Rhegmatogenous Retinal Detachment

6

Contents

6.1 Introduction

Strictly speaking, 'retinal detachment' is a misnomer. The term denotes separation of the neuroepithelium from the pigment epithelium (rather than detachment of the retina, which consists of the neuroepithelium and the RPE, from the choroid) and therefore implies re-establishment of the space between the original layers of the embryonic optic cup. The incidence is approximately 10/100,000 (Saidkasimova et al. 2009), and presentation is more common in affluent populations and possibly males. Black races are probably less affected than white (Day et al. 2010).

The most common cause of retinal detachment is the formation of a 'break' or full-thickness discontinuity in the neuroepithelium with recruitment of fluid from the vitreous cavity into the subretinal space via the break, creating 'rhegmatogenous retinal detachment'. Classically, breaks are subdivided into 'tears' (secondary to dynamic vitreoretinal traction) and 'holes' (secondary to localised retinal disintegration or atrophy).

6.1.1 Tears with Posterior Vitreous Detachment

Most retinal tears occur in association with posterior vitreous detachment by the operation of 'dynamic vitreous traction' Fig. 6.1). This term denotes the transmission of rotational energy (generated by saccadic contraction of the extraocular muscles) to the vitreous gel through the coats of the eye (sclera, choroid and retina). Whilst the vitreous remains attached to the retina, this energy transmission is dispersed throughout the total area of vitreoretinal contact. After posterior vitreous detachment, however, the forces produce considerable movement in the posterior gel. The vitreous base provides the centre of energy, whilst the posterior vitreous responds to the energy by accelerating into a violent movement.

If there is any area of 'abnormal' adhesion of the retina to the gel, the movement of the gel exerts considerable dynamic

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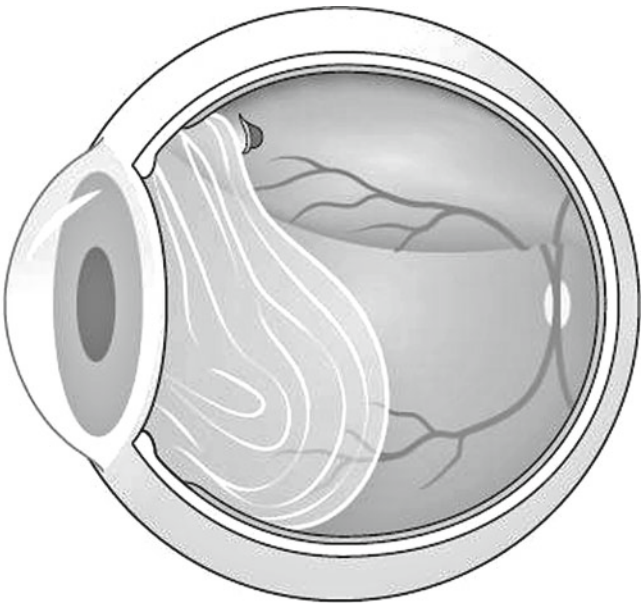


Fig. 6.1 A retinal tear occurs when the vitreous separates from the retina posteriorly. The vitreous produces traction on its attachments to the retina thereby tearing the retina, producing a retinal break

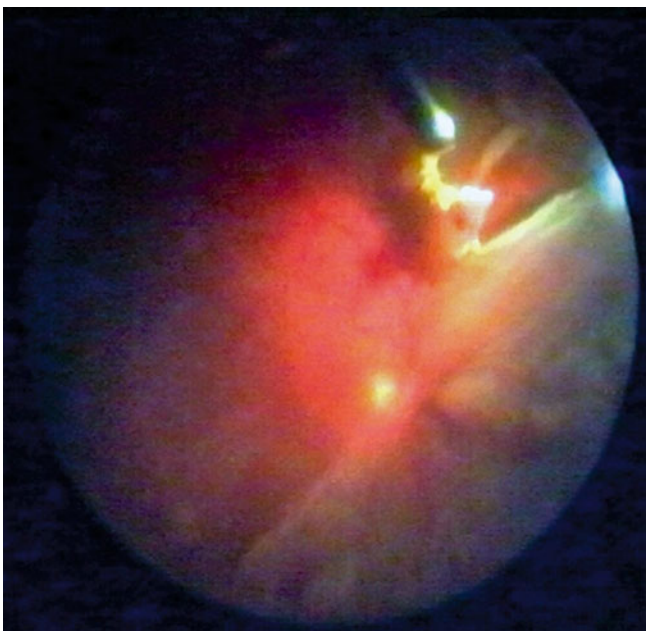


Fig. 6.2 A clot of fibrin can be seen extending from an artery torn by the action of PVD in tearing the retina

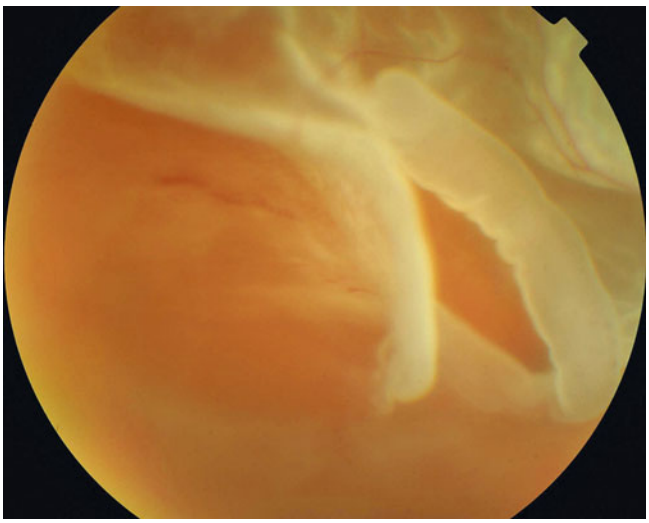


Fig. 6.3 A large retinal tear

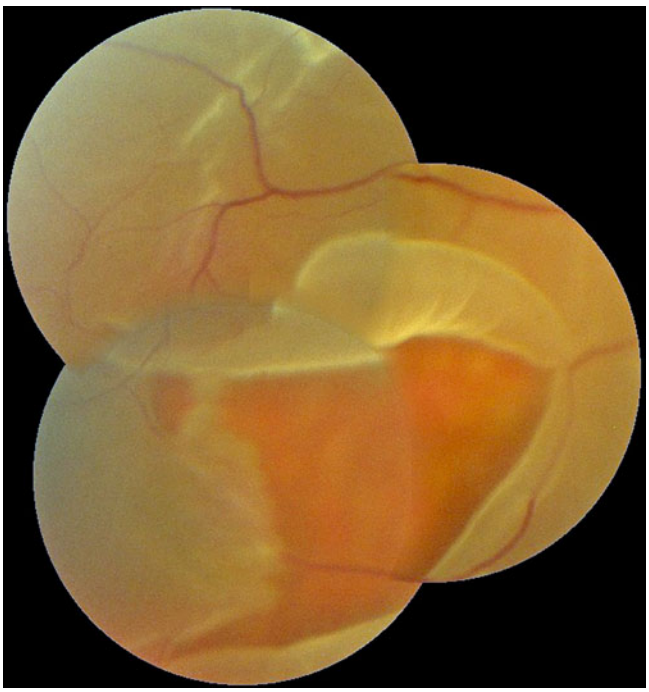


Fig. 6.4 A large U-shaped tear

traction on the retina sometimes producing a U-shaped tear of the retina. The base of the tongue of retina, which produces the 'U', is anteriorly placed because the vitreous separates first posteriorly tearing the retina at a point of adhesion and the action of the vitreous extends the tear anteriorly towards the vitreous base. If the flap of the tear separates completely from the retina, the piece of avulsed neurosensory retina is seen attached to the posterior vitreous membrane as an operculum and a round tear is produced. Ninety percent of tears are present at the initial examination after a symptomatic PVD. Approximately 10 % are not seen at the initial presentation or develop later therefore a follow-up examination is recommended (Sharma et al. 2004b).

If the symptoms are of a few days' duration, review in 1 week; if longer, review at 4–6 weeks.

Haemorrhage from rupture of a blood vessel that crosses a U tear may produce a 'tadpole' floater or shower of floaters. Floaters may also be seen from the posterior vitreous detachment and photopsia (flashing lights) from traction on the retina.

The vitreous is adherent to the rim of lattice lesions. U tears in lattice therefore tear along the posterior border of the lattice and then extend anteriorly around the edge of the lesion.

Multiple tiny flap breaks at the posterior border of the vitreous base are particularly associated with aphakia or pseudophakia. The reasons for this are not clear, but cataract extraction alters the architecture of vitreous through loss of the posterior bulge of the crystalline lens into the anterior vitreous.

6.1.2 Breaks Without Posterior Vitreous Detachment

Rhegmatogenous retinal detachment may be produced without posterior vitreous detachment by atrophic retinal holes often in young myopic patients (these patients are more likely to be female, 64 %, with bilateral pathology in 83 % (Ung et al. 2005)) or by retinal dialysis at the ora serrata (see Chap. 6). Both conditions usually produce a slow onset of retinal detachment which may only be noticed during coincidental examination of the eye or symptomatically by the patient when the fovea detaches. Atrophic holes are often equatorial, associated with lattice degeneration, myopia and found in 20–40-year-old patients. The vast majority will not cause retinal detachment, and prophylactic therapy is generally regarded as unnecessary. Recruitment of fluid in round hole detachment probably occurs by connection of the hole to lacunae in the vitreous. This may cause a stepped increase in the detachment with multiple pigmentary demarcation lines in a chronic-looking retinal detachment.

Retinal dialyses are ellipsoid separations of the retina at the ora serrata that are usually situated inferotemporally. They differ from U tears because the gel is attached to the posterior rather than the anterior margin of the break and posterior vitreous detachment is absent.

Fig. 6.5 Lattice degeneration

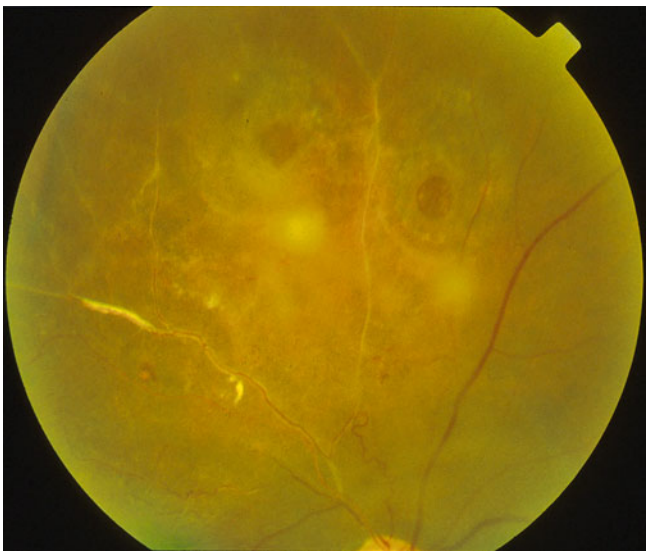


Fig. 6.6 These round breaks have overlying opercula of retina (seen out of focus) suggesting previous vitreal traction; these breaks are at low risk of causing retinal detachment

Fig. 6.7 Round holes are present in an inferior retina in this patient. These can be ignored if they are asymptomatic as the chances of their progression to retinal detachment are probably less than 1/200

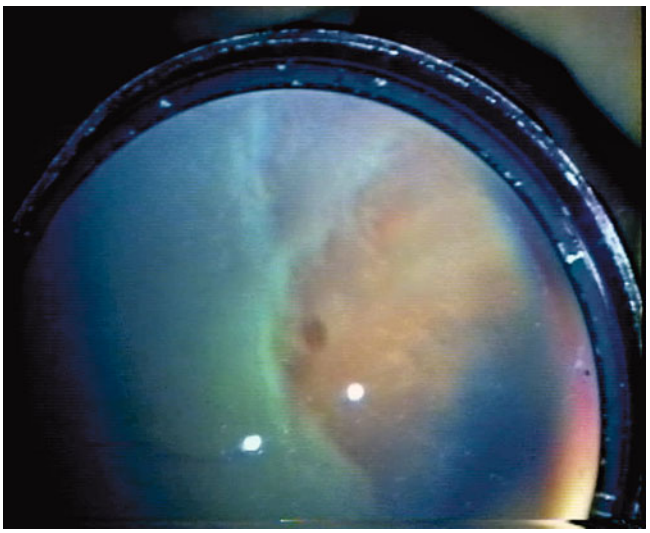


Fig. 6.8 A round hole is visible on indentation of this eye

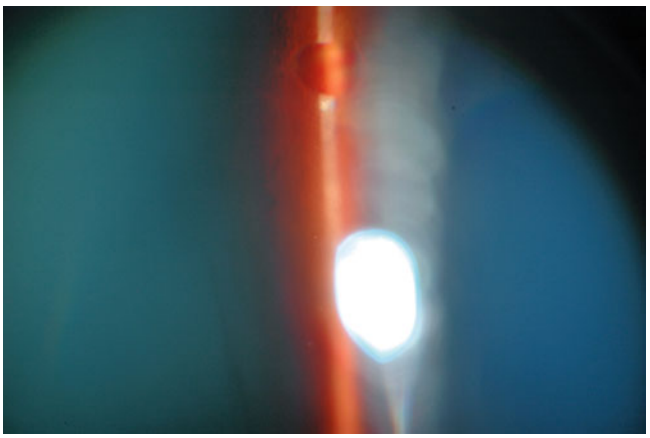


Fig. 6.9 A round hole seen on a slit-lamp camera

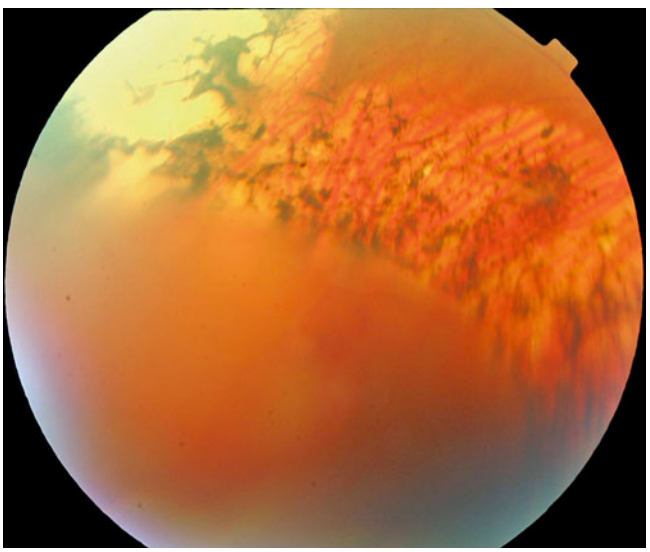


Fig. 6.10 A demarcation line is shown around this retinal detachment which has been chronic in nature. It is unlikely that the retinal detachment will extend through this demarcation, and therefore surgery is not required

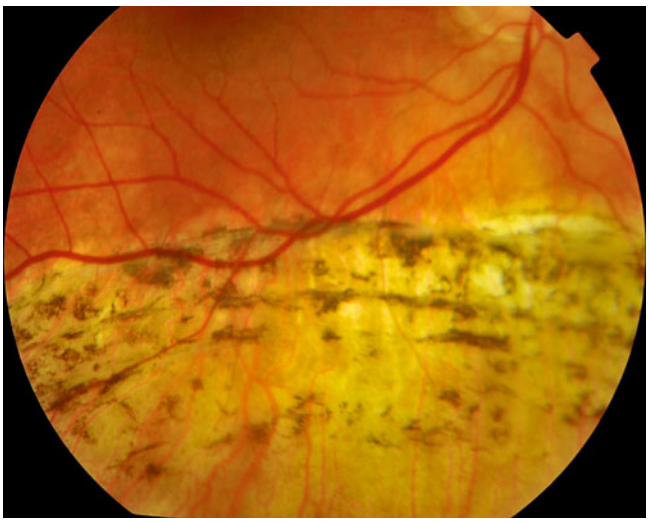


Fig. 6.11 A RRD may spontaneously reattach leaving RPE hypertrophy and atrophy. The arcs of pigment hyperplasia in this patient suggest that the RRD advanced, stopped and advanced again a phenomenon seen in vitreous-attached RRD. One theory for this observation is that lacunae of fluid vitreous empty through a retinal hole providing fluid for the subretinal space and advancement of the RRD edge. The RRD does not move again until another lacunae form and empty through a hole. In the meantime, RPE hyperplasia occurs at the juncture of the detached and attached retina creating arcs of pigmentation. Spontaneous reattachment may occur when vitreous gel plugs the retinal hole and the RPE is able to clear the SRF

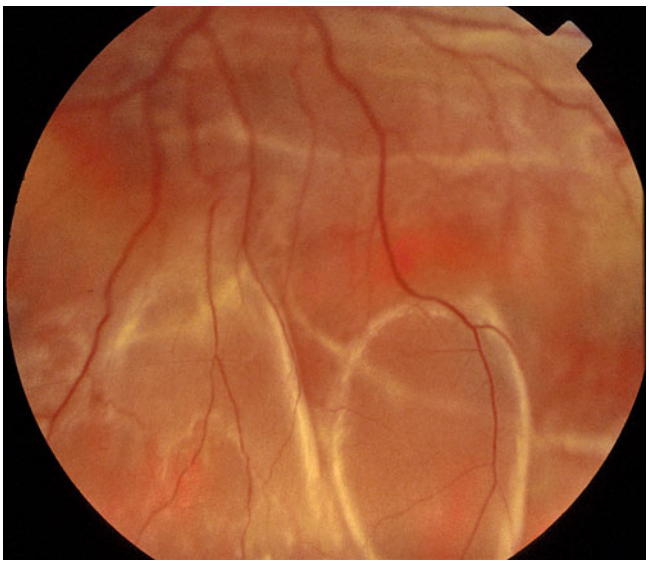


Fig. 6.12 A retinal cyst is a sign of longevity of retinal detachment, usually over 1 year. In this eye, two retinal cysts are inferiorly placed

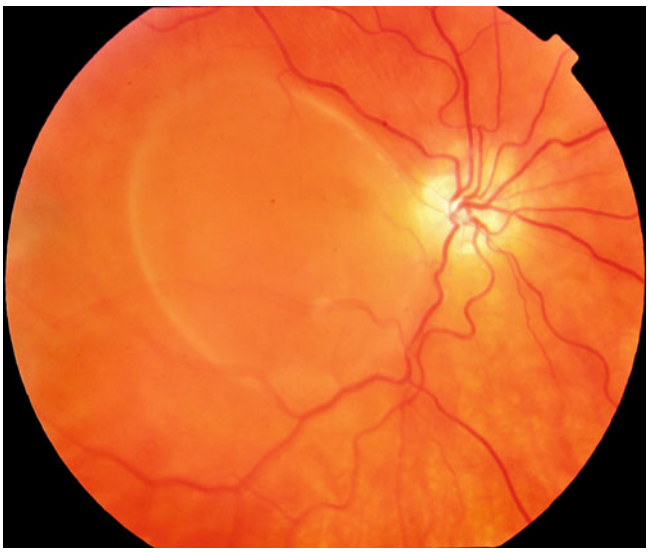


Fig. 6.13 A retinal cyst has formed in the macular area in this patient with chronic RRD

Fig. 6.15 The fovea was in place in this chronic RRD with subretinal bands. The retinal hole appeared to be plugged with vitreous perhaps preventioning further fluid vitreous entry through the break and further spread of the RRD (see Fig. 6.16)

Fig. 6.14 Subretinal bands in a chronic RRD, these are commoner in vitreous-attached RRD, e.g. retinal dialysis or round hole (young myope) RRD

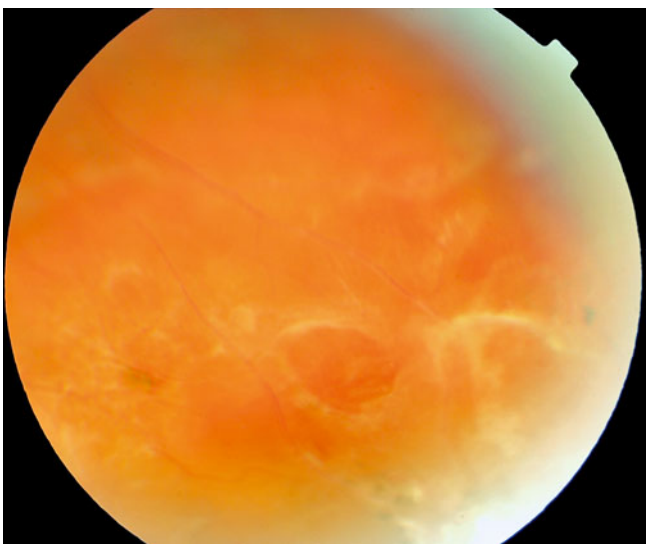


Fig. 6.16 See previous figure

6.1.3 Natural History

- Most retinal detachments if untreated will progress to totality or near totality. The visual loss is profound, and potential recovery of vision by surgery reduces as the weeks go by.
- The accumulation of SRF in the periphery seems to be important for the development of loss of vision as patients with RRD lose more vision in comparison to CSR for the same foveal.
- Initially, the retina is thickened and less transparent than normal.
- If the retina remains detached for many months, it becomes progressively atrophic.
- The longer the retina remains detached, the higher the risk of a scarring response, proliferative vitreoretinopathy (see PVR, Chap. 8).

Fig. 6.17 If a RRD spontaneously reattaches, retinal pigment epithelial changes may occur

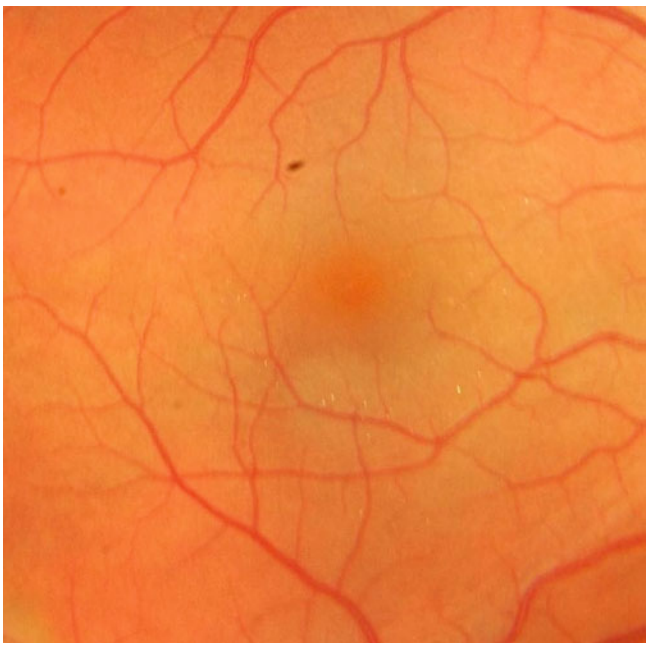


Fig. 6.18 Tiny white flecks can be seen in the fovea in patients with chronic retinal detachment. These are signs of oxalosis, a secondary complication from the chronicity of the retinal detachment

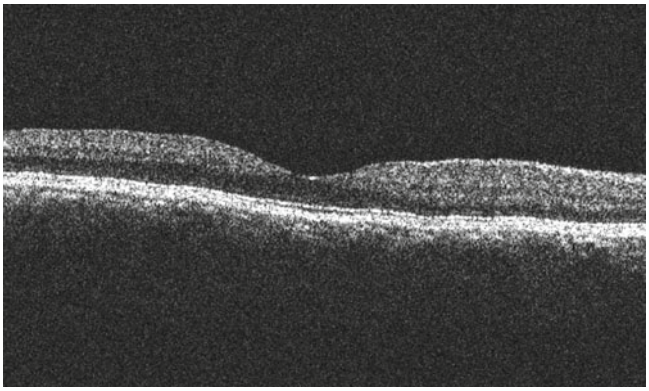


Fig. 6.19 A tiny speck of oxalate can be seen on the foveal surface on OCT (*greyscale image*)

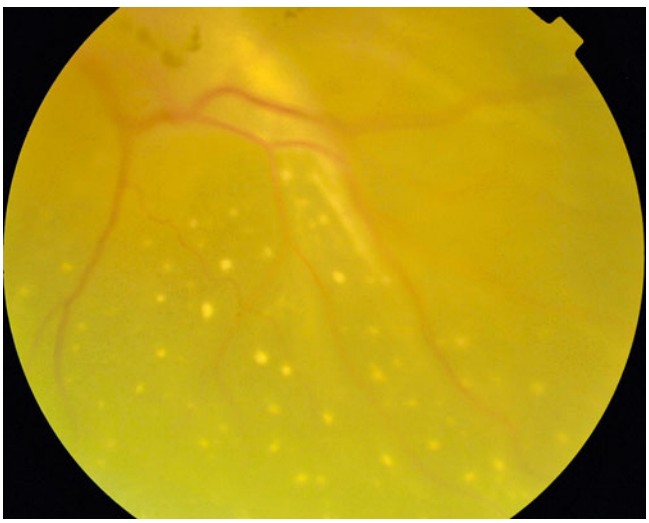


Fig. 6.20 Some long-standing RRDs, e.g. from retinal dialysis, will show white spots on the outer retina. These fade after reattachment of the retina (see Fig. 6.21)

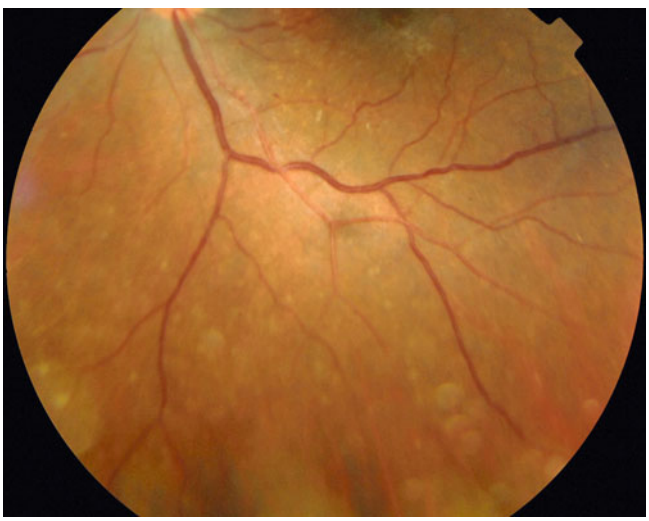


Fig. 6.21 See previous figure

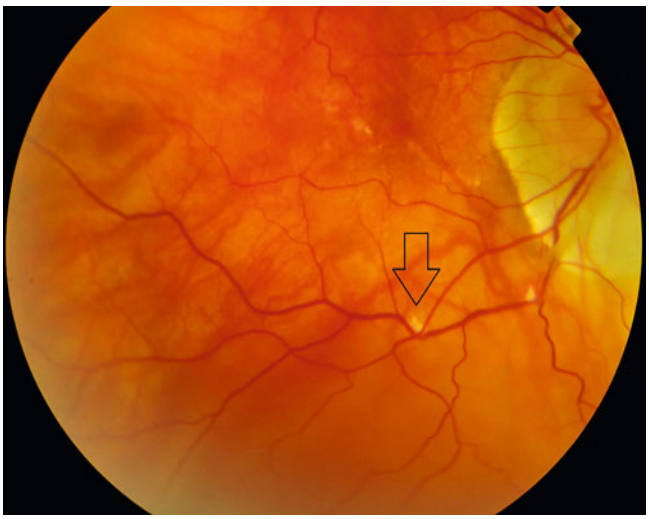


Fig. 6.22 The *arrow* indicates a point of adhesion which appears to have stopped the progress of a chronic inferior RRD

6.1.3.1 Chronic RRD

In a long-standing subtotal retinal detachment a 'high-water mark' or pigment demarcation line of retinal pigment hyperplasia may appear, which sometimes limits further extension of the detachment. Multiple high-water marks in detached retina indicate recurrent extension of the detachment and are more often seen in slower onset detachments associated with round holes or dialyses. Other indices of long-standing detachment include retinal cysts (secondary retinoschisis) (Marcus and Aaberg 1979), oxalate crystals on the macula (Ahmed et al. 1998) and peripheral neovascularisation.

Very rarely, the retina reattaches spontaneously sometimes leaving pigmented chorioretinal changes, but most often surgery is required to reattach the retina. After successful surgery, the rods recover their function surprisingly well, and any visual field defect disappears. If the fovea has been involved, recovery of function of the cones is good if the detachment is treated quickly (within 1 week of onset). After prolonged detachment of the fovea, central vision may be permanently impaired.

