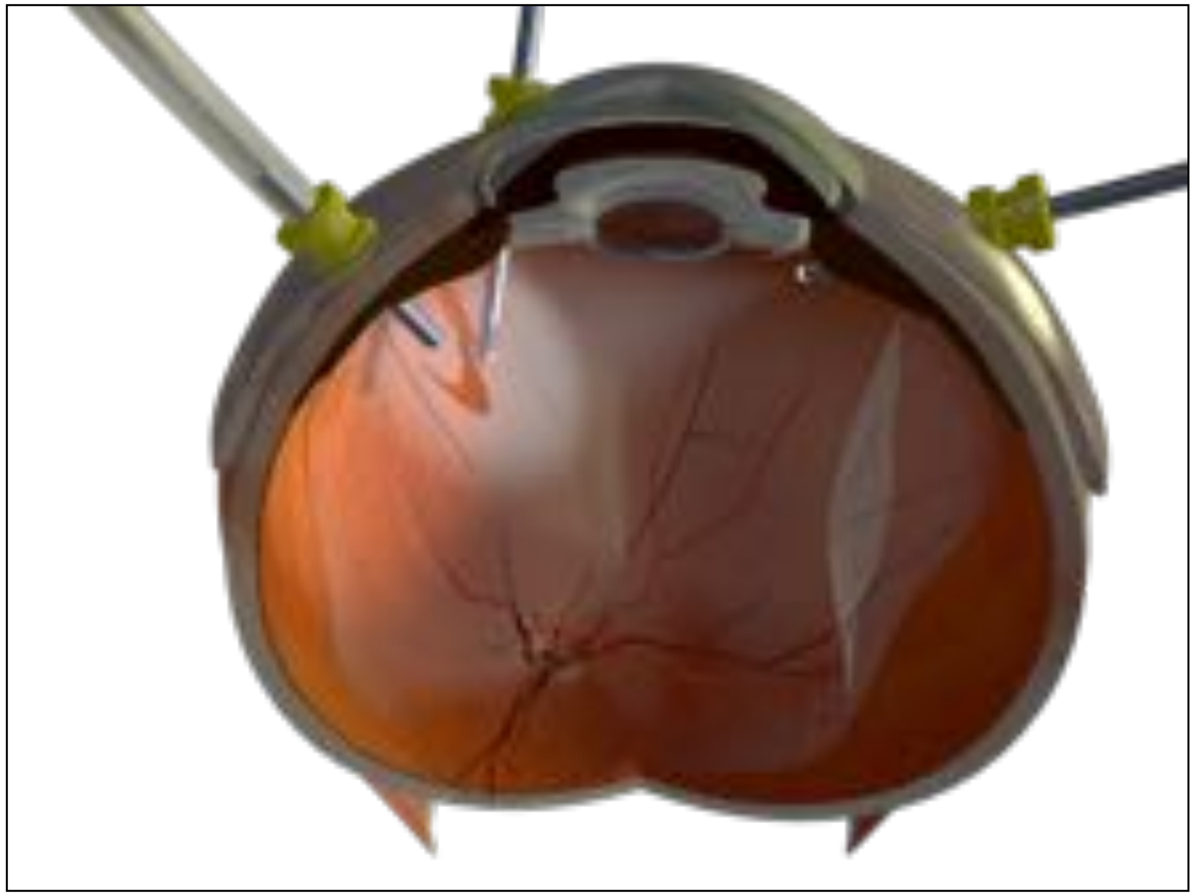
VITREORETINAL SURGERY

AN INTERACTIVE MULTIMEDIA ATLAS FOR OPHTHALMOLOGY TRAINEES



Paul Sullivan

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DEDICATION

This book is dedicated to my parents with thanks for making everything possible for me.

Paul Sullivan

London March 2014

Preface

Technological advances have transformed the management of retinal disease in the past half century. This period has also seen significant advances in the understanding of the various ways in which adults learn. The electronic book format allows various media to be used. Interaction though hyperlinks and widgets of various kinds allows the incorporation of elements of instructional design and retrieval practice in the learning platform.

This book has been designed to be dipped into, following links or using the search function to find areas of interest, rather than read from beginning to end. It is an educational tool for ophthalmology trainees, not a comprehensive well referenced textbook on every aspect of vitreoretinal surgery. There are several omissions from the current edition. There is very little discussion of pneumatic retinopexy. I recognize that many find it useful and have good results with it. It is however a technique I rarely use and I do not feel I am in a position to write about it. Chapters on management of severe ocular trauma, vitrectomy in ocular inflammation and dislocated intraocular lenses will be added in a future edition if this edition is found to be useful.

Like any book by a single author this book is subject to bias. I have tried to reflect the large diversity in practice that exists. While it has been reviewed and checked for errors this process is not infallible. If the reader disagrees with anything written here I would welcome feedback at paul.sullivan@moorfields.nhs.uk.

I would like to thank the special trustees of Moorfields Eye Hospital for their support in writing this book. I would also like to thank my colleagues at Moorfields Eye Hospital for some of the videos and illustrations in this book particularly Mr Bill Aylward.

The Eyelearning web site may be of interest to anyone who finds this book useful.

All versions of this book are completely free. If you find it useful please consider a donation to a charity such as Moorfields Eye Charity or Fight For Sight.

NAVIGATING IN THIS BOOK

There are many hyperlinks in this book. Clicking on these will take the reader to webpages or to other relevant sections within the book. To get back to the page with the original link when using an iPad touch the screen in a blank area to activate the menu bar. There is a small flag on the right hand side of this menu that can be used to return. This bar can also be used to select the table of contents view to quickly scan though chapters. If viewing the book on an apple computer a small icon appears at the bottom left hand corner which allows a return to the original page. Alternatively use 'Go' then 'Back' from the header menu bar.

Many of the images are actually interactive widgets. The function of most is obvious. Some are 3d renders. These have been used sparingly as some people have difficulty using them. To view these the reader should fixate on the images and then let the eyes drift apart. At this stage 3 images will be seen and a conscious effort is made to look at the central image.

Figure Preface.1 Navigating backwards

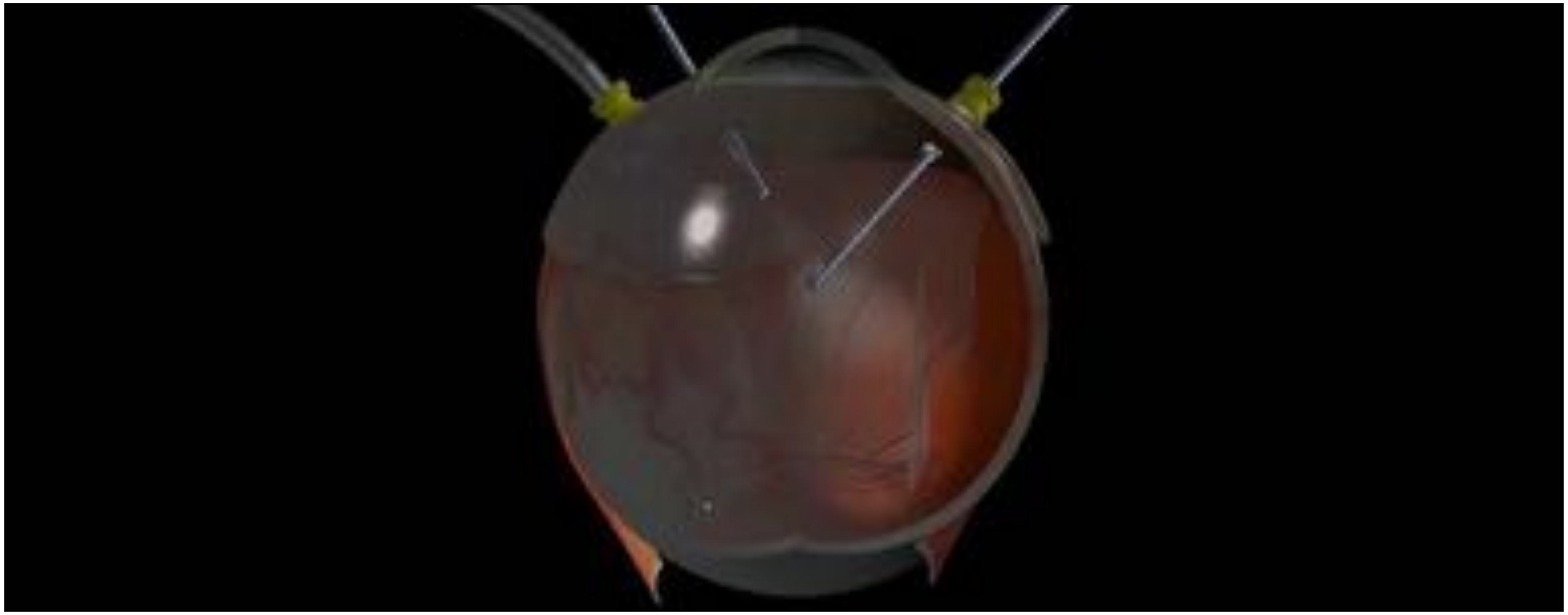
Touching a blank area of the screen activates the menu bar. The small page icon can be clicked.

KNOWLEDGE REVIEWS

Each chapter in this book ends with a knowledge review. These assume some prior knowledge. Sometimes the information required to answer the questions is buried in one of the hyperlinks. These tests are designed to be used in a formative way (to learn, not to test). If the reader does not know the answer to a question they will learn more if they do their own research before coming back to the question rather than guessing the answer.

CHAPTER 1

Surgical Anatomy



The importance of a good understanding of anatomy and physiology has been axiomatic to the practice of surgery since Vesalius. This book assumes a basic knowledge of ophthalmic anatomy. This chapter is a review of those aspects of the anatomy of the eye of particular relevance to vitreoretinal surgery.

Topography of the Eye

Figure 1.1 Zones and meridia

The terms meridian and zone, derived from geography, are used to describe orientation on the wall of the globe. The terms radial and circumferential are sometimes used in place of the corresponding adjectives (meridional and zonal).

Surface anatomy

The position of the ora serrata corresponds to the spiral of Tillaux connecting the rectus muscle insertions. This is relevant in the creation of **sclerotomies** and in the placement of scleral buckles.

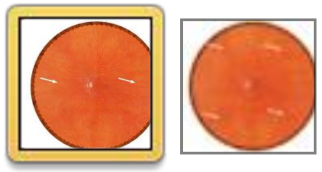
Figure 1.2 The surface anatomy of the ora serrata

The sclera has been rendered partially transparent to show the relative positions of the ora serrata and muscles.

Fundal landmarks

Figure 1.3 Retinal landmarks useful during surgery

The long ciliary nerves, visible at 3 and 9 o'clock, indicate the horizontal meridian of the globe.



Vitreous volume

The volume of the vitreous body is an approximate function of the cube of the axial length*. It is approximately 5.5 ml in the normal (emmetropic) eye. In highly myopic eyes the volume is higher. It may even exceed the 10 ml volume of most pre-filled silicone oil syringes. The percentage gas fill that is achieved by injection of a fixed volume of pure gas into an air filled eye also reduces with increasing axial length. Exchange of an expansile gas for air is therefore most predictable when a pre-diluted mixture is used.

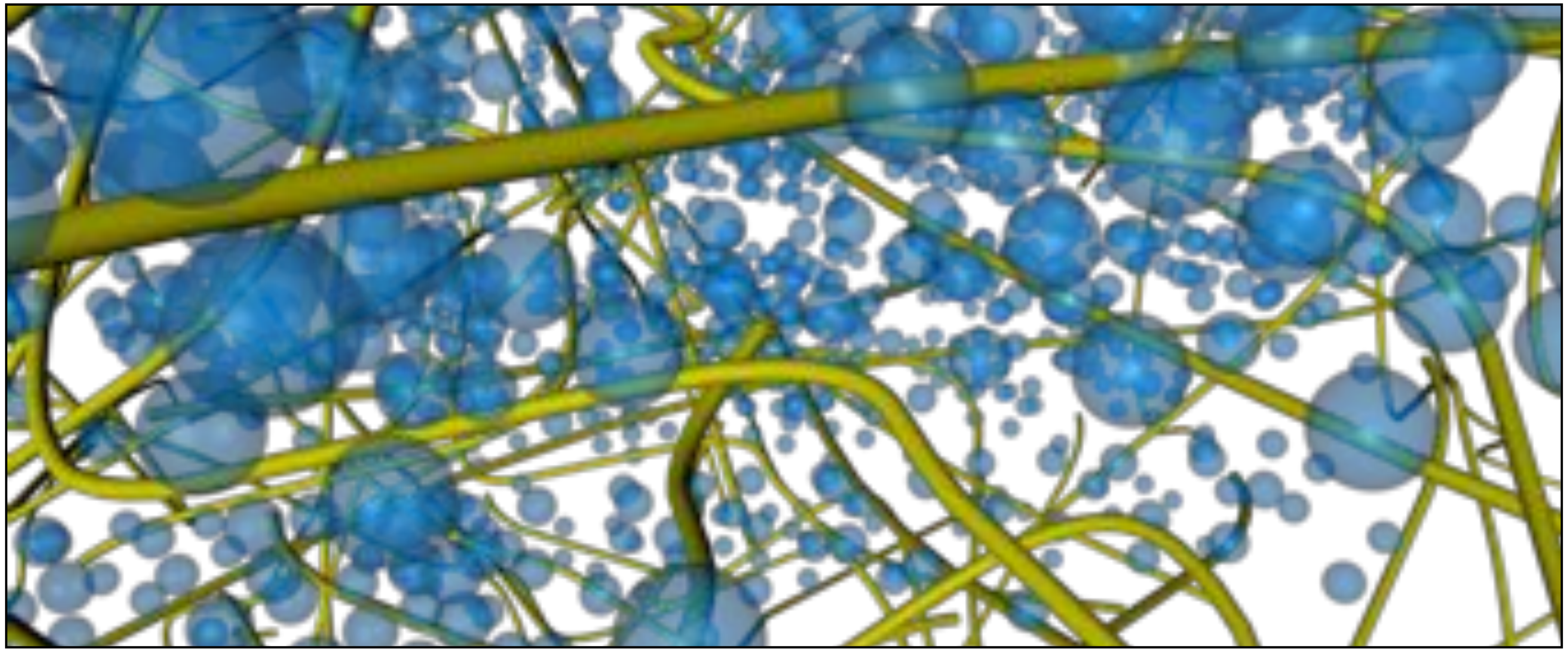
Figure 1.4 The vitreous cavity

With increasing axial length the volume of the vitreous cavity increases and it adopts a more prolate profile.

* This is not a constant relationship. Increasing degrees of myopia result in a less spherical and more prolate shape of the vitreous cavity.

Vitreous composition

Figure 1.5 Vitreous Structure



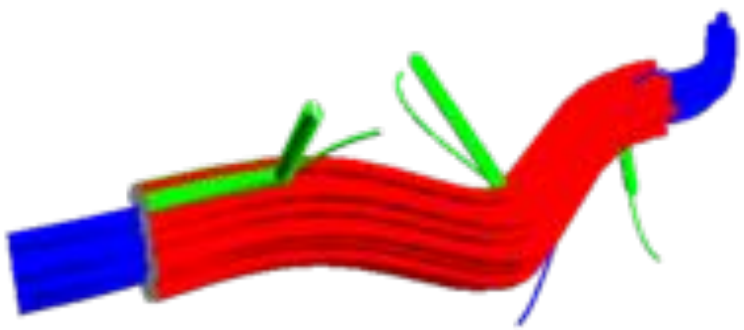
Schematic representation of collagen and hyaluronic acid molecules in vitreous. The gel state is maintained by the interaction between these molecules. Most of the vitreous is composed of water.

The vitreous is a hydrogel composed mostly of water (98%) but owes its structural properties to the collagen and **hyaluronic acid**. These maintain its **gel** state (i.e possessing some properties of a liquid with the structural coherence of a solid, like a jelly on a plate).

Hyaluronic acid has hydrophilic properties: it therefore acts as a spacer between the collagen fibrils. These fibrils are composed of several types of collagen. These include predominantly Types II but also Types IX and IV/XI collagen.

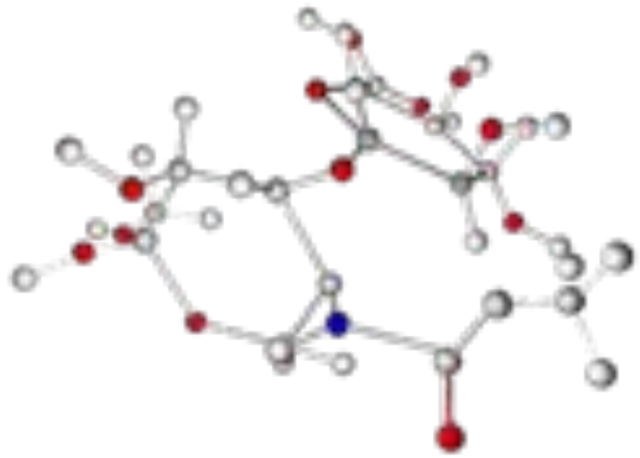
It is a mistake to imagine vitreous as a sort of minestrone filled with randomly orientated strands of vitreous. The collagen fibers interact with other molecules around them in quite sophisticated ways. For example features on their surface such as the chondroitin sulphate glycosaminoglycan chains of type IX collagen may interact with other collagen fibrils to maintain spacing and stability of the gel. This is probably key to the remarkable stability of the vitreous in a gel state. Most gels under laboratory conditions degenerate (i.e. separate into liquid and solid elements) in a year or 2. Changes in the chemical composition of vitreous may cause the vitreous to degenerate. For example decreased hyaluronic acid concentration after cataract surgery has been implicated in the pathogenesis of pseudophakic retinal detachment. Mutations of genes encoding collagen (e.g. **Stickler Syndrome**) may lead to quite specific forms of vitreous degeneration. A better understanding of the biochemical properties responsible for the stability of the vitreous may lead to therapeutic vitreolysis.

Interactive 1.1 A Vitreous Collagen Fibril



Note the laterally spreading chains which may be responsible for interactions with other collagen fibrils. Red = Type II Collagen. Green = Type IX Collagen. Blue = Type IV/XI Collagen. After Bishop, Progr Retina Eye Res 2000.

Interactive 1.2 Hyaluronic acid



Hyaluronic acid's molecular structure is such that it is extremely hydrophilic

The vitreous **core** has widely dispersed collagen fibers with a loose anteroposterior orientation and weak inter-fibrillar connections. The collagen fibers in the **vitreous base** are densely packed and more tightly bound to each than those of the core. They insert directly into the cytoskeleton of the superficial retinal cells. Consequently the vitreous in this area cannot be detached from the retina. The retina will tear before the vitreous base detaches from it - this is the cause of traumatic bucket handle retinal breaks.

Interactive 1.3 Traumatic bucket handle tear

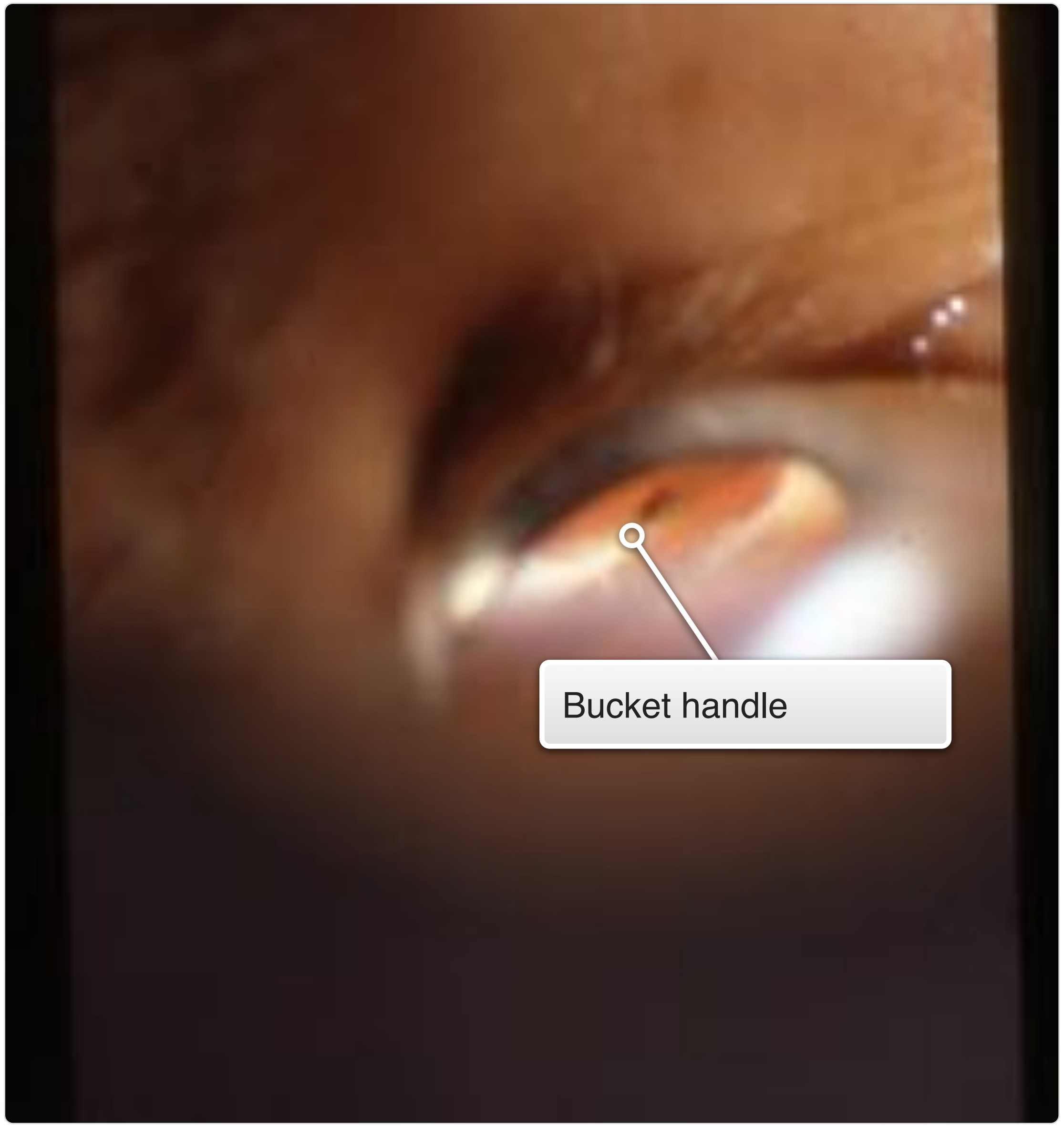
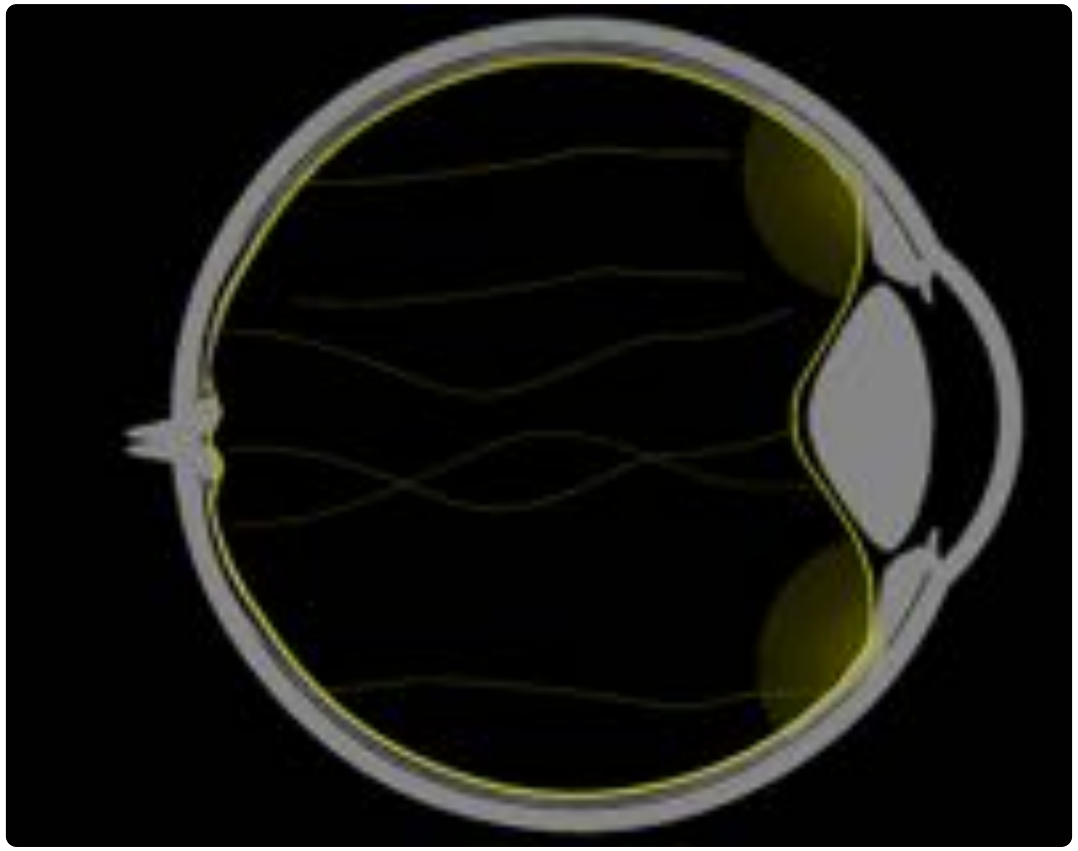
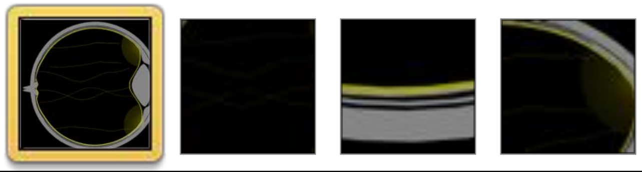


Figure 1.6 Local variation in the arrangement of vitreous collagen fibrils



The density and orientation of vitreous fibers is non homogenous.



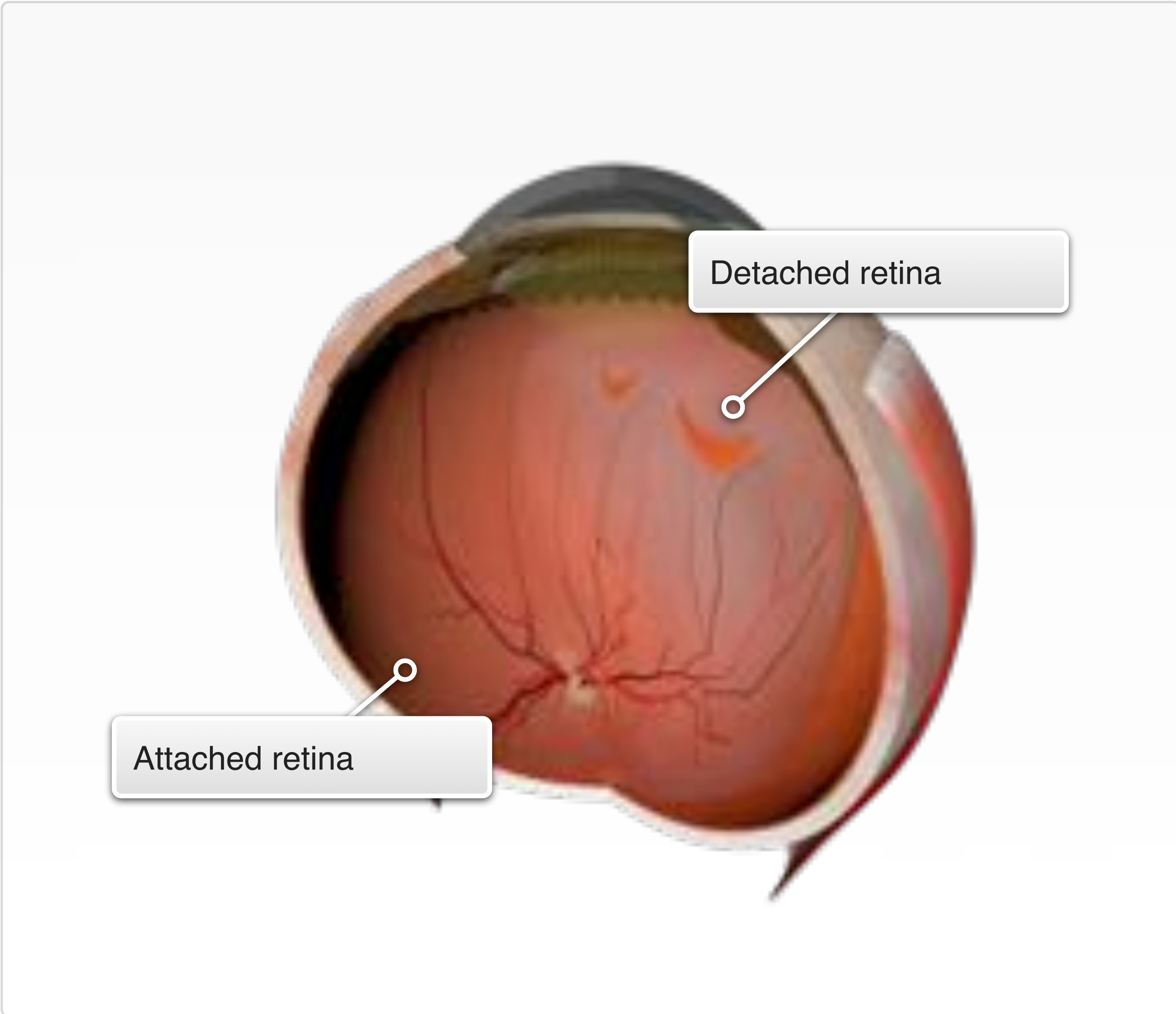
The cortical vitreous behind the vitreous base is composed of tightly packed collagen fibers. These are organized in lamellae running parallel to the retinal surface. The posterior hyaloid membrane is the outermost layer of the vitreous body. It is inelastic and can transmit forces which may deform or tear the retina. The posterior hyaloid is adherent to the inner retina. The glycoproteins laminin and fibronectin may play a role in maintaining this adhesion. Proteases such as plasmin and ocriplasmin hydrolyze these glycoproteins causing therapeutically useful vitreous detachment. As a result of the lamellar structure of the cortical vitreous it may split into separate sheets - vitreoschisis. The strength of vitreoretinal adhesion is variable. Adhesions are particularly strong at:

1. The vitreous base - causing the development of tears along the posterior border of the vitreous base.
2. The macula - this is important in the development of interface maculopathies such as macular hole and vitreomacular traction.
3. Retinal vessels. This may cause vitreous hemorrhage following posterior vitreous detachment without a retinal tear.
4. Peripheral retinal degenerations such as lattice degeneration.

Retinal transparency

The retina, apart from the vessels and luteal pigment, is transparent. Consequently the pattern of the choroidal vessels may be seen through the translucent pigment epithelium. When the retina loses its transparency these features are obscured. For example when the retina detaches its outer surface scatters light. Although the diffuse underlying orange/brown color of the pigment epithelium is still visible the choroidal markings are not seen. This is a useful indicator of the presence of shallow subretinal fluid.

Interactive 1.4 Effect of detachment on retinal transparency



In chronic retinal detachments the retina atrophies and there may be some increase in transparency.

Loss of retinal transparency is also the basis of the immediate reaction seen during laser retinopexy.

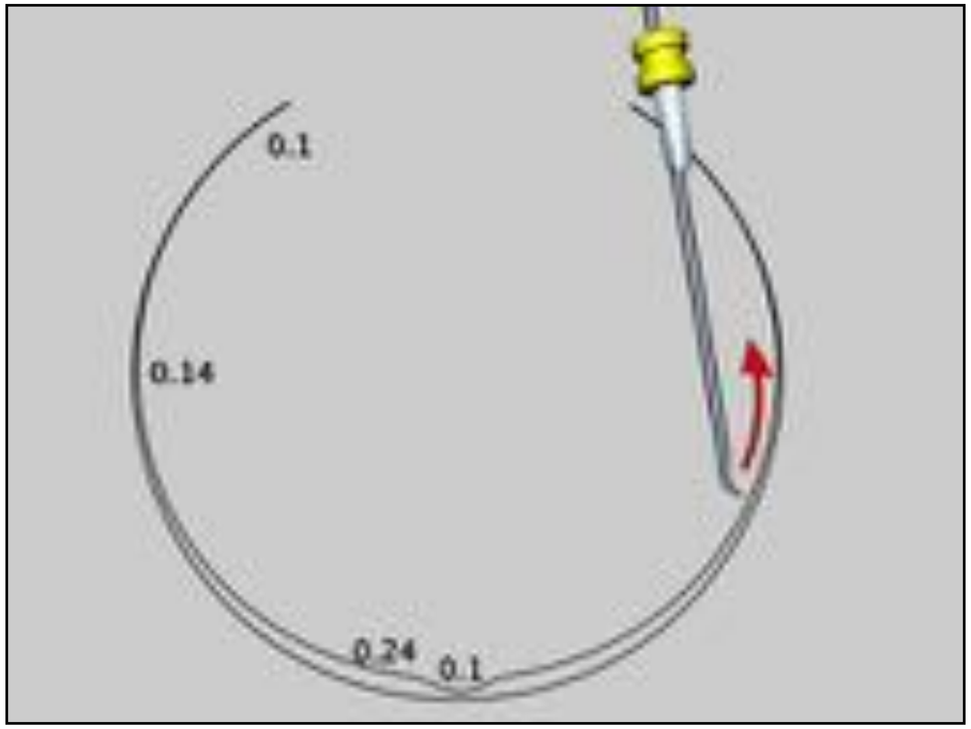
There is a small amount of optical scattering from each layer of the retina. Optical coherence tomography uses this to image the retinal layers.

Figure 1.7 Chronic retinal detachments

In very chronic retinal detachments the retina may become more transparent as it atrophies.

Retinal thickness

Figure 1.8 Retinal thickness and implications for peeling epiretinal membranes



The retina is thickest and strongest centrally. Epiretinal membranes should therefore be peeled centrifugally (away from the macula) whenever possible to avoid causing peripheral retinal breaks.

Physical properties - Retinal specularity

Specular reflection of light from the fovea during biomicroscopic assessment can be used to detect subtle changes in the inner retinal contour.

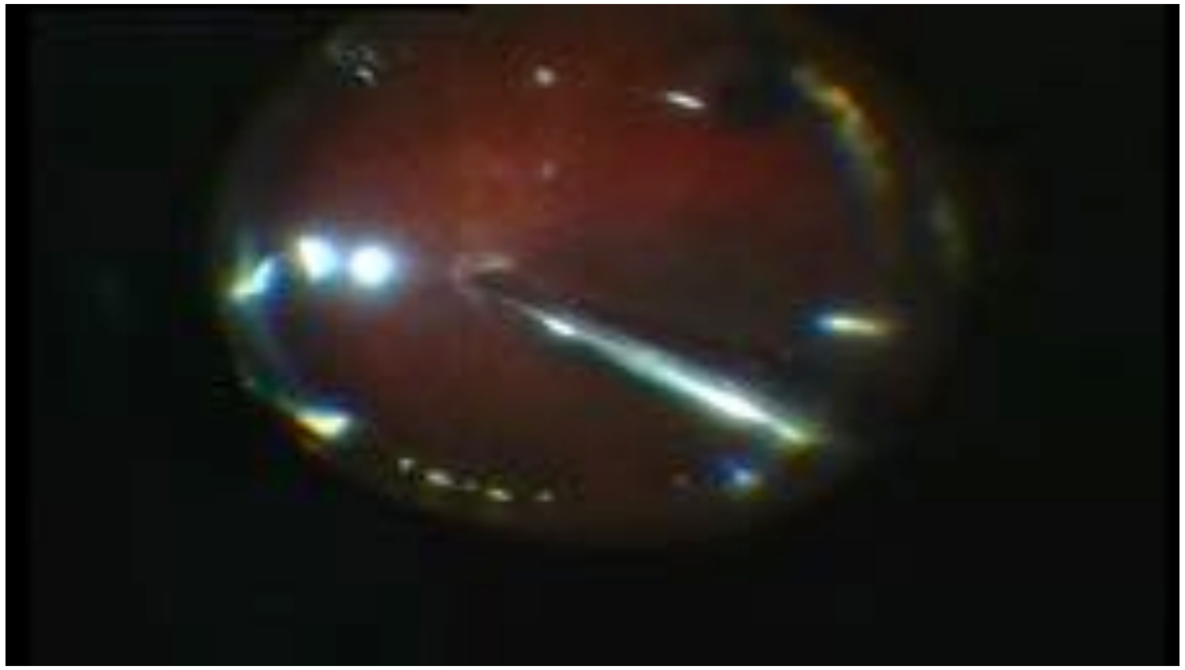
Changes in the **specular** reflex when the surface of the retina is touched, creating an indentation, are also useful while peeling epimacular membranes.

Figure 1.9 Specular reflections

The specular reflections in a normal eye.

Retinal specular reflections are enhanced when the eye is full of gas. This is useful in determining when a complete fluid gas exchange has been achieved as pronounced specular reflections are seen from the edges of the disc and the surrounding vessels.

Movie 1.1 Specular reflections during air fluid exchange



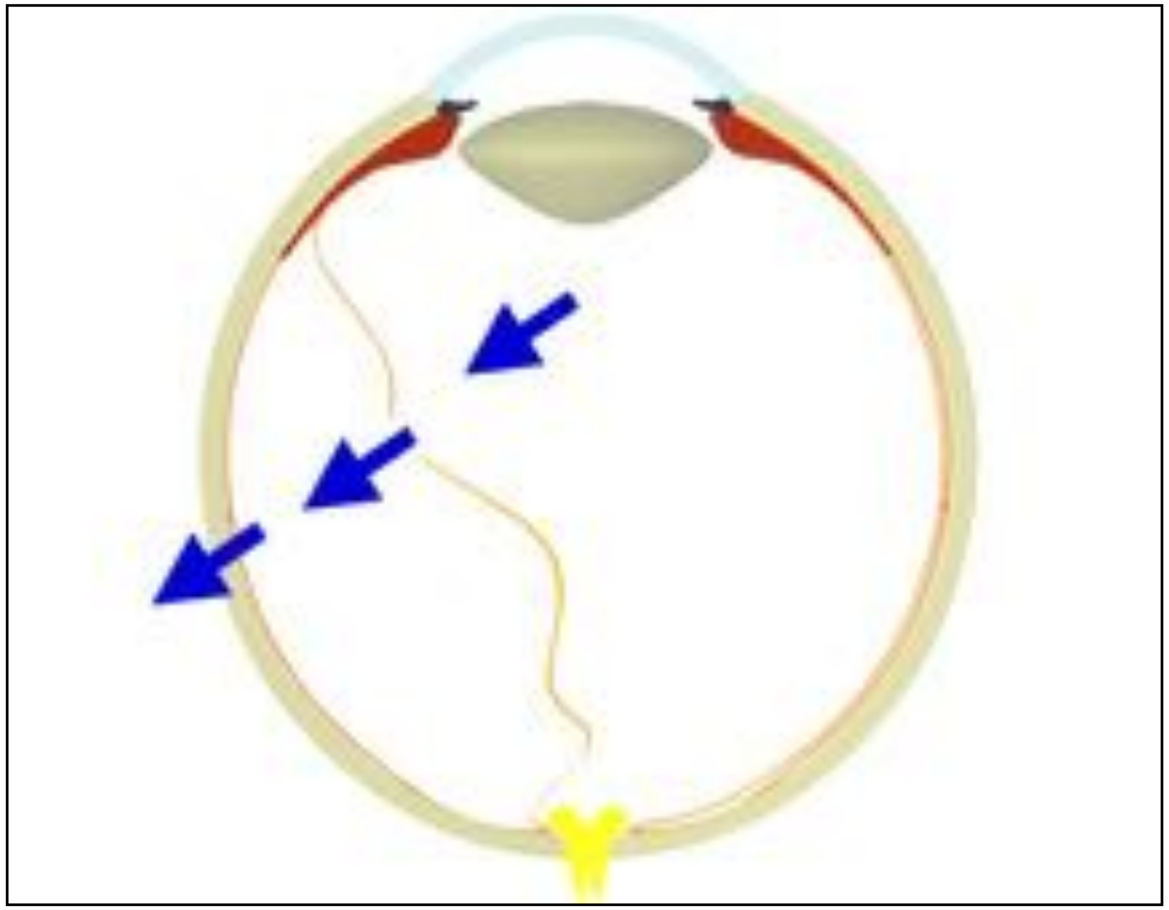
Note that the specular reflection from the surface of the residual fluid (which moves) is replaced by a fixed reflection from the optic disc.

Retinal hydraulic conductivity

The retina is a barrier to **uveoscleral outflow**. When the retina is detached a large area of bare pigment epithelium is exposed to liquid vitreous and the intraocular pressure frequently falls.

Retinectomy has been used as a treatment for glaucoma for this reason.

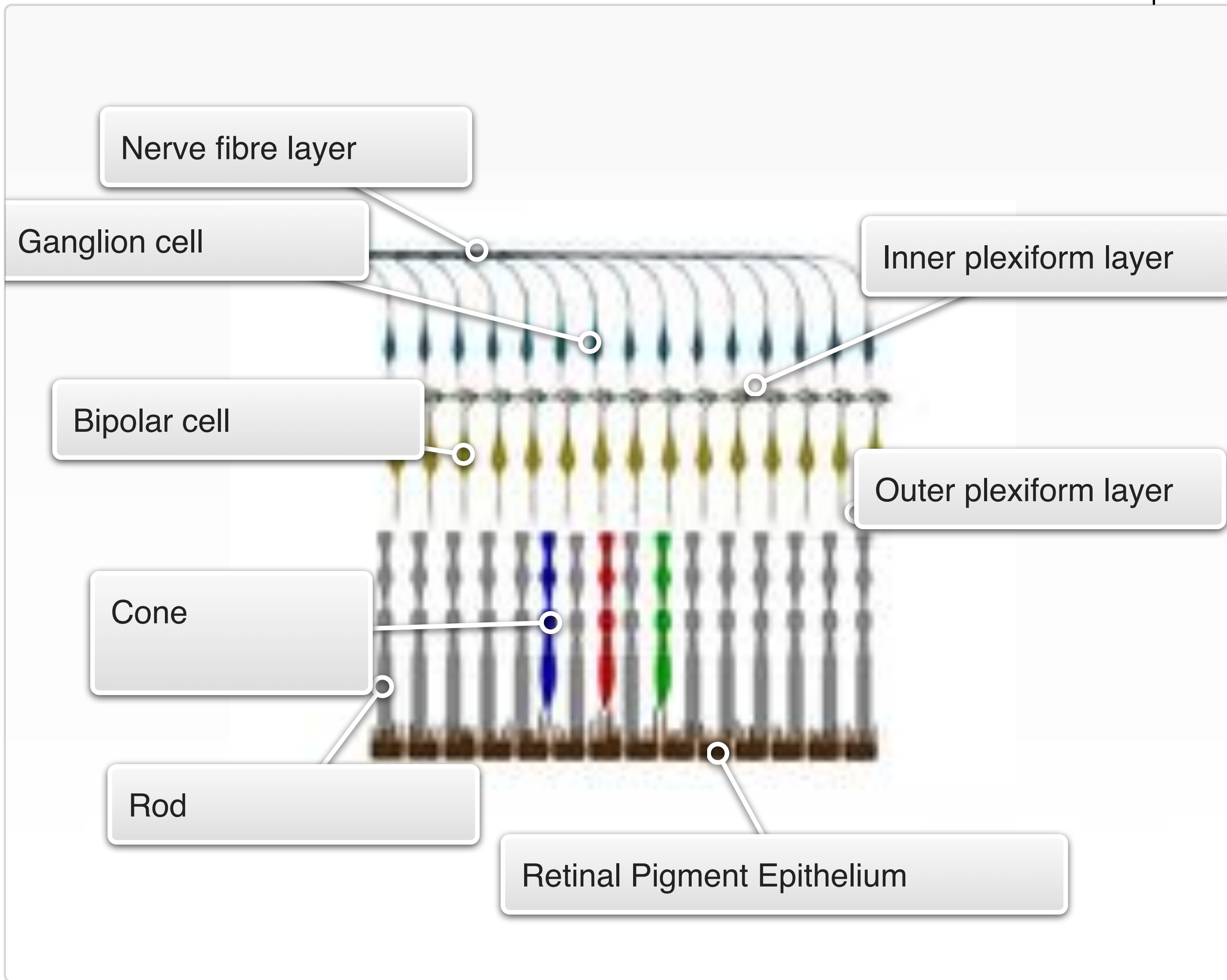
Figure 1.10 Uveoscleral outflow in retinal detachment



Retinal ultrastructure

The retina consists of functionally differentiated cells organized in layers which can now be visualized using **Optical Coherence Tomography** (OCT). Signaling after transduction proceeds from the outer to the inner retina. Splits in the retina (**retinoschisis**) therefore cause an absolute scotoma.

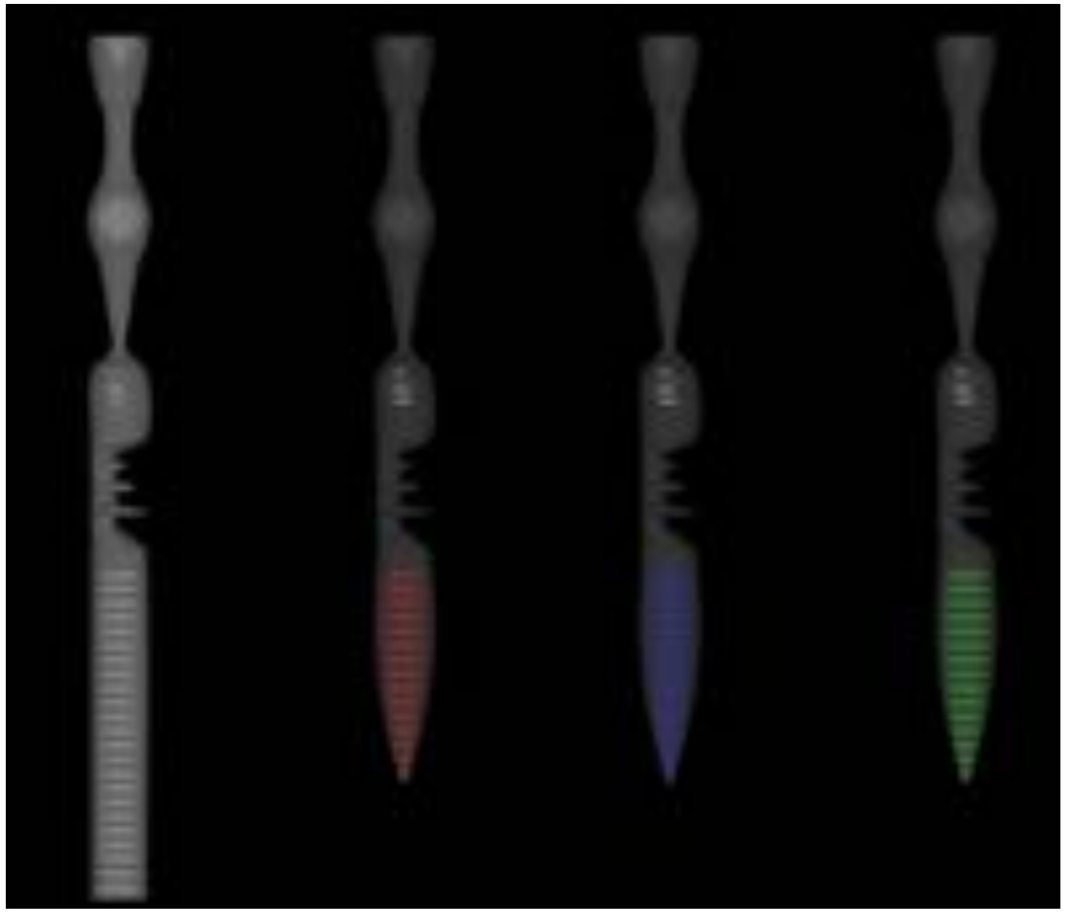
Interactive 1.5 Simplified scheme of retinal organization



This diagram omits key structures including Muller cells, horizontal and amacrine cells and the retinal vasculature.

Photoreceptors

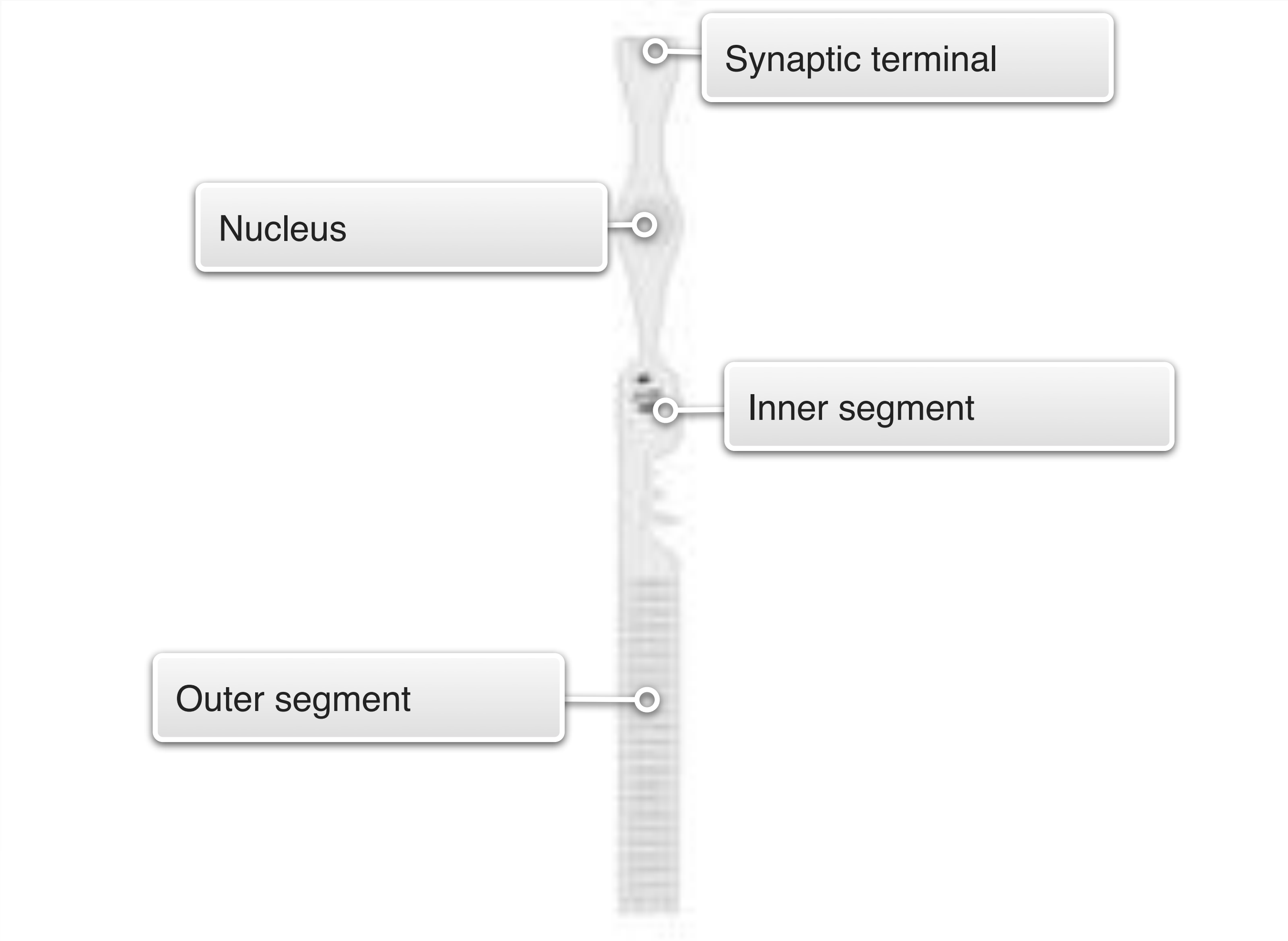
Figure 1.11 Photoreceptors



A cone and 3 rods - the color of the discs in the cones is purely schematic.

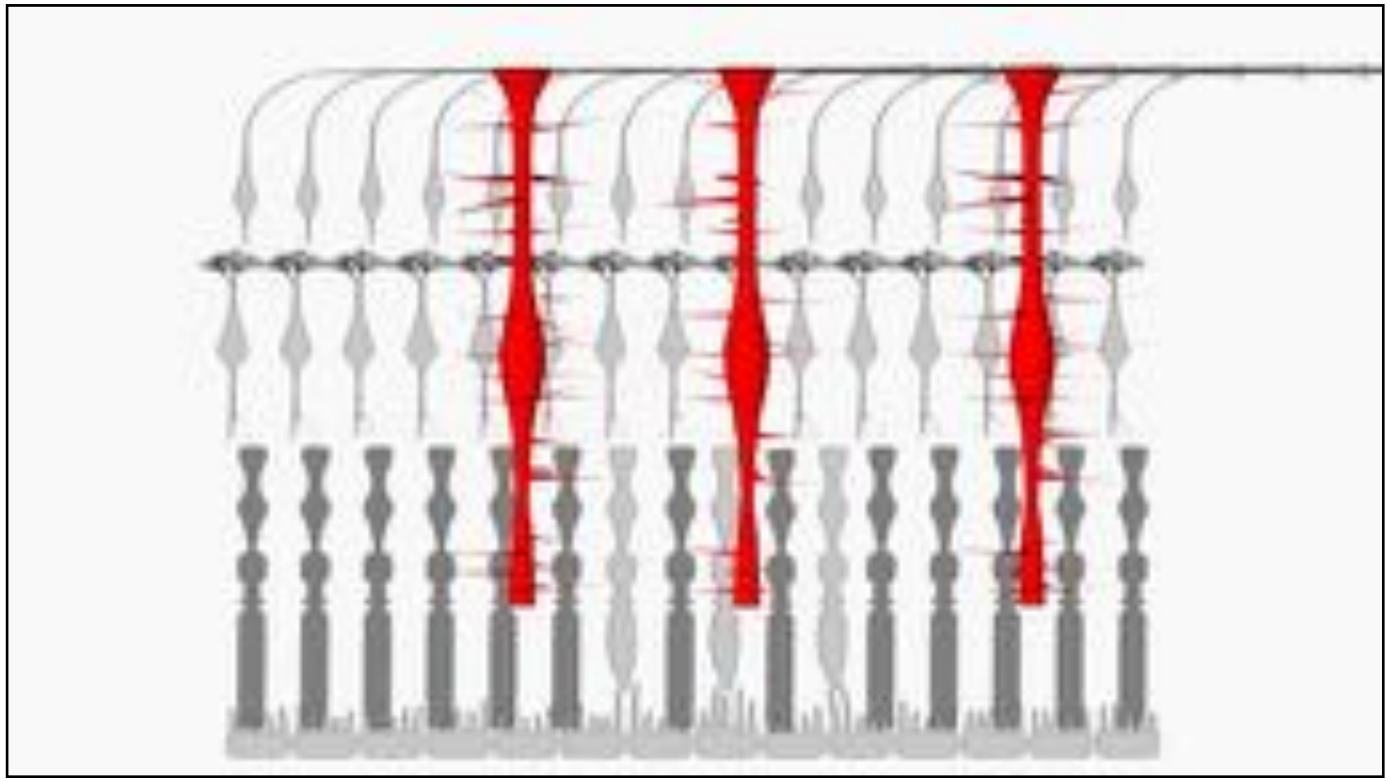
Light transduction occurs when a photon strikes a molecule of retinal which changes its isomeric form. This triggers a conformational change within an **opsin** molecule embedded in the wall of the membranous plates in the outer segment of the photoreceptors. This change of the opsin molecule triggers hyper-polarization of the cell and reduction in neurotransmitter release at the synaptic terminal.

