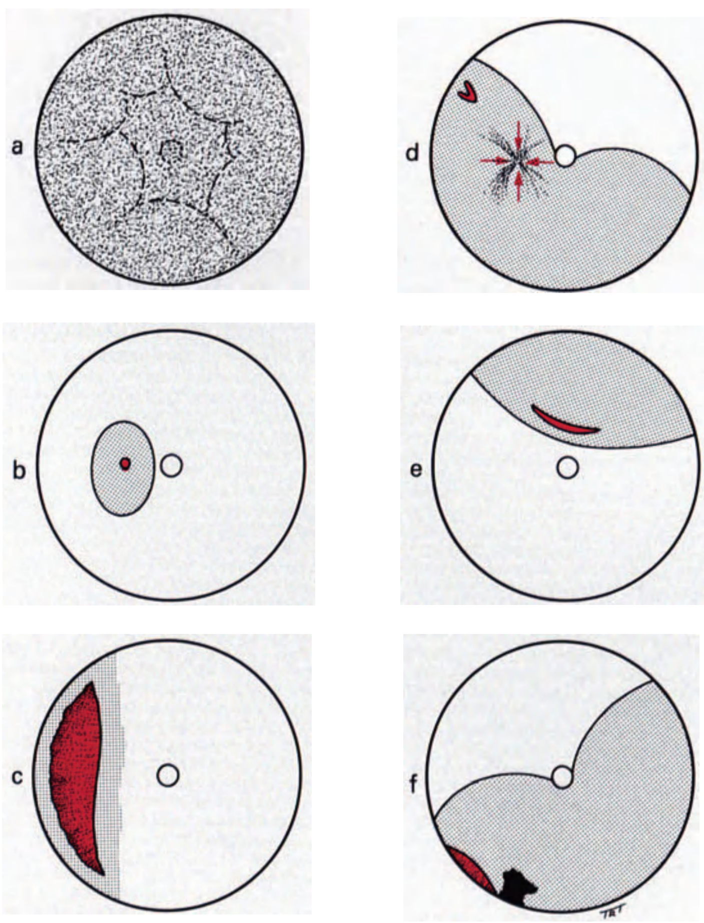

Fig. 3.15. *Example 6.* Cases suitable for pars plana vitrectomy. **a** An extensively detached retina in which the view is extremely limited by opacities in the media. **b** Macular break causing retinal detachment. **c** A giant retinal break. **d** Simple retinal detachment complicated by substantial macular pucker. **e** Large irregular posterior break. **f** Retinal detachment caused by retinal dialysis associated with an intraocular metallic foreign body.

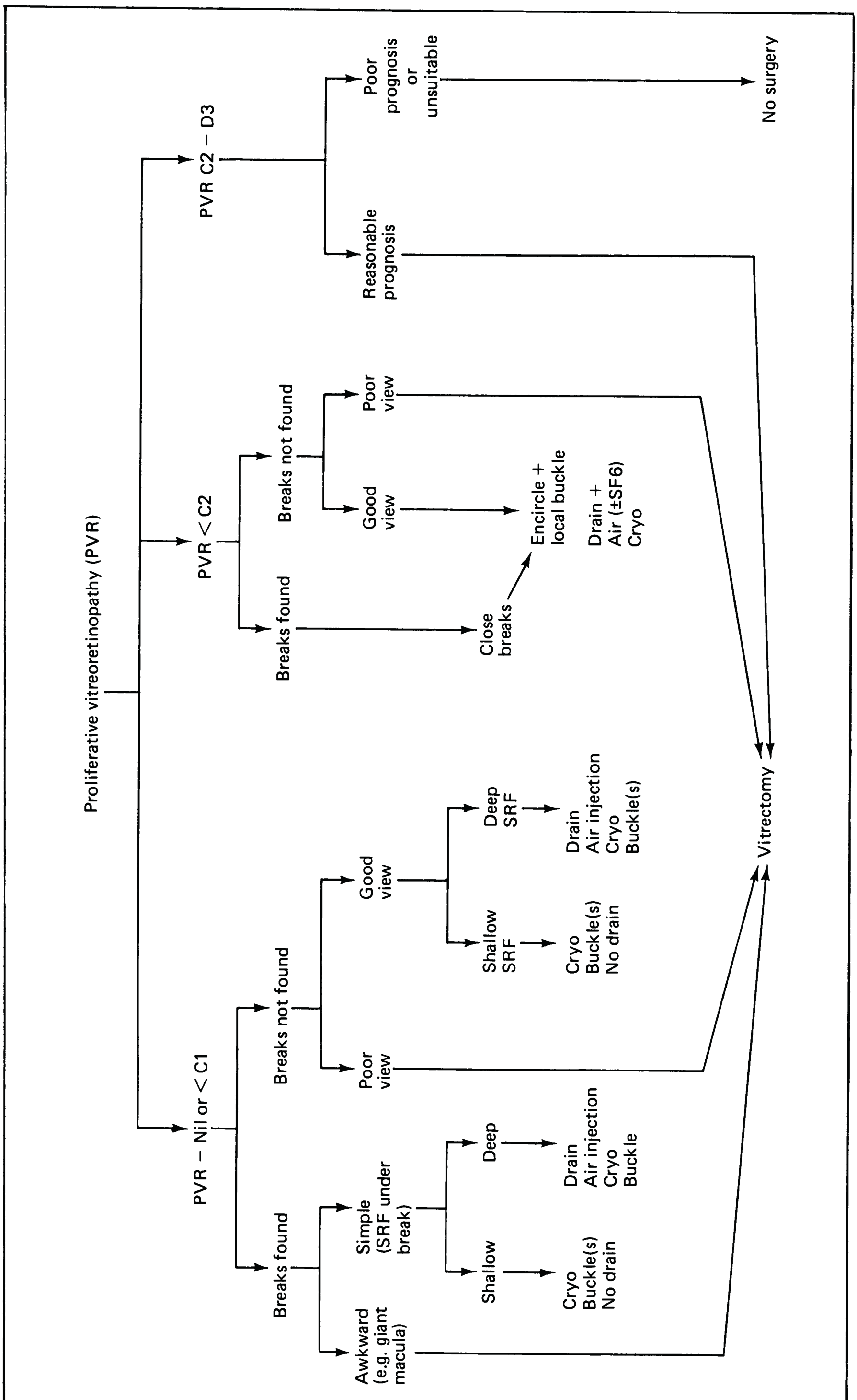

Fig. 3.16. The surgical approach to rhegmatogenous retinal detachment.

Prophylactic Surgery

The object of prophylaxis is to treat lesions that may lead to retinal detachment. Demonstration of the importance of retinal breaks in the aetiology of detachment, improved methods of examination, and the subsequent development of photocoagulation [70] and cryotherapy provided the impetus for the development of prophylactic treatment. It is not necessary to treat all retinal breaks and degenerations, because they do not all lead to retinal detachment [71] and complications may occur. The consideration of an eye for prophylaxis mainly concerns the treatment of those retinal breaks or degenerations which may lead to retinal detachment.

Retinal Breaks

The potential risk of untreated retinal breaks has been stressed [72–74]. In particular, there is marked vulnerability of the fellow eye of the patient with retinal detachment [75], and the incidence of retinal detachment is increased in fellow eyes following intracapsular cataract surgery [76]. The incidence of retinal breaks in the general population, however, is high. It was estimated to be 13.7% in volunteer patients without eye disease, and in one study 5.8% of 1700 patients were found to contain asymptomatic retinal breaks [77]. These clinical findings of a relatively high incidence of retinal breaks have been supported by pathological studies in which unsuspected breaks were found on post-mortem examination (an incidence of 4.8% [78] was noticed on one study and 10.6% in another) [79]. However, although the incidence of retinal breaks in the population is fairly high, the incidence of detachment is low: in a study of a relatively stable population it was estimated to occur in 0.004% per year [80]. It is therefore obvious that only a small proportion of patients with retinal breaks develop retinal detachment. The main importance of retinal breaks lies in their relationship to posterior vitreous detachment. Thus, breaks within the vitreous base are not subject to dynamic vitreo-retinal traction and are extremely unlikely to result in retinal detachment. However, retinal breaks associated with vitreous traction (particularly, therefore, retinal tears, following at least partial posterior vitreous detachment) are much more likely to lead to retinal detachment than are round holes [76].

In one study it was shown that breaks presenting to the ophthalmologist with fresh symptoms of posterior vitreous detachment (symptomatic breaks) had a much greater risk of progressing to retinal detachment than did asymptomatic breaks [76]. In symptomatic cases, retinal tears carried a much greater risk than round holes. The same study also showed that if a break is to proceed to retinal detachment, it is likely to do so within the first 6 weeks of its appearance, following which the risk of detachment rapidly decreases.

Thus some retinal breaks appear to carry a low risk of subsequent retinal detachment and others a high risk, but it is still not possible to forecast with absolute certainty which retinal breaks will proceed to detachment and which will not. It is not clearly understood why a retinal tear in one eye will proceed to retinal detachment while in another it will not. Therefore the need to treat retinal breaks when detachment seems a realistic threat has to be balanced against the need to avoid unnecessary treatment in those cases where there is little risk. It should be remembered that the distinction between symptomatic and asymptomatic breaks may be somewhat artificial. Symptoms themselves may be trivial, variable or even forgotten by the patient. Prophylactic treatment of retinal breaks is advised in the following circumstances:

1. *Symptomatic breaks.* A patient who attends complaining of flashes of light, floaters and sometimes reduction of vision due to vitreous opacities (usually vitreous haemorrhage) as a result of recent posterior vitrous detachment which has led to retinal break formation, is at relatively high risk of developing retinal detachment.

2. *Breaks in the high-risk eye.* In certain conditions – intracapsular aphakia [81] (particularly if there has been pre-existing myopia) and the fellow eye of an eye with retinal detachment – the chance of an individual retinal break proceeding to detachment is greater than usual. Prophylactic treatment is therefore recommended for all retinal breaks in aphakic or fellow eyes.

3. *Asymptomatic breaks.* These are small breaks discovered on routine examination of the eye in non-high-risk situations. The absence of recent symptoms suggests that the breaks are not fresh and studies have demonstrated that there is a low incidence of progression to detachment [77, 82]. Accordingly, prophylactic treatment is not advised for all phakic asymptomatic breaks, particularly if small and situated within the vitreous base. However, some asymptomatic breaks should be treated as there is still a risk of progression to detachment, e.g. retinal dialyses and breaks in the equatorial region of the eye. It would seem that the latter are particularly vulnerable if there is an increase in vitreo-retinal traction, as may occur with increasing posterior vitreous detachment (see below).

4. *Myopia.* The incidence of progression of asymptomatic breaks in myopic eyes to retinal detachment is apparently low [83]. However, the risk of retinal detachment in myopia is well established and it is certainly not possible to anticipate with confidence which breaks will progress to detachment and which will not. One factor may be the uncertainty as to the progression of posterior vitreous detachment; thus partial posterior vitreous detachment, which may result in a retinal break and which has not led to retinal detachment at the time of the break, may cause detachment from the same retinal break months or even years later if the detachment becomes more complete and increases vitreo-retinal traction on the break. In myopia, therefore, prophylactic treatment of all breaks except those within the vitreous base is advised. The degree of the myopia, the age of the patient and the likelihood of being able to keep the patient under observation are all factors for consideration. Thus, high myopia and relative youth would favour prophylactic treatment, whereas old age and a low degree of myopia would favour conservatism.

Retinal Degenerations

Lattice Degeneration

The high incidence of lattice degeneration noted at autopsy [84] in eyes that have not proceeded to retinal detachment and also on clinical examination of otherwise normal eyes [85] renders it impractical and unnecessary to treat all patients with this condition. However, true lattice degeneration, by leading to retinal break formation, is a known precursor of retinal detachment and occurs in approximately 30% of detachment cases. Nevertheless, even if lattice degeneration does have retinal breaks present, these do not necessarily progress to retinal detachment [85]. This relatively benign and non-progressive tendency in the majority of cases has led to a conservative attitude in the management of patients with lattice degeneration. On the other hand, it was found in one series that 2.8% of all cases of retinal detachment were caused by lattice degeneration associated with round breaks that lead to an insidious type of detachment [86], and lattice degeneration complicated by break formation and combined with myopia is particularly dangerous [87]. Once again it seems likely that posterior vitreous detachment is a key consideration in patients with lattice degeneration. If complete posterior vitreous detachment has occurred and has not produced breaks in lattice degeneration in the process of separation of the gel from the retina, then it is most unlikely that lattice degeneration in such a situation will result in subsequent break formation and retinal detachment. Conversely, if lattice degeneration is discovered in an eye in which posterior vitreous detachment has not yet occurred, it cannot be confidently said that retinal detachment will not occur at some time in the future, when posterior vitreous detachment occurs. Treatment of lattice degeneration is therefore advised in the following high-risk situations:

1. In the same or the other eye of a patient with retinal detachment.
2. When breaks are found within it.

Snail-Track Degeneration

Snail-track degeneration is usually associated with round breaks and has a strong tendency to progress to retinal detachment [88]. Prophylactic treatment is therefore advised in all cases in which retinal breaks are found, but it should be confined to the area that contains the retinal breaks. It is not necessary to treat all areas of degeneration, which are often extremely widespread.

Other Indications

Giant Breaks

There is a high incidence (reported at between 32% [89] and 75% [90]) of fellow eyes affected by giant breaks in atraumatic cases. The fellow eye of a patient with a giant break may contain obvious degenerative change or retinal break formation, but this is unusual. More often, areas of white with or without pressure or non-specific choroido-retinal degeneration are found, and sometimes the eye appears to be completely normal. Whatever the findings, 360° circumferential cryotherapy in the pre-equatorial region is advised.

Summary

To summarise, the main indications for prophylactic treatment are as follows:

1. All symptomatic breaks
2. All breaks in fellow eyes
3. Some asymptomatic breaks (e.g. retinal dialysis and breaks in lattice or snail-track degeneration)
4. Lattice degeneration in fellow eyes
5. The fellow eye of an atraumatic giant break

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4 Surgical Details

Speed, accuracy and gentleness are worthy attributes in any surgeon and are of particular value in retinal surgery, when dissection and multiple surgical steps are time consuming. The assisting nurse should be informed of the intended surgical steps so that unnecessary and sometimes dangerous delays do not occur during surgery while additional equipment is being sought. Such preparation of the nurse will enable the surgeon to progress rapidly but unhurriedly from one phase of the procedure to another.

Initial Dissection

The Lids

Lashes are not cut routinely and a lateral canthotomy is rarely necessary, though it may be performed when the palpebral fissure is too narrow to allow reasonable access for comfortable scleral dissection and placement of buckle sutures. This problem is likely to be greater when a posterior dissection is to be performed.

The Cornea

In most cases the cornea may be left undisturbed throughout the operation although it needs to be irrigated regularly with saline. Occasionally, however, the cornea will become progressively cloudy and removal of the epithelium proves necessary; nevertheless, this will increase postoperative discomfort and should be performed only if essential.

Conjunctival Incision

An incision is made 1–2 mm from the limbus [1] and parallel to it; the incision is extended to just beyond the extraocular muscle guarding the quadrant of sclera to be exposed. A relieving incision is made at each end and is extended backwards

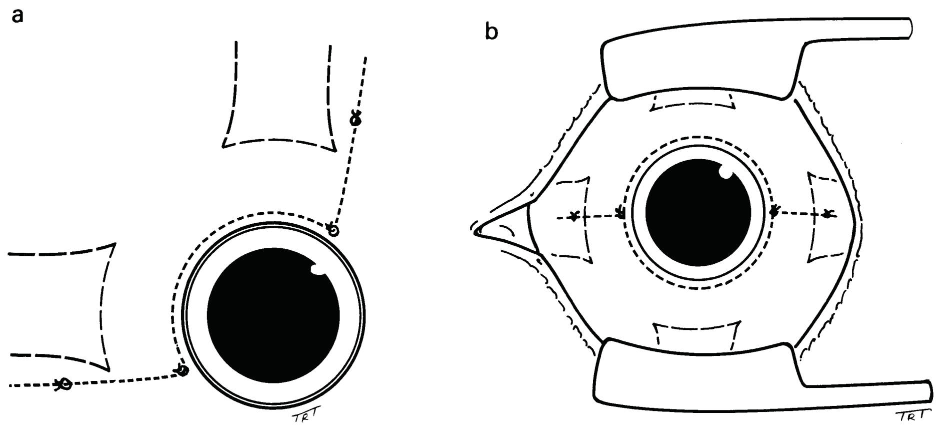


Fig. 4.1. **a** The conjunctival incision (*dotted line*) used to expose a single quadrant. **b** The incision used to expose all quadrants.

towards the fornix (Fig. 4.1). If all quadrants have to be exposed, a 360° incision is made, with relieving incisions in the 3 and 9 o'clock positions. The main advantages of the limbal incision is that it allows the simultaneous reflection of the conjunctiva and tenons layer, and at the end of operation these two layers are drawn forward together to provide a thick covering over the explants that are to be used. Occasionally, an incision 4–5 mm from the limbus will be necessary, particularly in reoperations if the limbal area is already scarred and adherent, if there has been recent limbal cataract surgery or if there is a draining conjunctival bleb from glaucoma surgery.