Descriptive statistics for a north European population (Laatikainen and Tolppanen 1985)

Mean age	53 years
Bilateral	10 %
Lattice degeneration	15 %
Total detachment	17 %
More than one break	41 %
No break found	11 %
More dialyses	<20 years old
Tears = atrophic holes	20–40-year-olds
Predominantly tears	>40-year-old
Bilateral simultaneous (Krohn and Seland 2000)	2.3 %

6.1.3.2 Risk to the Other Eye

Chance of RRD in the fellow eye later on is 12 % with a 12 % chance of requirement for retinopexy to a tear (Gonzales et al. 2004).

6.2 Clinical Features

The patient may experience symptoms of flashes and floaters (indicating posterior vitreous detachment with or without vitreous haemorrhage) followed by visual field loss. Some slow-onset retinal detachments will produce the symptom of a slow flashing light (often moving like a slow comet tail) lasting a few seconds and situated in the visual field appropriate to the leading edge of SRF. When the fovea detaches, there is loss of central vision, with the fovea just off the visual acuity may vary from 20/40 to 20/200. As the fovea lifts, the patient may experience distortion of vision. When the macula is fully detached, the vision may be 20/200 to hand movements.

6.2.1 Anterior Segment Signs

A few cells and some flare can be seen in the anterior chamber. Rarely a severe anterior uveitis occurs perhaps indicating a high risk of PVR. IOP is often lower than the fellow eye. Occasionally, a high IOP can be produced by blockage of the trabecular meshwork by the remnants of receptor outer segments (Schwartz's syndrome) (Netland et al. 1994; Schwartz 1972). Iris neovascularisation has been described which reverses after resolution of the RRD (Tanaka et al. 1991).

6.2.2 Signs in the Vitreous

Retinal tear formation is usually associated with the release of retinal pigment epithelial cells into the vitreous cavity (see Chap. 3). The presence of pigment cells in the retrolental gel (Shafer's sign) (Shafer et al. 2005) in a phakic eye strongly implies the presence of a retinal break. Differentiation of these cells into fibroblast-like cells and synthesis of new collagen within the gel and on the posterior hyaloid interface results in retraction and immobilisation of the gel. An early sign of this process is seen when the cells change from diffuse single cells to groups or 'clumps' of cells in the gel. Such changes are frequently associated with the proliferation and contraction of cellular membranes on the retinal surface in proliferative vitreoretinopathy (PVR). Vitreous haemorrhage may obscure the view of the retina and breaks. Suspect that any patient with vitreous haemorrhage of unknown aetiology has a retinal tear or detachment.

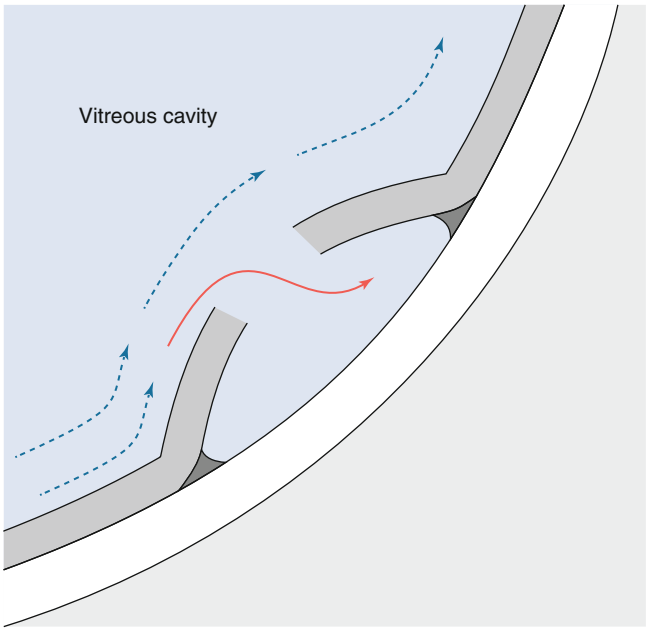


Fig. 6.23 Fluid currents (*arrows*) from the vitreous cavity may contribute to the lifting of the retina in rhegmatogenous retinal detachment

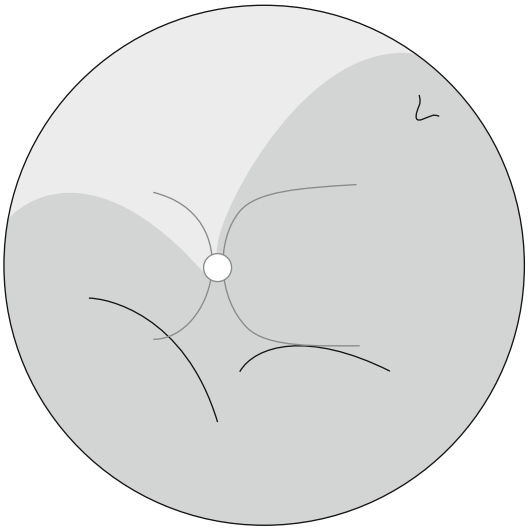


Fig. 6.25 The retinal break in a bullous RRD is usually located 1–2 clock hours from the superior edge on the highest side

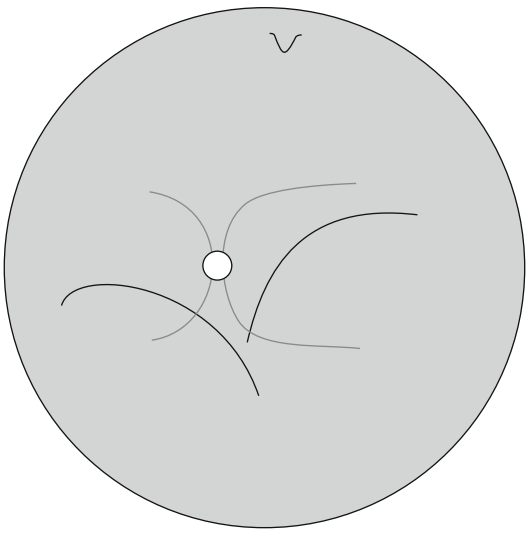


Fig. 6.24 A break at 12 o'clock causes a total bullous RRD

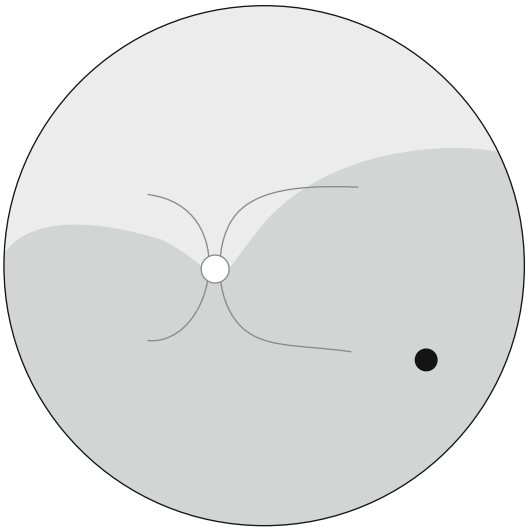


Fig. 6.26 The break in a non-bullous RRD is usually inferior and on the side of the highest retinal detachment upper edge

6.2.3 Subretinal Fluid Accumulation

Separation of the neuroepithelium from the pigment epithelium occurs first in the immediate vicinity of the break. Progressively more subretinal fluid is recruited from the vitreous cavity (from the retrohyaloid space or from syneretic gel) increasing the area and elevation of retinal separation. Progression has been estimated at 1.8 disc diameters/day (Ho et al. 2006) so that fovea on patients can become fovea off by the time of surgery. If the globe is completely immobilised at an early stage, the retina may partially or even completely reattach suggesting that three mechanisms may be implicated.

Movement of the eye (and the resultant vitreous gel movement) causes extension of the retinal detachment through the action of dynamic vitreoretinal traction.

The movement of the gel induces fluid currents in the retrohyaloid space, which forcefully elevate the neurosensory retina (Hammer et al. 1986).

Gravity encourages spread of the subretinal fluid.

The last mechanism causes a pattern of spread of subretinal fluid first described by Lincoff that may be used by the surgeon to aid localisation of a retinal break (Lincoff and Gieser 1971).

A tear between the 11 and 1 o'clock causes a retinal detachment, which becomes total soon after its onset.

Tears above the horizontal meridian (3 to 9 o'clock) produce subtotal detachments. Fluid is recruited progressing downwards on the same side as the tear at first and then upwards on the opposite side of the disc (but to a level lower than that on the side of the tear).

Inferior subretinal fluid from a superior tear tends to separate partially into two bullae with a cleft or 'cleavage' of less elevated retina in the 6 o'clock meridian.

A break located below the horizontal meridian tends to accumulate fluid more slowly compared with that descending from above. The upper limits of the detachment form convex-curved edges on each side, the higher edge indicating the side of the break. Bullae are not seen with inferior breaks.

Occasionally, a small anterior and superior tear leaks fluid down the post-oral retina causing an inferior retinal detachment. Therefore, inferior retinal detachments can occur from both superior and inferior tears.

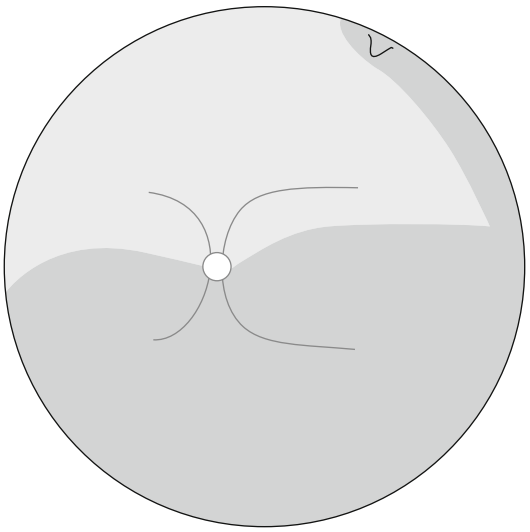


Fig. 6.27 Occasionally, a small anterior break will cause an inferior RRD by tracking SRF down the anterior retina

Subretinal fluid accumulates more quickly if fluid is recruited from the retrohyaloid space (e.g. via a U tear after posterior vitreous detachment) compared with breaks occurring without posterior vitreous detachment (e.g. atrophic holes and dialyses). In the latter, potential recruitment of fluid from syneretic gel may be limited by the size of the lacuna in the gel. As a retinal detachment progresses, the

Fig. 6.28 A wide-angle view of the retina with an inferotemporal RRD, leading edge (*arrow*) close to the fovea

Fig. 6.29 A composite picture shows an RRD passing through the macula

Referral procedure for RRD

Condition	Characteristics	Referral	Why?
RRD with PVD	Macula on	Immediate	Prevent macula detaching
	Macula off less than 1 week	1–3 days	Macula should recover fully
	Macula off 1–2 weeks	1 week	Macula should recover well
	Macula off 2–6 weeks	1–2 weeks	Macula will show moderate recovery
	Macula off >6 weeks	2–3 weeks	Macula unlikely to recover well
RRD without PVD		1–2 weeks	Slow progression

Fig. 6.30 It may not be obvious that the fovea is detached in which case OCT is useful (see Fig. 6.31)

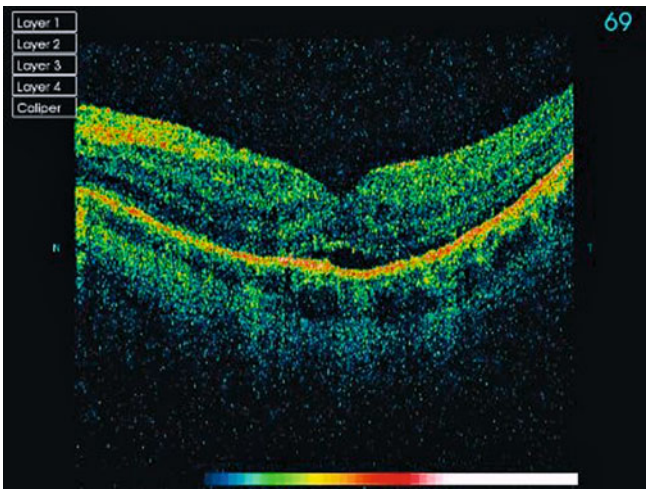


Fig. 6.31 See previous figure

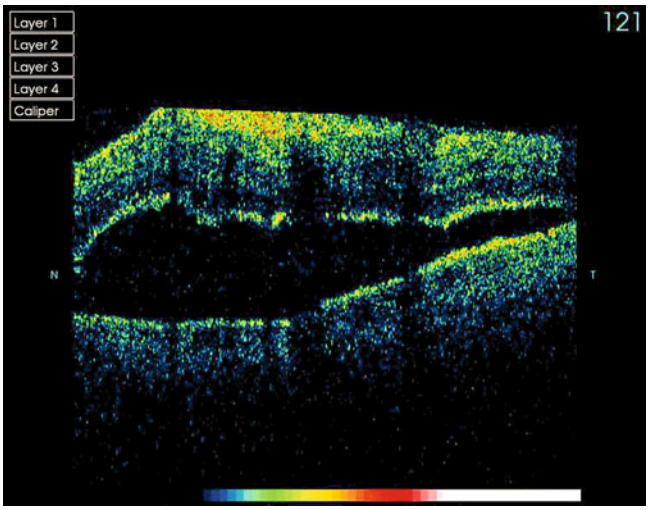


Fig. 6.32 The inferior retina for patient in Fig. 6.30

patient notices an increasing field defect corresponding to the detached area. Central vision is distorted and diminished as the fovea detaches.

6.2.4 Retinal Break Patterns in RRD

Breaks are more common temporally and superiorly than nasally or inferiorly in PVD-related RRD. See Chap. 7 for more details.

6.2.5 Macula Off or On

When the fovea of the macula detaches (usually called macula off), the chances of return of full central vision are reduced particularly after the first week of detachment. As a 'rule of thumb', the number of days the fovea has been detached is the same as the urgency for performing the surgery; for example, if the fovea has been off for 1 day, perform the surgery within 1 day; if off for 2 days, perform surgery within 2 days. Of course the sooner, the better, but this rule helps the scheduling of surgery and appropriate use of theatre sessions.

Chance of 20/40 or better after fovea off retinal detachment (Hassan et al. 2002).

10 days or less	71 %
11 days to 6 weeks	27 %
More than 6 weeks	14 %

Macula off retinal detachment is more likely to suffer subtle changes in vision such as distortion postoperatively; therefore, it is preferable to avoid the detachment of the fovea by performing surgery on 'macula on' retinal detachment promptly, for example, within 24 h. Chronic retinal detachments (e.g. when the vitreous is attached) in which there is slow accumulation of subretinal fluid can be left longer before surgery. By posturing, a retinal break to the dependant portion of the eye accumulation of SRF can be reduced or even reversed, whilst the patient is waiting for surgery.

For a temporal hole in the left eye or a nasal hole in the right eye, the patient would be asked to lie with their left cheek down to the ground.

For a nasal hole in the left eye or a temporal hole in the right eye, the patient would be asked to lie with their right cheek down to the ground.

For a superior hole, the patient lies supine with no pillows and the foot of the bed raised.

For inferior holes, sit the patient upright.

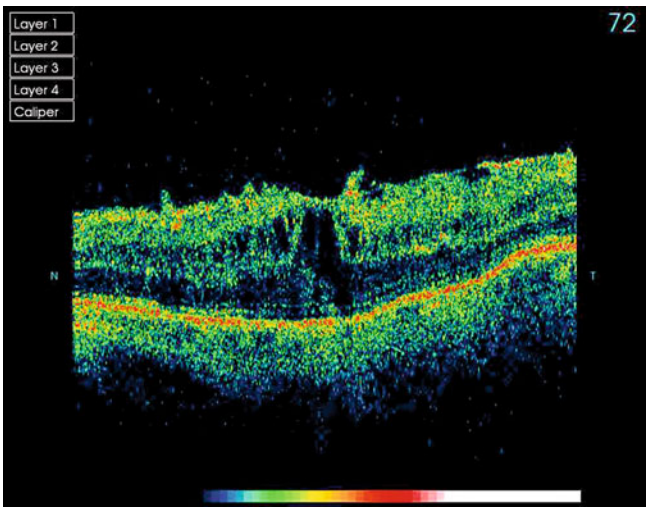


Fig. 6.33 Changes in the macula may be seen in association with inferior retinal detachment such as this with ERM and CMO. Ask the patient if the vision is worse in the morning or on lying supine in which case SRF may be moving into the subfoveal space (see Fig. 6.32)

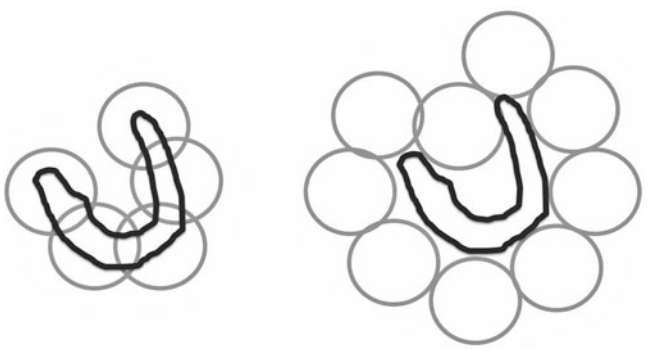


Fig. 6.34 Apply cryotherapy to a large tear as shown on the *left*, although this applies cryotherapy to the bare RPE in the tear; this is preferable to the increased number of burns required if the retina around the tear is treated as shown on the *right*

6.3 Surgery

6.3.1 Flat Retinal Breaks

6.3.1.1 Retinopexy

If a patient presents with a retinal break which is at high risk of producing a retinal detachment (U tear, paravascular tear, operculated tear or dialysis) but has no subretinal fluid, then retinopexy is applied to prevent accumulation of fluid underneath the neurosensory retina (Gonin 1930). This can be applied as laser therapy around the break (usually in two rows around the circumference of the break) or by transscleral cryotherapy. Both methods produce damage to the neurosensory retina, to the retinal pigment epithelium and perhaps to Bruch's layer and the choroid. The resultant reparative scar formation occurs in approximately 5–10 days and seals the layers of the retina together preventing fluid accumulation.

6.3.1.2 Cryotherapy

Cryotherapy employs the Joule-Thomson effect whereby expansion of certain gases, such as nitrous oxide or carbon dioxide, results in a reduction in temperature. The gas is compressed and then released through a small hole in a cryotherapy instrument tip, causing a rapid expansion of the gas and reduction in the temperature. Cryotherapy has the advantage that it can be applied trans-scleral without discernible damage to the conjunctiva, Tenon's layer and the sclera if not used excessively whilst creating a freeze and therefore a scar in the retina.

It takes effect and has maximum adhesion in approximately 10 days but causes dispersion of retinal pigment epithelial cells into the vitreous giving an increased risk of PVR especially in the presence of U tears with curled edges or tears greater than 180° (Bonnet et al. 1996). Apply cryotherapy sparingly, usually one freeze in the centre of the break. Although this may increase the chance of RPE dispersion through the break, it is preferable to multiple freezes around the tear, which increase the pro-inflammatory effects of the treatment (and the risk of PVR) and the discomfort to the patient. Cryotherapy is very useful for anterior breaks which are difficult to laser because it allows simultaneous indentation; a single cryotherapy application is often a less traumatic experience for the patient than a difficult laser session.

6.3.1.3 Cryotherapy in the Clinic Setting

1. Insert topical anaesthesia.
2. Insert a lid speculum if required, sometimes not necessary.
3. Give a localised injection of anaesthesia in the fashion of a peribulbar injection in the quadrant of the orbit with the retinal break. Warn the patient that they may experience some photopsia.
4. Always check that the tip will freeze and unfreeze before applying to the eye (these machines are notoriously unreliable).
5. Apply the cryotherapy tip trans-conjunctivally and use the tip to indent whilst observing with the indirect ophthalmoscope. Make sure you are visualising the tip and not the shaft of the cryotherapy probe when producing the indent; otherwise, the freeze will be posterior to the site that you are attempting to treat.
6. Once you are under the break, start the freeze commence until the break has been surrounded with ice crystals; do not overdo the freeze, it only needs to encompass the break by the equivalent of two rows of laser.
7. Provide topical postoperative antibiotics for a few days.

Fig. 6.35 A tear has been treated with laser retinopexy

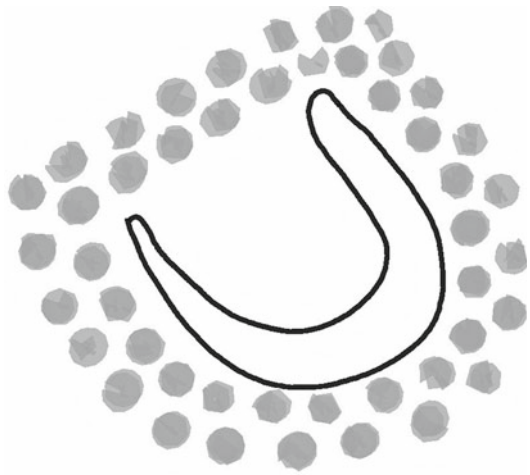


Fig. 6.36 Laser should be placed in two rows around a retinal tear as shown, laser the flat retina close to the edge of the tear

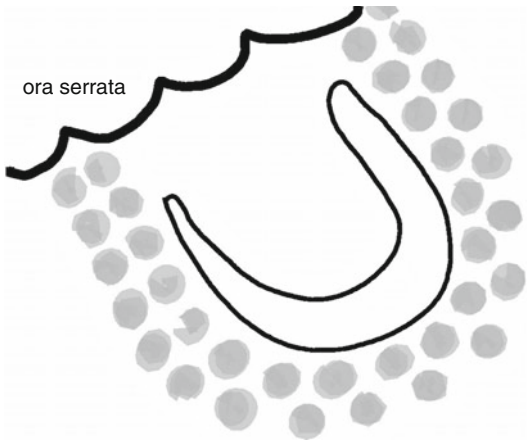


Fig. 6.37 If the retinal tear is close to the ora serrata, laser up to the ora serrata if you are unable to laser around the anterior edge of the tear

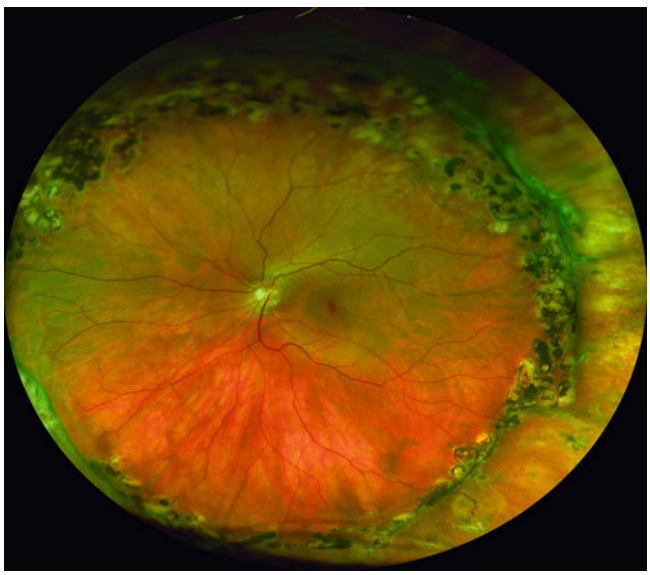


Fig. 6.38 360-degree laser has been applied to this RRD to try to prevent recurrence

Complications:

- Extraocular muscle injury causing diplopia, wait and the muscles will recover.
- Eyelid injury, loss of pigmentation. Avoid freezing through the lid.
- Subconjunctival haemorrhage or tearing of the conjunctiva.
- An over-freeze causing a retinal tear and haemorrhage. You only need to see the retina freeze in the early stages not a severe freeze with massive ice crystal formation.
- Never pull off a frozen tip as this may tear the sclera; be patient; before removing the tip, allow it to thaw.

6.3.1.4 Laser

Argon, diode or visible spectrum diode laser induces tissue injury and therefore scarring, from thermal burns on the tissues (photocoagulation). Non-visible diode can cause a disproportionate injury to the choroid and must be used with care. The laser should extend anteriorly around the tear or if not possible should extend to the ora serrata. Argon laser therapy can be applied either by a contact lens with a slit lamp or by indirect ophthalmoscopy with indentation. Maximum adhesion is approximately 5 days and requires two rows of burns around a break for maximal adhesion. Transscleral diode laser has also been used (Haller et al. 1997).

Typical laser settings for argon green:

- 200–300-mW power
- 0.1–0.2-ms duration
- Spot size 200–500 μm
- Repeat interval 0.1 s

6.3.1.5 Laser in the Clinic Setting

- Can be applied at the slit lamp using various contact lenses for posterior and equatorial tears (contact lenses have the advantage over noncontact fundus lenses of helping control eye movements during the laser session).

- Can be applied with indirect ophthalmoscopy thereby allowing indentation for anterior breaks.
- Apply laser of adequate power to produce a blanching spot.
- Two rows 360° around the break or for very anterior breaks around the posterior and lateral borders of the break and up to the ora serrata.

Complications:

- Retinal bleeding – Press on the eye to minimise.
- Lens damage – Reduce the power.
- Macular damage –Take care with three mirror lenses; keep the laser on standby when not in use.
- Excessive burns – Only use laser powers which produce retinal blanching; take care when lasering during scleral indentation not to get an excessive burn.

6.3.2 Retinal Detachment

The definition of rhegmatogenous retinal detachment is a retinal break with subretinal fluid. This may be as little as a small cuff of fluid or as much as total retinal detachment. Once the detachment has occurred, identification and closure of the retinal break or breaks is the primary aim of surgery.

Attachment of a silastic explant to the sclera of the eye to create a dent in the sphere of the eye underneath the break or breaks allows the retina to reattach. This may occur because of relief of traction or because of an alteration in the fluid currents in the eye.

Alternatively, the vitreous can be removed by pars plana vitrectomy and a long-acting gas bubble, such as sulphahexafluoride or perfluoropropane, inserted into the vitreous cavity. The gas bubble contacts the rim of the break preventing the passage of fluid through the break (tamponade). Thereafter, subretinal fluid will be reabsorbed by the RPE and the retina will flatten.

The gas bubble is only temporary, and the indentation from an explant may gradually lessen; therefore, retinopexy is also applied to seal the tear and avoid re-accumulation of the subretinal fluid.

The shortening on the retina produced by proliferative vitreoretinopathy may prevent retinal reattachment unless the fibrous membranes are surgically removed or the retina cut to fit the inside of the eye (retinectomy). In this circumstance, silicone oil may be inserted into the vitreous cavity to provide long-term support to the retina allowing time for the proliferative vitreoretinopathy process to stop. Silicone oil in the vitreous cavity is associated with a number of complications including cataract, glaucoma, refractive changes and low-grade retinal toxicity.

This type of surgery requires a preoperative assessment of the patient, particularly determining whether the patient requires conventional surgery or vitrectomy.

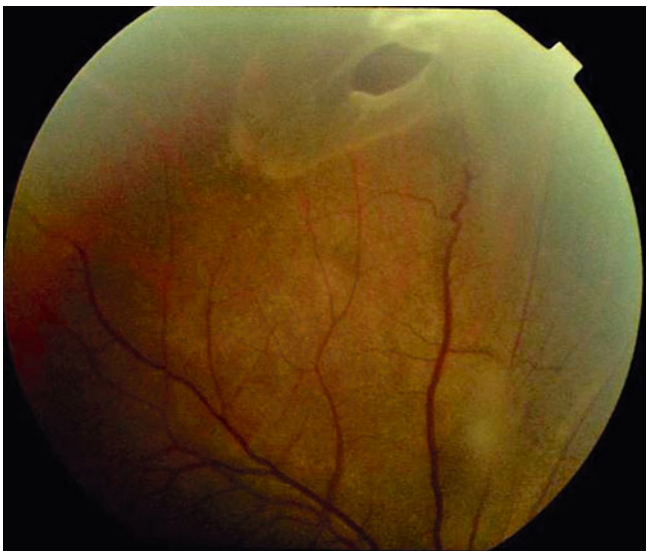


Fig. 6.39 This tear has SRF extending around its edge

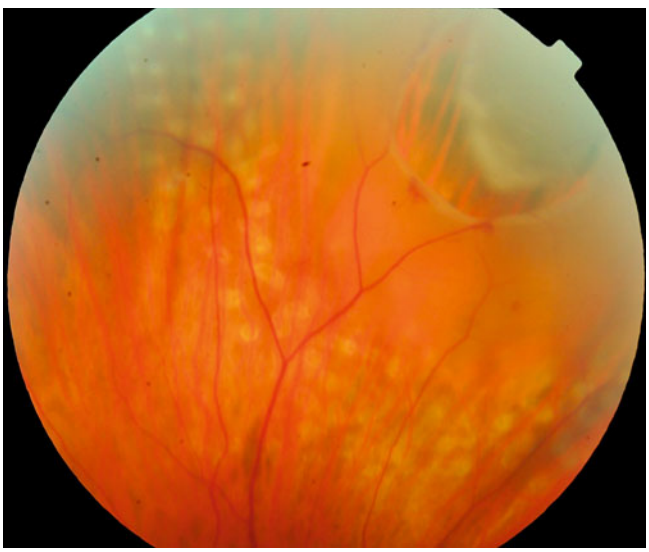


Fig. 6.40 The SRF around this tear is likely to lead to failure of the laser retinopexy

Although it is possible to perform most of these operations by vitrectomy alone, this may be inconvenient for the patient in that they will often develop a cataract requiring further surgery later. They may also be required to position their heads for 1–2 weeks and will have delayed visual recovery for 2–8 weeks depending on the gas used. A conventional procedure, on the other hand, does not produce cataract and requires no posturing in most circumstances. However, it requires the development of additional surgical skills, and visualisation of retinal breaks can be more difficult via indirect ophthalmoscopy.