Interactive 1.6 Anatomy of a cone



Muller cells

Figure 1.12 Muller Cells



Muller cells are glial cells extending from the inner to the outer limiting membranes of the retina, straddling the layers previously described. They provide structural and metabolic support to the neural cells of the retina and have been implicated in several disease processes.

The inner portion of the Muller cell expands into a funnel shape, connecting with the foot processes of adjacent Muller cells. The associated basal lamina constitutes the inner limiting membrane of the retina. Peeling of this membrane is used as an adjunct to epiretinal membrane removal to ensure that no residual glial elements are left on the retinal surface ('double peeling').

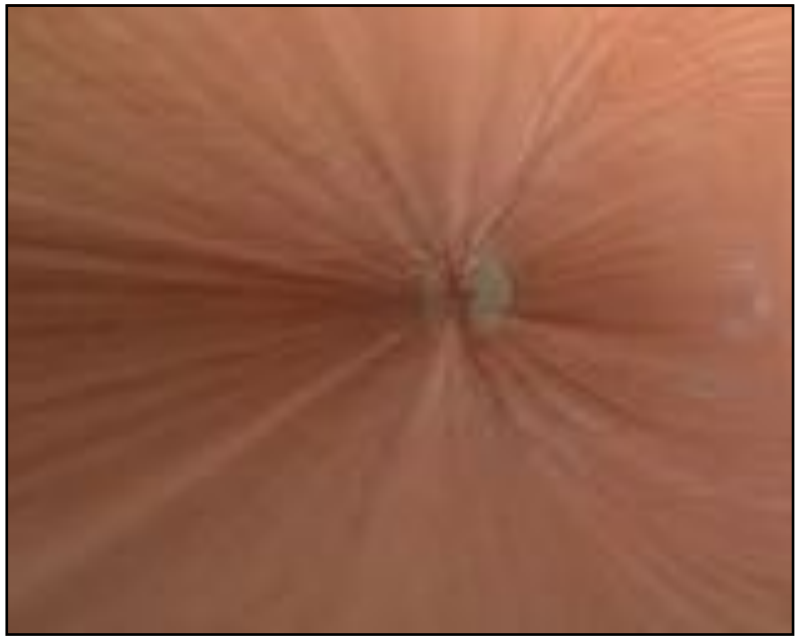
During development of retinoschisis stretched Muller cells form columns between the inner and outer leaves of the schisis. These are apparent on OCT examination and may aid in the differentiation from a retinal detachment.

The Muller cells in the centre of the fovea form an inverted cone which has been implicated in the development of macular holes.

Muller cells are a source of vascular endothelial growth factor production in ischaemic retinopathies.

The nerve fibre layer

Figure 1.13 The nerve fibre layer



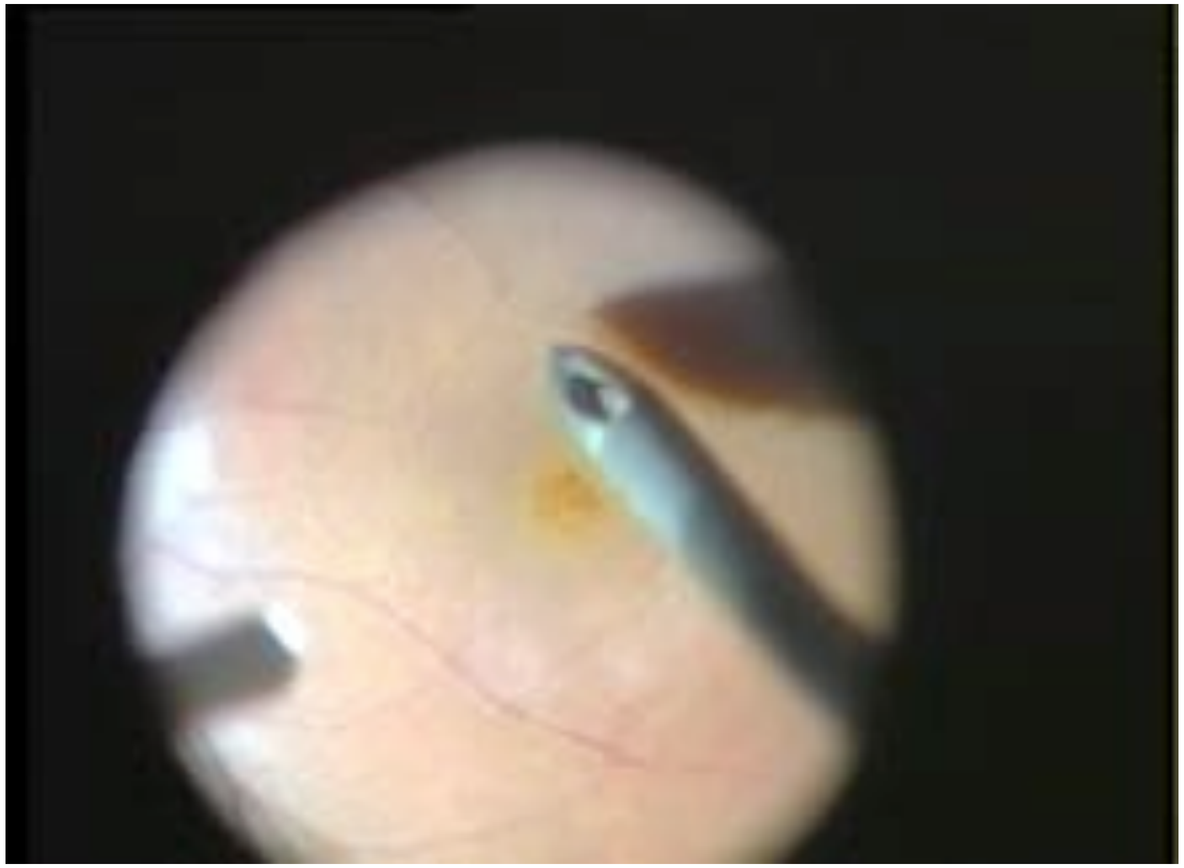
The nerve fibre layer radiates towards the optic nerve. Due to the large number of fibers from the macula (the papillomacular bundle) the fibers from the macula initially radiate centrifugally.

The nerve fibre layer is adjacent to the internal limiting membrane. Immediately following internal limiting membrane peeling the nerve fibre layer becomes edematous and whitens. This can be used to visualize the ILM during peeling if vital stains are not used.

Micro-trauma during internal limiting membrane peel may resulting in dimpling of the inner retina ('Dissociated Optic Nerve Fibre Layer').

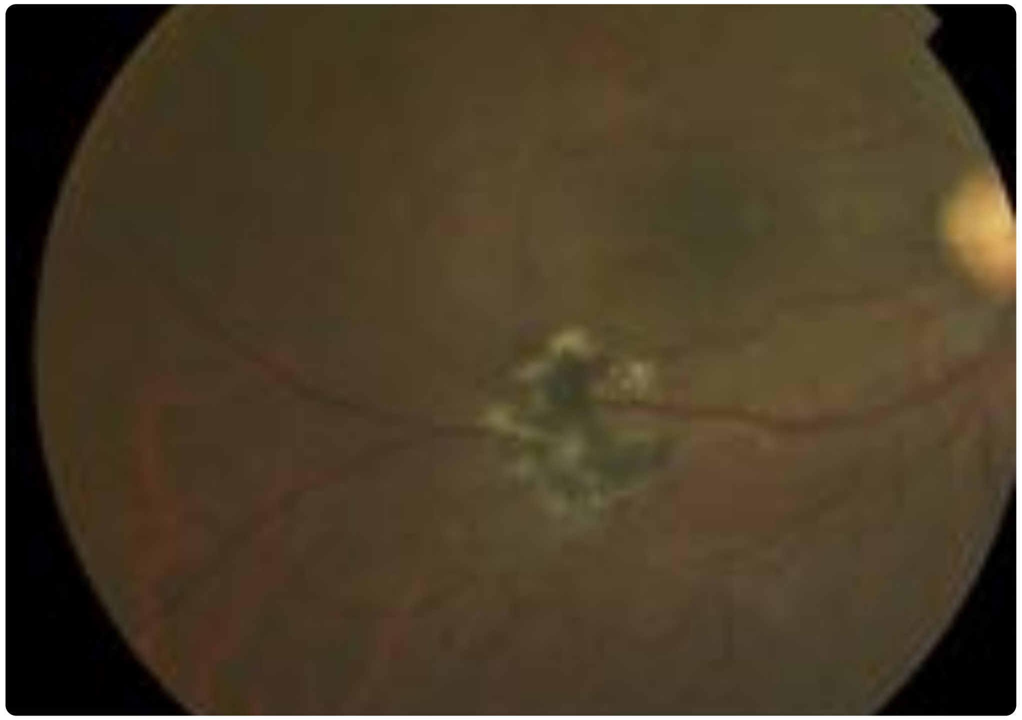
Retinal lacerations during vitreoretinal surgery may cause extensive scotomas corresponding to the paths of the damaged nerve fibers.

Movie 1.2 ILM removal without stain



Note the subtle whitening due to NFL edema - this is helpful in determining where to regrasp the flap.

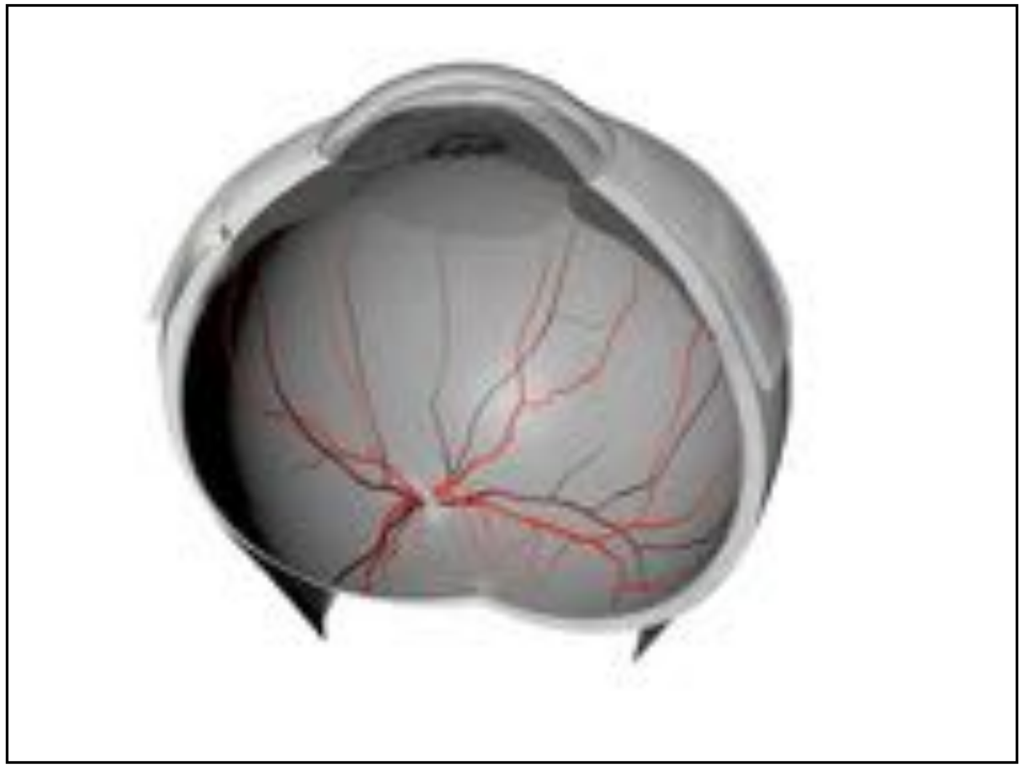
Figure 1.14 Retinal laceration



This laceration occurred during ERM peel caused a significant arcuate scotoma because the nerve fibre connections with more peripheral photoreceptors were severed.

The retinal vasculature

Figure 1.15 The retinal vasculature



The vascular system of the retina has much in common with that of the brain. Auto-regulation preserves retinal perfusion despite fluctuations in blood pressure. **Tight junctions** between endothelial cells (one of the two blood retinal barriers) limit the passage of plasma into the retina. These features maintain homoeostasis under physiological conditions.

Most of the retinal vasculature lies in the inner retina adjacent to the vitreous. Consequently:

1. **Angiogenesis** results in the proliferation of new vessels along the posterior hyaloid membrane.
2. Posterior vitreous detachment may result in trauma to the walls of blood vessels even in the absence of a full thickness retinal tear (haemorrhagic posterior vitreous detachment). This is because of the locations of these vessels in the inner retina adjacent to the internal limiting membrane.
3. Micro-trauma to superficial retinal capillaries may cause hemorrhage during internal limiting membrane peeling.

Figure 1.16 Haemorrhagic posterior vitreous detachment

There is no tear but hemorrhage has occurred due to avulsion of a section of the blood vessel wall (arrow).

At arteriovenous crossings the artery tends to be more superficial and the vessels share a common adventitial sheath. This may be a factor in the development of branch retinal vein occlusion. Sheathotomy has been used to treat branch retinal vein occlusion.

Figure 1.17 The shared arteriovenous adventitial sheath

This eye has a branch retinal vein occlusion.

The retinal arteries are end arteries. They supply 2 capillary plexi at different levels of the retina:

- A superficial plexus in the ganglion cell layer.
- A deep plexus in the inner nuclear layer.

The inner retina is metabolically supported by the retinal circulation while the outer retina including the photoreceptors is supported by the choroidal circulation. There are no retinal vessels in the fovea which is metabolically dependent on the choriocapillaris.

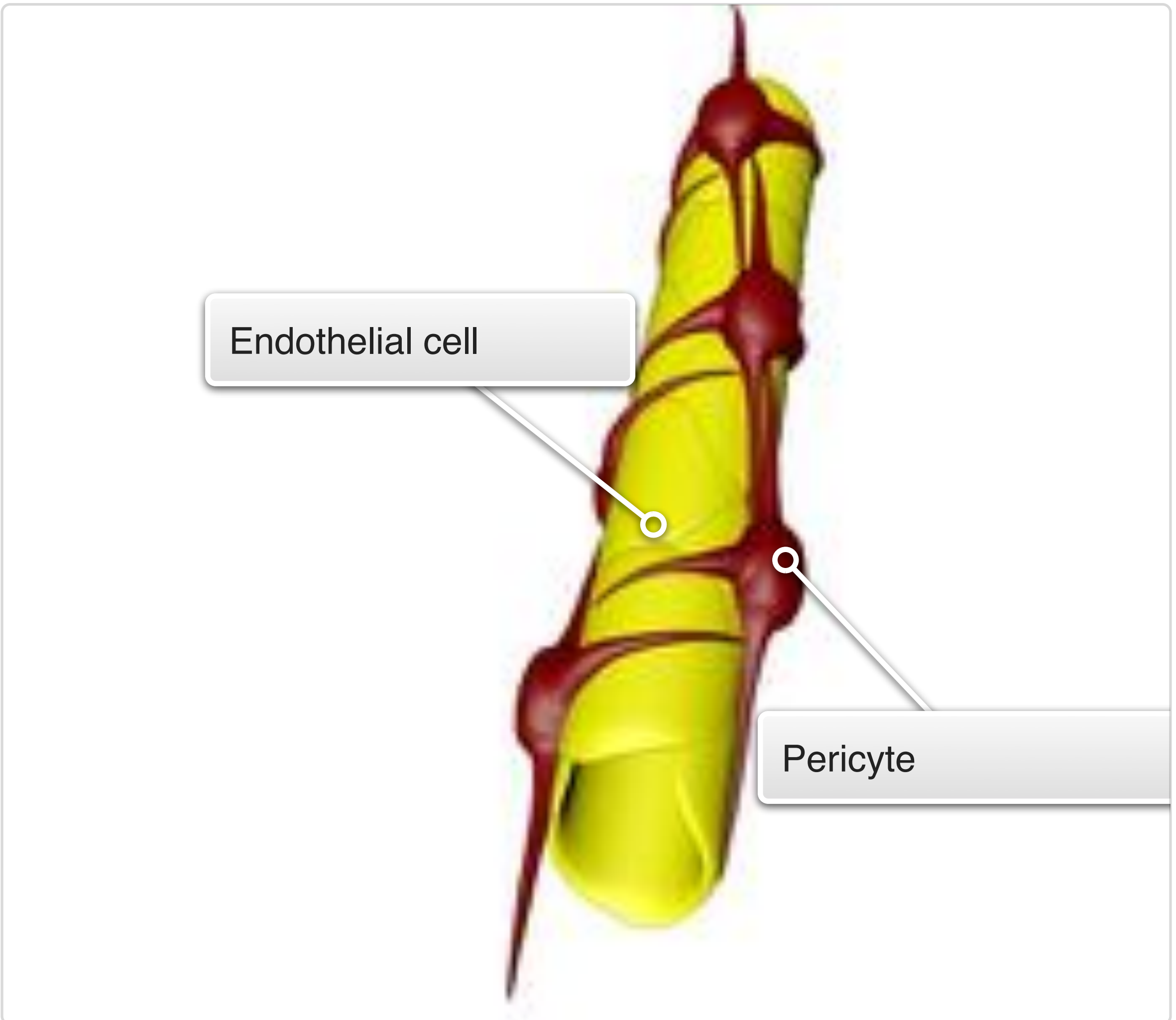
Retinal capillaries are composed of a luminal tube of **endothelial** cells surrounded by supporting **pericytes**.

The inner blood retinal barrier is a consequence two features of the endothelial tube:

- The absence of fenestrations (channels through the cell).
- The 'watertight' junctions between adjacent endothelial cells (zonulae adherens and occludens).

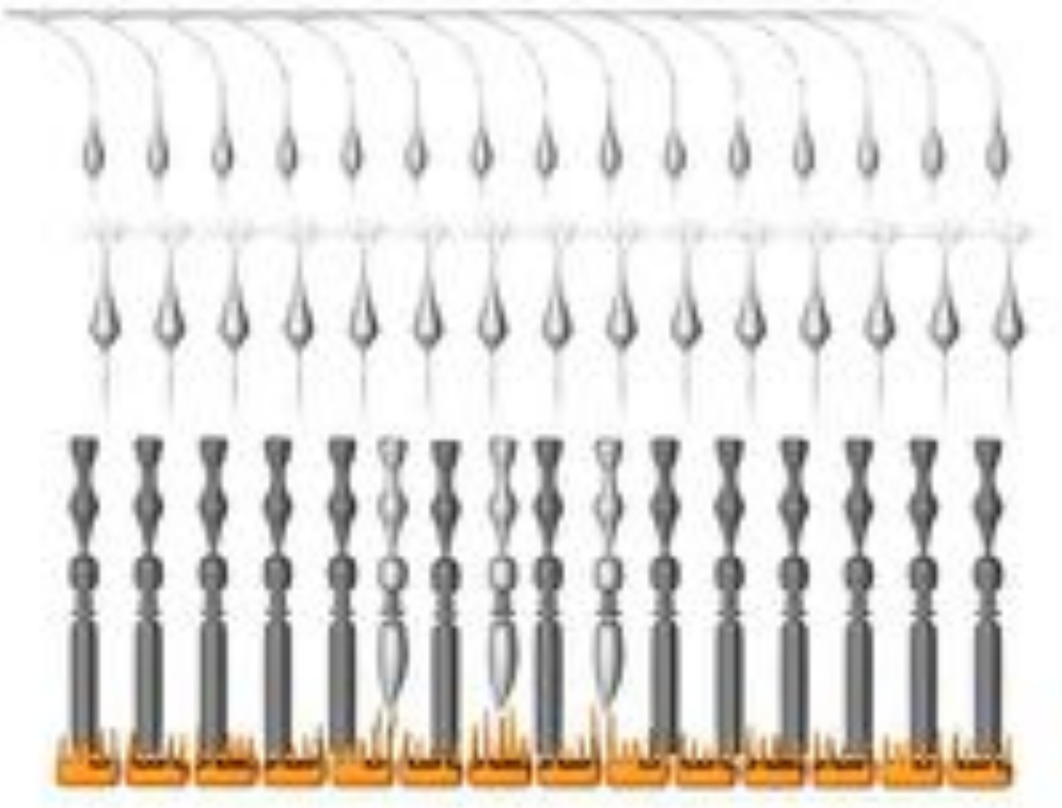
These features block the passage of osmotically active proteins across the vessel wall, preventing retinal edema. Cytokine up-regulation in many diseases may open the tight junctions causing edema.

Interactive 1.7 A retinal capillary



The retinal pigment epithelium

Figure 1.18 The retinal pigment epithelium



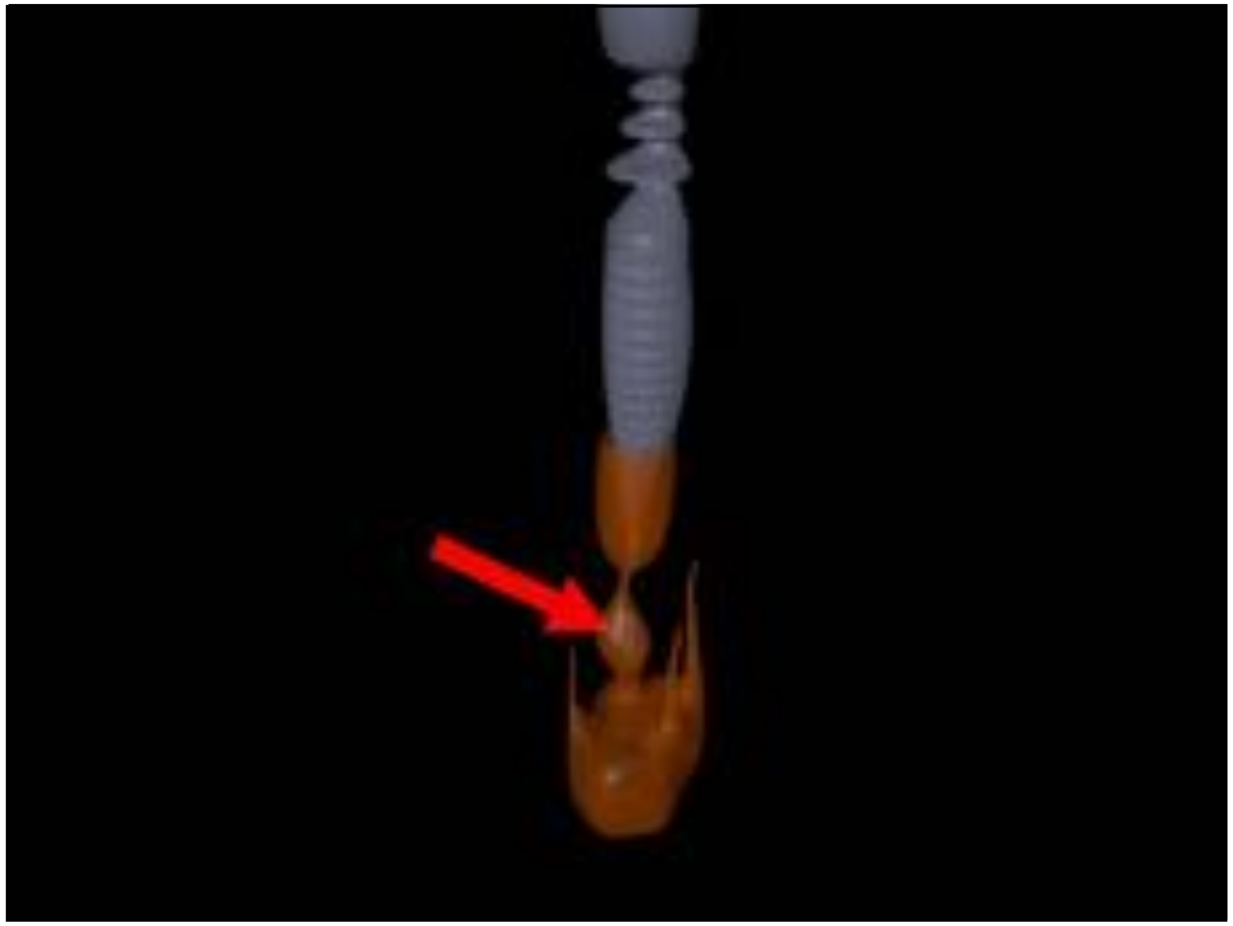
The retinal pigment epithelium (RPE) consists of a monolayer of hexagonal cells that sits on Bruch's membrane. Microvilli on the apical surface surround the outer segments of the photoreceptors. Pigment in the RPE absorbs light that has passed through the retina reducing light scatter within the eye.

Retina - RPE interaction

The RPE phagocytoses discs shed from the outer segment of the photoreceptors - recycling of rhodopsin occurs within the RPE cell. **Lipofuscin** is a by-product of this process and its concentration reflects the balance between the activity of photoreceptors and RPE cells. As lipofuscin is a fluorophore it can be imaged using fundus autofluorescence.

Detachment of the macula disrupts this process and adds to the metabolic disruption caused by loss of nutrition derived from the choroid.

Figure 1.19 Photoreceptor and RPE cell



A phagocytosed disc from the cone outer segment is visible in the cytoplasm of the RPE.

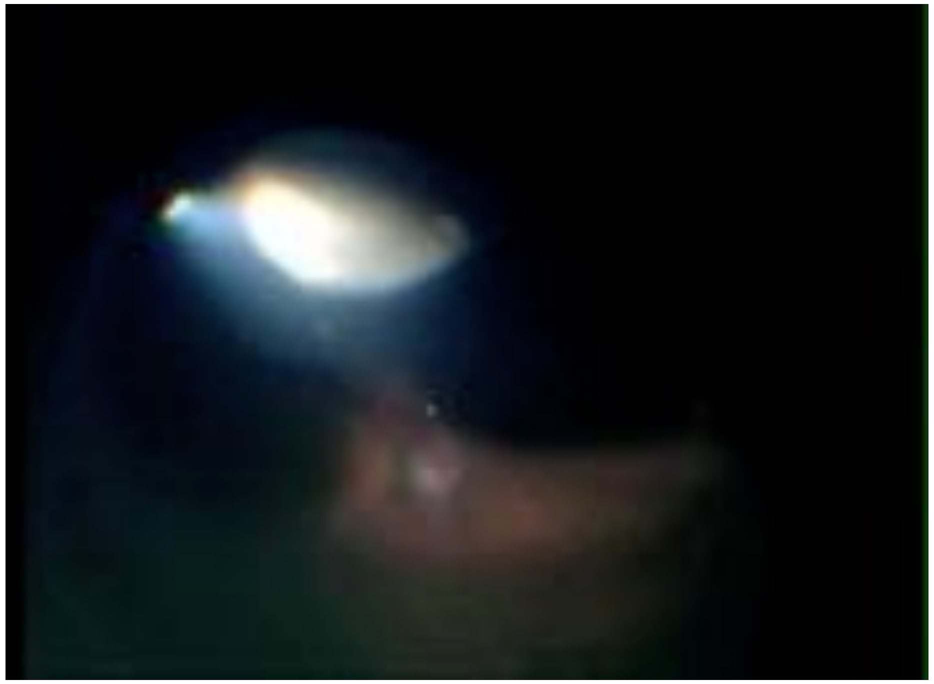
Although there is a potential space between the retina and RPE (which has its embryological origin in the optic cup) the 2 layers adhere by a number of mechanisms:

- The matrix between the retina and RPE contains glycoproteins which have a glueing effect.
- The microvilli surrounding the photoreceptors probably contribute ‘velcro’ like adhesions.
- As retinal adhesion seems to be oxygen dependent the cellular RPE pump is probably the most important adhesive force, sucking the relatively impermeable retina onto the RPE.

The retina only detaches when subject to a force that exceeds these adhesive forces.

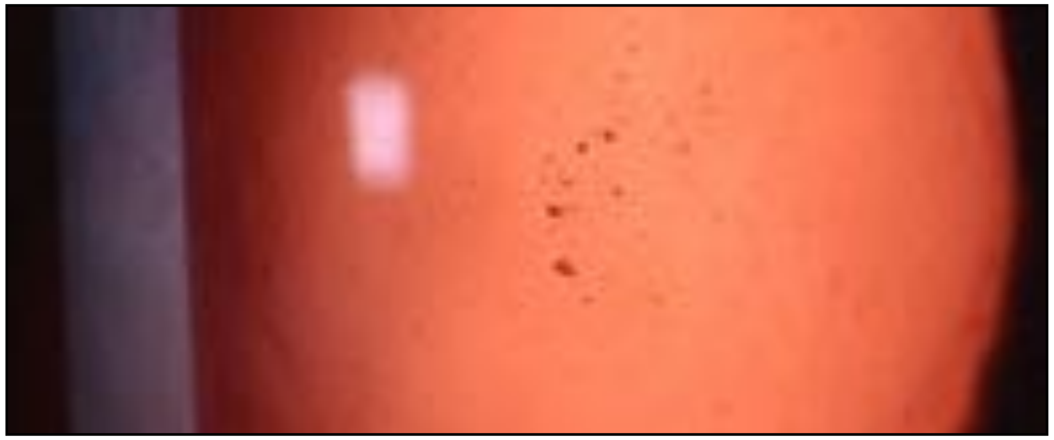
RPE and PVR

Movie 1.3 RPE cell dispersion though a retinal break



This was observed while doing an internal search during a vitrectomy for retinal detachment.

Figure 1.20 Pigment in the vitreous



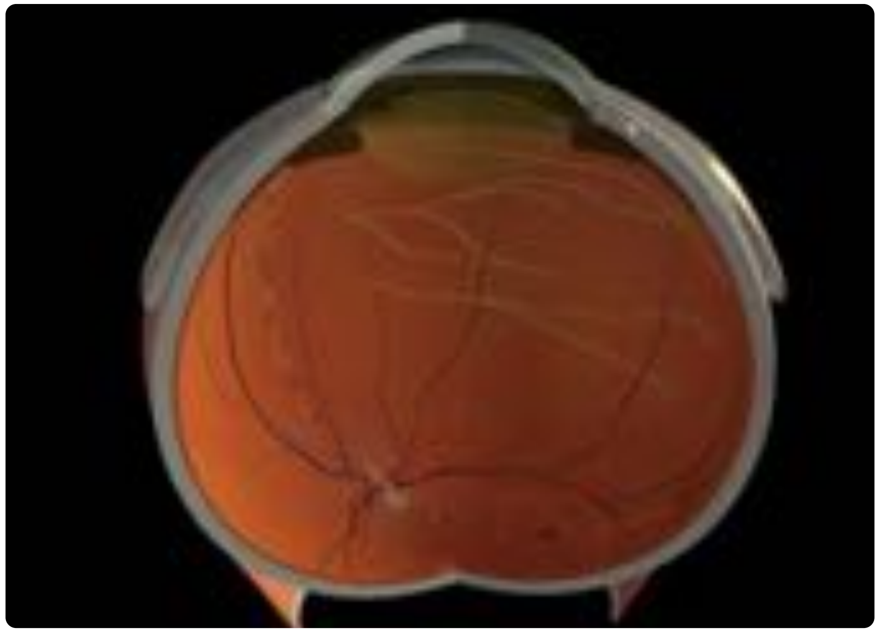
This may be a normal finding in eyes that have had cataract surgery (where the pigment derives from the iris) but otherwise indicates the presence of a retinal break (Shafer's sign).

Retinal pigment epithelial cells may pass through retinal breaks. Pigment in the vitreous (Shafer's sign) indicates the likely presence of a retinal break. These cells may proliferate and contract on the retinal surface causing proliferative vitreoretinopathy (PVR).

Retinal pigment epithelial cells may proliferate for a number of reasons. Retinal pigment epithelial cell cell migration onto the elevated retinal edge in chronic retinal detachments causes tide marks.

RPE envelops choroidal neovascular membranes which are above the level of the RPE causing a pigmented donut appearance and is an indication that these are type 2 membranes- i.e. potentially suitable for surgical excision.

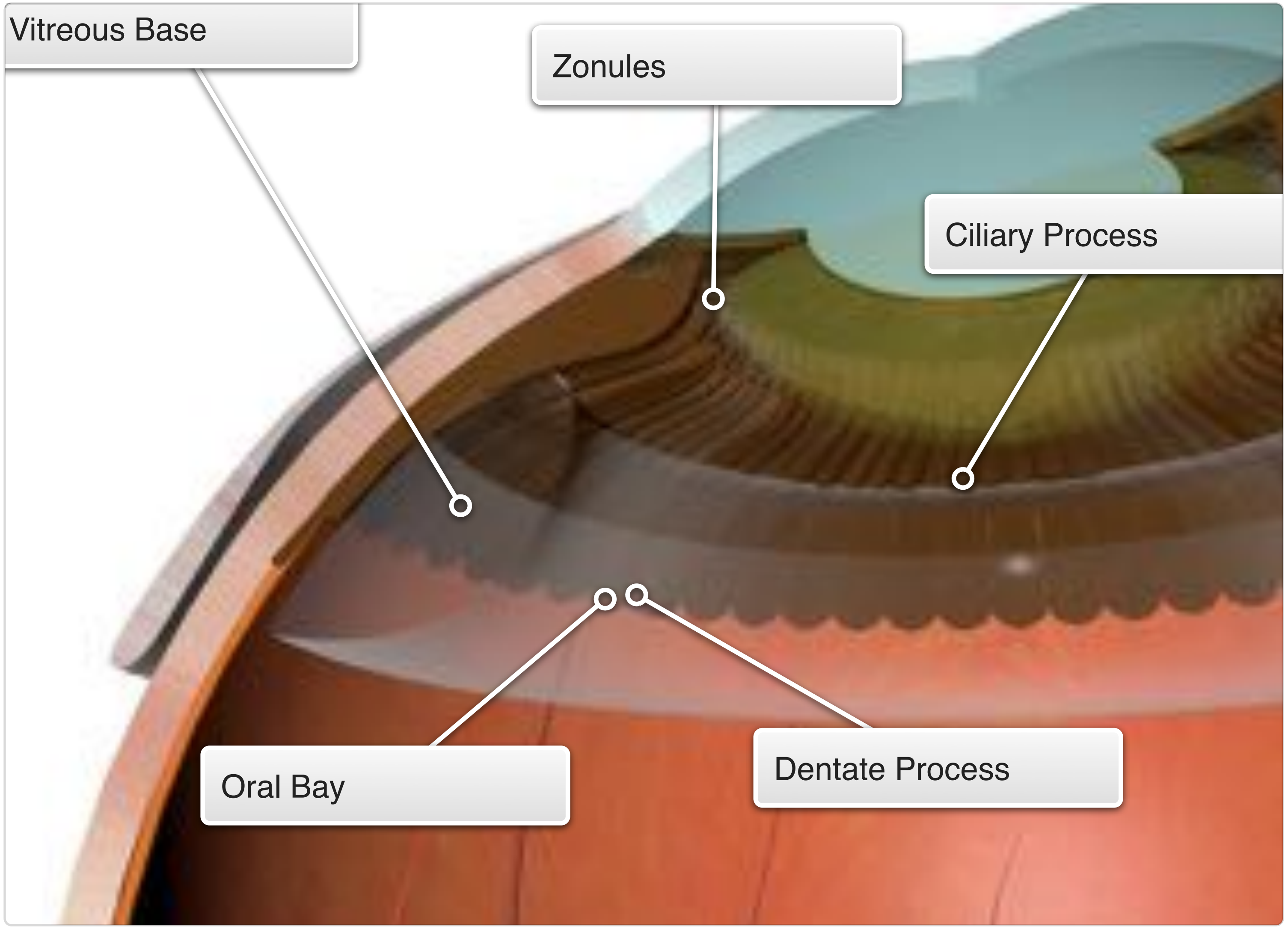
Figure 1.21 Retinal pigment cell hyperplasia



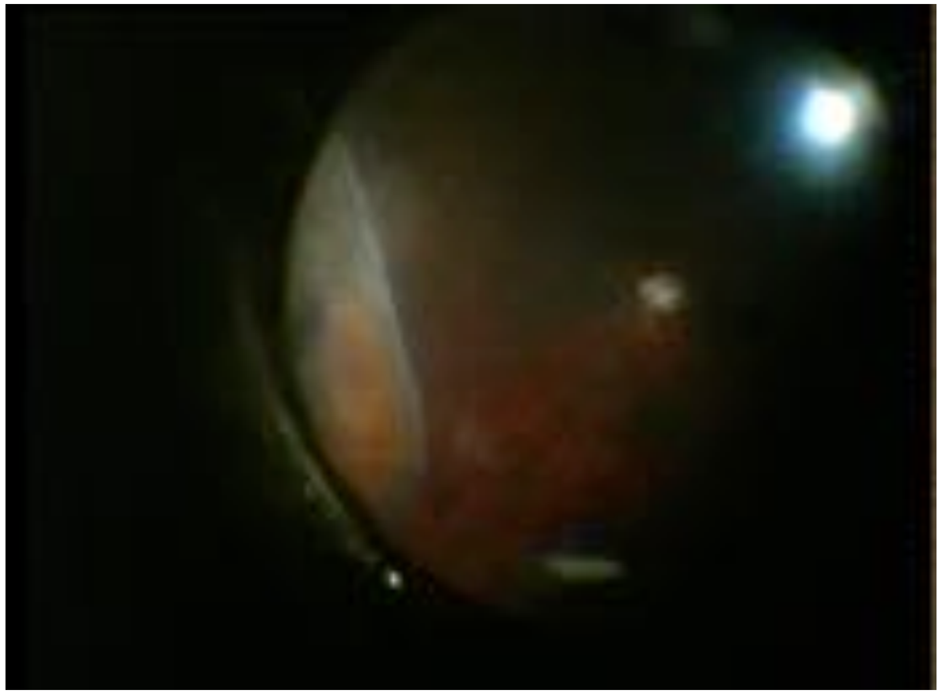
Retinal pigment cell hyperplasia at the borders of a retinal detachment.

The ora serrata

Interactive 1.8 Ora Serrata

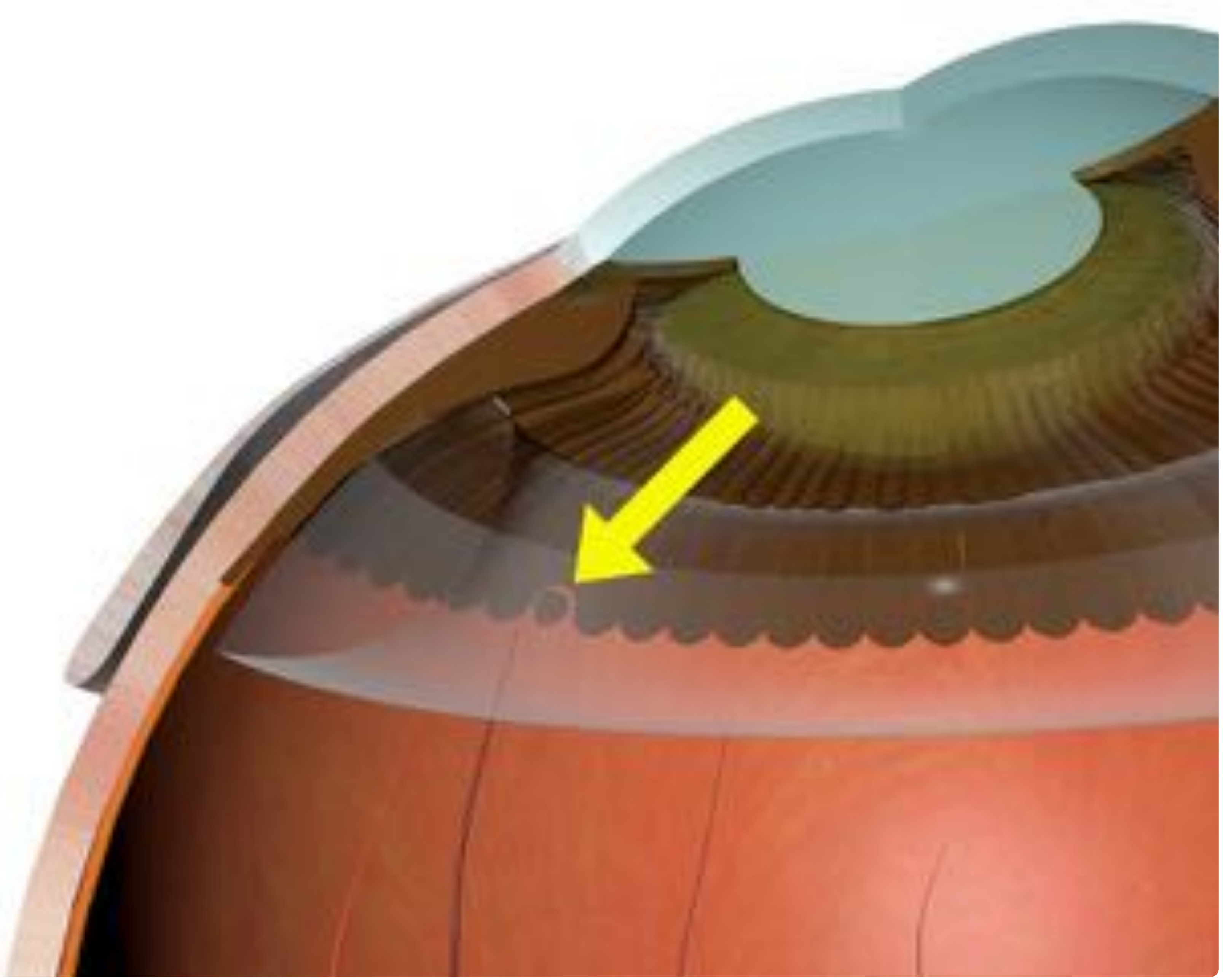


Movie 1.4 The ora serrata



Knowledge of the features of the normal ora serrata and its variants is particularly important during vitrectomy as some of these may mimic retinal tears and holes.

Figure 1.22 Normal Variants in the Ora Serrata

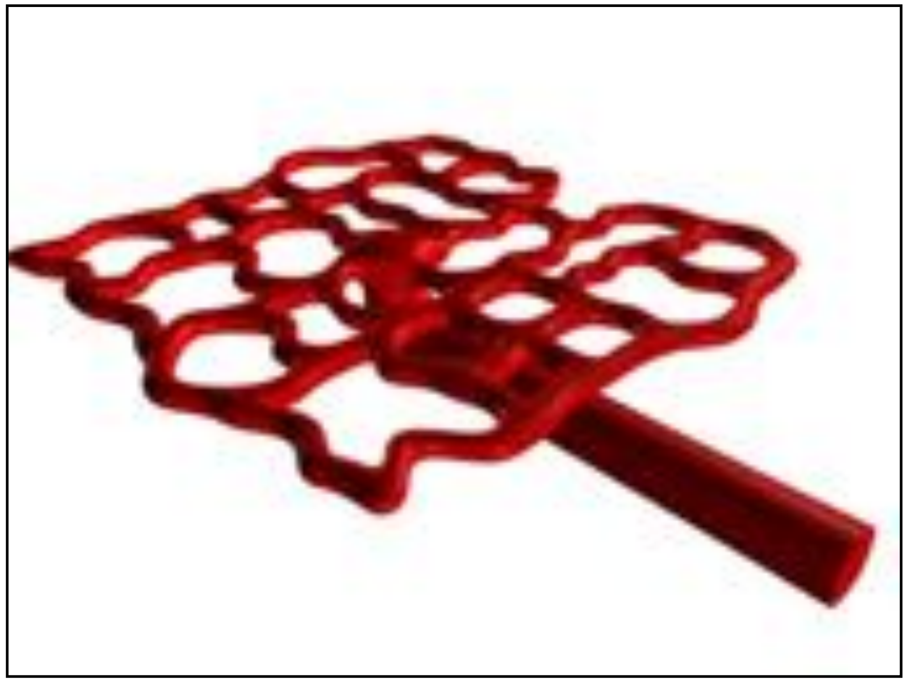


Two dentate processes joined at their tips surround an island of pars plana. These may be mistaken for a retinal hole.

The choroid

The **choroid** supplies nutrients to the outer retina which is very metabolically active. It therefore has a rich blood supply. If it is injured hemorrhage may accumulate under the retina or in the suprachoroidal space.

Figure 1.23 A lobule of choriocapillaris

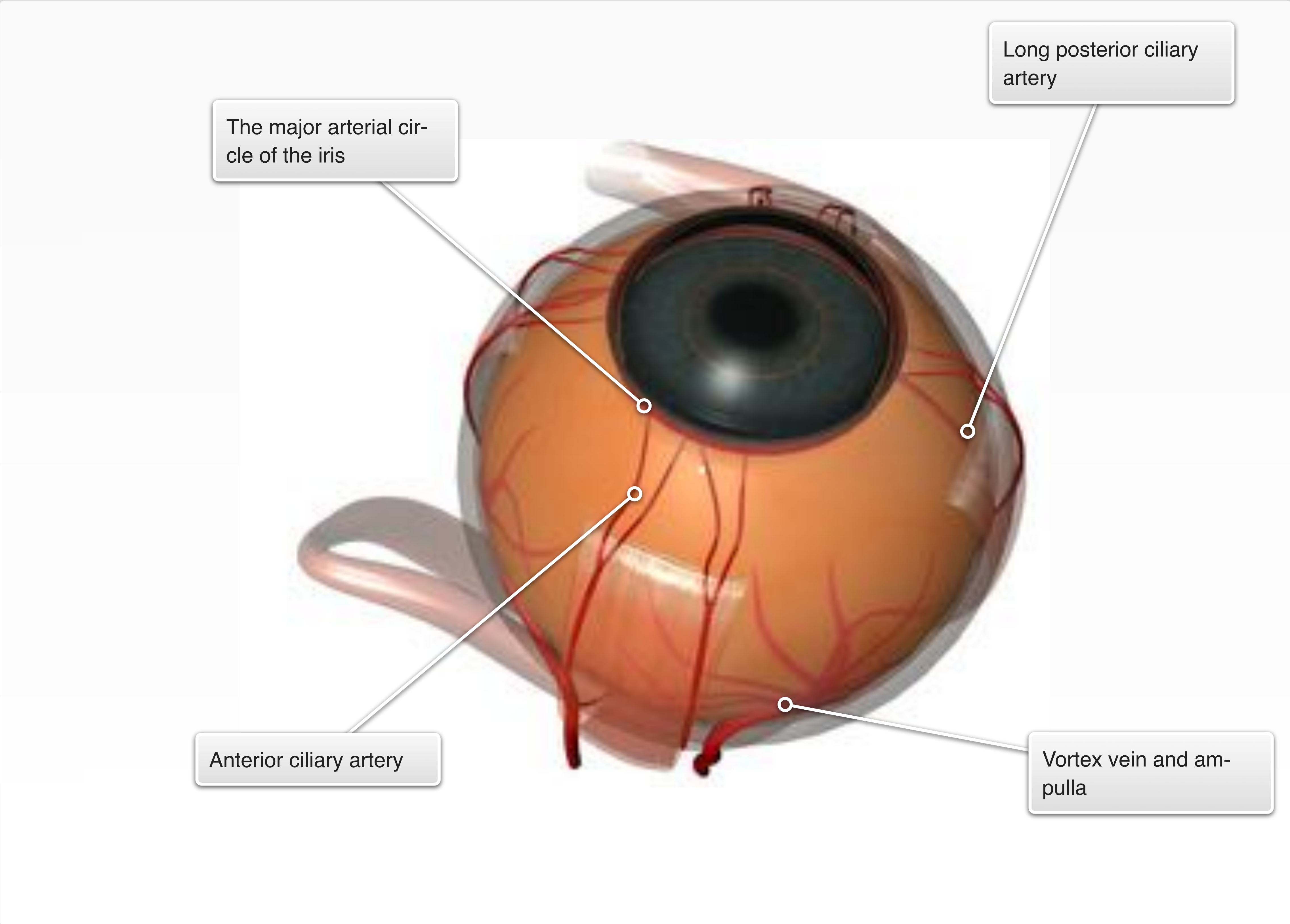


The choroidal capillary net is adjacent to Bruch's membrane, the arteries and veins that serve it lie on its scleral side.

Figure 1.24 Subretinal hemorrhage following scleral buckling surgery

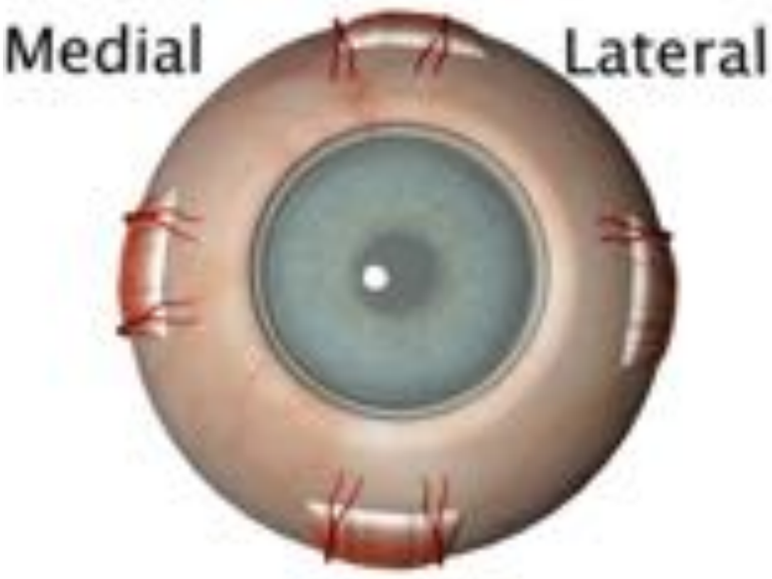
This followed subretinal fluid drainage.

Interactive 1.9 The uveal circulation



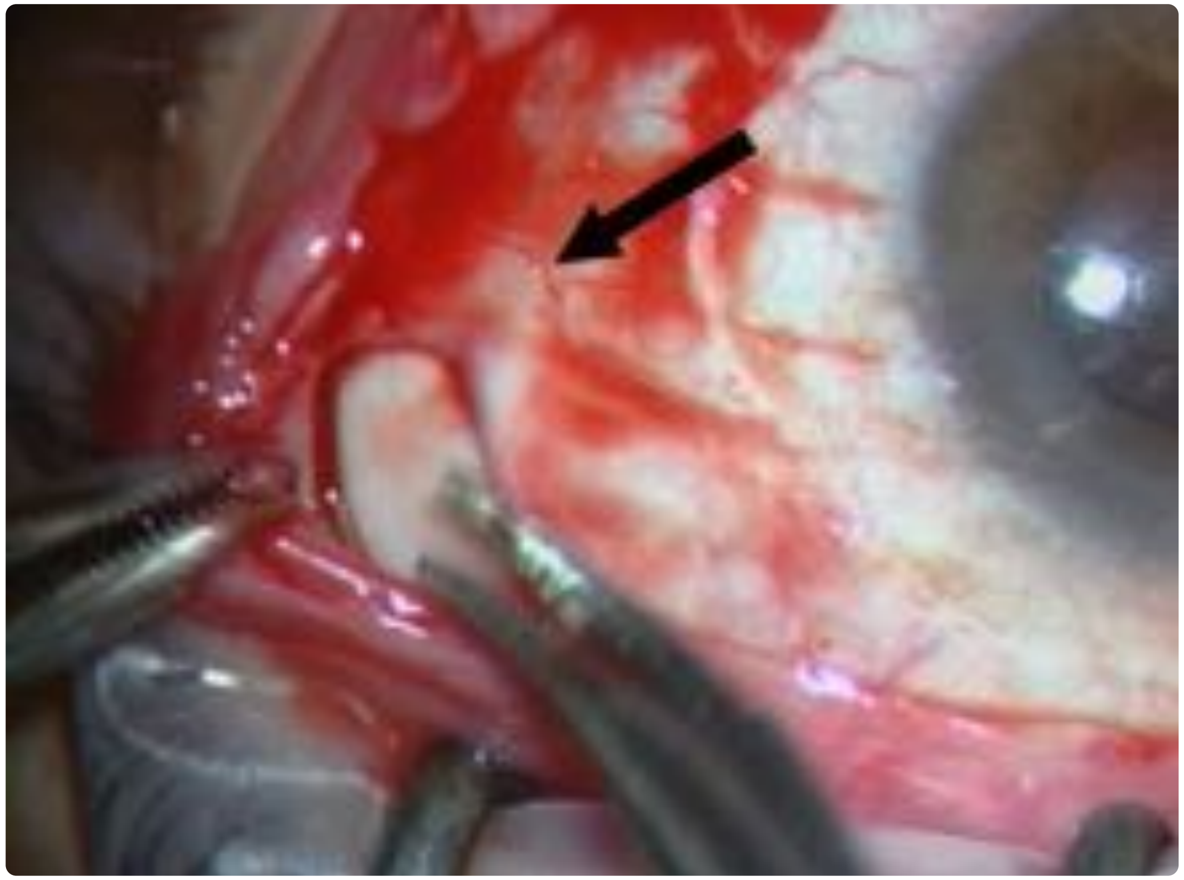
Each rectus muscle has two anterior ciliary arteries except the lateral rectus which only has one. As they run forward from the muscle insertion they may be quite useful indicators of the position of the rectus muscles especially in revision scleral buckling surgery. They make a major contribution to the vascular supply to the ciliary body and anterior segment ischaemia may result from surgical trauma if several of these are damaged.

Figure 1.25 Anterior ciliary arteries and the rectus muscles



Note that the lateral rectus only has one anterior ciliary artery.

Figure 1.26 Anterior ciliary arteries during surgery



During this revision buckling operation the anterior ciliary artery (arrow) indicates the upper border of the lateral rectus muscle.

The suprachoroidal space

The **suprachoroidal** space is a potential space between the choroid and the sclera in which fluid may accumulate. This is traversed by week connective trabeculae which break easily and by arteries and nerves supplying the ciliary body.