Isolation of Muscles and Exposure of Sclera

The rectus muscles on each side of the quadrant to be buckled are isolated by blunt dissection and tagged with 3.0 black silk sutures slipped underneath the muscles on a aneurysm needle. (If an encirclement operation is to be performed, all four muscles are isolated.) Tagging allows easy rotation of the globe during operation. This dissection, so easily performed in the unoperated eye, becomes an arduous and sometimes hazardous procedure in eyes that have undergone previous operations. In the latter cases it is often useful to place preliminary traction sutures at the insertions of the muscles to allow initial rotation of the globe and to facilitate the exposure of the muscle. Great care must be exercised in separating adherent muscles from the underlying sclera, which may have been rendered markedly thin by the previous use of diathermy. Unsuspected anterior staphylomas under muscles are an additional hazard, and forceful passage of squint hooks may result in accidental perforation of the globe. Vortex veins are also in jeopardy during the initial dissection since they may have been dragged forward by adhesions from previous operations. The inferior rectus muscle has the thickest adhesions, and the fine lateral rectus is the most difficult to identify. The inferior oblique muscle will usually be found to be strongly adherent to previous buckling materials in the inferior temporal quadrant.

The disinsertion of rectus muscles is now necessary only if large breaks are immediately related to the muscle insertion. In all but the most difficult exposures, scleral sutures may be manipulated beneath the muscles without detaching them from their insertions. Maintenance of muscle integrity will not only tend to preserve the arterial supply of the anterior segment via the anterior ciliary arteries but also reduce the risk of postoperative muscle imbalance resulting in troublesome diplopia, a problem which is particularly likely to occur if the vertical rectus muscles have been moved. Having isolated and tagged the appropriate muscles, the field where the scleral buckle is to be raised is exposed. Previous explants encountered at this stage should not be removed since by doing so unexpectedly weak sclera or even choroid itself may be exposed, introducing the risk of rupture of the globe and loss of subretinal fluid or vitreous. Immediate removal of explants will also result in some degree of hypotony, making subsequent surgical steps more difficult. Previous explants will usually be found to be enclosed in fibrous tunnels surrounding either the Silastic sponge or silicone rubber that has been used. The reaction is more marked in the former. If previous buckles have to be removed and replaced after application of cryotherapy and localisation of breaks, it is sometimes useful to pre-place mattress sutures prior to buckle removal to straddle the buckle and thus facilitate rapid tightening of the sutures if necessary. Recent sclerotomy wounds (if identifiable) from which subretinal fluid has been drained should likewise be avoided as their accidental reopening may result in release of subretinal fluid and sudden hypotony. If the failure of a retinal detachment is directly related to a previous buckle, readjustment or replacement of the buckle is necessary. If, however, a break has been found in a site well away from the old buckle, then the previous explant is best left undisturbed.

At this stage of the operation the surgeon will now be able to observe the sclera into which he is to place the buckling sutures. Scleral thinning and dehiscences in the sclera, either iatrogenic or naturally occurring as in a myopic eye, will be obvious.

Order of Procedure

After the initial dissection the subsequent order of procedure will depend upon the surgical method that has been chosen. The sequence of events will usually consist of one of the following three alternatives:

1. Cryotherapy → Localise break → Buckle → No drain (SRF shallow under break)
2. Drain subretinal fluid → Vitreal air → Cryotherapy → Localise break → Buckle (SRF deep under break)
3. Cryotherapy → Localise break → Place explant sutures → Drain subretinal fluid → Tighten buckle sutures (SRF moderate depth under break)

The various constituent parts of the operative procedures will now be considered in more detail.

Cryotherapy

Using a well-guarded retinal cryoprobe to avoid freezing the eyelids, cryotherapy is applied under ophthalmoscopic observation. In the application of cryotherapy most retinal surgeons prefer to freeze not only pigment epithelium but neuro-epithelium as well, as it is felt that only by freezing the latter will a secure lesion be achieved [2]. In addition to the treatment of obvious retinal breaks in degenerate areas, cryotherapy may be of value when the position of the retinal break is in doubt. Freezing of suspicious areas of the retina will reveal the characteristic appearance of the retinal break, the surrounding detached area freezing white to leave the central darkness of the break through which the pigment epithelium can be seen. Indentation with the cryoprobe at the time of surgery provides the surgeon with a further opportunity to examine the relationship between the pigment epithelium and the detatched retina (Fig. 4.2). If the break can be relatively easily closed by indentation it is likely that a non-drainage operation can be successfully performed. If subretinal fluid is deep so that indentation of the cryoprobe does not approximate pigment epithelium to neuro-epithelium, cryotherapy should not be applied until subretinal fluid has been drained from the eye. Attempts at freezing through deep subretinal fluid result in gross damage to pigment epithelium and risk of complications.

Cryotherapy should be confined to the immediate vicinity of the retinal break and to other degenerative areas if they are considered to require treatment. Refreezing of retina should be kept to an absolute minimum. In cases of retinal breaks in the equatorial region of the retina it is not necessary to extend the application from the area of the break towards the ora. Cryotherapy in cases of retinal dialysis needs special attention. In experienced hands the anterior situation of the break will often make visualisation of the cryotherapy response more difficult. This will tend to result in the application of cryotherapy far too posterior to the edge of the dialysis. Cryotherapy should involve the dialysis edge itself and its insertion in the ora serrata [3].

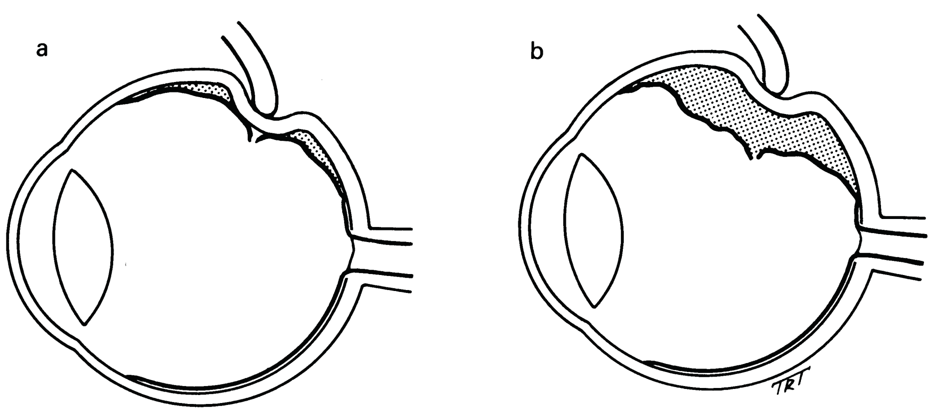


Fig. 4.2. **a** Indentation with the cryoprobe closes the retinal break and the cryotherapy reaction is easier to see. **b** Indentation does not close the break if subretinal fluid is deep, and the cryotherapy reaction is difficult to see.

The need to minimise the risk of refreezing and also not to omit areas of retina that should be treated emphasises the value of complete familiarity with the local anatomy around the retinal breaks, something that can be achieved only by careful preoperative examination. When mainly linear areas are to be treated, as in lattice degeneration or in a row of small holes, the cryotherapy application should extend on both sides of the lesion and slightly beyond each end.

Operative Complications

Freezing of Eyelids

Inadvertent freezing of the lids due to inadequate insulation of the retinal cryoprobe may cause marked postoperative lid oedema and in severe cases actual burns to the lid margins. These changes do not lead to permanent damage but can greatly increase discomfort in the postoperative period.

Anterior Segment Complications

Intraocular Lenses. The distortion of the globe that occurs during the application of cryotherapy may result in dislocation of unstable intraocular lenses. If an intraocular lens dislocates posteriorly into the vitreous cavity, the pars plana vitrectomy approach will usually be necessary to enable successful retrieval of the lens and repair of the retina. If the intraocular lens dislocates but remains in the anterior segment, the lens may be stabilised by suturing one or more of its loops (in the case of an iris clip lens) to the underlying iris. If an anterior chamber lens is present, distortion of the globe may result in hyphaema due to iris trauma from the lens.

Recent Cataract Section. If retinal detachment surgery has to be performed a short time after cataract surgery (within a week or two of the extraction), manipulation of the globe during either the initial dissection or the application of cryotherapy or as a result of raising up the scleral buckle may lead to loss of aqueous through the cataract wound. This, in turn, may produce either simple shallowing of the anterior chamber, hyphaema or iris prolapse. The anterior segment wound will need to be resutured and the anterior chamber reformed.

Scleral Rupture

During the application of cryotherapy the cryoprobe is fused to the wall of the glove by the ice ball. At the end of each cryotherapy application, this ice ball must be allowed to melt before removing the cryoprobe from the globe. The temptation to crack the probe off the side of the globe prior to melting must be resisted. Such cracking may result in scleral rupture, which is more likely to occur if the underlying sclera is thin.

Haemorrhage

Retinal. Indentation and freezing underneath a retinal break, particularly a break that has a prominent vessel running in the operculum, may result in haemorrhage from the vessel. Although alarming, these haemorrhages are rarely severe. Blood from the vessel will tend to cascade down the back of the detached posterior vitreous and settle at the posterior pole of the eye. Such haemorrhages may be discouraged by increasing the intraocular pressure by indenting the side of the glove with a squint hook or finger. Smaller dot retinal haemorrhages are sometimes seen on the surface of the detached retina after cryotherapy but they are of no particular significance and absorb quickly in the postoperative period.

Choroidal. Choroidal haemorrhage may occur if cryotherapy is being applied in the region of the vortex veins. These haemorrhages are rare but are occasionally severe. It is unusual for this type of haemorrhage to produce a haemorrhagic choroidal detachment; more usually there is bleeding from the choroid into the subretinal space. Once again blood will tend to be deposited at the most posterior aspect of the retinal detachment, within the subretinal space, but may also spread via the retinal break into the vitreal compartment. Compression of the globe at the time of surgery may discourage severe bleeding but if this occurs it may warrant cessation of a full retinal detachment procedure and conversion of the procedure into a pars plana vitrectomy to enable blood to be cleared from the vitreous and subretinal space.

Serous Choroidal Detachment

Serous choroidal detachment, which is a rare event, appears a few minutes after cryotherapy has been applied and may be associated with some degree of choroidal haemorrhage. The serous effusion, which may rapidly become bullous, usually occurs after cryotherapy has been applied in the region of the vortex veins although the actual mechanism is not understood. Such an occurrence is alarming, but the surgeon will usually be able to proceed provided it has not been accompanied by extensive choroidal haemorrhage. If the break can be buckled in the usual way, the choroidal detachment will disappear spontaneously in the postoperative period.

Pigment Fallout

Pigment fallout occurs after extensive cryotherapy [4, 5] and is due to either over-freezing or repeated freezing of the pigment epithelium (Fig. 4.3) [6]. Cryotherapy in these circumstances causes the pigment epithelium to explode and to release pigment granules into the subretinal space, and these granules are deposited at the most dependent part of the detachment; when the patient is supine at operation this is usually the posterior pole of the eye. Clinically it seems that in some cases (e.g. in long-standing detachments in myopes) the pigment epithelium releases its granules with unusual ease. Sometimes pigment passes directly through the retinal break into the vitreous and may be deposited on the

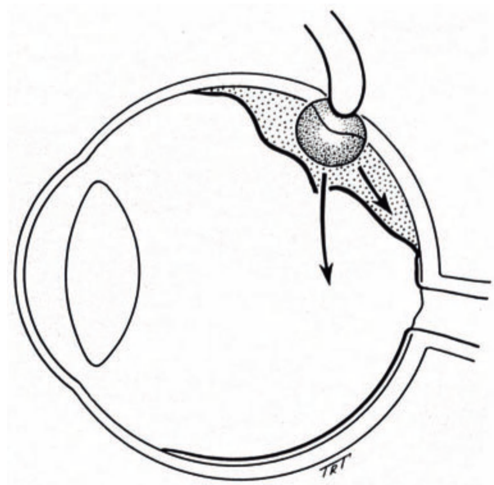


Fig. 4.3. Pigment fallout from excessive cryotherapy spreads into the subretinal space or less commonly into the vitreous cavity.

preretinal surface. Pigment fallout does not appear to jeopardise postoperative visual acuity even if it occurs in the paramacular region [7]. In cases when subretinal fluid has to be drained following extensive cryotherapy, pigment granules may be seen to emerge in the subretinal fluid as it flows from the eye.

Periretinal Membrane Formation

Extensive cryotherapy may contribute to the production or progression of periretinal membranes, which are the most potent contributory reason for failure in retinal detachment surgery. Appreciation of the potential of cryotherapy to have this effect on membrane production should make the retinal surgeon beware of its injudicious use. Usually, however, the very cases which are more likely to lead to periretinal membranes (e.g. reoperations, blood in the vitreous and difficulty of seeing retinal breaks) are precisely those in which there is a tendency to apply more extensive cryotherapy.

Localisation of Retinal Breaks

Retinal breaks are localised by using a modified scleral depressor [8] which, when indented vertically onto the sclera, leaves a small circular mark (Fig. 4.4a). This mark is then gently touched with a methylene-blue marking pencil, which leaves an easily identifiable spot on the sclera (Fig. 4.4b). The depressor itself must be sharp enough to mark the sclera without too much pressure having to be applied but not so sharp as to perforate the globe! When breaks are small the single mark is placed so that it is just posterior to the break. This mark will be the central point of the mattress suture and the buckle will then extend just posterior to the break.

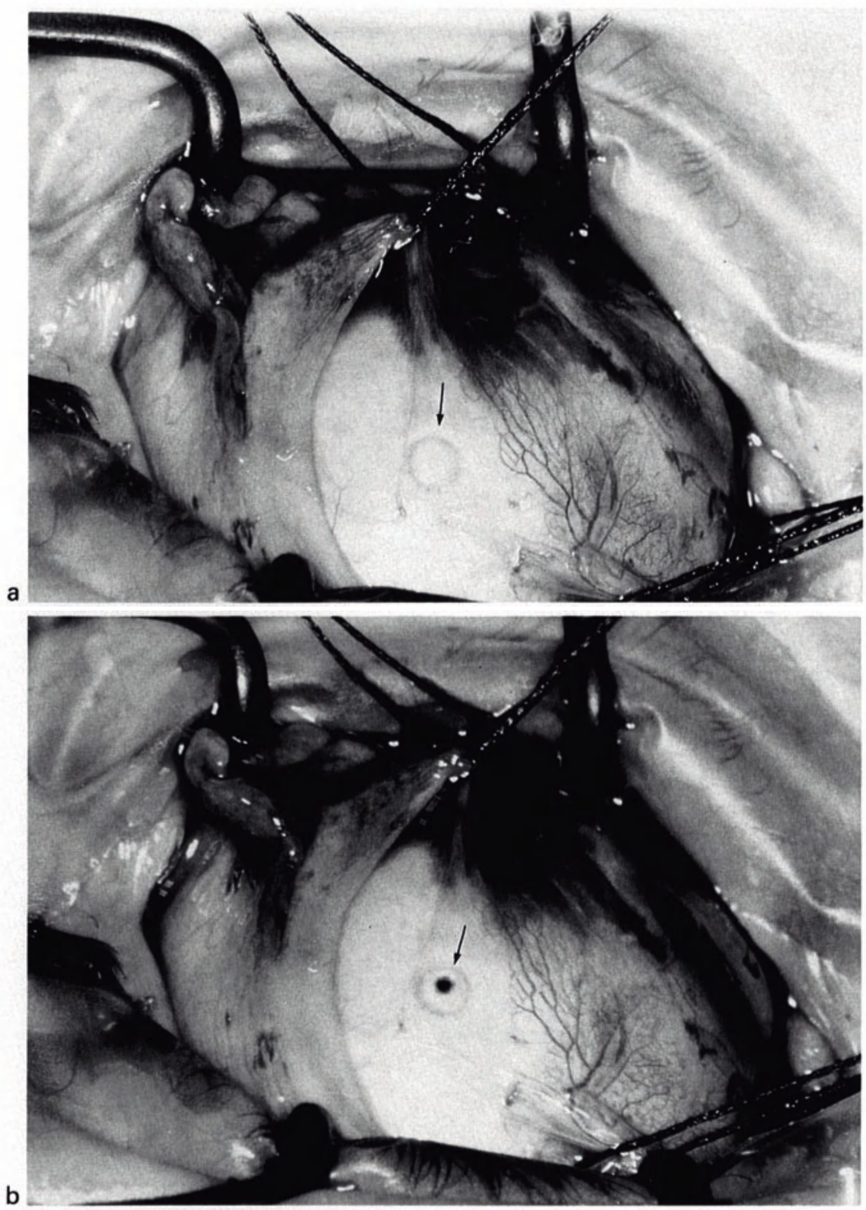


Fig. 4.4. **a** Circular mark on sclera left by scleral indentor (*arrow*). **b** The identifying spot of methylene blue.

If the retinal break is large, the extremities are localised by making as many separate markings as necessary. In large horseshoe-shaped tears this usually takes the form of one mark at the posterior limit and one for each of the two anterior extremities. In dialyses, two anterior marks are made at each end and one mark at the mid-point of the posterior edge. This method of marking may not be suitable in all cases. In reoperations the scleral surface is uneven and is not easily marked by the depressor. Also, if the eye is enophthalmic and the break is posterior, difficulty may be found in rotating the depressor so that a mark can be made. In these latter conditions it is easy to apply undue force to the tip of the depressor and this may cause anterior segment complications (see p. 58). When the scleral depressor is not satisfactory, the localisation can be achieved using an episcleral stitch, holding the stitch in forceps that are used as a scleral depressor [9]. However, although accurate, this latter method is time consuming.