I treat most RRD with PVD by PPV, and those with attached vitreous are operated by non-drain; however, there

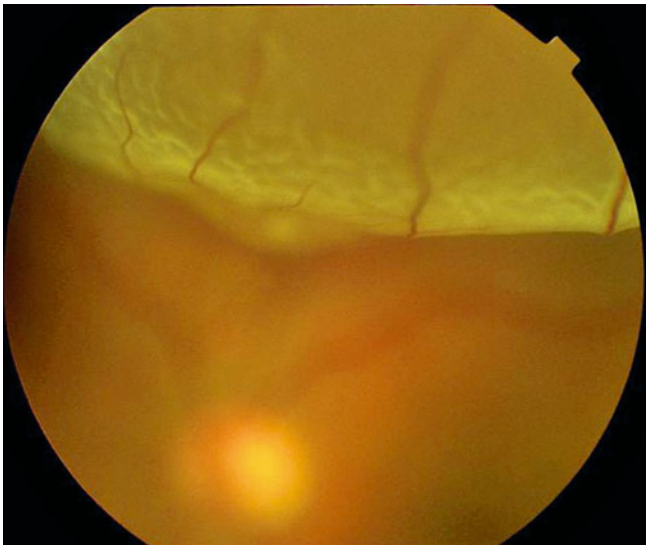


Fig. 6.41 The superior bulla of a RRD

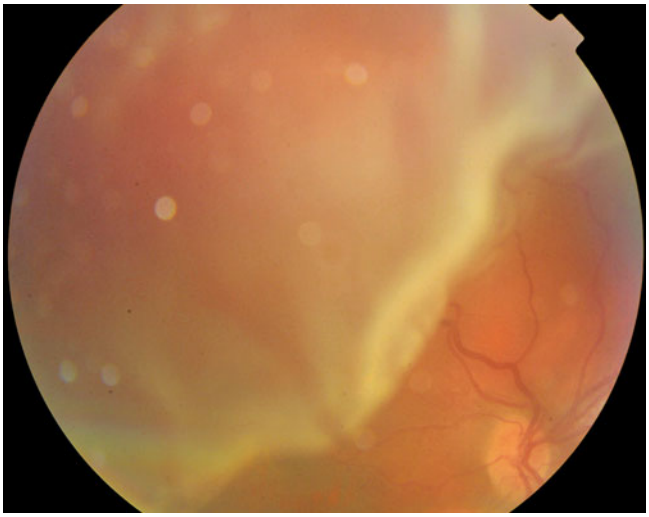


Fig. 6.43 A superior bullous RRD may overhang the macula blocking a view of the fovea. It is therefore difficult to judge whether the fovea is detached. Usually, the fovea is found to have this SRF peroperatively

Fig. 6.42 Wrinkling of the retina in RRD

Fig. 6.44 Choroidal effusions should not be confused with retinal detachment; the appearance is of an immobile smooth elevation with a green or brown underlying colour due to the detachment of the RPE

is wide variation in methods worldwide, and, therefore, non-drain, DACE, pneumatic retinopexy and PPV are all described in this text.

6.3.2.1 Principles

The principles of surgery are break closure, relief of traction, alteration of fluid currents and retinopexy (Custodis 1952). Under normal circumstances, the retina is held in place by physiological forces such as hydrostatic and osmotic pressure, weak intracellular bonds and the intracellular matrix. If a break appears in the retina, these forces are not sufficient to prevent the accumulation of subretinal fluid, which usually comes from fluid vitreous behind the posterior hyaloid.

6.3.2.2 Break Closure

Any treatment of a retinal detachment depends primarily on identification of all the breaks in the patient. A small 'pinprick' break will quite easily result in a redetachment if it is missed and remains untreated. Therefore, careful inspection of the retina is of paramount importance. Once identified, the breaks can be closed in a number of ways. In conventional surgery, this is performed by placing an indent underneath the break or breaks (Goldbaum et al. 1975). In vitrectomy surgery, the break is apposed to the RPE by the action of a gas bubble (or silicone oil) on the retina.

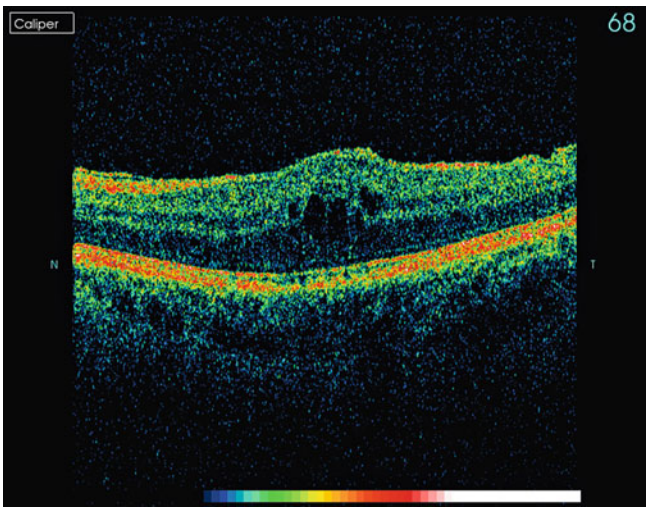


Fig. 6.45 This patient had a persistent inferior retinal detachment postoperatively with CMO present. Some surgeons argue that peripheral RRD has secondary effects on the macular receptors

6.3.2.3 Relief of Traction

The placement of a plombage may also have the effect of relieving traction by shortening the distance to the centre of the eye if vitreous traction is present. However, it is likely that vitreous traction is already relieved by production of the retinal detachment. The traction of the vitreous on the retina is negated by the removal of the vitreous in vitrectomy. Traction becomes important when this is adjacent to a retinal break, for example, in PVR, (proliferative vitreoretinopathy) when the break is prevented from closing onto an indent or onto the back of the eye with gas. Traction by scar tissue is removed during membranectomy in PVR surgery.

6.3.2.4 Alteration of Fluid Currents

Fluid currents are present in the retina in the presence of PVD, which help lift the retina through their action on a retinal break. The effect of currents can be seen in the non-drain retinal detachment repair where appropriate placement of a plombage will allow resolution of SRF and closure of the break onto the indent, even if at the end of the operation, the break is not flat onto the indent itself. Although it is not necessary to close the break onto the indent at the end of surgery, it is important that the indent is in the correct position to modified fluid currents to produce break closure over the next 24–36 h. The indent produces an increase in the velocity of the fluid over the indent because the cross-sectional area through which the flow of fluid can pass through the break has been reduced. This in turn induces a pressure drop by Bernoulli's principle (velocity of a fluid increases causing a decrease in pressure in the fluid) causing the retina to move onto the indent. For this reason, it is not necessary to perform drainage of SRF in all patients.

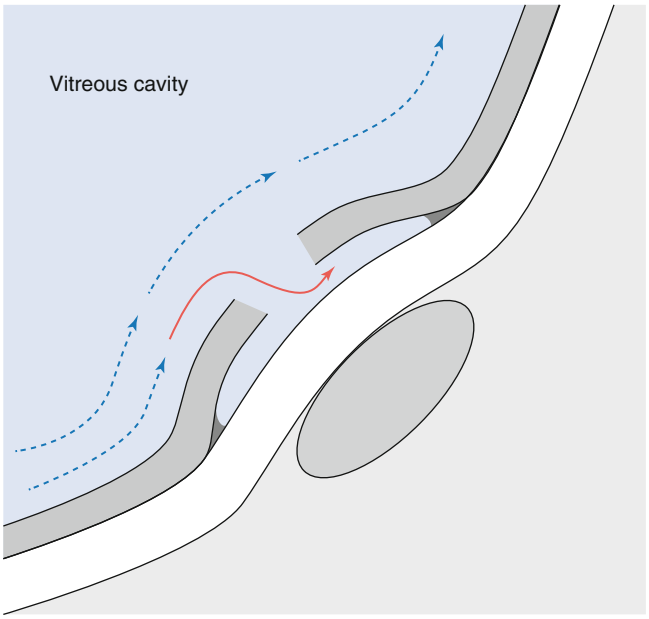


Fig. 6.46 Application of an indent under a tear alters the fluid currents (*arrows*); by increasing the velocity of fluid flow, the pressure is dropped drawing the retina to the sclera (Bernoulli's principle)

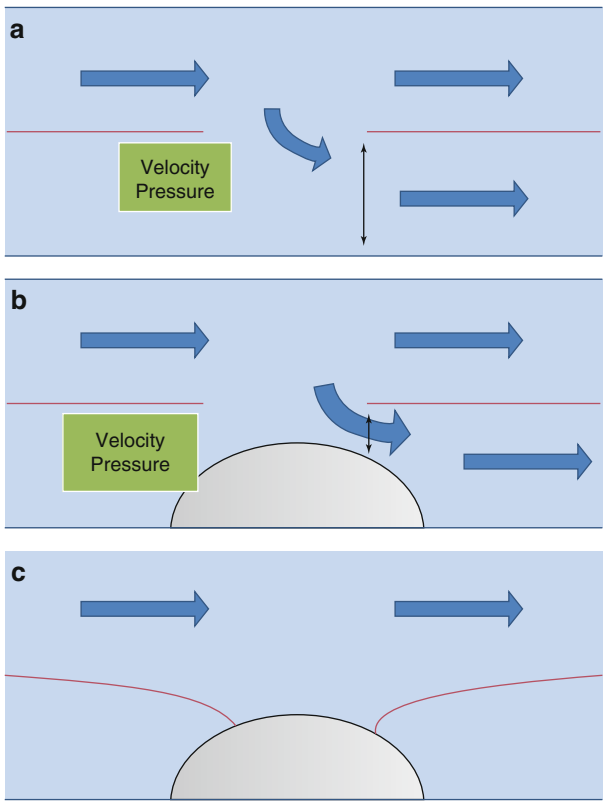


Fig. 6.47 If fluid passes over a membrane with a hole in it, the fluid enters through the hole (**a**). If an indentation is inserted under the hole (**b**), the space the fluid must go through narrows (*double arrow*); for the same flow, the velocity of the fluid increases. According to Bernoulli's principle, this drops the pressure at this point, causing the membrane to move towards the indent eventually closing the hole on the indent (**c**) and preventing any other fluid entering

Bernoulli's principle states that as the speed of a moving fluid increases, the pressure within the fluid decreases.

6.3.2.5 Retinopexy

Retinopexy is important because the means of closing the break is often temporary, such as with absorption of a gas bubble or when a plombage gradually loosens with ageing or becomes adrift from loosening of the sutures. Once retinopexy has taken effect, it is entirely appropriate to remove a plombage at 10 days. This has been exploited by Lincoff and his balloon indent procedure (Oge et al. 2001) whereby a balloon is inserted into the orbit to produce an indent of the eye and is later deflated and removed. Similarly, internal tamponade is only necessary until the retinopexy has sealed the break.

The percentages of operations performed in my team for RRD between 1998 and 2006.

Table 6.1 Proportion of methods used for RRD in my team

Operations for RRD ($n=1,528$)	%
Pneumatic retinopexy	0.7
Non-drain	22.8
DACE	1.6
PPV	74.9

Surgical Pearl of Wisdom

'Although rare, it occasionally happens that an expansive concentration of gas is incorrectly injected at the end of surgery (e.g. 30 % C_3F_8 instead of 30 % SF_6).

Postoperatively, the patient is in acute pain, with a shallow AC, no meniscus below the gas, and a very high IOP. The management is to remove some gas, but how much to remove? How to do it in such a way that the pressure does not crash catastrophically?

Putting a needle through the pars plan could result in a sudden egress of gas, hypotony and choroidal haemorrhage.

The following method allows a controlled and predictable removal of exactly the right amount of gas.

First, measure the IOP, which we will assume for the sake of this example is 80 mmHg. Then, convert this value into a height of water. Atmospheric pressure is about 760 mmHg, which corresponds to 10,330 mm of water, a conversion factor of 14. Hence, 80 mmHg is equivalent to 1,087 mm of water.

Take a 27-gauge needle and put it on the end of a giving set, run through with Hartmann's solution. Sit or lie the patient down, and adjust the height of the top of the fluid to roughly 1,087 mm above the eye.

Pass the needle through the pars plana and turn on the drip. Nothing happens! That is because the pressure of the fluid is exactly the same as the IOP.

Now get an assistant to lower the height of the bag slowly (say over the course of 1 min) to a height corresponding to the target pressure (210 mm water is equivalent to 15 mmHg).

As the bag is lowered, you will see the gas coming slowly out through the needle and up the giving set. Once the pressure is normalised, the needle can be removed.

By using this method you can achieve exactly the target pressure you desire, but in a controlled way with no sudden changes in IOP'.

(Bill Aylward, Moorfields Eye Hospital, London, UK)

6.3.3 Pars Plana Vitrectomy

Additional surgical steps:

1. Search for breaks with deep scleral indentation.
2. Apply cryotherapy.
3. Drain subretinal fluid (SRF).
4. Drain SRF and insert air.
5. Drain residual vitreous cavity fluid off disc.
6. Apply cryotherapy or laser retinopexy as required.
7. Exchange long-acting gas.

6.3.3.1 Introduction

PPV is becoming more popular for RRD repair because of the ease of application and good visualisation of the retina with wide-angle viewing systems. Examination of Medicare data for fees in the USA shows a 72 % increase in the use of PPV for RRD and a 69 % reduction in the use of scleral buckles from 1997 to 2007 (Ramulu et al. 2010). In addition, cataract can easily be dealt with peroperatively or postoperatively by phacoemulsification and posterior chamber lens implant. Perform the PPV in the usual way. Take care if operating on a bullous RRD not to encourage incarceration of the retina into the sclerotomies or into the infusion cannula. So far, randomised studies support the use of PPV or scleral buckle in RRD surgery (Heimann et al. 2007).

To avoid this:

- Try to drain some SRF internally early in the procedure from a break (this also aids removal of the gel without risk of biting the retina).
- Remove as much vitreous as possible (vitreous incarcerates first then the retina) from around the infusion cannula and sclerotomies.

Fig. 6.48 The eye is orientated with the lens superiorly for PPV

Table 6.2 Difficulty rating of PPV for RRD

Difficulty rating	Moderate
Success rates	High
Complication rates	Medium
When to use in training	Early

- Use scleral plugs.
- Use self-sealing sclerotomies or small-gauge surgery with stents with valves in situ.
- Insert heavy liquid to splint the retina posteriorly.

Perform an internal search by indenting with a squint hook to locate all of the retinal breaks.

6.3.3.2 Finding the Breaks

Approximately 55 % of RRD have more than one break. Success of surgery requires finding and treating all the breaks. These manoeuvres can help:

- Indentation dynamic movement of the retina.
- Look out for small elevations of retina at the posterior border of the vitreous base (the posterior border can be seen as a faint white line on the retina), use the light pipe to engage the vitreous behind the elevation and lift the vitreous to see if you can open the break hidden behind it.
- Use heavy liquid to force SRF out of the break (especially if small), thus making the break pout.

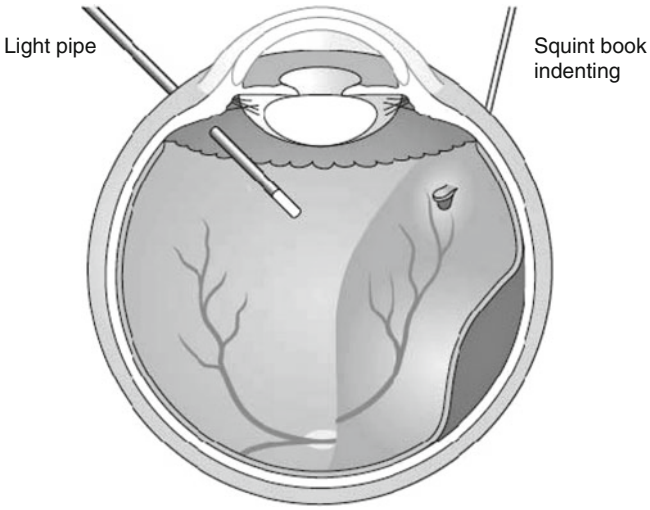


Fig. 6.49 During vitrectomy, indentation is required to bring peripheral retina into view and to aid internal search for retinal breaks

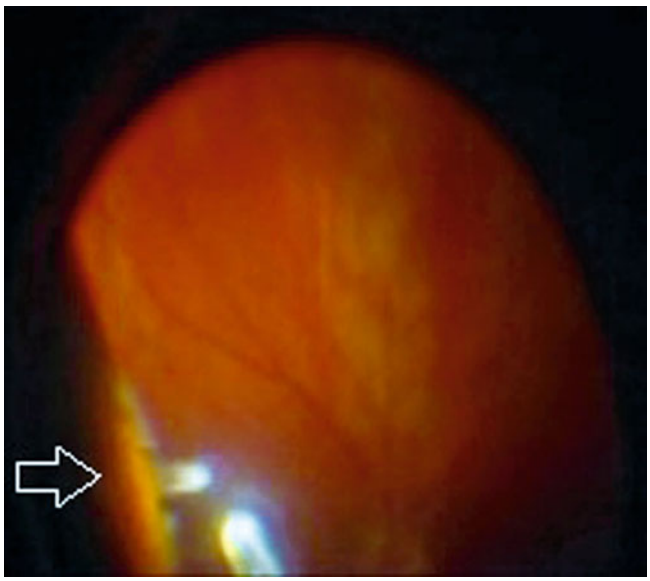


Fig. 6.50 The flap of a U-shaped tear can be seen on indentation during PPV (*arrow*)

- Watch for Schleren, the oily track of SRF exiting the retinal break.
- Apply cryotherapy which makes the break 'shine' up inside the frozen retina.
- Detect the release of circulating RPE cells into the vitreous cavity through the hole, which looks like a tiny volcano. This is especially helpful if cryotherapy has been applied and confirmation of the presence of a break is required.

- Apply laser retinopexy which will blanch the attached retina around the break but not the bare RPE in the centre of the break.
- Gently aspirate over the suspected break with the flute needle to see if SRF will drain through the suspected break; take care that you do not create a hole by doing this thereby fooling yourself that you have found the break.
- If you have tried everything else use a 40-gauge needle to inject some Trypan blue dye into the subretinal space, heavy liquids can be inserted to move the dye towards the periphery, and egress of the dye through the break will allow location of the break (dye extrusion, DE-TECH, method) (Jackson et al. 2007; Wong et al. 2009).

Surgical Pearl of Wisdom

When performing an internal search for tears, it is important to use the right technique and apply some basic anatomy. Tears occur on the back edge of the vitreous base. This is usually 2 mm behind the ora, but this can be variable. One can often identify the vitreous base in attached retina by a white (or more realistically mild grey) with pressure reaction. This arises because the collagen strands in the vitreous base insert perpendicularly into the ora. In detached retina, there is often a transition line or fold visible at the back edge of the vitreous base. The combination of vitreous traction and a tear mean that the flap will often stand up when rolled. I use an empty plug forceps for this and roll in a posteroanterior then anteroposterior direction from ora posteriorly and then anteriorly. The aim is to create an indent with the surgeon's line of sight tangential to the retina. As the indent moves posteriorly, the break rolls up and then down onto and off the indent and will frequently stand up in the process. Other people use a squint hook just as effectively. The important point is that it involves dynamic rolling as well as indentation. Granules of pigment in the peripheral vitreous close to back edge of the vitreous base should also be treated with great suspicion; they often mark the position of a tear.

D. Alistair, H. Laidlaw, Dept of Ophthalmology, St Thomas Hospital, London, UK

Apply cryotherapy or endolaser to any flat breaks and any which are indentable. Any breaks which are not can be treated with retinopexy after insertion of the air by cryotherapy or laser. Laser must be applied to flat retina and therefore is applied after air insertion or with heavy liquid in situ. Laser should be used if there are very large breaks or multiple breaks to help prevent overuse of cryotherapy which increases the risk of PVR. Many surgeons like to mark the edge of retinal breaks with a small burn from endodiathermy. This allows visualisation of the burn and therefore the location of the tear after the air insertion (unmarked breaks are difficult to see after air injection) to allow easy retinopexy. Alternatively, remember where the break is using anatomical landmarks such as blood vessels to direct you to the break.

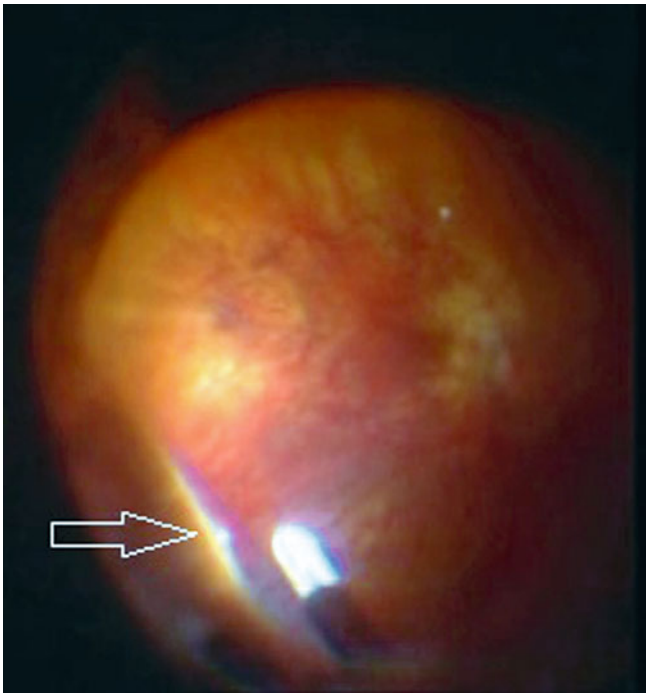


Fig. 6.51 If you see a tiny tag like this, there may be small U tear in its posterior edge (*arrow*). Lift up the vitreous frill to expose the break

6.3.3.3 Advantages and Disadvantages of Retinopexy Under Air

Advantages of retinopexy under air:

- Breaks are flat allowing laser application.
- Cryotherapy application is much quicker under air because of the insulating properties of the air.
- Peripheral laser can be easier to apply because the air allows a wider field of view (but with reduced magnification) with the IVS in a phakic patient.

Disadvantages:

- Breaks are more difficult to visualise.

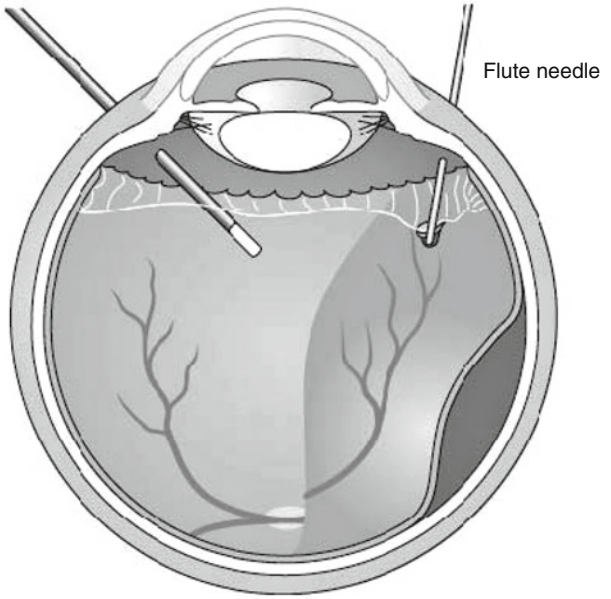


Fig. 6.52 Subretinal fluid can be drained by placing a 'flute' instrument just anterior to the posterior edge of the retinal break, thereby avoiding vitreous attached to the anterior edge of the break

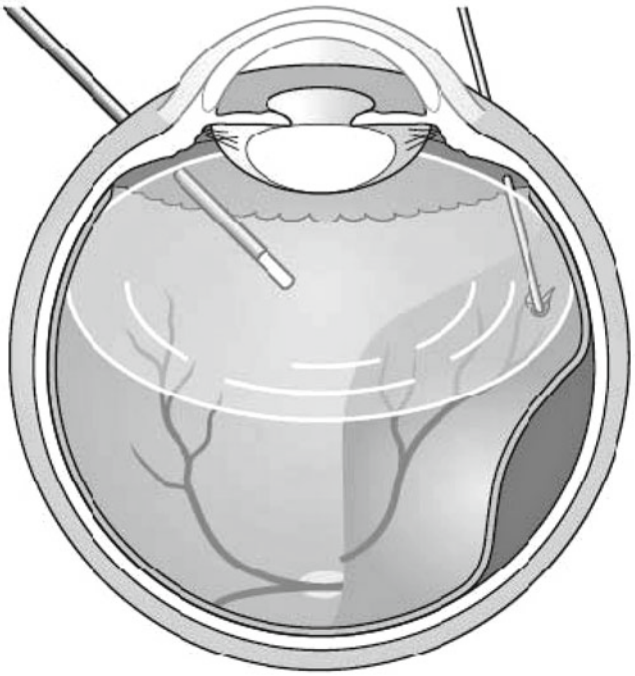


Fig. 6.53 Injecting air during a vitrectomy whilst draining SRF through a retinal break. By flattening the retina extensively before insertion of air, complete SRF drainage is facilitated. Keep the flute needle over the break till a maximal air fill and SRF drainage have been achieved before draining any fluid from the back of the eye

- Cryotherapy releases RPE cells which will not be removed (air fluid exchange has already been completed).
- Condensation on the IOL in the presence of a capsulotomy reduces the view.
- Posterior lenticular opacification in a phakic patient reduces the view.
- Glare from the tip of the endo-illumination is increased. If you are using a bullet light pipe, cut off the exposed end to make it flush with the sleeve to reduce glare.

6.3.3.4 Draining Subretinal Fluid

Drain the SRF internally with a flute needle placed over one of the breaks. It helps to drain as much SRF as possible by fluid/fluid exchange before going to air/fluid. With the retina as flat as possible, commence inserting air through the infusion (using the air pump of the vitrectomy machine). There will be a moment when the vitreous cavity is half filled when the view of the needle tip and the break is lost. Keep the needle over the break and advance very slightly into the eye to compensate for the flattening of the retina. Do not stop draining. The moment of poor visualisation will pass and the view will return, and the SRF drainage can be completed. When bubbling is heard from the flute needle, only air is being removed, and the needle tip should be advanced gently towards the break to drain more SRF.

Once the retina is flattened, drain off any vitreous cavity fluid from the optic disc.

Note: When coming away from the break to observe the posterior retina and the remaining SRF, do not be tempted to drain vitreous cavity fluid off the disc. If you do, you will be left with a pool of SRF at the macula and no means of

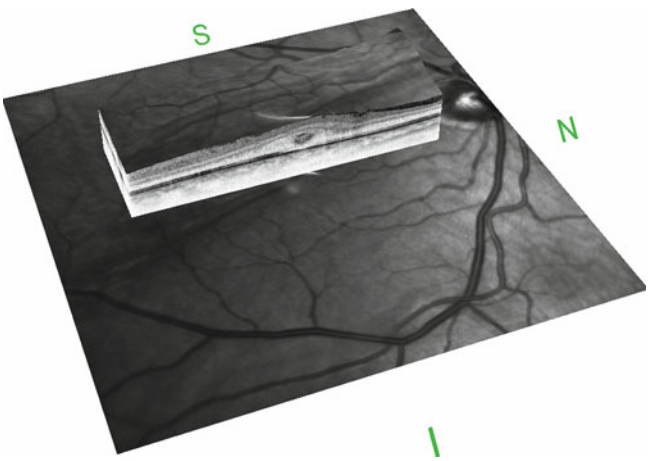


Fig. 6.54 A retinal fold after PPV for RRD in an eye in which the edge of the RRD was transecting the fovea. A fold is seen in the deep layers of the retina

draining it because the break is now closed and not in communications with the SRF (refill the eye with BSS and recommence drainage).