Figure 1.27 Suprachoroidal infusion cannnula during vitrectomy

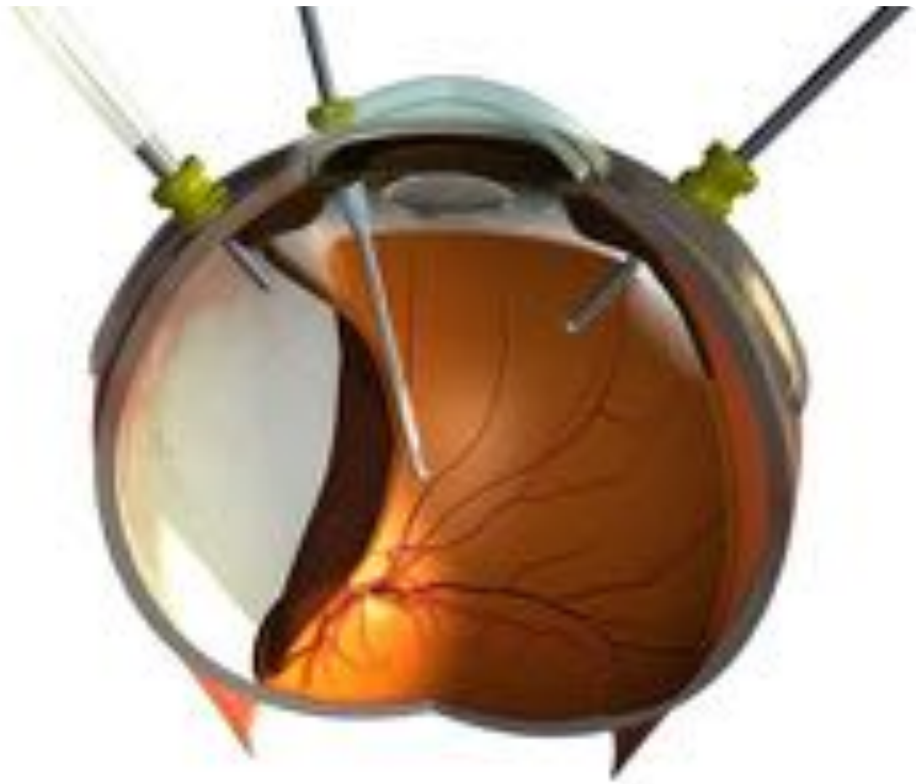


Figure 1.28 B scan ultrasound of choroidal detachment

Note the vortex veins crossing the suprachoroidal space

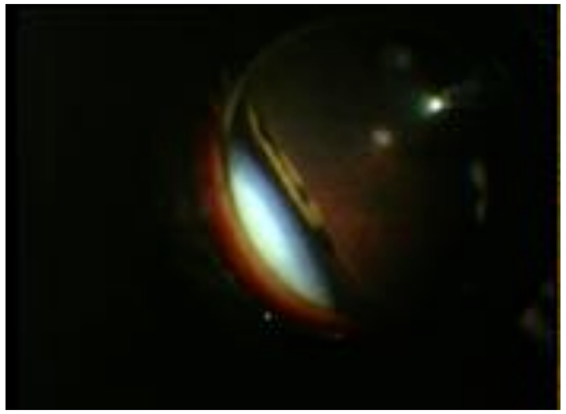
The ciliary body

The pigmented and non pigmented epithelia of the **ciliary body** are continuous with the retinal pigment epithelium and neurosensory retina respectively. Retinal detachments occasionally extend anteriorly to involve this layer.

Aqueous fluid is produced by the **non pigmented epithelium** of the pars plicata. Contraction of scar tissue in the vitreous base (cyclitic membranes due to uveitis, anterior PVR following retinal detachment, anterior hyaloid proliferation in advanced cicatricial diabetic retinopathy) may cause hypotony and pthisis.

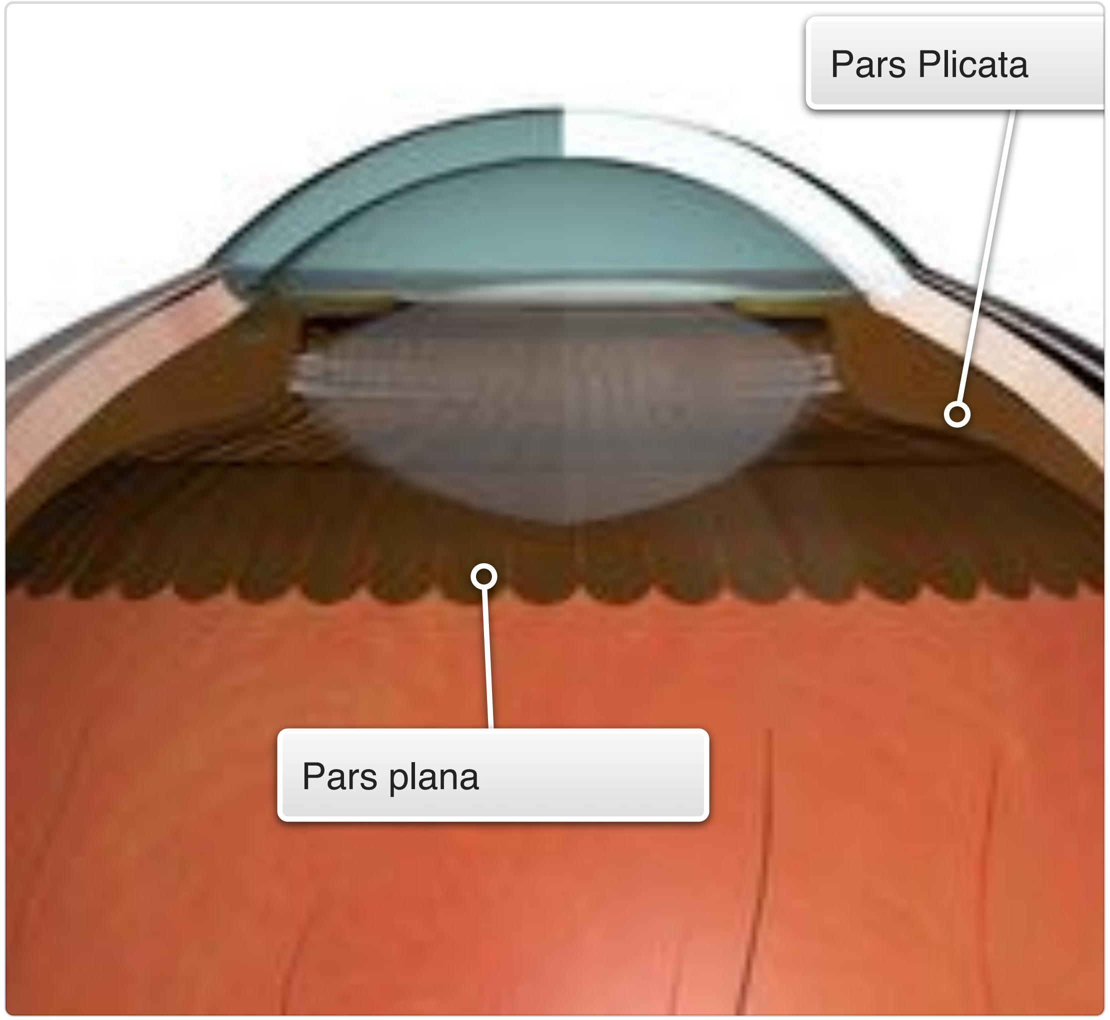
The pars plana is relatively avascular and is a ‘safe zone’ for the passage of instruments into the eye.

Movie 1.5 The ciliary body



Pars plana and plicata are clearly seen in this aphakic eye.

Interactive 1.10 The Cillary Body



The sclera

The sclera is the posterior extension of, and is continuous with, the cornea.

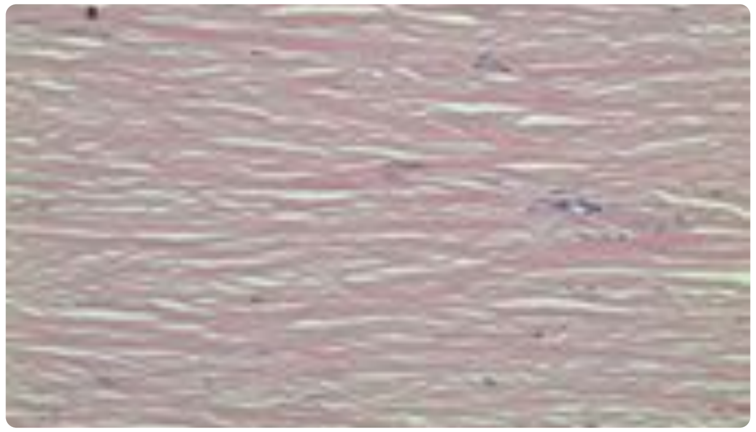
Like the cornea it is composed of Type 1 collagen fibers arranged in **lamellae**. These lamellae are less well organized than those of the cornea so the sclera is opaque. The sclera is nevertheless sufficiently lamellar to allow a spatulated needle to glide between lamellae during placement of scleral sutures.

Local areas of scleral thinning manifest as dark areas as the color of the underlying choroid shows though. The sclera is composed of approximately 70% water - if this level falls significantly (for example during prolonged retinal surgery) the sclera becomes translucent.

The thickness of the sclera varies from 1.0 mm (around the optic nerve) to 0.3 mm behind the rectus insertions then increasing to 0.6 mm at the limbus.

Figure 1.29 Scleromalacia during buckling surgery

Figure 1.30 Scleral histology



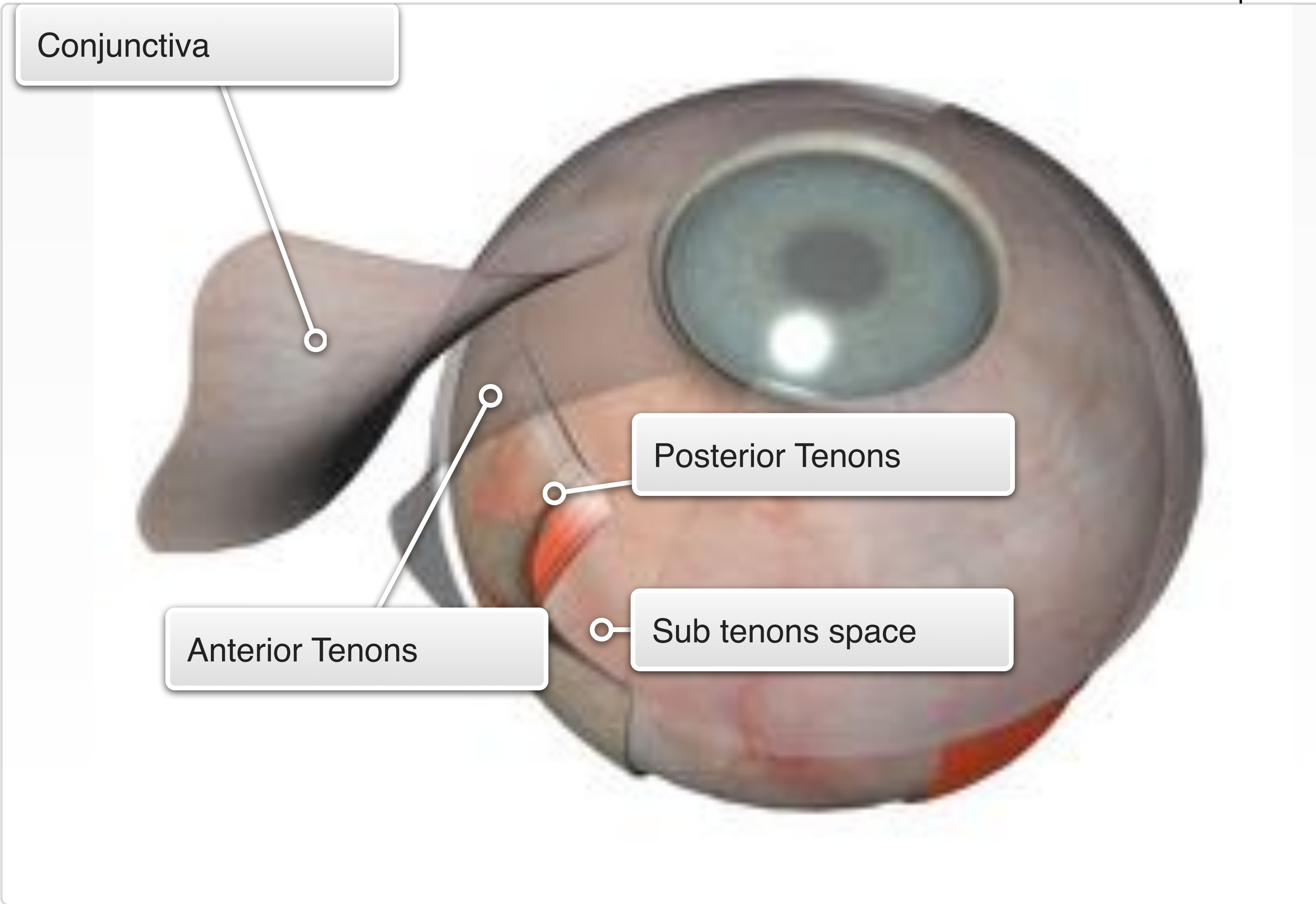
Human sclera has a partially lamellar structure. This facilitates the partial thickness passage of spatulated needles.

Figure 1.31 Orientation of scleral fibers

Note the circumferential arrangement around the spiral of Tillaux.A Hemi-Halstead mattress suture has been added to illustrate the relation between suture bites and scleral fibers.

Tenons capsule

Interactive 1.11 The two layers of Tenons Capsule



A fascial capsule envelops the whole globe from the optic nerve to the limbus.

The rectus muscles pierce this capsule as they run anteriorly, dragging finger like invaginations of the capsule to their insertions - the muscle sheaths. These muscle sheaths are connected by an intermuscular septum - together these are known as the posterior layer of tenons capsule.

The consequence of this complex arrangement is that 2 layers of **Tenons Capsule** have to be incised to open the sub-tenons space when performing scleral buckling surgery.

Tenons capsule is strongly adherent to episclera about 2 mm behind the limbus. The conjunctiva is adherent at the limbus. In practice it is often best to dissect conjunctiva and the anterior layer of Tenons capsule off the globe together - this can be done by initiating incisions a few mm behind the limbus.

The extraocular muscles

Figure 1.32 The extraocular muscles

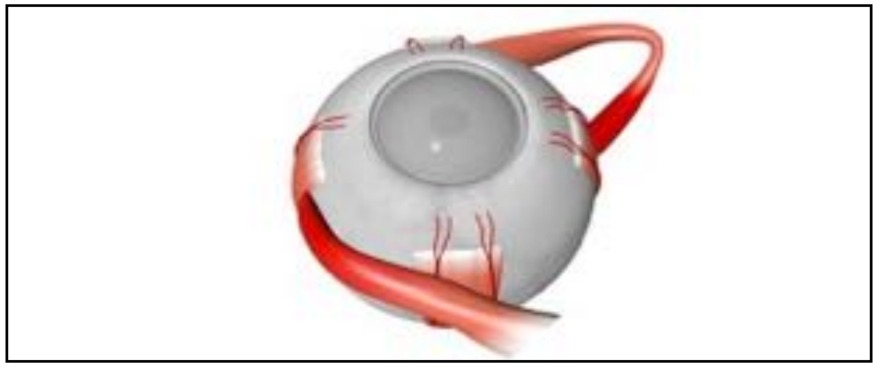


Figure 1.33 The oblique muscles

The relationship between the superior rectus and the superior oblique muscles. In buckling surgery the superior rectus is hooked from the temporal side to avoid the superior oblique.

The relationship between the spiral of Tillaux and the ora serrata has been described in another section.

Transscleral cryotherapy through the rectus muscles may be difficult as the vascular muscle bellies are quite effective insulators.

The superior and inferior oblique muscles lie under the superior and lateral rectus muscles and may be engaged unintentionally with a muscle hook. This is best avoided by engaging the lateral rectus from above and the superior rectus from the lateral side.

Innervation of the globe

Vitreoretinal surgery often entails some manipulation of structures around the eye - for example during a vitrectomy the infusion cannula may press against the lower eyelid when the eye is depressed to operate on the inferior retina.

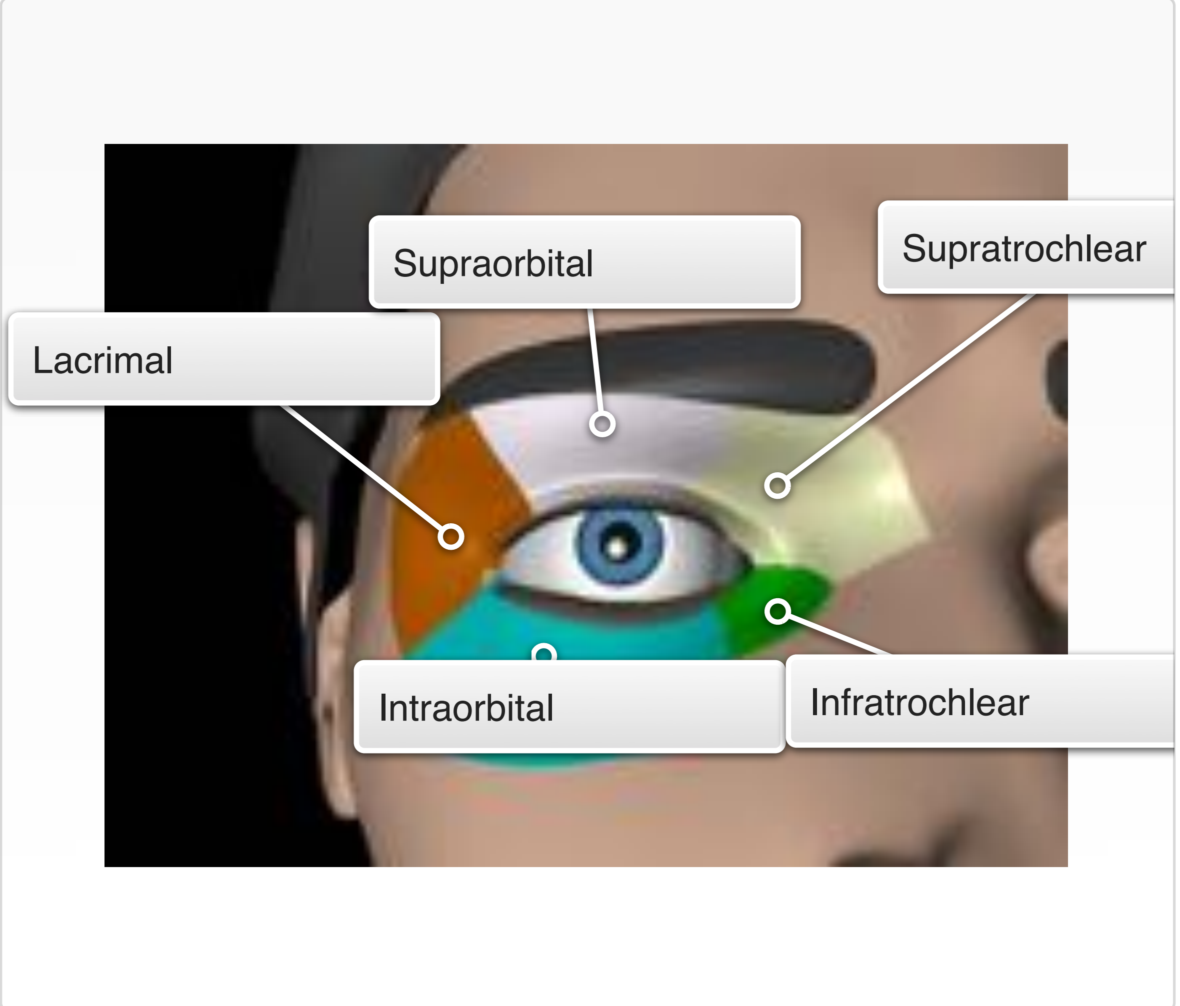
The surgeon therefore needs to be aware of the innervation of the ocular adnexae as well as the globe.

Subtenons anesthesia is becoming increasingly used in vitreoretinal surgery. Although very safe it does have some limitations because of the paths of the branches of the trigeminal nerve around the orbit. Peribulbar anesthesia is much more effective in blocking the nerves that innervate tarsal conjunctiva.

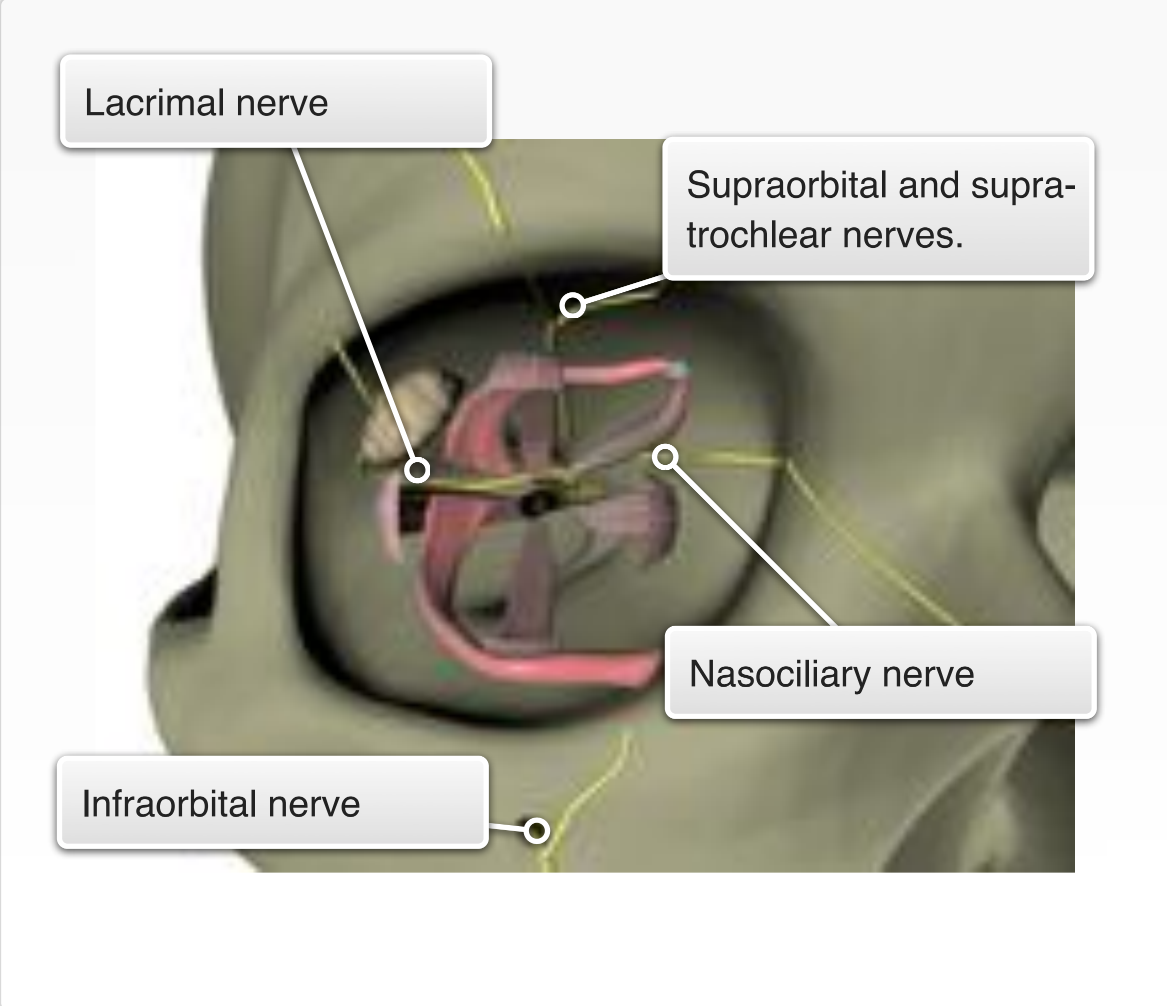
The globe and bulbar conjunctiva are innervated by the ophthalmic division of the maxillary nerve via the long and short ciliary nerves from the ciliary ganglion. All commonly used local blocks anesthetize these.

The tarsal conjunctiva is innervated by whichever branch of the trigeminal nerve innervates the overlying skin of the lid. For example the lower tarsal conjunctiva is largely innervated by the infraorbital nerve. This nerve does not actually travel pass through the orbit and is unaffected by a subtenons block. If a patient experiences lid pain during vitrectomy under subtenons anesthesia the block may be supplemented by a lid block.

Interactive 1.12 Innervation of the lids and tarsal conjunctiva



Interactive 1.13 Figure 1.33 The nerves in and around the orbit

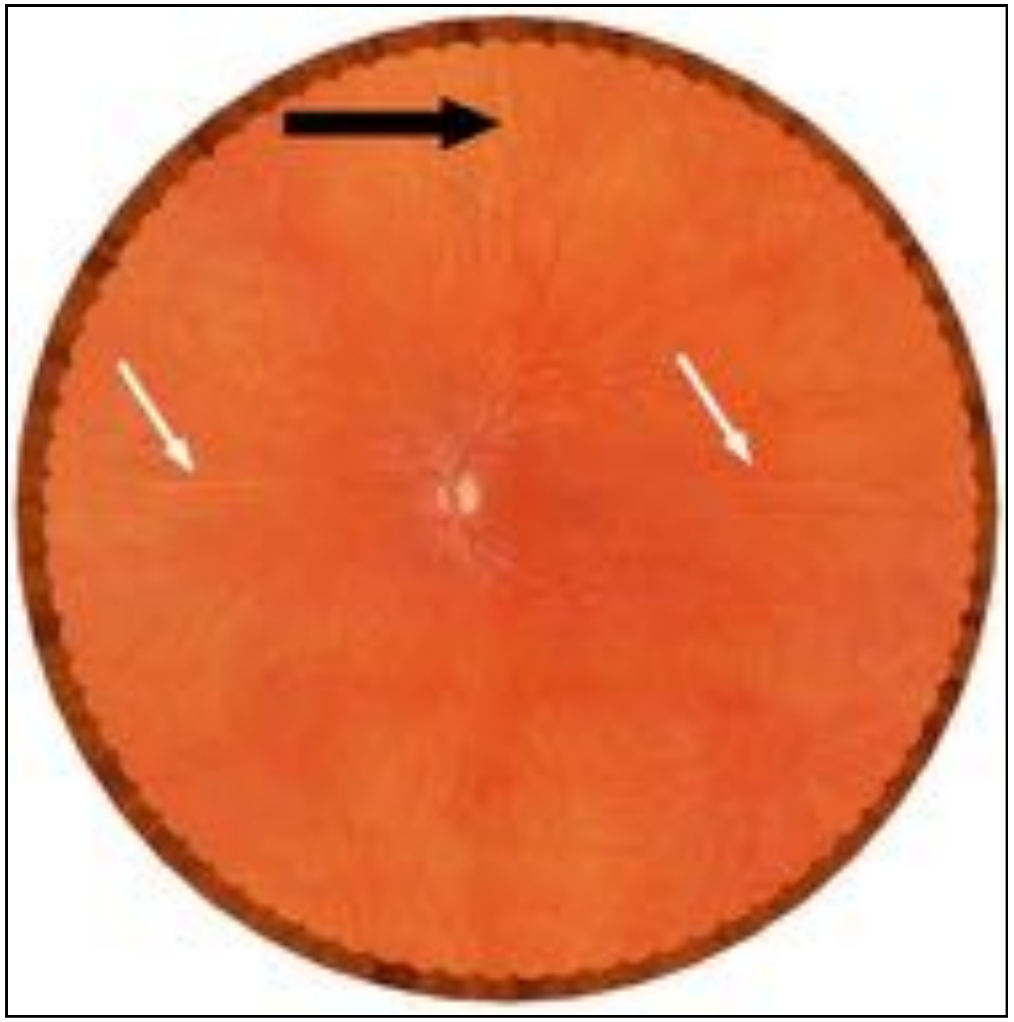


Ciliary nerves

The **long ciliary nerves** carry sensory fibers from the nasociliary nerve to the cornea. After they pierce the sclera they travel anteriorly with the long posterior ciliary artery at the 3 and 9 o'clock meridia where they are usually visible. They may be damaged by heavy laser photocoagulation resulting in severe neurotrophic ketaratopathy.

The **short ciliary nerves** carry sympathetic and parasympathetic fibers from the ciliary ganglion to the iris muscles. The may be difficult to identify as their position is variable and they become visible more anteriorly than the long ciliary nerves. Thermal injury from laser may cause a dilated pupil with loss of accommodation.

Figure 1.35 Ciliary nerves



The white arrow indicates the location of the long ciliary nerves at 3 and 9 o'clock. There are usually several short ciliary nerves. They are not always easily visible but the dark arrow indicates the position of one of them.

Figure 1.34 Neurotrophic keratopathy after heavy photocoagulation

Knowledge Review

Review 1.1 Surgical Anatomy

Question 1 of 5

The arrows indicate

- **A.** The vortex veins
- **B.** The long posterior ciliary arteries

◀ Check Answer ▶

CHAPTER 2

Clinical assessment

It is assumed that the reader is competent in basic clinical ophthalmic examination. Some principles that are of particular importance are described very briefly here. In any patient undergoing vitreoretinal surgery one should also be alert for conditions, such as glaucomatous optic neuropathy, that may influence management decisions.

Examination of the vitreous

The significance of pigment in the vitreous has been described previously.

The presence of a vitreous detachment has major implications in planning surgery.

The presence of a **Weiss ring** indicates detachment of the vitreous from the optic nerve. An important caveat is that there may be some residual vitreous collagen remaining on the surface of the retina (**vitreoschisis**).

Interactive 2.1 Weiss Ring in PVD

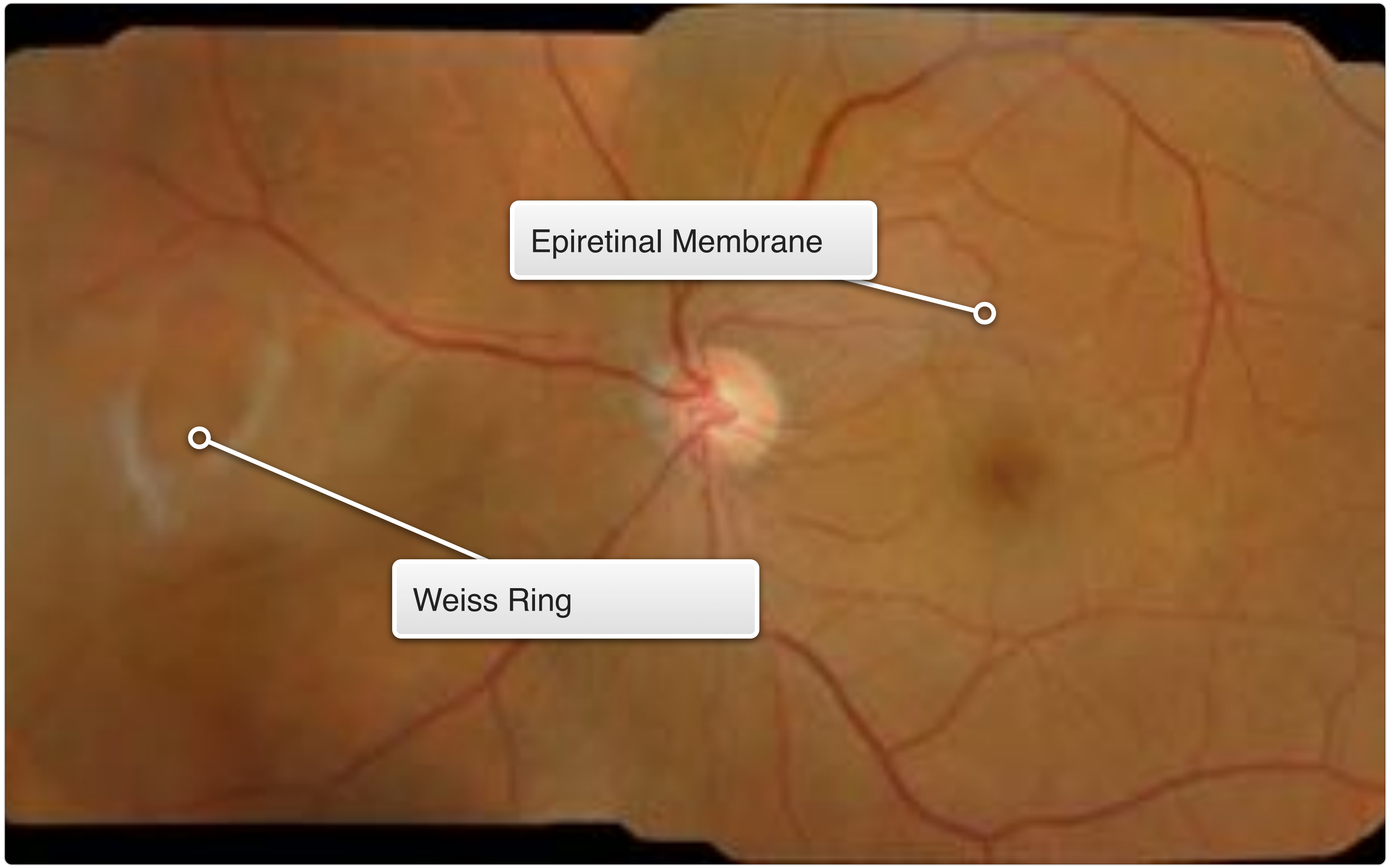


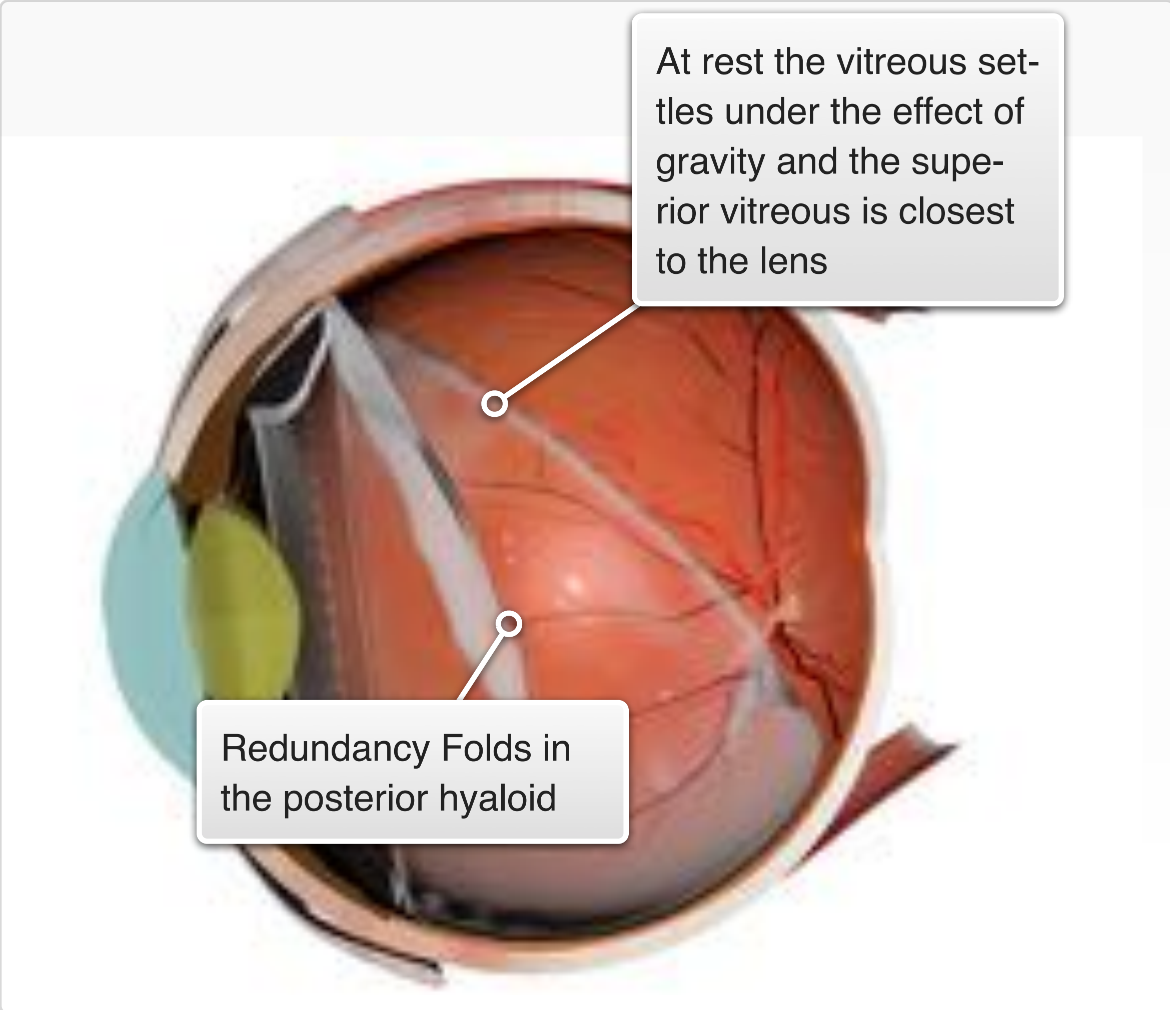
Figure 2.1 Weiss Ring

The Weiss ring may be some distance from the disc due to collapse and folding of the posterior hyaloid membrane.

A Weiss ring may be difficult so see if the vitreous body has collapsed as it may be some way from the optic disc and may have lost its ring shape.

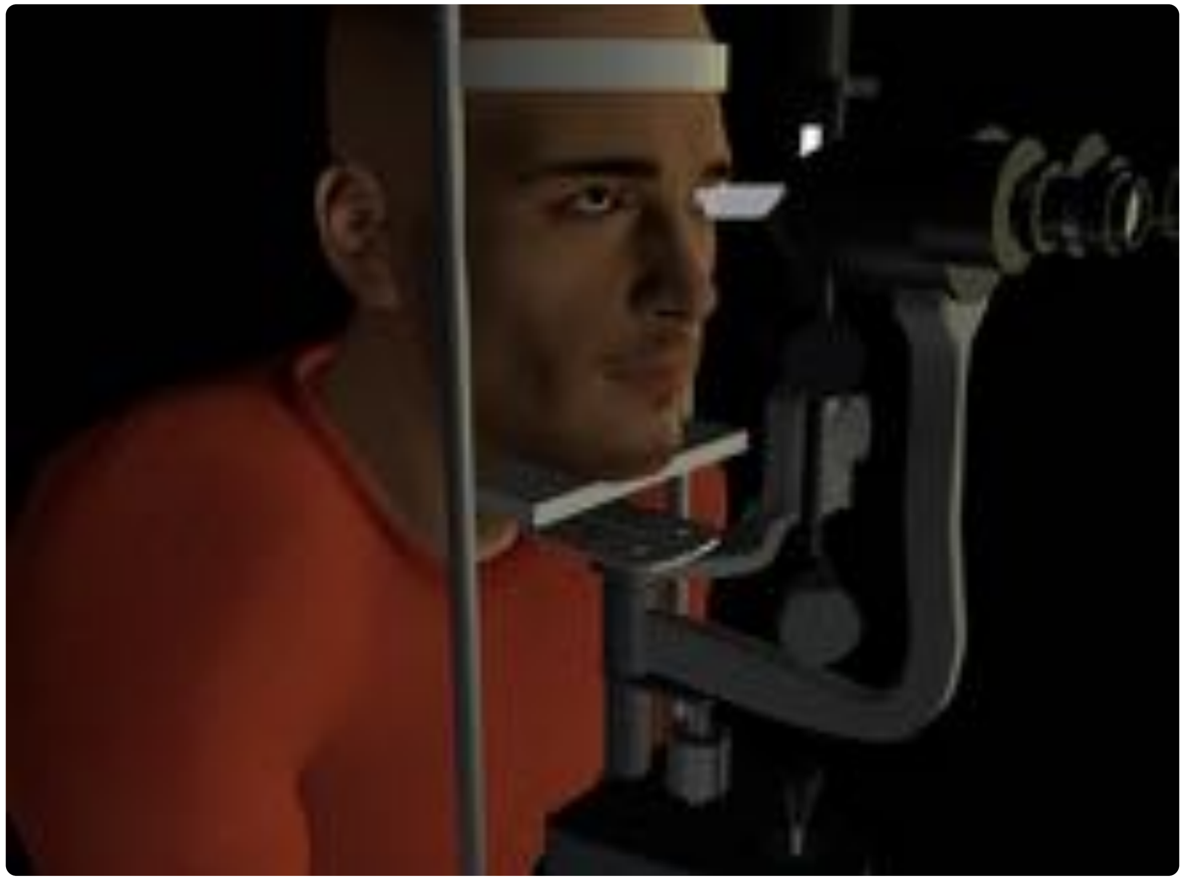
In this situation the posterior hyaloid membrane may be visualized using slit lamp biomicroscopy. Due to its inelasticity the posterior hyaloid membrane develops marked redundancy folds when it collapses from the surface of the retina. It is easiest to see superiorly where, due to the effect of gravity, it is closest to the lens.

Interactive 2.2 Pleats in the posterior hyaloid

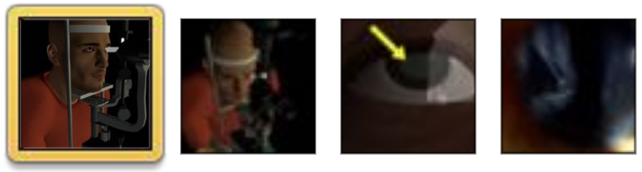


The detached posterior hyaloid may therefore be viewed on the slit lamp by asking the patient to look steadily upwards. No condensing lens is used. The illumination beam diameter is reduced to a narrow slit and it is offset by about 20°. After focusing on the patient's lens the slit lamp is advanced slightly towards the patient so that the anterior vitreous comes into view. After the vitreous comes to rest the posterior hyaloid may be seen as a pleated sheet.

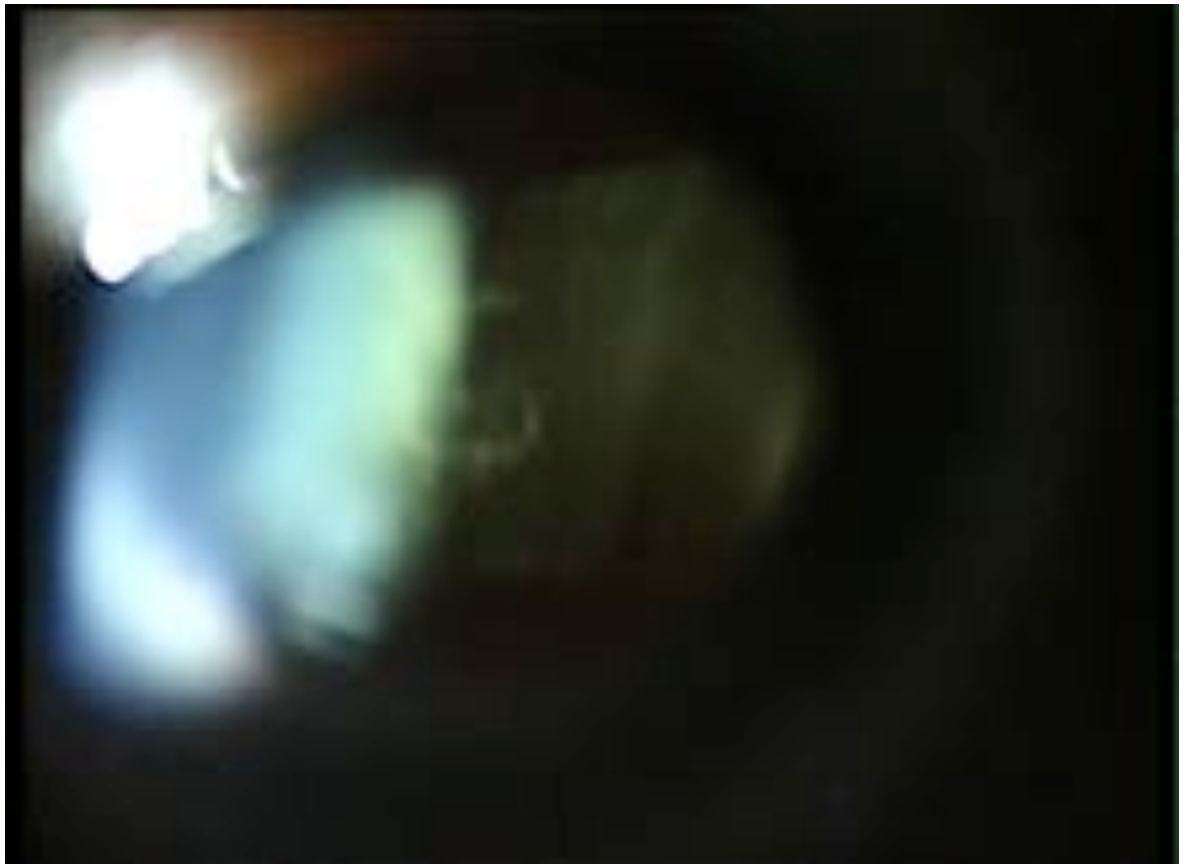
Figure 2.2 Biomicroscopic assessment of vitreous detachment



The patient is asked to look up.



Movie 2.1 The posterior hyaloid face seen on a slit lamp



Notice the redundancy folds formed when this inelastic structure collapses away from the retina.

Indirect ophthalmoscopy

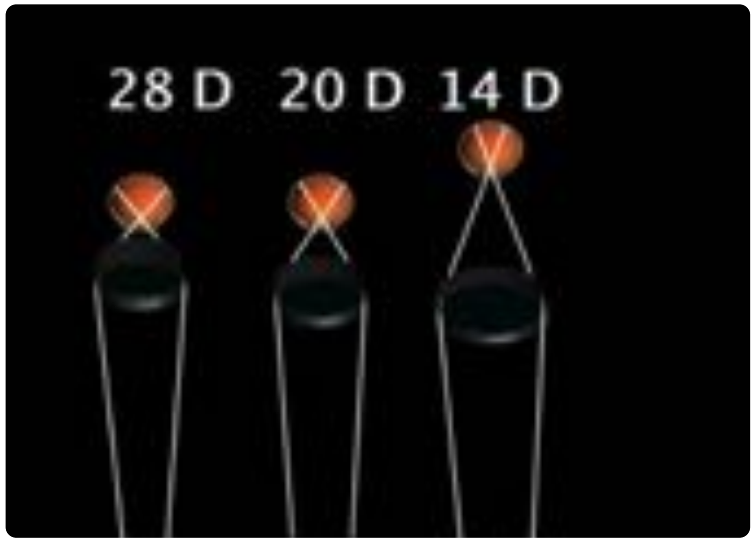
Binocular **indirect ophthalmoscopic** examination has a number of advantages including a wide field of view and the ability (with indentation) to view the anterior retina.

Optically the condensing lens produces a laterally inverted real image between the observer and the condensing lens.

Condensing lenses of different dioptric powers are available. The higher the dioptric power of the lens:

- The wider the field of view.
- The lower the magnification.
- The closer it has to be held to the subject's eye.

Figure 2.3 Indirect Condensing lenses



Note the effect of power on field of view and distance from the subject's eye.

Figure 2.4 Simplified optics of the indirect ophthalmoscope

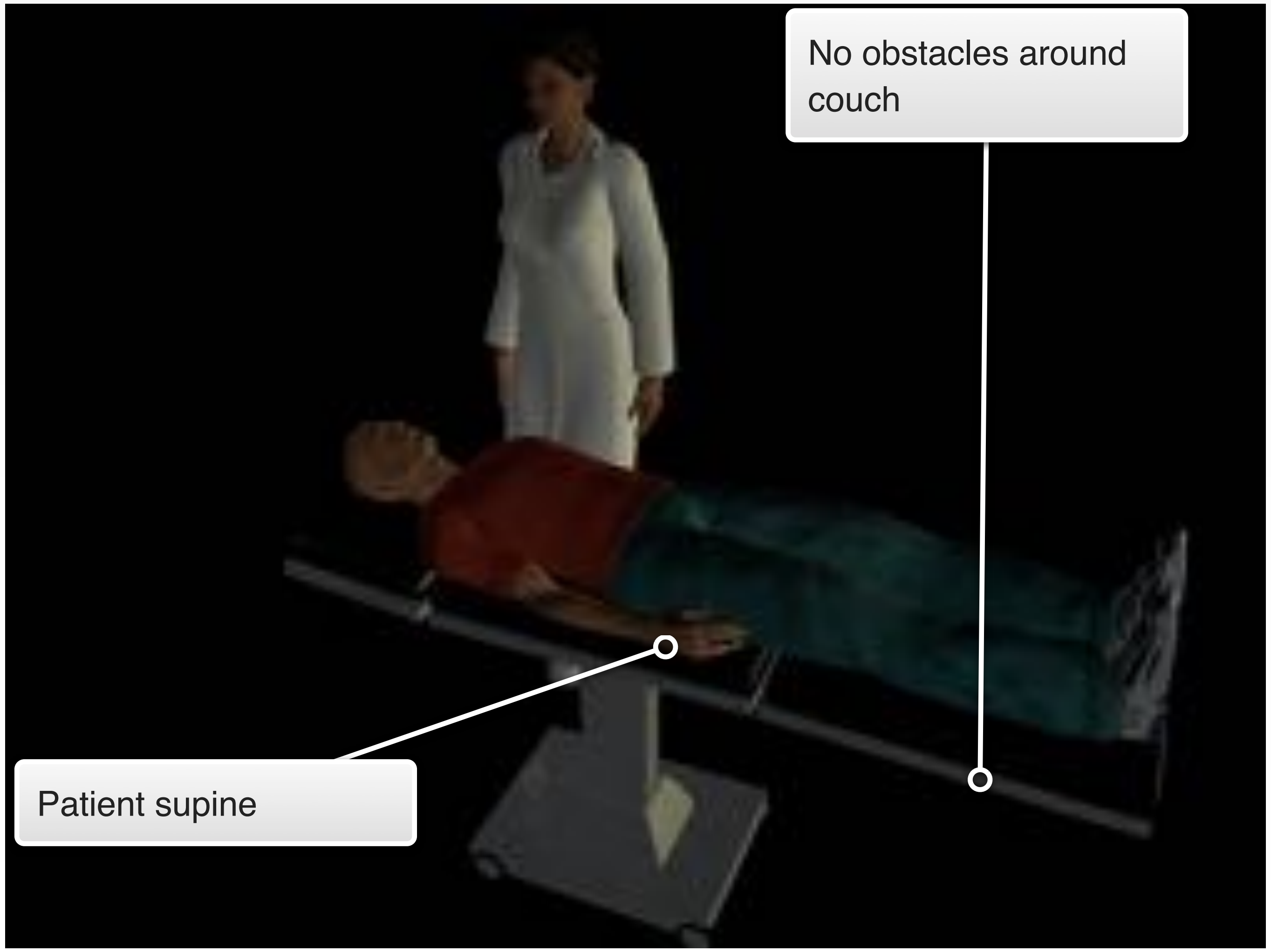
Note that the rays cross over i.e. the image is horizontally inverted.

Good indirect ophthalmoscopy technique helps to visualize the retina clearly. It is also important in preventing lumbar and cervical degenerative changes which are prevalent among vitreoretinal surgeons.

The patient should be lie on a couch or reclinable chair. The ideal position of the head is prone at approximately the level of the examiner's waist.

The examiner needs to be able to move freely around the patient in order to examine the whole retina.

Interactive 2.3 Positioning for indirect ophthalmoscopy

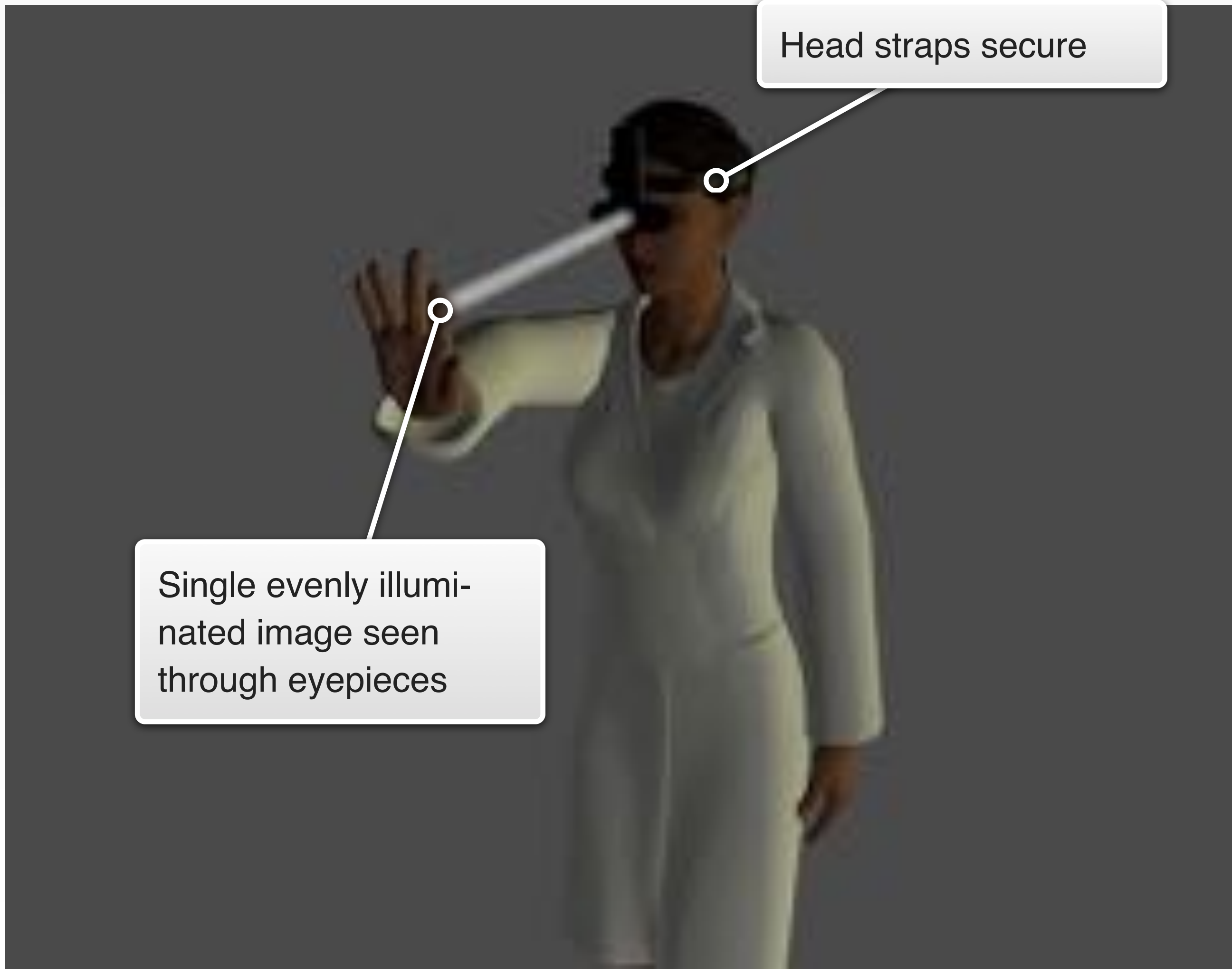


USING THE INDIRECT OPHTHALMOSCOPE : STEP 2

The **indirect ophthalmoscope** is placed on the head and the tension in its coronal and transverse straps adjusted.

The inter-pupillary distance of the eyepieces is the adjusted and the angle of the illumination altered by rotating a small mirror so that a single evenly illuminated image is seen through the eyepieces.

Interactive 2.4 Adjusting the indirect ophthalmoscope.



USING THE INDIRECT OPHTHALMOSCOPE : STEP 3

The ophthalmoscope is directed at the patient's eye so that the eye so that it is visible through the indirect ophthalmoscope. The condensing lens is then moved into the field of view.

Patients often find the brightness of the light uncomfortable initially. They may close their eyes and look up (Bell's phenomenon). For this reason the superior retina is examined first. After about a minute patients accommodate to the light and find it easier to look in other directions. No attempt is made to perform scleral indentation at this stage.