When the breaks are localised this is a convenient time to check the depth of subretinal fluid in various sites so that the correct site for the drainage of fluid can be selected. If there is any doubt it may be useful to mark the site where subretinal fluid is to be drained by the use of the scleral depressor.

Buckle Sutures

Placement

When placing the suture, the sclera is made firm and stationary by counter-traction with non-tooth forceps on an adjacent rectus muscle insertion. This movement will also tend to straighten the sclera so that the normal curvature of the globe is less pronounced, making for easier passage of the needle. The needle should assume its running depth as soon as possible, without a long entry or exit course before the depth is reached (Fig. 4.5a). This will prevent weakness at one

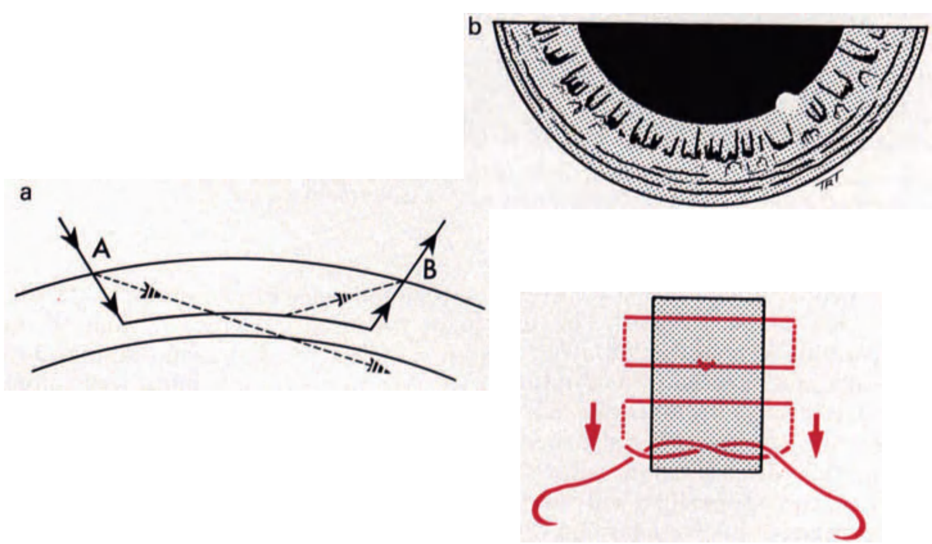


Fig. 4.5. **a** Intrascleral course of the needle should follow the unbroken line from *A* to *B*. The interrupted line shows two suture defects: one resulting in a shelving suture with a tendency to cut out when tightened, and the other resulting in accidental perforation of the globe. **b** A double-armed suture is used to facilitate the placement of a posterior buckling stitch.

Fig. 4.6. A radial sponge has been sutured in position. The suturing is uneven and due to poor technique the anterior suture has partially cut from the sclera (*arrow*).

or both ends of the suture track with a resultant tendency for the suture to cut out when tied under tension. The placement of these sutures is a matter of considerable judgement: too deep a suture will result in accidental perforation with subsequent release of subretinal fluid while too shallow a suture will cause cutting out when the suture is tied (Fig. 4.6). In sclera of normal thickness the suture runs at approximately one-half to two-thirds of the scleral thickness in depth. This will result in the suture being just detectable in its intrascleral course, although this appearance will vary with the thickness of the sclera. The sutures are arranged in mattress fashion to straddle the intended explant and (Fig. 4.7), until tied, are provisionally held in bulldog clips (it is convenient to have these individually colour-marked so that rapid identification can be achieved later).

During suturing the vortex veins must be carefully avoided. They can be damaged in the following ways:

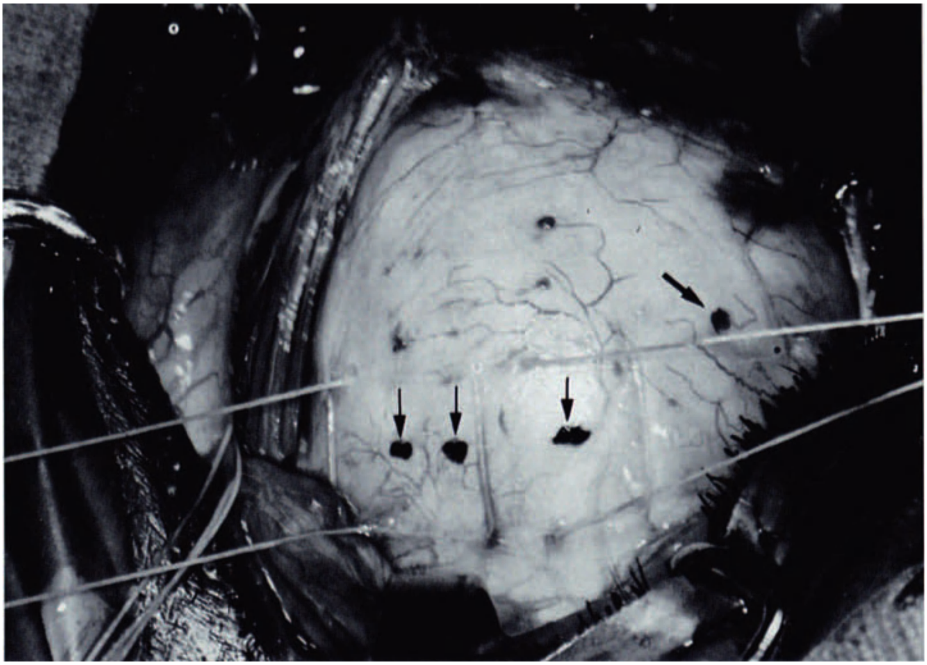


Fig. 4.7. Three breaks have been localised (*thin arrows*) and two mattress sutures placed in position. The limbs of the sutures are equidistant from the scleral marks. Intended site for subretinal fluid drainage site has also been localised and marked (*thick arrow*).

1. Their intrascleral course may be damaged directly by the needle as it passes through the sclera.
2. As the needle is actually removed from the sclera, difficulty in retrieving it may be encountered in posterior sutures and the tip of the needle may damage the vortex veins during the manoeuvre.
3. As the suture is pulled from the sclera the vortex veins, which are adherent to the loose periocular fascia, may be dragged into the suture track by the thread.

If the needle is nearing a tributary of the vortex vein it is removed from the sclera at this point – which leaves a gap in the suture track –, passed over the vortex vein, and reintroduced into the sclera on the other side of the vein. If a vortex vein does become damaged during dissection and bleeding commences, firm pressure is required to stop the flow of blood but diathermy is rarely necessary.

When radial buckles are used to seal posterior breaks the most posterior suture is often difficult to place; placement is rendered easier by using a double-ended suture and allowing both needles to be passed in turn in an antero-posterior direction (Fig. 4.5b).

During placement of the scleral sutures the subretinal space many be accidentally entered with release of subretinal fluid [10]. However, due to the very small puncture site, incarceration of the retina and vitreous loss will rarely occur unless the perforation has occurred over flat retina. If accidental drainage occurs the perforating suture should be removed and the leak of subretinal fluid sealed by oversewing with a more widely placed suture. Accidental perforation will be a particular problem if the pressure in the eye has already been elevated by the tightening of previously placed buckle sutures as part of an intended non-drainage operation. In these cases release of subretinal fluid will be rapid and the eye will become hypotonic quickly. The intraocular pressure must be restored by retying and tightening a further buckle suture as soon as possible after the offending stitch has been removed. If the eye is still too soft, intraocular pressure is restored by intravitreal injection of air or saline. If accidental drainage occurs in a case when drainage was planned anyway, then the accidental drainage site can be used and subretinal fluid allowed to drain.

Local Explants

The sutures found to be most satisfactory for securing local explants are 5/0 Dacron on a spatulated quarter- or half-circle needle. The quarter-circle needle is better for obtaining a long scleral bite and is preferred when there is good scleral access. However, the half-circle needle is particularly valuable when access to the dissection site is difficult (e.g. under muscle or in a posterior position). When placing the sutures the intrascleral course of the suture should be as long as possible (approximately 5 mm), thereby reducing the risk of the sutures coming out when they are tightened or in the postoperative period. If sutures do cut out following surgery they contribute to explant extrusion. The separation of the limbs of the sutures will vary according to the width of the explant being used. A good general rule is to place them approximately half as far apart again as the width of the explant. Thus, for a 4-mm explant the limbs of the sutures are placed 6 mm apart, for a 5-mm explant 8 mm apart, and for a 7-mm explant 10 mm apart. It should be borne in mind that increasing the distance between the limbs of the sutures for any explant will not increase the width of the resulting buckle (which is controlled by the diameter of the explant) but will increase the internal height of the buckle. A small gap of approximately 1 mm is left between the end of one mattress suture and the beginning of another (Fig. 4.6). Most radial explants will require two sutures. The number required when a circumferential explant is being used depends very much on the extent of the buckling procedure needed; usually two to three sutures are required per quadrant of retina buckled.

Encircling Bands

The eventual height of the buckle produced by an encircling band is dependent on the amount by which the band is shortened at the end of the operation. For encirclement, therefore, small matress sutures are only required for gently tethering the episcleral band in the four quadrants, allowing the band to run freely. The width apart for these sutures need only be just greater than that of the band, as the sutures are not being used to achieve a buckling effect. The sutures should not be tied so that the material comes to lie between the band and the sclera, because this may result in subsquent inward erosion of the suture owing to the pressure of the band. If the band is to be placed anterior to the equator in any quadrant, it is often necessary to have two anchoring sutures in the same

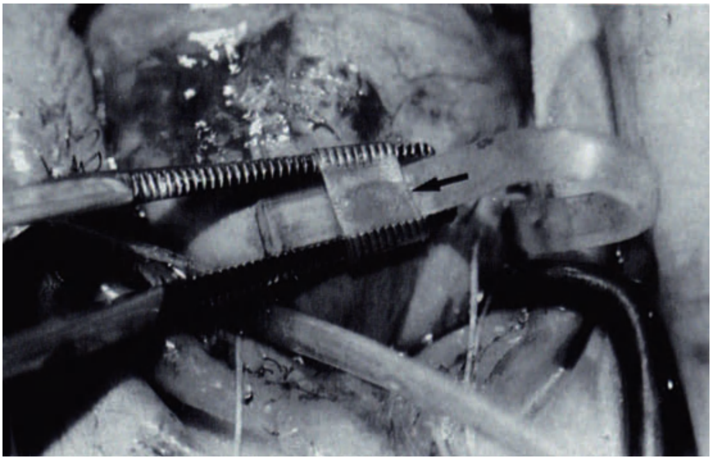


Fig. 4.8. A Watzke sleeve (*arrow*) is stretched in cross-action forceps and allows the passage of the two ends of the silicone band.

quadrant, as there is some tendency for the strap to bowstring forward between the sutures if they are too widely separated. If the encircling band is being used to relieve traction, it will generally be found to be equatorial in its distribution and thus to lie 12 mm from the limbus. If, on the other hand, the band is used mainly to seal visible or suspected retinal breaks, then it must be positioned so that these areas will come to rest just on the anterior slope of the indent produced. In most cases when retinal breaks are found and an encircling band is to be used, a relatively narrow band (such as a 40 band, which is 2 mm in width, or a 240 band, which is 2.5 mm in width) will be augmented by an additional local indentation. This will either take the form of a Silastic sponge explant if a single tear is to be buckled, or an underlying silicone rubber gutter of appropriate width if a longer segment of retina needs buckling. The ends of the encircling rubber band are gripped lightly by means of a Watzke sleeve of silicone rubber, which allows for easy adjustment in the tension of the band (Fig. 4.8). It is convenient not to tie the strap in the same quadrant where there is to be an additional explant but in general if the lower temporal quadrant is available, this is a convenient site, as exposure is simple.

Combined Local and Encircling Procedures

An encircling procedure is not often performed without the addition of extra local explants. The encircling ridge can be heightened in places in order to seal the retinal breaks and this will obviate the tendency for excessive tightening of the whole encircling element. A small heightening of the local strap may be achieved by simply over-sewing the strap with a mattress suture. However, this technique is not suitable for the majority of cases, and can be dangerous if reoperation is necessary. At reoperation the straps are easily exposed for mobilisation by slitting the roof of the fibrous covering to the band. If sclera has been sutured over the band, such a movement may cause scleral perforation. If a radial explant is to be used, the local explant sutures are placed *first* and the explant then put into position, as some difficulty may be found in placing them if the encircling element is already in place. The band is then passed around the eye and tethered on either side of the explant. The anchoring sutures in the other quadrants are tied and the ends of the band lightly held in a Watzke sleeve. When the buckles come to be raised, the local explant sutures are tied before the encircling band is shortened. If local indentation is to be achieved with an underlying silicone rubber explant then it is convenient to place the local sutures (of appropriate width according to the gutter being used) to straddle the encircling band *after* the latter has been placed in position. The gutter to be used can be slipped through the sutures and under the band prior to tightening.

Handling a Sponge Explant

During the operation the Silastic sponge should not be removed from its sterile container until just before it is needed. This reduces the risk of it being contaminated before its introduction to the eye. Prior to its placement on the eye, it is soaked in gentamicin and during manipulation on the sclera it is held in non-tooth forceps to avoid damage and disruption to its cellular structure.

Drainage of Subretinal Fluid

If subretinal fluid is to be drained from the eye, this is either done towards the end of the operation, after cryotherapy and placement of buckle sutures, or much earlier in the procedure, when it is succeeded by intravitreal injection of air and subsequent cryotherapy and buckling.

Selecting a Site

Selection of the site of drainage of subretinal fluid is made according to the following criteria:

1. The site should be at a point where subretinal fluid is deep. The depth of subretinal fluid should be checked at the time of surgery, as there may have been some redistribution of fluid as the patient lies supine on the operation table. For most purposes drainage under pre-equatorial retina is satisfactory (about 10 mm from limbus).
2. The site should preferably be in the lower half of the globe, because in the event of haemorrhage, blood will tend to track away from the macula if the patient sits upright in the post-operative period.
3. Drainage of subretinal fluid should not be made through areas that have just been treated with cryotherapy, which results in vasodilatation of the underlying choroid and an increased risk of choroidal haemorrhage.

4. Major choroidal vessels must be avoided.
5. Drainage should not be performed in the vicinity of large breaks for fear of losing vitreous through the break and subsequent incarceration of the posterior hyaloid membrane. This may result in the establishment of difficult vitreo-retinal tractional forces and also subsequent distortion of a retinal break thus affected.
6. The drainage site should not be placed directly underneath an explant. If this is done it is difficult to reopen the drainage site if necessary, after the buckle sutures have been tightened.
7. If a gas injection is to be used, the drainage site must be positioned somewhat more posteriorly than usual. This is because as the injection continues, peripheral retina will be flattened first and any anterior drainage sites will quickly be closed, leaving posterior subretinal fluid and possibly insufficient room for gas. If gas is to be injected, subretinal fluid drainage has to be performed under equatorial retina or in an even more posterior position.

Drainage on the nasal side of the globe is always more awkward owing to difficulty of access. In general it will be found that one of the best sites for draining subretinal fluid is at the lower border of the lateral rectus, provided deep retinal fluid is present at this point. Exposure is easy and the sclera is relatively thin, allowing easy access to choroid and examination of the choroidal knuckle by transillumination.

Technique

Drainage in the Equatorial Region

A radial incision is made at the selected site. An 11 blade on a Bard Parker handle is excellent. The incision should be long enough (about 3–4 mm) to allow a good view of the underlying choroid (about 2 mm) and the sclera is gently dissected until a knuckle of choroid is exposed (Fig. 4.9). A mattress suture of 5.0 Dacron is then placed across the lips of the wound. This suture not only allows for immediate closure of the sclerotomy site when necessary, but also permits the lips of the sclerotomy to be elevated. This can improve the flow of subretinal fluid. The drainage site is then transilluminated by shining a fibre-optic light through the pupil via the cornea (Fig. 4.10a). In a darkened room and provided the sclerotomy is sufficiently large, any large choroidal vessels crossing the knuckle that is to be perforated can be seen clearly (Fig. 4.10b) with an ordinary operating loupe. If these are too numerous to be avoided or if during the preparation of the drainage site there has been spontaneous external bleeding from the choroid, then the wound is secured and a further site selected. If no blood vessels can be seen, the knuckle of choroid is cauterised (with low heat) to discourage bleeding. During the course of the cauterisation, subretinal fluid is often released. If the incision into the sclera has been made to small, application of the cautery can be difficult and there is very poor exposure of the underlying choroidal knuckle. If low heat cautery has not resulted in release of subretinal fluid, the subretinal space is entered by perforation with the tip of a sharp needle.