6.3.3.5 When to Use Heavy Liquids

To avoid retinal incarceration into sclerotomies.

Flute needle or infusion cannula. Some retinae are very bullous and mobile. These can incarcerate into sclerotomies, flute needle or infusion cannula. If the breaks are very large, drainage of SRF alone may not control the situation because re-accumulation of fluid is very rapid. Insert heavy liquids via a two-way needle onto the optic disc. Keep the tip of the needle just in the heavy liquid bubble to maintain a single bubble. Expand the bubble to force some SRF out through a break. Even a small bubble will help control the situation by stabilising the retina.

Note: If an incarceration of the retina into a sclerotomy or the infusion cannula is encountered, the insertion of heavy liquid into the vitreous cavity will usually free the retina. Search the damaged retina for new breaks and treat appropriately. A small incarceration into the flute can be extracted using a back flush or by removing the light pipe to release some of the intracavity pressure.

To flatten the retina when there is a difficult to reach break.

Heavy liquid can be used to flatten the retina followed by air/heavy exchange. This minimises the need to drain SRF out of a break. If the retina is flat under the heavy liquid, retinopexy can be applied at this stage (useful for giant retinal tears, see Chap. 6).

Take Care. If inserting a large bubble for this purpose, small bubbles can separate off at the vitreous base and be left in the eye. These may enter the anterior chamber postoperatively. How the heavy liquid enters the anterior chamber is uncertain, but it is likely to pass through a small hole in the zonules which may act in the fashion of a lobster pot allowing liquid to enter the AC but not to leave again. Anterior chamber heavy liquid can be removed by paracentesis with a fine-gauge needle.

To change the contour of the retina when it is not possible to find the breaks.

In some retinae, it is not possible to identify the break. Inserting heavy liquid causes the break (usually a very small U tear) to pout as the SRF leaves (you may spot the Schleren, i.e. oily tube of SRF in the vitreous cavity fluid exiting the break). This may be enough to allow detection of the break on reinspection by indentation.

6.3.3.6 Removal of Heavy Liquid

Fluid/heavy liquid exchange is straightforward, but more often air/heavy liquid exchange is desirable in RRD because this has the advantage that the SRF is pushed anteriorly and peripher-

Fig. 6.55 Closure of the hole before drainage of residual SRF means that the SRF will be trapped at the posterior pole, and there will be no channel for removing that SRF as the hole is now flattened

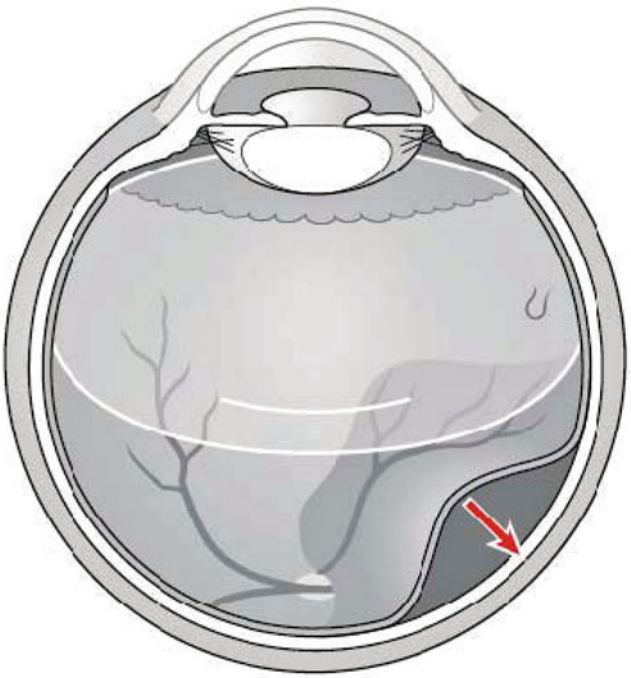


Fig. 6.56 If fluid is trapped at the macula and you are unable to reverse the situation, insert a 60 % fill of gas and position the patient 'face up'. Allow 24 h for the RPE to pump the residual SRF out (*arrow*) before positioning the patient upright thereby avoiding a fold in the retina

ally by the heavy liquid during the exchange. Perform the air/SRF exchange and then lastly the air/heavy liquid to maintain a flattened macula. Heavy liquid can be difficult to see under air, so make sure that it is taken out in one smooth action so that visualisation of the position of the bubble as it gets smaller is not lost. Stopping and restarting is not recommended because the position of the remaining liquid may be lost.

6.3.3.7 Choice of Tamponade

A long-acting gas is inserted to support the retina, whilst the retinopexy takes effect.

- SF_6 can be used for any breaks above the horizontal meridian.
- SF_6 can be used for breaks above 4 and 8 clock hours, but posture may be needed.
- C_3F_8 is used if breaks are below 4 and 8 clock hours to ensure that there is a large bubble for longer aiding contact of the bubble to the inferior breaks.

A method of fastidious removal of SRF, heavy diode laser retinopexy and no gas tamponade has been described with successful retinal reattachment (Martinez-Castillo et al. 2007). This method involves inserting air on top of heavy liquid to extract the SRF with subsequent removal of the air again. Most surgeons would leave the air in and exchange with a gas mixture.

6.3.3.8 Avoiding Retinal Folds

It is essential that a large bulla of retina is not left at the macula when a gas bubble is in the eye because when the patient changes posture, the retina can be folded by the action of the gas. Try to minimise the amount of SRF left in the eye at the end of surgery. If a small bulla remains in the eye, do not completely fill the eye with air, that is, do not drain all of the vitreous cavity fluid off the disc. Posture the patient face up for the first 24 h to allow the residual SRF to absorb.

Retinal folds are problematic because they induce oblique diplopia and distortion which are difficult to remedy postoperatively.

Once the SRF is drained, apply laser or cryotherapy as required to any untreated breaks (it may be prudent to retreat the break that was drained from if there was any difficulty encountered in case if extension of the tear).

Surgical Pearl of Wisdom

Macular folds following retinal detachment surgery can result in extremely distracting distortion of vision, which can be more problematic for the patient than reduced acuity alone. It is notable that Snellen visual acuity can be surprisingly well preserved with macular folds, but this is in striking contrast to the dissatisfaction of the patient. This may be because of the dissociating effect of the distortion, making it difficult for the brain to fuse the images from the two eyes, particularly when one of the images is distorted but sharply in focus.

Fig. 6.57 Early postoperative posturing face-forward when there is subretinal fluid retained at the posterior pole may cause folding of the retina, as shown

Macular folds are essentially a micro- or macroscopic (usually downwards) translocation of the retina when there is (almost inevitable) residual subretinal fluid below the macula in the presence of preretinal gas. The latter is important because if there is no preretinal gas, there is no relative difference in the density of the fluid below and in front of the retina. But in the presence of pre-macular gas, the subretinal fluid is denser than the preretinal gas and will therefore gravitate downwards taking the retina with it.

Treatment of macular folds is possible but requires surgical redetachment of the macula, which is a manoeuvre that can be challenging and may increase the risk of PVR and late redetachment. Therefore, prevention is better than cure.

Macular folds can be prevented by the following:

Whenever subretinal fluid has been under the macula or when there is any possibility that subretinal fluid could track below the macula at the end of a case, the following routine will minimise the risk of a fold developing:

Position 1 (*Operated-Side-Down*) – *Immediately at the end of the vitrectomy*, *roll the patient so the operated side ear is on the pillow*.

If there is any submacular fluid, it will run temporally away from the disc, but the retina will have limited possibility of moving with the fluid and will 'hang' from the disc because it is anchored to the disc (it may stretch slightly but will recoil later). The patient should be transported to the recovery ward on a trolley in this operated-side-down position (with no upright period).

By the time the patient arrives at the recovery ward on the trolley (5–10 min later), the subretinal fluid will be lying temporal to the macula.

Position 2 (*Face-Down*) – *The patient should then be immediately positioned face-down for about 30 min* (*with no upright period during the transfer from the operated-side-down to the face-down position*).

The face-down position will cause the macula to 'stick' with re-establishment of the macular RPE pump. The subretinal fluid will gravitate anteriorly and safely towards the ora serrata.

Position 3 (*Non-Operated-Side-Down*) – *Finally, the patient should roll on to their non-operated side completing a log roll*.

This last manoeuvre is probably not necessary, but it is a more comfortable position for the patient than remaining face-down and will usually tamponade temporal or superior breaks that led to the macular detachment. In addition, the nursing staff will become used to performing a log roll as a routine, and therefore inappropriate posturing positions will be avoided.

NB: Cases where there is residual subretinal fluid just in the nasal periphery at the end of surgery need not follow the above log roll routine.

The disadvantages of other postoperative positioning regimes in a gas-filled eye that do not follow the above principles are as follows:

- *Immediately Upright* – Even for a minute, the residual submacular fluid may gravitate inferiorly and result in downwards translocation of the macula. This does not always occur, presumably because the volume of subretinal fluid is low, so only a trivial movement of the macula occurs. However, a greater volume of subretinal fluid can result in a larger translocation, and a fold will result.
- *Immediately Face-Down* – In this position, there is a possibility of a bubble of subretinal fluid being trapped underneath the macula, which could later shift downwards when the patient becomes upright resulting in a micro-translocation. This position can also be difficult for some patients to maintain.
- *Immediately Flat-On-Back* – There will be no translocating movement with this position, but pigment or blood cells may settle on the macula and could conceivably result in epiretinal membrane formation on the macula at a later date.

Richard Haynes, Bristol Eye Hospital, Bristol, UK

6.3.3.9 Inferior Breaks

Controversy exists over the best way to deal with breaks between 4 and 8 clock hours inferiorly. High success rates have been described with PPV and gas alone but with extensive laser application (Campo et al. 1999). A solid silicone buckle can be applied but carries a risk of inducing a choroidal haemorrhage (Sharma et al. 1997; Piper et al. 1993; Tabandeh and Flynn 2001; Wickham et al. 2004) and adds the potential complications of the explant. If this is used, it is recommended to place the sutures for the explant with closed self-sealing sclerotomies and to have heavy liquid in the eye during placement of the explant. The latter applies a force on the retina because of its increased density and helps limit any spread of any choroidal haemorrhage. PPV without buckle and with face up posturing for the first postoperative week has been used but must only be tried when the risk of PVR is low and a complete gas fill has been obtained (Tanner et al. 2001; Sharma et al. 2004a).

6.3.3.10 Posterior Breaks

These are easily dealt with as they facilitate SRF drainage and laser retinopexy. Sometimes in myopes, the vitreous is still attached to the anterior break edge; usually, it is not possible to actively detach the vitreous further anteriorly at the break, but it can be detached further anteriorly elsewhere. Leave the vitreous at the break and tamponade as usual. Myopic macular holes are dealt with in Chap. 6.

6.3.3.11 Multiple Breaks

Occasionally, an excessive amount of retinopexy is required because there are many breaks or some breaks are very large. In this situation, the judicious use of endolaser reduces the chance of PVR. Even so occasionally, the risk of a small missed break or PVR is too high and silicone oil should be inserted (see Chap. 7). If this is done, the pro-inflammatory effects of the operation (and therefore the increased risk of PVR) can be allowed to subside before taking the risk of retinal redetachment (i.e. at oil removal). If long-acting gas is inserted, the patient must be watched more often in the postoperative period. If the retina detaches, reoperation must be performed immediately before PVR can become established.

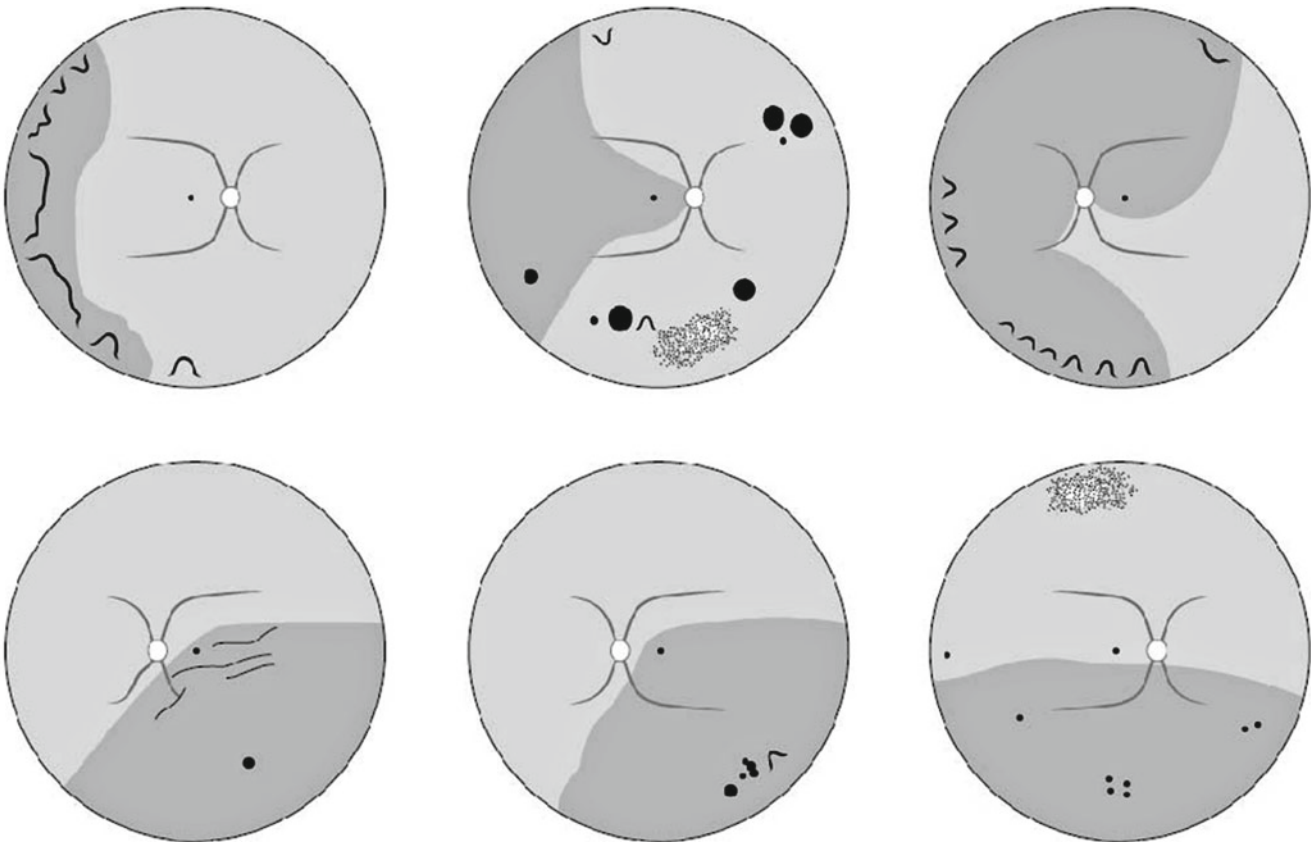


Fig. 6.58 Inferior holes can often be treated by PPV and long-acting gas and posture as long as there is no risk of inferior proliferative vitreoretinopathy and the patient is willing to posture 'face up'. The upper three retinas were treated by PPV and gas, and the lower row treated by non-drain repair

Fig. 6.59 An inferior U tear

6.3.3.12 Medial Opacities

Cataract and vitreous haemorrhage can be removed during surgery. If the vitreous haemorrhage is severe, care must be taken to identify the position of the RRD behind the haemorrhage to avoid injury to the retina with the cutter. Corneal opacities and small pupils can usually be overcome with use of the wide-angle viewing system which is effective through surprisingly small apertures.

6.3.3.13 Complications

- Retinal incarceration into sclerotomies or the infusion cannula:
  - Perform good vitreous clearance, early SRF drainage and use of heavy liquids.
- Choroidal haemorrhage:
  - Maintain the IOP throughout surgery.
  - Avoid scleral buckles.
- Iatrogenic Retinal Breaks
- Retinal bites with the cutter, low vacuum near bullous retina, early SRF drainage and use of heavy liquids:
  - Take care with mobile bullous RRD.
  - Drain SRF early during vitreous removal.
  - Use heavy liquid if the retina is still very mobile.
  - Use high-speed cutters which are more predictable near mobile retina, smaller more frequent bites mean less movement of the retina with each bite.

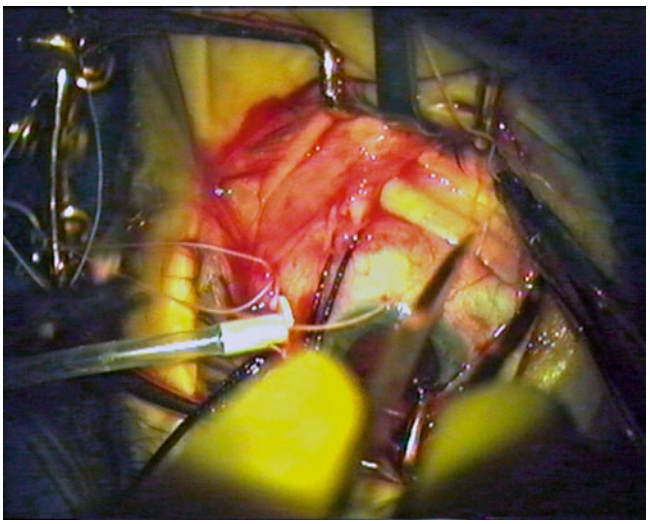


Fig. 6.60 Placing a solid silicone explant onto an eye during PPV is difficult because the eye is soft and the infusion cannula is in the way

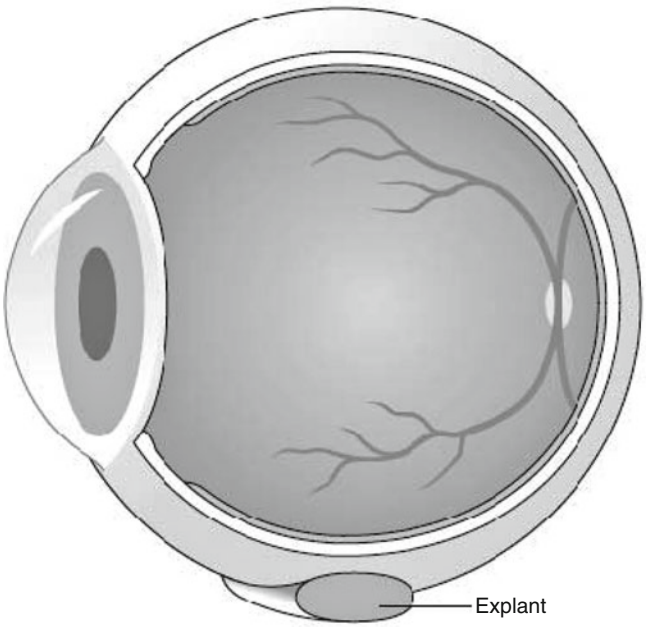


Fig. 6.61 Applying an inferior buckle to a vitrectomised eye runs the risk of inducing a choroidal haemorrhage

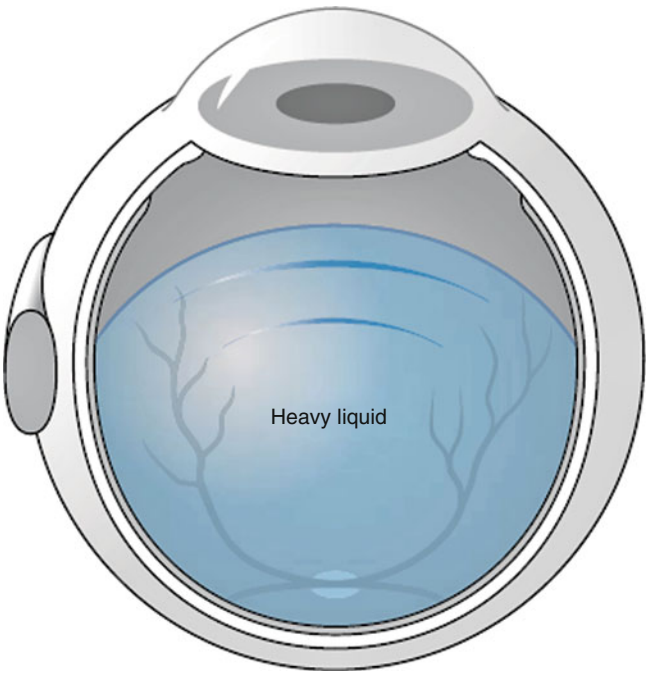


Fig. 6.62 One way to restrict any extension of choroidal haemorrhage is to insert heavy liquids into the eye before the buckle is attached

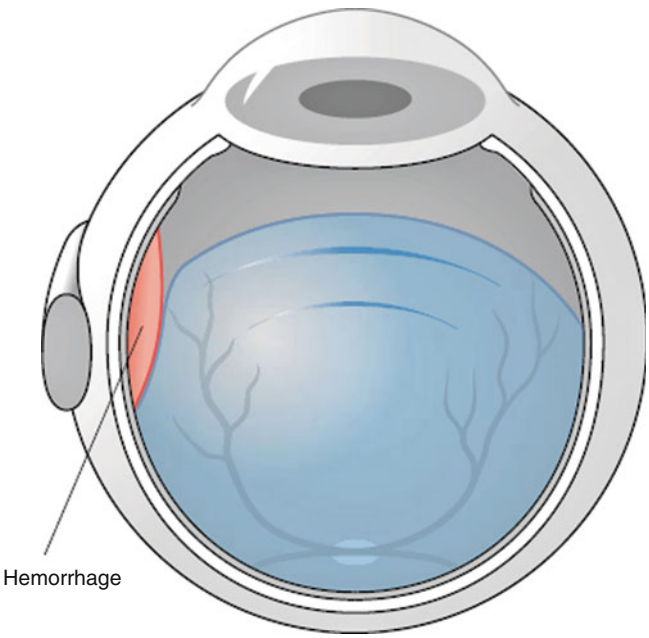


Fig. 6.63 Should a haemorrhage occur, it will be restricted to the site of the buckle and not spread to the posterior pole

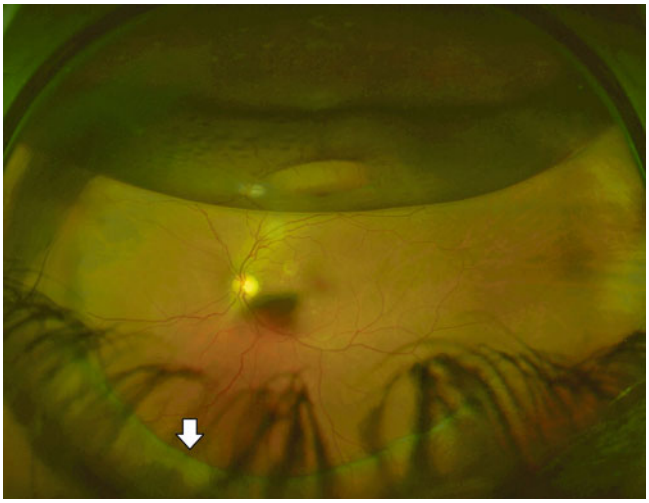


Fig. 6.64 An indentation is shown (*arrow*) from an inferior buckle. Gas is seen superiorly

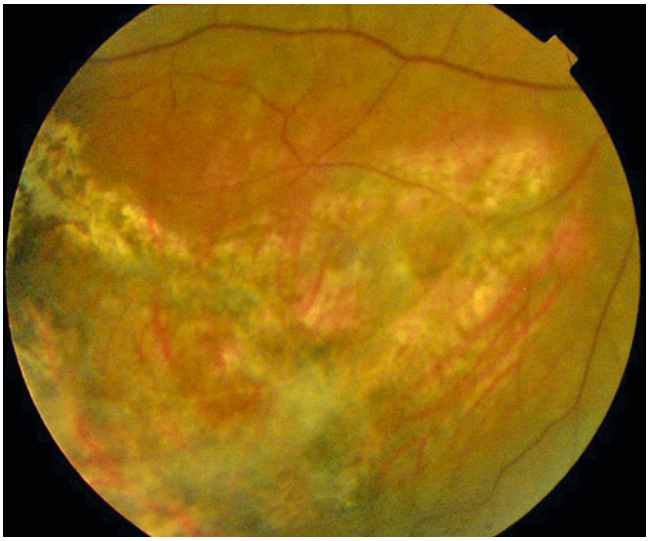


Fig. 6.66 A large tear postoperatively with laser retinopexy

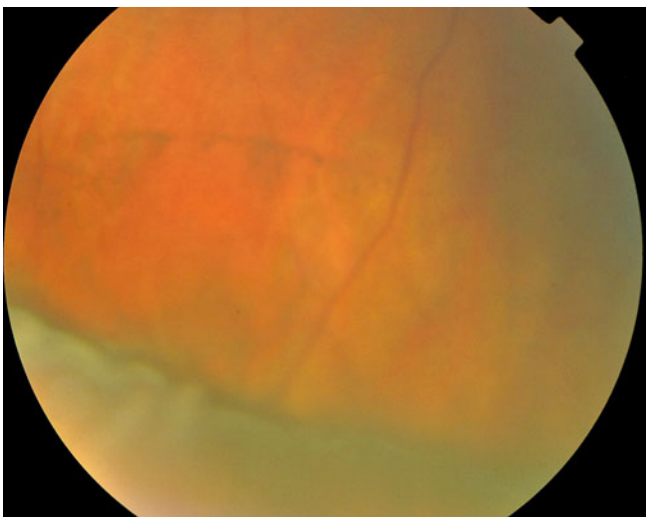


Fig. 6.65 An inferior indentation from a solid silicone explant used to treat inferior breaks during vitrectomy. Minor fold in the retina as in this case will flatten with time

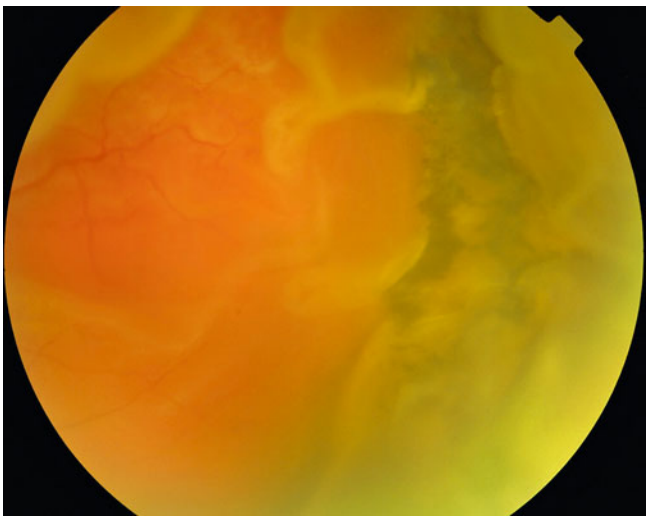


Fig. 6.67 The hypotony from RRD can result in choroidal effusion. Why hypotony occurs in RRD is uncertain but may be due to the detachment spreading anteriorly into the ciliary epithelium

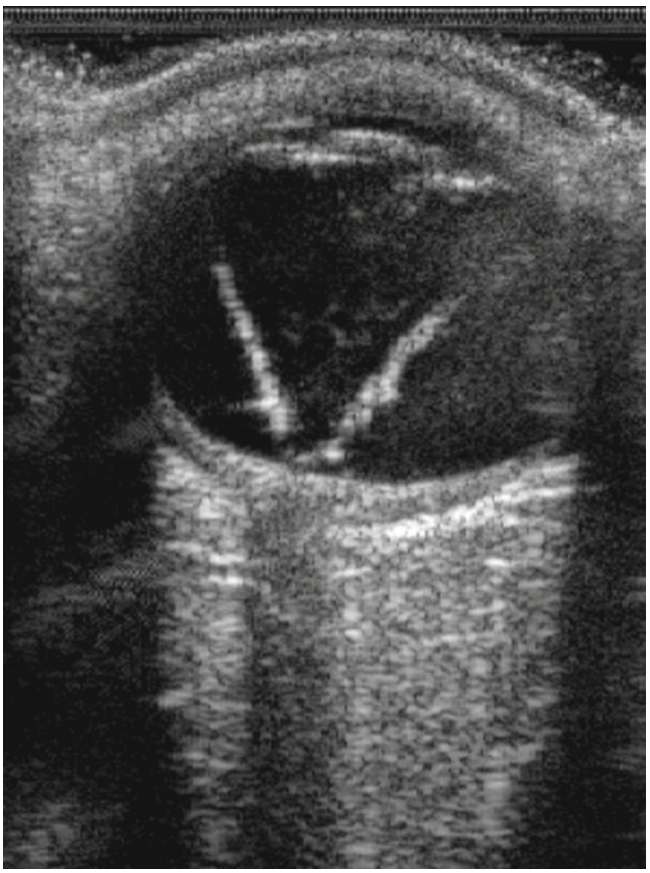


Fig. 6.68 An ultrasound of a hypotonous eye with a total funnel retinal detachment from trauma

Fig. 6.70 See previous figure

Fig. 6.69 The vitreous and retina are incarcerated into a sclerotomy. The incarceration is reversed by the insertion of heavy liquid (see Fig. 6.70)

- Entry site breaks:
  - Perform a good vitreous clearance especially at the sclerotomies to avoid vitreous and then incarceration of the bullous retina.
  - Close instruments on insertion.
  - Make sure that vitreous incarceration into sclerotomies is minimal without vitreous wicks and that sclerotomies are secure at the end of surgery (i.e. no leaks and no vitreous present outside the sclerotomy).
- Retinal folding:
  - Good SRF drainage, that is, do not leave SRF in the macula at the end of the operation and avoid upright positioning for two hours post operatively.
  - Face up posturing for first 24 h postoperatively if there is persistent SRF, thereby allowing the RPE to pump out the residual SRF before the gas contacts the macular retina.
  - Underfill with gas, for example, 80 % fill at the end of the operation, to keep the gas away from the macula during face up posture.
- Lens touch:
  - Be aware of the instrument shafts especially when searching for anterior breaks.