If patients find it difficult to look in the desired direction it they are ask them to look at their hand which is then moved.

Figure 2.5 Initial retinal examination

It is easier to examine the superior retina first. Note the use of the hand as a mobile fixation point.

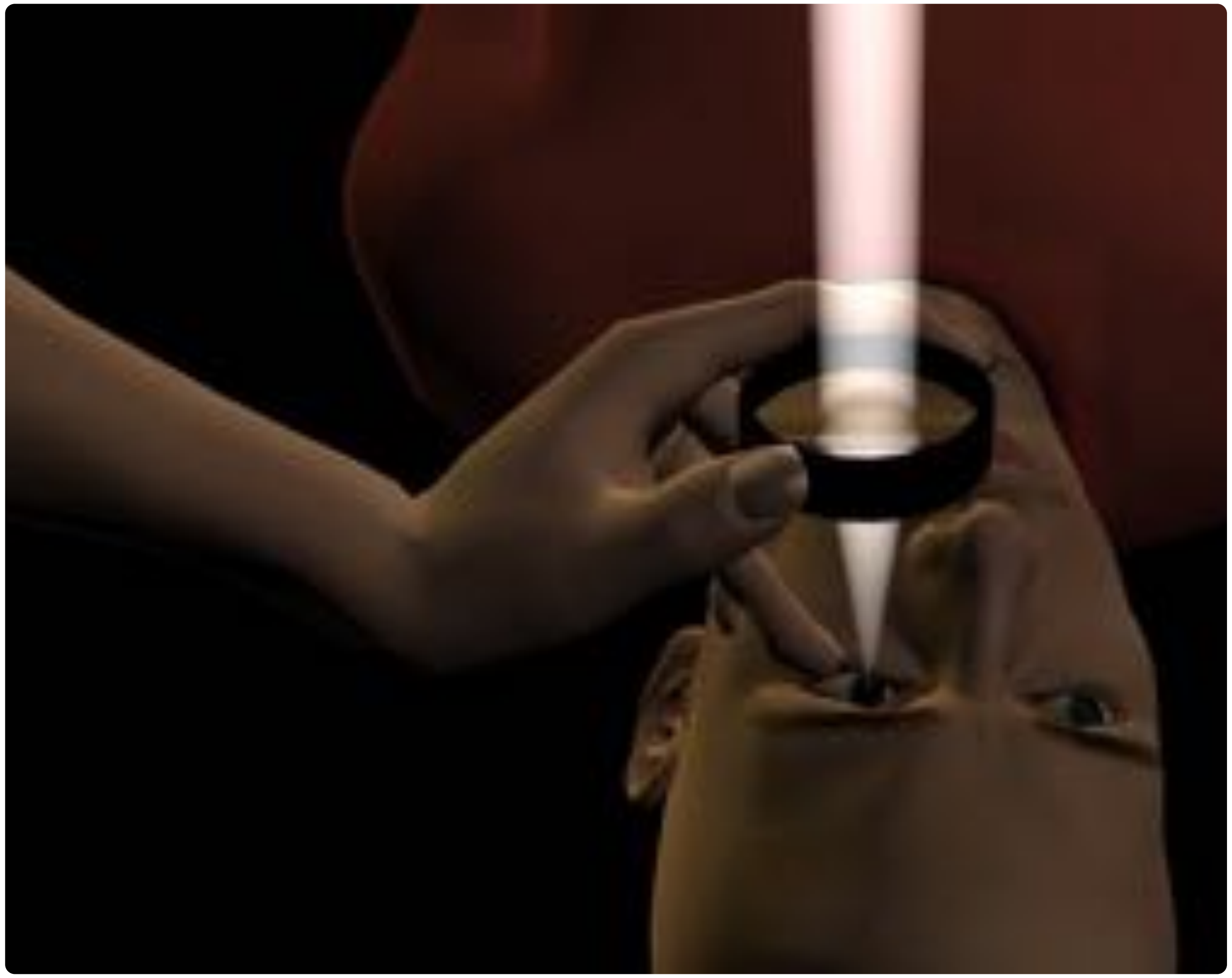
USING THE INDIRECT OPHTHALMOSCOPE : STEP 4

The condensing lens should be held gently between the thumb and first finger. This leaves the other fingers free to rest gently on the patient's cheek, stabilizing the lens. One of the other fingers may be used to very gently retract the patient's eyelid if this is obscuring the view. While moving around the patient to examine the retina the hand holding the lens is alternated.

In the correct position the illuminating light from the condensing lens should come to a focus near the nodal point of the eye. For a 20 Dioptre lens this implies the lens should be about 5 cm from the cornea. Common mistakes include:

- Holding the lens too near or too far from the cornea.
- Failure to stabilize it so that it moves from side to side causing vignetting of the image.

Figure 2.6 Holding the condensing lens



Note the light comes to a focus in the pupil and the left ring finger finger rests gently on the lower lid to retract the lower lid. Note also the ring finger resting on the cheek to stabilize the lens and maintain alignment.

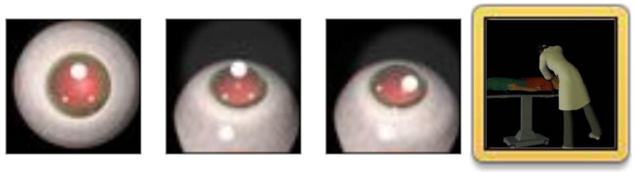
USING THE INDIRECT OPHTHALMOSCOPE : STEP 4

To examine the retina the examiner's head is inclined at a 45° angle. This is because the pupil becomes more elliptical as the peripheral retina is examined.

This is best accomplished by lifting one leg from the floor pivoting at the hip.

Figure 2.7 Light paths into the eye

This tilting is achieved by a combination of flexion and rotation of the neck, flexion of the lumbar spine and shifting most of the weight onto one leg (even taking one foot of the floor on occasion).

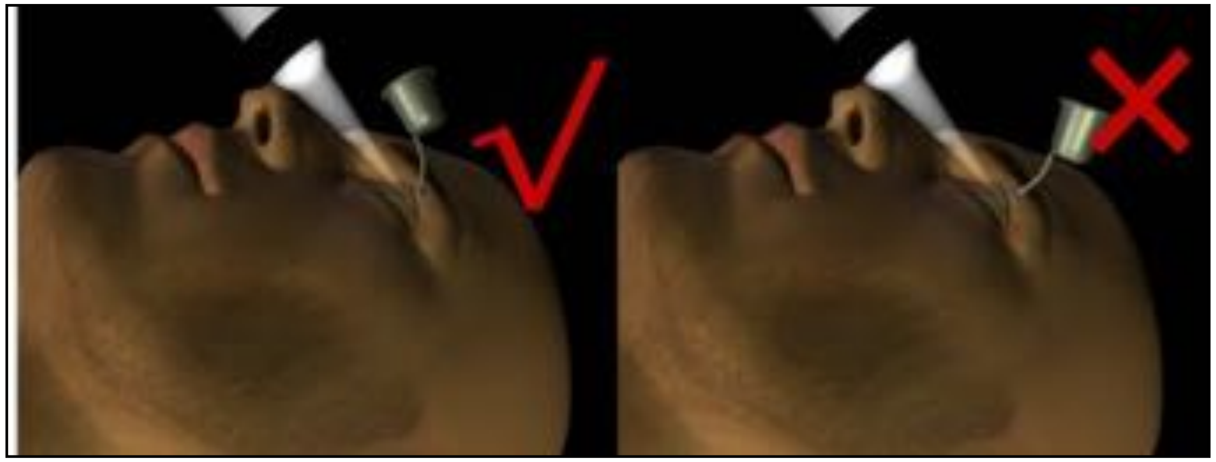


Scleral indentation

The steps taken to perform scleral indentation effectively and without hurting the patient are illustrated here.

Figure 2.8 Scleral Indentation

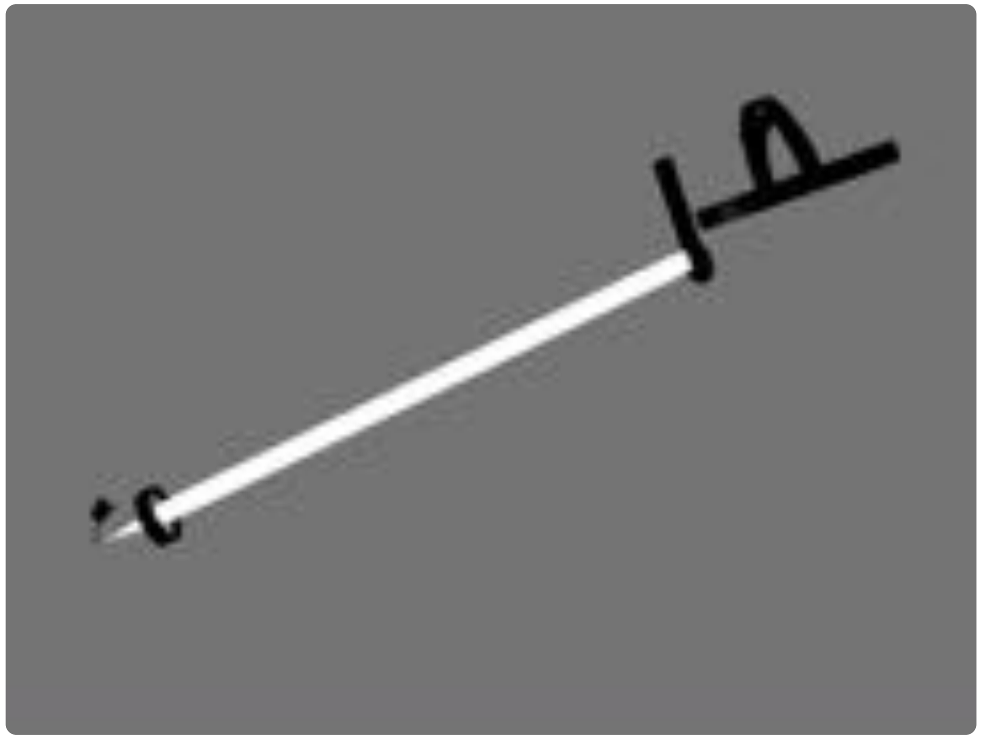
This sequence of images shows the steps in performing scleral indentation in the superotemporal quadrant of the left eye.



The indent should be held tangentially - a common mistake is to hold it too vertically.

The ophthalmoscope, the lens and the indenter should be aligned with each other. Failure to do this is a common mistake while learning indentation.

Figure 2.9 Alignment during scleral indentation



The tip of the indenter,the condensing lens and the indirect ophthalmoscope need to be aligned.

Indirect ophthalmoscopy is particularly challenging when the pupil is small. Some ophthalmoscopes have a small pupil setting in which the paths of light can be adjusted.

Figure 2.10 Small pupil adjustment

Note that the paths of light are closer together in the eye on the right.

Knowledge Review

Review 2.1 Indirect ophthalmoscopy

Question 1 of 3

When using the indirect ophthalmoscope, the stronger the condensing lens:

A. The closer it is held to the cornea.

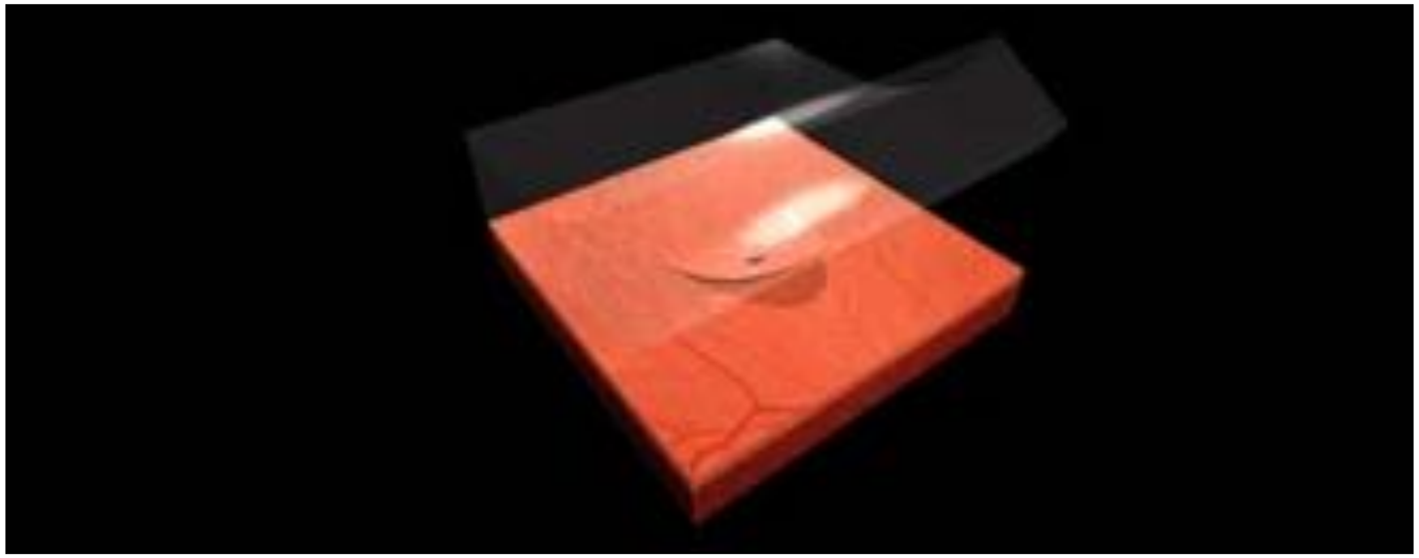
B. The higher the magnification is.

C. The narrower the field of view is.

Check Answer

CHAPTER 3

Pathogenesis and prevention of retinal detachment



Rhegmatogenous retinal detachments occur due to breaks in the neurosensory retina. These in turn are caused by degenerative changes in the vitreous and retina. Prophylactic treatment is highly effective in preventing retinal detachment in patients with tractional retinal tears.

Vitreous degeneration

The vitreous is a gel. Like all gels it is prone to degeneration: separation of its solid and liquid phases. The terms synchysis and syneresis are used in inconsistent and confusing ways to describe this process. The term **synchysis** (*"to mingle or confuse" Gr*) is generally used to describe the early stage of liquefaction. **Syneresis** is a term used by chemists to describe the extraction of liquid from a gel. In ophthalmology it generally implies that there has been more significant liquefaction with collapse of the vitreous.

The etiology of **posterior vitreous detachment** (PVD) is unknown but it may follow the development of a break within the posterior hyaloid membrane that allows access of fluid from the lacunae into the retro hyaloid space. While progressive degeneration of the vitreous occurs throughout adult life posterior vitreous detachment has been thought, on the basis of the typically acute presentation, to be a rapidly evolving condition. Optical coherence tomography has demonstrated slow progression of PVD starting at the posterior pole in some patients.

Following vitreous detachment the vitreous body is free to move within the eye. Saccadic eye movements generate tractional forces on the remaining points of attachment to the retina (dynamic traction).

Figure 3.1 Syneresis and vitreous detachment.

Initially small pockets of fluid appear in the vitreous (synchysis).

Movie 3.1 Movement of the eye and vitreous

This generates traction on remaining points of vitreoretinal adhesion such as the posterior border of the vitreous base.

Flashing lights (photopsia) and **floaters** are the typical symptoms of posterior vitreous detachment.

Photopsia due to vitreous detachment are typically experienced in the temporal visual field and are more noticeable in the dark. This contrasts with photopsia from other causes such as migraine. Migrainous photopsia are often colored, seem to sparkle (scintillation) and are associated with visual obscuration. A careful history is therefore helpful in the assessment of the patient complaining of flashing lights.

Floaters due to PVD may be particularly marked if the tear involves a retinal blood vessel with resulting vitreous hemorrhage. Not all patients presenting with floaters have PVD. Many young myopic patients complain of troublesome floaters due to mild syneresis. Floaters may also be a symptom of other eye disease, particularly uveitis.

All patients with PVD should undergo thorough examination of the peripheral retina for retinal breaks.

Figure 3.2 Anterior segment examination in patients with floaters

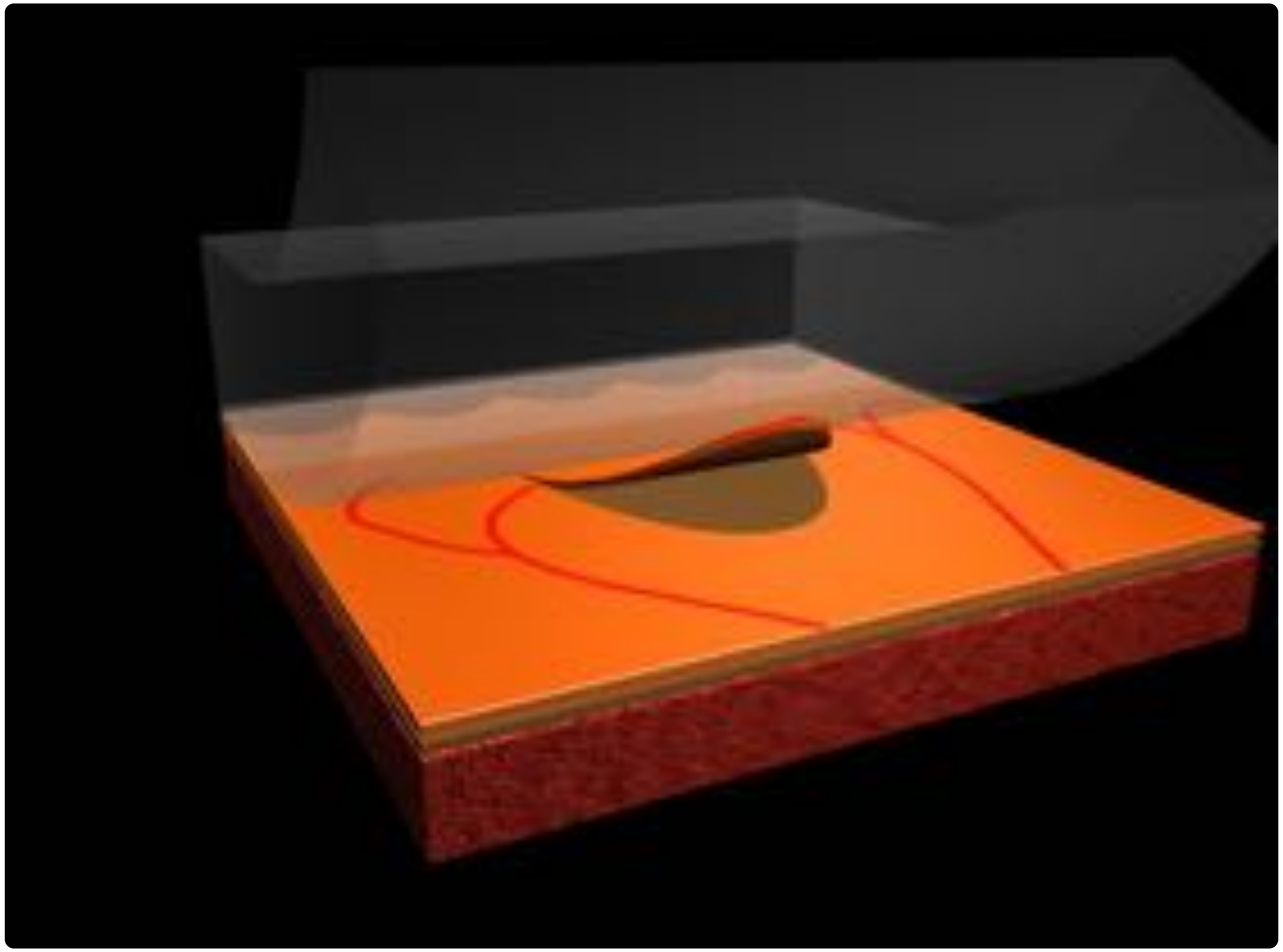
Not all patients with floaters have vitreoretinal problems.

Retinal breaks

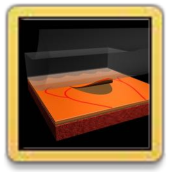
TRACTIONAL TEARS

Following vitreous detachment the retina may tear at points of vitreoretinal adhesion. Typically these adhesions are continuous with the vitreous base. The tearing extends to the vitreous base which gives the tear a horseshoe (or 'U') shape. The portion of retina that remains adherent to the vitreous is the **operculum** (*"lid", La*). The operculum is subject to on going traction from movements of the vitreous. If the vitreoretinal adhesion is behind the vitreous base the operculum may detach completely (operculated tear). If an operculated tear is distant from the vitreous base there is no dynamic traction on the tear and progression to retinal detachment is unlikely.

Figure 3.3 Tractional tears



Horseshoe tear extending to the vitreous base.



ATROPHIC RETINAL HOLES

These occur due to atrophy of the retina, independently of vitreous detachment.

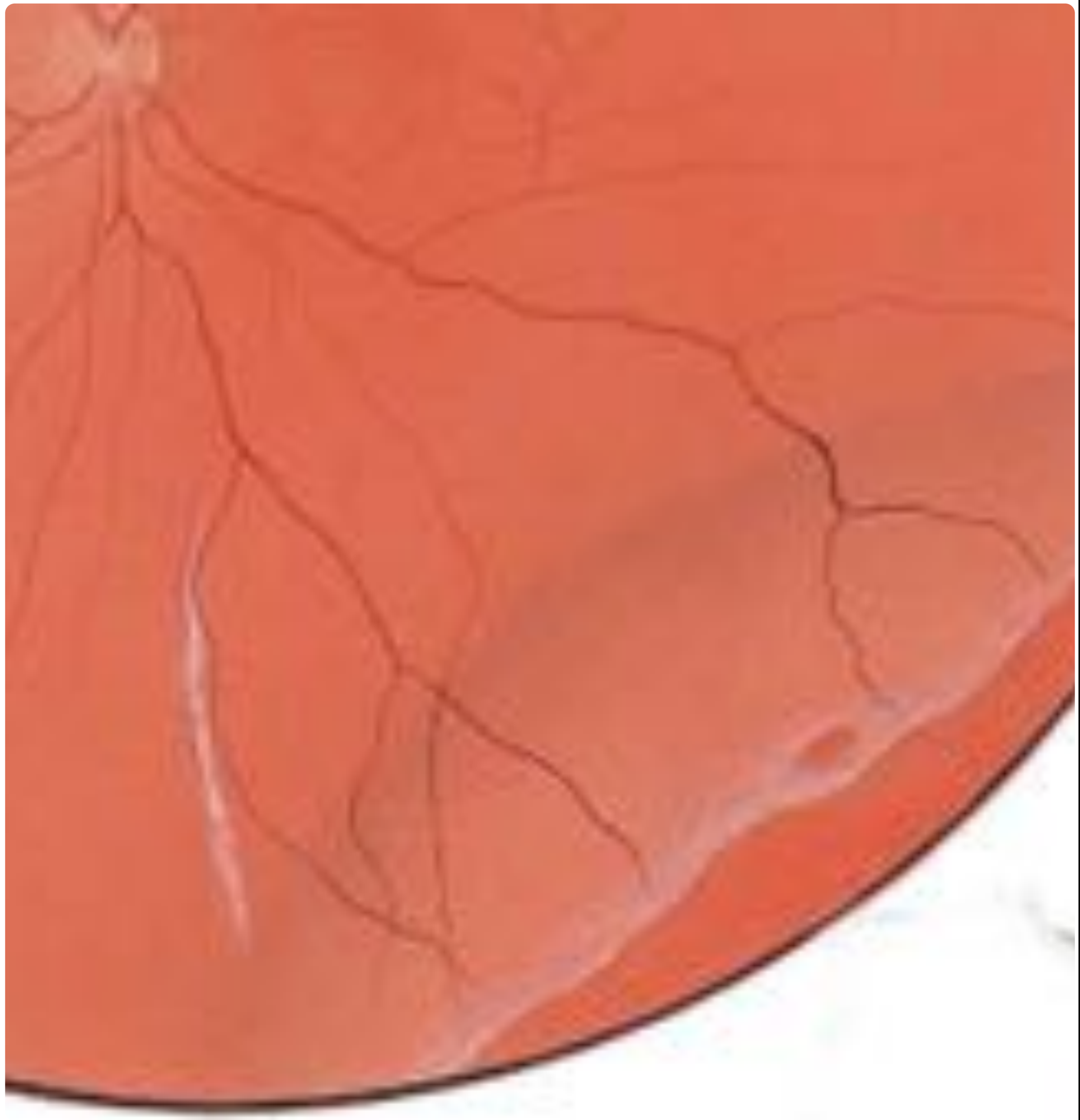
RETINAL DIALYSIS

Circumferential breaks near the ora serrata. There is no vitreous detachment in contrast to a giant retinal tear.

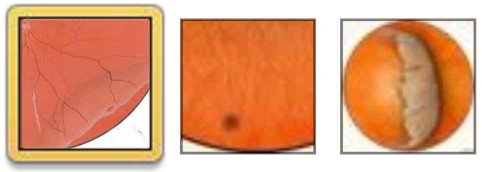
GIANT RETINAL TEAR

A large tear extending more than 3 clock hours. Unlike retinal dialysis a vitreous detachment is present. Movements of the flap are not dampened by attached vitreous and are subject to rotational fluid currents as the eye moves. The flap of the tear therefore appears very mobile.

Figure 3.4 Types of retinal break



Atrophic hole.



Retinal degenerations and breaks

Figure 3.5 Lattice degeneration

Lattice degeneration (drawing by Mr T Tarrant).

Lattice degeneration is a peripheral vitreoretinal degeneration of unknown etiology. The appearance is variable but generally includes the criss-crossing white lines that give the condition its name and varying degrees of pigmentation. **Snail track degeneration** (ovoid areas of tightly packed small white dots) is probably a variant of lattice degeneration.

Pathologically lattice lesions consist of atrophic areas of retina surrounded by vitreoretinal adhesions and overlying pockets of liquid vitreous.

Retinal breaks may form in lattice lesions in one of two ways:

- Tractional tears on the borders of the lattice lesion following PVD. Approximately 1/3 of retinal tears are associated with lattice degeneration.
- Central atrophic holes within the lattice lesion.

Interactive 3.1 Pathology of a lattice lesion

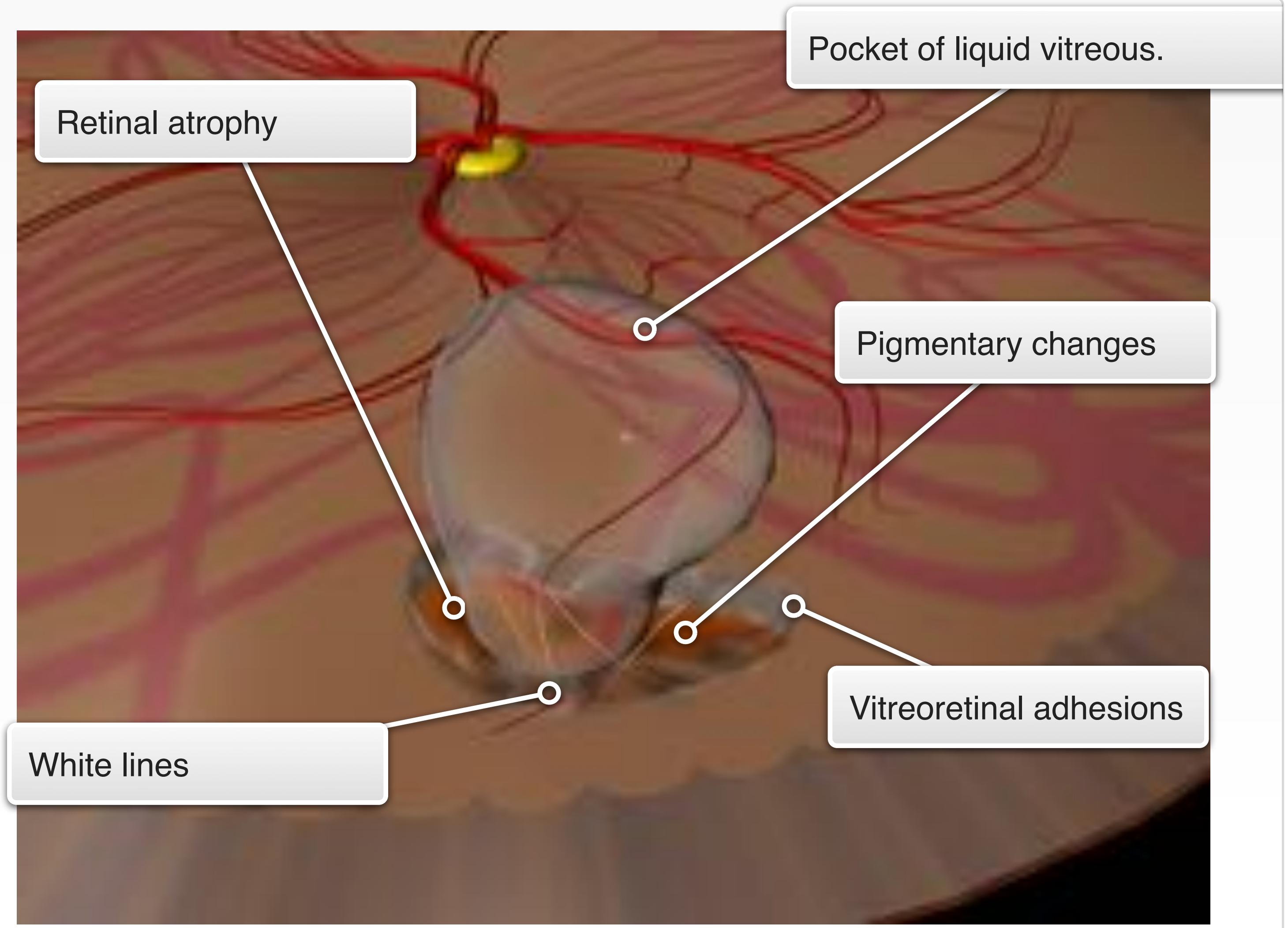
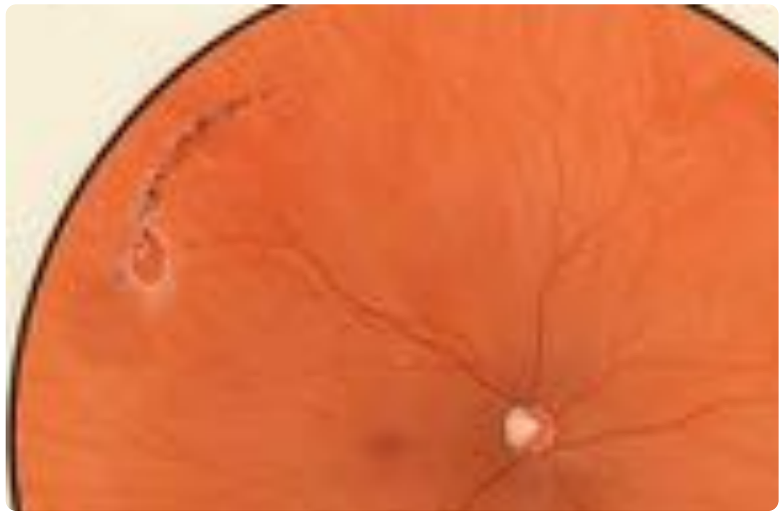


Figure 3.6 Retinal breaks in lattice lesions



Retinal tear along the borders of a lattice lesion following PVD. Painting by Mr Terry Tarrant.

Some of normal variants in the anatomy of the vitreous base already described may be confused with retinal breaks. Some of these, such as cystic retinal tufts and zonular traction tufts, may affect the vitreous base and therefore be associated with tears if the vitreous detaches.

Pavingstone degeneration is characterized by round or oval areas in the pre-equatorial retina in which the pigment epithelium is depigmented and the underlying choroid is more easily visible. It is an outer retinal condition which does not affect the vitreous and is not associated with, although sometimes confused with, a retinal break.

Reticular ('net like') degeneration is an outer retinal degeneration with net like areas of hyper-pigmentation. It is an aging change associated with macular degeneration but is sometimes confused with lattice degeneration. It is not associated with retinal breaks.

Congenital hypertrophy of the retinal pigment epithelium (CHRPE) is, as its name suggests, hypertrophy of the pigment epithelium that is present at birth. It does not carry a risk of retinal detachment.

Figure 3.7 Other peripheral retinal degenerations

A cystic retinal tuft - a slightly elevated area of granular tissue in the vitreous base. Often mistakenly treated as a retinal tear. Unlike a tear the protruding area has volume and depth. Unlike tears they are not confined to the posterior border of the vitreous base and are often found in eyes with a PVD.

Development of retinal detachment

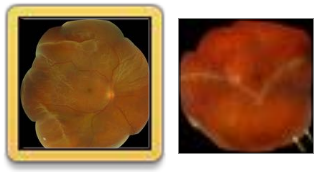
The retina detaches when the rate of fluid entry into the subretinal space exceeds that rate at which fluid can be pumped out of the subretinal space by the pigment epithelium.

Retinal detachments due to tractional tears may progress very quickly due to traction on the operculum of the break. Additionally the large volume of liquid vitreous behind the detached hyaloid face has direct access to the subretinal space via the tear. Gravity seems to play a role as superior detachments progress more quickly than inferior detachments.

Retinal detachments due to atrophic holes and dialyses typically progress more slowly. There is no traction on the break and recruitment of subretinal fluid via the formed vitreous is slow.

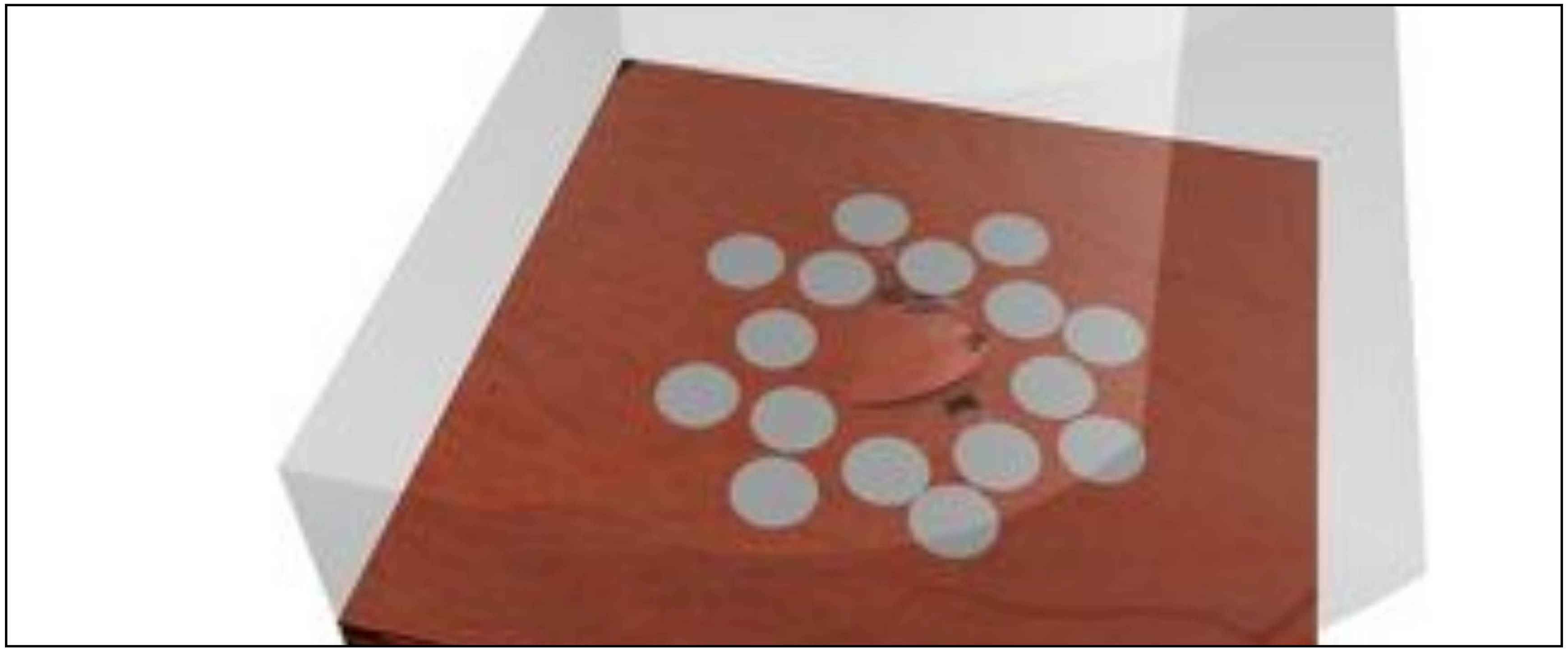
Figure 3.8 Development of retinal detachment from retinal breaks

A superior retinal tear with a rapidly progressive retinal detachment.



Prophylactic retinopexy - indications

Figure 3.9 Prophylactic retinopexy



Retinal tear treated with 2 rows of laser

Retinopexy, whether by cryotherapy or photocoagulation, is highly effective in preventing retinal detachment from retinal breaks and relatively safe.

The risk of detachment varies between different peripheral retinal lesions. In the absence of clinical trials natural history studies can be used to make rational decisions about treatment.

INDICATIONS FOR LASER RETINOPEXY

1. Tractional retinal tears

The risk of detachment in patients with symptomatic of retinal tears is high (34% in one study) and there is agreement that these should be treated. Symptomatic breaks in which the operculum has separated from the retina seem to carry a lower risk (approximately 16%).

2. Lattice Degeneration

Lattice degeneration is very common. In highly myopic patients the incidence may be as high as 33%. Furthermore between 72% and 79% of retinal tears occur in areas of retina that appear normal. Even in eyes with lattice lesions a significant proportion of tears occur in areas that appear normal (see figure), presumably due to areas of abnormal vitreoretinal adhesion without accompanying visible changes.

A very large study of lattice degeneration by Norman Byer showed that the risk of retinal detachment in patients with lattice degeneration is very low and prophylactic retinopexy in this group is no longer recommended. The term 'symptomatic lattice' is meaningless as lattice degeneration per se produces no symptoms. When a patient presents with vitreous detachment and lattice degeneration a very careful retinal examination should be performed to exclude tractional tears.

Figure 3.10 Retinal breaks outside areas of visible lattice degeneration

Prophylactic retinopexy to areas of visible lattice in this eye would not have treated all the tears that occurred when the vitreous detached.

3. Atrophic retinal holes

Atrophic retinal holes are very common. The risk of retinal detachment is very low. Very few physicians now treat these, irrespective of size or location.

Some have recommended treatment of all atrophic holes before cataract surgery. The rationale for this was the belief that pseudophakic retinal detachment occurred due to tiny pre existing atrophic holes; the detachment was believed to follow increased liquefaction of the vitreous leading to reduced viscosity of the vitreous and increased flow through the breaks. With increasing use of vitrectomy surgery to manage pseudophakic retinal detachment it has become possible to view breaks under the operating microscope. It has become clear that in most cases the causative breaks are tiny flap tears, not preexisting atrophic holes. As there is no reason for believing that treatment of a preexisting hole should reduce subsequent development of tractional tears there is no logic in treating atrophic holes before cataract surgery.

4. Fellow eyes.

If one eye suffers a retinal detachment the retina in the fellow eye should be examined carefully. Most surgeons would treat tractional tears in the fellow eye.

There is no consensus on the value of prophylactic treatment to fellow eyes with lower risk lesions such as atrophic holes and lattice degeneration. One study suggested a statistically significant reduction (1.8% vs 5.1%) in retinal detachment in fellow eyes undergoing prophylaxis but there was no observable difference in highly myopic eyes or those with extensive lattice degeneration. Much of the published literature consists of retrospective studies in which important data such as the state of the vitreous is not analyzed. There is also considerable potential for bias in studies where the rate of detachment is compared between different groups. For example in the Iowa study, probably the most informative study to date, phakic eyes which received retinopexy had many more pre-existing tears than the control eyes that did not receive treatment. This suggests that the prevalence of PVD at baseline differed in the treatment and observation groups.

Whether one believes that fellow eye prophylaxis is effective or not there seems little logic in treating lattice degeneration in a fellow eye that already has a PVD as new tractional tears are unusual more than 5 weeks after vitreous detachment.

5. Fellow eyes of giant retinal tears

Fellow eye prophylaxis has also been advocated for the fellow eye of patients with giant retinal tears. Less than half of patients in one study received 360^0 prophylaxis to the fellow eye. One study reported a very low incidence of fellow eye involvement with long term follow up following peripheral cryotherapy. The comparison was made with historical control groups. As Norman Byer has pointed out historical studies of bilateralization were often very high (Prophylaxis in Fellow Eye of Primary Retinal Detachment: What Not to Do and What to Do in Primary Retinal Detachment: Options for Repair ; Springer 2005). A review of the literature found inadequate evidence to support or refute fellow eye prophylaxis in giant retinal tears.

6. Hereditary vitreoretinopathies

Detachments in Stickler syndrome are often sequentially bilateral and difficult to treat. This has lead a group with much experience of this condition to advocate routine performance of 360º retinopexy in these patients. A review of the evidence of treatment efficacy concluded that there was a high risk of bias in the studies carried out to date and a need for further data before firm treatment recommendations could be made.

Prophylaxis - techniques

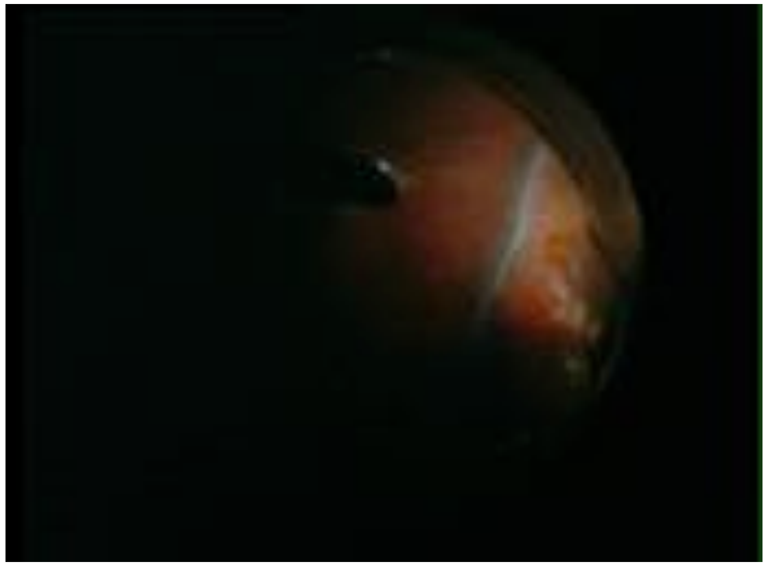
The use of wide field contact lenses makes it possible to treat many retinal breaks by slit-lamp photocoagulation. The aim is to surround the tear with at least 3 rows of non contiguous laser spots (as a minimum). For anterior breaks treatment may need to be delivered 'ora to ora'. Treatment of anterior tears may be easier with indirect laser retinopexy.

The principles of cryotherapy are described in greater detail in the chapter on scleral buckling. It is helpful if the patient retains the ability to move the eye so subconjunctival anesthesia is preferable to a complete regional block.

Figure 3.11 Retinopexy by photocoagulation

Indirect laser photocoagulation of a peripheral break. This technique is relatively simple to perform once mastery of scleral indentation has been achieved and can be used to treat very anterior breaks.

Movie 3.2 Anterior tear



Note that the treatment extends to the ora on either side of the break, which had been treated with indirect laser. The retinopexy had been successful and the eye was undergoing vitrectomy for an epiretinal membrane.

Failure and complications of retinopexy

Prophylactic retinopexy seems to be a relatively safe procedure but there are few effective medical interventions completely without risk.

The development of epiretinal membrane formation following retinopexy may not be a causal relationship. Posterior vitreous detachment causes both retinal tears and epiretinal membranes. Epiretinal membranes are frequently found in association with untreated retinal tears.

An important issue which has not been completely resolved is the safety of prophylactic therapy in eyes with attached vitreous. This is particularly important if the patient is completely asymptomatic and the retinal lesions that are being treated carry relatively low risk. Even a small risk of complications may be unacceptable in this situation. Retinal breaks that develop following retinopexy may be incidental, a consequence of excessive treatment or a rare and unavoidable complication of treatment.

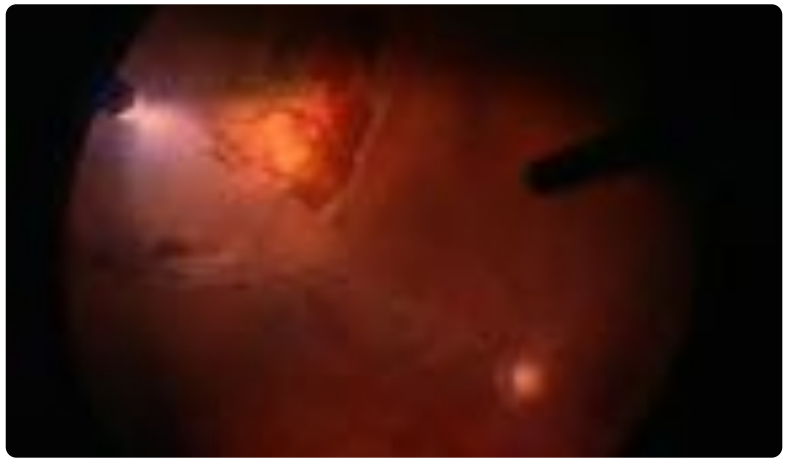
Failure may be partially attributable to the high proportion of breaks that occur in areas of retina that appear normal, even in eyes with coexisting lattice.

Heavy cryotherapy may cause retinal necrosis. This may lead to early retinal breaks ('cryonecrosis') which may also be seen with heavy laser. The author has personally seen a massive giant retinal tear develop immediately after 360^0 photocoagulation in the fellow eye of a young girl with Stickler syndrome. The RPE was pale (as it often is in such patients) and titration of the intensity of the laser burns was difficult. The resulting burns were very intense. The vitreous was attached and surgery to repair this was unsuccessful. Such tears have also been seen after fellow eye prophylaxis in giant retinal tears. MacKenzie Freeman stated that he had ‘seen a considerable number of eyes in which very serious, difficult-to-treat posterior giant retinal breaks have developed along the posterior margin of the treatment” (reference). There are a number of reports, particularly in the French literature, of similar cases which may relate to the enthusiasm with which 360 degree retinopexy had previously been advocated as a tool to eradicate retinal detachment.

Excessive cryotherapy and photocoagulation may also affect the overlying vitreous. Resulting vitreoretinal adhesions could account for the development of late vitreoretinal breaks around laser scars (see accompanying Figure).

Heavy photocoagulation around ciliary nerves may lead to a dilated pupil and loss of accommodation (short ciliary nerves) and neurotrophic keratopathy (long ciliary nerves).

Figure 3.12 Retinal breaks following prophylaxis



Retinal tears adjacent to old retinopexy

Knowledge review

Review 3.1 Retinal breaks

Question 1 of 3

Regarding flap tears (horseshoe tears, 'U' tears), the tear is located:

- **A.** Posterior to the vitreous base.
- **B.** At the posterior border of the vitreous base. ✓
- **C.** Within the vitreous base.
- **D.** May be at any one of the above positions.

Check Answer

Predisposing lesions

Question 1 of 3

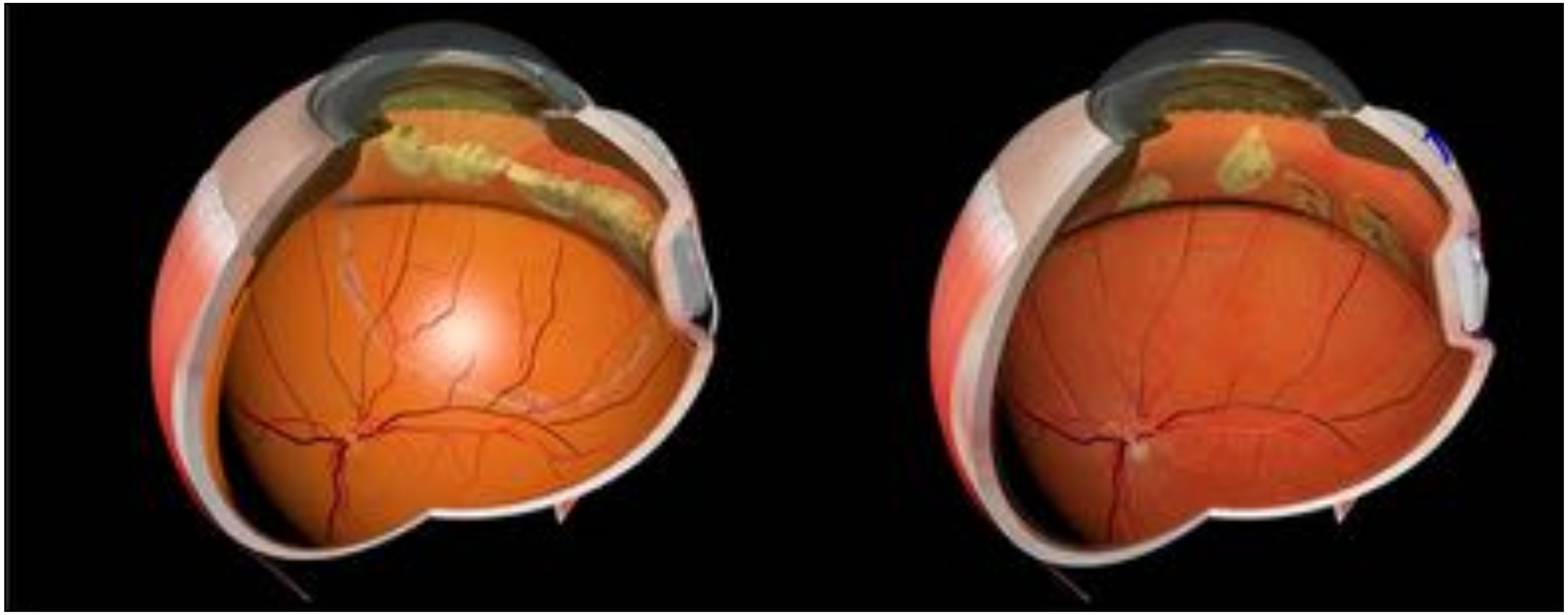
The risk of retinal detachment is significant in:

- **A.** Congenital hypertrophy of the retinal pigment epithelium.
- **B.** Pavingstone degeneration.
- **C.** Lattice degeneration. ✓

Check Answer

CHAPTER 4

Scleral Buckling



Vitrectomy is increasingly used to repair retinal detachments. However scleral buckling still has an important role particularly in the management of retinal detachments in younger patients without posterior vitreous separation. These include detachments due to retinal dialysis and atrophic retinal holes.

Overview and history of conventional detachment

There is a huge geographic diversity in the practice of retinal detachment surgery. For example in the UK and Australia it is common practice to suture a trimmed segment of a tire without an accompanying encircling band. Silicone tires were not designed to be used in this way (they have a central groove for an accompanying band, and were designed to be used as implants rather than explants). In some countries local buckling is considered the norm and encirclement exceptional and vice versa.

There are is also significant variation in terminology which may add to the confusion. For example in North America the term **buckle** is synonymous with an encircling element while this is not the case in the United Kingdom. In this chapter the term is used to refer to any episcleral explant, either local or encircling.

Some of the techniques described in this chapter will therefore be unfamiliar to some practitioners.

In order to make some sense of this variability in practice it is helpful to consider the historical development of conventional retinal detachment repair.

The father of modern retinal detachment surgery is Jules Gonin. His contribution to retinal surgery was the concept that retinal breaks were the cause of retinal detachment and not just a secondary consequence. Consequently his ignipuncture operation (in which retinal breaks were localized and the subretinal fluid drainage and chorioretinal adhesion were achieved simultaneously) was the first successful treatment. Many were initially skeptical when he published his findings.

Major landmarks since Gonin have included:

The binocular indirect ophthalmoscope.

Gonin had been forced to rely on the direct ophthalmoscope and a sophisticated system derived from the geometry and optics of the eye to derive the location of retinal breaks. The development of the binocular indirect ophthalmoscope by Charles Schepens allowed peroperative location of retinal breaks on the sclera.

Scleral tires

The concept of scleral buckling originally arose from a misunderstanding of the role of myopia in the development of retinal detachment.. The association between myopia and axial length was well known and it had been hypothesized that resecting part of the sclera could therefore cure a detachment. It was subsequently recognized that the effectiveness of this therapy was due to internal indentation of the wall of eye. Schepens developed solid silicone rubber elements that could be implanted within the sclera using lamellar dissection. The same elements are now used as explants with an accompanying band and in some cases as segmental explants without an accompanying band.

Cryotherapy

Schepens used transscleral diathermy within the bed of his lamellar dissections to achieve chorioretinal adhesion. Harvey Lincoff discovered that cryotherapy could be used transsclerally without lamellar scleral dissection.

Episcleral sponges

Harvey Lincoff was inspired by Custodis' work on episcleral elements. He developed sponges made of silicone rubber to replace the polyviol that Custodis had used and combined this with local transceral cryotherapy. The result was a highly successful operation that did not require subretinal fluid drainage or extensive surgery to areas without breaks. This was a return to Gonin's vision of treatment targeted at retinal breaks.

Local 'schools' of vitreoretinal surgery arose as clinicians took different techniques, combined them in different ways and passed on their ideas. A common example is the use of binocular indirect ophthalmoscopy (Schepens), trans-scleral cryotherapy (Lincoff) and silicone tires with an encircling band (Schepens). Others (including those who trained the author) took the concept of local buckling (Lincoff) and applied it to tires (Schepens). Confirmation bias has resulted in somewhat entrenched attitudes to best practice. This chapter attempts to reflect the resulting diversity impartially.

Preoperative management

The general principles of examination of the retina and vitreous are described in Chapter 2. Two elements of the preoperative assessment are worth emphasizing:

- The need to exclude non rhegmatogenous retinal detachment.
- The location of the retinal break(s). The position of occult breaks can be predicted from the distribution of subretinal fluid using Lincoff's rules.

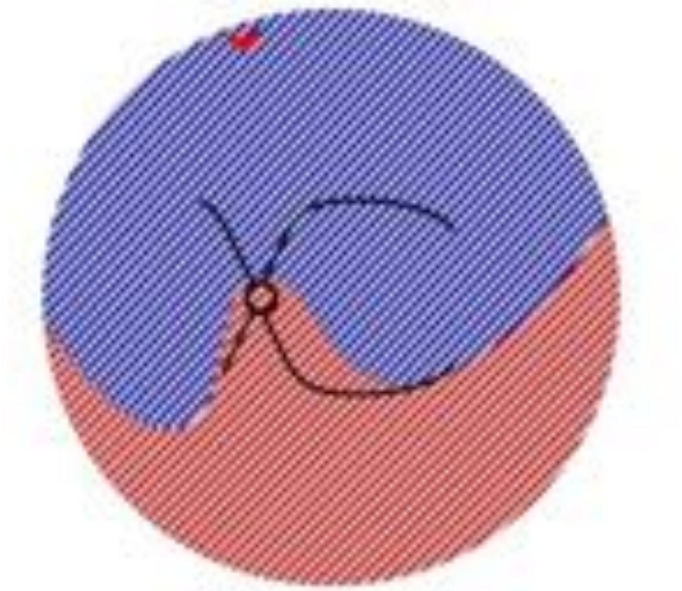
The patient should be examined thoroughly using both slit lamp biomicroscopy and indirect ophthalmoscopy (frequently both techniques being used in alternation). Slit lamp coupling gels interfere with the indirect ophthalmoscopic view and should not be used just immediately before surgery.