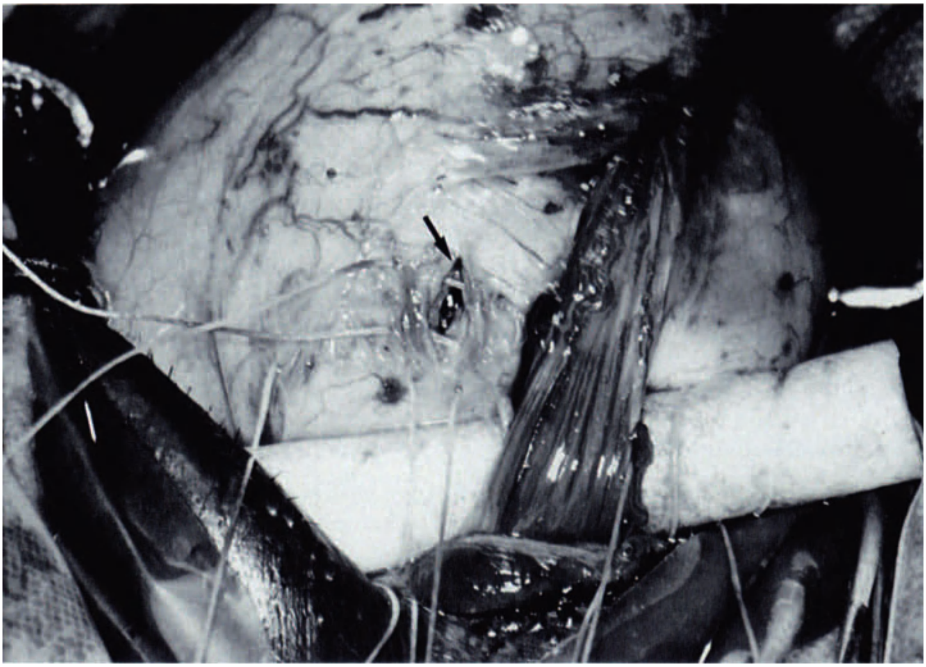


Fig. 4.9. The sclerotomy site (*arrow*) has been prepared at the lower board of the lateral rectus muscle. There is good exposure of the choroidal knuckle. A mattress suture has been placed across the incision prior to drainage to enable easy closure.

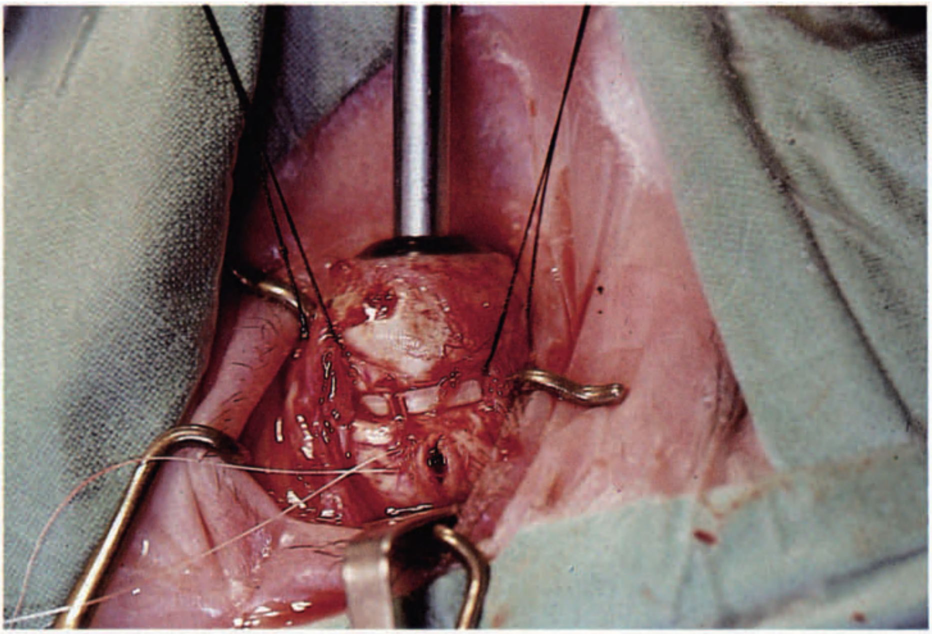
Post-equatorial Drainage

When drainage of subretinal fluid has to be performed from a particularly posterior position, radial incision of the sclera and exposure of a satisfactory choroidal knuckle with transillumination may be difficult owing to limited access (e.g. in the upper nasal quadrant). For drainage of these situations, the subretinal space may be entered by a small scratch-like incision through the sclera and choroid using a number 12 Bard Parker blade. This curved blade with a sharp point is particularly useful for this somewhat uncontrolled step and the small resulting puncture site does not need to be sutured.

In recent detachments, the subretinal fluid will be watery and have a colourless appearance, whereas in long-standing cases it will be thicker and xanthrochromic. Pigmented particles may be seen to be emerging in the subretinal fluid; they result either from recent cryotherapy and disruption of pigment granules into the subretinal space or from metaplastic pigment epithelium associated with periretinal membrane formation.

Post-drainage Planning

When subretinal fluid is released, the operation enters its least predictable phase, the eye softens and the risk of complications, particularly haemorrhage, rises. It is



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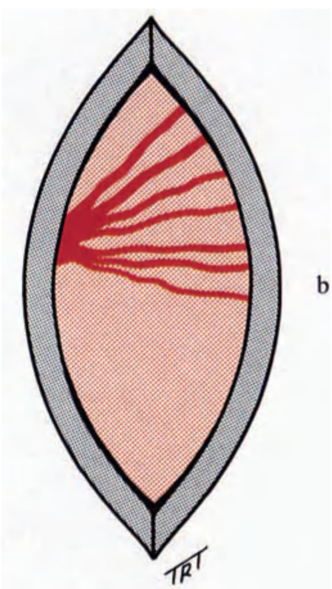

b

Fig. 4.10. **a** A fibre-optic transilluminator has been placed on the cornea after preparation of the sclerotomy site. **b** Transillumination of the choroidal knuckle allows choroidal vessels to be seen.

therefore vital not only that the surgeon has a clear-cut "post-drainage plan" but also that it has been decided how much fluid needs to be drained from the eye.

Intraocular Gas Injections

If the retina is mobile and not significantly affected by periretinal membranes, subretinal fluid is drained from the eye in sufficient quantity to allow a reasonable intraocular injection of air to be made (usually 1–2 ml). As soon as the eye softens after drainage, the vitreous injection will be performed. The eye must be allowed to soften substantially to provide room for the injection but it must not be allowed to collapse. This increases the risk of haemorrhage as well as making vitreous injection more difficult. Injection will restore intraocular pressure, and as the injection proceeds the break in the retina will be pushed towards the pigment epithelium. When approximation has been achieved, residual subretinal fluid may still be present. If this fluid will not freely drain from the eye, there is no need to pursue it as it will absorb in the postoperative period.

If membranes are present and postoperative tamponade of the retinal break is considered necessary, subretinal fluid drainage should be as complete as possible to allow for maximum size of vitreous gas bubble.

Vitreous Injection Not Planned

In these cases, cryotherapy and placement of the buckle with its attendant sutures will have already been performed. As soon as subretinal fluid drainage has commenced and the eye softens, tightening of the buckle sutures may be started. If the buckling process is extensive (e.g. an encircling band with an underlying silicone rubber gutter in one or two quadrants), drainage of subretinal fluid will usually have to be as complete as possible to provide for room for all the buckle sutures to be tightened, care being taken to ensure that there is no rise in intraocular pressure which would encourage retinal incarceration into the drainage site. When the flow of subretinal fluid ceases spontaneously, the drainage site is closed, the rest of the buckling sutures are tightened and the encircling band is shortened. If marked hypotony persists after the tightening of the buckle sutures and of the encircling band, then the temptation to increase the buckling further by excessive tightening of the encircling band must be avoided; the intraocular pressure in the eye should be restored by intravitreal injection of air or saline.

Complications

Cessation of Flow

Flow of subretinal fluid may cease abruptly and if it does, the surgeon should check the intraocular situation. Should it be judged that drainage of subretinal fluid is sufficient, the drainage site can be closed. On the other hand, it may be that the flow of fluid is stopped before evacuation is adequate. Indirect ophthalmoscopy will show whether or not there is any residual depth of subretinal fluid over the drainage site. If the retina appears to be flat at this site, or very nearly so, then another site has to be selected for further drainage. If, on the other hand, there appears to be reasonable depth of fluid at the drainage site, then the flow of fluid may be started again by gently manipulating the lips of the sclerotomy. Sometimes, simple separation and elevation of the lips of the sclerotomy with a pair of forceps will re-establish flow by keeping the retina away from the site. Flow may be encouraged by applying gentle pressure to another quadrant of the globe with a squint hook. Occasionally the choroid itself may act in a valve-like way, tending to shut off the flow of subretinal fluid, and this may necessitate reintroduction of the needle to promote a further flow of fluid.

Choroidal Haemorrhage

Choroidal haemorrhage is the most important and dangerous complication of retinal detachment surgery. It may occur directly at the time of perforation of the choroid and release of subretinal fluid, or after fluid has been drained. In the first instance, it is caused by direct perforation of a choroidal blood vessel and in the second, probably by hypotony or manipulation of the globe subsequent to the release of fluid. Occasionally, choroidal haemorrhage will begin before the subretinal space has in fact been entered. Under these circumstances, blood will not enter the subretinal space and will emerge through the sclerotomy hole. When this happens it is wise to close the site and perform drainage in another position. If the subretinal space has been entered, the extent to which the choroidal haemorrhage will spread internally is variable. If the eye is hypotonic, there will be a greater tendency for spread of blood into the subretinal space and vitreous cavity via the retinal break. Sometimes, the haemorrhage is slight and most of it may emerge as part of the stream of subretinal fluid. Blood that does enter the eye will be seen to produce a red-black reflex in the subretinal space or a bright red reflex if it has gained the vitreous cavity. In the subretinal space, blood may be seen to trickle under gravity towards the most posterior part of the retinal detachment. If the macula is detached, of course, it will tend to settle in the macular region and threaten subsequent recovery of central acuity. In very severe cases, haemorrhage will be extensive and the globe, softened by the drainage of subretinal fluid, may suddenly become firmer. Haemorrhagic choroidal detachment sometimes occurs and will be seen as a black mound beneath the detached retina. As soon as choroidal haemorrhage has been detected, it is advisable to tighten the buckle sutures as quickly as possible, if necessary supplemented by intravitreal injection, to promote rapid restoration of normal or even raised intraocular pressure to discourage further bleeding.

In most cases of choroidal haemorrhage, the bleeding will be slight and will not unduly interfere with the completion of the operation. If haemorrhage has spread through the retinal break into the vitreous cavity, resulting in rapid obscuration of the fundus, the conventional operation should be abandoned and vitrectomy performed.

Retinal Haemorrhage

Rarely severe haemorrhage will result from direct trauma by the perforating needle to the underlying retinal blood vessels. Such trauma usually leads to the formation of jagged iatrogenic retinal breaks.

Retinal Incarceration

The occurrence of retinal incarceration is usually easily recognised; the retina has a thin greyish appearance at the sclerotomy site and on ophthalmoscopy the typical stellate formation can be seen in the centre of the sclerotomy site (Fig. 2.9). This appearance is often further accentuated by vitreous incarceration, which is a frequent accompanying event. The retina may become incarcerated in the drainage site in various ways:

1. *Poor selection of drainage site*:
a) If the retina is in fact flat at the site that has been chosen for drainage of subretinal fluid, perforation of the choroid will be succeeded by that of the retina, with resultant loss of the vitreous through the retina.
b) If the subretinal fluid is very shallow at the site of drainage, retina may be incarcerated after the flow of fluid has started. Should this incarceration not be recognised, further manipulation or probing of the sclerotomy site with a needle may produce perforation of the retina itself, and a flow of vitreous.

2. *Raised intraocular pressure*. If the normal evacuation of subretinal fluid has occurred, followed by a rise in intraocular pressure, either from over-injecting an intravitreal gas or from excessive tightening of buckle sutures, incarceration may result if the sclerotomy site has not been closed or has been poorly secured.

When an incarceration occurs, and ophthalmoscopy still reveals the presence of substantial subretinal fluid in the vicinity of the sclerotomy site, lifting the edge of the sclerotomy with a pair of forceps may on occasion (but unfortunately rather rarely) disengage the incarcerated retina and flow of subretinal fluid is recommenced. On no account should incarceration be followed by further probing of the sclerotomy site. The incarceration should be supported by a buckle to counteract secondary traction at the site of incarceration and to close any iatrogenic retinal break.

Tightening the Buckle Sutures

As soon as the drainage of subretinal fluid has been deemed adequate, the sclerotomy site is closed with a temporary knot and the remaining untightened buckle sutures are rapidly tightened. If a local explant has been used in association with an encircling band, the local buckle sutures are first tightened, followed by tightening of the band. During tightening of the buckle sutures, or of the encircling band, it may be decided that the drainage of subretinal fluid has not been adequate. More fluid may be allowed to escape from the eye, if present, by reopening the sclerotomy wound. This must not be done before the tension of the buckle sutures is released and the eye is once again softened, since an elevated pressure will encourage retinal incarceration into the reopened sclerotomy site.

When a non-drainage operation is performed, the technique of tightening the buckle sutures in different and more difficult because the eye (particularly in a smaller volumed non-myopic eye) offers much greater resistance to being buckled and, apart from a tendency for poorly placed sutures to cut out, various other problems may be encountered. The rise in intraocular pressure may prejudice the retinal circulation and the central retinal artery at the optic disc must be carefully watched for patency as soon as the buckles have been tightened to any degree. These sutures are best secured with temporary knots (a single tucked reef knot) which can easily be released in the event of the central retinal artery being occluded. When non-drainage detachment surgery is being performed, the anaesthetist should be warned that hypotension is undesirable as it results in a poor filling pressure to the eye, makes central retinal artery occlusion more likely and increases the difficulty of the surgical task.

To allow the intraocular pressure to fall after the tying of one suture, several minutes must sometimes be allowed to elapse before a further suture can be tightened. Softening of the eye can be encouraged by massage of the globe with a squint hook and may be further assisted by the administration of Diamox (500 mg intravenously). This may usefully be given at the beginning of a non-drainage procedure. Rarely, paracentesis is necessary. The rapid rise in intraocular pressure that occurs as each suture is tightened may contribute to the production of troublesome corneal oedema, particularly in older patients and those in whom the corneal endothelium is in a somewhat precarious state. The oedema usually clears as the intraocular pressure falls but is sometimes severe enough to warrant removal of the corneal epithelium. After the tightening of the local buckle sutures, attention is turned to the encircling band, if one is to be used. In the rather uncommon situation of an encircling band being used in a non-drainage retinal detachment operation, there is usually some delay while the eye is restored to a normal intraocular pressure before any attempt at tightening the band can be usefully made. In order to produce an internal indentation of approximately 2 mm, the band must be shortened by approximately 15% of its circumference. This works out at approximately 12 mm of shortening, a measurement that is not markedly altered by variations in the ocular size because the changes in circumferential shortening in these ranges is small [11]. However, measurement to the nearest millimetre is difficult when shortening the band, particularly as the initial resting point of the band around the globe is hard to establish accurately. In practice, the effect of band shortening can usually be observed directly, even in the non-drainage operation. Gentle indentation observed at surgery will be found to result in satisfactory height of buckle in the postoperative period. The tightening of the band will once again result in a rise in intraocular pressure in a non-drainage operation, and it is often necessary to wait several minutes in between each few millimetres of tightening before the desired amount of shortening has been achieved. When subretinal fluid has been drained from the eye, the immediate effect of band tightening can be observed on ophthalmoscopy.

After the encircling element has been tied, the Watzke sleeve is further reinforced by two additional sutures on either side of the sleeve.

Problems in Placing the Buckle

Care taken with the initial localisation of the retinal breaks and appropriate selection of the size and direction of the explant to be used will be repaid by the rapid production of a buckle of satisfactory height and width, accurately located under the retinal breaks. A buckle that has been poorly placed or is of inadequate dimensions will have to be repositioned or entirely replaced. This will involve replacing all the buckle sutures. In the non-drainage operation this may be done without much difficulty (although multiple replacement of buckle sutures results in a somewhat torn and lacerated sclera), but if drainage has been performed, then the surgeon will usually be suturing into a much softened globe. This is not only technically difficult, often resulting in sutures of irregular depth and therefore of unreliable strength, but the additional manipulation of the hypotonic globe may once again contribute to the precipitation of choroidal detachment and haemorrhage.

If the buckle is correctly positioned and of appropriate dimensions, but is considered too low, it may be increased simply by over-sewing with more widely placed mattress sutures.

Fish-mouthing of Breaks

When mattress sutures are tightened over a circumferential explant, the scleral segment being buckled is shortened. Internally this tends to create redundant retina, which assumes the configuration of radial folds. These folds are particularly likely to be produced when deep subretinal fluid is drained and high circumferential buckles are raised (Fig. 3.8). Folds are avoided by radial buckling [12] and by removing the risk of their formation by the use of intravitreal gas to iron out retina against the concavity of the globe before the raising of the scleral buckle.

Retinal Dialysis

In cases of retinal dialysis the anterior ends of the circumferential buckle should be extended to the ora serrata to make quite sure that the extremities in the dialysis are not left unsealed. The retracted edge of a long-standing dialysis often extends posteriorly and will not fall back into place at the ora serrata as subretinal fluid is drained or absorbed; hence the buckle will need to be arched backwards so that the centre of the explant corresponds with the edge of the dialysis. However, the commonest fault in the surgery of retinal dialysis is to place an explant that is too posterior, i.e. leaving the dialysis unsealed.

Intravitreal Injection of Gas

In the great majority of cases the gas will be injected after the drainage of subretinal fluid and before the buckle sutures have been tightened.