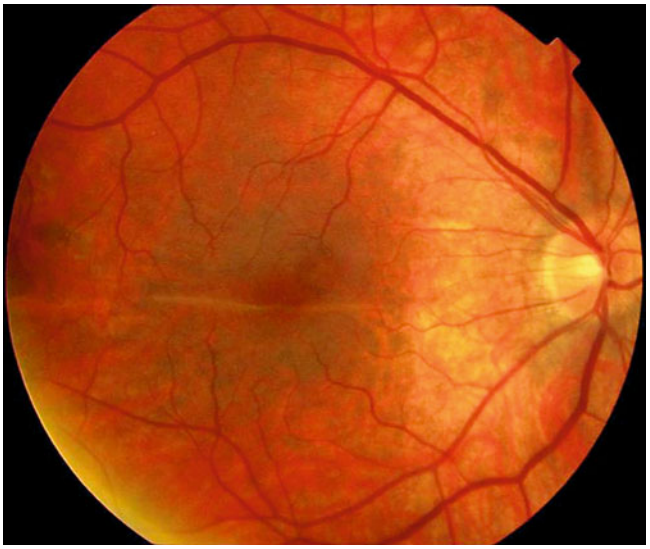


Fig. 6.71 If fluid is left at the posterior pole during vitrectomy and gas tamponade, during post operative positioning, this can cause a fold in the retinal detachment. If this fold passes through the fovea as in this patient, it can cause considerable problems with distortion and diplopia, which can be difficult to alleviate

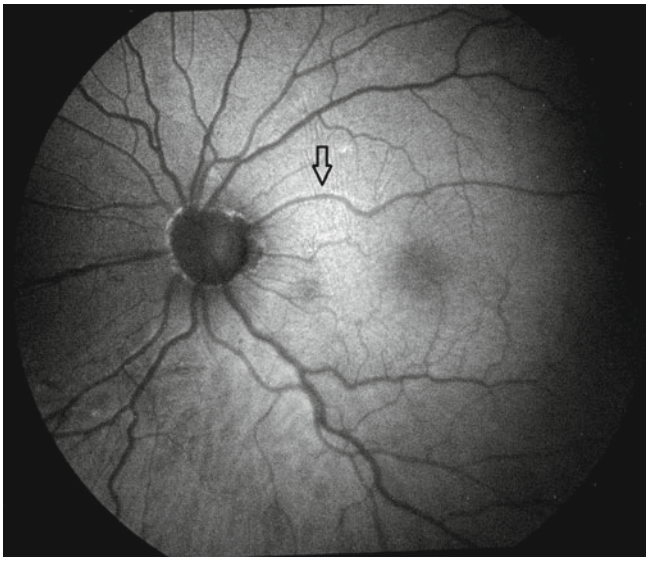


Fig. 6.73 Displacement of the retina after RRD surgery can be demonstrated by the increased fluorescence of the RPE, (*arrow*) which previously was posterior to the blood vessels and is now uncovered, and shows as a *white line* adjacent to the blood vessel

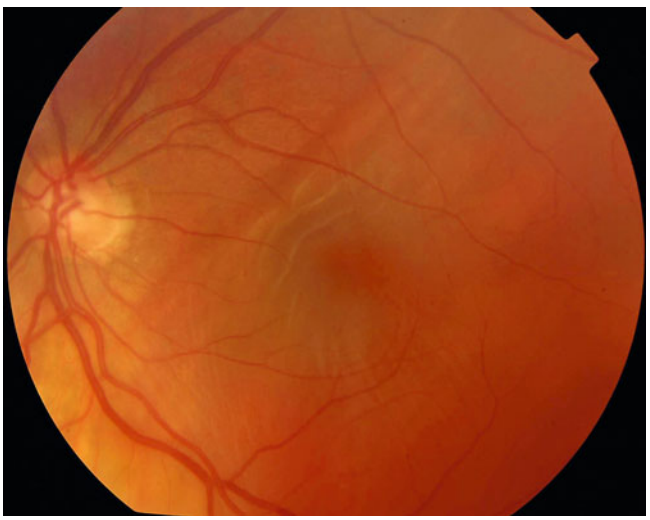


Fig. 6.72 When the macula is just elevated as in this patient, there is a risk of retinal folding postoperatively. The surgeon must be careful that SRF at the end of the operation is not trapped in the macula. Depending on access to the retinal break for drainage, you may need to insert heavy liquids prior to the air exchange to maximise extrusion of SRF through the break during the air/heavy exchange

Fig. 6.74 The *arrows* indicate autofluorescence of RPE cells which were formerly covered by blood vessels and are now exposed after RRD and retinal reattachment. Comparing the blood vessels with the white lines illustrates how far the retina has rotated around the disc and away from its original position even in this eye without retinal folds

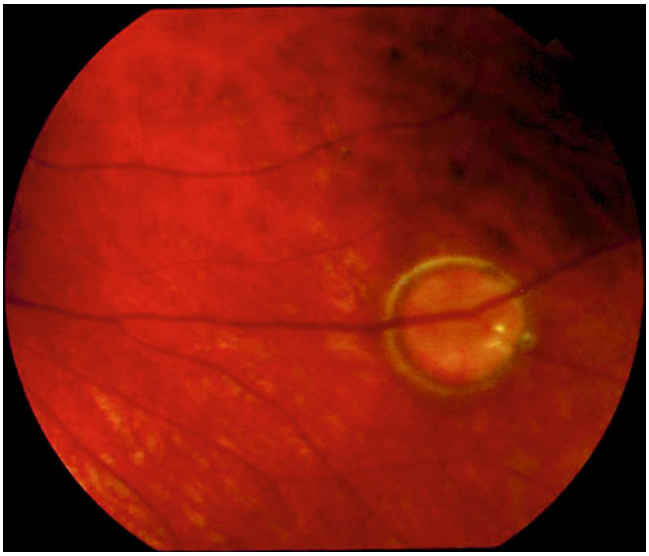


Fig. 6.75 A droplet of heavy liquid has been trapped under the retina. Small bubbles will not move and cause damage. Larger bubbles will move causing diffuse RPE disruption

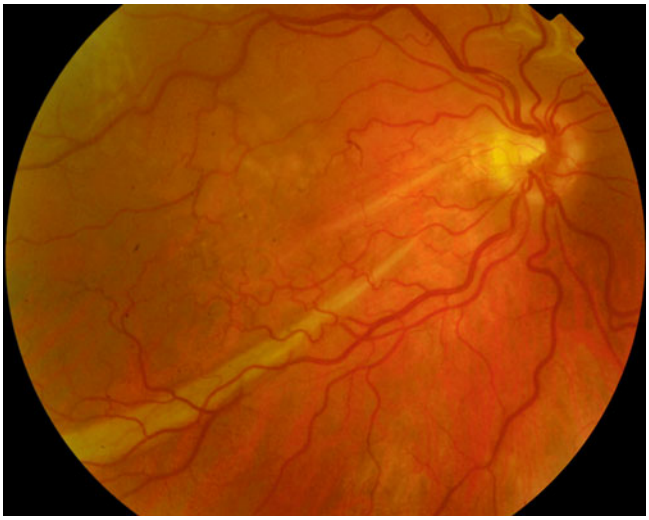
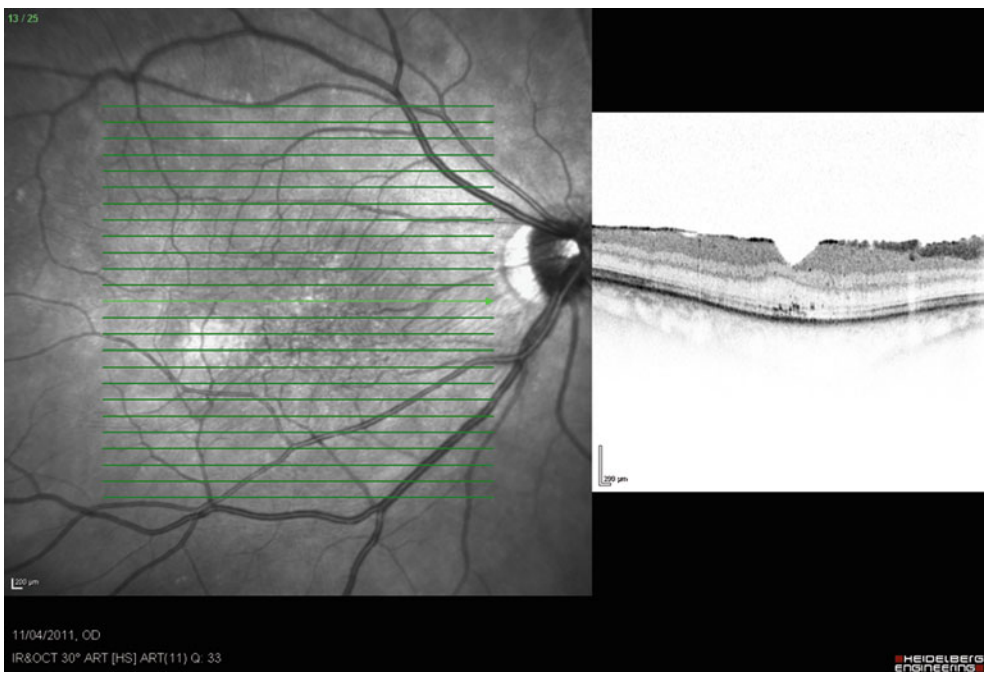


Fig. 6.77 A fold in the retina postoperatively such as this causes postoperative distortion and sometimes diplopia from difficulty fusing the abnormal image with the normal image of the other eye. This can be difficult to remedy; redetachment of the retina can be attempted by reoperation and infusing fluid subretinally via a 40-gauge needle (see macular translocation surgery, Chap. 8), but this has risks such as creation of a macular hole during infusion under the fovea

Fig. 6.76 This patient has had a repair of RRD by PPV but has pigment dispersed under the fovea and ERM



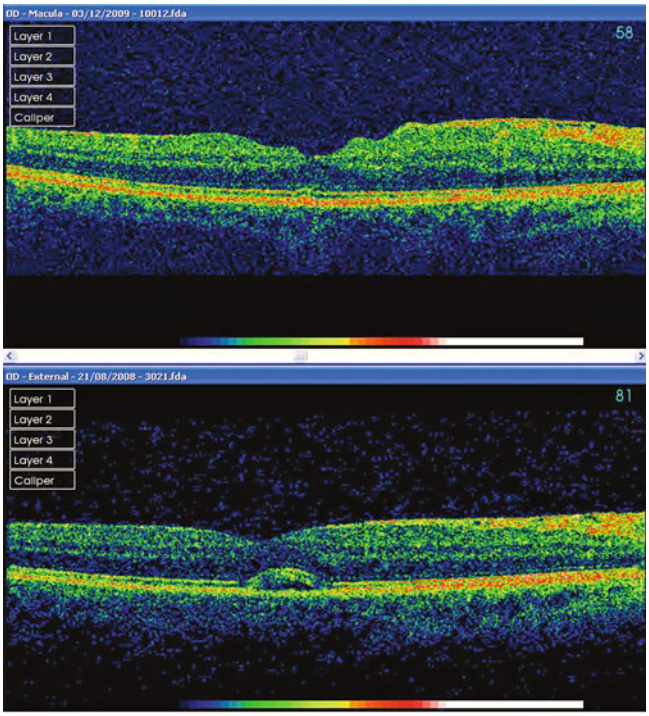


Fig. 6.78 A macular fold after RRD surgery (*bottom scan*) which resolved over 6 months (*top scan*)

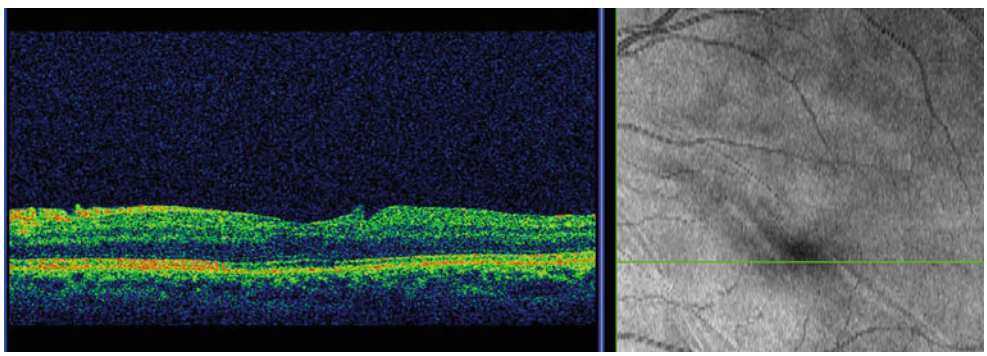


Fig. 6.79 Minimal retinal folding postoperatively should settle over 6–9 months

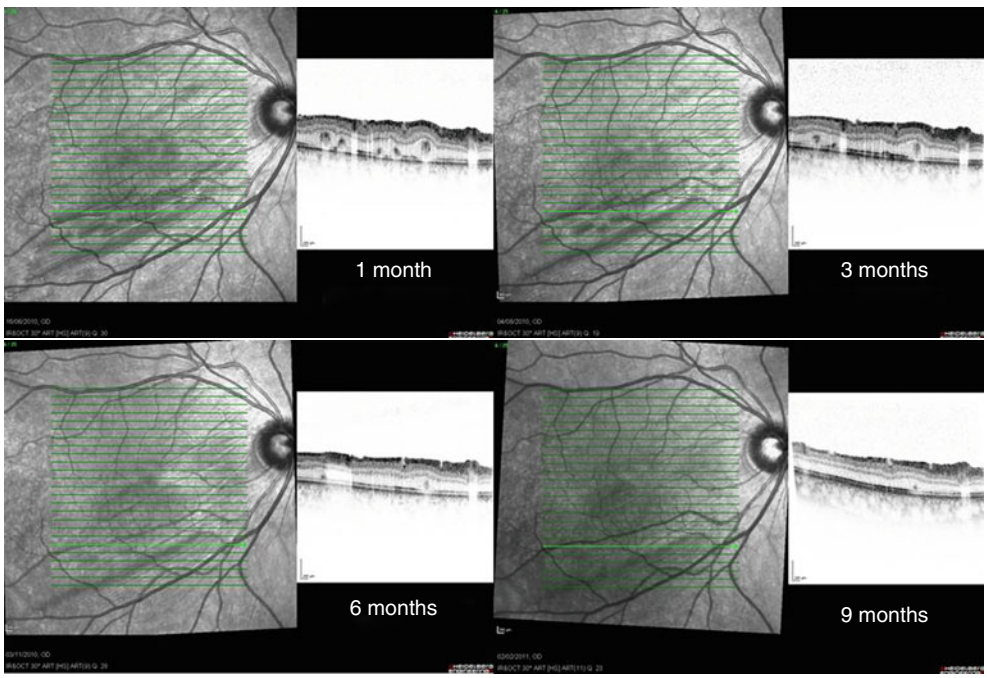


Fig. 6.80 This patient with postoperative folding of the retina after PPV and gas for rhegmatogenous retinal detachment shows gradual reduction of the folding over 9 months

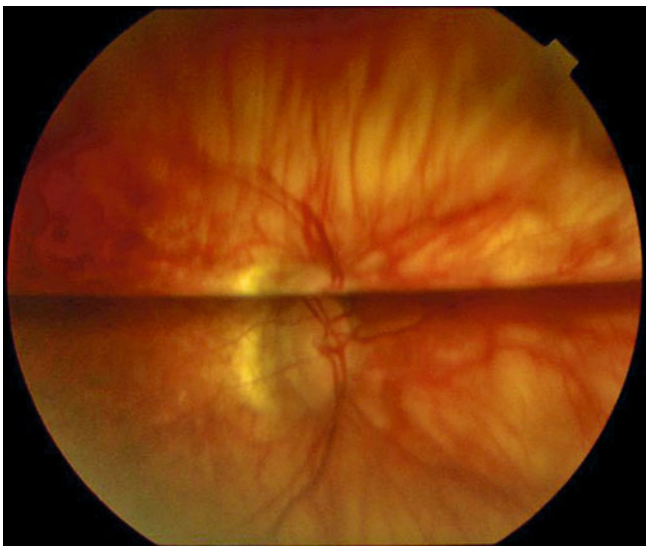


Fig. 6.81 A 50 % fill of gas

Fig. 6.82 Pigment has settled onto the otic nerve head after cryotherapy, perhaps a sign of overly heavy cryotherapy retinopexy

6.3.3.14 Surgery for Eyes with No Breaks Found

There are rare eyes (0.4 %) in which no retinal break is found despite thorough searching, insertion of heavy liquids, etc. Flatten the retina with heavy liquid and internal air tamponade. If the retina cannot be flattened satisfactorily in this way, a posterior retinotomy can be used to allow SRF drainage. Make the retinotomy in detached retina as superiorly and anteriorly as possible. First, use endodiathermy to create a weak site on the retina; then aspirate over the weak spot with the flute needle (this creates a smaller hole than a vitrectomy cutter bite). Apply laser around the retinotomy after air insertion. Apply laser also to the quadrant in which the retinal break should be according to Lincoff's rules, three rows straddling the posterior border of the vitreous base. If you are unsure where the break should be, apply three rows to straddle the vitreous base in the area of detached retina or 360° if a total RRD. This has a 70 % chance of successful outcome (Salicone et al. 2006; Wu et al. 2002; Wong et al. 1987).

6.3.3.15 Use of 360° Laser or Routine 360° Encirclage

In modern surgery using the latest retinal viewing systems, the chance of not finding any break should be low at 0.4 %; therefore, direct treatment of RRD pathology is recommended. It should not now be necessary to use 360° laser or encirclage to compensate for the small chance of missing a break. Older studies reported 8 % of patients in whom no break was seen with more chances of missed break resulting in redetachment (Phillips 1963; Ashrafzadeh et al. 1973), and, therefore, prophylactic measures were justifiable. Even so, 360° laser or routine 360° encirclage are used by some surgeons for eyes with RRD. There are a number of problems with this approach:

- Any extra retinopexy especially cryotherapy increases the chance of PVR.
- Blue light hazard (damage to retinal cones) from laser.
- Some patients are aware of the loss of visual field associated with retinopexy.
- The surgeon is not encouraged to determine the exact pathology present in each case and therefore is at risk of losing the skills to find all breaks and the ability to recognise patterns of RRD pathology.
- Encirclage requires opening of the conjunctiva.
- Encirclage has the potential for suture-related complications.
- Encirclage may change the refraction of the eye because the eye is elongated by the reduction of the equatorial circumference, in extreme cases resulting in an hour glass shape to the eye.

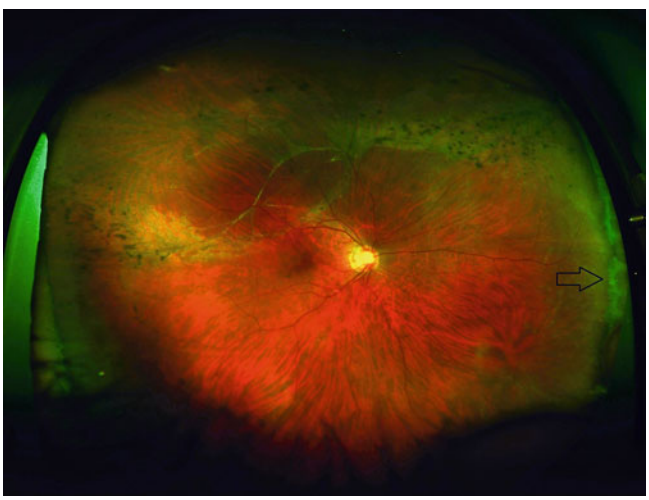


Fig. 6.83 A 360 encirclage has been used but has caused a large myopic shift from −5D to −8D resulting in anisometropia in this patient

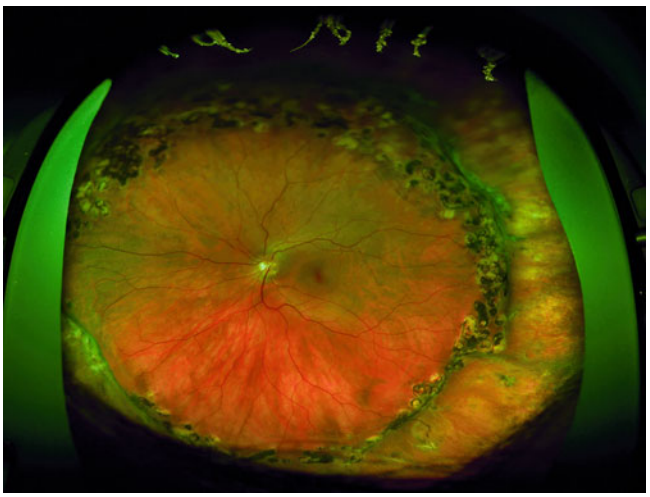


Fig. 6.84 360 laser and encirclage has been used, but this is usually unnecessary, and instead individual breaks can be treated to minimise the area of retina requiring treatment

6.3.3.16 Posturing

The patient does not need to posture if the breaks are above the horizontal meridian. Use posturing for breaks inferior to 3 and 9 o'clock. They should posture for 50 min in the hour for the first 7 days postoperatively.

For a temporal hole in the left eye or a nasal hole in the right eye, the patient would be asked to lie with their right cheek down to the ground.

For a nasal hole in the left eye or a temporal hole in the right eye, the patient would be asked to lie with their left cheek down to the ground.

For an inferior hole, the patient lies supine (face up) with no pillows and the foot of the bed raised if possible.

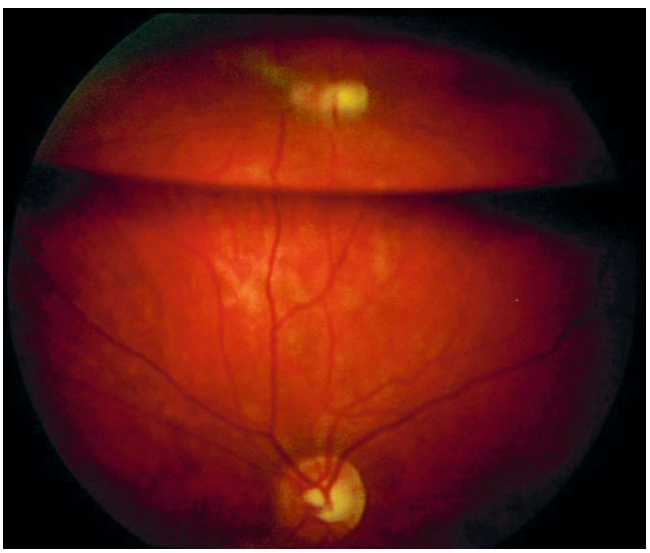


Fig. 6.85 A 20 % fill of gas

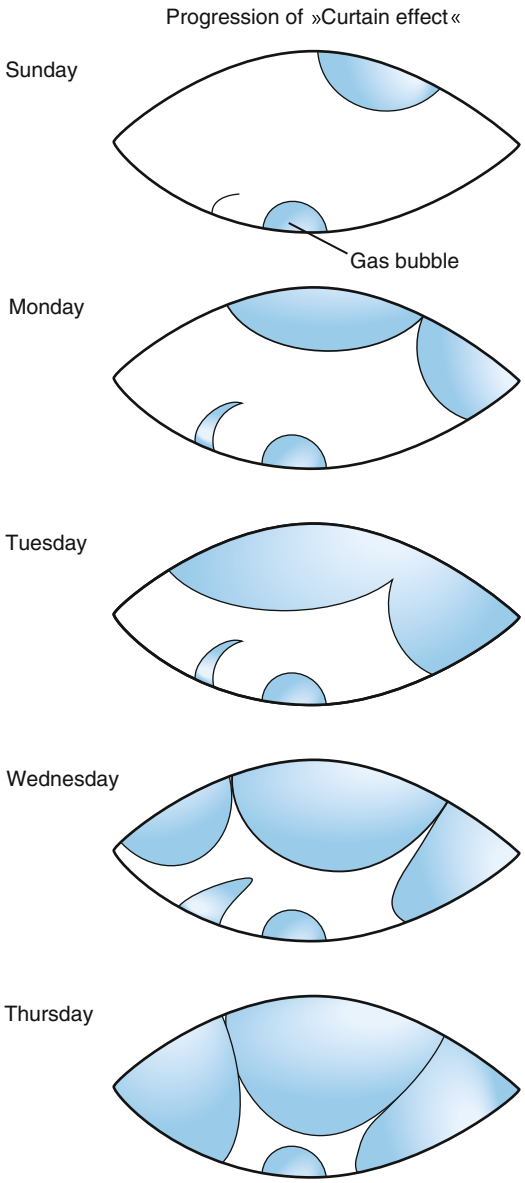


Fig. 6.86 This is the patient's perception of recurrence of his retinal detachment. As the patient's visualisation of events is inverted, he sees the gas bubble at the bottom of the diagram and the retinal detachment returning at the top of his diagram

6.3.4 The Non-drain Procedure

Surgery for RRD evolved over the twentieth century from surgery with scleral buckling (Custodis 1965) to PPV and gas (Machemer et al. 1972). The non-drain retinal detachment procedure involves placement of a silicone sponge underneath a retinal tear. Placement of the sponge is crucial to the success of the procedure. A 3-, 4-, 5- or 7-mm silicone sponge can be used, but in the majority a 5-mm sponge is appropriate. Some surgeons use a solid silicone explant which provides a broader but shallower indent. Preoperatively, the facility for using this operation can be determined by the

Table 6.3 Difficulty rating of the non-drain procedure

Difficulty rating	Moderate
Success rates	High
Complication rates	Low
When to use in training	Early

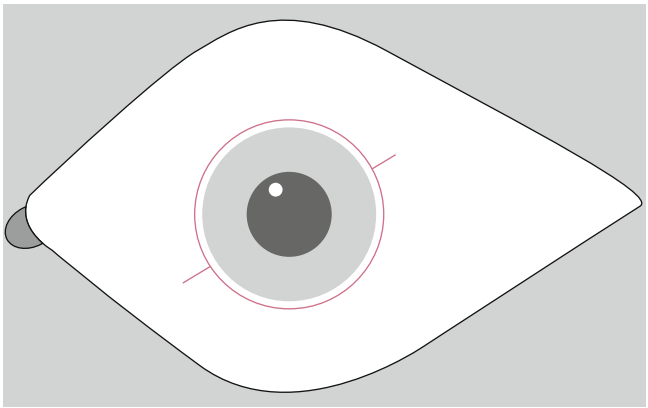


Fig. 6.87 Use a limbal conjunctival perimetry for a non-drain procedure. Incise the conjunctiva and Tenon's close to the limbus and sweep the scissor blade under the Tenon's and up to the limbus. Keep as close to the limbus as possible by pulling with the scissor blade towards the cornea. Make two small radial slits as shown to allow the conjunctiva to open for access to the sclera; otherwise, there is a risk of tearing of the conjunctiva later in the surgery. Keep the slits on the oblique axis to avoid extraocular muscles and also place them in quadrants where you are not proposing to place an explant

ability to 'indent the tear', that is, it should be possible to oppose the retinal pigment epithelium to the neurosensory retina indicating that it will be possible to apply cryotherapy retinopexy during surgery without drainage of subretinal fluid (SRF).