When abnormal areas are detected by indirect ophthalmoscopy there may be uncertainty whether they are full thickness breaks. These areas may be examined by retroillumination using a condensing lens on the slit lamp. This is used to distinguish between breaks, atrophic areas and hemorrhages.

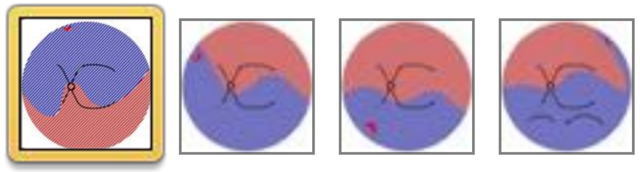
Figure 4.1 Transillumination of retinal breaks

The slit beam is shone to one side of any suspicious areas to see how they retroilluminate. Retinal hemorrhages (top) appear dark, retinal breaks (bottom) transilluminate brightly and atrophic areas (middle) transilluminate to a limited degree.

Figure 4.2 Lincoff's Rules

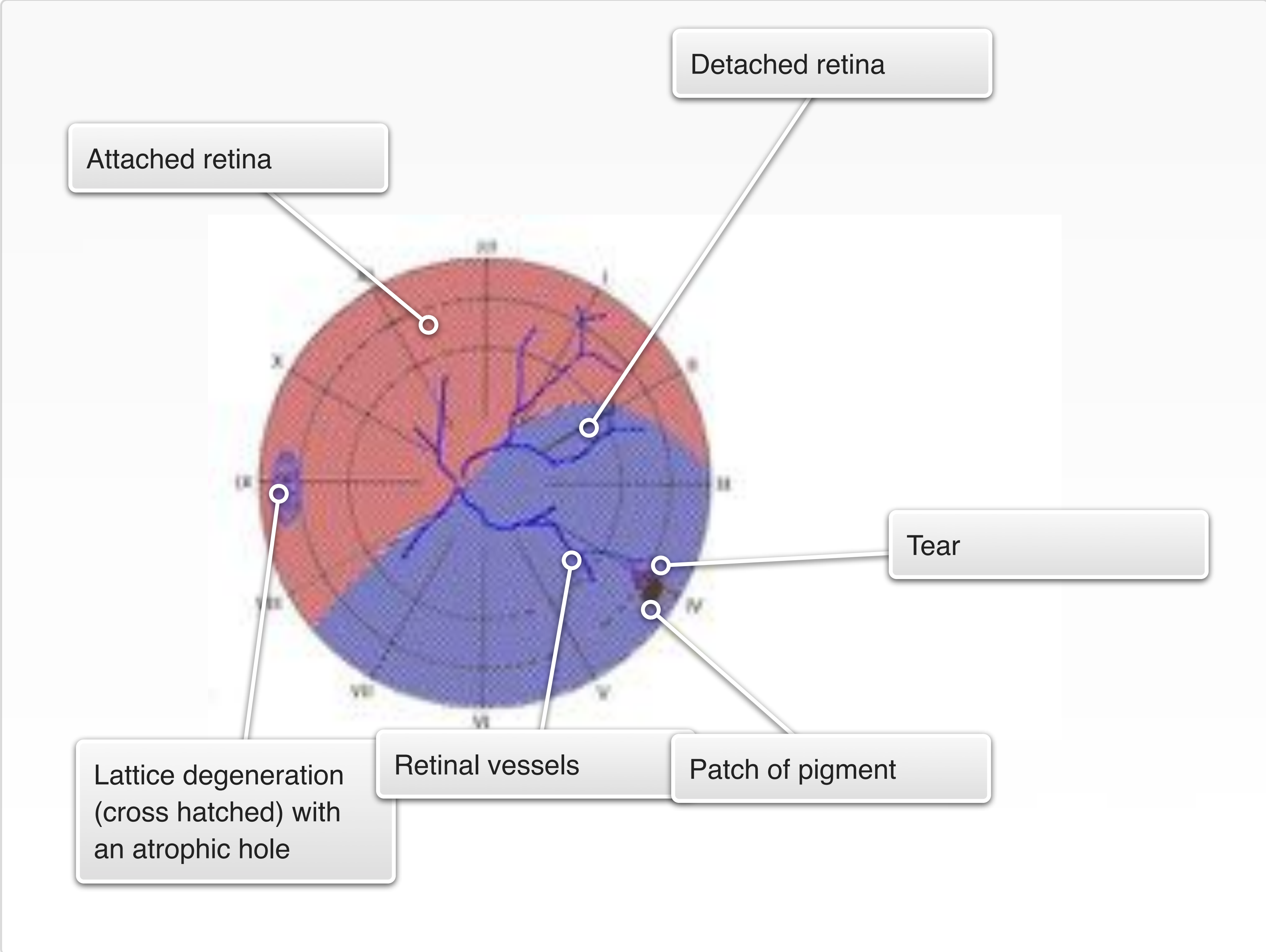


1. If a detachment involves both superior quadrants the break is within one clock hour of 12 o'clock in 93% of cases.



A detailed drawing at this stage can be a useful reference during surgery if the view deteriorates. The aim is to document the position of retinal breaks with respect to easily identifiable landmarks.

Interactive 4.1 Preoperative retinal drawing



Surgery is generally scheduled to prevent detachment of the macula. This requires a judgement on the likely rate of progression. Cases of chronic detachment due to atrophic retinal holes with tidemarks at the borders of the subretinal fluid are clearly less urgent in cases with superior tractional breaks. In any individual a balance needs to be struck between carrying the surgery out urgently and ensuring that operating conditions are optimized to carry out the surgery safely.

Where the macula has been detached for a relatively short period surgery should be carried out urgently to reduce the ongoing macular photoreceptive degeneration that occurs while the macula is detached.

In the past it was common practice to put patients on bed rest with restrictions on reading to prevent extension of subretinal fluid. While effective this is often impractical in the current era of ambulatory surgery but may be used as a temporizing measure for short periods if the macula appears imminently threatened.

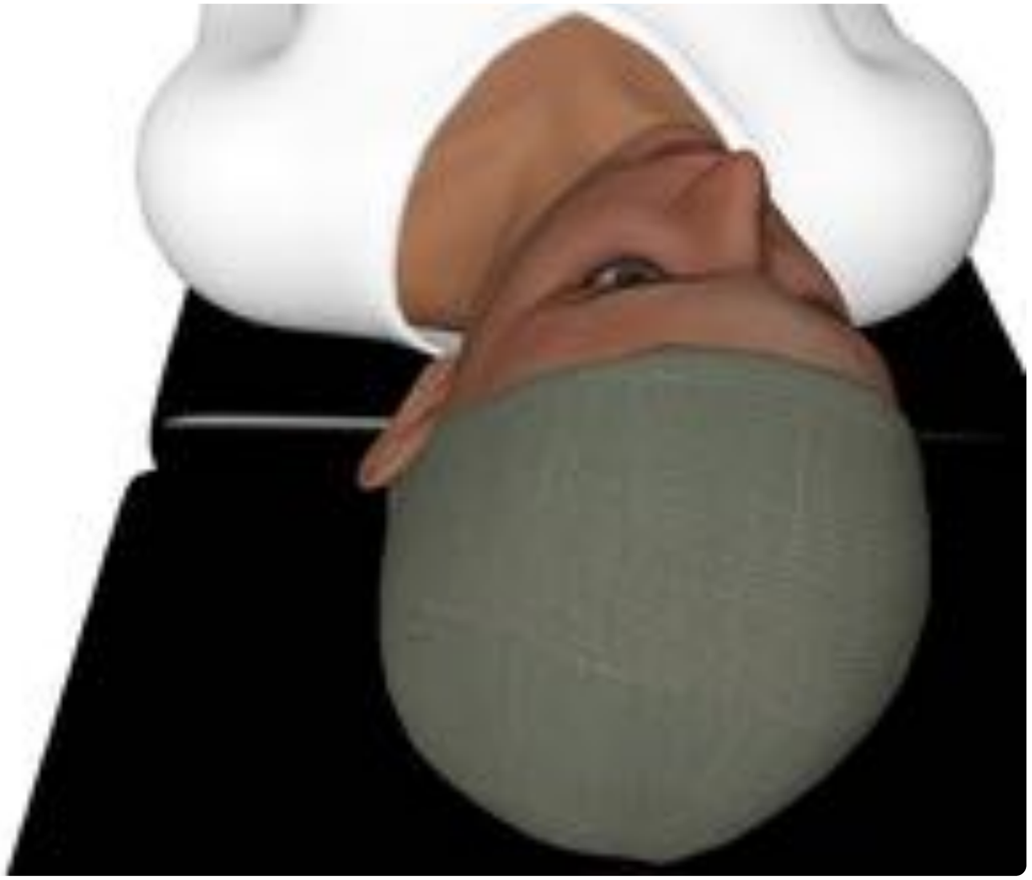
Surgical preparation

Buckling surgery involves manipulation of tissues around the globe, in particular the lids, as well as the globe itself. General anesthesia offers many advantages over regional blocks, especially in younger patients. When surgery is performed under local/regional anesthesia peribulbar blocks are more effective then subtenons blocks as already described.

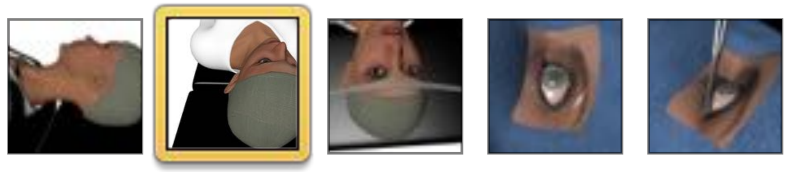
Surgical access to the globe is maximal if the orbit is flat. This may be achieved by rotating the head and flexing or extending the neck. Once a desirable position has been achieved the head may be loosely strapped with adhesive tape.

Sterile preparation and draping is carried out as it would be for any operation on the eye.

Figure 4.3 Surgical preparation



The orbital rim has an inclination of 30^0. If the eye socket is deep it may be helpful to rotate the neck slightly to the opposite side.



Conjunctival peritomy

Poor surgical technique during **peritomy** leads to heaped up conjunctival scars. These may contribute to post operative tear film problems which the patient will have to live with for the rest of his or her life.

The conjunctiva is often friable, especially in the elderly. Dissecting conjunctiva and tenons capsule together helps to prevent conjunctival tearing.

While a 360° peritomy is required if an encircling buckle is used a more localized peritomy is usually sufficient for segmental buckling.

Figure 4.4 Conjunctival peritomy

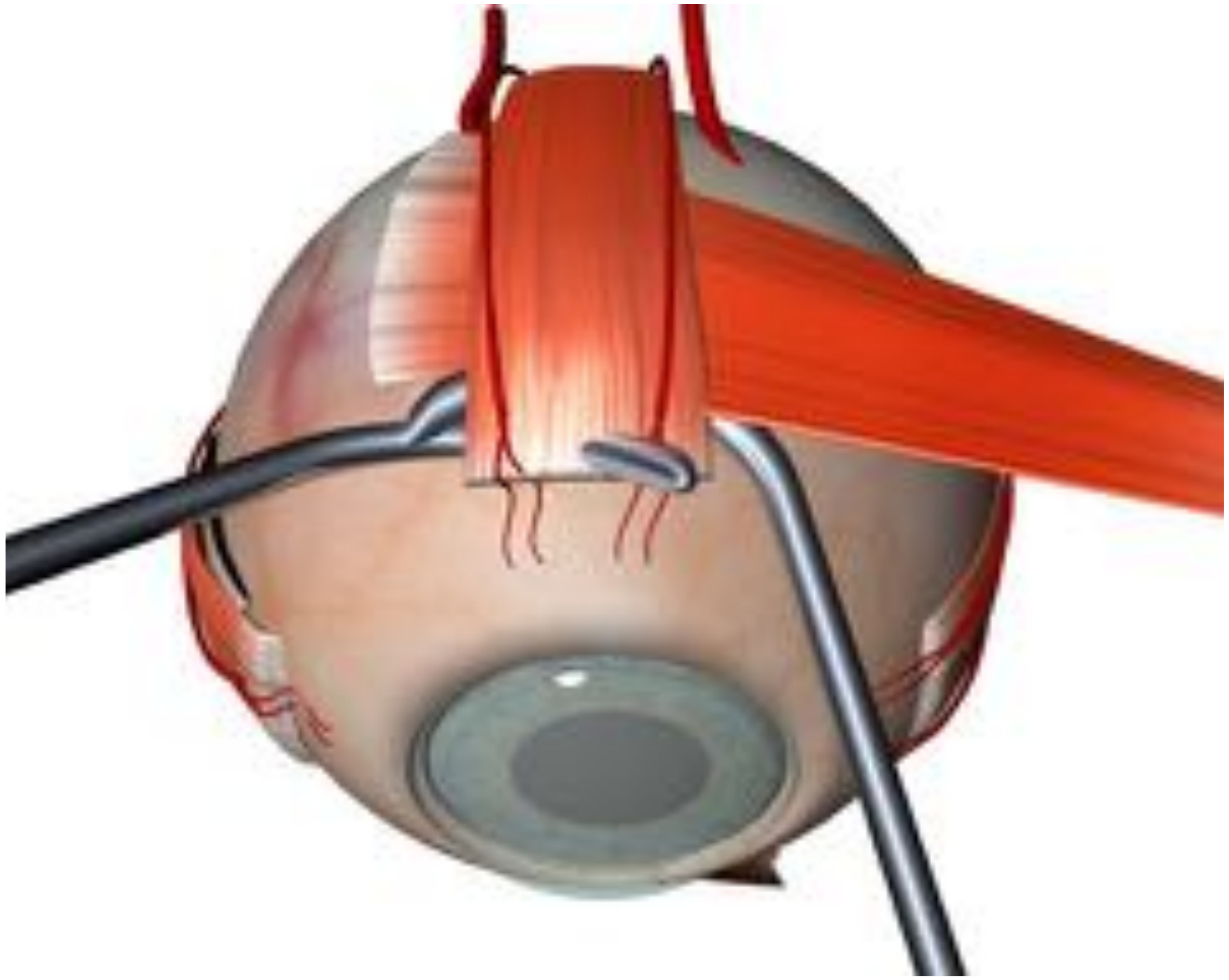
Many surgeons perform the circumferential peritomy a little more posteriorly. This can facilitate closure as additional sutures may be placed between the peritomy and the limbal frill during closure.

Slinging muscles

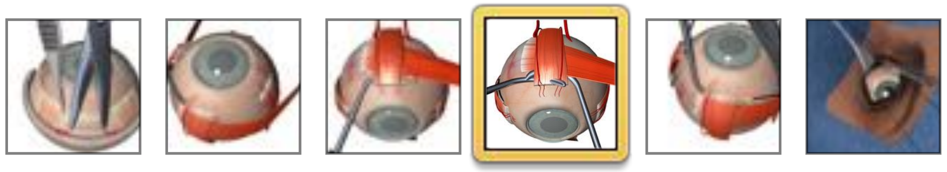
The intermuscular septum is opened on either side of the muscles to be slung. Some important considerations about the anatomy of the recti have already been discussed. A posterior sweep of a **muscle hook** engages the muscle allowing a reverse mounted suture such as a 5/0 silk suture to be placed around the muscle belly.

The number of muscles that need to be slung in this way will be determined by the size of the buckle - if an encircling buckle is planned all four rectus muscles should be slung. When starting buckling surgery it may be very helpful to have traction sutures on all 4 recti even if a local buckle is planned. This can be accomplished by placing traction sutures transconjunctivally.

Figure 4.5 Rectus Traction Sutures



The muscle has been inadvertently split by the first muscle hook (see its position with respect to the anterior ciliary artery). It is left in place while a further hook is introduced from the opposite side. The first hook pulls the globe down a little which allows the superior oblique muscle to fall posteriorly out of the way.



Examination under anesthesia

The sclera is inspected for areas of visible ectasia.

Indented ophthalmoscopic examination of the retina confirms the position of all the retinal breaks and allows their position to be marked on the sclera.

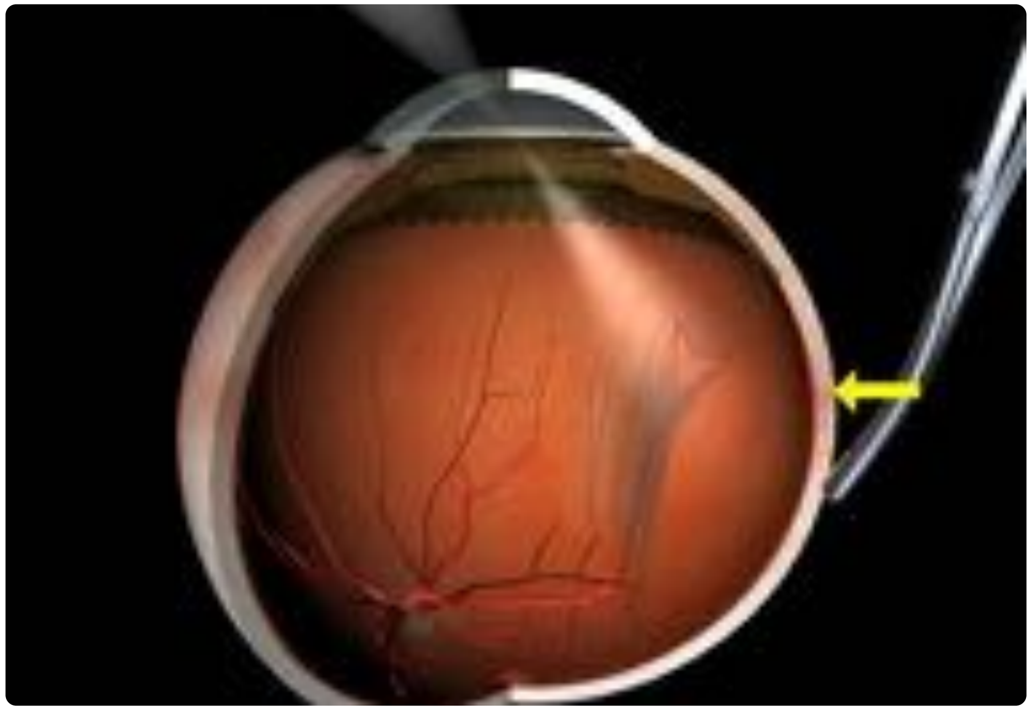
When performing indirect ophthalmoscopic examination of the anesthetized eye use of a cotton tipped swab to indent may be helpful in rotating the eye.

Once the location of all the breaks is known and they have been marked the rest of the operation can be planned.

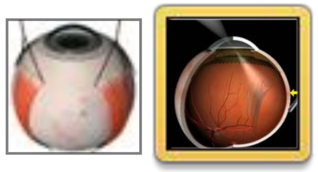
Errors in the localization tend to be in the zone, not the meridian, of the break.

It is only necessary to mark the location of breaks associated with subretinal fluid, as breaks in flat retina do not require support from the buckle.

Figure 4.6 Examination under anesthetic

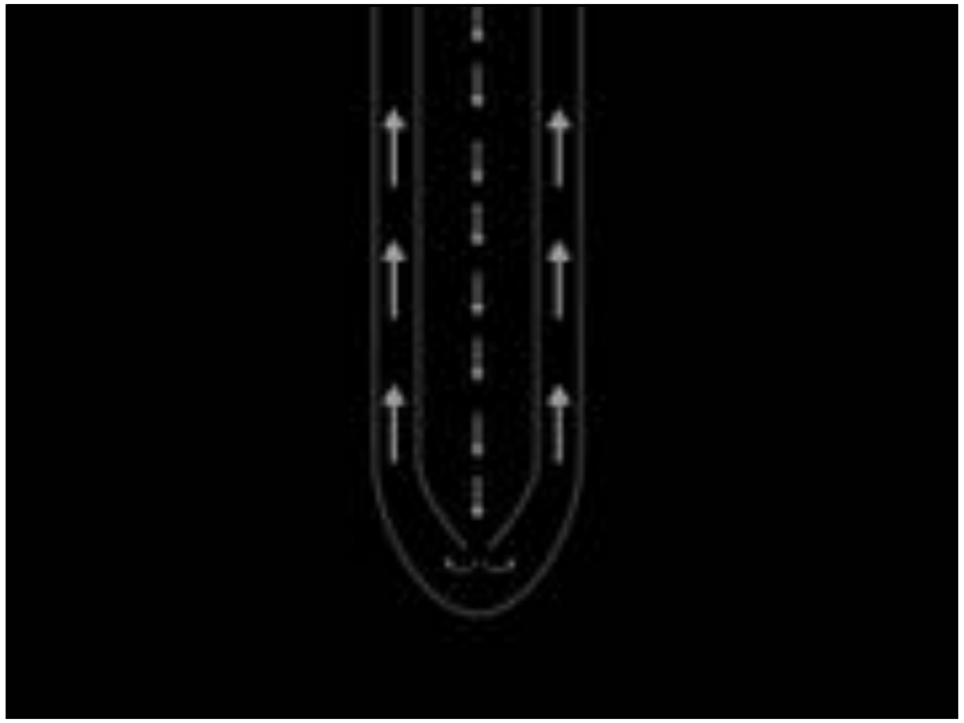


The explanation for zonal localization errors in bullous detachments: the deep subretinal fluid produces a parallax effect. The yellow arrow marks the correct position of the retinal break.



Retinopexy

Figure 4.7 The Joules-Thompson effect



Nitrous oxide gas is under very high pressure in the inner tube. After passing through the small nozzle at the tip the gas expands, cooling the tip.

The aim of retinopexy is to produce a chorioretinal adhesion which will persist even if the indent caused by the explant disappears.

Such a chorioretinal adhesion can be produced by cryotherapy, transscleral diode laser or postoperative retinal laser photocoagulation. Peroperative transpupillary indirect laser retinopexy may be used if the retina can be apposed to the RPE by indentation but in the presence of even shallow subretinal fluid this may lead to iatrogenic retinal breaks due to the high laser power required. Its use in this way is strongly discouraged.

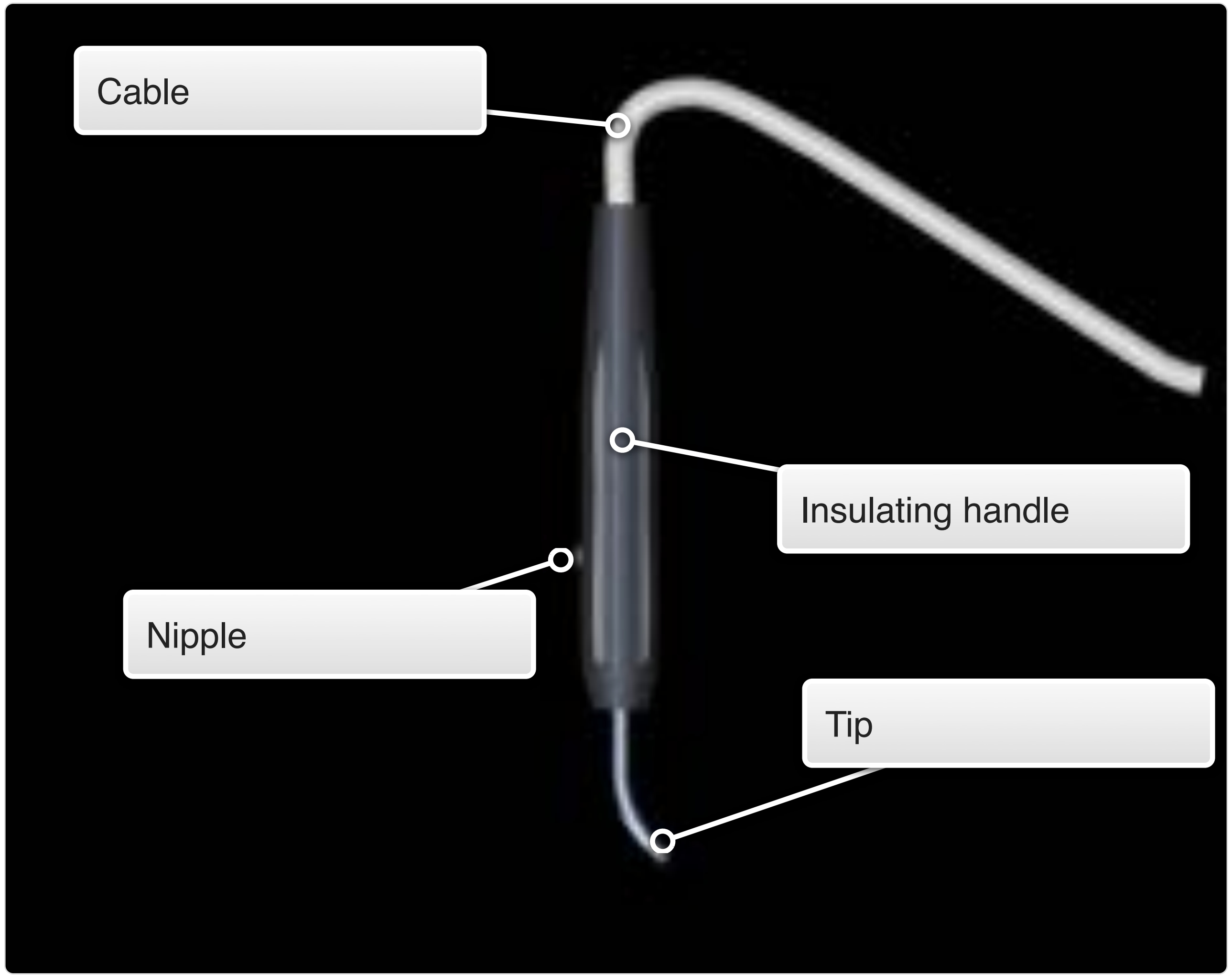
Cryotherapy is safe and effective in the presence of shallow subretinal fluid. The theoretical advantages of other forms of retinopexy do not always translate into significant tangible benefit in clinical practice.

THE PHYSICS OF CRYOPEXY

It is important to understand how cryoprobes work in order to be able to troubleshoot a malfunctioning **cryoprobe**.

The physical basis of cryopexy is the Joules-Thompson effect - the fall in temperature of a gas as it expands.

Interactive 4.2 Features of a cryoprobe



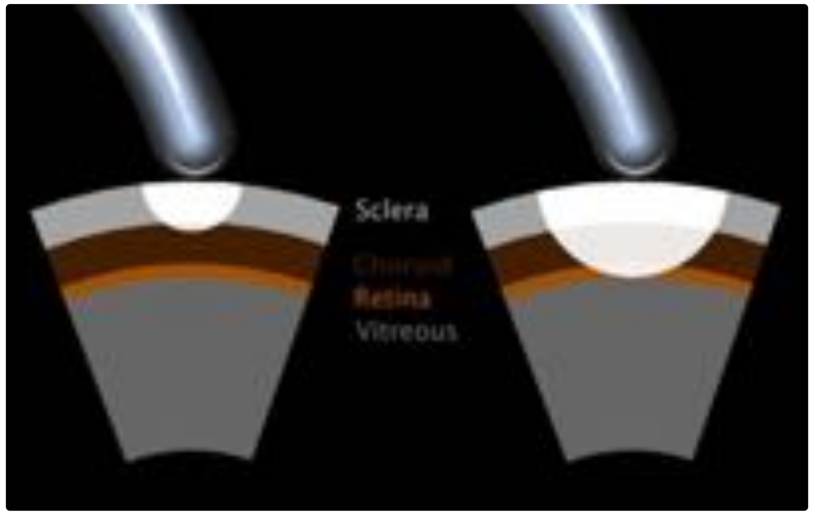
Water or water vapor in the tubing may freeze, blocking the tube. The system must be purged of all air before use.

Common causes of failure of the mechanism to activate include low pressure in the gas cylinder and blockage of the tubes by residual water - particularly likely if autoclave sterilization is used.

BIOLOGICAL EFFECTS

When the foot switch is activated its temperature is reduced to -70^0 Celsius. An ice ball is produced at the tip of the cryoprobe. This grows progressively larger as long as the cryoprobe foot pedal is depressed. Extraocular muscles have an insulating effect so that the appearance of a visible cryotherapy reaction takes longer when the breaks being treated are under a muscles. The fluid in the vitreous acts as a heat sink and the cryotherapy reaction manifests more quickly in gas filled eyes.

Figure 4.8 Extent of freezing



Note that the ice ball grows progressively to involve more tissue.

The pathophysiology of tissue injury is uncertain but it seems to involve rupture of cell membranes by ice crystals. It follows that it is the transition to or from, rather than the amount of time spent in, the frozen state that causes tissue injury. Refreezing of the same area seems to be particularly destructive and should therefore be minimized. It also follows that a heavy or excessive cryotherapy reaction such as **cryonecrosis** is more likely to be a consequence of refreezing than the length of the cryotherapy application.

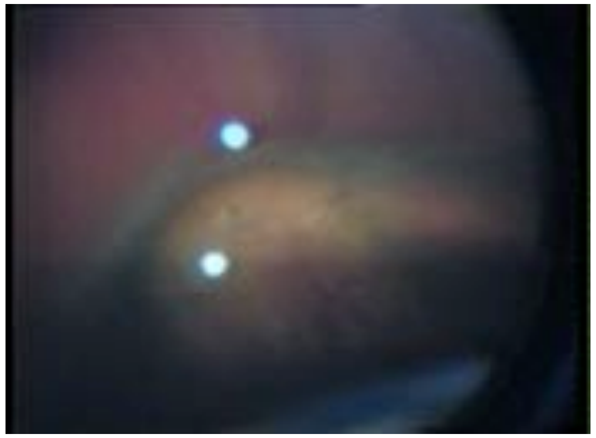
USING THE CRYOPROBE

Cryopexy is usually applied under indirect ophthalmoscopic view.

When the indent from the tip is seen in the desired position the cryoprobe is activated by the foot pedal. The head will usually have to be tilted as for indirect ophthalmoscopic examination. This may make it awkward to operate the cryoprobe foot pedal - which may be delegated to a trusted assistant.

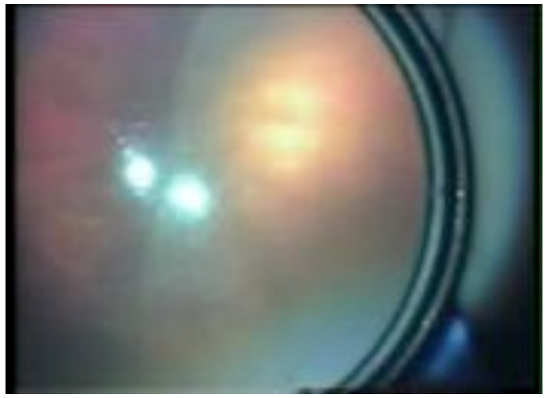
Visible whitening indicates that the ice ball has reached the retina. Small breaks light up as dark spots within the ice ball due to the absence of retina. Freezing of the RPE does produces some whitening but it is much less marked then that of the neurosensory retina because is masked by the pigment in the cells. In the presence of subretinal fluid there is a delay between the gentle blush of RPE freezing and the intense whitening when the ice ball reaches the retina. There is some debate over which of these is the more desirable end point, but freezing of RPE alone does seem to work in practice.

Movie 4.1 Cryotherapy of a retinal break



The break shows up as a darker area within the ice ball. Note that the probe is left in place during thawing to prevent fractures of the choroid and scleral avulsion.

Movie 4.2 Cryotherapy in the presence of subretinal fluid



Note the delay between the RPE and retina whitening.

Figure 4.9 Posture during cryotherapy

Cryopexy in theatre. Note that the surgeon's weight is on one foot and someone else may need to activate the cryotherapy pedal.

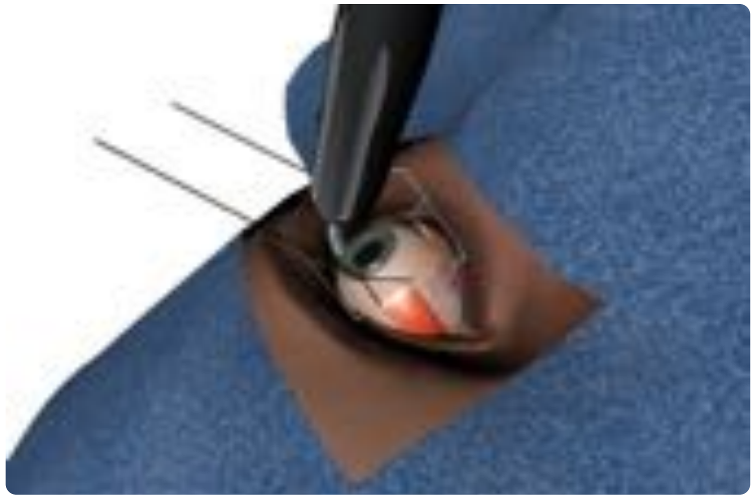
It is desirable to avoid freezing of large patches of bare RPE to reduce the risk of pigment dispersion. Larger breaks should be treated with **contiguous** applications with minimal overlap, working methodically around the margins of the tear. This may be difficult to achieve as cryotherapy applications are hard to see per-operatively. There are a number of ways of dealing with this problem:

- Very subtle whitening of the treated areas takes after about 30 seconds.
- Use the cryoprobe is used to very gently rotate the eye while the ice ball is thawing and the cryoprobe remains adherent to the sclera. It is possible to visualize directly where the previous application was made and move the cryotherapy under direct vision before looking back in the eye with the indirect ophthalmoscope.
- Try to actively memorize the location of features, such as irregularities in the tear or areas of pigment, and use them as landmarks for the next cryotherapy application.

Figure 4.11 Cryotherapy to a large break

Application of a single very large freeze to a large retinal break. Considerable freezing of RPE has occurred.

Figure 4.10 Traction sutures during cryotherapy



There is a superotemporal break. As well as the traction sutures around the superior and lateral rectus, which are required to suture the explant, traction on sutures around the other 2 recti allows the eye to be maintained in the optimum position for cryotherapy.

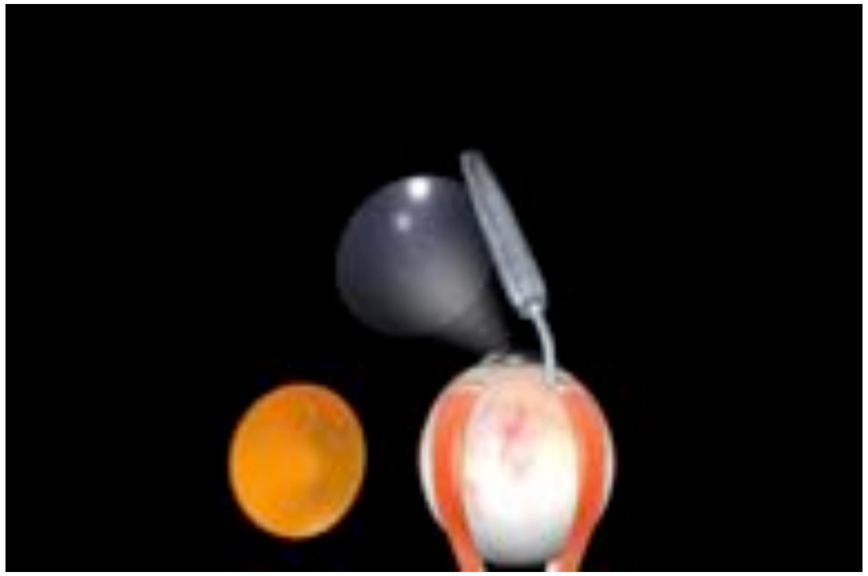
The tip of probe does not produce as much friction on the globe as (for example) a dressed orange stick. When treating very anterior breaks the tip of the cryoprobe is being used to both rotate the globe and move the probe with respect to the surface of the globe. The balance between these 2 movements depends on the exerting just the right amount of pressure on the globe with the tip. This is a difficult skill to master. Two strategies to deal with this are:

1. Using additional traction sutures so that the eye can be moved away from the surgeon. This also allows the eye to be fixed so that the movements of the cryoprobe only change its position on the surface of the sclera.

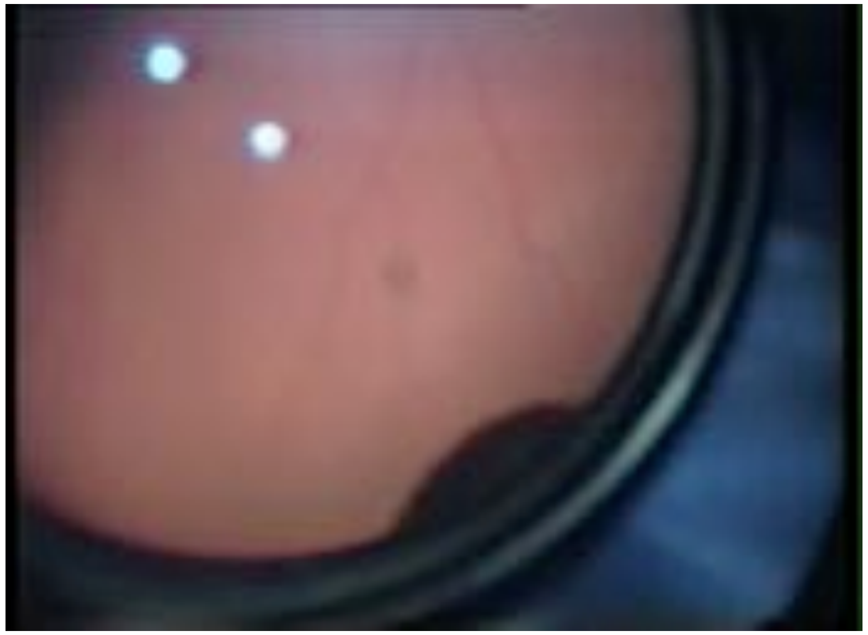
2. Using controlled slippage of the cryoprobe on the sclera.

- The cryoprobe is placed on the globe anterior to the break.
- The eye is rotated into the desired position under pressure.
- Under ophthalmoscopic view the pressure of tip of the cryoprobe on the globe is slowly reduced. The eye slowly returns to its primary position. The cryoprobe is held still so that the tip slowly slip backwards relative to the surface of the globe.
- When the break appears on the apex of the indent pressure is slightly increased to keep it in position and the cryoprobe is activated.

Movie 4.3 The controlled slippage technique animation



Movie 4.4 The controlled slippage technique



COMPLICATIONS OF CRYOTHERAPY

While freezing and for some seconds afterwards the probe is adherent to the globe. Forced removal of the cryoprobe at this stage may fracture the choroid and may even avulse a plug of sclera.

Posterior cryotherapy is a consequence of shaft indentation - the shaft of the cryoprobe is mistaken for its tip. The shaft of the cryoprobe looks quite different from the tip. Trainees may reproduce this error without activating the cryoprobe to familiarize themselves with the appearance of shaft indentation. This is a cognitive error. Simple awareness is enough to prevent it.

Very heavy cryotherapy of large breaks causes pigment dispersion which may increase the risk of PVR. Attempted cryotherapy in the presence of deep subretinal fluid where the retina cannot be opposed close to the break on indentation is particularly prone to do this.

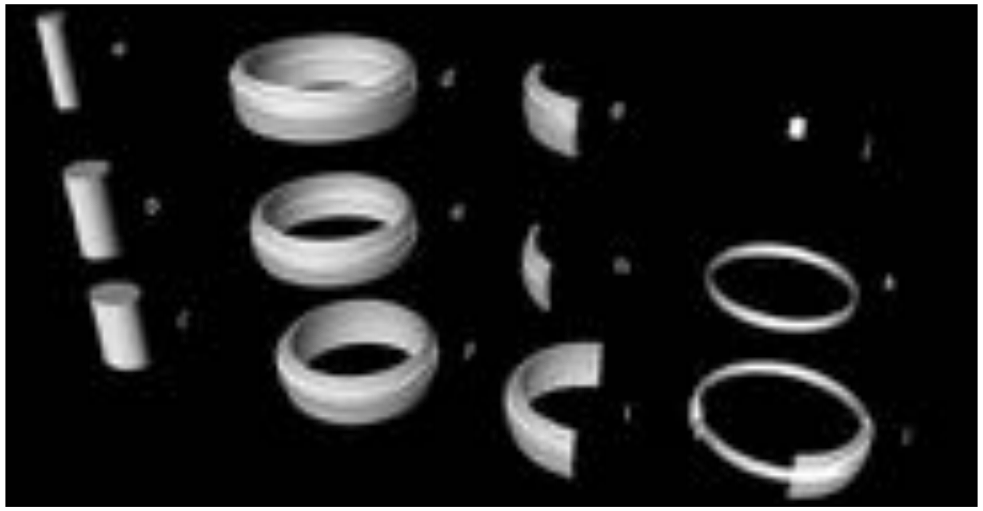
Extremely heavy cryotherapy may cause retinal necrosis - 'cryonecrosis'.

Figure 4.12 Complications of cryotherapy

Posterior cryotherapy

Choosing a scleral explant

Figure 4.13 Types of Explant



Some of the wide variety of explants available: silicone sponges of various diameters (a-c); solid silicone tires d-f) which may be trimmed to give local explants (g-i). Encircling elements: a Watske sleeve and a band alone (j,k) and combined with a segmental tire (l)

There are many different types of explant available. The choice between them depends on the location of the retinal breaks and the height of the detachment.

THE PURPOSE OF THE EXPLANT

Retinal detachments develop when recruitment of subretinal fluid through a retinal break exceeds the ability of the retinal pigment epithelium to pump the fluid out of the eye. The purpose of the explant is to alter the internal geometry of the eye, producing an internal indentation. This alters the balance between forces promoting detachment and those promoting attachment. This alters vitreous traction and fluid currents within the eye. The height of the internal indentation required to achieve this varies. Detachments in which vitreous traction is present require a higher indent than **those** in which it is not.

TYPES OF EXPLANT

All modern explants are cylinders made of silicone rubber. This inorganic polymer is completely inert. It may be used in the form of a **sponge** or a solid silicone **tire**.

Figure 4.14 A tire and a sponge

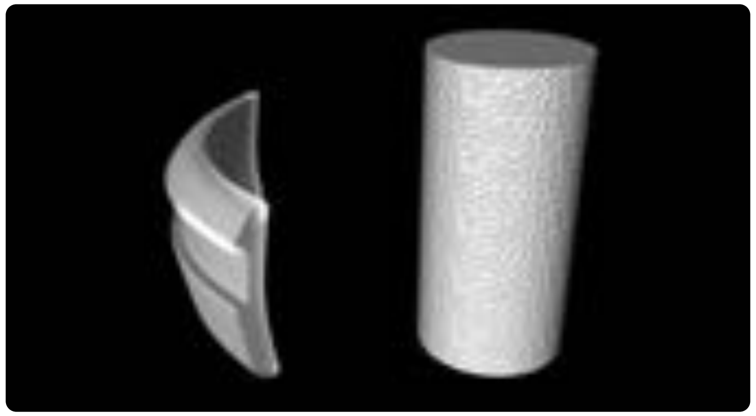
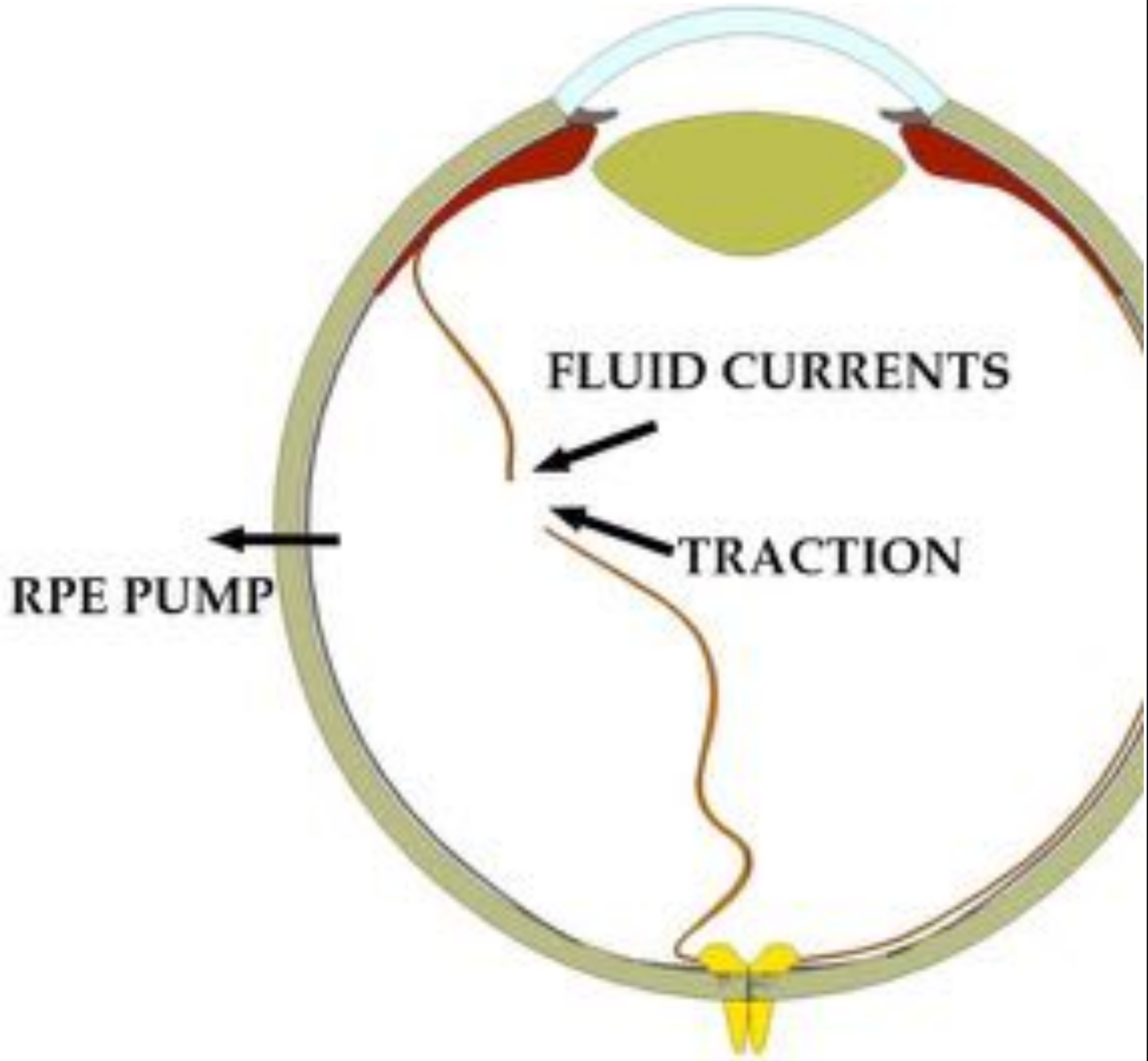


Figure 4.15 Factors in development of retinal detachment



The indentation from the explant alters some of the forces that promote recruitment of subretinal fluid.

	TIRES	SPONGES ('PLOMBS')
Composition	Solid silicone	Sponge with closed air filled cells
Response to pressure	Incompressible	Compressible
Cross sectional profile	Inner surface conforms to surface of sclera, outer surface has central groove for band	Variable, often circular or ovoid
Usual orientation on the sclera	Circumferential	Radial. Circumferential under certain circumstances with precautions to avoid fishmouthing
Typical use	Either local (segmental) or with a band (encirclement)	Local
Indent Profile	Broad, shallow	Narrow, high
Notes	Broad indent supports a wide area, unable to close elevated tractional breaks unless subretinal fluid drained or gas injected	Can close very elevated tractional tears without drainage, needs precision in location

CASE HISTORIES

This section consists of a series of individual cases. These examples showing how different types of explant may be used and how their choice influences the rest of the procedure.

In practice many surgeons would treat many of these detachments by vitrectomy.

The scenarios considered are:

1. Bullous retinal detachment with a single tear.

2. Shallow detachment with atrophic holes.

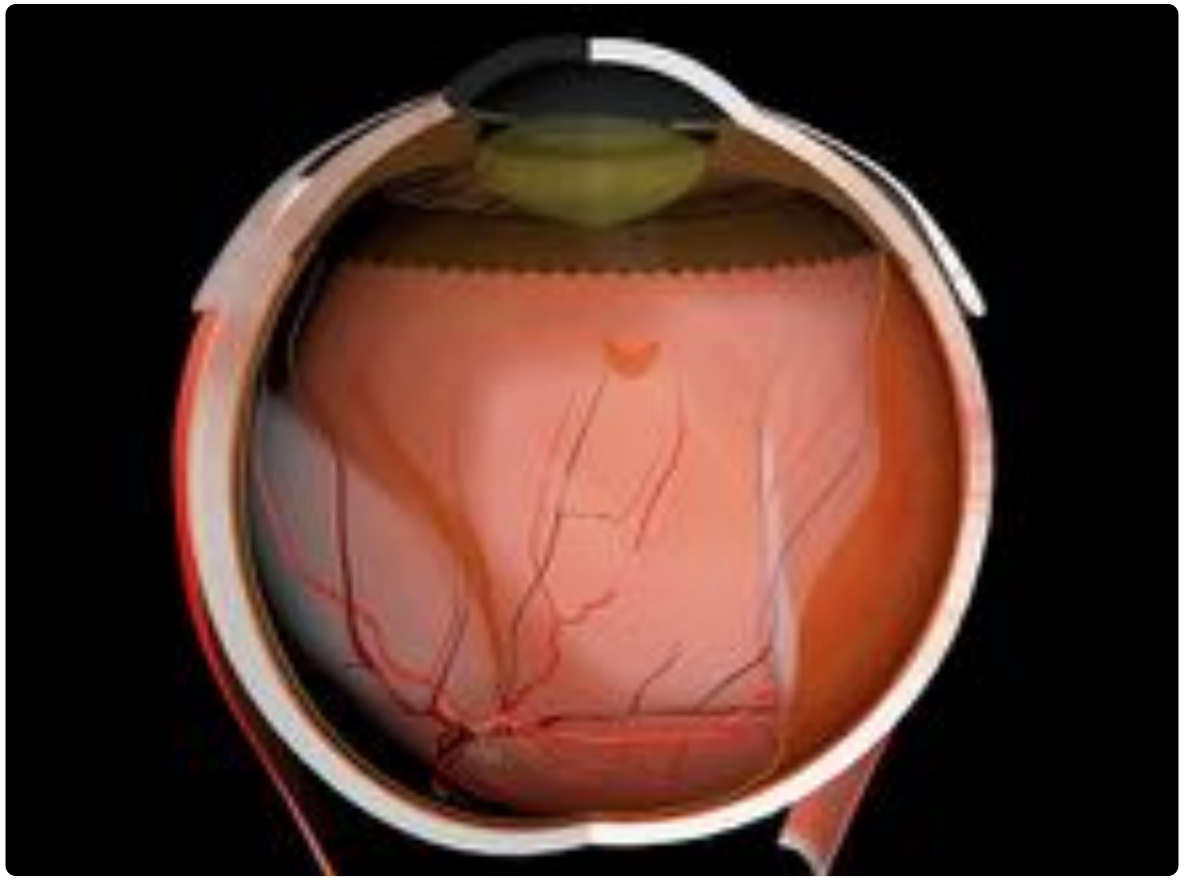
3. **Bullous** detachment - multiple tears.

4. Pseudophakic eye, no breaks seen per operatively.

5. Retinal dialysis.

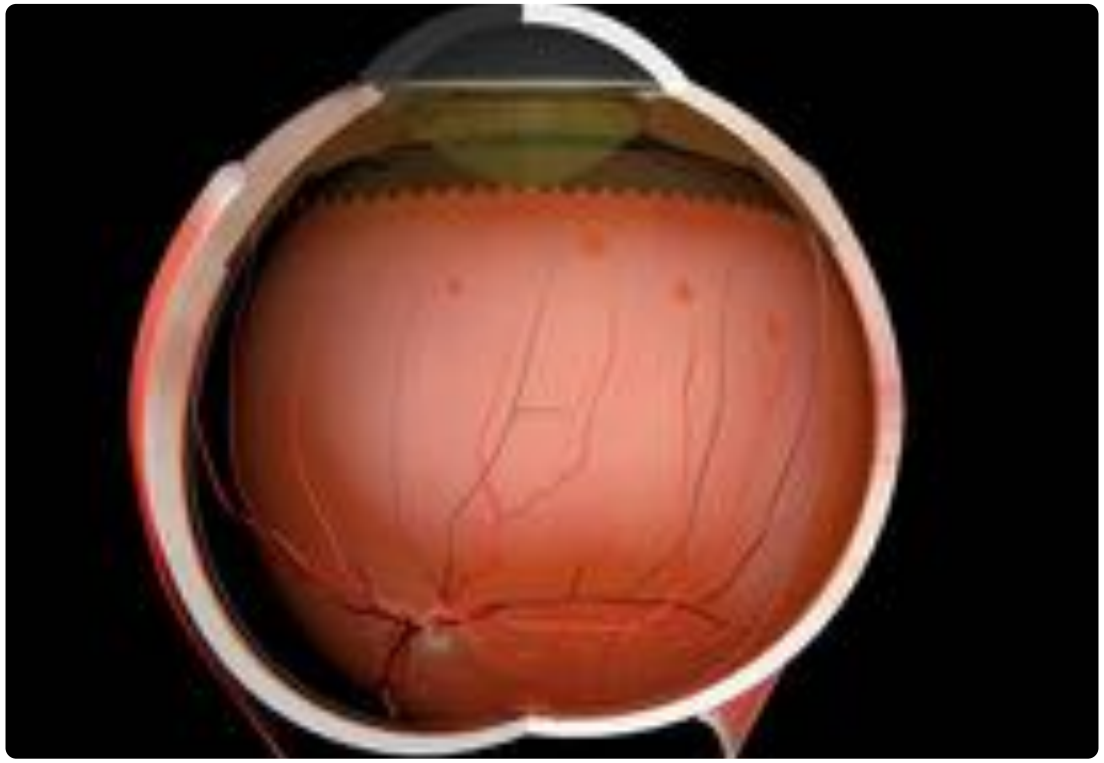
It will be seen that in many cases more than one approach is possible and that the choice of explant is just one component in making a plan for the whole operation.

Figure 4.16 Case 1: Bullous detachment, single tractional break



There is a bullous detachment with a single tear.

Figure 4.17 Case 2: Shallow detachment with atrophic holes



There is a chronic detachment with several atrophic retinal holes at various distances from the ora.