Technique

Injection Site

The eye is rotated so that the injection site is uppermost. Access is facilitated by slight rotation of the head to the other side. The rotation of the eye should be performed soon after subretinal fluid drainage has started as rotation of a very soft eye is difficult. The object of this rotation is to ensure that when the needle has been introduced into the eye it is in the vertical position and the gas bubble will stay around the needle tip as the injection proceeds, thus tending to keep a single bubble. The site selected for the injection depends on the site of subretinal fluid drainage. The latter should be dependent when the globe has been rotated for injection. If subretinal fluid has been drained near the superior rectus muscle, as is often the case in bullous upper detachments, then injection can be conveniently performed just temporal to the inferior rectus muscle when the eye is rotated upwards. If drainage has been performed above the lateral rectus, injection will be on the nasal side near the medial rectus, and if subretinal fluid has been drained nasally then injection should be near the lateral rectus.

The surgeon with the indirect ophthalmoscope in place is positioned opposite the injection site and the needle introduced towards him, 5 mm from the limbus (i.e. to gain access to the vitreous cavity via the pars plana and vitreous base), using a 27 gauge needle on a 5-ml syringe.

Injection of Gas

The gas is placed in a sterile freely running dry glass syringe by aspirating through a 0.22 millipore filter. The syringe is tested by the surgeon prior to use since a plunger which tends to stick and thus causes hesitant injection of gas is to be avoided. The tip of the needle enters the vitreous cavity through the pars plana and this movement is assisted by counter-traction on an adjacent rectus insertion.

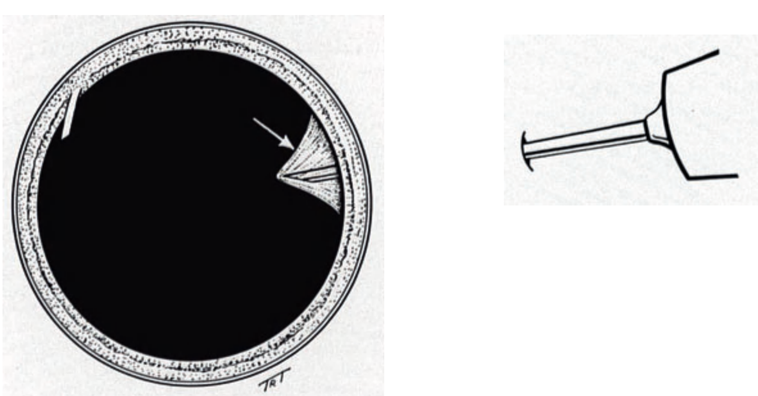

Fig. 4.11. Gas is to be injected into the vitreous cavity. The needle has not yet reached the cavity and is tenting up non-pigmented pars plana epithelium (*arrow*).

The direction of the needle is posterior, towards the centre of the vitreous body, to avoid damage to the posterior lens capsule. The tip of the needle is best observed through the indirect ophthalmoscope, and will readily become visible through the pupil.

The injection of gas, which is performed by the surgeon himself, is not begun until it has become clearly established that the tip of the needle has in fact reached the vitreous cavity and is not tenting up a fine grey layer of tissue, representing the non-pigmented part of the pars plana epithelium (Fig. 4.11). A sharp needle will usually penetrate these layers, but occasionally a short thrust may be necessary to enter the vitreous cavity. When the needle tip is seen to be in the vitreous cavity, the needle is withdrawn so that only the tip is clearly visible, and checking once again that the needle is in the superior position, the injection is commenced at a steady speed. If the needle is correctly positioned, the intravitreal gas bubble can be seen to be forming in the immediate vicinity of the needle. Progressive injection will then produce a single gas bubble, into which the needle tip can be advanced as the injection proceeds to ensure a single bubble (Fig. 4.12). In this way, multiple bubbles affording a limited view of the retina will be avoided.

Volume to Be Injected

While the gas injection is proceeding, the subretinal drainage site is left open. For this reason it is important to monitor the intraocular pressure (with a finger-tip) extremely carefully. Cessation of the flow of subretinal fluid with raised intraocular pressure will produce retinal incarceration through the drainage site. The intravitreal injection of gas proceeds slowly after the initial hypotony has been corrected. Slow injection will allow simultaneous drainage of subretinal fluid to occur. Fundoscopy will reveal when the retina is close to the subretinal fluid drainage site and if the break is against pigment epithelium. At this point, the gas injection should cease and sclerotomy should be closed. The situation in

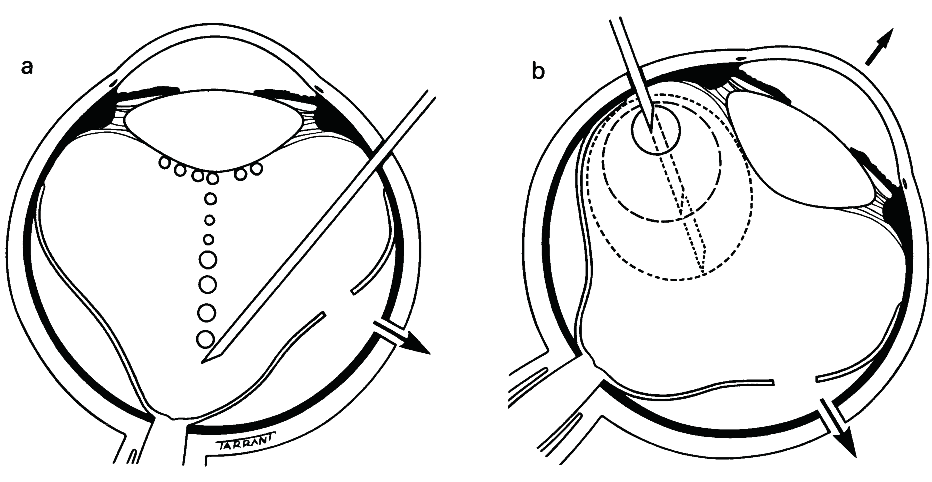

Fig. 4.12. **a** Posterior injection of gas causes multiple bubbles. **b** Correct technique after rotation of the globe results in a single bubble injection. The subretinal fluid drainage site is dependent.

the posterior segment is then reappraised. At this point it will be usual to see that the break has come to lie in close proximity or is actually opposed to the pigment epithelium. The eye should be only slightly hypotensive. If two or three bubbles have inadvertently been produced in the vitreous cavity, it is usually still possible to make out the retinal break without too much difficulty; this is so even when the break looks much smaller due to the minification effect of the gas bubbles, although breaks may be difficult to find if they are small and multiple.

If multiple bubbles are present, massage of the globe sometimes helps them to coalesce.

If there is still substantial subretinal fluid present more can be allowed to drain and further air injected until break closure occurs. If the break(s) is seen to be in an adequate position relative to the retinal pigment epithelium, the vitreous injection is deemed adequate. Cryotherapy can be applied and the buckle raised. A substantial advantage of this procedure is that only a relatively low scleral buckle needs to be used.

Aphakia

Injection of gas into an eye that has undergone an intracapsular cataract extraction will tend to result in gas coming forward into the anterior chamber, even if a preoperative examination has revealed an apparently intact anterior vitreous face in the pupillary area. For this reason it is very unwise to rely upon a view of the posterior segment after such an injection. In these cases, injection of gas should be avoided. Injection of gas following extracapsular cataract surgery can be performed without fear of anterior movement of the bubble into the anterior chamber. When an intraocular lens is present, care has to be taken if there is any tendency to instability of this lens. Posterior chamber lenses are stable, but iris clip lenses of one sort or another may be dislocated by the expanding gas bubble. Injection of a visco-elastic substance into the anterior chamber prior to gas injection into the posterior segment tends to provide stability of an intraocular lens and reduces the risk of gas gaining the anterior chamber around the lens.

Operative Complications

Poor Positioning of the Needle

This may result in suprachoroidal or subretinal injection of gas. The unwelcome sight of subretinal gas can be recognised by highly distinctive opalescent bubbles in the subretinal space.

Direct Damage

The tip of the needle may cause direct damage within the eye, e.g. to the lens, resulting in cataract formation, and to the retina, with the risk of retinal haemorrhage and break formation.

Raised Intraocular Pressure

A sudden rise in intraocular pressure due to over-injection of gas results in displacement of the adjacent structures. In the anterior segment this may cause movement of the lens iris diaphragm and dislocation of unstable intraocular lenses, while in the posterior segment the result may be incarceration of retina into a drainage site or closure of the central retinal artery of the retina. Immediate aspiration of the gas bubble must be performed to alleviate the problem. This can be done using a needle with a finger placed over the end of the needle to act as a release valve to withdraw air as necessary after the needle has been placed within the intravitreal bubble of gas. Sometimes difficulty may arise rather more insidiously, as a result of a rise in intraocular pressure. If air is injected into the eye and nitrous oxide is being used as part of general anaesthesia, then this gas will tend to pass into the eye during surgery, enlarging the intravitreal gas bubble. This makes extensive buckling procedures subsequent to air injection more difficult and necessitates removal of gas. The problem can be avoided by requesting the anaesthetist to use an agent other than nitrous oxide during this procedure.

Closure of the Wound

The explants that have been used are neatly trimmed, particularly Silastic sponges, and the limbal incision is then closed by drawing forward the conjunctiva and Tenon's layer in one layer and securing it with interrupted sutures of 6/0 collagen. A sub-Tenon injection of Genticin is given in all cases (20 mg for adults and 10 mg for children). If Silastic sponge has been used, the injection is given into the same quadrant in which the sponge has been placed.

Methods of Prophylactic Treatment

The majority of patients receiving prophylactic treatment are those in whom the second eye is treated at the time when a retinal detachment is being dealt with in the other eye. It is convenient to treat the fellow eye at the same time because the patient will usually be receiving general anaesthesia and will not have to suffer a further procedure at a later date. The patient undergoing retinal surgery should always have the fellow eye examined while under anaesthesia to avoid missing the opportunity for prophylactic treatment to the second eye. This is particularly important in patients in whom preoperative examination of the fellow eye has not been satisfactory for some reason and there has been incomplete examination of the peripheral retina. In these cases prophylaxis consists of trans-conjunctival cryotherapy. Most of the lesions to be treated will not be posterior to the equator and the conjunctiva will not have to be opened. In all cases, treatment is applied under ophthalmoscopic control.

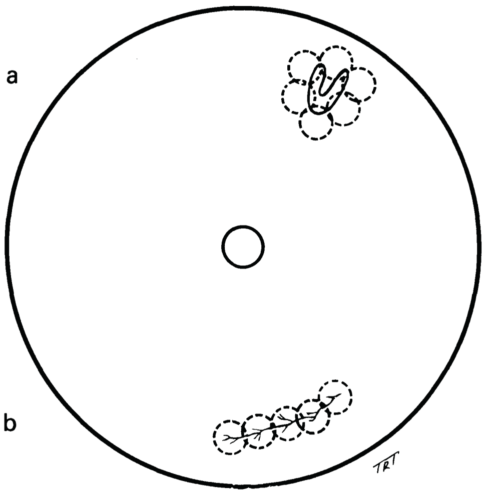

Fig. 4.13a,b. Prophylactic treatment with cryotherapy. **a** A large horseshoe-shaped tear. **b** A linear area of lattice degeneration.

When small retinal breaks are being treated, the cryoprobe may be placed directly underneath the break and usually only a single application of cryotherapy will be necessary to freeze the retina around the break. With much larger breaks, several applications will be necessary to effect a complete treatment, and there is risk of retreatment although it is not necessary to freeze an area more than once (Fig. 4.13a).

When linear degenerate areas are to be treated, starting at one end of the lesion, the cryoprobe is manipulated to indent the centre of the area and this will result in freezing on both sides of the lesion (Fig. 4.13a). Careful observation of local retinal landmarks will be necessary to see that areas are not unnecessarily retreated or missed altogether. In the heavily pigmented eye, retinal oedema usually appears shortly after treatment and can be a useful localising aid. In the less pigmented eye, however, this oedema may be difficult to detect. It is particularly easy to miss small parts of the retina when extensive cryotherapy is being applied, e.g. during 360° cryotherapy in the prophylactic treatment of the second eye of a patient with a giant retinal break.

When prophylaxis is needed and the patient is not receiving general anaesthesia, local anaesthesia is suitable in the great majority of cases and the treatment is conducted on an out-patient basis. The choice lies between cryotherapy and laser photocoagulation. There is little to choose between the efficacy of the two methods [13], the choice being made mainly on the basis of convenience of access and visibility.

Laser Photocoagulation

Argon laser photocoagulation has been found to be the most convenient method for out-patient prophylaxis and has now completely superseded xenon photocoagulation. Only topical anaesthesia is required and the energy is delivered through a three-mirror contact lens. The circular spots of photocoagulation are placed so that the edges of the rings are nearly touching each other. When retinal breaks

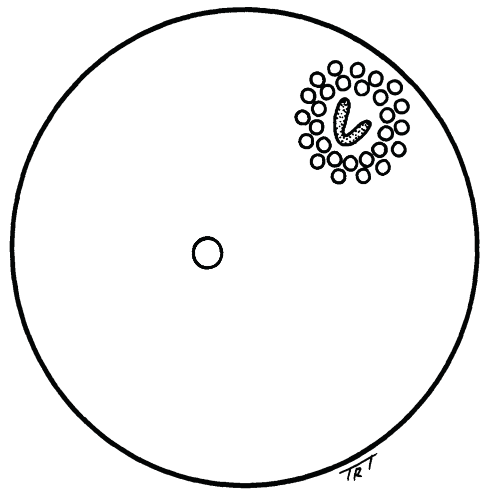

Fig. 4.14. A retinal break surrounded by laser photocoagulation.

are being treated in this way, usually two concentric rings of photocoagulation burns are used (Fig. 4.14).

Cryotherapy

Cryotherapy is particularly useful when laser photocoagulation is rendered difficult by either opacities in the media or the need to treat an anterior lesion. The conjunctiva is anaesthetised with surface anaesthesia (amethocaine 1%). Cryotherapy is applied under indirect ophthalmoscopic control. A few applications are usually well tolerated by the patient, with little discomfort. However, if more extensive or posterior treatment is required, a retrobulbar anaesthetic will be necessary (2–3 ml lignocaine 1%). On some occasions when extensive and particularly posterior cryotherapy is to be used (e.g. when extensive and posterior lattice degeneration is present), general anaesthesia will be more comfortable for the patient, especially if it is found necessary to open the conjunctiva to allow access of the cryoprobe to treat these more posterior lesions. Following prophylactic treatment, pigmentation around the lesion begins after 4 or 5 days and a firm adhesion is achieved after 2 weeks. During this time, patients are advised not to indulge in violent exercise, although normal work activities are not curtailed.

Complications

Cryotherapy has proven over the years to be a very safe method of prophylaxis. Minor side-effects, such as conjunctival chemosis, conjunctival lacerations or even small retinal or choroidal haemorrhages, do not have any permanent sequelae. Sometimes small and reversible serous choroidal detachment occurs.

Occasionally, serious side-effects of correctly used cryotherapy have been reported, such as macular pucker [14] or cystoid macular oedema [15].

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5 Postoperative Management, Complications and Failure

Mobilisation

Patients are mobilised as soon as possible following surgery, usually on the first postoperative day. This is particularly important in older patients to avoid the risk of deep vein thrombosis in the lower limbs. There is no place for bed rest in the management of a postoperative patients and it should not be used in the mistaken belief that it will encourage any residual absorption of subretinal fluid. In the majority of cases the patient may leave hospital a few days after surgery, the time of discharge depending less on immediate ophthalmic needs than on social convenience and the availability of help at home. When intravitreal gas has been used as part of retinal surgery, postoperative positioning of the patient will be necessary. Immediately after surgery (usually on the first postoperative day) the patient will be positioned to encourage tamponade of the break by the intravitreal air bubble (Fig. 5.1). Posturing can be boring for the patient and encouragement must be given by nursing and medical staff while in hospital and family on returning home. If posture fails, the success of the operation is jeopardised. This failure may be pathological (mental incapacity to co-operate with the manoeuvre) or on occasion simply due to an uncaring and casual approach by the patient. For either reason the volume of gas should be as by generous as possible. The posture should be maintained as long as the bubble of gas is effective in maintaining tamponade.

External Signs

There is a variable amount of discomfort in and around the eye following surgery and there is usually some lid swelling and chemosis. The external signs are related to the type of procedure that has been performed and also to whether the surgery employed has been the first operation. The extraocular tissue disturbance is minimal in the case of retinal detachment where only a local buckling procedure has been performed without drainage of subretinal fluid in a previously unoper-

Fig. 5.1. The ambulant postoperative head-down position to produce gas tamponade of an upper retinal break.

ated eye. The extraocular tissue signs are much more marked if, on the other hand, there has been a long and more complicated reoperation procedure involving, say, encirclement, cryotherapy and drainage of subretinal fluid and separation of previous extraocular adhesions. If the dissection has been particularly posterior, some degree of proptosis is often produced in the postoperative period.

Postoperative Activity

Sedentary activity is advised for the first postoperative week to enable the adhesive strength of the cryotherapy to develop. Strenuous physical activity such as heavy lifting or sporting activities such as riding or squash racquets do not appear to promote redetachment [1] and can be resumed when the eye feels comfortable. Although reading involves saccadic movements of the eye, this does not appear to unduly disturb the postoperative progress and is not therefore discouraged. The length of time that a patient has to remain off work will depend to some extent on the job and also the nature of the operation performed. In uncomplicated cases work may be resumed approximately 1–2 weeks after surgery, whereas in more extensive operative procedures or visually demanding jobs this interval will be longer. The patient may later return to most activities of their choice, although sports where direct damage to the eye is a reasonable possibility (e.g. boxing) should be avoided.