6.3.4.1 Operative Stages

- Open the conjunctiva and sling the recti muscles.
- Search for retinal breaks with the indirect ophthalmoscope and scleral indentation.
- Apply cryotherapy to the breaks.
- Mark the site of the breaks on the external sclera.
- Preplace the scleral sutures.
- Insert the sponge.
- Tie one suture.
- Perform a paracentesis to remove some aqueous.
- Tie the remaining sutures.
- Check the optic nerve perfusion and break position on the indent.
- Close the conjunctiva.

When starting with this surgery, open the conjunctiva 360° to facilitate isolation of the recti muscles and to ease indentation of the sclera. Later, when skills are more honed, restrict the conjunctival perimetry if you wish. Start by making a radial cut of 2–3 mm (usually one snip of the scissors)

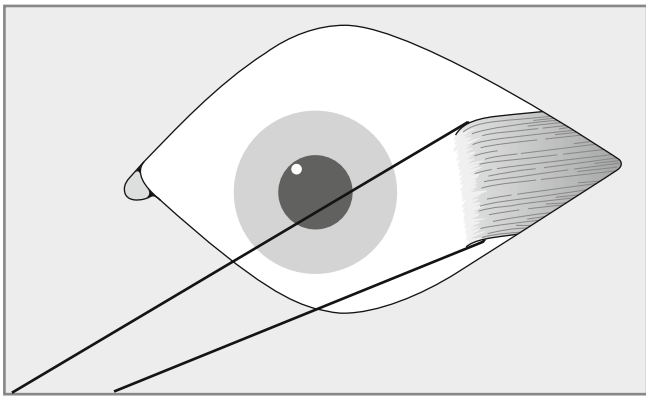


Fig. 6.88 Sling the extraocular muscles

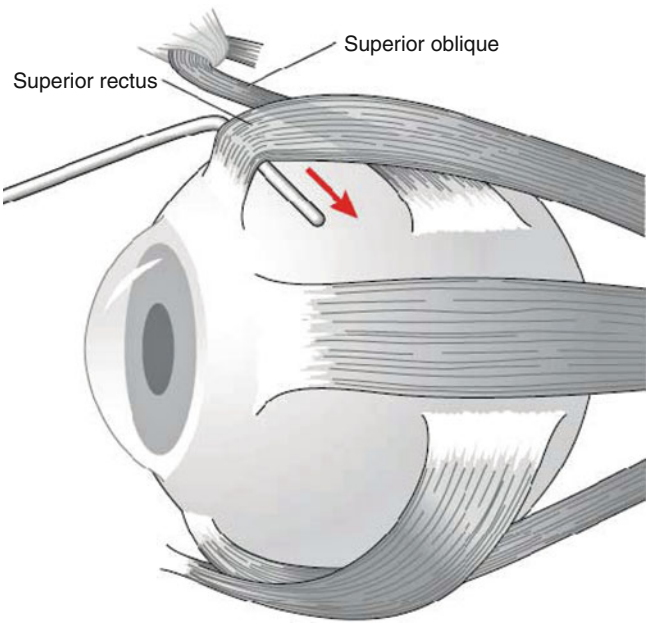


Fig. 6.89 When hooking the superior rectus, take care not to hook the superior oblique

in the conjunctiva and Tenon's layer on one of the oblique meridians (thereby avoiding the extraocular muscle insertions); sweep one of the blades of a blunt-ended scissor under the Tenon's and anteriorly towards the limbus of the cornea and sclera to leave as little tissue as possible at the limbus. Repeat the sweep and cut all around the limbus. Make a second radial cut 180° from the first.

Note: It is preferable not to make the radial cuts in the quadrant in which the explant is being placed. This keeps intact conjunctiva and Tenon's over the explant in the postoperative period. Pass a squint hook instrument behind the rectus insertion to be able to pull the muscle anteriorly. Next, take a damp piece of swab in forceps and push the conjunctiva and Tenon's posteriorly over one of the longitudinal borders of the rectus muscle and then the other border

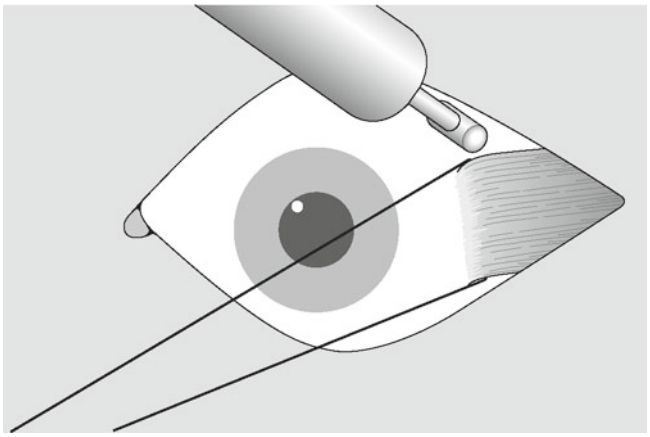


Fig. 6.90 Indent the sclera to view the peripheral retina

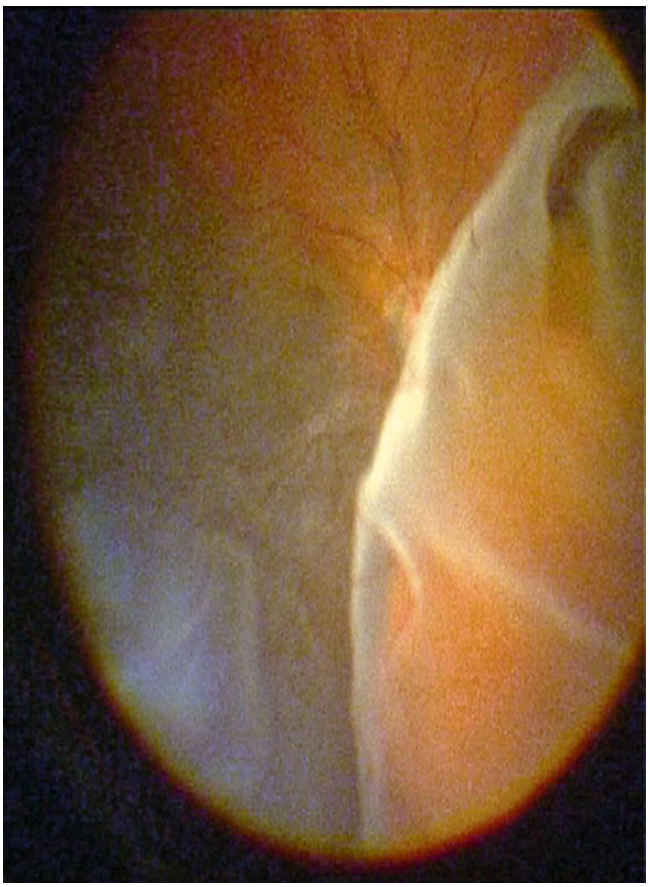


Fig. 6.91 A U tear can be seen on indentation of the sclera to allow visualisation of the peripheral retina

of the muscle. The aim is to free the muscle from its attachments to Tenon's. Do this to all the recti muscles. This should leave clean sclera between the muscle insertions, tendon and anterior muscle belly with no attached Tenon's. If any is attached, clear this off now because it will only hamper the surgery later.

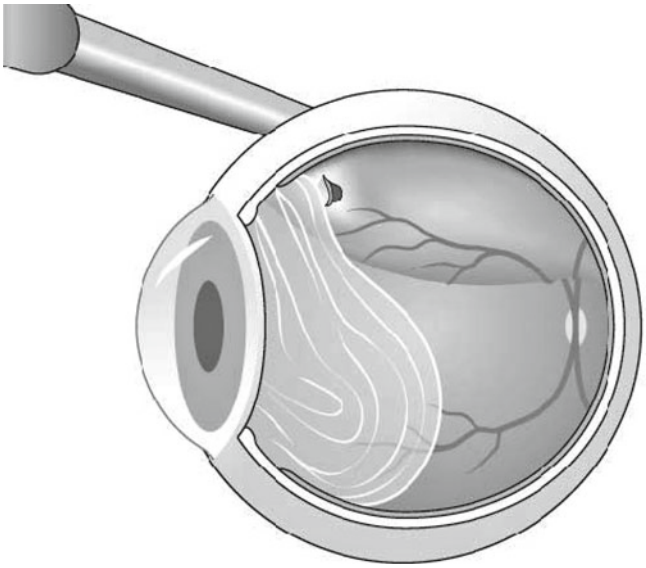


Fig. 6.92 Indent the break with the cryotherapy probe

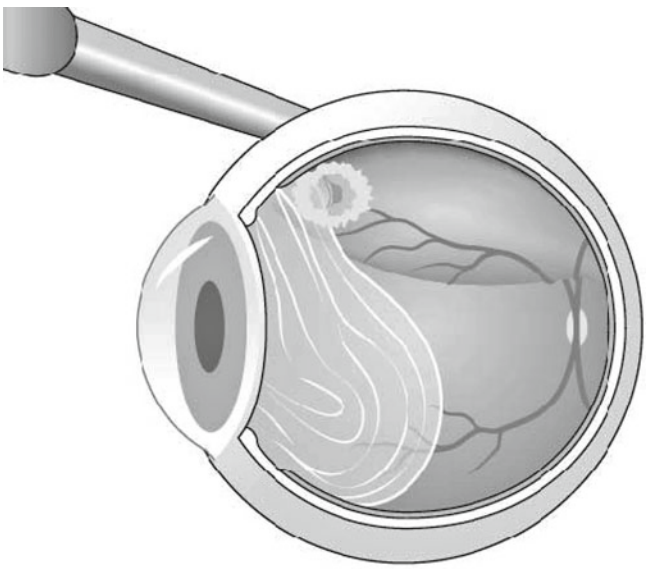


Fig. 6.93 Apply the freeze

Slinging the muscles:

- Whilst holding the position of the muscle with the squint hook.
- Pass a 2/0 braided suture (20 cm long) through the eyelet of an instrument, for example, an aneurysm needle (this is a bent tool with an eyelet at its tip), whilst holding the muscle insertion forwards with the squint hook.
- Pass the aneurysm needle under the muscle insertion.
- Remove the squint hook.
- Pull one of the ends of the suture through.
- Hold that end of the suture (press it against the orbital rim with the squint hook).

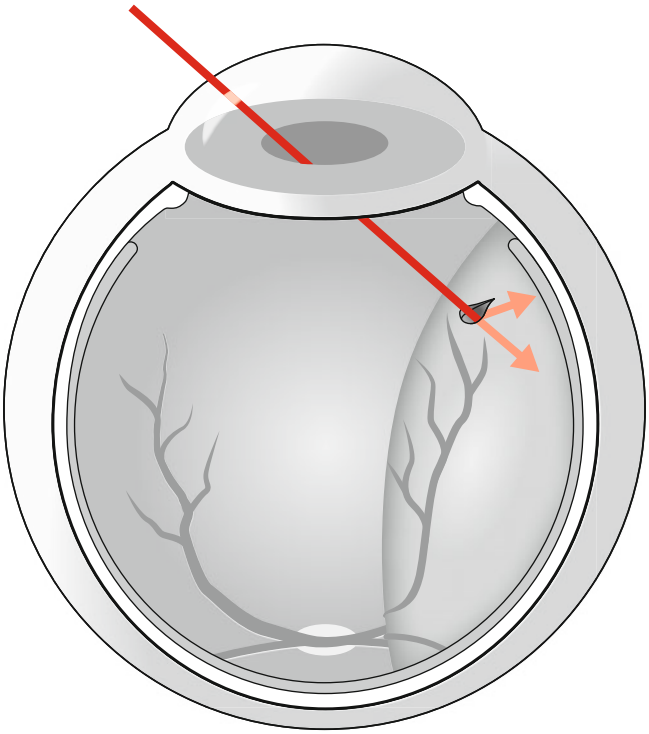


Fig. 6.94 Visualisation of a break in a retinal detachment by indirect ophthalmoscopy gives the impression that the break should settle more posteriorly because of the phenomenon of parallax (*arrow*). Take this into consideration when applying a plombage

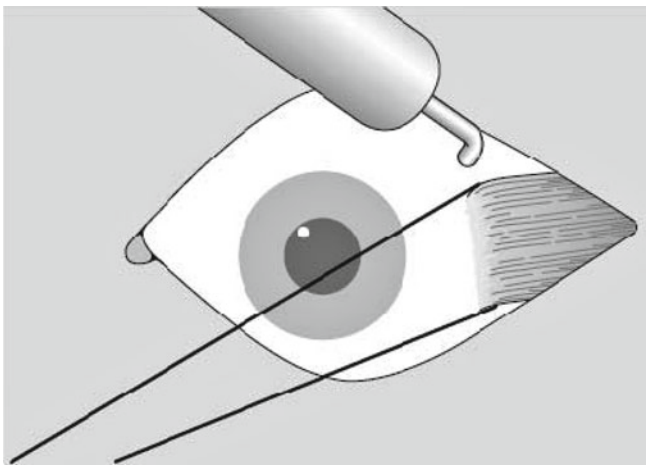


Fig. 6.95 With indentation mark on the external sclera, the position of the break or breaks

- Remove the artery needle and disengage it from the suture.
- Tie the ends of the suture with a simple knot and weigh down by clamping the end with an artery clip.

Always sling both horizontal recti with a suture. The horizontal slings will allow movement of the eye in a circumferential manner if, for example, there is difficulty viewing a particular portion of the retina because of the anatomy of the patient, for example, a large nose, deep socket or kypho-scoliosis of the patient. With superior breaks also sling the superior rectus, if inferior breaks sling the inferior rectus. The slings will be required to move the eye to expose the sclera overlying the break for the application of the explant.

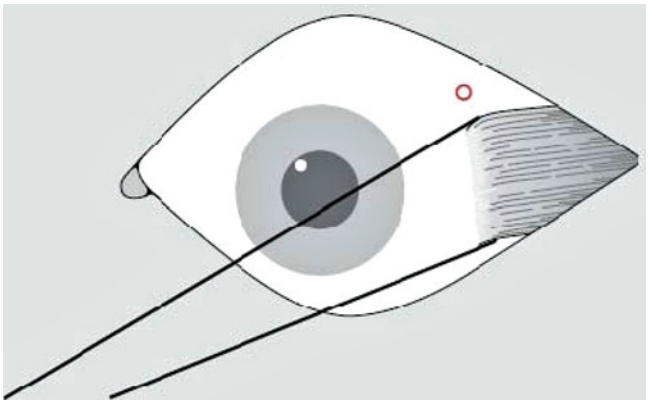


Fig. 6.96 The mark is used to guide the placement of the sutures

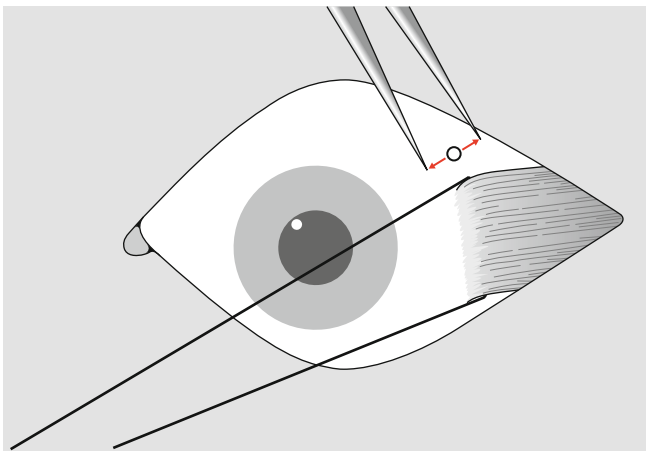


Fig. 6.97 Place the sutures an equal distance from the mark

Search the eye with binocular indirect ophthalmoscope (BIO) and 20D lens or equivalent and indentation for 360° (use a thimble with attached prong and *T* bar on the end or a squint hook). Remember start at one shoulder whilst viewing the 12 o'clock retina and work around the head to the other shoulder and back to the 12 o'clock position. The slings help to manoeuvre the eye during indentation. The weight of the artery clips helps stabilise the eye during this search (reducing rotation and posterior displacement of the globe).

Note: To further stabilise the eye, place the fifth finger of the hand holding the lens and press down on to one of the horizontal slings and the orbital rim. This stops the eye moving both circumferentially and also posteriorly into the orbit during indentation.

Apply cryotherapy to all of the breaks. Usually, each break only requires one freeze starting in the middle of the

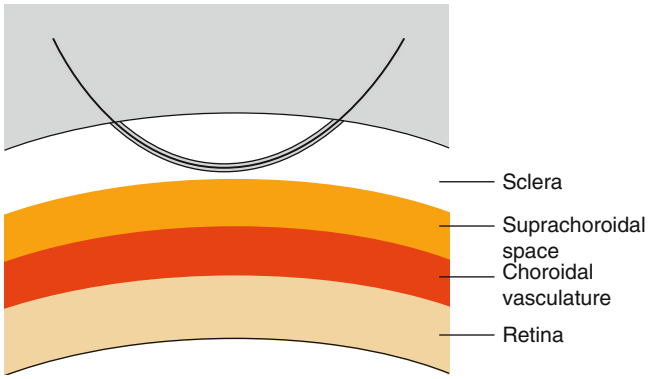


Fig. 6.98 The scleral suture should go deep through the sclera without penetrating it

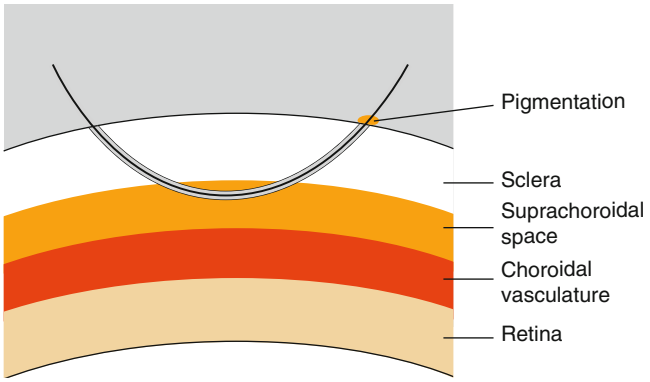


Fig. 6.99 Penetration into the suprachoroidal space is often evidenced by the presence of some pigmentation in the suture track

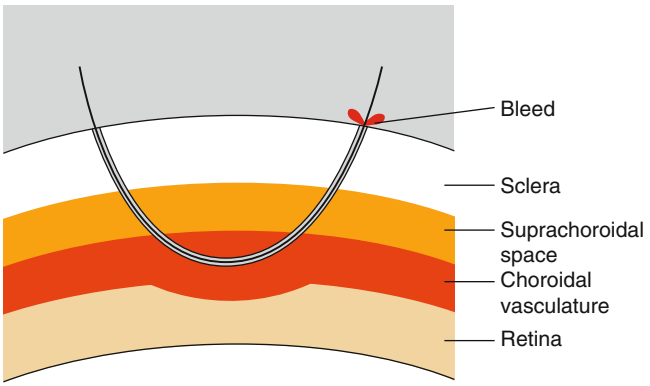


Fig. 6.100 Penetration into the choroid can cause a bleed subretinally or into the choroid. This may be indicated by the presence of bleed at the far end of the needle track

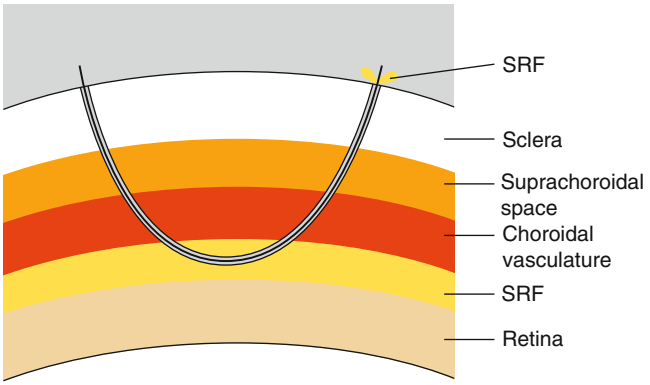


Fig. 6.101 If the stitch is too deep, subretinal fluid can leak through the suture track causing hypotony of the eye

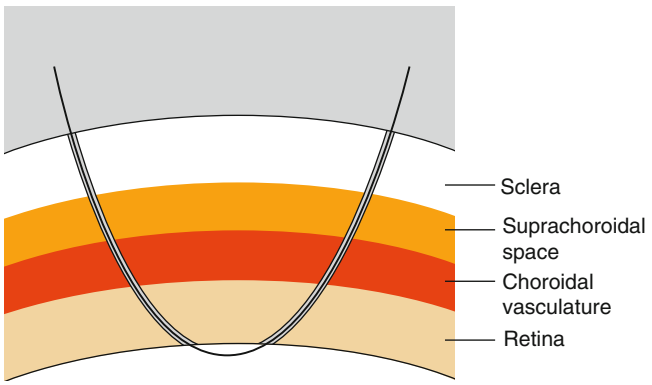


Fig. 6.102 It is possible to produce a retinal perforation if the patient has flat retina at the site of the insertion of a sclera suture

break and extended to the equivalent of two laser rows around the break. Produce a mark on the external sclera, indicating the site of the breaks, using an indenter, for example, Gass indenter, a thimble-shaped instrument with a prong attached with a 1 mm diameter elevated circular rim at its end. After indentation, this leaves a circular mark on the sclera. Dry the sclera and mark the spot with ink from a sterile indelible marker pen. Swab again to remove excess ink; otherwise, it will stain the Tenon's.

Note: If you are unsure of your accuracy, grasp the sclera at the mark gently with toothed forceps and indent whilst checking the break is over the indent internally with the BIO.

Observe the position of the marks on the sclera breaks and decide upon the appropriate explant (plomb) that can cover the marks. Much has been argued about the type and orientation of the plomb. A circumferential plomb is easy to apply and successful in most cases. If using a sponge, three factors determine the choice of size:

- The size of the break or breaks, bigger breaks requiring larger indentation surface area
- The presence of multiple breaks in different circumferential positions, for example, in a young person's low-myope round hole retinal detachment
- Height of break from the RPE, for example, in retinal dialysis

Note: Try to use the smallest explant to achieve placement of the break or breaks on the apical ridge of the indentation.

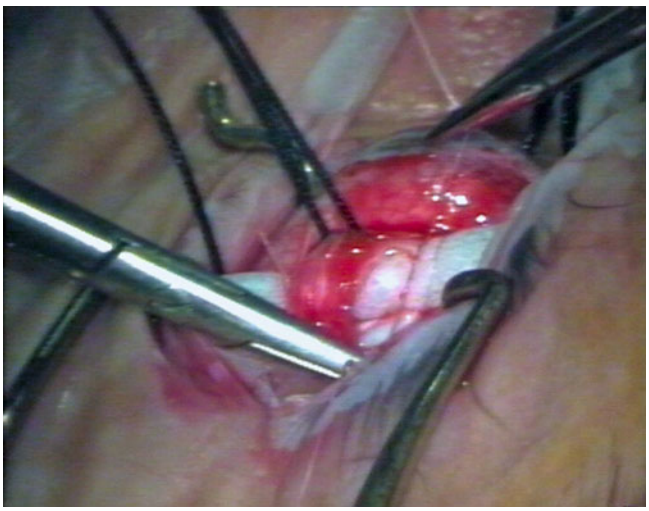


Fig. 6.103 When applying tension to the sutures, be careful to apply pressure tangentially to the globe surface and not perpendicular to it which risks tearing the sclera

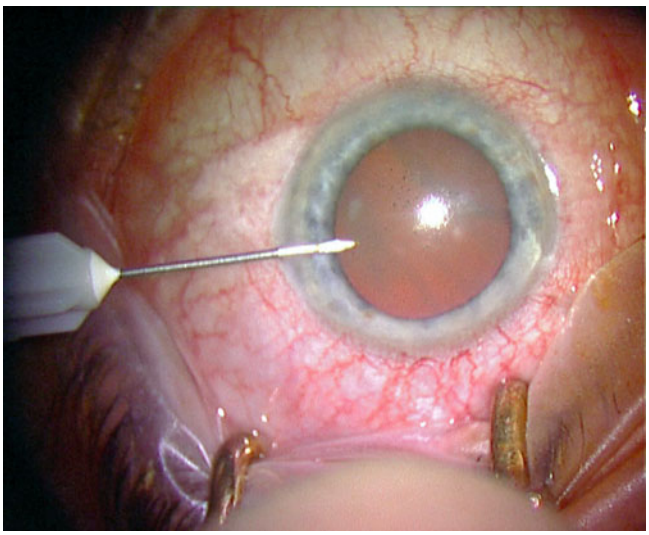


Fig. 6.104 It can be useful to release some aqueous after the first stitch is applied to a plomb in a non-drain procedure to prevent an IOP rise from compromising the blood supply to the optic nerve head. Insert a 30-guage needle attached to a 1-ml syringe with the plunger removed. The aqueous will exit slowly through the needle, and the quantity of aqueous can be monitored as it enters the syringe. Usually, removal of 0.1 ml is adequate to maintain a normal IOP

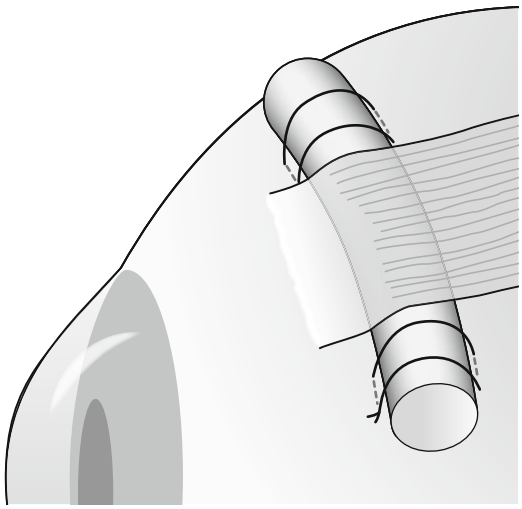


Fig. 6.105 Placing a plombage underneath a muscle requires a stitch which can be passed around the edge of the muscle without any sequelae such as diplopia

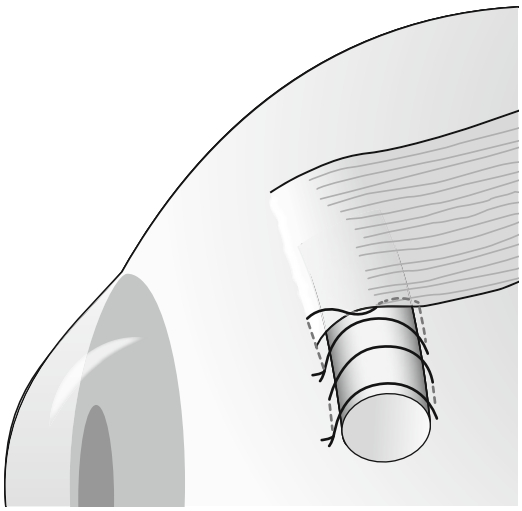


Fig. 6.106 If the plomb passes completely under the muscle to the other side of the muscle, stitches should be placed on either side of the muscle, avoiding suturing through the thin sclera underneath the muscle

If there are multiple breaks in different circumferential meridians, you will need a larger plombage, and not all breaks will be on the apex, but try to keep them as close as possible, that is, on the apical one-third of the total area of the indent.

Use 5/0 non-absorbable sutures at a width of 1.5 × the diameter of the sponge (approximately, half the circumference of the cross section of the plomb, i.e. $0.5 \times 2\pi r$), for example, 7.5 mm for a 5-mm sponge or 6 mm for a 4-mm sponge. Insert the suture with a spatulated needle into the sclera for 2–3 mm for each insertion and as deep in to the sclera without going into the suprachoroidal space. The sclera will allow a plane to open up for the suture to pass along.

Note: If you can see the dark of the needle as it passes through the sclera, you are too shallow, and there is a risk the suture will tear through the sclera during suture tightening. Remove the needle and try again.

Each incision is orientated parallel to the explant.

Signs that the stitch is too deep are:

- Extrusion of SRF (straw-coloured viscous fluid).