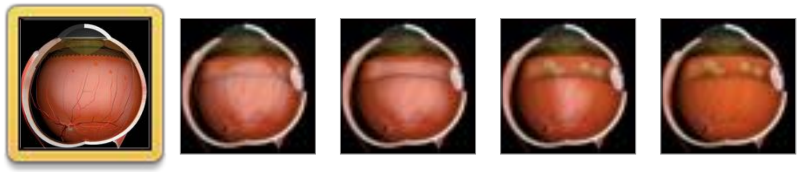
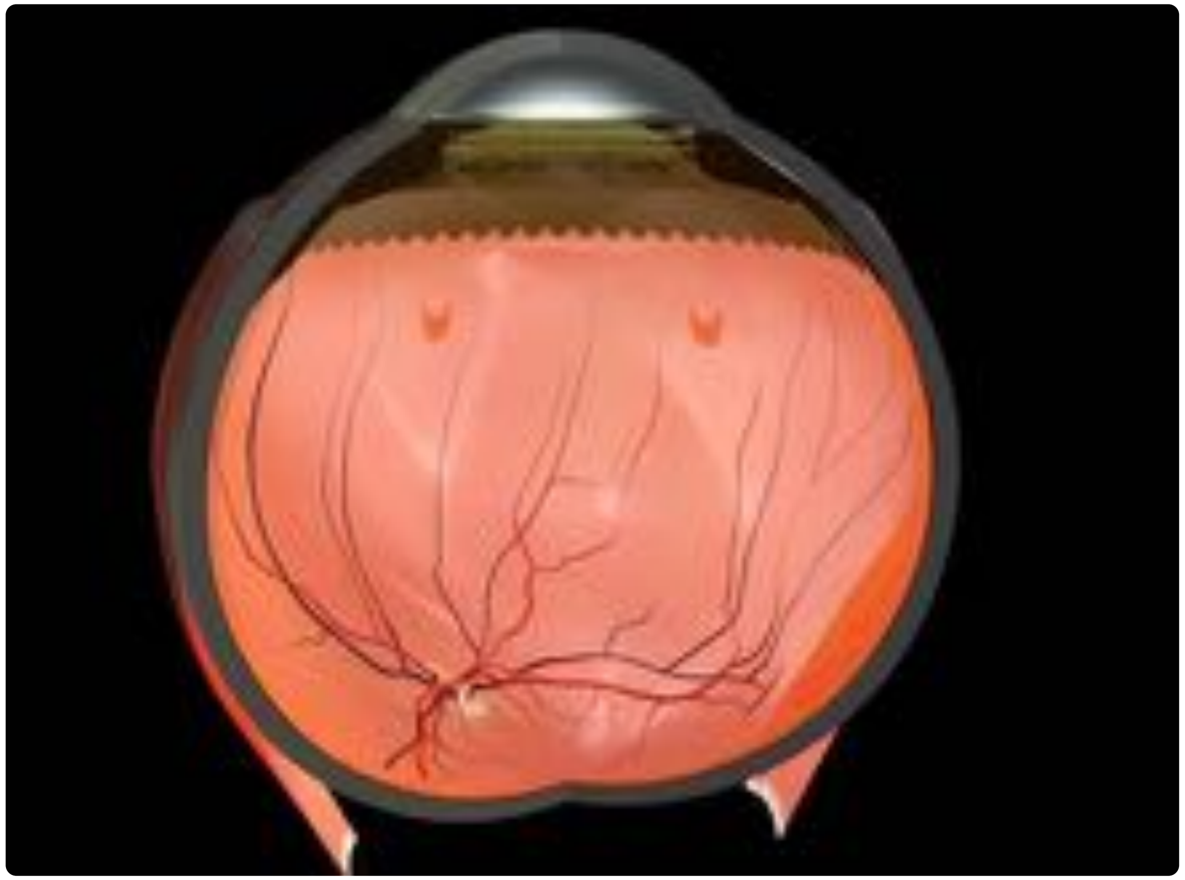


Figure 4.18 Case 3: Bullous Detachment - multiple tears



There are two quite elevated tears in this eye. While many surgeons would feel more comfortable performing a vitrectomy there are a number of buckling options available.

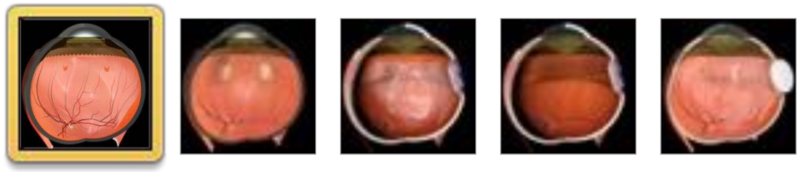
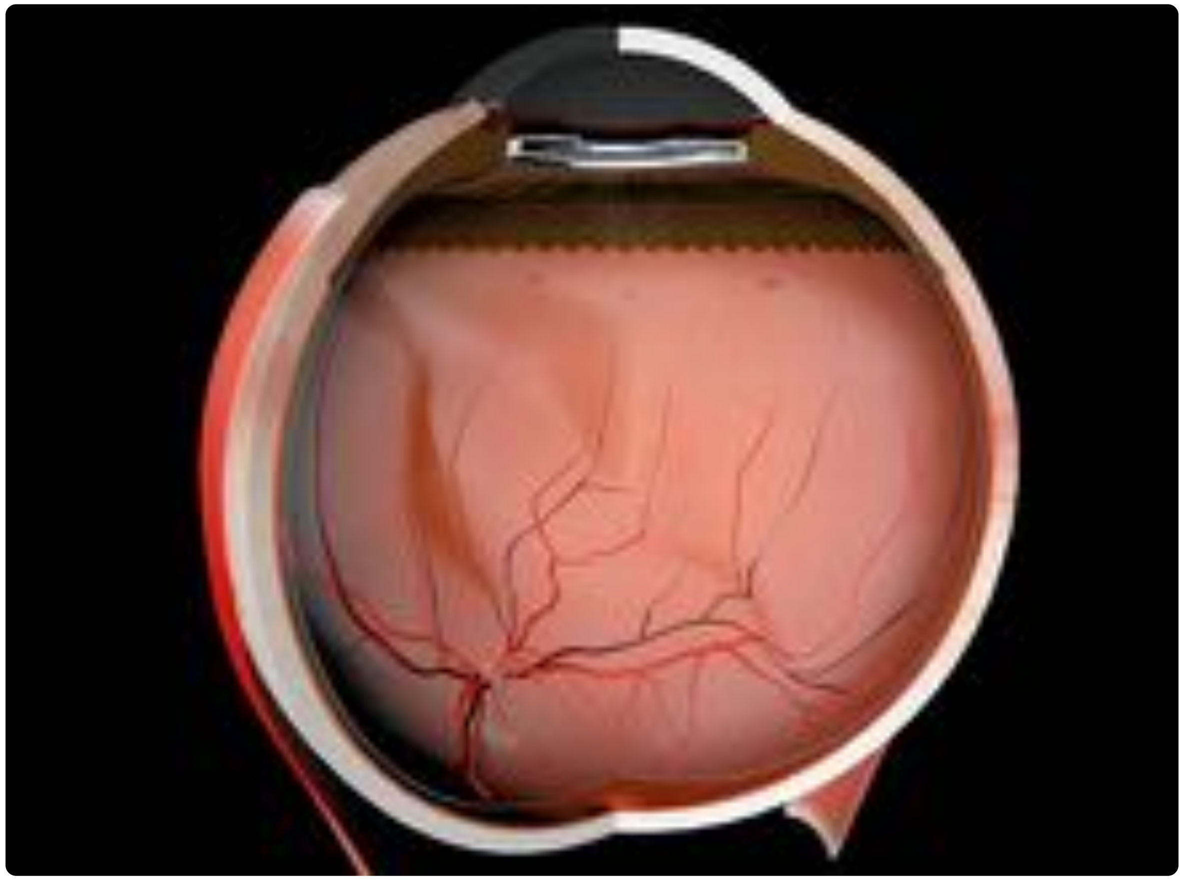


Figure 4.19 Case 4: Pseudophakic eye, no breaks seen per operatively



This pseudophakic eye has an extensive detachment with several small very anterior tears.

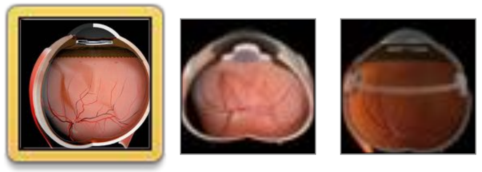
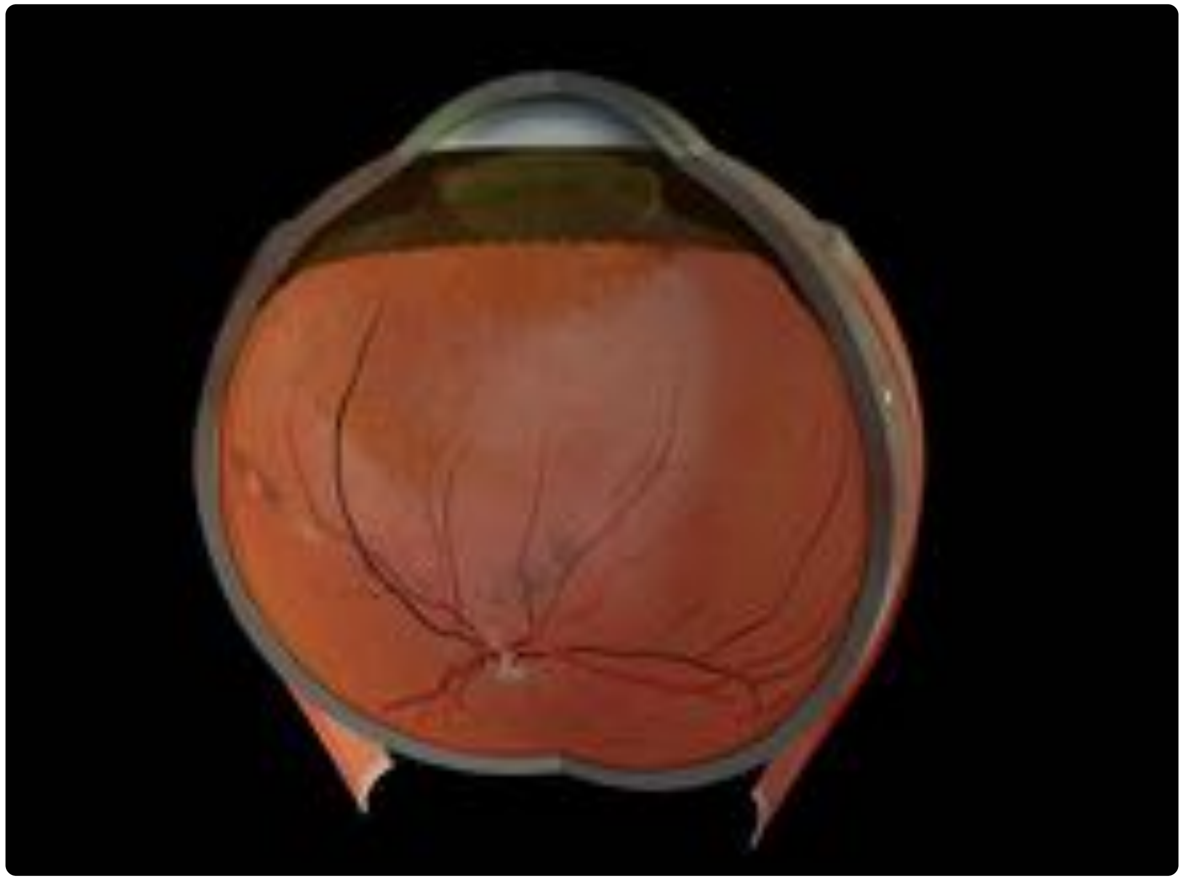
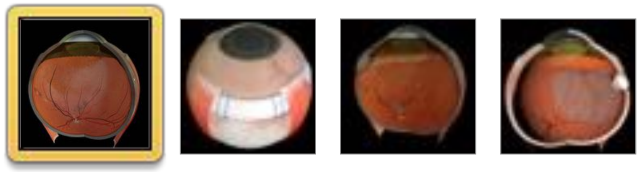


Figure 4.20 Case 5: Retinal dialysis



This eye has a retinal dialysis.



Scleral sutures

Figure 4.21 Spatulated needle

Note the flattened surfaces to enable passage between scleral lamellae at constant depth

PLACING A SCLERAL SUTURE

When passing a scleral suture the **spatulated** needle design and lamellar structure of the sclera are important considerations.

The tip of the needle is placed flat on the sclera and pressed down. This creates small indent. Advancing the tip of the needle while maintaining this downward force moves the needle tip into the sclera. The greater the downward pressure that is applied the deeper the indent and the steeper the approach into the sclera.

Once the needle is in the sclera there are 3 ways of advancing it:

- Rotating the needle. This brings the tip out of the sclera quickly.
- Continuing to advance the needle while pressing down. This takes the tip deeper into the sclera.
- Advancing the needle with no downward pressure: the needle tip will follow an upward arc depending on the radius of curvature of the needle.
- Advancing the needle tip with downward pressure but also a slight upward angulation of the tip. This allows a constant depth to be maintained.

In practice a all 4 of these maneuvers are used alternately to control the suture depth.

There are 2 useful visual clues to the depth of the needle in the sclera:

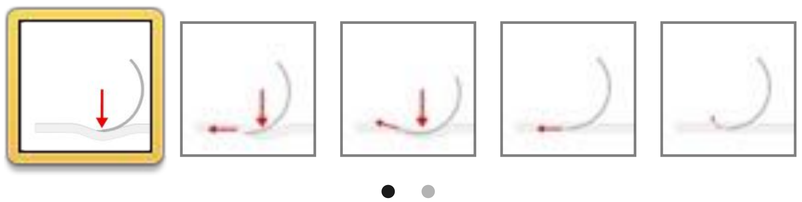
- The visibility of the needle tip. At the correct depth (just over half the scleral thickness, approximately 600 μm) the needle is just visible through the translucent sclera.
- A slight ridge over the surface of the needle when no force is applied to it. This is caused by upward pressure from the scleral fibers deep to the needle and is lost if the needle perforates the sclera.

If the needle enters and exits the sclera at a very shallow angle the roof of the suture track may tear at these points when the suture is tightened.

A deep suture may result in perforation of the sclera, drainage of subretinal fluid, subretinal hemorrhage and very rarely a retinal break. This is much more likely if the eye is very firm (for example after tightening a band or injecting gas). In general deep sutures should be replaced.

Figure 4.22 Scleral suture bite

The starting point. Downward pressure creates an indent. The steepness of the needle entrance into the sclera varies with the downward pressure.



Movie 4.5 Scleral suture bite.

Note that the needle remains visible throughout and creates a visible ridge on the surface of the sclera.

The surgeon varies the downward pressure and angulation of the needle tip continuously to keep it in the sclera until the suture path is long enough.

Banking should be avoided when using spatulated needles. This may be problematic when access is difficult.

This can only be achieved by operating ‘over the cornea’ - i.e. sitting on the opposite side of the eye from the area undergoing surgery.

SUTURE WIDTH

The explant is secured with overlay mattress sutures.

The aim of the mattress suture is to raise an internal indent to close retinal breaks. To achieve this the sclera must partially envelop the explant.

The distance between the bites of the mattress suture depends on the width and height of the explant. For example a 5mm sponge may be secured with bites 8mm apart. This distance is measured on the sclera with calipers - gentle indentation of the caliper tip leaves a temporary visible indentation to guide suture placement.

Figure 4.23 Needle Banking

Banking of a spatulated needle is undesirable

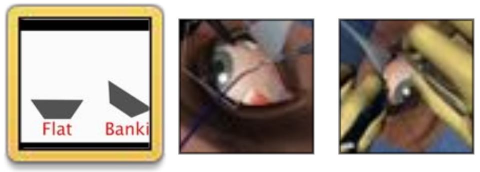
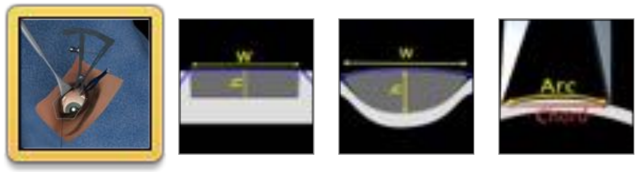


Figure 4.24 Bite separation

Use of calipers to measure bite separation - in this case 8mm for a 5mm radial sponge



Movie 4.6 Using an explant to measure suture bites

Alternatively the explant can be used to gauge the distance between bites. This is useful when adding a suture to an explant that is already in place. Pressing down on the explant creates a ridge on the sclera. This indicates where the bite should be placed.

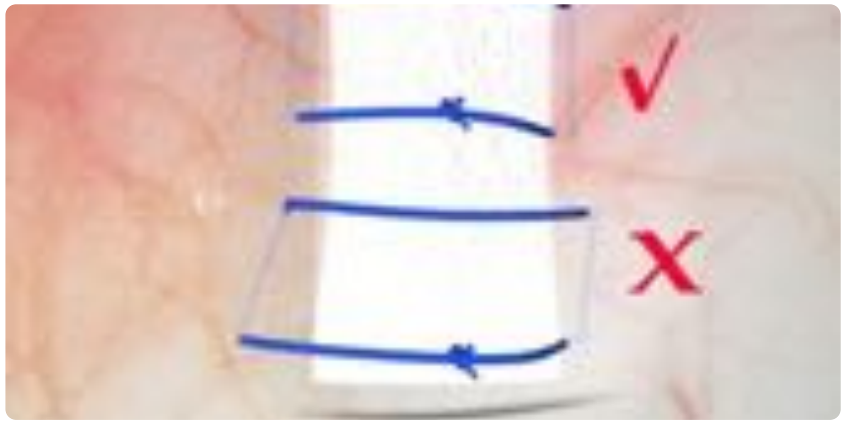
SUTURE ORIENTATION

The bites of a scleral mattress suture should be oriented so that they run parallel with each other and with the axis of the explant, crossing it perpendicularly. Non parallel bites may compromise the height of the indent.

For example when suturing a radial sponge the bites are orientated along a meridian (radially). They should be form a box shape rather than crossing over each other on the surface of the buckle. The knots should be left posteriorly (to reduce the risk of extrusion). The first bite should start posteriorly the second bite should start in the opposite direction.

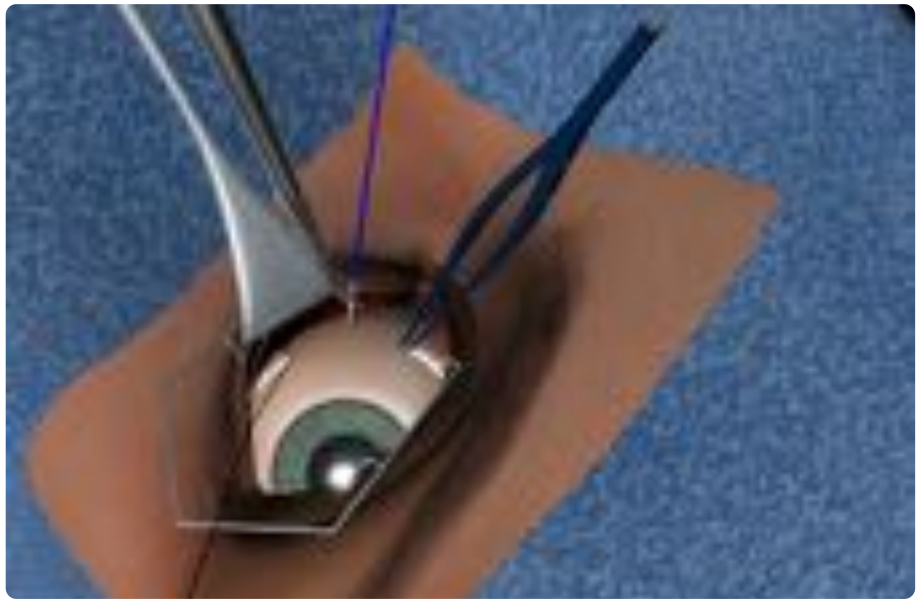
Placing posteroanteriorly orientated sutures behind the equator may be very difficult. Lack of space makes it difficult to properly control the orientation of the needle. In this case two anteroposterior bites may be made. In order to avoid the sutures crossing each other on the buckle the suture is cut between the two bites and each side of the box is tied separately.

Figure 4.25 Common suture errors

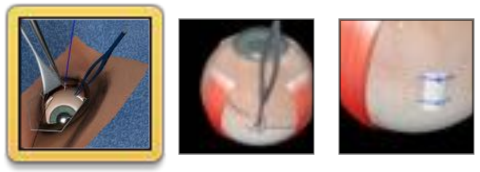


The bites of the lower suture are not parallel or aligned with the axis of the explant.

Figure 4.26 Anteroposterior and posteroanterior bites



The first bite should be made anteroposteriorly and the second posteroanteriorly. If access is difficult two antero-posterior bites are made.

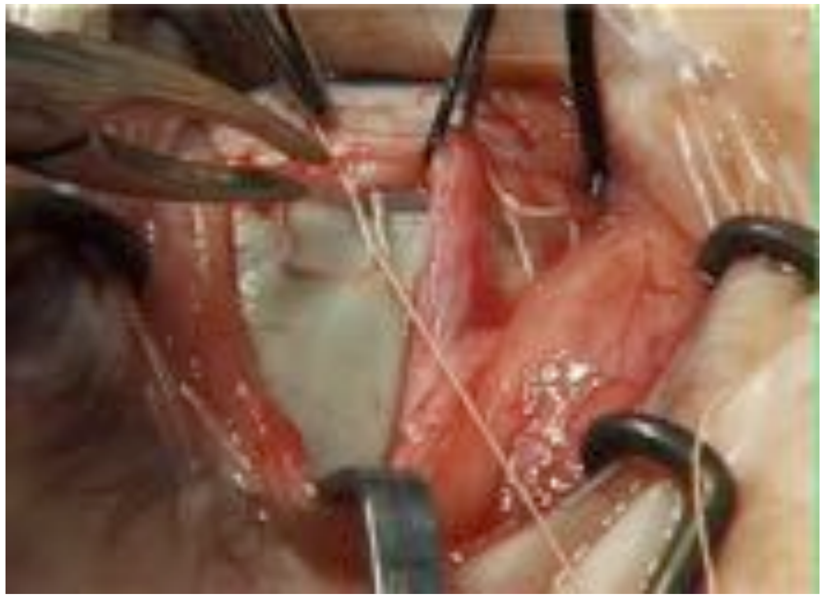


There are several non-absorbable sutures with different properties that may be used in buckling surgery and there are several ways of tying knots. The aim of knot tying in non drainage buckling surgery is to produce tension in the suture. After subretinal fluid drainage when the eye is soft care may need to be taken not to over-tighten sutures.

- Synthetic monofilament sutures such as polypropylene have low friction and are suitable for tying slip knots. The low friction may make tying surgeon's knots under tension difficult as the first throw tends to slip. This can be overcome by making several loops in the first throw as the material has sufficient memory to maintain tension when this is done.
- Braided materials such as polyglcolic acid have high friction. This makes them unusable in slip knots but easy to handle tying other knots.

Not all of the available techniques of knot tying are illustrated here. A complete discussion of knot tying techniques with illustrative videos may be found in 'The Open Globe', available as a free download from the Apple iBooks store via iTunes.

Movie 4.7 Tying a surgeon's knot with the help of an assistant



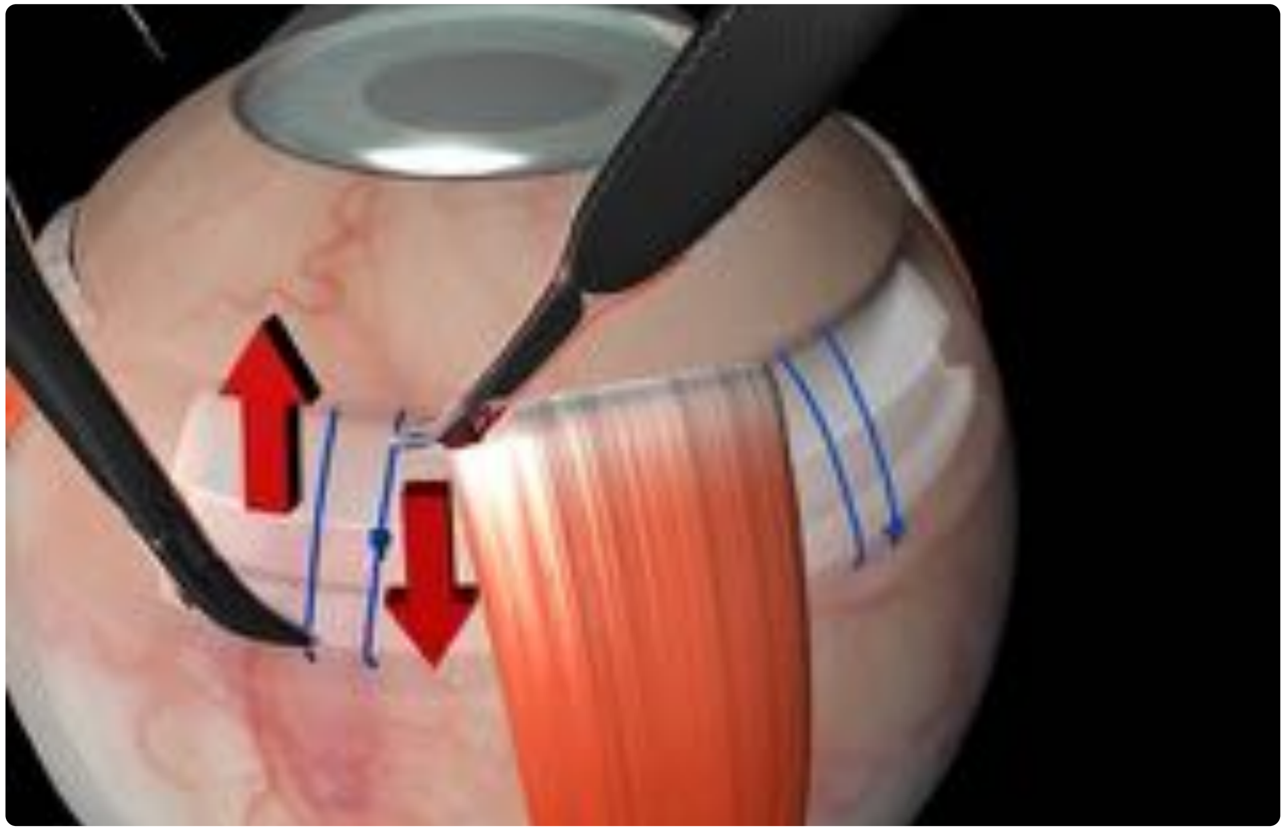
Note that the assistant uses pressure to help create the indent before holding the first double throw to allow an opposing single throw to be tied without slippage.

Figure 4.27 Types of knot in buckling surgery

A slip knot - in this case the second throw of a Dangel knot. Two separate single throws in the same direction following which the suture is tightened then an opposing third throw made. The ends of the suture are colored differently so the lack of symmetry in the knot can be seen.

Late exposure of the buckle may lead to extrusion and infection. In order to prevent this the sutures should be rotated bimanually so that the knots lie posteriorly.

Figure 4.28 Suture rotation



Note that this is a bimanual maneuver.

Subretinal fluid drainage

Many of the intraoperative complications complications of buckling surgery arise from subretinal fluid drainage. The decision to drain should not be made lightly.

WHEN SHOULD SUBRETINAL FLUID BE DRAINED?

- If retinal breaks can be closed without drainage the subretinal fluid will eventually resorb as several of the previously presented cases demonstrate.
- Retinal breaks without traction (atrophic holes, retinal dialyses) are particularly suitable for non drainage surgery. It is possible that the overlying vitreous helps to 'plug the hole' in these cases.
- Subretinal fluid drainage should not be attempted in shallow detachments.
- When retinal breaks cannot be opposed close the indent on indented examination subretinal fluid drainage is required in order to localize the breaks accurately and to treat them safely.
- The decision to drain subretinal fluid influences the rest of the operation (for example choice of buckle and whether to inject gas).
- While subretinal fluid drainage has been advocated to make room for an indent this may be achieved safely by serial paracentesis
- Gas injection provides an alternative means of supplementing the indent in eyes with elevated breaks.
- Pneumatic retinopexy or vitrectomy are alternatives to buckling surgery for such bullous detachments.

TIMING OF SUBRETINAL FLUID DRAINAGE

When used to facilitate the location of breaks and their treatment it is logical to perform subretinal fluid early in the operation. The sequence is Drain - Air - Cryotherapy - Explant ('DACE').

Subretinal fluid can be drained at any point of the operation however. Fears of choroidal congestion and excessive risk of hemorrhage have not been borne out in practice. *CDE* and *CDAE* sequences are frequently used in practice.

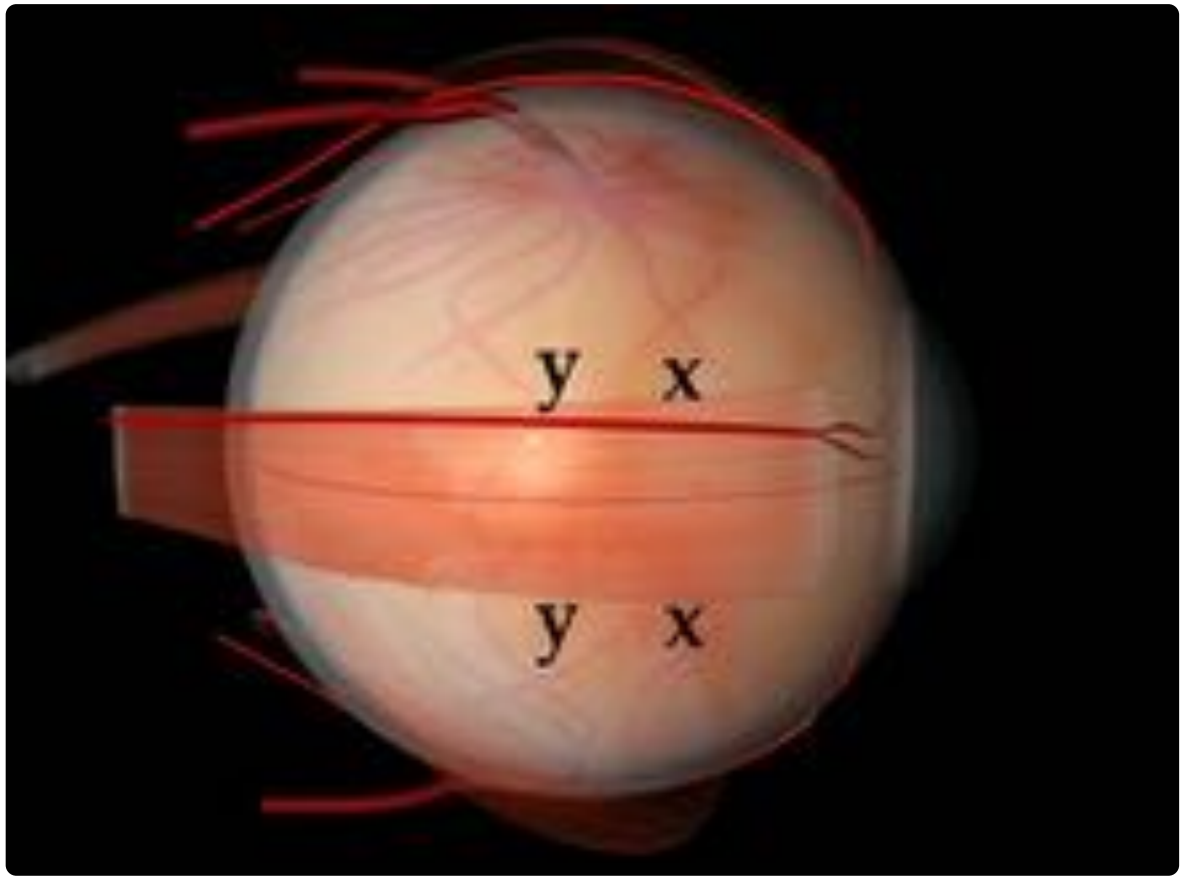
SITE OF SUBRETINAL FLUID DRAINAGE

The upper and lower borders of the horizontal recti have relatively few choroidal vessels. More anterior drainage may be less complete as the detached retina is closer to the RPE. If an anterior drain site is used it may be located in the bed of the explant so that any incarceration will be supported.

The proposed drain site should be examined immediately before drainage to confirm the presence of deep subretinal fluid.

Drainage directly under a retinal break may lead to vitreous incarceration on the drainage site and should be avoided.

Figure 4.29 Sites for drainage



There are few choroidal vessels immediately above and below the horizontal recti. More anterior sites (x) may result in incomplete drain but may be placed in the bed of the explant.

DRAINAGE TECHNIQUES: SCLERAL CUT DOWN

The radial scleral incision approximately 3 mm in diameter is made in the sclera. The incision is incrementally deepened while monitoring the depth of the incision closely. When the choroid is exposed a tiny knuckle is seen.

A choroidotomy is made. A thermal choroidotomy reduces the risk of hemorrhage. This can be performed with endolaser or diathermy.

Because of the large sclerotomy no pressure is required to express subretinal fluid drainage with this technique. The risk of incarceration is greater than with other techniques so the incision is often made in the base of the buckle.

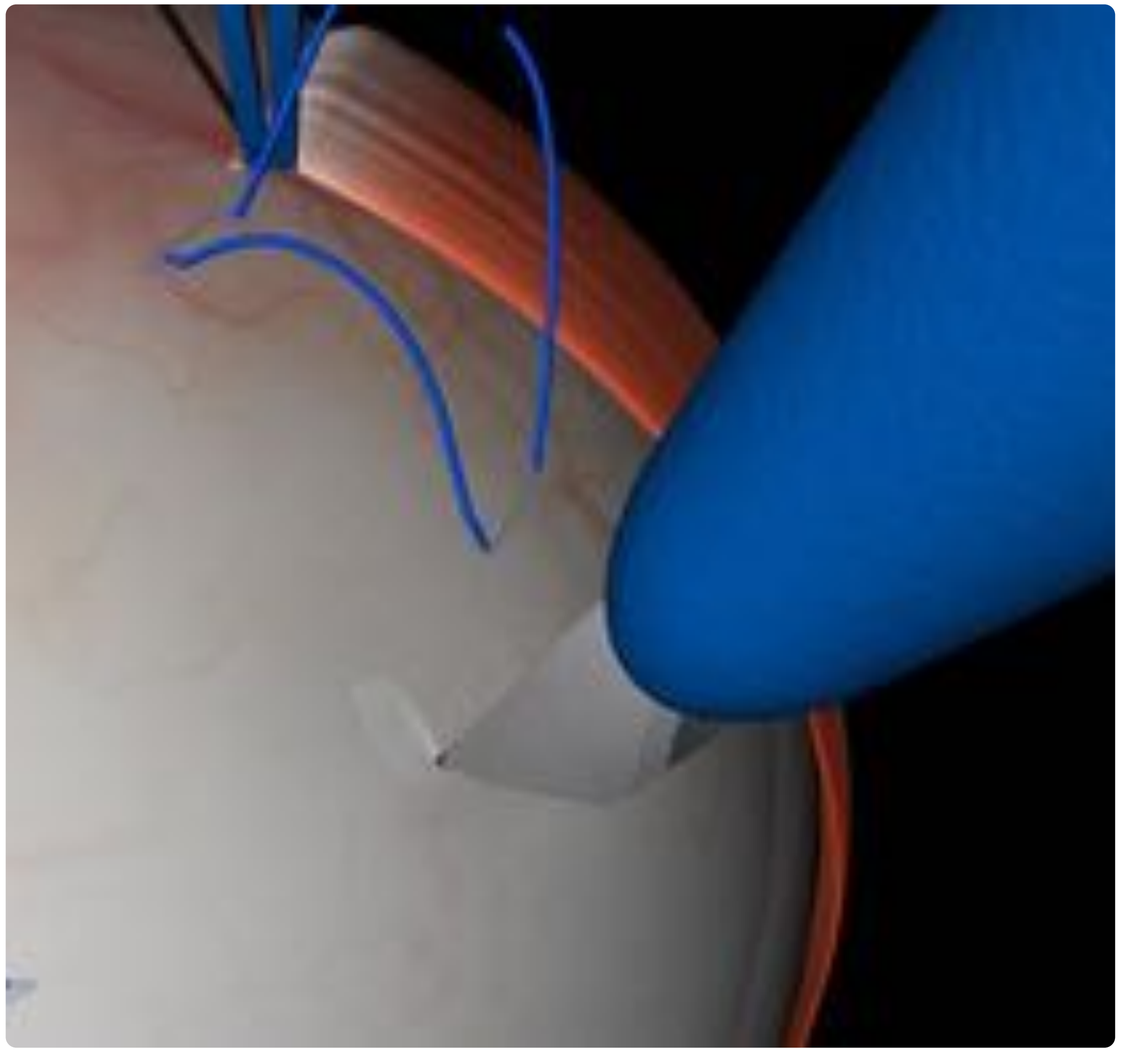
DRAINAGE TECHNIQUES: NEEDLE DRAINS

Sclera and choroid are pierced together using a needle.

In the Charles technique a 25-gauge hypodermic needle is mounted on a syringe without a plunger. It is passed through the sclera anteriorly and directed posteriorly under ophthalmoscopic guidance. High intraocular pressure reduces the incidence of hemorrhage with this technique.

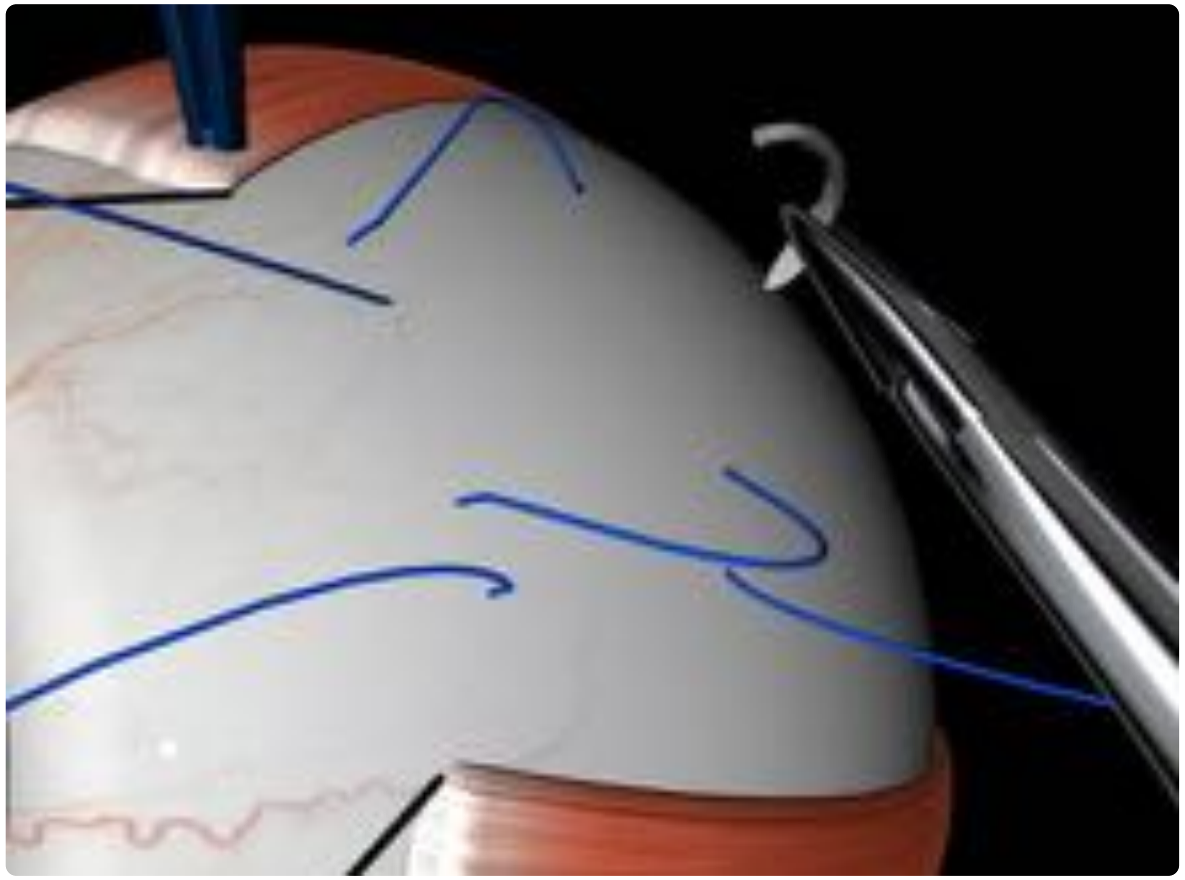
An alternative technique ('prang drain') uses a suture needle mounted on a needle holder. Again, very high pressure is used to close down the choroidal circulation prior to needle passage. There is no risk of incarceration with this technique. Some have found an increased risk of hemorrhage although the validity of this has been disputed.

Figure 4.30 Cut down drains



A shallow 3mm radial cut is made in the sclera.

Figure 4.31 Prang drainage



A spatulated needle is grasped in a locking needle holder with 3mm protruding. The jaws of the needle holder act as a guard preventing penetration of the needle beyond this point. A rectus insertion is grasped firmly with notched forceps.

Figure 4.32 Hollow syringe (Charles) technique

A 25-gauge needle is mounted on a 5 ml syringe with the plunger removed.

AFTER SUBRETINAL FLUID DRAINAGE

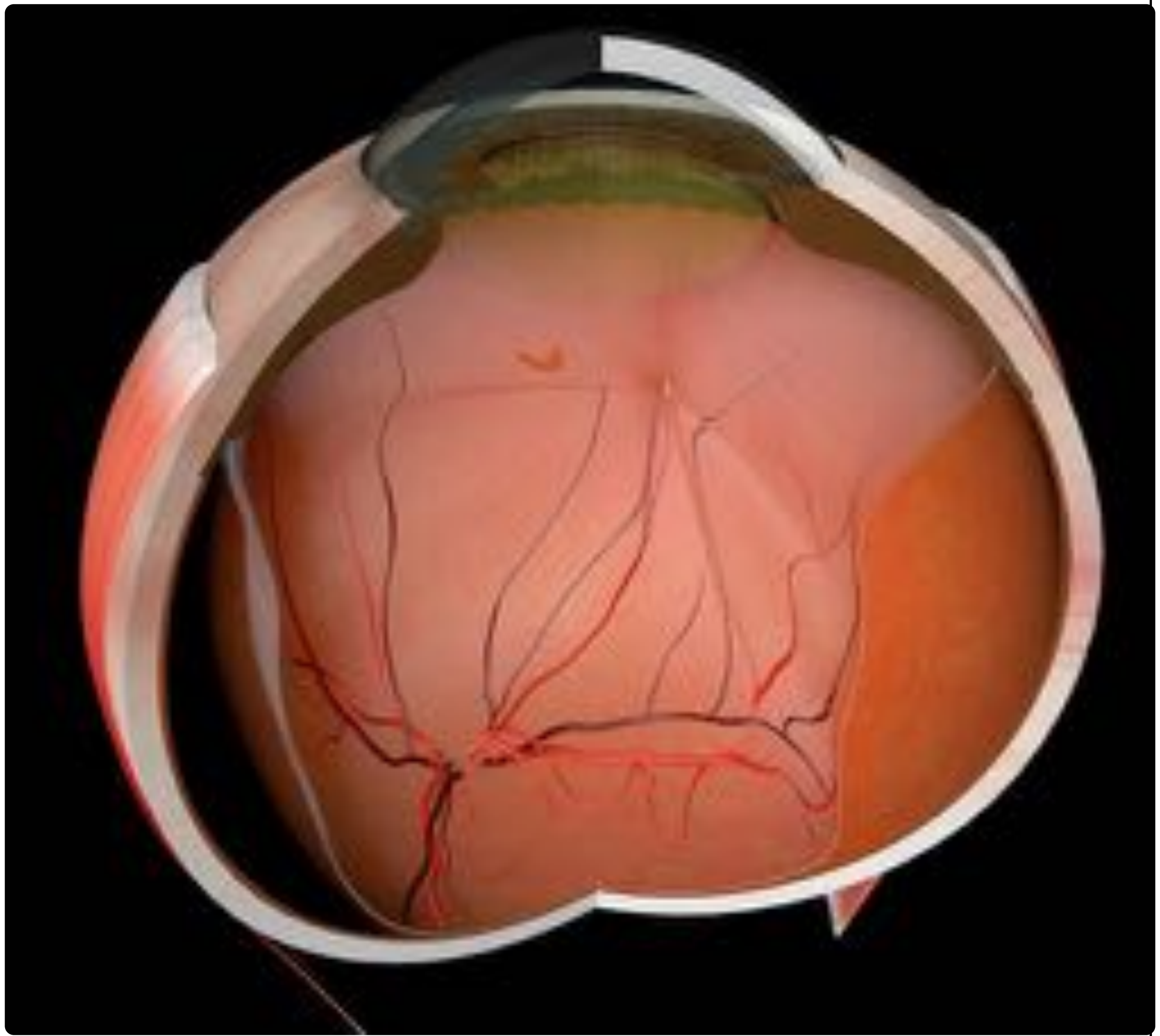
If a needle drain is used the intraocular pressure must be maintained to prevent hemorrhage for 5 minutes after the drain. If the detachment is bullous large amounts of subretinal fluid may leave the eye quickly. To maintain the intraocular pressure an injection of saline (or air in the presence of large breaks) may be required. This should prepared before drainage so that it is readily available if needed. Excessive intraocular pressure should be avoided after cut down drains as it may lead to retinal incarceration. The subretinal fluid in chronic detachments is more viscous due to a greater concentration of protein.

The flow of subretinal fluid should be monitored closely. A few pigment granules may indicate that the drain is almost complete.

Once the flow stops the retina should be examined to assess the amount of residual subretinal fluid and exclude incarceration. It is unnecessary to drain all of the subretinal fluid so a little residual fluid is not an indication for further drainage.

If no subretinal fluid at all flows and there is no incarceration an attempt may be made to establish flow. In the presence of deep subretinal fluid the sclerotomy may be teased open. If this fails the attempt at drainage may be abandoned or an alternative drain site used.

Figure 4.33 Retinal incarceration



Radiating retinal folds to a small white dot. The incarceration is causing traction on the break.

COMPLICATIONS OF SUBRETINAL FLUID DRAINAGE

If the retina is found to be incarcerated at the drain site:

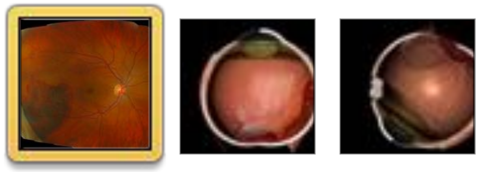
- The sclerotomy should be sutured.
- No attempt should be made to reposit the retina.
- The buckle may be extended to cover the drain site as well as the retinal break.
- Any associated retinal breaks should be treated with postoperative transpupillary photocoagulation if the retina lies flat on the buckle.
- Vitrectomy and even retinectomy may be required for major incarceration. This is best done as a secondary procedure.

Subretinal hemorrhage from drainage is the commonest serious intraoperative complication of retinal detachment repair:

- The blood has a tendency to track posteriorly under the influence of gravity to the posterior extent of the detachment. If the detachment involves the macula sub-macular hemorrhage is likely.
- Sub macular hemorrhage seriously affects macular photoreceptor function resulting in poor visual recovery.

Figure 4.34 Subretinal hemorrhage following subretinal fluid drainage

Subretinal hemorrhage following prang drainage. As the detachment did not involve the macula there is no blood under the fovea.



Immediate management of bleeding during subretinal fluid drainage is to:

- Reduce the bleeding by elevating the intraocular pressure (for example by tightening explants)
- Tilt the patient's head so that the macula is not dependent.

Postoperative management options are

- Pneumatic displacement of the hemorrhage
- Vitrectomy with drainage of the blood.

Air and gas injection.

Following subretinal fluid drainage the eye may become very soft. The intraocular pressure must be restored before any further manipulation of the globe. Failure to do this may result in miosis of the pupil and intraocular bleeding.

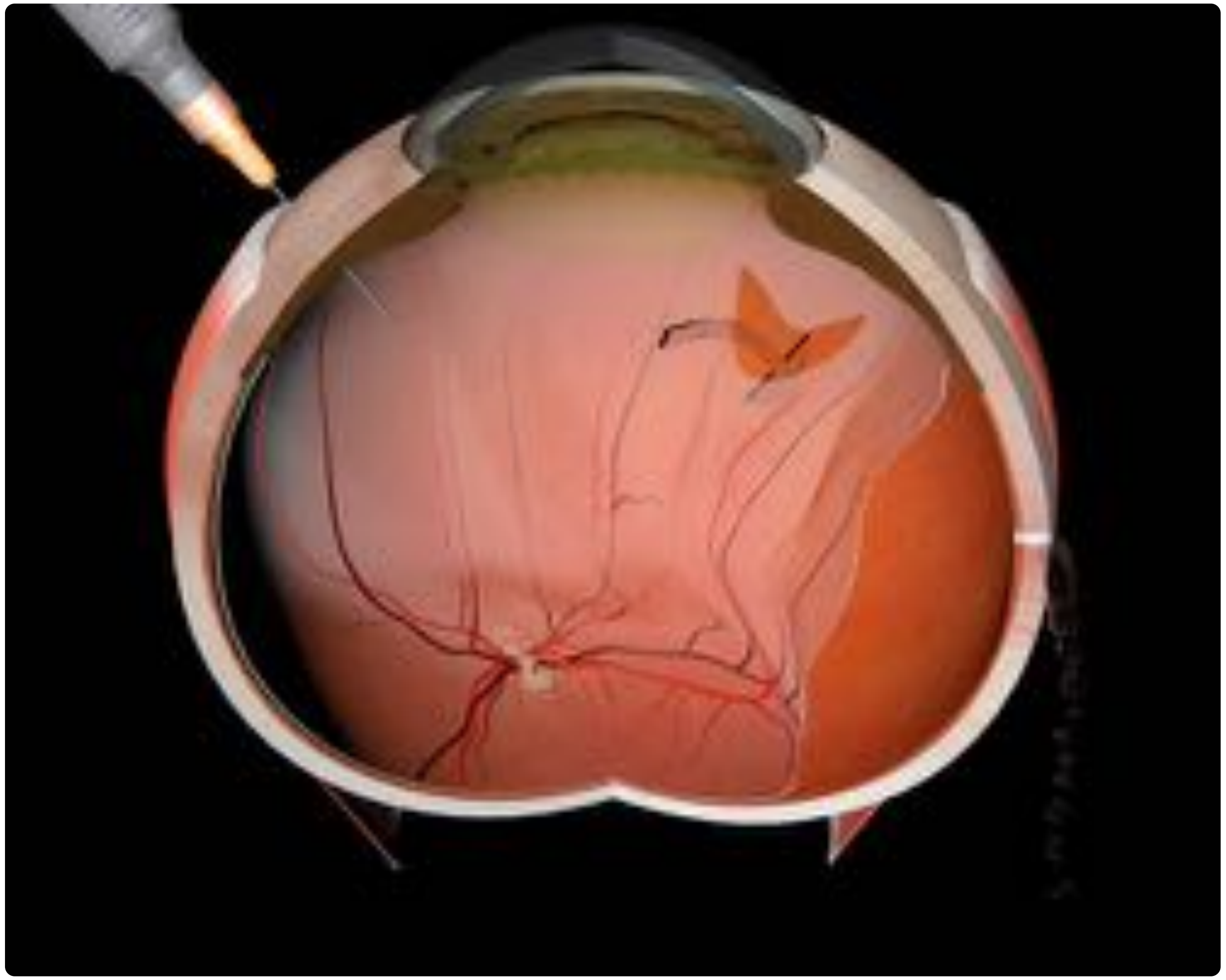
Sometimes this can be used as an opportunity to tighten sutures and encircling bands but in a very soft eye this risks a buckle that is excessively high.

Saline may be injected if the breaks are relatively small. In the presence of large tears the injected saline may pass easily through the break allowing the hypotony to recur.

The intraocular pressure can be restored with air injection. The interfacial surface tension between air and water prevents the its passage through retinal breaks. Internal tamponade to seal breaks is a secondary benefit.

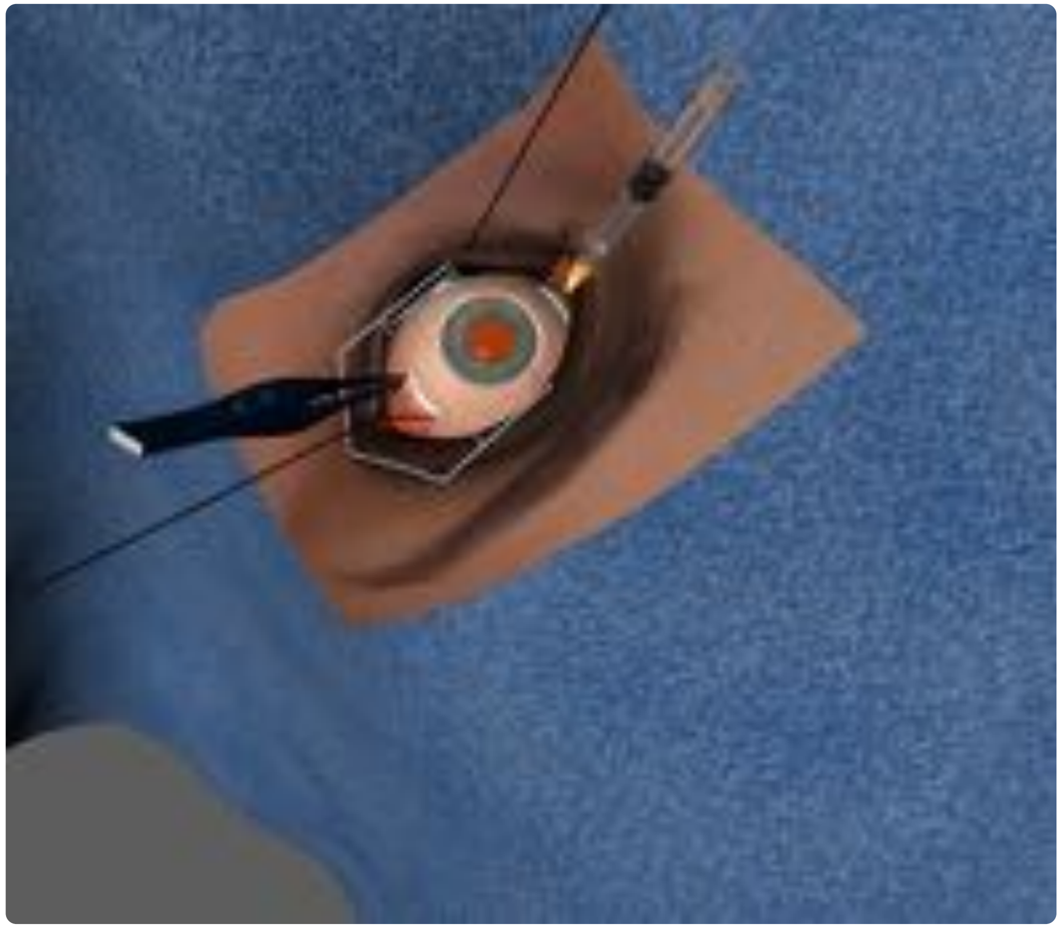
If the patient is undergoing general anesthesia using nitrous oxide the anesthetist should be informed that air is going to be injected several minutes before the injection.

Figure 4.35 Saline injection



The saline can easily leave this eye via the large tear.