Recovery of Vision

In the event of successful reattachment of the retina, subjective improvement in the quality of the field of vision is noticed by the patient almost immediately. Preoperative symptoms may continue into the postoperative period; thus, floaters as a result of vitreous haemorrhage may persist for weeks or months and, although diminishing, they may never disappear completely. Flashes of light may likewise persist for some time and may even appear postoperatively in patients in whom they had not been present pre-operatively. The recovery of central visual acuity is a measure of the restoration of macular function following its detachment and subsequent reattachment by surgery. The length of time that the macula has been detached is the most important factor influencing the restoration of the central visual acuity [2–4]. Thus the longer the detachment has been present, the poorer will be the eventual recovery as measured by visual acuity, visual field and colour discrimination [2]. A less satisfactory return of vision is also seen in old age and myopia [5]. In general, it is found [6] that recovery of macular function in terms of visual acuity is likely to be approximately 40% of its preoperative level in freshly detached cases but is worse if the macula has been detached for a long period; for example, a preoperative vision of 6/60 might be expected to improve to 6/18 provided macular attachment is achieved promptly. Sometimes, and somewhat unexpectedly, visual acuity will return to normal after prompt macular reattachment. However, it should be stressed and the patient warned, that the recovery of central vision may be slow and may take up to 2 years from the time of surgery. Although preoperative detachment of the macula indicates that the case is less urgent than one in which the macula has not detached, most surgeons would prefer to achieve reattachment as soon as is reasonably possible.

The Cryotherapy Lesion

Retinal oedema resulting from the application of cryotherapy may or may not be detectable for 1–2 days as a slight whitening of the detached retina following surgery. Pigmentation of a cryotherapy lesion usually appears after 4–5 days in areas of flat retina but generally takes a few days longer in cases in which the retina was detached. The eventual appearance of the cryotherapy scar will vary according to the intensity of application. The initial pepper and salt pigmentation gradually gives way over a period of weeks to a somewhat coarser range of pigment, but if the choriocapillaris and retina have not been completely destroyed, the affected area is apparently of normal thickness and has a somewhat pinkish colour. In heavy applications pigment clumps are found on the edge of the lesion, which is itself very pale and thin owing to the destruction of choriocapillaris and neuro-epithelium. Larger choroidal vessels, however, invariably remain intact and are seen in the scar. The intrinsic strength of the cryotherapy lesion is related to the severity of the lesion and this may be assessed by the appearance of the eventual scar. The actual pigmentation of the cryotherapy lesion, however, is due to clumps of macrophages and is not intrinsically related to the adhesive quality [7]. When the retina is detached, the maximum strength of the cryotherapy lesion probably takes about 2 weeks to develop.

Following retinal detachment surgery the anatomical success or failure of the operation will be judged by the subsequent behaviour of the subretinal fluid.

Behaviour of Subretinal Fluid

The postoperative absorption of either a substantial amount of subretinal fluid following a non-drainage operation or of residual fluid following drainage mainly depends upon the relationship of the break to the buckle at the end of the operation [8]. If break closure has been achieved at the time of surgery, then subretinal fluid absorption will be rapid: it is usually complete within 2 days of operation and will take place regardless of the length of time that there has been preoperative detachment of the retina, an event which is readily exemplified by the absorption of subretinal fluid following dialysis surgery, when fluid which may have been present for many years can be absorbed within a few hours [9].

The rapid and complete absorption of subretinal fluid following break closure even when the fluid is extensive, as in a total retinal detachment, is an outstanding reminder to the surgeon that the only object of surgery in cases not complicated by periretinal membrane formation is to close breaks. If it has not been possible to close the break at the time of surgery then the absorption of subretinal fluid is slower and depends on how long it takes for the break to close. This may take a worryingly long time, sometimes more than 1 week from surgery. Such cases are usually those in which there is rather pronounced vitreo-retinal traction acting on the break (as in some retinal tears). During the time that the break takes to close there is nearly always absorption of some retinal fluid but total absorption will only be achieved after the break has been completely sealed. Subretinal fluid may persist if periretinal membranes, resulting in shortening of the retina in their vicinity, prevent settling back of the detached neuro-epithelium against the pigment epithelium.

Even in the absence of periretinal membranes, reabsorption of subretinal fluid may unexpectedly take several weeks [10]. This is not unduly influenced by the age of the patient, the presence of myopia or the initial volume of subretinal fluid. Delay in absorption can be seen even though the break is apparently completely closed, and may be related to defective action of the pigment epithelium in pumping out residual fluid. The surgeon must not be tempted to reoperate just because of the presence of this fluid unless an unsealed retinal break can be demonstrated. Initial reabsorption of fluid followed by redevelopment of subretinal fluid after fluid has been completely drained at the time of surgery indicates the presence of an imperfectly sealed or a missed break. If the retina does not flatten around the site of the buckle then the original break is usually at fault, whereas if retina around the buckle becomes flat but detachment persists elsewhere the presence of a break in another site is indicated (Fig. 5.8).

The complications of retinal detachment surgery may be divided into early and late. Early complications usually arise within a week of surgery whereas late complications can occur at any time in the postoperative period.

Early Complications

Sudden Blindness

Fortunately, sudden blindness in the postoperative period is extremely rare. It is usually discovered at the first postoperative dressing when the patient is unable to perceive light in the operated eye. Central retinal artery occlusion is the usual cause and is most likely to have resulted from a prolonged rise in intraocular pressure which may have been augmented by systemic hypotension during anaesthesia or in the immediate postoperative period. This rise in intraocular pressure may occur as a result of either excessive tightening of the buckle sutures (the reason for constantly monitoring the patency of the central retinal artery during surgery) or over-expansion of a gas bubble that has been used as a peroperative surgical manoeuvre. There is no treatment for central retinal artery occlusion.

Infection

The routine use of Genticin-soaked Silastic sponge explants and the invariable use of a subconjunctival injection of Genticin in cases of retinal surgery have greatly reduced the incidence of postoperative infection. It is very unusual for silicone rubber explants to become infected but occasional infection of Silastic sponges still occurs. If a non-drainage detachment operation is being performed then any infection that occurs either early or late is always extraocular in nature and only if drainage of subretinal fluid has been performed will there be any risk of intraocular extension. Extraocular infection of explants may now be classed as a late complication of retinal surgery.

Intraocular Infection

Intraocular infection is now extremely rare. The onset is at any time between 1 and 5 days after surgery, and the onset of infected endophthalmitis is heralded by pain and increase in lid swelling with chemosis. Flare and cells in the anterior chamber are prominent features and may progress to hypopyon formation, particularly in the aphakic eye. A mucopurulent discharge may appear from the breakdown of the conjunctival wound (a Gram stain or culture of which may demonstrate the causative pathogen). Increasing haze of the vitreous cavity may progress to extensive infiltration of the vitreous and obscuration of retinal details. Treatment is initially by the intensive administration of antibiotics, both local and systemic. If the infection is confined to the anterior segment then the inflammation may resolve without surgical interference. If there is involvement of the vitreous into which penetration of antibiotics is poor, pars plana vitrectomy should be performed as soon as possible. This will quickly effect resolution and give the best chance of preserving useful vision. Any infected explants can be removed at the same time that vitrectomy is performed.

Previous Corneal Grafts

The phakic graft is unlikely to be affected but in the aphakic graft the endothelium may suffer as a result of the posterior segment manoeuvres [11].

Anterior Segment Ischaemia

Ischaemia of the anterior segment following retinal detachment surgery is a result of poor perfusion and arises because of either a reduction of arterial inflow from the anterior or long ciliary arteries or obstruction of venous drainage by the vortex veins. It is probable that in severe cases a combination of circumstances exists. Encircling procedures, by virtue of their very nature in compressing the whole globe, are more likely to produce changes than are local buckling operations. Clinical syndromes produced by ischaemia of the anterior segment vary greatly from mild to severe changes [12]. Appreciation that over-constriction of the globe by an encircling band may produce ischaemic syndromes has led to a progressive rarity in the production of the end-stage picture. Mild ischaemic states are probably still quite common but are of little clinical significance.

Clinical Syndromes

The onset is 2–5 days after surgery. In mild cases there may be slight corneal oedema, flare and cells in the anterior chamber and an appearance of segmental atrophic changes in the iris. These changes are usually insignificant and require no special treatment other than the usual administration of dilating drops and local cortisone preparations in the postoperative period. In more severe cases there is a thick flare and cells and marked iris atrophy, the latter assuming a somewhat greenish tinge due to the infarctive nature of the problem. Posterior synechiae develop with hypotony, secondary phako-donesis and eventual cataract formation. In the past, diagnosis of the ischaemic states was by iris fluorescein angiography [13] (Fig. 5.2) but this is seldom indicated now. In severe cases of

Fig. 5.2. Anterior segment ischaemia following a local buckling procedure. There is non-filling of a sector of iris and corresponding sectorial iris atrophy.

anterior segment ischaemia, removal of the offending encircling band should be advised.

Prevention

Preoperative examination may reveal a high-risk anterior segment perfusion problem, e.g. an eye with ipsilateral carotid stenosis, a carotico-cavernous fistula or a general haematological problem such as HbSc disease. These groups of patients may be expected to tolerate poorly even slight interference with ocular perfusion; hence encircling bands should be avoided in these cases if possible.

At operation extraocular muscles should not be detached unless absolutely necessary to preserve the anterior ciliary artery supply, and damage to vortex veins should be carefully avoided.

Sterile Uveitis

Sterile uveitis due to trauma is found to a varying degree following most types of retinal detachment surgery. Its severity is related to the type of procedure performed and to the occurrence of complications. Uveitis is minimal following non-drainage detachment surgery but can be quite severe following a complicated detachment operation. Although uveitis is often unavoidable in these difficult cases, gentle rapid handling of the tissue at the time of surgery will be rewarded by reducing postoperative inflammatory changes. Uveitis may be confined to the anterior segment or be combined with some degree of vitreous haze. It usually appears within the first 2 days after surgery and there is often progressive improvement in the first postoperative week. The severity of uveitis is increased if there has been any degree of intraocular haemorrhage or of serous choroidal detachment either arising at operation or in the postoperative period.

The tendency to postoperative uveitis may be exacerbated by the extensive use of cryotherapy at the time of surgery [14]. It is, however, no longer the practice to attempt to apply cryotherapy to the neuro-epithelium through deep subretinal fluid, and this reduces the risk of excessive application in simple cases.

In the majority of cases of postoperative uveitis, local steroid drops (dexamethasone 0.1% instilled 2 hourly) are all that is necessary. Occasionally, however, systemic steroids are required (starting dose of prednisolone 60 mg/day, reducing by 5 mg/day after the 3rd day).

The clinical distinction between the milder forms of anterior segment ischaemia and of uveitis is not of much importance as spontaneous resolution is the outcome in either case. A worsening uveitis, however, with increasing pain and progression of anterior segment signs such as hypopyon or increasing vitreous haze is strongly suggestive of infection.

Glaucoma

Severe glaucoma following retinal surgery is unusual (about 1% of cases) [15] and may by either closed or open angle in nature. In closed angle glaucoma the intraocular pressure rises to a particularly high level (50–60 mmHg) and the eye is very painful.

Closed Angle Glaucoma

Closed angle glaucoma is the result of:

1. An anterior shift of the lens–iris diaphragm [16] induced by deep buckling procedures (usually encircling). The movement of the lens–iris diaphragm is further accentuated by compression of the vortex veins with subsequent venous congestion of the posterior segment [17]. The onset of this mechanism is usually within 1–2 days of surgery.
2. Serous choroidal detachment. If this is extensive the inevitable associated detachment of the ciliary body may result in the ciliary body hinging forward on the scleral spur with a resulting shallowing of the anterior chamber and angle closure. This type of glaucoma may reveal itself at any time up to a week after retinal surgery and usually occurs subsequent to the obvious appearance of choroidal detachment. The presence of choroidal detachment can be confirmed by B-scan ultrasonography.

Open Angle Glaucoma

Open angle glaucoma is usually secondary to uveitis and less commonly secondary to extensive vitreous haemorrhage (haemolytic glaucoma). It is more likely to occur in cases where there is underlying aqueous outflow obstruction, e.g. in underlying chronic simple glaucoma or in an eye in which the angle has been markedly compromised as a result of trauma.

Prevention

The occurrence of glaucoma, particularly of an angle closure type, underlines the need for careful assessment of the angle by gonioscopy at the time of the preoperative three-mirror examination. If the angle is found to be narrow, high posterior buckles should be avoided if possible.

Serous choroidal detachment may be avoided by reducing peroperative ocular hypotony to a minimum and avoiding damage to vortex veins.

Management

In all types of glaucoma the management should be conservative and surgical treatment avoided. Diamox 250 mg four times a day is given orally and Timolol 0.5% twice a day to the affected eye. In closed angle glaucoma miotics are of little benefit and in open angle glaucoma mydriatics should be prescribed. Medical treatment will usually control the intraocular pressure to satisfactory levels and if there has been no predisposition to glaucoma in the preoperative period then spontaneous resolution will occur over the following week or two. Only in the exceptional cases (such as very high intraocular pressures caused by angle closure situations) is surgery indicated. In the latter cases removal of the buckles may have to be performed. YAG iridotomy or surgical iridectomy will not relieve angle closure glaucoma. The postoperative complications of infection, uveitis and glaucoma accentuate the need for regular slit-lamp examination of the retinal detachment patient in the postoperative period.

Postoperative Complications of Intravitreal Gas

Excessive Expansion

Excessive expansion of gas from overfilling may result in:

1. Central retinal artery occlusion
2. Angle closure glaucoma from shallowing of the anterior chamber as the lens–iris diaphragm moves forward (this will be relieved by the head-down posture)

Cataract

Cataract may result from:

1. Needle damage at the time of the intravitreal injection. Such a cataract resulting from perforation of the lens capsule is usually progressive and the patient will require cataract surgery at a later date to correct the opacity.
2. Posterior subcapsular lens opacity. This type of reversible cataract is commonly seen following vitrectomy in the postoperative period owing to contact of any gas bubble with a posterior lens capsule, but rarely after conventional retinal detachment surgery where there is a protective layer of anterior

vitreous between the bubble and the posterior lens capsule [18] and the volume of gas is smaller.

Subretinal Gas

On rare occasions gas has reached the subretinal space via the retinal break [19, 20]. It is exceptional for it to be possible for these bubbles to be induced to return to the vitreous cavity via the retinal break. If only air has been used and the amount in the subretinal space is very small, then this air can be allowed to be absorbed. If, however, the amount of gas in the subretinal space is large and particularly if it consists of an air/SF6 mixture, retinal reattachment will be prevented and indeed the extent of the detachment will usually increase. The gas bubble should be allowed to be absorbed spontaneously before reoperation (usually consisting of pars plana vitrectomy) is performed.

New Breaks

New breaks are rare following gas injection. Most injections of the gas are made into the intravitreal compartment, i.e. anterior to the posterior hyaloid membrane, although the advantages of deliberate retrohyaloid injection in the management of giant breaks has been suggested [21]. Gas in the retrohyaloid space may result in stripping of that structure from the retina if posterior vitreous detachment has been incomplete. This movement can either cause fresh breaks or increase traction on existing ones. These breaks may cause redetachment in the postoperative period [22].

Fibrovascular Ingrowth

At the time of injection the injecting needle is introduced into the vitreous base via the pars plana. On rare occasions this needle track may induce fibrovascular ingrowth into the vitreous cavity. Unless very extensive, this ingrowth is usually of little clinical significance.

Haemorrhage

Haemorrhage from the injection site into the vitreous is rare but can be quite severe.

It seems likely that reported complications of gas injection will increase as the procedure becomes more popular.

Choroidal Detachment

Choroidal detachment observed in the postoperative period may be serous or haemorrhagic, the former being much the more common.

Fig. 5.3. Extensive serous choroidal detachment following a non-drainage retinal detachment operation.

Serous Choroidal Detachment

Serous choroidal detachments usually arise in the first 48 h following surgery (although they may appear at the time of surgery itself) but their appearance may be delayed by up to a week. They are smooth, dome-shaped elevations which may or may not be in direct relationship to the buckle (Fig. 5.3). They may remain localised to one quadrant or extend to involve the whole peripheral fundus. The elevations themselves have a brownish colour and the fluid within them does not shift. Posterior extension does not extend behind the equator and the anterior extension tends to push the peripheral retina into view, exposing the ora. Anterior extension may involve the ciliary body with a risk of angle closure glaucoma. Having appeared, choroidal detachments absorb spontaneously within 1–2 weeks after surgery. If the choroidal detachment is only slight, no residual change is to be seen after absorption. If, however, the detachments have been extensive, there is often a residual pepper and salt pigmentary disturbance taking the form of thin concentric demarcation lines under the retina.

Factors found to increase the likelihood of such detachments are vortex vein interference, myopia, the use of diathermy and the drainage of subretinal fluid [23]. A greater incidence was also found in the older age group [24]. Choroidal detachments are less often seen following non-drainage techniques [25], which suggests that hypotony resulting from drainage of subretinal fluid is one of the main factors contributing to the production of choroidal detachment. However, vortex vein interference is important since posterior buckling procedures are more likely to result in choroidal detachments.