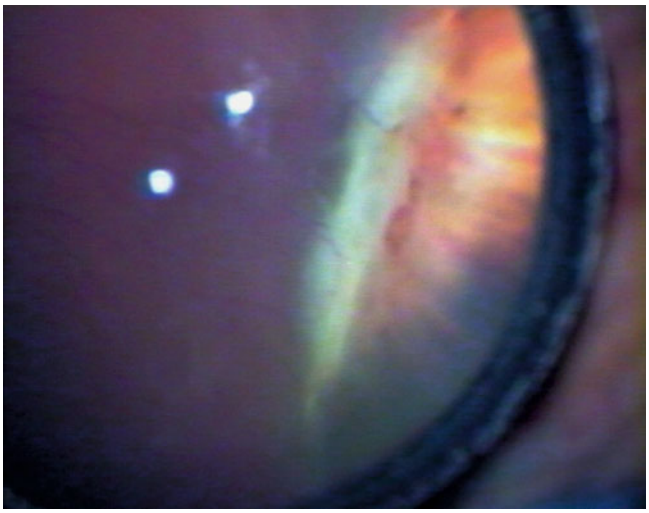


Fig. 6.107 The break should be seen situated over the apex of the indent but does not need to be flat on the plomb at the end of the operation

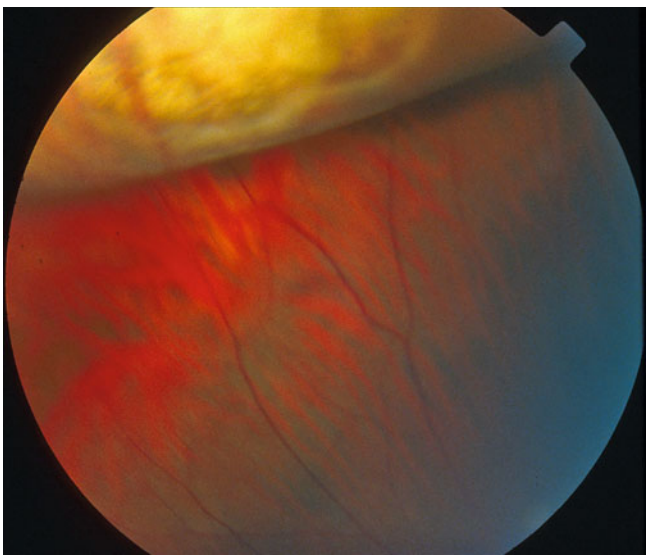


Fig. 6.108 An internal indent is seen with a cryotherapy scar

- Haemorrhage from the suture track.
- A speck of pigment appears at the end of the suture track.

If too deep, inspect the inside of the eye with the BIO. A white spot will be seen in the choroid, and some subretinal bleeding may be encountered. In the latter circumstance, indent the eye to increase the IOP and to limit the spread of the bleed long enough to allow clotting to occur. Occasionally, fluid vitreous will come out of a deep stitch causing progressive collapse of the eye. The vitreous fluid passes through the retinal break and then out through the needle track (also seen rarely with external drain procedures). In this circumstance, indent the break if possible to do so. This prevents further recruitment of fluid vitreous into the subretinal space. Reinflate the eye with an air bubble, which will also prevent further extrusion of fluid (see DACE procedure).

If the retina has been penetrated, that is, you have created a retinal break, treat this as one of the breaks. Retinopexy the retina and include the site on the indent by readjusting the explant.

Usually, two or three sutures are required for each explant. Be careful not to insert a suture through a vortex vein which may pass unseen (or as a faint blue line extending from a visible vein) through the sclera for a 1 or 2 mm. It is usually safe to insert a suture through the insertion of a rectus muscle, but make sure to bite into some sclera to avoid tearing the suture out. If this happens, take another bite further away from the edge of the explant.

Insert the explant and tie the first suture with three throws then one throw and one throw. Cut the sutures but leave 2 mm of length from the knots as these sutures can slip. For a 5-mm sponge or larger, remove a small amount of aqueous via a paracentesis through the peripheral cornea to avoid an IOP rise (this is usually unnecessary with 3- and 4-mm explants). Tie the remaining sutures.

Note: Never put the stitch through the explant itself as this will make subsequent removal hazardous.

The indent is produced by tightening the sutures. A silicone sponge allows compression of the explant producing a narrow high indent ideal for the non-drain procedure. Solid silicone explants produce a flat broad indent (easy to place under the retinal break) but in my experience too often requiring postoperative gas injection because of lack of resolution of SRF. Check that the breaks are on the apex of the indent. If the breaks are not correct, reposition the sutures. Move all bites to achieve the appropriate repositioning; usually, you will have to move them further than anticipated at first. The breaks need not be flat on the indent. If the break is close to the surface of the indent, the altered fluid dynamics will cause the retina to flatten in a few hours.

Check the optic nerve is still perfused. At the end of surgery, make sure no Tenon's is caught up in the sutures; if so, clear out the Tenon's from any site. I suspect Tenon's adherent to sutures in this way provides a focal point for scar formation that increases the risk of postoperative diplopia. To aid in the correct apposition of the conjunctiva, grasp the horizontal recti insertions with non-toothed forceps and gently push the globe back into the orbit. This causes the conjunctival and Tenon's layers to return to their correct position around the limbus. It is now easy to see where the radial cuts in the conjunctiva are for suturing. Close the conjunctiva with an absorbable 7/0 suture at each of the radial incisions. Insert the suture through the Tenon's, then conjunctiva on one side and then the conjunctiva and the Tenon's on the other side of the wound with one suture. Bury the knot under the Tenon's. Apply subconjunctival antibiotics.

Surgical Pearl of Wisdom

No cryo, no cry!

Do not use cryotherapy during buckling procedures for retinal detachment, but apply laser 2 months postoperatively on a reattached retina. These are the reasons why:

It shows that there is no need for immediate retinopexy. Retinopexy is only needed to prevent late redetachment in case the buckle sutures erode or after buckle removal because of diplopia or buckle infection.

It diminishes the number of manipulations on the globe, thereby reducing surgery time, trauma and possibly breakdown of the blood–retina barrier and dispersion of retinal pigment epithelium cells.

It greatly improves the quality of a vitreoretinal fellows' work (no long searches for the break with their cryotherapy) and diminishes proportionally the anxiety of the coaching VR surgeon.

The major drawback is that postoperative laser hurts. Just use peribulbar anaesthesia.

Jan C. van Meurs, the Rotterdam Eye Hospital, Rotterdam, The Netherlands

6.3.4.2 Postoperative Care

The next day postoperatively, much of the subretinal fluid will have reabsorbed, and in fact the retina is usually flat. A topical steroid, antibiotic and cycloplegic should be used for 1 month. This procedure has a low morbidity depending on the experience of the surgeon.

6.3.4.3 Complications

6.3.4.4 Peroperative

Explant

Sutures tear out. Replace with a scleral bite further away from the explant; avoid by making sure that the stitches are deep and long and taking care when compressing the explant during tightening of the suture. Do not attempt plombage in high myopes with thin sclera; perform PPV instead.

Deep stitch, remove and check the retina.

Scleral tear (Tabandeh et al. 2000) can happen rarely when clearing scar tissue from the sclera in a redo operation especially from under the extraocular muscles; it is important to recognise the complication and repair the sclera.

Hypotony from a deep stitch and drainage of SRF insert air; see DACE procedure.

Raised IOP causes poor optic nerve blood flow. Perform a paracentesis to remove aqueous, or massage the eye with your finger tip to cause egress of aqueous through the trabecular meshwork and recheck the optic nerve.

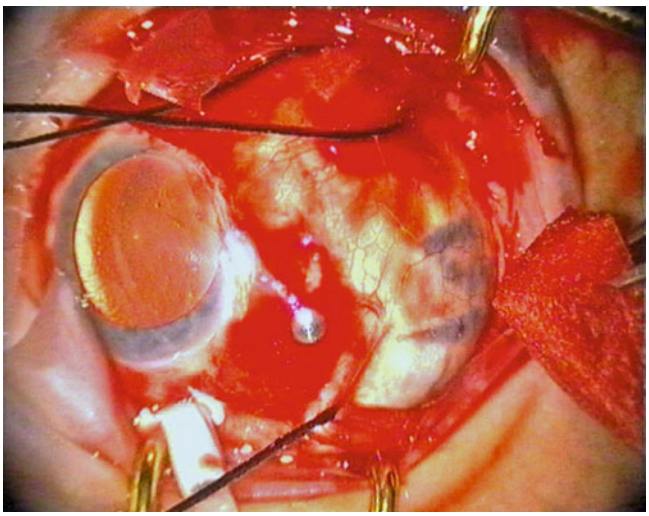


Fig. 6.109 In highly myopic patients, thin sclera may be evident underneath the muscles and elsewhere, as thin blue striae in the sclera. This is a contraindication to external buckle

6.3.4.5 Postoperative

Explant erosion through the conjunctiva; remove the explant in the outpatient setting if the hole in the conjunctiva is large enough. The eye will not heal until the explant is removed.

Explant infection early. Infections immediately after surgery are often seen as a localised scleritis should be treated with systemic antibiotics and will usually settle.

Explant infection late; remove the explant.

For cosmetic problems, remove the explant. The explant may be visible if anteriorly placed or large; in some circumstances, this is cosmetically unacceptable for the patient.

Diplopia: Remove the explant early. Explants are particularly likely to cause diplopia if placed under the vertical recti. Scar formation around the explant can be very rapid and is soon established. Early removal will reduce the scar formation and reduce the bulk effects of the explant. Some patients will still require prismatic correction or even extraocular muscle surgery.

Raised IOP is usually due to a steroid response to the postoperative drops and can be treated medically.

The macula vision can be reduced by:

Persistent SRF in the Postoperative Period under the Fovea. This is very common when non-drain is used for macula-off chronic round hole or dialysis-related detachment (Wolfensberger and Gonvers 2002; Wolfensberger 2004; Baba et al. 2004). The viscous SRF becomes loculated under the fovea preventing full recovery of visual acuity. No convincing method (PPV, laser, intravitreal injections) has been described to deal with this complication. The SRF may eventually reabsorb over the course of a year, but visual recovery is variable.

RPE Dispersion into the Macula from Cryotherapy. Heavy use of cryotherapy may disperse RPE cells into the subretinal space which may settle in the macular area postoperatively. This may be associated with mild visual reduction.

Distortion. Any eye which has suffered macular involvement may have a change in the image seen by the patient in the postoperative period (Ugarte and Williamson 2006). Many patients experience a minification of the image and some mild distortion. Often these symptoms lessen at 6 months after surgery; however, they may be accompanied with a reduction in stereopsis.

HD-OCT allows assessment of the recovery in the fovea in these patients; abnormalities are common (Wakabayashi et al. 2009):

Foveal changes	62 %
Disruption of the inner/outer segment line	43 %
Later restored in	50 %
Disruption of the external limiting membrane	39 %
ERM	23 %
CMO	4 %

Astigmatism is rare after plombage but can occur with steepening of the corneal curvature in the axis of the plombage. This case illustrates the effect of the indents on the cornea where inferotemporal and superonasal circumferential indents in a right eye induced −3.25D of astigmatism at 145°, that is, a steep cornea between the indents. The eye is being pinched inwards by the plombs rather like squeezing a small ball between two fingers.

Surgical Pearl of Wisdom

Cutting the Encircling Band

An encircling band reduces pulsatile ocular blood flow (POBF) by 60 %. The reduction is independent of the amount of the constriction (5–25 %). Cutting the band restores 85 % of the loss of POBF, with little risk of redetachment.

Harvey Lincoff, New York Presbyterian Hospital, New York, USA

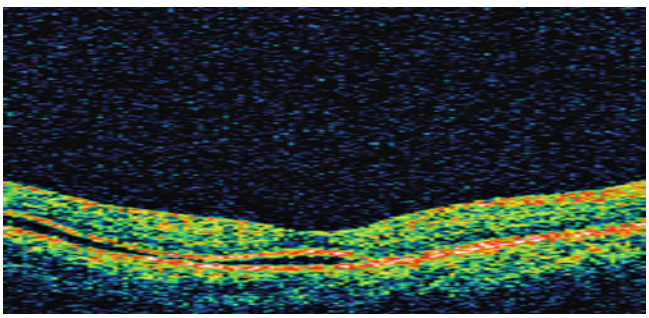


Fig. 6.110 Subretinal fluid can sometimes be trapped under the fovea in patients who have had non-drain retinal detachment repair. This restricts the visual recovery at approximately 20/60 and may persist for up to 12 months postoperatively. In this patient, the subretinal fluid has resolved with the recovery vision limited to 20/40 (see Figs. 6.111–6.113)

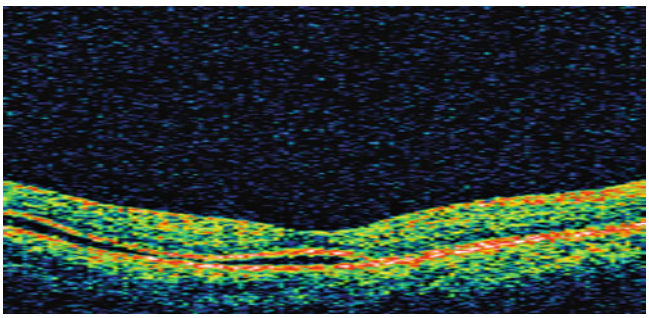


Fig. 6.111 See previous figure

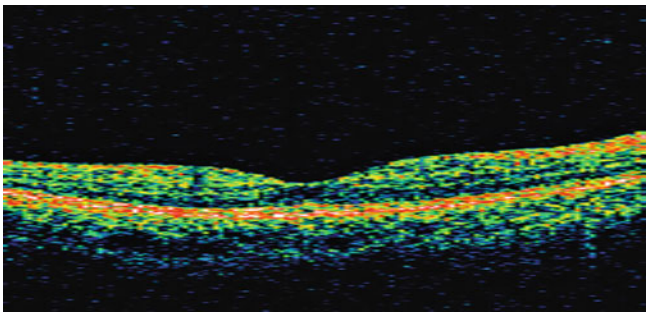


Fig. 6.112 See Fig. 6.110

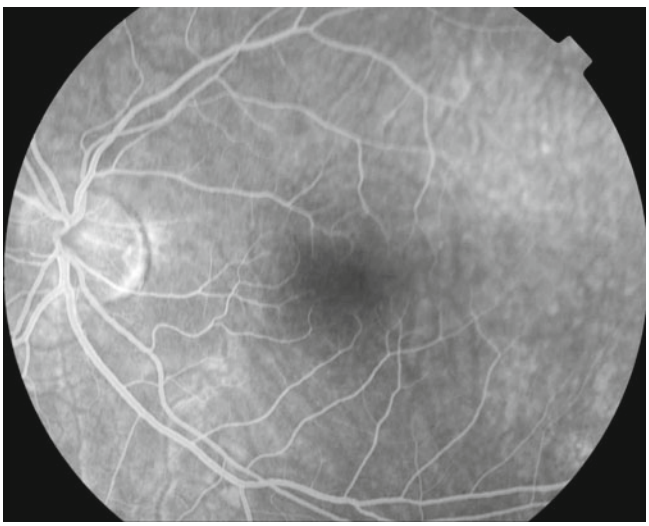


Fig. 6.113 See Fig. 6.110

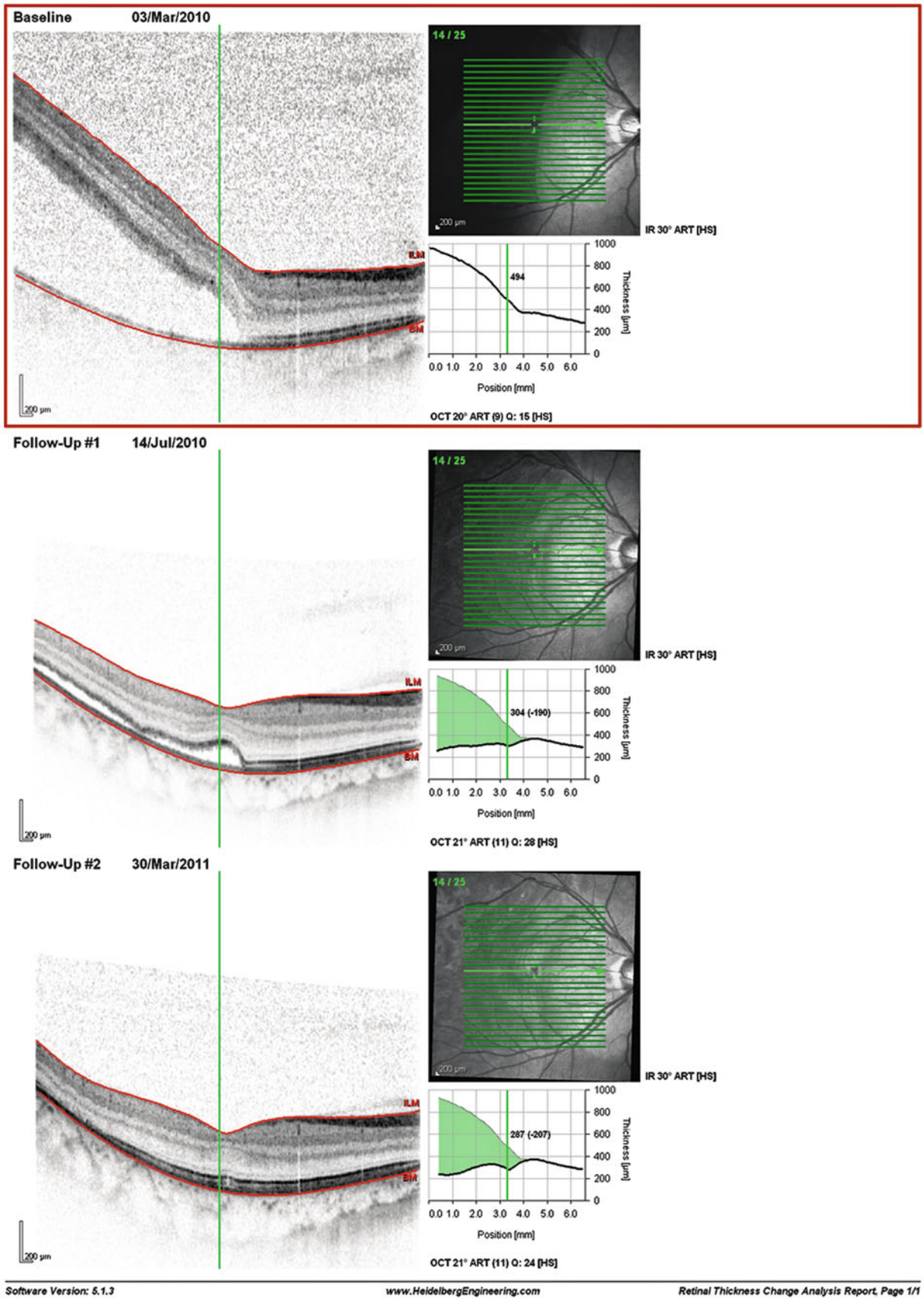


Fig. 6.114 A sequence of OCTs showing the preoperative macula with fovea detached, fovea at 4 months and finally attached at 12 months

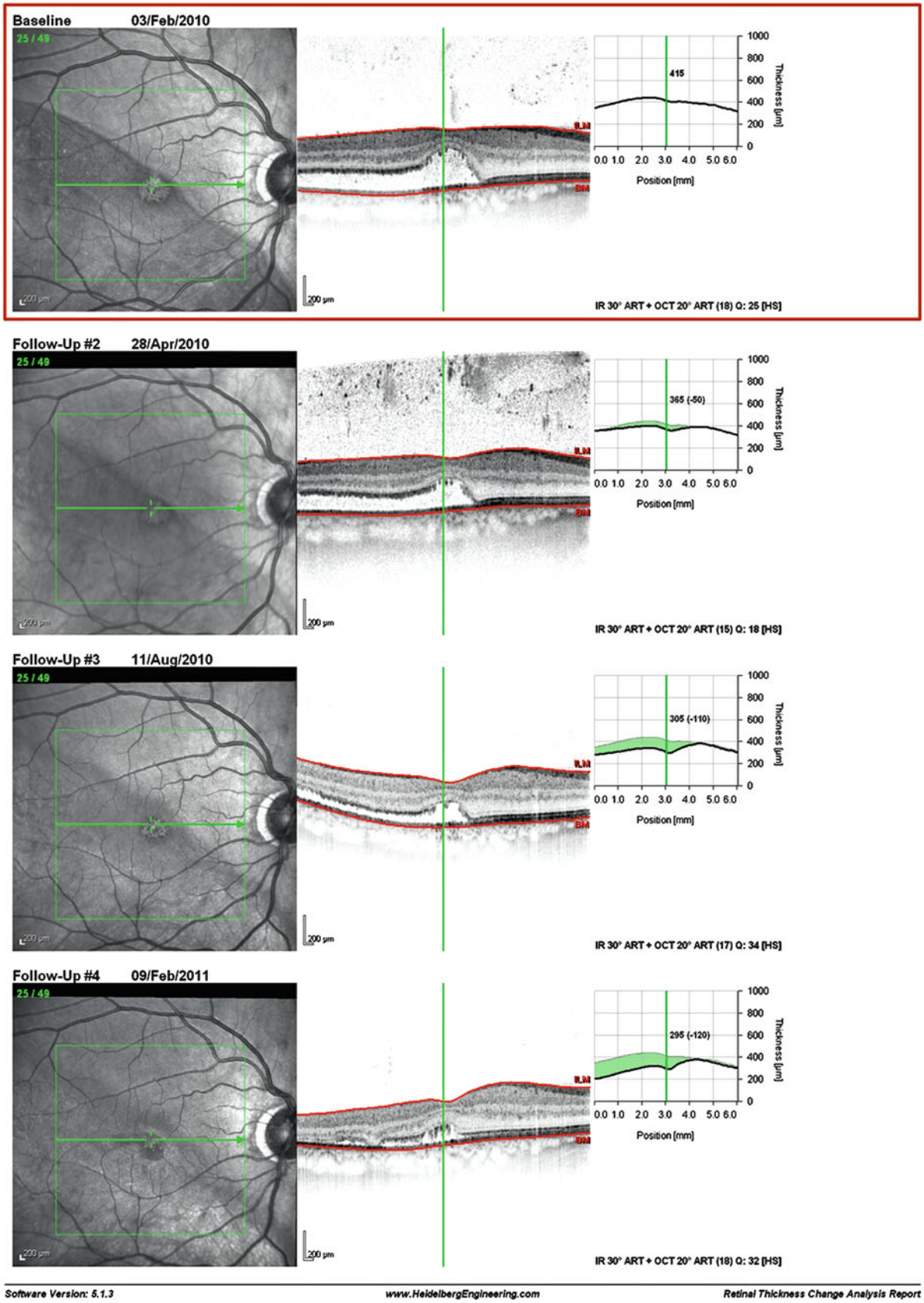


Fig. 6.115 A sequence of OCTs show gradual reduction of persistent SRF under the fovea in patient with atrophic round hole retinal detachment treated with non-drain surgery

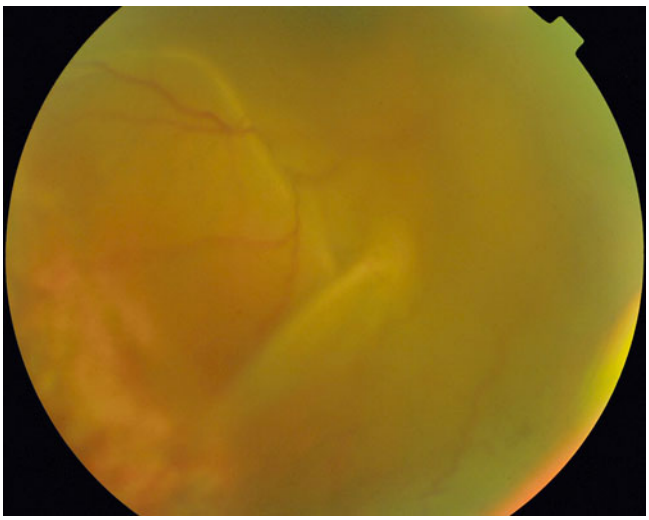


Fig. 6.116 Creating a large indent with an external plombage reduces the internal diameter of the eye wall. This leads to redundancy of the retina; the internal circumference of the eye wall is too small to allow the retina to reattach, and fold in the retina is produced as in this patient in whom a large indent has been applied. The retina will flatten as long as there is no retinal break in the fold

6.3.5 Drainage Air Cryotherapy and Explant (DACE)

The only indication to change to a DACE procedure (drainage, air, cryotherapy and explant) is when the retina is so bullous that it is impossible to apply cryotherapy preoperatively. This can usually be decided preoperatively by the 'indenting the break' test. The DACE procedure has a risk of choroidal, subretinal or vitreous haemorrhage which varies between 3 and 10 % and but can be catastrophic to the vision of the patient (Jaffe et al. 2003). Therefore, it is not favoured

Table 6.4 Difficulty rating of DACE

Difficulty rating	Moderate
Success rates	High
Complication rates	Medium
When to use in training	Middle

in all conventional procedures, and many surgeons including myself proceed to PPV rather than perform DACE. The extra steps are however useful skills to have for unusual situations or for a non-drain procedure which does not look safe without drainage of SRF.

Steps:

1. Open conjunctiva and sling recti muscles.
2. Search for breaks.
3. Mark breaks.
4. Perform external subretinal fluid drainage.
5. Air injection.
6. Cryotherapy.
7. Attach explant.
8. Close conjunctiva.

There are two additional skills required compared with the non-drain procedure, subretinal fluid drainage and air insertion.

6.3.5.1 Subretinal Fluid (SRF) Drainage

Select a quadrant where there is a bullous retinal elevation. Rotate the eye with the muscle slings to expose the sclera in this quadrant. With a fine-gauge needle, puncture the sclera at a point halfway from the insertions of the recti muscles but anterior to the insertion of the vortex veins. Make the puncture perpendicular to the sclera (a bend in the needle tip of 2 mm will prevent inserting the needle too far); any oblique hole will close too easily stopping drainage. Allow the SRF

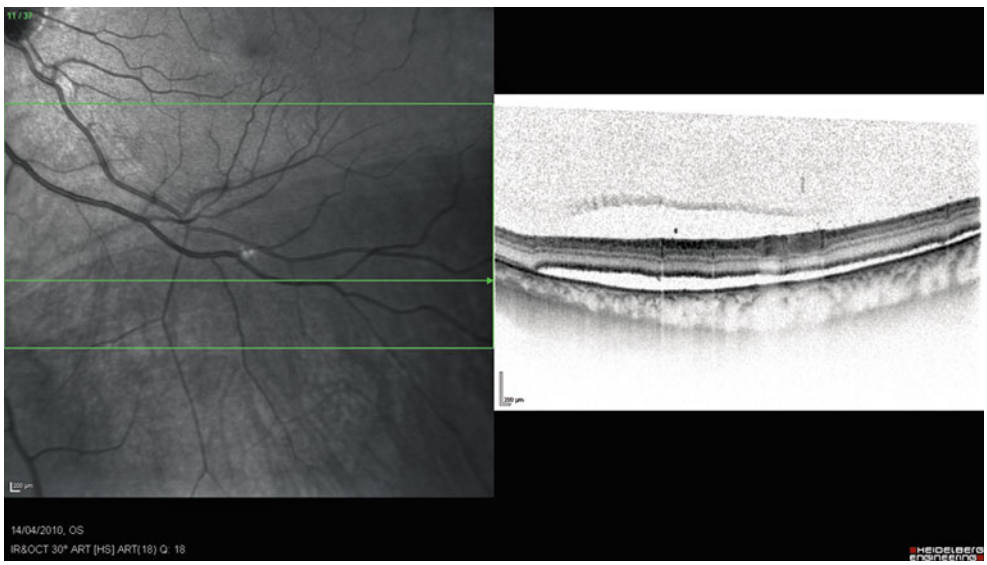


Fig. 6.117 SRF can be trapped peripherally despite reattachment of the retina after non-drain surgery

to drain out whilst maintaining the IOP by indenting the eye in another quadrant. Once adequate SRF has been removed, insert air.