Figure 4.36 Air injection technique



The indirect ophthalmoscope is set up on the surgeon's head. Sterile air is drawn up in a syringe of sterile air with a 25- or 27-gauge hypodermic needle. The surgeon then sits at the temporal side of the eye so that the needle can be inserted into the globe nasally. The injection distance is 4 mm from the limbus in a phakic and 3.5 mm in a pseudophakic eye. The horizontal meridian should be avoided because of the presence of the ciliary artery and nerve. Inserting the needle may be difficult if the globe is collapsed and counter pressure from a forceps on the other side of the eye is helpful.

Movie 4.8 Gas injection

Note that the needle is withdrawn till the tip is just visible before injection to give a single gas bubble.

If fish eggs occur they usually coalesce after a few minutes. Gently tapping the eye may assist this.

Figure 4.37 Fish eggs

Small bubbles of air (fish eggs). These interfere with the fundal view and, because of their small size, may pass through retinal breaks.

An air pump may be used to perform the injection. In that case the hypodermic needle is attached to the infusion line. It should be activated and the infusion line clamped before the needle is placed in the eye. When the line is unclamped the rapid uniform injection speed usually gives rise to a single bubble.

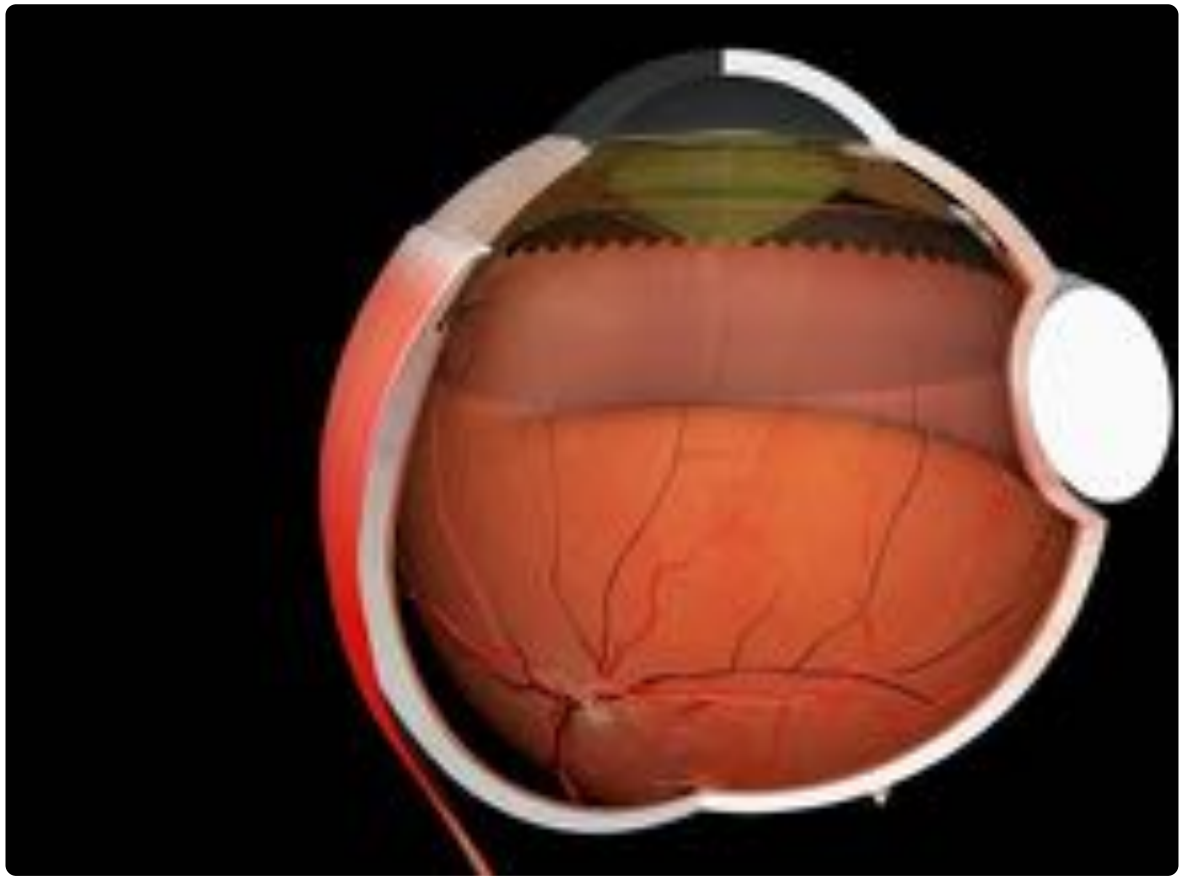
Macular folds may occur in eyes undergoing air injection with a high scleral buckle. They arise from a combination of:

- retinal redundancy (induced by high indents)
- residual subretinal fluid (from incomplete drainage)
- displacement of detached retina by the buoyancy of the gas bubble

It has been hypothesized that it may be prevented by postoperative prone posturing.

If internal tamponade is required without subretinal fluid drainage 0.3 ml of an expansile gas bubble may be injected into the eye - although with some caution as inferior retinal breaks may occur. These are presumed to be caused by dynamic traction in the inferior vitreous base induced by movements of the bubble within the vitreous.

Figure 4.38 Macular folds



Macular compression fold associated with incomplete drainage, large buckle and intraocular gas.

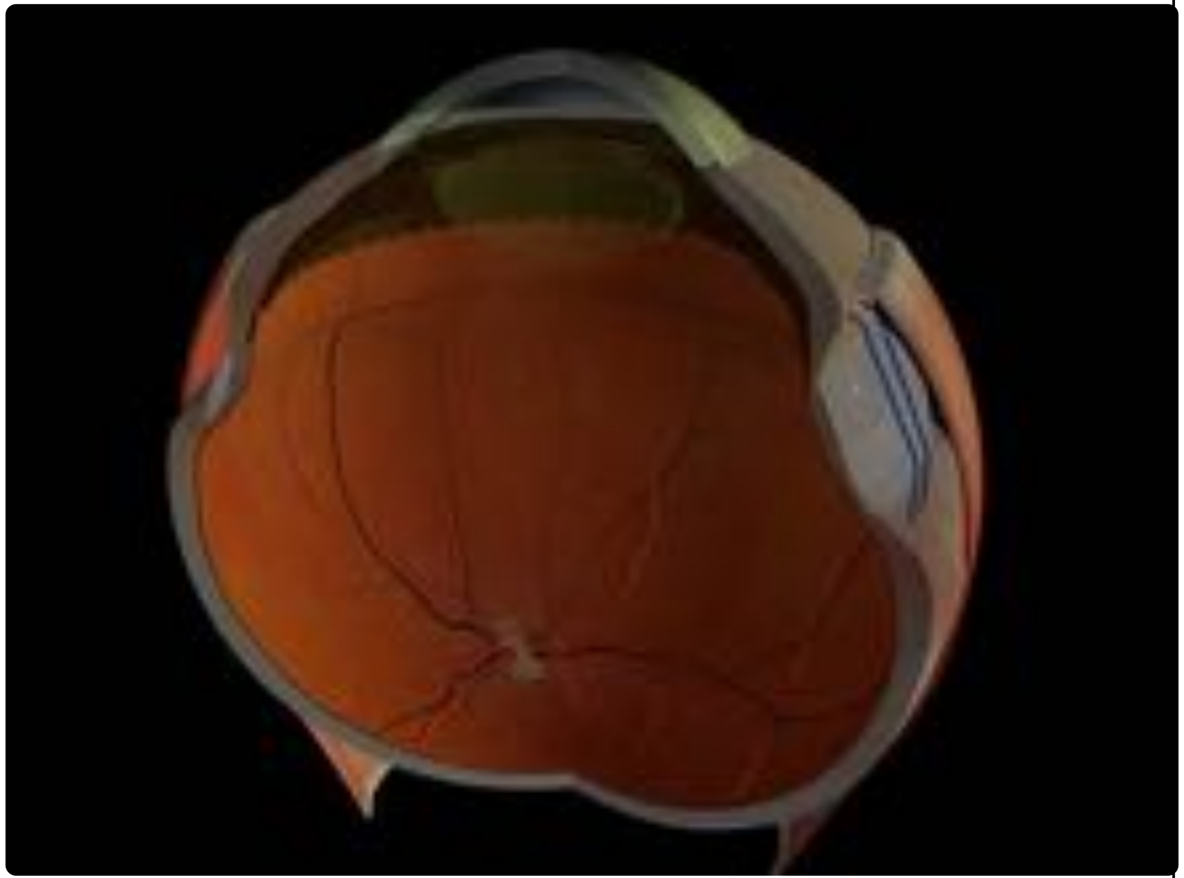
Encirclement

Possible indications for **encirclement** include:

- Creation of a permanent indent (local indents from segmental buckling are prone to fade as the sutures erode through sclera).
- Support of any unseen breaks (for example when the fundal view is poor).
- Support of the whole vitreous base to reduce vitreous traction as prophylaxis against future break development.
- The presence of vitreous base contraction (anterior PVR).

There are counter arguments to all of these and encirclement does have a significant risk of complications. The use of encirclement seems to be declining. It is many years since the author performed one.

Figure 4.39 Rationale for encirclement

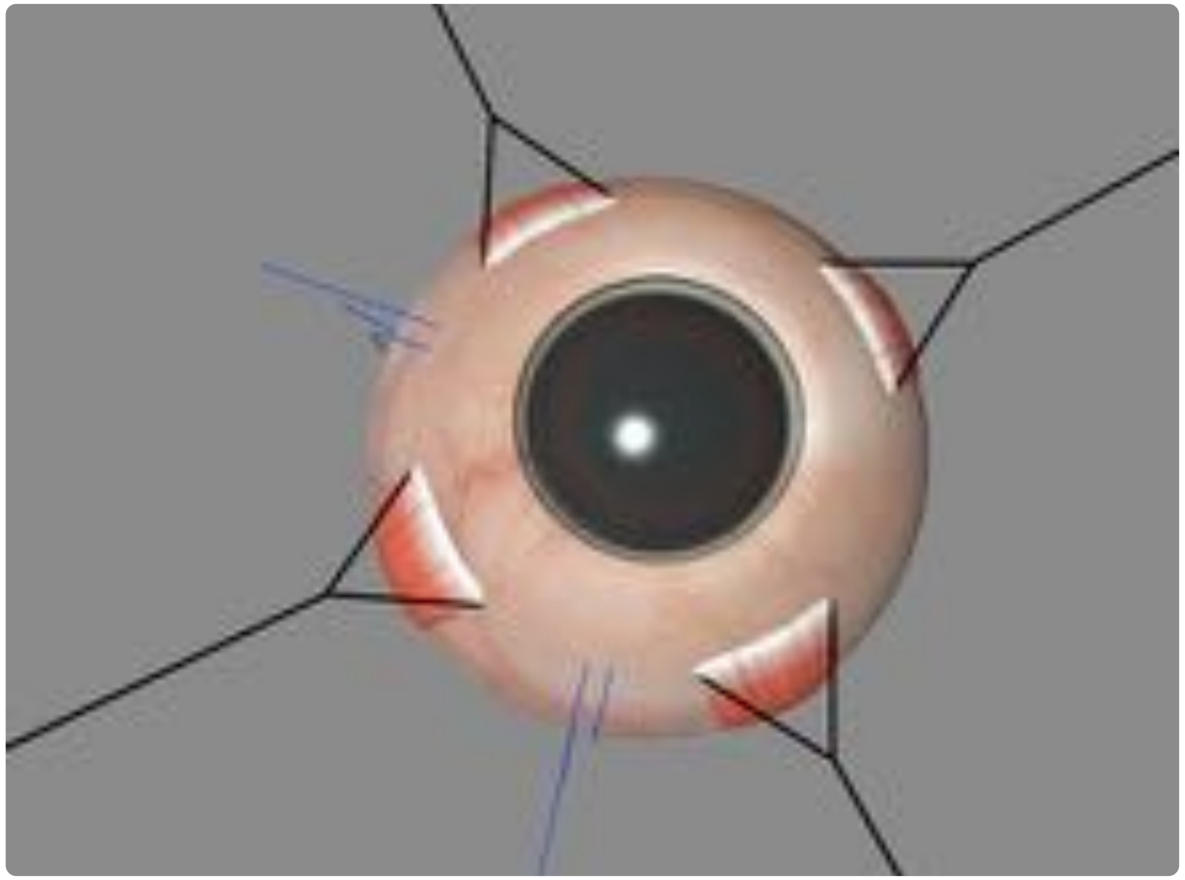


Encirclement in theory supports the whole vitreous base. Note however that the area supported by the band (on the left) is much less than that supported by the tire (on the right).

TECHNIQUE OF ENCIRCLEMENT

One of the many ways of placing an encirclement is demonstrated here.

Figure 4.40 Placing an encircling tire and 40 band



Traction sutures are placed on all 4 recti and scleral mattress sutures pre-placed. Sutures for the band will be added later.

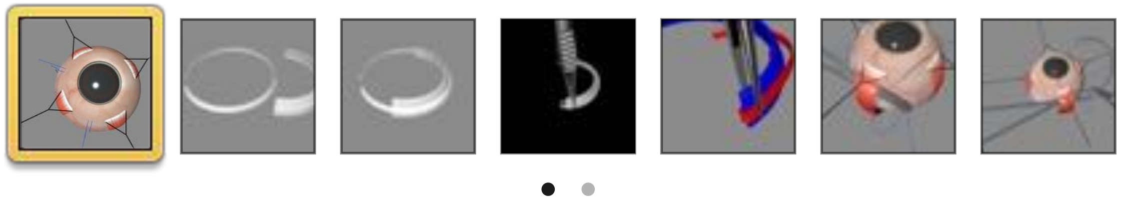
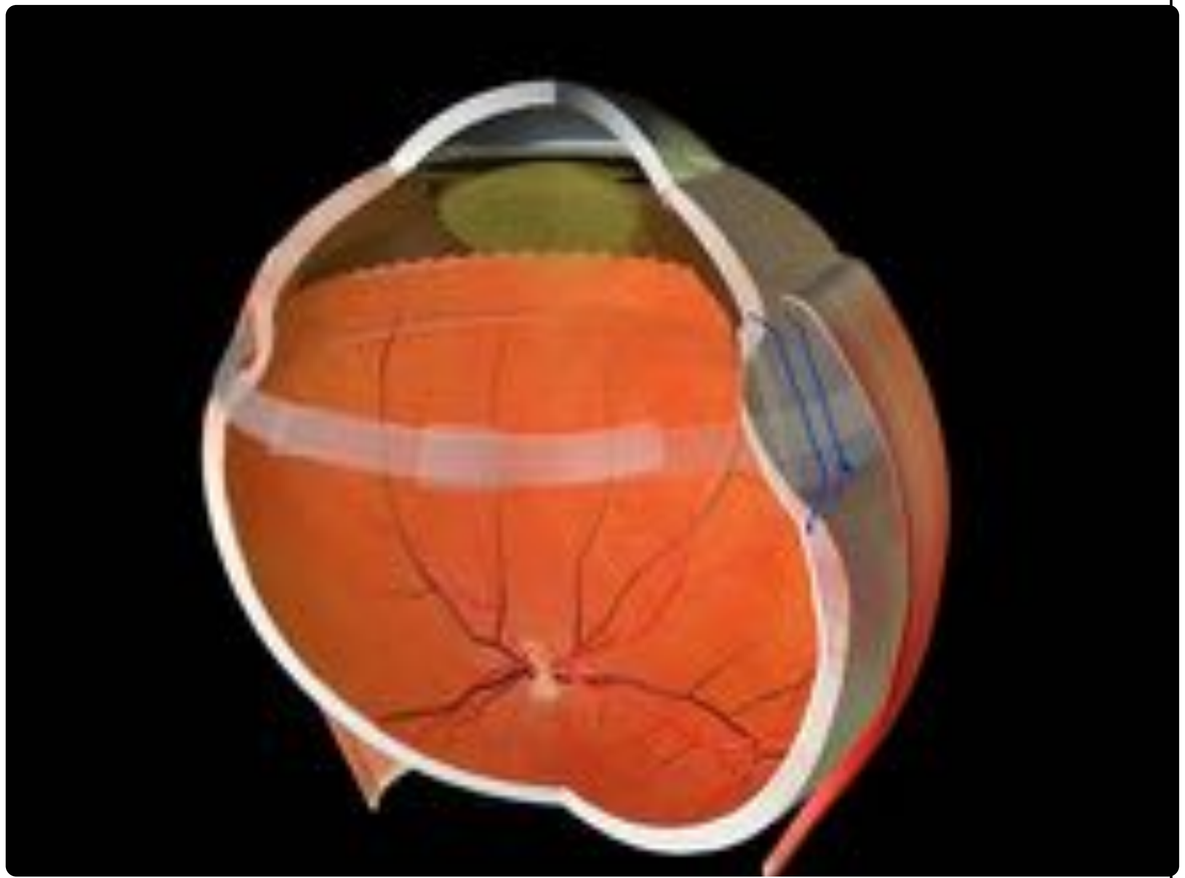


Figure 4.41 Tightening the watske sleeve

A Watske forceps is a cross acting forceps designed to allow the tips to be opened with considerable force.

The advantage of a Watske sleeve in encirclement is the ease with which the tension in the band can be adjusted. The height of the desired indent will vary a little from case to case. Shortening the band by 6 mm produces a 1 mm high indent. Most cases require an indent approximately 1 - 1.5 mm high. A useful end point is the appearance of a low indentation from the band on indirect ophthalmoscopy. The ends of the band should be trimmed at the end of the operation but it is wise to leave a few mm of one end protruding in case the band needs to be loosened. Placing the sleeve near a muscle allows this to be left under the muscle belly.

Figure 4.42 The end point of tightening a band



The indent from the band is just visible but not prominent. Over-tightening the band may produce many problems.

Finishing the operation

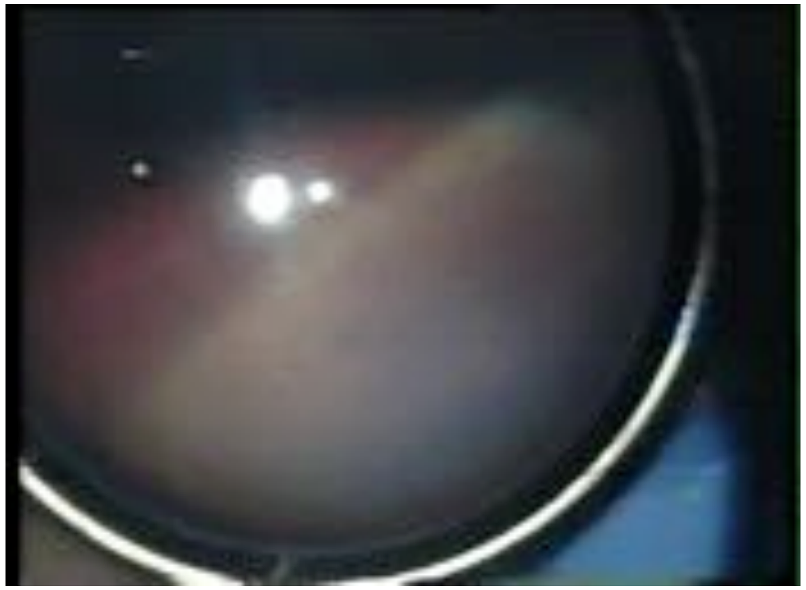
ASSESSING THE INDENTATION

The indentation produced by the explant is inspected to ensure that all breaks in detached retina are supported. The presence of subretinal fluid under breaks does not always require any intervention. If the buckle is deemed inadequate subretinal fluid may be drained or gas injected.

Figure 4.43 Assessment of subretinal fluid at the end of surgery

The breaks are highly elevated and the retina has large ridges which do not conform to the surface of the buckle. The indent does not seem to have had any impact at all on the distribution of subretinal fluid. Subretinal fluid drainage and/or gas injection are required.

Movie 4.9 Final check of the indent



All the breaks are well supported.

CHECKING THE CENTRAL RETINAL ARTERY.

The central retinal artery is inspected.

If the intraocular pressure is above the systolic pressure in the central retinal artery the disc appears pale and no pulsation is seen.

If the intraocular pressure is between the systolic and diastolic pressure in the central retinal artery spontaneous pulsation is seen.

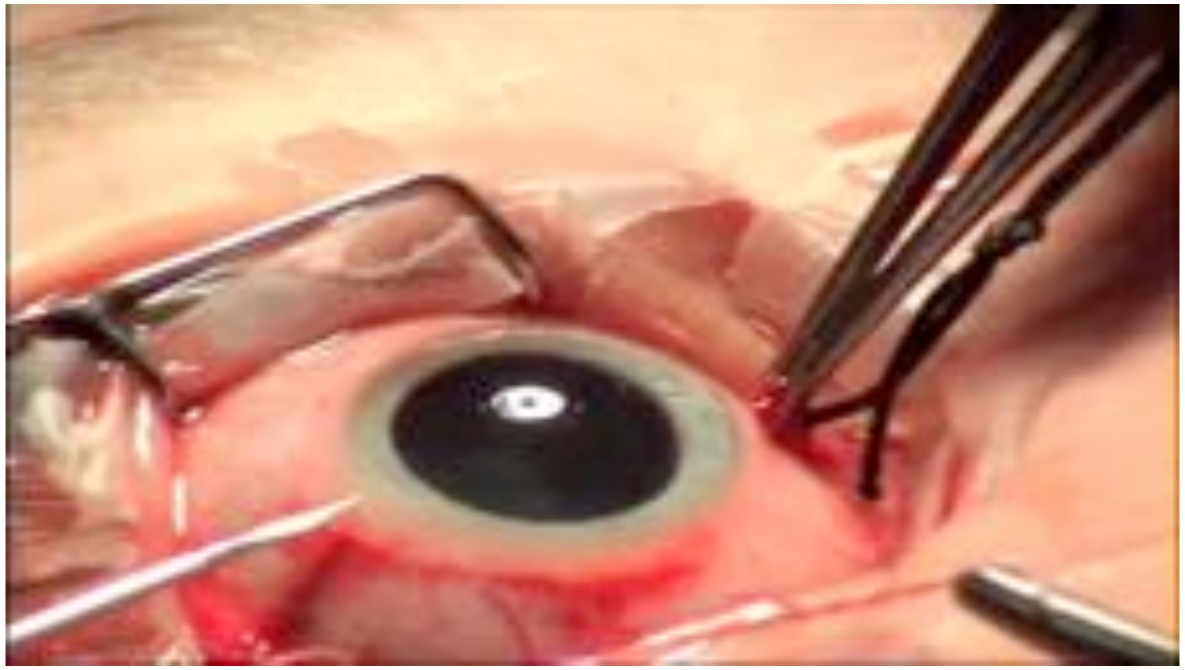
If the intraocular pressure is below the systolic and diastolic pressure in the central retinal artery no pulsation is seen and the vessels appear patent and the disc pink.

Pulsation induced by pressure on the eye is therefore a useful test to confirm patency of the artery if the view is poor.

Movie 4.10 Checking perfusion of the central retinal artery.

Spontaneous pulsation of the central retinal artery.

Movie 4.11 Paracentesis



Note the use of an mvr blade to give a self sealing incision and backwards pressure while withdrawing to release aqueous.

CLOSURE

Any protruding elements of the buckle are trimmed and the conjunctiva is closed using absorbable sutures.

Closure of tenons capsule as a separate layer prior to closing conjunctiva may reduce the risk of late buckle extrusion.

Great care is taken to achieve to restore the conjunctival anatomy to as close to its preoperative state as possible. This is important for patient comfort but also makes revision surgery easier.

Finally a subconjunctival injection of a broad spectrum antibiotic is given.

Figure 4.44 Conjunctival Closure

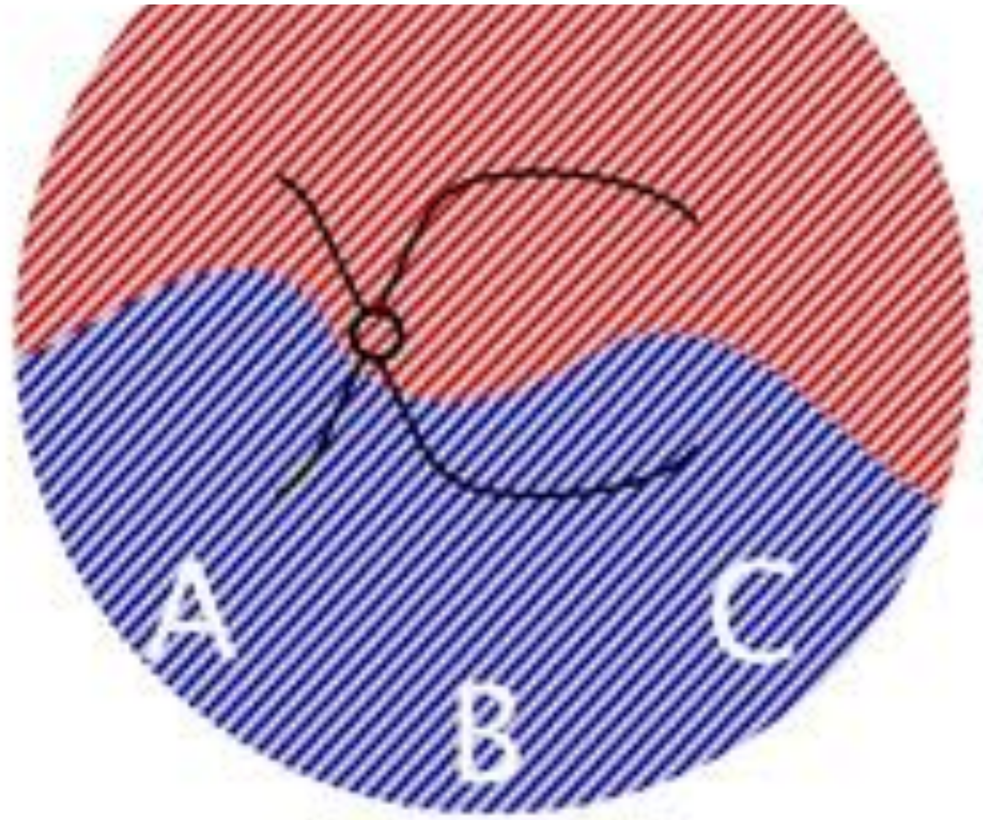
Prolapse of tenons capsule due to poor closure.

Knowledge review

Review 4.1 Localizing retinal breaks

Question 1 of 2

Using Lincoff's rules, predict the likely location of the primary break in this patient:



- **A.** A
- **B.** B
- **C.** C

Check Answer

Review 4.3 Marking breaks

When marking the position of a retinal break on the sclera:

- **A.** Errors are more likely if the subretinal fluid is shallow.
- **B.** Errors are most likely to be zonal.
- **C.** Errors are most likely to be merdional.

Check Answer

Review 4.2 Using the cryoprobe

Question 1 of 3

The cooling effect of the cryoprobe is based on:

- **A.** Laplace law.
- **B.** The Joules-Thompson effect.
- **C.** The Bernoulli principle.

Check Answer

Review 4.4 Scleral suturing

Question 1 of 3

The preferred needle profile for scleral suturing is:

- **A.** Spatulated. ✓
- **B.** Round bodied.
- **C.** Reverse cutting.
- **D.** Cutting.

Check Answer

Review 4.5 Retinopexy

Question 1 of 4

A visible cryotherapy freeze of the retina develops more quickly when:

- **A.** Performing cryotherapy in an air filled eye. ✓
- **B.** Performing cryotherapy in the presence of subretinal fluid.
- **C.** Performing cryotherapy through a rectus muscle

Check Answer

Review 4.6 Subretinal fluid drainage

Which statement is correct:

- **A.** The areas immediately above and below the horizontal recti are very vascular and should be avoided.
- **B.** Draining at the site of a retinal break is an effective way of draining a large amount of subretinal fluid.
- **C.** The goal is to completely drain the subretinal fluid.
- **D.** Many retinal detachments may be managed without drainage of subretinal fluid.
- **E.** If the eye goes very soft during drainage in an eye with a pre-placed band the band should be tightened until the intraocular pressure is normal.

Check Answer

Review 4.7 Air injection

Which of the following is true:

- **A.** Air should usually be injected at the 9 o'clock meridian.
- **B.** The needle should be passed into the centre of the eye before injecting.
- **C.** The air should be injected very slowly.
- **D.** The location of the needle should be monitored using an indirect ophthalmoscope.
- **E.** The patient should be recovered in the upright position to prevent macular compression folds.

Check Answer

Review 4.8 Encirclement

Shortening an encircling band by 6mm produces an indent

- ✓ **A.** 1 mm high.
- **B.** 2mm high.
- **C.** It varies depending on the axial length.
- **D.** None of the above

Check Answer

Review 4.9 The end of surgery.

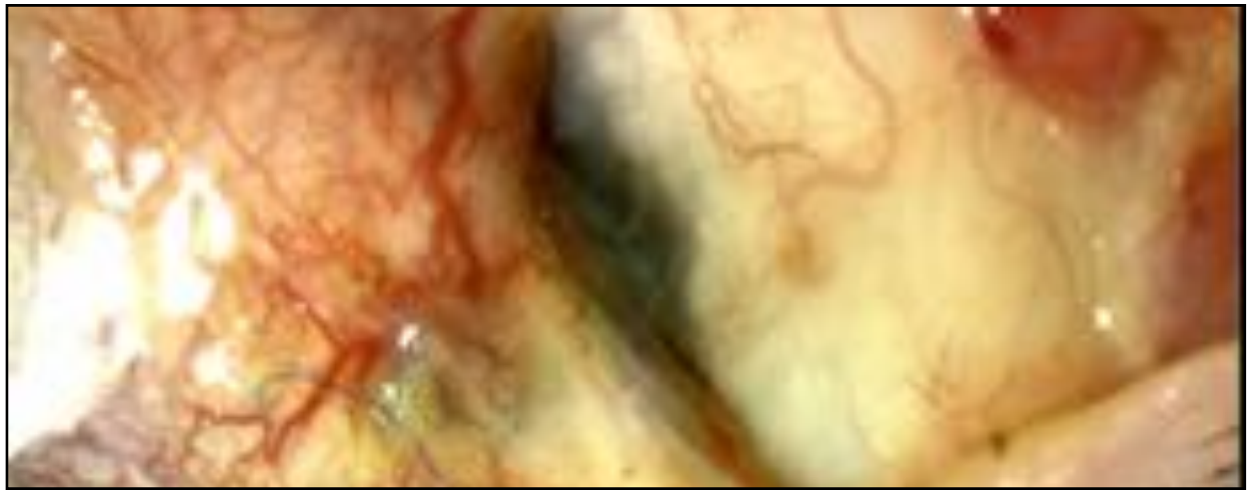
Spontaneous pulsation of the central retinal artery is observed at the end of surgery. This implies that the IOP is

- **A.** Greater than the systolic pressure in the central retinal artery.
- **B.** Less than the diastolic pressure in the central retinal artery.
- ✓ **C.** Between the systolic and diastolic pressures in the central retinal artery.

Check Answer

CHAPTER 5

Complications of Scleral Buckling Surgery



The commonest complication of retinal detachment repair is recurrent retinal detachment. There are also a number of intraoperative and postoperative complications, some of which have already been discussed.

Recurrent retinal detachment

DELAYED RESORPTION OF SUBRETINAL FLUID

The presence of persistent subretinal fluid after surgery does not necessarily imply that the primary operation has failed, particularly if non drainage surgery was carried out. The RPE is very efficient at pumping water but subretinal fluid also contains mucopolysaccharides that may persist for much longer, even several months. This fluid usually accumulates inferiorly but may also sit at the macula.

Features which are suspicious of rhegmatogenous redetachment include:

- Increasing subretinal fluid.
- Subretinal fluid on the indent involving retinal breaks.
- Subretinal fluid in a new location.

RECURRENT RETINAL DETACHMENT

Recurrent retinal detachment usually occurs because a retinal break:

- Was not detected.
- Was not adequately supported on the indent.
- Had inadequate retinopexy.

Proliferative vitreoretinopathy is often associated with one of the above avoidable factors.

The purpose of retinopexy is to permanently seal breaks so that, in the event of the indent disappearing, the retina does not redetach. For as long as the indent persists the breaks remain closed. Inadequate cryotherapy to retinal breaks therefore manifests as late redetachment. This is presumably a result of fading of the indent as it is not seen when the retina is encircled.

Figure 5.1 Inadequate retinopexy

The retina is attached but there is an untreated break.

UNDETECTED OR NEW RETINAL BREAKS

The distinction between undetected and new breaks is difficult to make in practice. Both present with recurrent detachment due to an untreated break in the post operative period. The high success rate of segmental buckling in highly experienced hands suggest that the majority of these cases are missed rather than new breaks.

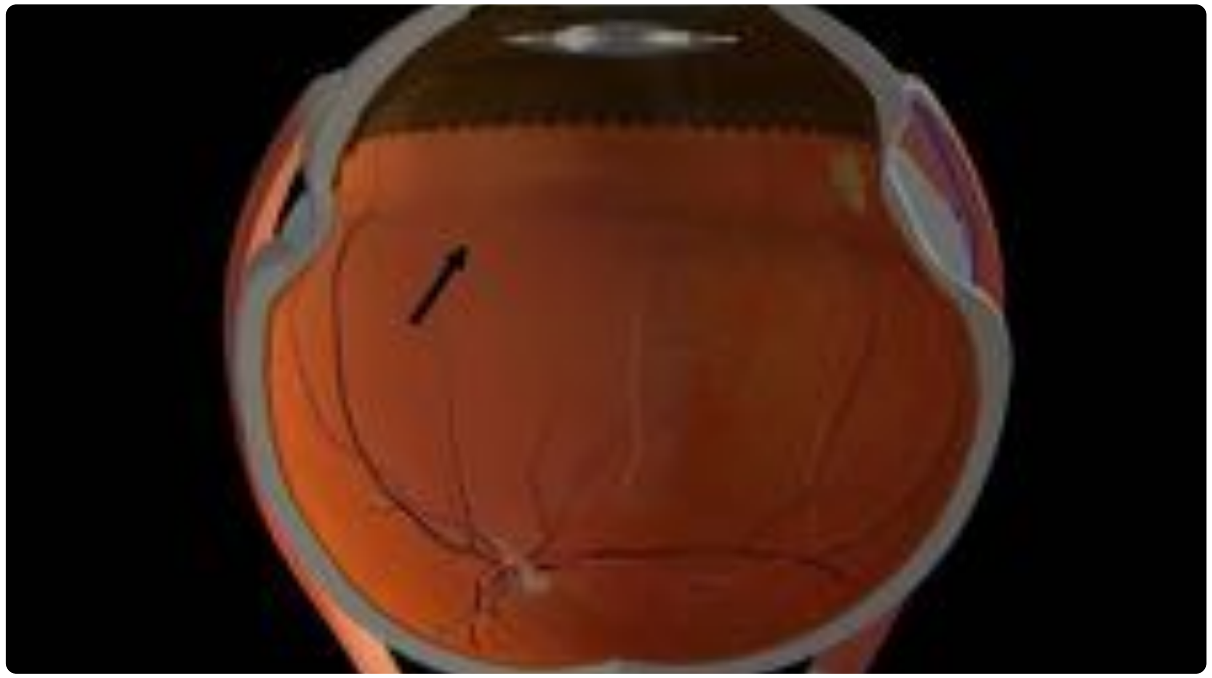
The key to finding all the retinal breaks is meticulous examination of the retina, both pre and per operatively.

Failure to detect all the causative breaks is particularly common in pseudophakic eyes due to a combination of:

- Small size of the breaks.
- Anterior location of the breaks.
- High probability of multiple breaks.

Lincoff's original rules for the detection of retinal breaks are not applicable after retinal detachment surgery. A modified set of rules may be used to determine the location of the breaks after non drainage surgery.

Figure 5.2 Missed retinal break



This pseudophakic eye has undergone surgery with a local tire under the superior breaks and an encircling band. The superior breaks are well supported by the tire. The nasal break (arrow) was missed in the primary surgery. The indent from the band is not wide enough to support it. Bands maintain the height of tires but cannot be relied upon to support the entire vitreous base.

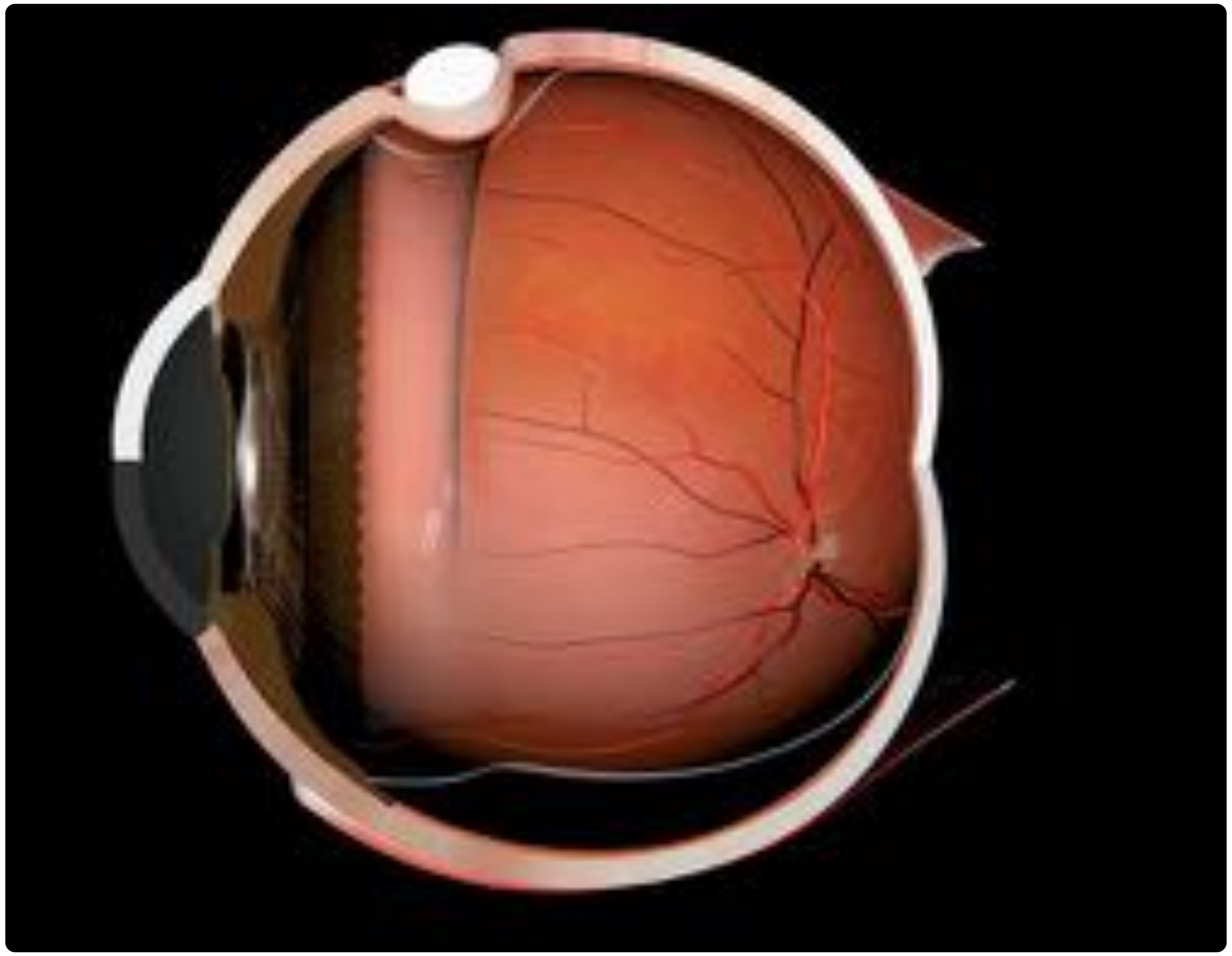
INADEQUATE INDENT

The indent may fail to support a break either because it is in the wrong position or because it is not high enough.

Malposition of buckles is usually due to errors in judging the zone of the break.

Buckles may be too low because of poor choice of explant or because of errors in placing or tying the securing mattress sutures. The presence of subretinal fluid on the indent is a sign that the buckle is inadequate and a further procedure is required. Some of these cases may be treated successfully with postoperative injection of expansile gas.

Figure 5.3 Inadequate indent



An anterior unsupported break due to a zonal localization error during surgery. The anterior part of the tear is not adequately supported. Note the fluid sinus which trickles down anteriorly on the indent causing an inferior detachment. This could have been avoided by using a break-ora occlusive buckle (in which the indent extends to the ora).

PRINCIPLES OF REVISION SURGERY

The principles of repeat buckling surgery are the same as those of primary surgery: all the retinal breaks have to be found and treated and those with associated subretinal fluid supported with an indent.

When performing revision surgery:

- The conjunctiva is frequently scarred and adherent to the sclera.
- There is a fibrous capsule enveloping the explant.
- The sclera under the explant may be very thin, particularly under long standing encirclements.

STEPS OF REVISION SURGERY

Movie 5.1 Revision conjunctival dissection

Cutting rather than blunt dissection in a revision peritomy

The conjunctiva may be torn during revision peritomy. To avoid this less blunt dissection (spreading of scissors under conjunctiva) and more sharp dissection (cutting by closing scissors) is necessary.

Subconjunctival injection of fluid may be helpful in establishing tissue planes. The dissection starts anteriorly, working slowly backwards and staying in the same plane (the surface of the sclera) until the edge of the fibrous capsule surrounding the explant is visible. If a circumferential explant is in place which travels under one or more rectus muscles this is used to help find and sling the muscles. The capsule is incised on top of the explant mid way between two recti so that the explant is exposed.

The capsule is opened to the border of the muscle (indicated by the anterior ciliary arteries). Any mattress sutures over the explant are divided as this is done. A squint hook is then placed directly on the explant and swept over it to engage the muscle. The squint hook must not be placed under the explant as the condition of the sclera is unknown.

The scar tissue is dissected off the muscle and traction sutures are placed.

Figure 5.4 Slinging the muscle.

The squint hook is passed under the muscle in the capsule over the explant.

Only when this has been done is the explant removed.

Movie 5.2 Opening the capsule around the explant

Movie 5.3 Removing scar tissue from the muscle.

Note scar tissue must be cut off, not swept off, in revision surgery

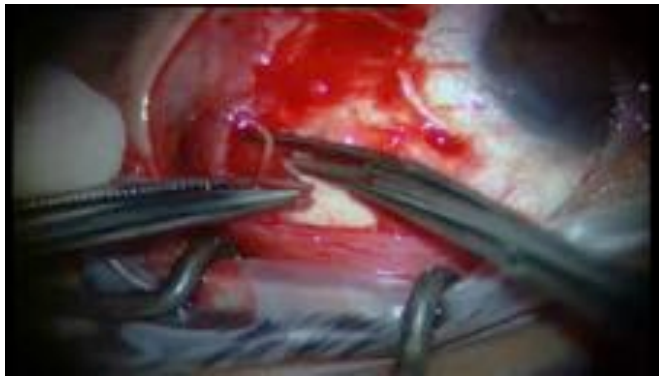
Movie 5.4 Removal of the explant

The sclera is inspected for signs of thinning.

Movie 5.7 Inspection of the sclera

The rest of the fibrous capsule is dissected off the sclera.

Movie 5.5 Dissection of the anterior portion of the explant capsule



All associated sutures are also removed. They cannot be pulled out because of scar tissue in the knots.

Movie 5.6 Dissection of the posterior portion of the explant capsule

Note the linear adhesion where this meets the sclera - one blade of the scissors has to be placed on either side of this.

From this point the surgery is the same as primary surgery.

Subretinal hemorrhage

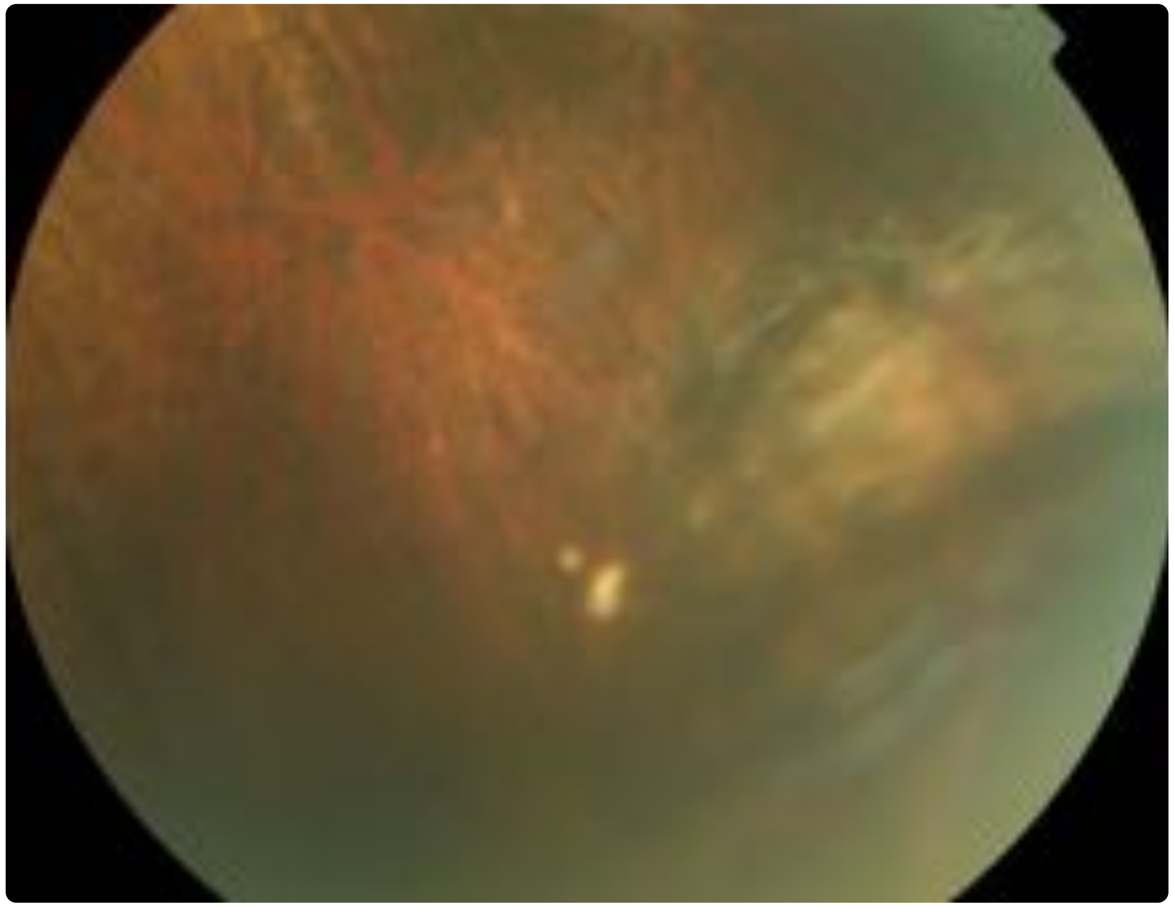
Figure 5.5 Subretinal hemorrhage

Subretinal hemorrhage may occur while placing scleral sutures or while draining subretinal fluid. Its management was discussed in the previous section.

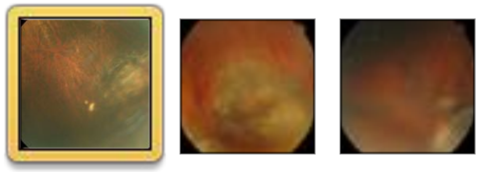
Scleral wounds

Suture perforation has already been discussed. The wound is very small. If subretinal fluid is present at the perforation site it may cause subretinal fluid drainage without creating a retinal break. A perforation in an area of attached retina is more likely to involve the retina. It is managed by replacing the suture and dealing with the secondary consequences (subretinal hemorrhage, ocular hypotony and, rarely, retinal perforation). Perforations are frequently unnoticed during surgery and may be seen post operatively as yellow dots beside the explant.

Figure 5.6 Suture perforations



Many suture perforations have no adverse consequences



Movie 5.8 Scleral wound

Large scleral wounds usually arise in areas of scleromalacia, sometimes in the bed of an old explant. If the sclera around the wound is healthy the wound may be oversewn by placing mattress sutures in healthy sclera around the wound edge.

This occurred in an area of ectasia in the bed of an old explant

Movie 5.9 Scleral patch graft

The patch is secured with overlay mattress sutures after episcleral tissue has been removed.

If the wound is too large or the surrounding sclera unhealthy cyanoacrylate glue, a scleral buckle or a scleral patch graft may be applied.

Scleritis

Figure 5.7 Scleritis

Posterior scleritis

Suture related episcleritis is very common - patients complain of superficial ocular discomfort and have obvious injection around the sutures. In many cases it is a reaction to polyglycolic acid (vicryl) or the dyes in the suture.

Mild posterior scleritis is quite common after buckling surgery. It is probably a reaction to cryotherapy or to superficial hemostatic diathermy of the sclera. Patients complain of severe dull ache worse on eye movement and lying down. There may be relatively little anterior scleritis. B scan ultrasound shows thickening of the sclera. It is treated with oral non steroidal anti-inflammatory agents.

Early infective scleritis is a very rare but potentially visually devastating condition which may lead to scleral necrosis and perforation. It should be suspected if there are signs of severe progressive scleritis and purulent discharge. Removal of the explant is the only effective treatment.

Late infective scleritis usually follows exposure of a suture end and is associated with buckle extrusion - it tends to run a protracted course and can only be managed by removing the explant.

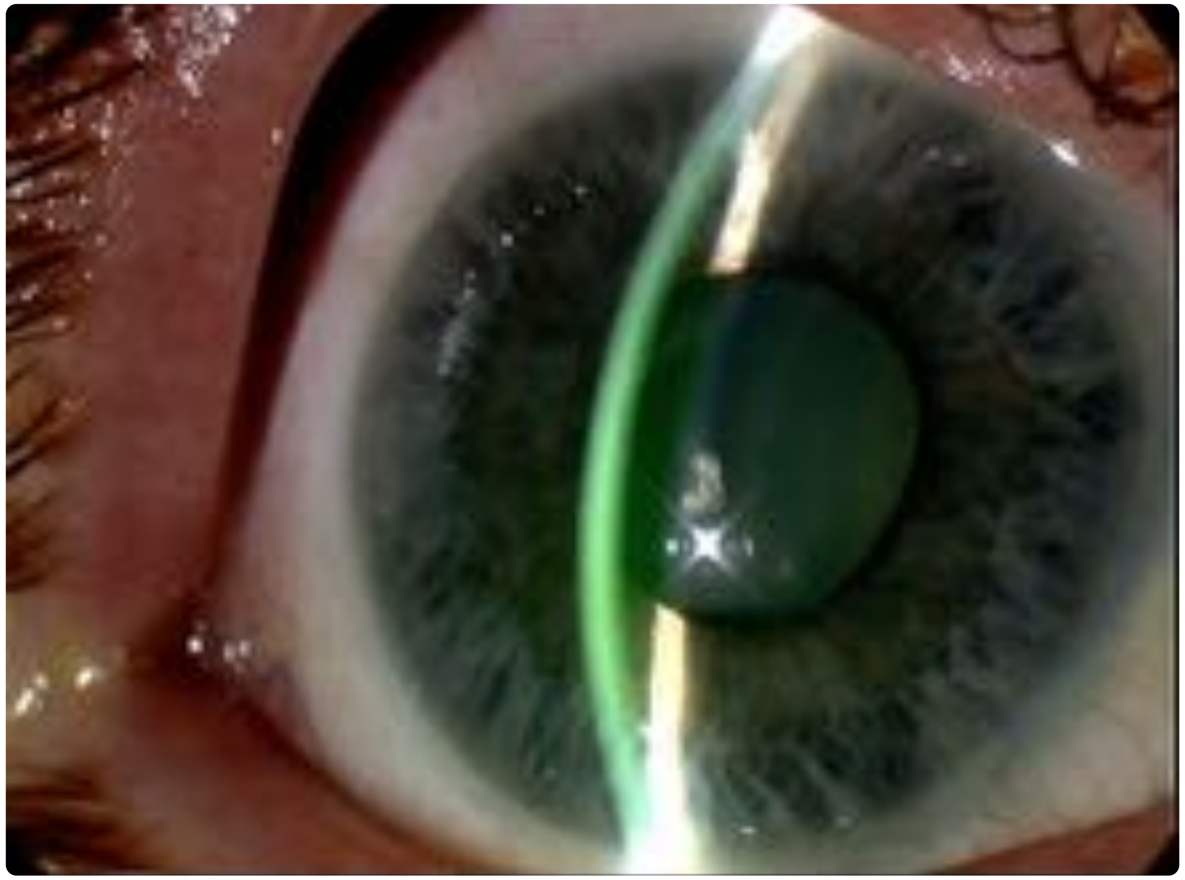
Surgically induced necrotising scleritis is a very rare condition of buckling surgery. The appearance is dramatic with large areas of while totally avascular sclera. It responds well to systemic immunosuppression.

Glaucoma

Most cases of raised intraocular pressure are steroid related and resolve when steroids are discontinued.

Large encircling buckles may cause congestion and forward rotation of the ciliary body which pushes the iris and lens forward causing angle closure without pupil block. Unlike pupil block the central anterior chamber is shallow. The distinction is important because angle closure without pupil block is treated with mydriatics which are contraindicated in angle closure.

Figure 5.8 Angle closure following encirclement



Angle closure without pupil block following encirclement.

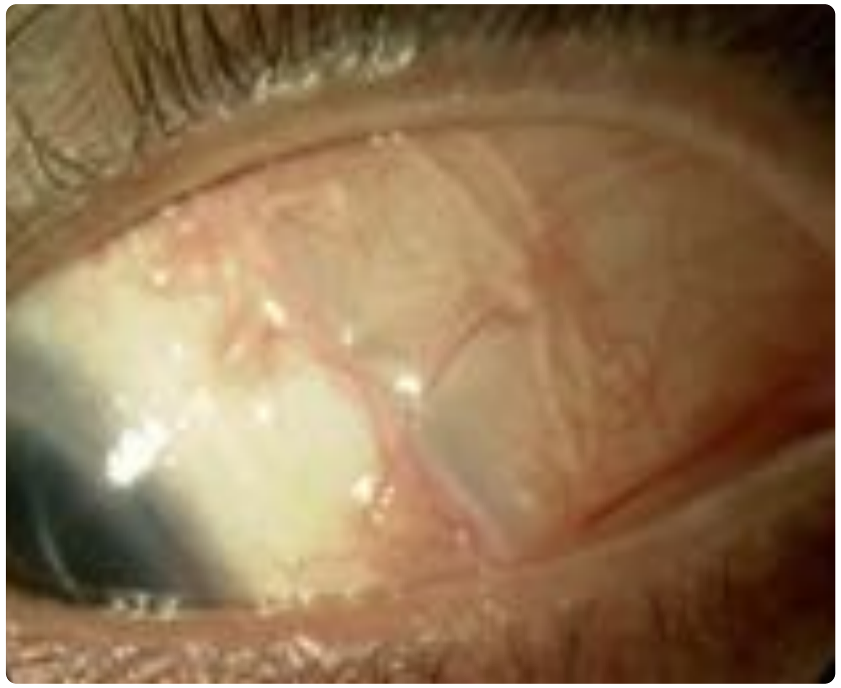
Explant extrusion

The conjunctiva may dehisce over a suture. Secondary bacterial contamination sets off a spiral of infection, inflammation and further conjunctival dehiscence. As the bacteria produce protective biofilm on the surface of the explant eradication by medical means is not possible. The only effective treatment is removal of the explant. Provided all the retinal breaks have been sealed with retinopexy the risk of detachment when the buckle is removed is low. Retinopexy is performed to any visible untreated retinal breaks before the explant is removed.