If an eye has had a postoperative choroidal detachment that has reabsorbed and further surgery is necessary, a reappearance of the choroidal detachment in the postoperative period can be predicted with certainty. Small choroidal detachments localised to one quadrant, although an unwelcome sight in the postoperative period, do not appear to jeopardise the outcome of the operation. However, extensive choroidal detachments involving the greater part of the fundal circumference can contribute to failure by increasing postoperative intraocular inflammation with a subsequent increase in the risk of periretinal membrane activity. It is exceptionally unusual for choroidal detachments to be so extensive as to require surgical intervention.

Haemorrhagic Choroidal Detachment

Haemorrhagic choroidal detachment almost invariably arises as a result of an operative choroidal haemorrhage and rarely de novo in the postoperative period. It is often associated with some degree of overlying serous detachment. The haemorrhagic detachment is seen as a black, rounded mass underneath the retina, and it may undergo some degree of enlargement in the first few postoperative days. Unless very small, choroidal haemorrhage usually spreads into the subretinal space and via the retinal break into the vitreous 2 or 3 days after surgery and obscures the retinal view. The presence of blood in the choroidal, subretinal and vitreous spaces greatly increases the risk of failure of a retinal detachment procedure.

If the view of the retina is obscured by vitreous haemorrhage, the status of the retina must be checked carefully by periodic B-scan examinations. If these show that the retina is detached, pars plana vitrectomy should be performed to remove the blood from the vitreous cavity and to reattach the retina.

Vitreous Haemorrhage

Vitreous haemorrhage in the postoperative period usually arises as a result of extension of a choroidal haemorrhage and more rarely from further haemorrhage from a retinal break. The latter haemorrhages may be multiple and occur for many months or even years after the time of the operation. In most such cases, the haemorrhages arise from repeated bleeding from a vessel in the edge of the operculum. It is exceptional for these haemorrhages to require vitreous surgery, as they usually clear spontaneously.

Exudative Retinal Detachment

Exudative retinal detachment is a rare type of detachment which has been attributed to the use of cryotherapy, particularly if it has been excessively applied [26]. Subretinal fluid starts to accumulate on about the second postoperative day and may or may not be continuous with the retinal breaks. The fluid shifts markedly like other exudative detachments, and is invariably accompanied by vitreous flare and cells and by anterior uveitis. A similar type of exudation is sometimes seen after cryotherapy or photocoagulation of peripheral vascular angiomatous lesions. The exudative response, which may extend to involve practically the whole retina, has a benign course, with spontaneous absorption of fluid within a week or two after its appearance. The administration of systemic steroids may induce a more rapid resolution.

Late Complications

Cosmesis

Local buckles or low buckling encircling procedures cause almost no alteration in the appearance of the eye. Eyes that have had multiple operations with loss of periocular tissue (particularly those in which high encircling buckles have been used with distortion of the globe) tend to be enophthalmic with consecutive ptosis. The majority of patients will gladly accept this cosmetic defect in exchange for a sighted eye. They will be less happy, however, if retinal surgery has not been successful in restoring useful vision.

Explant Extrusion and Infection

Many months or years after surgery there is a tendency for explants (particularly Silastic sponge) to work themselves loose and to assume a rather bulky swelling underneath the conjunctiva. This does not require treatment, although patients are sometimes alarmed by the appearance of such a lump. If sponge actually extrudes through the conjunctiva itself, it is likely that infection has played at least a part in the event. Loosening of sponges may be prevented by (a) meticulous suturing techniques aimed at maintaining the integrity of the scleral suture by the use of long intrascleral sutures, (b) the provision of a good covering of tenons and conjunctiva over the trimmed explant by the use of a limbal incision, and (c) the reduction of infection by the use of antibiotic-soaked sponges and subconjunctival injection of antibiotics at the end of operation [27, 28].

In spite of all precautions, however, explants may become infected. Silastic sponge is more likely to get infected than solid silicone explants, as are explants used in reoperation [29]. The infection takes the form of an extraocular syndrome. A mucopurulent discharge is produced at the site of a dehiscence in the conjunctiva and this may be associated with granuloma formation (Fig. 5.4) and recurrent subconjunctival haemorrhage at the site [30, 31]. Although an infection may manifest itself many months after surgery, it probably arises as a result of low-grade organisms introduced at the time of surgery.

The eye with an infected explant is usually red and irritable with a mucopurulent discharge. A patient complaining of a persistent low-grade pain, often dating from the time of surgery and not explained by any other complications, should be

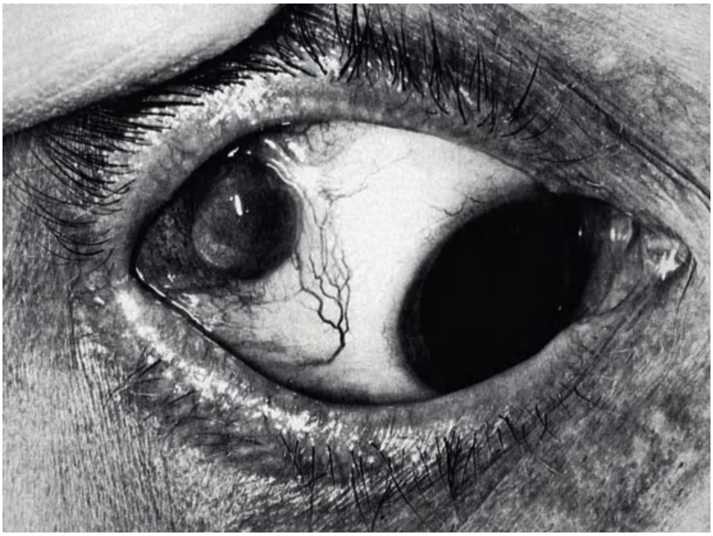


Fig. 5.4. An infected sponge has led to granuloma formation.

suspected of harbouring an extraocular infection. Careful examination of the conjunctiva and application of gentle pressure in the vicinity of any dehiscence may produce purulent material. The administration of antibiotics, either local or systemic, has no effect in ameliorating the infection, the treatment of which is to remove the explant. The treatment of an infected implant is removal although sometimes the explant will be extruded spontaneously with rapid resolution. Provided the retina is firmly reattached, there is little risk of redetachment following the removal of the explant. If the explant can already be seen protruding through the lips of the conjunctival incision, it may be removed after the application of topical anaesthetic drops, simply by grasping it firmly and pulling gently. If, on the other hand, the explant is buried and covered by granulomatous tissue, removal is best performed under general anaesthesia. Any scleral sutures which may also tend to contribute to the infection should be removed at the same time. The underlying sclera will be found to be normal.

Intraocular Erosion of Explants

The use of full thickness scleral buckles and the avoidance of deep indentation, particularly of solid explants, has greatly reduced the risk of intraocular erosion. Improvements in the materials used for encirclement have also reduced the tendency to erosion; thus an encircling element lying underneath the retina, or indeed in the vitreous cavity itself, is a rare sight. Scleral sutures may, however, erode with the passage of time, particularly if they are placed underneath the encircling band at the time of surgery. The appearance of these sutures on routine examination is of no more than passing interest, as they rarely cause problems or need to be removed. If in fact an explant has eroded within the eye, symptoms are seldom produced. On some occasions, however, detachment may occur as the retina becomes torn by the eroding material. Recurrent vitreous haemorrhages are also sometimes produced. Vitreous haemorrhages themselves are usually not extensive. If retinal detachment surgery has to be performed in the presence of an eroded explant, no attempt should be made to remove the explant. The detachment can be cured by closing the break produced by the explant and leaving the latter undisturbed.

Postoperative Pain

In the majority of cases pain encountered in the postoperative period wears off within a week or two of surgery, but on occasion it may be very considerable and last for many weeks or even months. The pain usually takes the form of a dull ache around the eye and may be referred to the side of the head in the distribution of the ophthalmic branch of the trigeminal nerve. Although intraocular problems (such as ischaemia, glaucoma or uveitis) may be the cause of such pain, it may be impossible to demonstrate any obvious cause, the pain apparently being caused by constriction by the scleral buckle. Encircling elements are more likely to produce lasting pain, but occasionally local buckles may be the cause. If pain is unremitting, it may be necessary to cut or loosen the buckle.

Postoperative Diplopia

Diplopia following retinal detachment surgery has become unusual owing to the tendency not to disinsert muscles at the time of surgery. Even in those cases where diplopia does occur in the postoperative period, this usually clears spontaneously in a few weeks following surgery [32]. On occasions, however, intractable double vision may be encountered in the postoperative period [33]. This interference with ocular motility is caused by the adhesions produced as a result of scleral buckling procedures in the vicinity of the muscles. A period of several months has to elapse before the ocular motor system becomes stabilised following surgery. A recent series of cases [34] has shown that simple removal of the explant and freeing of adhesions may result in improvement of diplopia, but eventually squint surgery may be necessary to manage those cases in which prismatic correction of the spectacles is not adequate to control diplopia.

Refractive Changes

Encircling Elements

In most cases when gentle indentation is produced, changes in refractive error are of very little significance. When, however, the buckle is somewhat higher, there is a tendency to myopia due to elongation of the globe [35, 36]. By contrast, when there is a deep encircling element, the actual length of the globe is surprisingly shortened and there is a resultant shift towards hypermetropia [37].

Local Buckles

Minor degrees of change in refraction both of the astigmatic and spherical components are common following local buckling procedures. High deep local buckles, however, particularly if radial, may produce very substantial degrees of astigmatism [38, 39]; this may be unacceptable to the patient and removal of the explant becomes necessary, although there is often some reduction of the change in refractive error if the scleral buckle becomes lower in the months succeeding the operation.

Intraocular Changes

The Macula

Macular Pucker

Macular pucker, which is due to the presence of contracting preretinal membrane at the macula, has been described following all forms of retinal detachment procedure [40] and also following prophylaxis with both light coagulation and cryotherapy. When macular pucker occurs in an eye in which the macula had not been detached prior to surgery, the effects on vision are particularly devastating. About 6 weeks after surgery there is reduction of central vision with micropsia and metamorphopsia. Macular changes begin as retinal oedema with disturbance of the normal macular reflex and wrinkling of the internal limiting membrane (cellophaning). Fine retinal folds form and arise either in a general pattern or from a focus. These folds, initially invisible, thicken to form perceptible white strands [41–43]. As the whitish membrane contracts, neighbouring blood vessels become distorted; they are drawn into the centre of the membrane in a tortuous manner and the more central part of the vessels becomes straightened (Fig. 5.5). The posterior hyaloid is always detached and intraretinal white dots, small haemorrhages and later small exudates may be found together with serous fluid under the neuro-epithelium. In the majority of cases of macular pucker, vitreo-retinal traction plays no part in the mechanism, although occasionally attachments are found extending from the macular area to the posterior hyaloid face [44]. In the early stages, fluorescein angiography will show no abnormality apart from slight tortuosity of vessels, but in more advanced cases leakage is demonstrated into the area of the membrane and spread into adjacent subretinal fluid. In their simplest form the membranes consist of retinal glial cells [45] gaining the preretinal surface via breaks in the internal lamina but when more extensive and thicker, other derivatives are found, e.g. fibroblasts and pigment epithelial cells. Usually the pucker that forms remains confined to the macular region and relatively localised, but sometimes extensive radiating fibrous sheets may form, and involve the whole of the posterior pole of the eye (Fig. 5.6).

In mild cases, pucker formation is slight and reduction of central vision minimal. More often, reduction of central vision is profound (6/60 approximately) and even in those cases in which central visual acuity is only slightly lowered, the patient may be greatly troubled by the incapacitating symptoms of metamor-

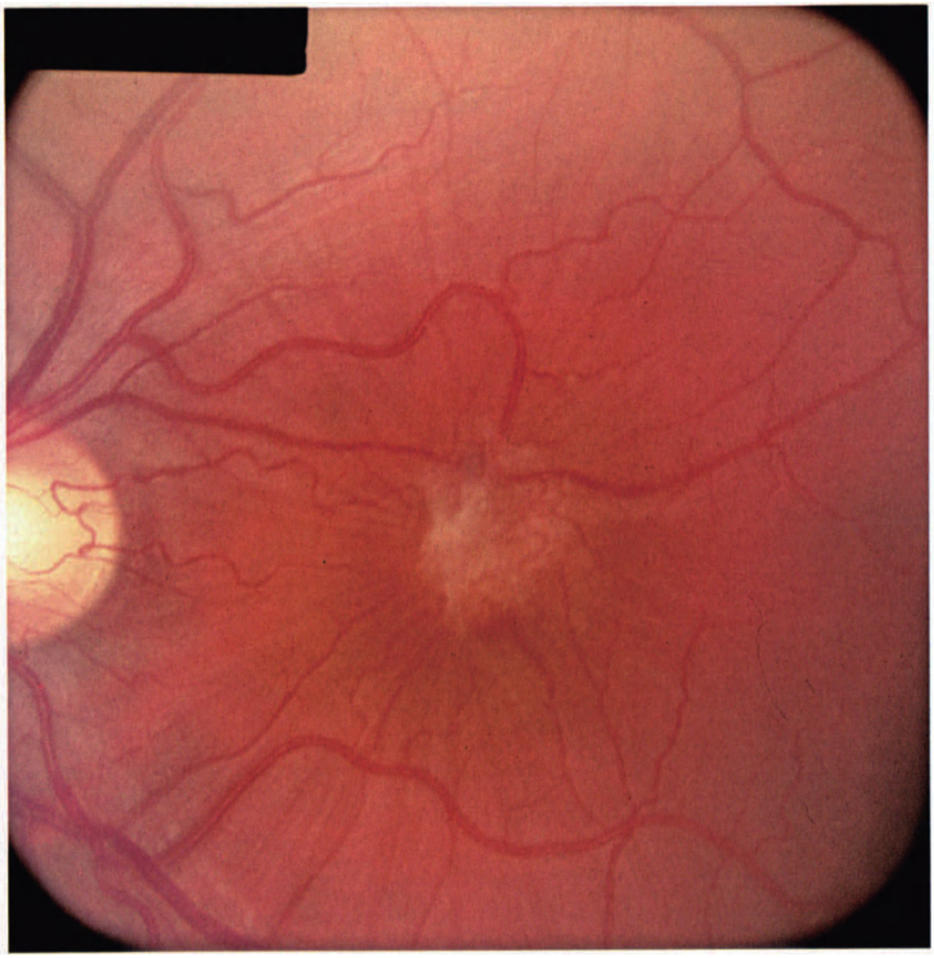


Fig. 5.5. Macular pucker.


TARRANT

Fig. 5.6. Extensive preretinal membrane of the posterior pole.

phopsia. Macular pucker of some degree occurs much more frequently in cases in which the retinal detachment had involved the macula in the preoperative period. Presumably the actual presence of subretinal fluid beneath the macula, combined with the trauma of detachment and reattachment, is the stimulus to the formation of membranes in these cases. The occurrence of macular pucker also appears to be related to the complexity of the surgical procedure.

Macular pucker may be treated by pars plana vitrectomy and peeling of the preretinal membrane [46]. The results of such surgery are somewhat variable, but even if visual acuity cannot be improved, removal of the membrane may result in relief of symptoms.

Other Macular Changes

Changes at the posterior pole following successful reattachment of the retina in cases in which the macula had been detached are not uncommon [47]. They may be non-specific pigment epithelial changes, revealed as small areas of pigment proliferation with interspersed areas of pigment epithelial atrophy. Cystoid macular oedema is sometimes seen [48] but macular hole formation is rare. Pigment epithelial changes are particularly likely to be found following long-standing preoperative detachment of the macula and may contribute to poor recovery of central acuity [49]. Pigmentary changes may also occur secondary to subretinal haemorrhage arising as a result of choroidal haemorrhage entering the subretinal space during surgery and settling in the macular region.

In most cases in which the expected level of return of visual acuity following retinal detachment surgery fails to occur, changes at the macula can be found. However, in some cases, after prompt reattachment of a detached macula, the expected improvement will not occur, even when the macula appears to be quite normal on biomicroscopic and fluorescein angiographic examinations. In these cases failure of photoreceptor regeneration may explain the deficit.