Surgical Pearl of Wisdom

Technique of Drainage of SRF

I prefer to use the Hanscom Transcleral Drainage Cannula® which was designed especially for this purpose. This cannula has an external plastic sleeve which prevents the needle from penetrating too deeply into the globe. The opening of the needle faces the RPE, thus avoiding retinal incarceration. The cannula is placed on a 3-ml syringe, with the plunger out. I use the indirect ophthalmoscope to locate a drainage site, and then perforate the sclera as anteriorly as possible and away from the vortex veins, where there is less vascularity of the choroid. After the tip of the cannula is passed through the sclera, the indirect ophthalmoscope is used to observe the egress of subretinal fluid from the eye. This is the PEARL, which is a very important step. During the drainage process, my surgical assistant gently holds a cotton-tipped applicator against the globe. The constant pressure on the globe accelerates the speed of the drainage process, and it prevents choroidal formation from hypotony. Infrequently, a subretinal haemorrhage can be detected at the drainage site. When this occurs, it is typically seen at the end of the manoeuvre. The tip of the cannula is withdrawn from the eye, but the pressure is maintained with the cotton-tipped applicator for 5 min. This will eliminate further bleeding, and the buckling procedure can be completed.

When draining subretinal fluid from a chronic retinal detachment, the plunger should remain in the syringe. In this case, the fluid is too thick to spontaneously flow through the cannula. Whilst viewing the tip of the cannula in the subretinal space, the assistant can slowly retract the plunger until the retina has reattached. Interesting, as the retina slowly reattaches, it will fall onto the tip of the needle, but due to the elasticity of the retina, it will not create a break. This technique can also be used to flatten a retinoschisis cavity.

Andrew W Eller MD, The Eye & Ear Institute, University of Pittsburgh School of Medicine, Pittsburgh, USA

6.3.5.2 Air Insertion

Use a fine-gauge needle attached to the air insertion pump of the vitrectomy machine with the pressure set at 70 mmHg. Insert through the pars plana (3.5–4 mm from the limbus); rotate the eye to make this insertion at the highest point of the globe. Check that the needle is in the vitreous cavity and perpendicular to the sclera. Take the pressure off the indenting hand (do this quickly but smoothly). Insert the gas at the highest point and quickly. Both actions help to achieve a single bubble in the eye allowing a good view for the cryotherapy and the placement of the explant. The air is only inserted to reinflate the eye; any effect on the tamponade of the break is secondary (fluid is not used to reinflate because fluid will pass through the break causing re-accumulation of SRF).

Cryotherapy can now be applied to the flattened retina. A solid silicone explant is used because there is a gas-filled eye (and therefore a compressible vitreous cavity). The solid

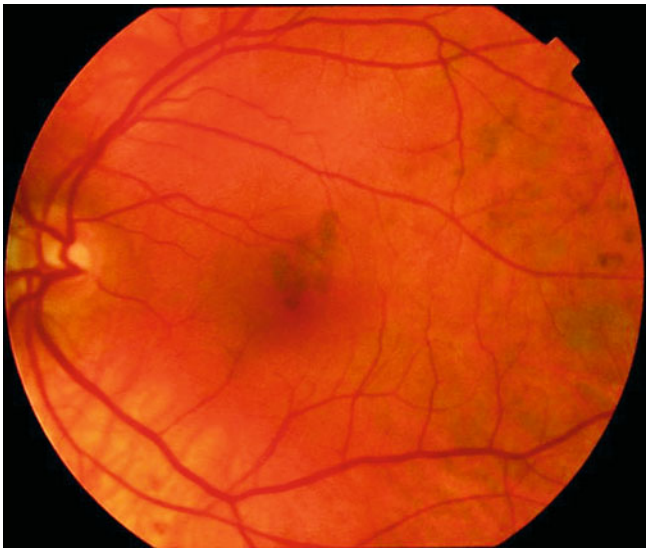


Fig. 6.118 RP cells have been dispersed by heavy use of cryotherapy in this non-drain retinal detachment. These have settled under the fovea and restricted visual recover: there is masking defect on fluorescein angiography (see Fig. 6.119)

Fig. 6.119 See previous figure

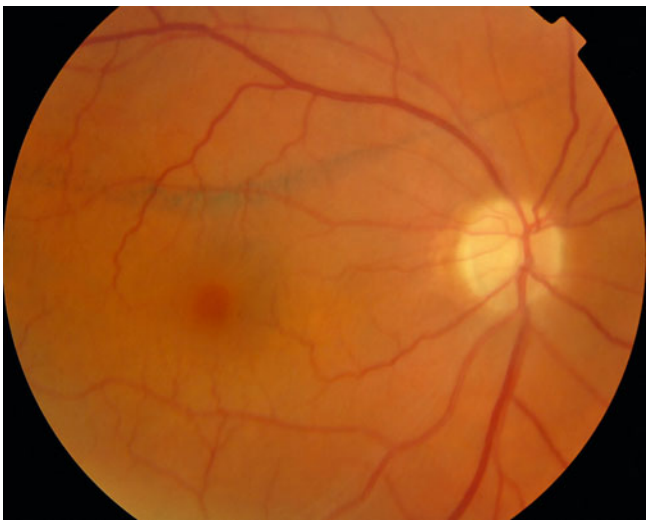


Fig. 6.120 In this postoperative image, pigment can be seen which has settled at the leading edge of the flattened retinal detachment

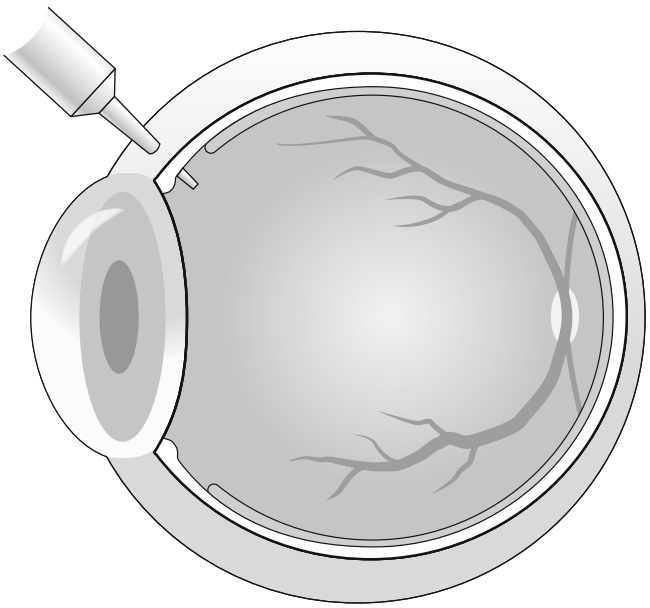


Fig. 6.121 When injecting air in the DACE procedure, inject into the pars plana

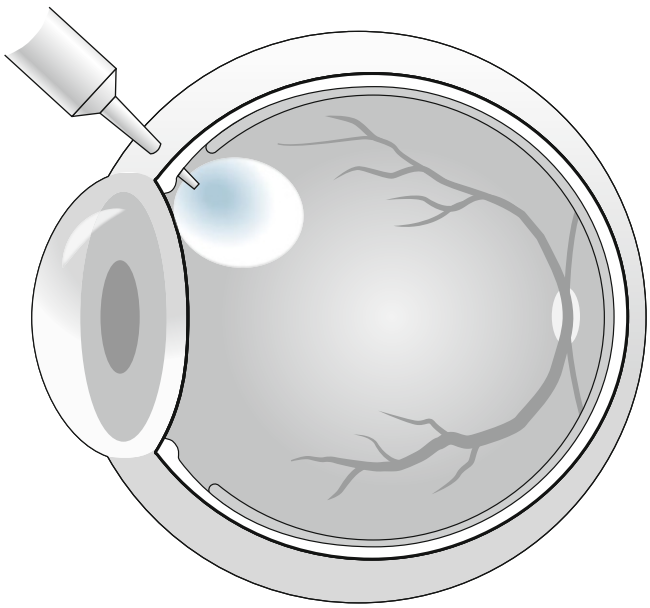


Fig. 6.122 Inject at the highest point

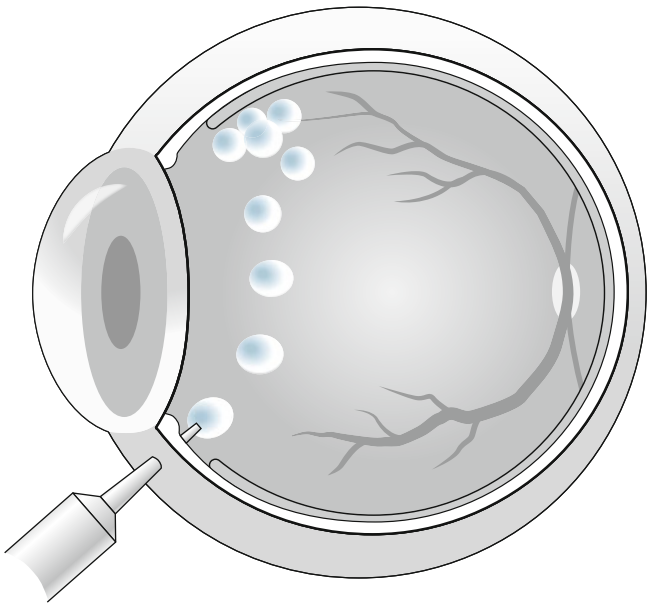


Fig. 6.123 Injecting inferiorly allows separation of the air into separate bubbles

explant produces less pressure on the sclera and avoids too high indent.

6.3.5.3 Complications

Drainage

Retinal Incarceration. This is rare if the drainage incision is small, for example, from a fine needle tip; include the incarceration site on the indent if there is a large incarceration if you can.

Choroidal or Subretinal Haemorrhage. Raise the IOP with pressure from your instruments on the globe until the bleeding stops. Consider converting to PPV to remove any submacular blood. This is an advanced step and should only be performed if you are confident of your skills at inserting a flute needle through a retinal break and towards the subretinal space. Beware if you perform a PPV in eyes with vitreous attached; you will need to detach the vitreous and run a risk of producing retinal tears. Performing a PPV in a patient with dialysis bring you very close to the back of the lens in order to access the break-risking damage to the lens. It is however possible to access the macular subretinal space from a peripheral dialysis using a flute needle.

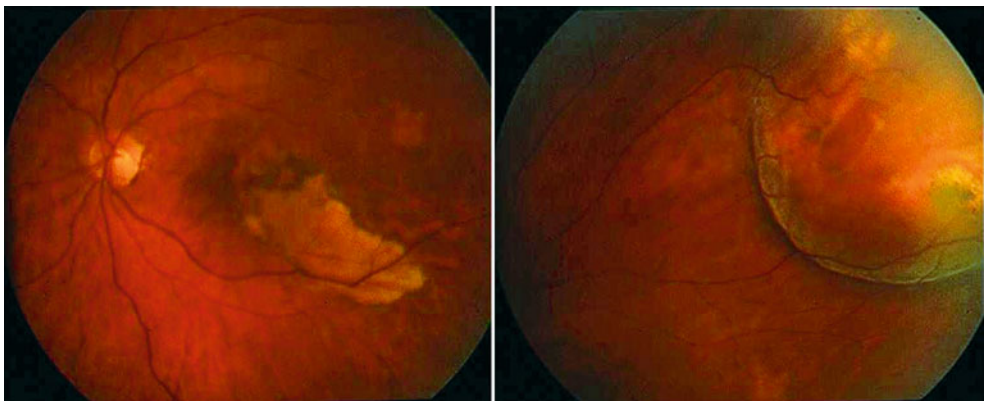


Fig. 6.124 A large buckle placed peripherally has been associated with the formation of a subretinal haemorrhage which is tracked down to the macula. This has severely restricted the visual recovery in this patient

Fluid vitreous loss: Close the sclerotomy and inject air into the vitreous cavity.

Retinal tear: Include on the indent.

Hypotony: Inject air into the vitreous cavity.

Air injection

Injury to lens: Leave for later cataract extraction.

Air in the wrong place:

- Anterior chamber – Remove if the procedure is not completed, otherwise leave to dissipate postoperatively.
- Anterior to the vitreous producing a doughnut air injection – Leave in place.
- Subretinal or suprachoroidal air – Very rare, you may need to convert to a PPV to remove.

Fish egging of the air (multiple separate bubbles of gas): Proceed with surgery but with reduce visualisation.

Raised intraocular pressur: Perform anterior chamber paracentesis to remove some aqueous.

6.3.6 Pneumatic Retinopexy

Successful reattachment of the retina can be achieved by injection of gas and retinopexy without PPV (Hilton and Grizzard 1986) especially with single superior breaks in the presence of a posterior vitreous detachment. However, the success rates are lower than other methods approximately 65 % reattachment with one procedure (McAllister et al. 1988; Han et al. 1998), and there is the risk of inducing new inferior retinal breaks (Poliner et al. 1987). Even in the best hands and with selection of easy cases (1–2 breaks), the success rate is 80 % (Mudvari et al. 2009) probably 10 % less than the expected success rate from PPV on the same cases. For these reasons, I only use this in special circumstances such as a patient who is unfit to attend more extensive surgery. As an office procedure, the method can show improved visual recovery over scleral buckling especially if strict criteria are applied to treat superior RRD with small retinal breaks and no PVR (Tornambe and Hilton 1989; Tornambe et al. 1991).

Table 6.5 Difficulty rating of pneumatic retinopexy

Difficulty rating	Low
Success rates	Moderate
Complication rates	Low
When to use in training	Early

6.3.6.1 Surgical Steps

- Apply cryotherapy via scleral indentation with the cryotherapy probe to the break.
- Inject 100 % SF_6 0.5 ml via the pars plana with a 30-G needle.
- Remove some aqueous via a paracentesis to equalise the IOP.

Apply head posturing by the patient in the first few days so that the gas bubble contacts the break or breaks, and monitor the patient daily to ensure retinal reattachment and no IOP rises. Be careful that SRF is not pushed into the fovea in a macula on RRD. If this is a risk, start the patient off with face-down posture gradually rotating to upright over a few hours to push SRF through the break before it is closed by the gas.

6.3.6.2 Complications

- New retinal break formation in the inferior retina causing redetachment.
- Missed or new retinal breaks are the commonest cause (75 %) of redetachment.
- IOP rises.

6.4 Success Rates

Primary (flat retina after one operation) and secondary (flat retina after multiple operations) success rates depend in particular on the case mix of patients, rates of PVR at presentation and speed of access to surgery.

Primary Eighty one to ninty two percent in uncomplicated cases (Ah-Fat et al. 1999; Campo et al. 1999; Girard and

Karpouzas 1995; La Heij et al. 2000; Oshima et al. 1999; Thompson et al. 2002; Minihan et al. 2001)

Sixty five to seventy percent in high-risk eyes or 75 % when no break is found (Hakin et al. 1993; Heimann et al. 1996; Campo et al. 1999; Schmidt et al. 2003; Tewari et al. 2003; Wong et al. 1987)

Secondary or final success rates should be approximately 95–97 % (Doyle et al. 2007), but this drops in PVR and when no break is found (Salicone et al. 2006). You should be able to produce a visual outcome of 20/40 in most patients (Campo et al. 1999), 83 % of fovea on patients (Ho et al. 2006); however, visual outcome if the macula is detached is reduced to a 44 % chance of 20/40 or better. Patients may describe metamorphopsia (change in image shape), micropsia is common, after macula-off retinal detachment, and this may be accompanied by a reduction in stereo acuity (Ugarte and Williamson 2006).

So far, no difference in success rates has been found between buckling procedures and PPV (Miki et al. 2001; Oshima et al. 2000; Ahmadieh et al. 2005).

In a recent analysis of Medicare insurance forms looking at individual patients rather than eyes, pneumatic retinopexy was twice as likely to be followed by further surgery (40 %) than PPV or scleral buckling (20 %) despite PPV being used for more complex cases but with PPV having twice the adverse complication rate (2 %) (Day et al. 2010).

6.5 Causes of Failure

Surgical capability will affect the success rate of such technical operations. Missing and therefore failing to treat breaks or new breaks will lead to redetachment in half of failures. PVR is less predictable and controllable causing failure in the remainder (Richardson et al. 2000). In addition, severe complications of surgery must be added such as endophthalmitis and choroidal haemorrhage. Persistent thin areas of subretinal fluid have been described on OCT, occasionally affecting the macula and thereby reducing visual acuity in buckling procedures (Baba et al. 2004; Wolfensberger and Gonvers 2002). Late macular breaks have been described in rare cases after scleral buckle (Moshfeghi et al. 2003). Late redetachments over 1 year can occur in approximately 2 % (Foster and Meyers 2002). The cause is usually from new break formation although old breaks can reopen.

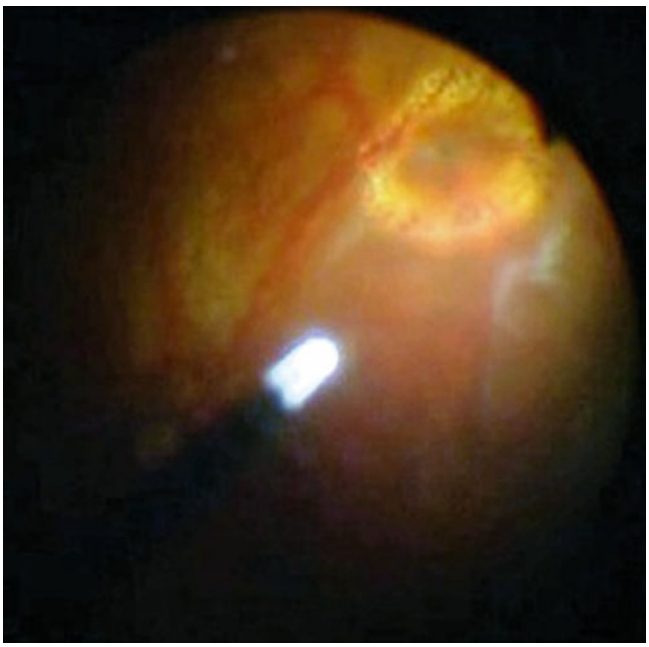


Fig. 6.126 If you see a redetachment through a treated break like this, the commonest cause is another untreated break that was missed during the operation, allowing the SRF to return and elevate the lasered break

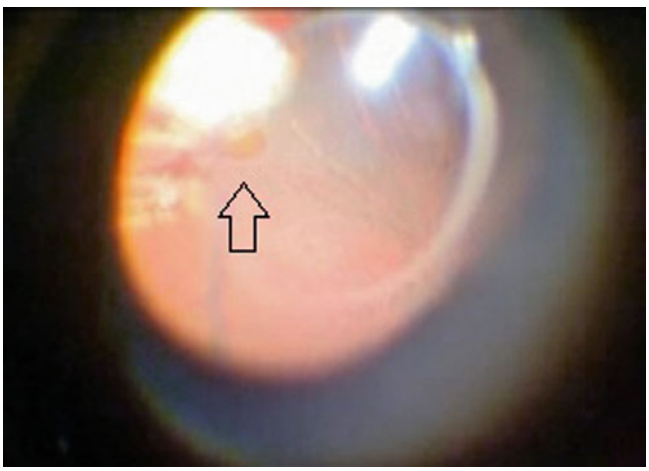


Fig. 6.125 A retina has redetached from a break (*arrow*) on the edge of cryotherapy scar; this is a very rare occurrence

6.6 Surgery for Redetachment

Despite the surgeons greatest efforts, redetachment of the retina occurs at rates of 10–15 %. The rate of redetachment is closely linked to the PVR rate at presentation with higher rates with more PVR.

Causes of redetachment are:

- PVR – the surgery stimulates the PVR to progress overcoming the effects of internal tamponade and reopening retinal breaks causing RRD.
  - Be aware of the presence of PVR at presentation; use longer acting gases or silicone oil; restrict the use of cryotherapy.
- Missed retinal breaks – Tiny retinal breaks may be missed during the first surgery; usually, these are easier to see at the second operation because slight contraction of the

remaining vitreous base causes the breaks to open up slightly.
- New retinal breaks – Occasionally, larger breaks appear that are unlikely to be missed from the first operation; these may be produced from problems at the sclerotomies (entry site breaks) or secondary to PVR.
- PVR and missed/new breaks – Often the two accompany each other, and it is not possible to say with certainty which is the cause of the redetachment. However, if a break is found which was not treated at the first operation by retinopexy, it was probably missed or created at the first surgery and is therefore the cause of the redetachment; the PVR is secondary. This emphasises the importance of seeing and treating all pathology at the first operation and therefore the need for a technically competent surgeon.

Again choose the operation appropriate to the pathology, that is, non-drain surgery for vitreous-attached RRD, or PPV for vitreous-detached RRD.

6.6.1 Redo Vitreous-Attached RRD Surgery

In vitreous-attached surgery, the RRD will often go concave in shape with resolution of most of the SRF but not all. Often the retina is too stiff to enter into the space immediately behind the indentation especially with high indents from the use of sponges. There may be small areas of peripheral concave-loculated SRF, unfortunately often also at the macula. These will settle but can take up to 1 year to do so; they do not require reoperation.

If the RRD is unchanged from preoperatively or there is convex SRF, there is likely to be a break which is still open or pre-existing PVR which is preventing flattening of a break on the indent. In the former, find the break and treat with redo non-drain procedure; in the latter, proceed to PPV and PVR surgery. Usually, subretinal PVR bands (which are common with vitreous-attached RRD) will only tent up the retina, but the RPE pump will allow the rest of the retina to settle; again, the residual RRD will be concave.

Redo non-drain: Either a round hole has been missed or a dialysis not covered properly. Reopen the conjunctiva; remove the existing explant; the thick fibrous capsule should be excised, otherwise it will prevent indention and restrict adequate searching in that area and make sewing on the new explant will be more difficult. Produce an indent under any open detached breaks.

Note: The eye will be softer after removal of the indent.

6.6.2 Redo Vitreous-Detached RRD

Again the reason for the recurrent RRD is open breaks which have been missed or are new. If there is no PVR, the eye requires PPV, find and treat the breaks and insert gas. Often a missed break is easier to see in the second operation because slight contraction of the vitreous base opens up the breaks by curling the flap anteriorly. If you have detected the recurrent RRD early in the postoperative period, the SRF should be localised near the break. If you are still unable to find the break scatter, laser can be applied to the localised area of RRD at the location of the posterior border of the vitreous base, making sure that you laser to the ora serrata at the ends of your treatment area to stop SRF spreading anteriorly past the laser. Do not delay the repeat surgery as PVR is a risk if the retina is not flattened soon. If PVR is the cause of the redetachment, proceed to PVR surgery. Usually, postoperative PVR is associated with risk factors such as preoperative PVR, intraocular haemorrhage, multiple breaks, large breaks, complicated surgery and excessive retinopexy.

6.7 Secondary Macular Holes

Macular holes can be found associated with RRD preoperatively and can spontaneously close after surgery without any additional procedures (Riordan-Eva and Chignell 1992). Holes that develop after surgery can occur in 1 % of patients usually after scleral buckle of macular off RRD (Moshfeghi et al. 2003). Those that do not close spontaneously can be treated by PPV and gas as for idiopathic macular holes. Posterior breaks have been described in the postoperative period around the arcades after PPV which can be treated by laser retinopexy although it is possible that no treatment is required (Okada et al. 1997).

6.8 Detachment with Choroidal Effusions

If the retina detaches into the pars ciliaris, hypotony occurs and choroidal effusions may form. These can be drained early in the PPV through the sclerotomies using positive pressure from the infusion (take care when inserting the infusion that the tip has penetrated in to the vitreous cavity) (Ghoraba 2001; Yang 1997). The fluid is often greenish in colour. Once the suprachoroidal fluid has drained, the RRD can be managed by the usual processes although some advocate the use of silicone oil because these patients probably have an increased risk of PVR (Loo et al. 2001). Others suggest preoperative systemic steroid therapy (Sharma et al. 1998).

Note: Very rarely, a sequence of events is seen whereby:
1. A break causes RRD.
2. RRD causes hypotony.
3. Hypotony causes effusions.
4. Effusions indent onto the retinal break.

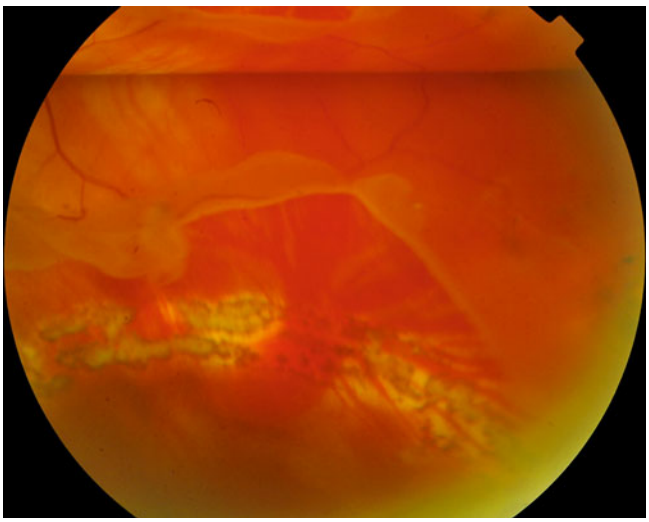


Fig. 6.127 This inferior retinal U tear has lifted through the laser as the gas bubble has absorbed

5. The RRD subsides.
6. Leaving a flat retinal break on an apparently spontaneous choroidal effusion, laser the break and wait for the effusions to settle.

6.9 Removal of Explant

There are occasions when an explant will require removal approximately 1 in 25 explants:

6.9.1 Diplopia

If the explant is placed beneath the extraocular muscles especially the vertical recti (there is a reduced fusion range vertically), diplopia can be induced. Remember that the indent is only required for as long as the retinopexy needs to take effect. Therefore, an explant can be removed at 2 weeks postop. If diplopia occurs, early removal of the plombage will usually resolve the situation. Sometimes diplopia is from unmasked prior phoria, for example, old forth nerve palsy.

6.9.2 Erosion Through Conjunctiva

With time, the end of an explant can erode through the conjunctiva causing pain and discharge in the eye. If the erosion is large enough, the explant should be removed at the slit lamp. The wound will granulate and close spontaneously. The wound cannot be repaired over the explant, and it must be removed before orbital infection occurs.

6.9.3 Infection

An inflamed explant early in the postoperative period should be assumed to be infected and systemic oral antibiotics prescribed. Usually, this will settle the inflammation. Late onset infection is usually associated with erosion through the conjunctiva.

6.9.4 Cosmesis

Plombage is often used in young patients with attached vitreous, and, therefore, the appearance of the eye is important. Patients should be warned that they may feel the explant under the lid and it may be visible on extreme eye movements but that it can be removed to improve the appearance.

6.9.5 Irritation

If the end of the explant is high, an area of drying can occur in the conjunctiva.

6.9.6 Surgery for Removal of the Explant

Inject some local anaesthetic over the end of the explant that is most accessible. Cut down through the conjunctiva and Tenon's onto the end of the explant. The explant is covered very rapidly in the postoperative period by a thick fibrous capsule. Cut down onto the explant through this capsule and

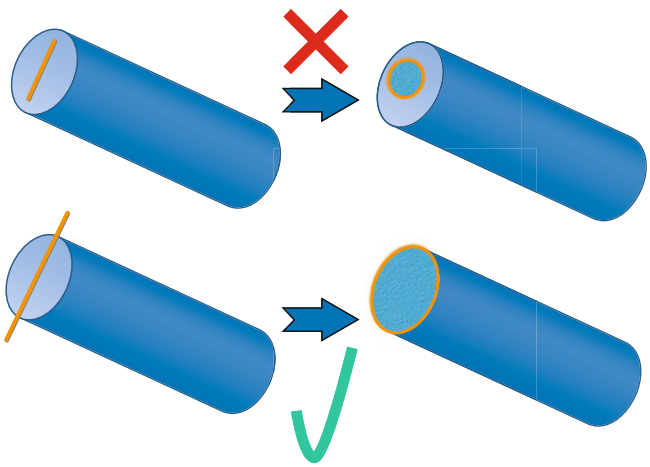


Fig. 6.128 Make sure the incision in the tough capsule at the end of the plomb will be big enough to allow the plomb to come out, approximately 1.5 × the diameter of a cylindrical plomb

make sure the incision is large enough to allow the explant to pull through. The capsule is inelastic; therefore, the hole needs to be large enough to accommodate the circumference of the end of the explant ($1/2 \times 2\pi r$ or approximately $1.5 \times$ the diameter of a cylindrical explant). Once the end of the explant is exposed, the explant will exit very easily. Remove any sutures near the incision; allow the conjunctiva to close without suturing.

6.10 Summary

RRD can be treated by non-drain retinal detachment repair (vitreous-attached RRD) or PPV and gas insertion (vitreous-detached RRD). Using only these two surgical procedures, almost all RRD without proliferative vitreoretinopathy can be dealt with. The skills of SRF drainage and air injection from the DACE procedure and pneumatic retinopexy are useful in case the surgeon has unexpected problems perioperatively which these methods could remedy.

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