Periretinal Membrane Changes

The response of periretinal membranes to surgery is variable. If, for example, in preretinal membrane formation the process is not advanced and the membranes are still weak (up to C1 of the International Classification) and little contraction has occurred, then successful closure of the retinal break will result in reattachment of the retina with subsequent membrane regression, so that in the postoperative period and a follow-up examinations they are scarcely detectable. The retroretinal strands seen in long-standing detachments, while not interfering with retinal reattachment, may still be clearly seen and are often sharply demarcated on the back of the reattached retina (Fig. 5.7). Similarly, even more advanced full thickness retinal folds (up to approximately C1–C2 in the Classification) may likewise undergo almost complete regression, leaving only a

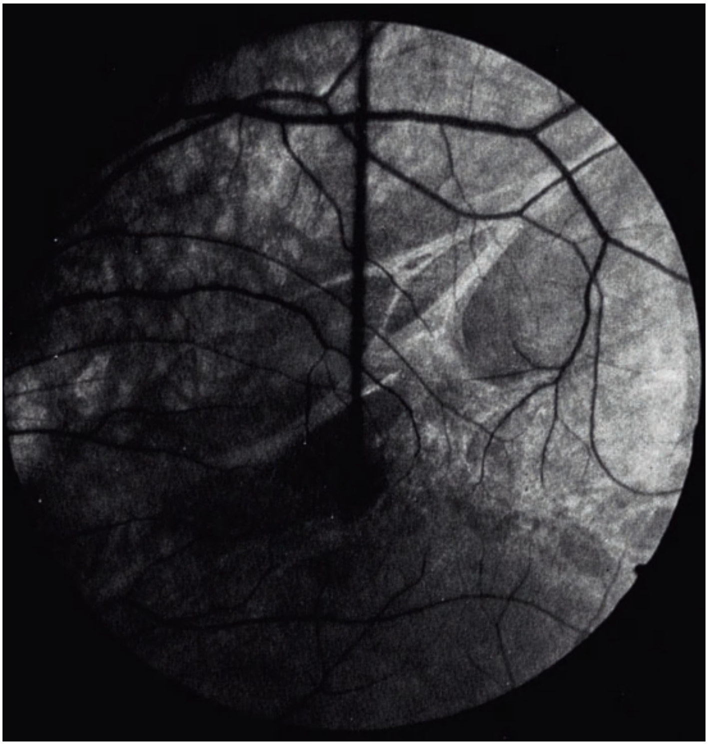


Fig. 5.7. Retroretinal strands seen on the back of a reattached retina.

small whitish scar on the surface of the retina to indicate where they had been situated. When membranes are extensive and traction is severe, simple closure of the retinal breaks will not result in complete retinal reattachment. Sometimes, residual traction detachment will remain localised. More often, however, the membrane process continues with progressive contraction. Breaks will tend to be reopened and redetachment occurs. Progressive proliferative vitreo-retinopathy terminating in an end-stage appearance may arise in the following ways:

1. *Preoperative proliferative vitreo-retiopathy*

a) Remorseless progression of membranes that were present preoperatively and in which retinal surgery has failed to completely reattach the retina. In these cases retinal surgery may actually have accelerated the progress of membranes, particularly if the surgery was complicated by haemorrhage or inflammation [50].
b) Preoperative proliferative vitreo-retinopathy which appears to have been halted by an initially successful operation with complete reattachment of the retina, only to be followed by a sudden onset of reproliferation and detachment 1–2 months after surgery. This is uncommon.

2. *Postoperative proliferative vitreo-retinopathy*

Membranes will almost inevitably appear eventually after failed surgery in cases that preoperatively did not have proliferative vitreo-retinopathy.

a) Failure to close breaks will not result in absorption of subretinal fluid and membranes will tend to appear a few weeks after unsuccessful surgery.
b) Slow reaccumulation of subretinal fluid from an incompletely sealed break following what seemed to have been a successful procedure may cause insidious membrane formation. A typical situation is inadequate superior break closure resulting in some accumulation of subretinal fluid via a narrow subretinal fluid sinus (Fig. 5.8).

Once membranes have appeared in the postoperative period, remorseless progression is the rule although spontaneous regression has been seen [51]. Even if detachment is extensive, spontaneous peeling of preretinal membranes and resolution of detachment has unexpectedly occurred [52].

Failure in Retinal Detachment Surgery

Reattachment of a detached retina (which should be achieved in well over 90% of previously unoperated cases) will result in improvement of at least peripheral vision in nearly all cases, even those that are very long-standing and in which the detached retina is seemingly atrophic. This improvement in visual field is often helpful to the patient and also serves as an insurance policy should the other eye become diseased. In some so-called successes, however, return of vision is so poor that it has not made much of a contribution to the patient's life, especially if the other eye is seeing well; indeed, occasionally the patient will complain that the poor vision in the operated eye actually interferes with normal vision in the good eye.

In failed cases it becomes a matter of clinical judgement as to whether or not further surgery should be advised, especially if there is good vision in the other eye. It should be remembered that the first operation has the best chance of success. Subsequent procedures have not only a reduced chance of success but also a worse visual prognosis. Each case must be carefully considered on its individual merits and this mainly depends on the patient's age, the visual demand, the complexity of the case and the chances of further surgery achieving reattachment. In younger patients, reoperation should usually be advised, unless there is no reasonable hope of reattachment; conversely, in old patients the enthusiasm of the surgeon to achieve reattachment must be tempered by careful consideration of the general risk (general anaesthetics may have already been given) and the likelihood of the restoration of worthwhile vision.

The causes of failure in retinal detachment consequent to scleral buckling may be considered under the following heading:

1. *Unbuckled breaks*. Unsealed breaks are the only cause of failure in cases uncomplicated by periretinal membranes.

a) Missed breaks. The failure to buckle a break at all implies that the break has escaped detection on the preoperative examination and at the time of surgery (Fig. 5.8c). It is extremely unusual for fresh breaks in the postoperative period to cause failure.

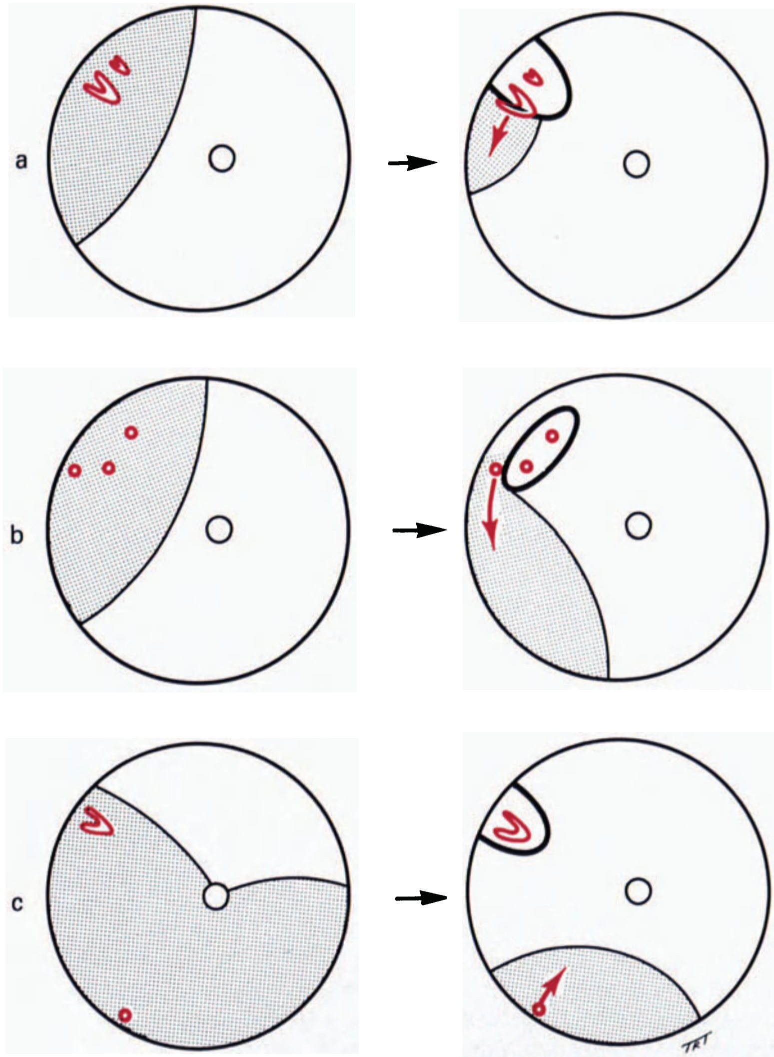
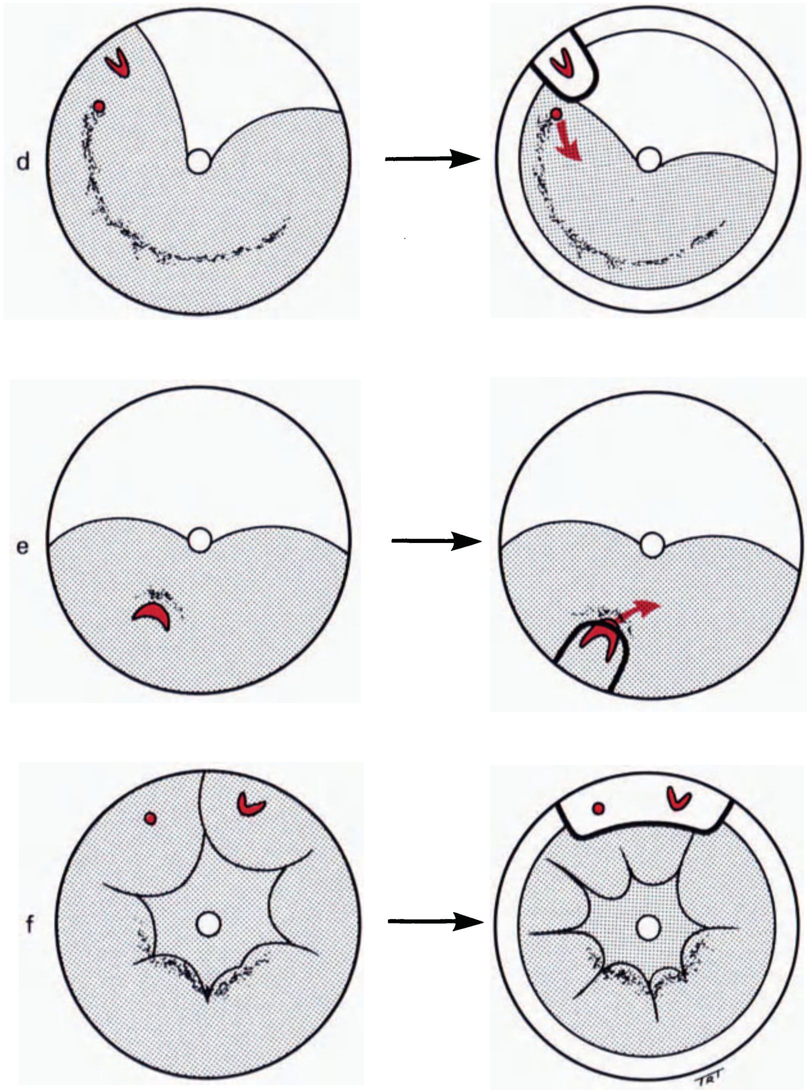


Fig. 5.8a–f. Failed situations. **a** A radial buckle has failed to close a tear. **b** A circumferential buckle has failed to seal a small anterior hole. **c** An undetected inferior round hole has prevented the absorption of inferior subretinal fluid. **d** A missed hole hidden by preretinal membrane formation has resulted in residual inferior half retinal detachment. **e** An inferior retinal tear immobilised by preretinal membrane formation has been inadequately sealed. **f** In spite of adequate closure of superior breaks, substantial equatorial preretinal membrane formation has prevented retinal reattachment with ongoing proliferative vitreo-retinopathy.

b) Poorly buckled breaks. A break may be poorly buckled because of (a) inadequate proportions of the buckle (insufficient height and radial or circumferential extent; Fig. 5.8), (b) poor selection of direction of buckle (i.e. radial vs. circumferential; Figs. 5.8b, 5.9) or (c) failure to close breaks at the time of surgery in the presence of marked traction, either dynamic or static.

2. *Proliferative vitreo-retinopathy* (see p. 150).



Surgery of Failed Cases

Failure is best judged either by the reaccumulation of subretinal fluid after almost complete reabsorption or, more commonly, by increase in the preoperative volume of subretinal fluid after surgery (see p. 136). It is wise not to hasten reoperation if absorption of subretinal fluid is delayed and the buckles appear to have been placed correctly. Patient observation of the situation may reveal slow but sure diminution of subretinal fluid. However, when it is clear that the operation has failed, further surgery should be carried out as soon as is reasonably possible. Before reoperation the case must be entirely re-examined with indirect

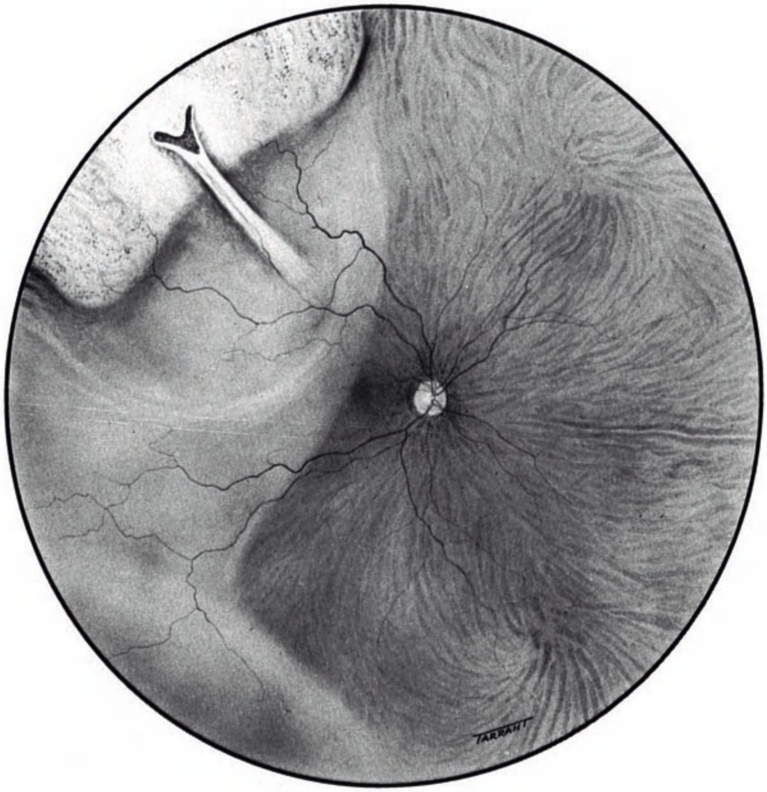


Fig. 5.9. A circumferential buckle has been used to attempt to close a retinal break. A fold connects the tear with subretinal fluid behind the buckle.

ophthalmoscopy and scleral depression (if possible) and three-mirror gonioscopy with charting of the altered retinal detachment situation. The distribution of subretinal fluid in the failed situation may reveal the source of the failure. If the original break is closed and subretinal fluid does not extend to it, then a further break must be responsible for the failure (Fig. 5.8c). If this is separated from the original break by a substantial area of retina, then the contour of subretinal fluid will be substantially altered. If, on the other hand, the original break is still at fault, the contour of the fluid will remain unaltered after the failed procedure.

Selection of Operation

Photocoagulation

Photocoagulation using the xenon arc (more effective as it is more powerful than laser photocoagulation) can sometimes still be useful in the postoperative period to promote closure of an incompletely sealed retinal break [53]. For this manoeuvre to be successful, the buckle must be in the correct position near the break and separated from the break only by a thin layer of subretinal fluid.

Photocoagulation may also be of some value if radial folds leading from the break to subretinal fluid behind the buckle have been produced. Local retrobulbar anaesthesia is used and photocoagulation applied to completely surround the retinal break. The sealing of the break will result in rapid disappearance of residual subretinal fluid.

It is now unusual to find cases that may be cured by this form of treatment.

Further Buckling

In most cases it is possible to establish the cause of failure. If an offending break is identified, then a logical reoperation can be planned. If the break had previously been missed altogether or had been inadequately buckled with an explant inaccurately placed or of insufficient proportion, then a further simple buckling procedure using a buckle of adequate proportions is all that is necessary to achieve success. Subretinal fluid will be drained according to criteria previously described (Chap. 2). Although the clinical situations existing will result in drainage of subretinal fluid in a greater proportion of cases undergoing reoperation, subretinal fluid must not be drained from the eye just because a reoperation is being performed [50]. If, however, an experienced surgeon has failed to close a break with a buckle, it is likely he would like to close the break at the time of reoperation and for this drainage of subretinal fluid may be necessary with or without the added tamponade of a vitreous gas bubble and heightening of the buckle. If the cause of failure can be established by finding a further break, the buckling procedure need only be a local one. If, on the other hand, the retina is extensively detached and no further break can be established, an encircling procedure will usually be selected if a local buckle had been previously used. However, the manoeuvre of moving an encircling procedure in a more posterior position in an attempt to seal a presumed but unseen retinal break is rarely successful. In cases when there is an unsealed superior break, a simple intravitreal injection of an expanding gas (approx. 1 ml SF6 or 0.3 ml C_3F_8) to achieve tamponade and close off the break results in rapid resolution of subretinal fluid. The extent of application of this procedure has yet to be assessed.

Even in the most expert hands, the need for reoperation in retinal detachment surgery arises not infrequently (approximately 15% of primary cases may need a second operation). Although in some cases it is possible to warn the patient about the possibility of reoperation, the fact that reoperation is indicated will come as a disappointment to both patient and surgeon and will certainly have a morale-lowering effect on the former (if not the latter!). However, reoperation must not be unnecessarily delayed with the attendant risks of detachment of an otherwise undetached macula and the development of periretinal membranes.

Follow-up of Patients

Patients should be followed up with the length of time between visits being increased until eventually only an annual assessment to check up on both the operated and the fellow eye is made. This examination will concentrate on visual acuity, reassessment and fundal examination. If redetachment is to occur it will generally do so within a few weeks of surgery. Failure of improvement in visual acuity will remind the examiner of the need to examine the macula. Refraction will be carried out approximately 2 months from the time of surgery and any alteration in spectacles or contact lenses can then be made. A previous retinal detachment operation should not act as a deterrent to subsequent cataract surgery, should it be necessary, nor in the majority of circumstances should the use of an intraocular lens be contra-indicated, particularly if combined with the extracapsular approach. If cataract surgery is to be performed to the fellow eye, then prophylactic cryotherapy should only be advised if high-risk areas such as lattice degeneration or retinal breaks are present.

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