Prevention of extrusion may be achieved by:

- Leaving the knots on sutures as posterior as possible - the risk of extrusion is reduced because a protective layer of tenons capsule is thicker posteriorly.
- Trimming protruding corners and edges of explants to leave them as flush as possible with the ocular surface.
- Closure of tenons capsule over the explant as a separate layer. This prevents retraction of tenons capsule which leaves explants and sutures covered with only a thin layer of conjunctiva.

Figure 5.9 Explant extrusion



Extrusion seems start with conjunctival dehiscence over protruding sutures and buckle elements.

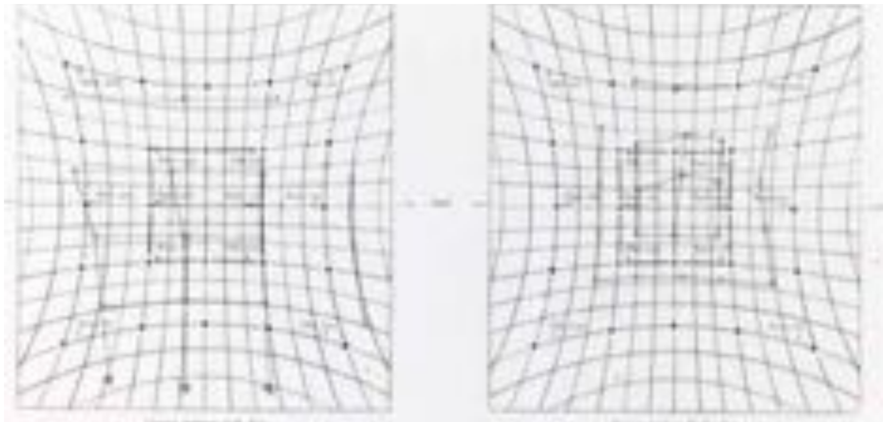
Diplopia

A comprehensive account of motility problems after vitreoretinal surgery is beyond the scope of this book.

Motility problems after scleral buckling surgery are related not just to the presence of large explants under rectus muscles but also to surgical trauma and secondary post-operative scarring. Not every case will therefore respond to removal of the explants. It may be addressed with prisms, botulinum toxin injection and muscle surgery.

Before referring the patient with diplopia to a strabismologist one should exclude the presence of sensory diplopia. Patients with macular involving retinal detachments suffer from post operative diplopia related to metamorphopsia and aniseikonia. It is simply impossible for the brain to fuse a normal image from one eye with a distorted image from the other and no surgical procedure on the muscles will address this problem. In a patient in whom both motor and sensory diplopia seem to coexist (a common scenario) the use of botulinum toxin to temporarily address the motor problem is a useful test in determining the potential for binocular single vision with muscle surgery.

Figure 5.10 Diplopia after buckling surgery



Hess chart of diplopia following buckling surgery.

Knowledge review

Review 5.1 Persistent subretinal fluid post operatively

When assessing subretinal fluid postoperatively:

- **A.** Subretinal fluid behind the indent that persists for more than 2 weeks indicates a need for revision surgery.
- **B.** Increasing subretinal fluid on the indent involving a break indicates a need for revision surgery. ✓
- **C.** Persistent subretinal fluid under the macula indicates a need for revision surgery.
- **D.** Lincoff's rules may be used to predict the location of undetected breaks.

Check Answer

Review 5.2 Explant extrusion

Which intervention is least likely to reduce the risk of late extrusion of a scleral buckle:

- **A.** Excising tenons capsule. ✓
- **B.** Rotating the sutures so that the knots lie posteriorly.
- **C.** Trimming any protruding elements of the buckle.

Check Answer

Review 5.3 Diplopia after surgery

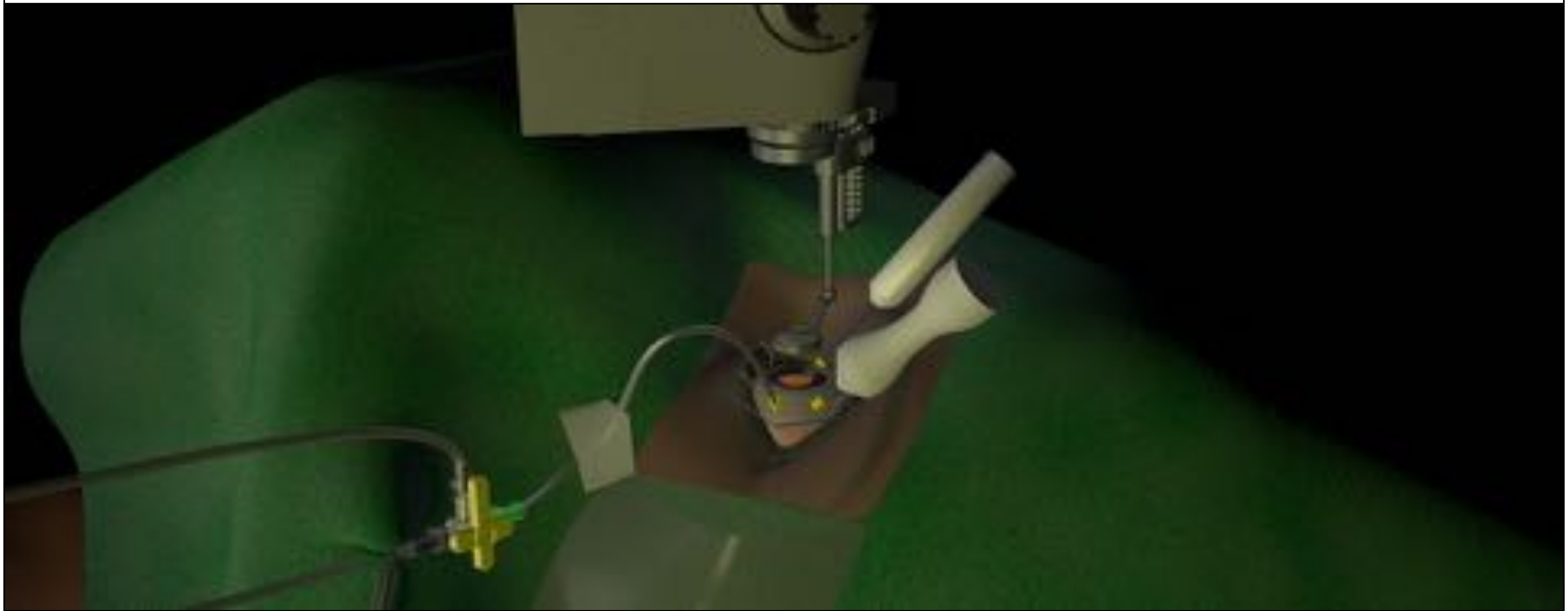
A patient complains of severe distortion and binocular diplopia after buckling surgery for a macula-involving retinal detachment. The symptoms are likely to respond to:

- **A.** Botulinum toxin injection.
- **B.** Prisms.
- **C.** Removal of the buckle.
- **D.** Muscle surgery.
- **E.** All of the above.
- **F.** None of the above. ✓

Check Answer

CHAPTER 6

Vitrectomy Equipment

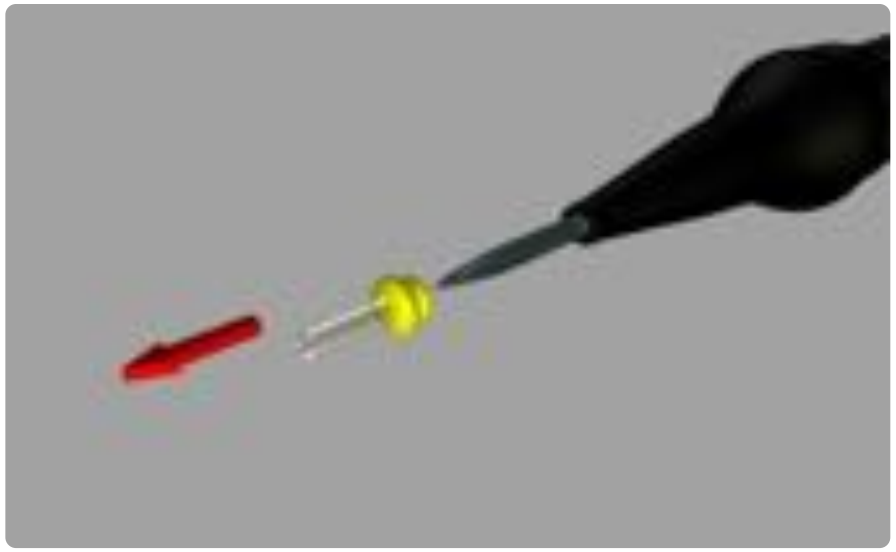


The rapid rate of technological advance precludes a completely up to date and comprehensive account of this important subject. The general principles of vitrectomy instrumentation, which will be described in relation to 23-gauge vitrectomy, can be applied to other gauge instruments.

Entry Site Alignment

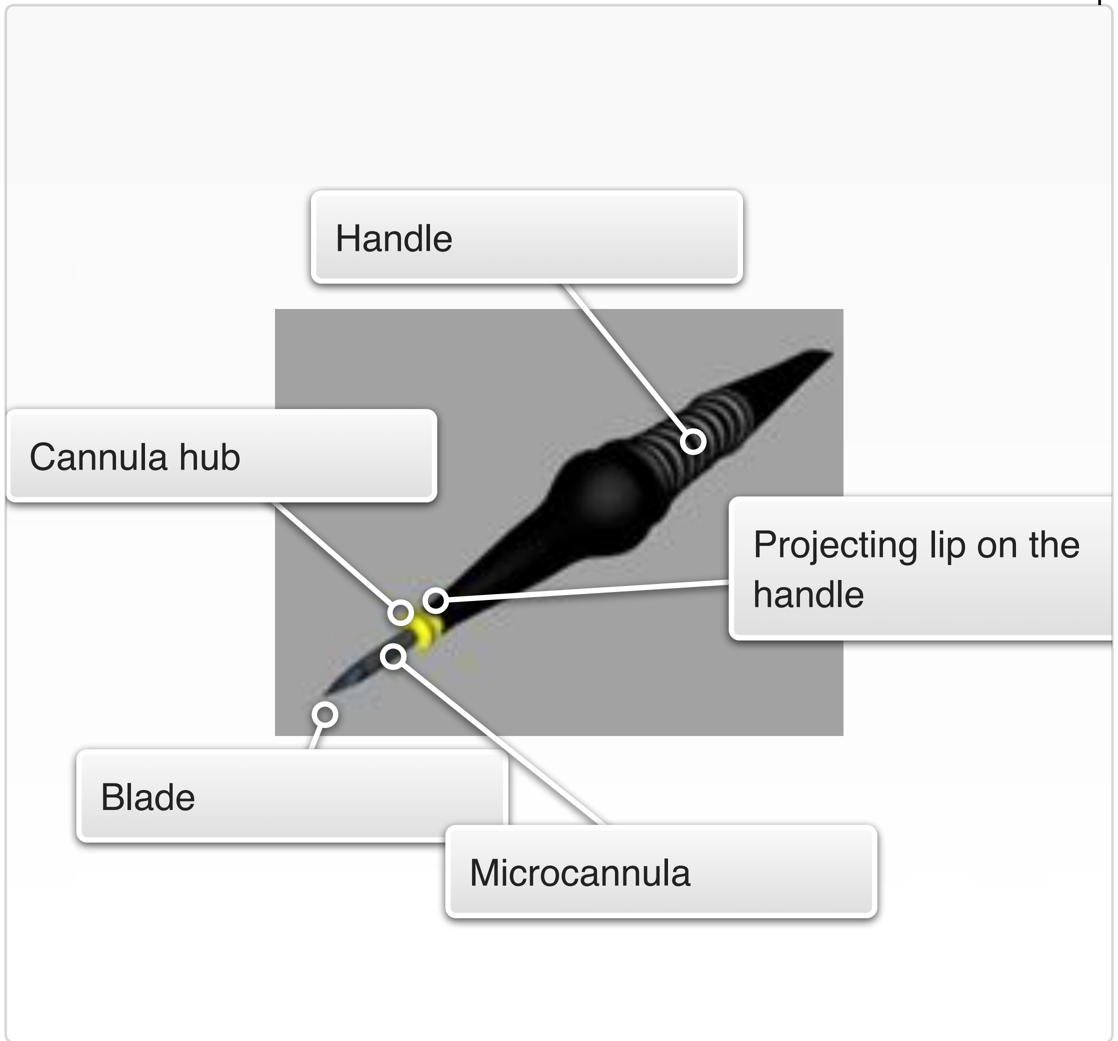
The **entry site alignment system** (ESA) is designed to introduce the polyamide cannula into the eye. The cannula has a hub which acts as a stop on the cannula, preventing its migration into the eye. The hub is used to move the cannula off the trocar after insertion and to remove it at the end of surgery.

Figure 6.1 Entry site alignment system



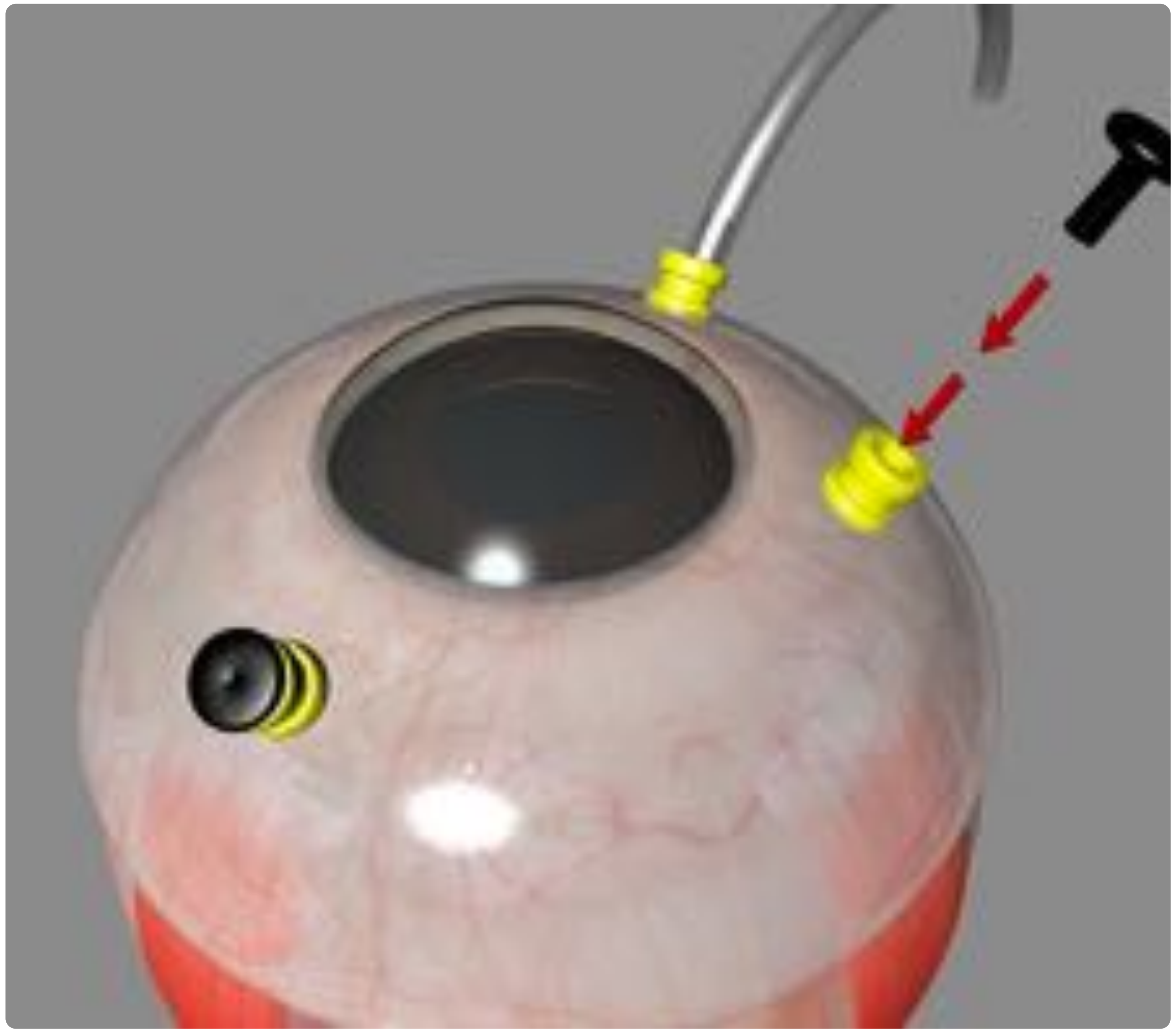
The cannula and its hub detach together from the trocar blade

Interactive 6.1 Features of a typical entry site alignment system.

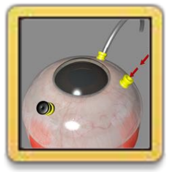


Many hubs have incorporated valves. These are silicone membranes with small slits though which instruments can be passed but which prevent the passage of vitreous and fluid out of the eye. If they are not used plastic plugs may be used to block the cannulas when a port is not in use. The plugs do not always conform exactly to the lumen of the hub and leakage may occur around them.

Figure 6.2 Plugs and valves.



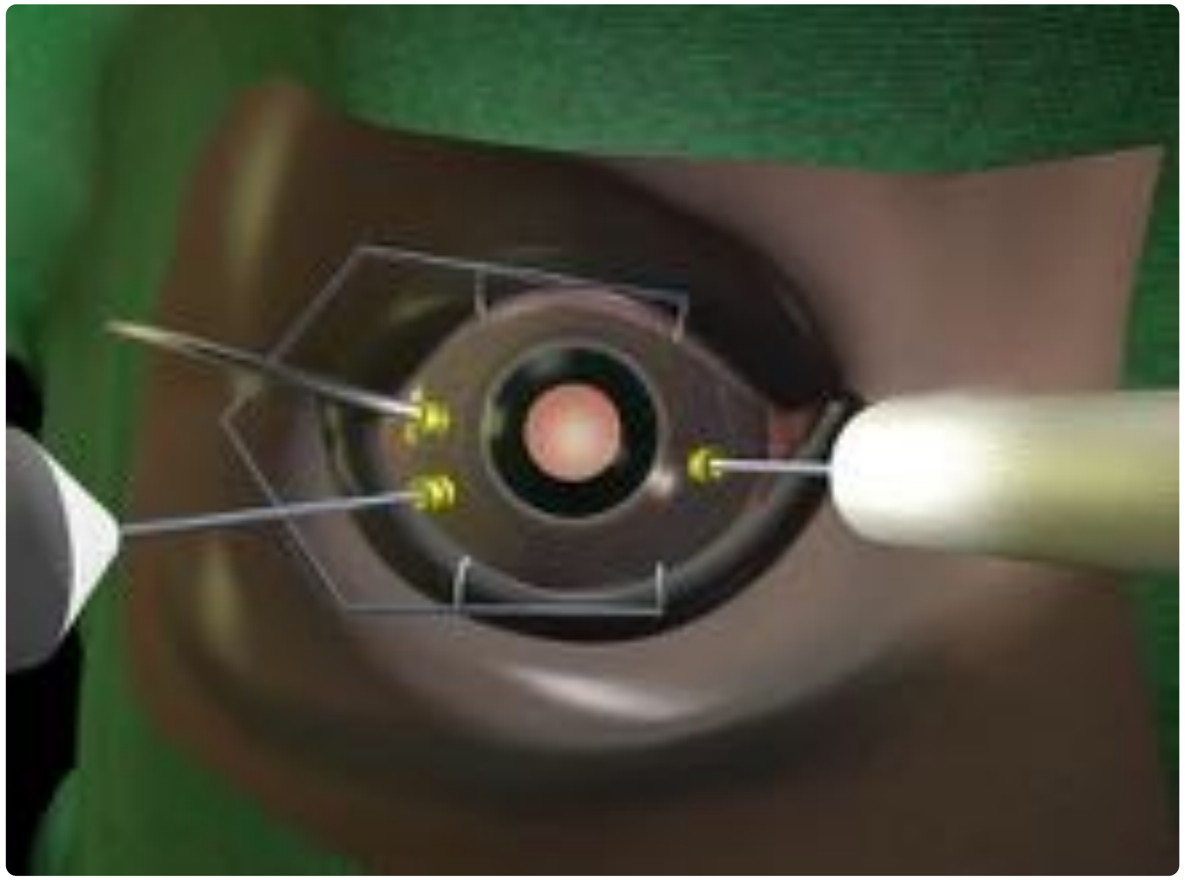
Plugs to seal the ports when not in use.



Zonally the ports should be placed 4 mm behind the limbus in a phakic eye and 3.5 mm behind the limbus in a pseudophakic eye.

Meridionally the ports should be placed at the level of the borders of the horizontal recti to allow adequate freedom to move the eye around. The infusion cannula is placed first, at the level of the lower border of the lateral rectus.

Figure 6.3 Location of the ports



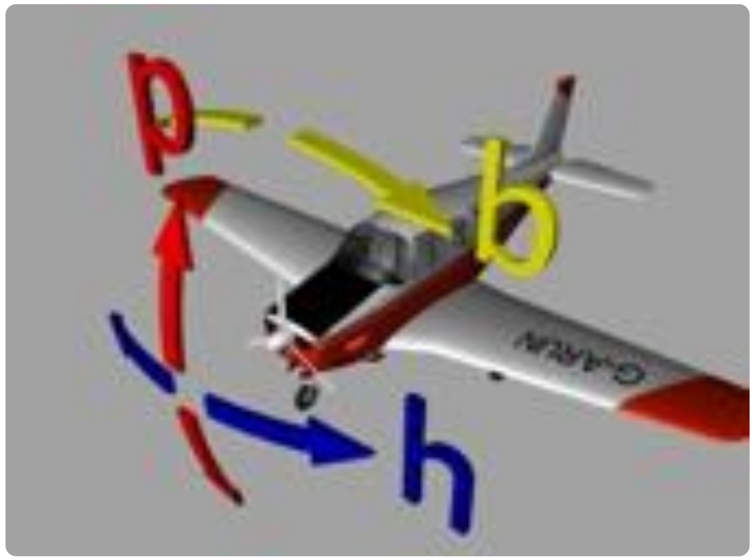
The correct meridional placement of the ports. Rotational movements of the globe can be made without interference from the lids.

ORIENTATION OF THE TROCARS.

Trocar orientation can best be described using Euler angles. These describe the orientation of an object in 3-dimensional Euclidian space. These are typically denoted as α, β and γ. In order to understand them it may be useful to consider an aircraft in flight. The Euler angles here are usually termed heading (α), bank (β)and pitch (γ).

A shallow pitch (oblique entry) gives a longer incision with better self sealing properties but carries the risk of suprachoroidal placement of the tip. This particularly significant when placing the infusion port. The infusion port is subject to less torque during surgery. It therefore rarely leaks and a steeper pitch may be used used.

Figure 6.4 Euler angles

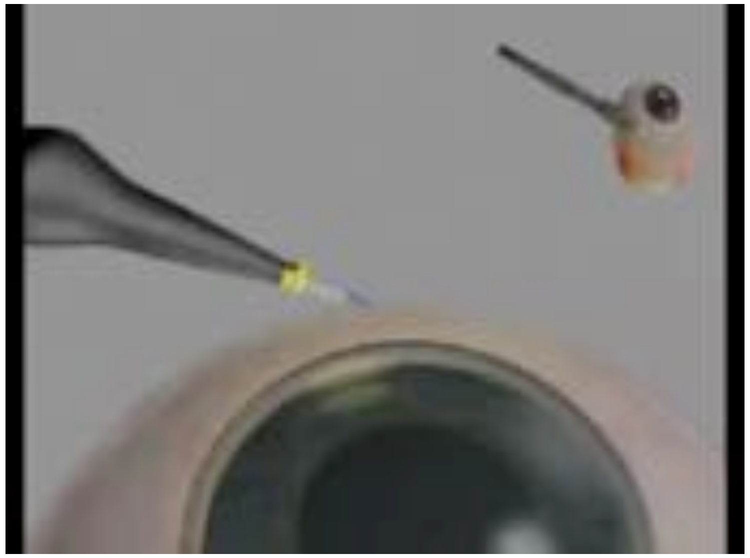


Heading describes the direction the plane is traveling in. For example to fly from London to Edinburgh the plane would be heading north.

Pitch describes ascent or descent.

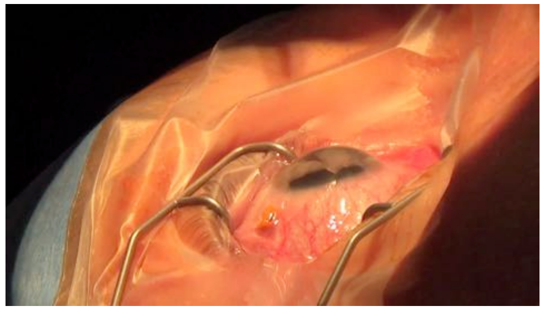
Banking describes tilting of the plane.

Movie 6.1 The pitch during trocar insertion



The initial pitch (angle of entry) is fairly acute. Significant resistance is encountered when the polyamide sleeve reaches the sclera. This is a cue to steepen the pitch. The tip of the trochar is directed downwards into the globe. The video above shows the appropriate pitch when placing the infusion. The other trocars are inserted more obliquely.

Movie 6.2 23-gauge trochar orientation



DISPLACING CONJUNCTIVA AND STABILIZING THE GLOBE

Lateral displacement of the conjunctiva ensures that the conjunctival and scleral openings are not aligned. This may reduce the probability of a conjunctival wick on the surface of the eye which could act as a conduit for microorganisms into the vitreous cavity. Because the conjunctiva is fixed at the limbus the displacement is centripetal - i.e. peripheral conjunctiva is dragged towards the limbus.

A second instrument such as a forceps or cotton bud may be used to simultaneously stabilize the globe and displace conjunctiva.

Movie 6.3 Stabilizing the globe and displacing conjunctiva.

In this case a forceps is used. A cotton bud can also be employed. A very small amount of rotation may be helpful during the final steep phase of the passage.

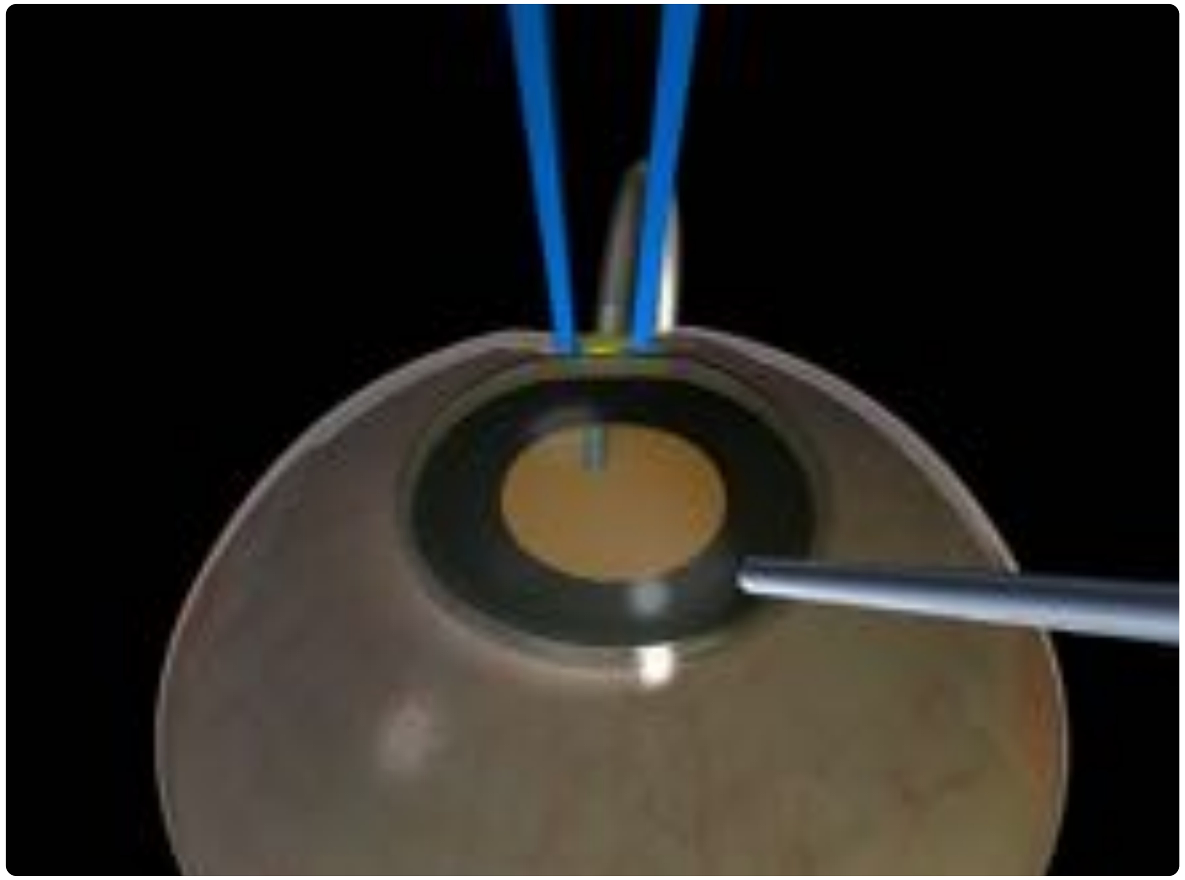
VIEWING THE INFUSION TIP

The location of the tip of the infusion cannula should always be clearly seen before the infusion is turned on. This may be best appreciated under the microscope - the indentation required to do this can be achieve by grasping the infusion hub with forceps. Transcorneal illumination by the light pipe may also be helpful.

It is not sufficient to simply see diffuse reflection from the cannula. This can be seen through a thin layer of non pigmented ciliary epithelium. It is important to be able to appreciate the specular glint of the metal shaft (which is obscured if there is any overlying tissue).

In the presence of dense vitreous hemorrhage the tip of the infusion cannula may be obscured. A light pipe may be passed down the infusion cannula to confirm its presence in the vitreous cavity.

Figure 6.5 Visualizing the infusion tip.

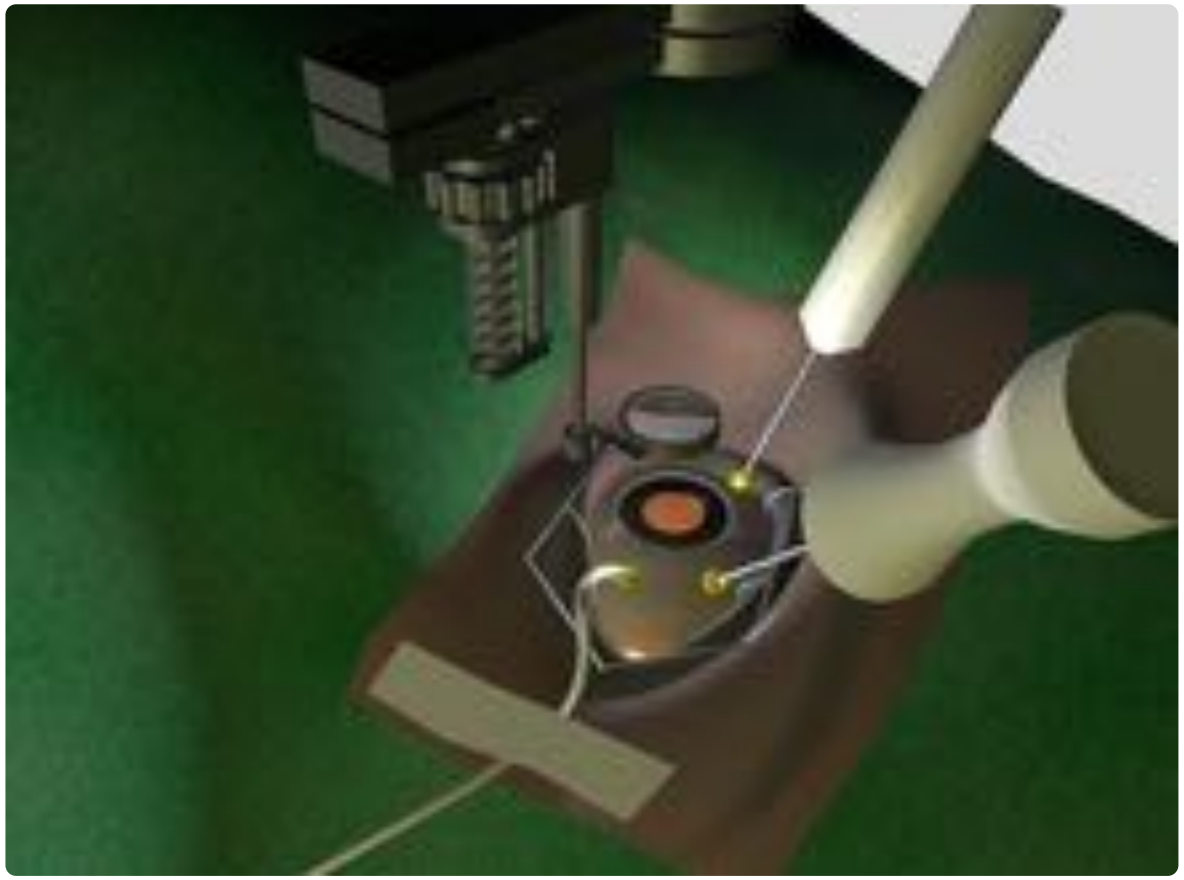


The infusion tip clearly visualized with the help of indentation of the cannula hub and a light pipe.

SECURING THE INFUSION LINE

The infusion line is secured to the drape using a clip or adhesive tape. A loop of infusion tubing preserves the perpendicular orientation of the infusion line to the eye.

Figure 6.6 Securing the infusion line



In this case an adhesive steristrip has been used. Note the loop in the infusion line which allows the eye to move without the infusion line dragging on the cannula hub.

COMPLICATIONS USING THE ENTRY SITE ALIGNMENT SYSTEM

If the pitch of trocar entry is too shallow the infusion may be inadvertently sited in the suprachoroidal space. This manifests as low infusion pressure and choroidal detachment. This may also occur if a poorly secured infusion cannula slips during surgery.

The condition may be managed by:

1. Moving the infusion line to one of the other trocars (having carefully confirmed its patency) to maintain the intraocular pressure.
2. Removing the infusion cannula and hub and remounting them on the trocar.
3. Inserting the infusion trocar in another position. It is possible to do a vitrectomy using an inferonasal infusion cannula.

Frequently the suprachoroidal fluid will have drained while the above steps are carried out. If it does not drain and is of a significant size it can be drained transsclerally using a fine needle.

Intraoperative disconnection of the infusion line should be managed by reconnecting and then rechecking the position of the cannula tip before switching the infusion on.

Movie 6.4 Subretinal infusion cannula

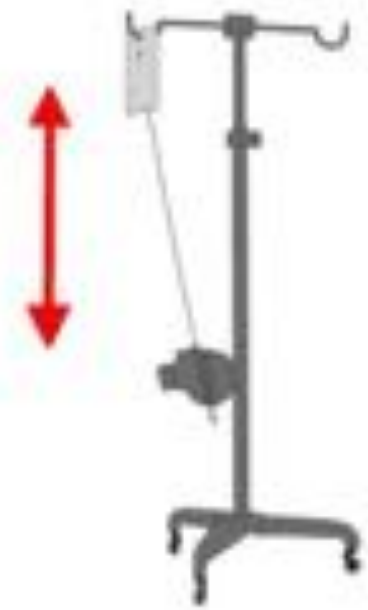
The infusion line is simply moved to the superonasal cannula hub. A new trocar is then placed inferonasally for the infusion line.

Movie 6.5 Suprachoroidal infusion cannula

In this vitrectomy for diabetic vitreous hemorrhage the infusion is checked and the tip thought to be in the vitreous cavity. In fact it is not - there is a thin layer of ciliary epithelium over it. When the infusion is turned rapid elevation of the choroid is seen.

Infusion

Figure 6.7 Gravity fed infusion systems



In gravity fed infusion systems the intraocular pressure is determined by the height of the bottle if there is no aspiration.

The **infusion** replaces the vitreous removed from the eye with saline to maintain the intraocular pressure. Infusion systems may be:

- Gravity fed. These have the advantage of simplicity and reliability.
- Pressure fed, with an air pressure line running into the infusion bottle or the air chamber beneath it. These display the exact intraocular pressure and allow more rapid changes in the intraocular pressure than gravity fed systems.

In a gravity fed system when the eye is closed (i.e. no fluid outflow) the intraocular pressure (IOP) is equivalent to the height of the bottle above the eye (hydrostatic pressure). As mercury is 13.5 times denser than water the height of the bottle above the eye (in cm) can be converted to mmHg by multiplying by 0.74, so a bottle height of 28 cm above the eye gives an IOP of 21 mmHg.

Once aspiration of vitreous starts factors other than the infusion pressure come into play in determining the intraocular pressure (fluid dynamics). In particular the resistance to fluid flow through a tube is proportional to the fourth power of its radius. **Micro-incisional vitrectomy systems** (MIVS) therefore require greater infusion pressure when aspirating than than they do when no aspiration is occurring. This is problematic when a gravity based system is used. Sophisticated systems are now available for assessing intraocular pressure based on the actual intraocular pressure (based on flow measurements in the system). These adjust the rate of infusion to compensate for drops in the pressure between the infusion bottle and the eye, maintaing the IOP.

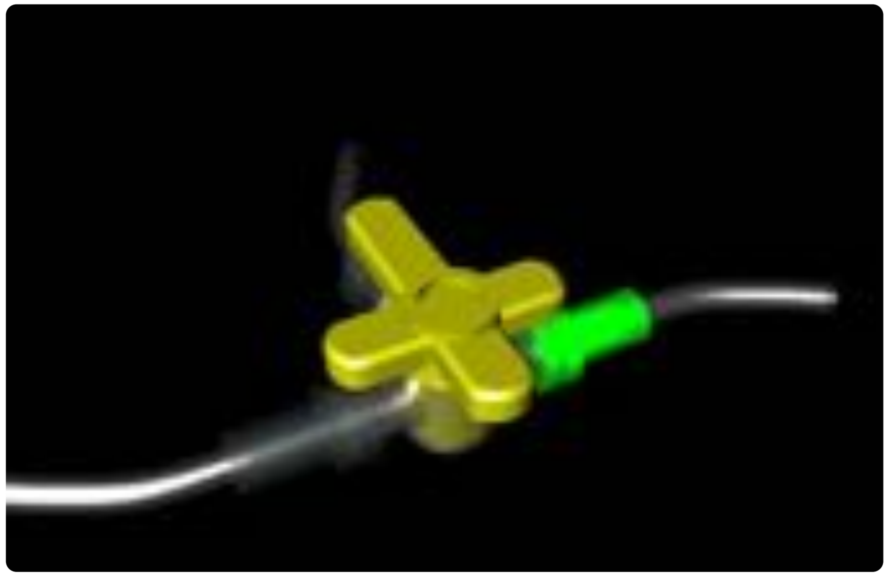
Another consequence of the reduction in tube diameter of MIVS is that the volumes of fluid flowing through the eye are much lower than with 20-gauge instruments. If a narrow gauge instrument is exchanged for a 20-gauge outflow instrument (for example if a particularly tough lens requires a 20-gauge fragmatome) there may be profound infusion/aspiration mismatch resulting in hypotony unless the infusion pressure is significantly increased.

Abnormally high or low intraocular pressure are both undesirable during vitreoretinal surgery. When performing vitreoretinal surgery (even if an IOP compensating system is used) the surgeon should be vigilant for the signs of abnormal IOP and act quickly to adjust it.

AIR INFUSION

Pumps that deliver air at a predetermined and controllable pressure were formally stand alone units but are now generally integrated into the body of modern vitrectomy systems. When a separate air line is used it may be attached to the infusion line using a three way tap (stopcock). Whenever connections between infusion lines such as this are used a locking device such as a Luer lock is employed to prevent accidental disconnection.

Figure 6.8 Three way tap/stopcock



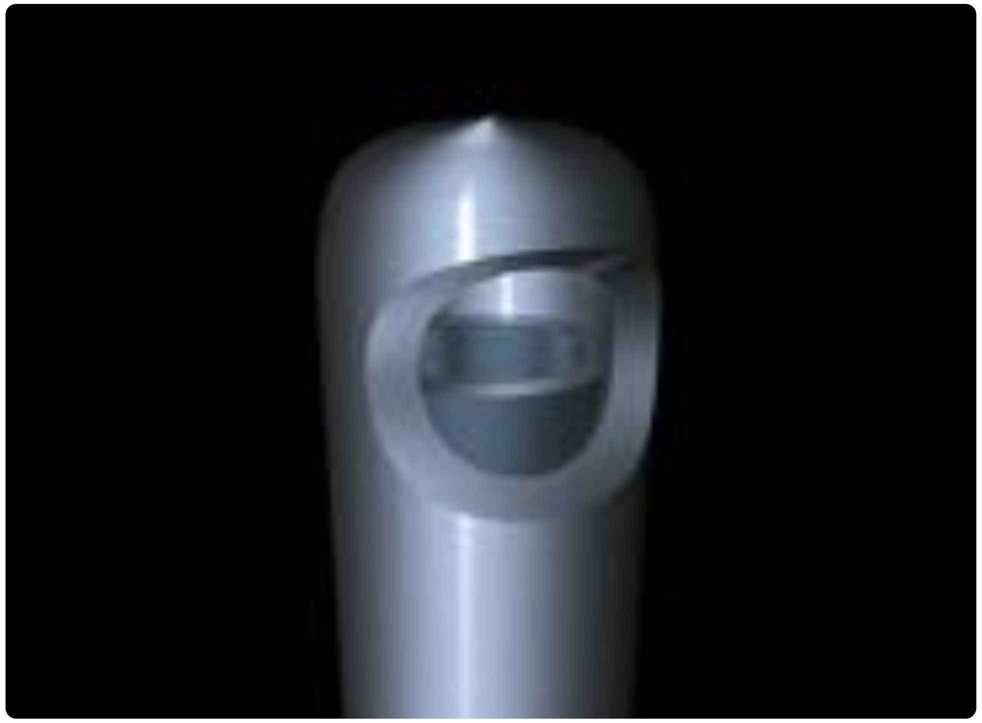
The tubes are Luer locked into place. The long arm of the handle indicates the branch which is closed. If it is rotated through 45⁰ all the branches are closed.

Vitrectomy cutters

Vitrectomy cutters are designed to remove vitreous with minimal traction. They consist of 2 metal cylindrical tubes. The outer tube is fixed and has an oval aperture near its tip. The inner tube has a lumen connected to an aspiration line and oscillates longitudinally so that its tip traverses the edge of the oval aperture, creating a small guillotine.

When removing vitreous aspiration and cutting are combined to remove vitreous more effectively and safely. As a general rule the lowest amount of suction and the highest cut rate consistent with safe and efficient removal of vitreous are used. The exact level of these parameters varies with the design of the vitrectomy machine.

Figure 6.9 The cutter tip



The inner and outer tubes of the cutter.

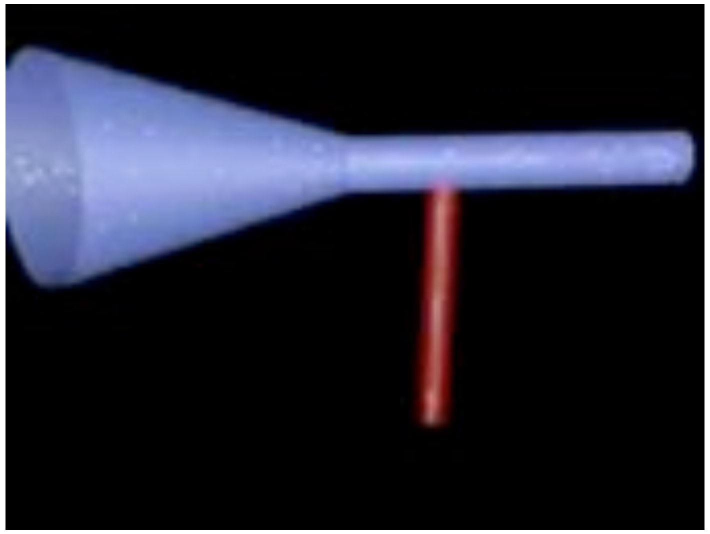
ASPIRATION

Aspiration is provided by either a Venturi or a peristaltic pump. Some systems have both. There is currently no consensus about their relative merits.

As with infusion design, the diameter of the tube is an important determinant of resistance. Micro-incision vitrectors require considerably higher vacuums than conventional 20-gauge instruments.

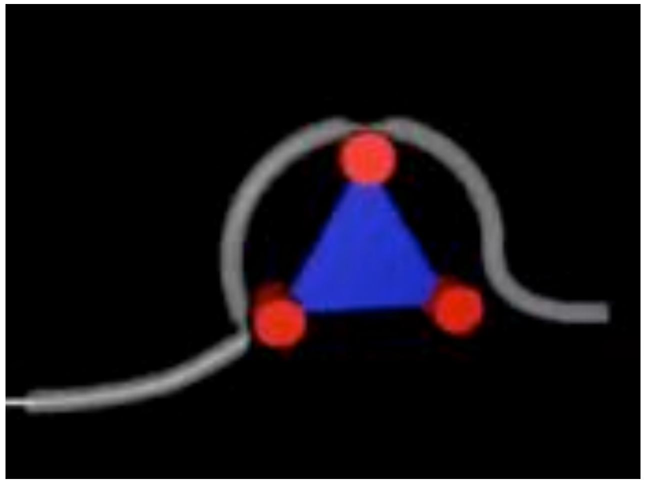
In conventional 20-gauge vitrectomy it was necessary to manually adjust the infusion height prior to making significant changes in aspiration to prevent collapse of the eye. In more modern machines there is a degree of automated 'coupling' to avoid dramatic changes in intraocular pressure.

Movie 6.6 Venturi pump



The Venturi effect is a consequence of the Bernoulli principle. The gas particles in the blue tube accelerate when they move into the narrow section and the pressure drops. This is used to draw fluid up the red tube. Note that the vacuum is the controlled variable and the flow changes are a secondary consequence.

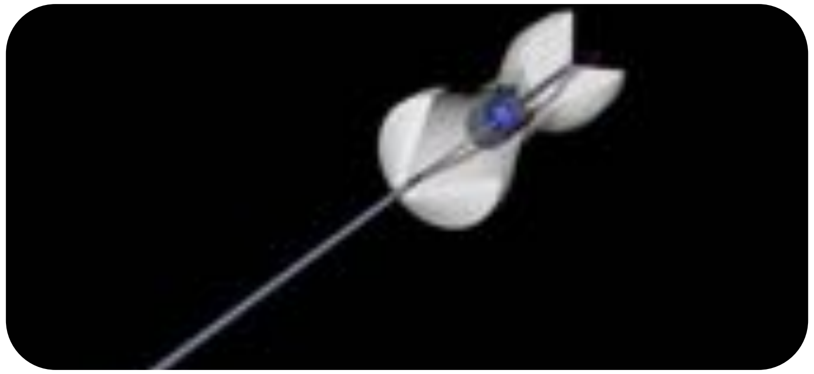
Movie 6.7 Peristaltic pump



In a peristaltic pump fluid is milked along a tube with rollers. The controlled variable here is the suction and the vacuum develops as a consequence of the this.

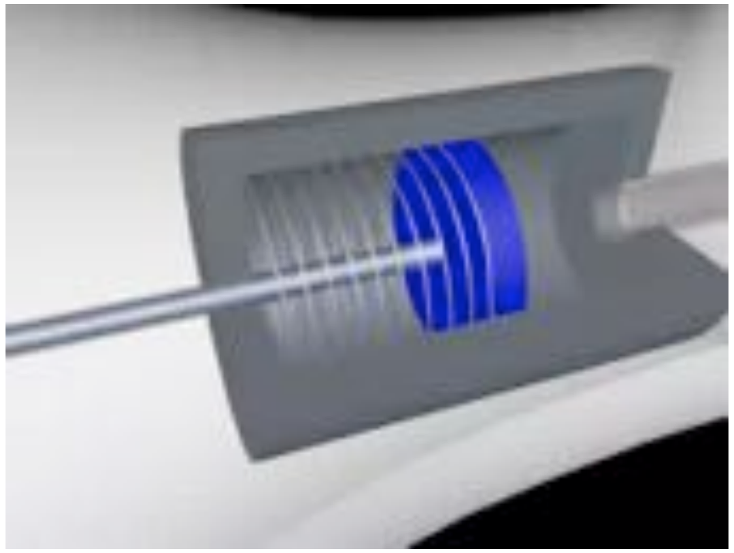
The oscillation of the inner tube / blade of the guillotine is driven by a pneumatic or electrical mechanisms within the handpiece of the cutter.

Figure 6.10 Schematic representation of pneumatic cutter handpiece.



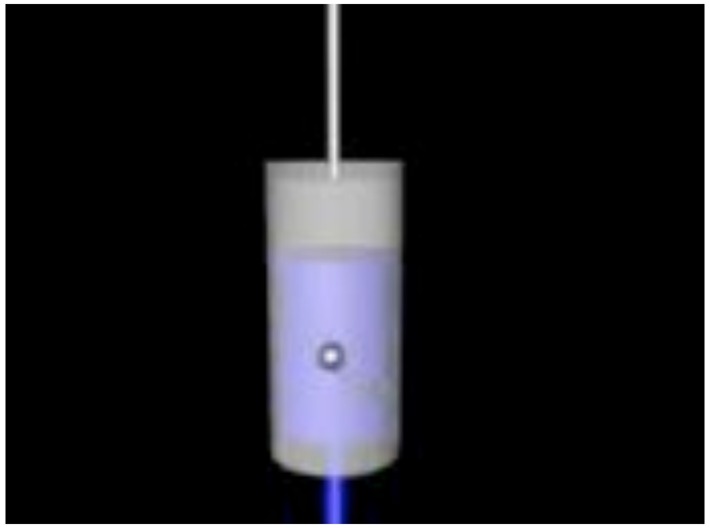
For clarity the aspiration line has been colored red and the actuator line blue.

Movie 6.8 Pneumatically driven cutter



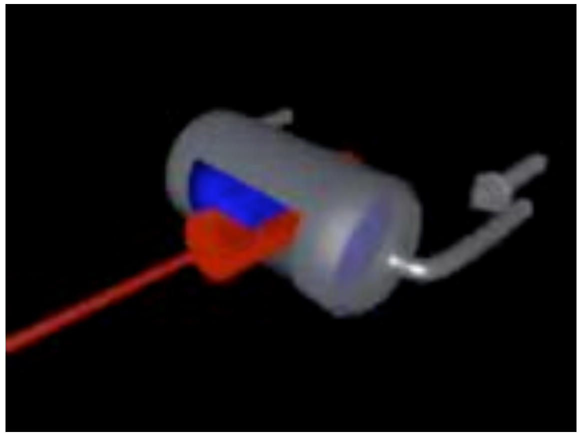
A short burst of pressure from a tube (the actuation line) moves the diaphragm. When this stops a spring returns the diaphragm to its original position. This produces an oscillating movement of the cylinder on the left which is connected to the inner tube of the cutter. Although high speed cutting is possible it is not possible to adjust the proportion of time the port stays open (the duty cycle).

Movie 6.9 Electrically driven cutter



The clue to understanding this is the position of the small ball bearing - this sits in a groove on the rotating spindle attached to the motor. Its movement is constrained to the small hole in the outer sleeve which it therefore moves up and down. This is capable of extremely high cut rates but the profile of the movement is always sinusoidal so it is not possible to adjust the duty cycle.

Movie 6.10 Dual pneumatic cutter



Separate pneumatic actuation lines open and close the cutter. A rack and pinion attached to the diaphragm translate the horizontal movement to rotary movement in this case. Newer machines have longitudinal guillotines. This allows very fast cutting and control over the duty cycle.

CUTTING AND ASPIRATION

Although cutting, aspiration and infusion have been discussed separately these processes are closely related in practice.

In conventional 20-gauge vitrectomy increasing the cut rate would reduce the proportion of time the cutter port was open, reducing the aspiration rate. Consequently it was often taught that one had to reduce the cut rate to achieve high aspiration rates.

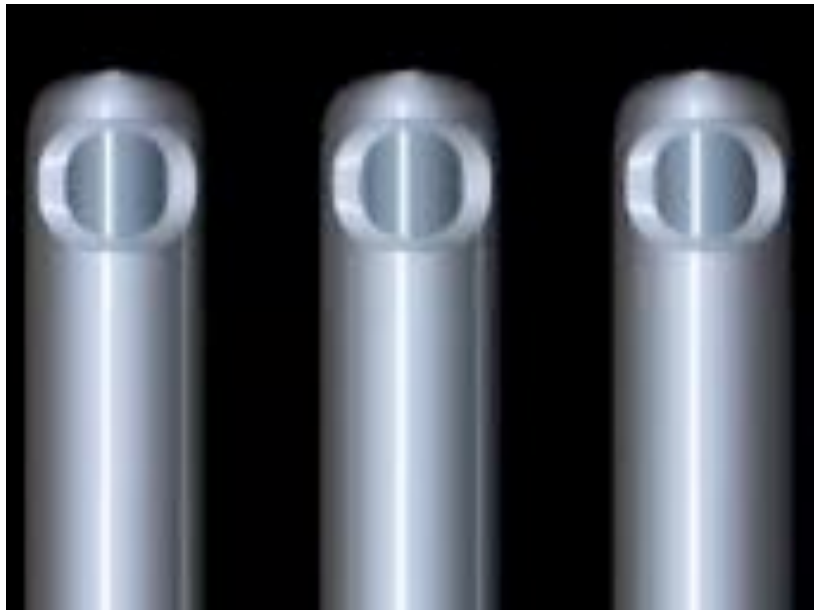
The new generation of vitrectors allow the port to stay open for a greater proportion of the cutting cycle which allows high volume aspiration with high cut rates.

The practical implication of this is that high cut rates can be used at all times with most modern vitrectomy machines.

THE FOOT PEDAL

The foot pedal gives the surgeon the means to control many vitrectomy parameters. This is achieved by a variety of linear pedals (i.e. progressive pressure gives a progressive linear change in a parameter e.g. aspiration) and switches (which turn some functions on and off). The functionality of machines varies so much that it is not possible to give a comprehensive account in this book but trainees should familiarize themselves thoroughly through extended practice with the machine they are using prior to starting surgery on a patient. In an institution with several different machines a moment may be spent at the start of each case to refamiliarize by checking all the functions of the footswitch with the cutter tip immersed in saline.

Movie 6.11 Duty cycle



All of these cutters are cutting at 30 cuts per minute. The profiles of movement vs time of their guillotines are very different. The guillotine on the left has a sinusoidal movement profile, the other two a more asymmetric movement profile. The port in the middle is open for a greater proportion of the cutting cycle ('open biased' duty cycle). The port in on the right is closed for a greater proportion of the cutting cycle ('closed biased' duty cycle).

Aspiration and reflux

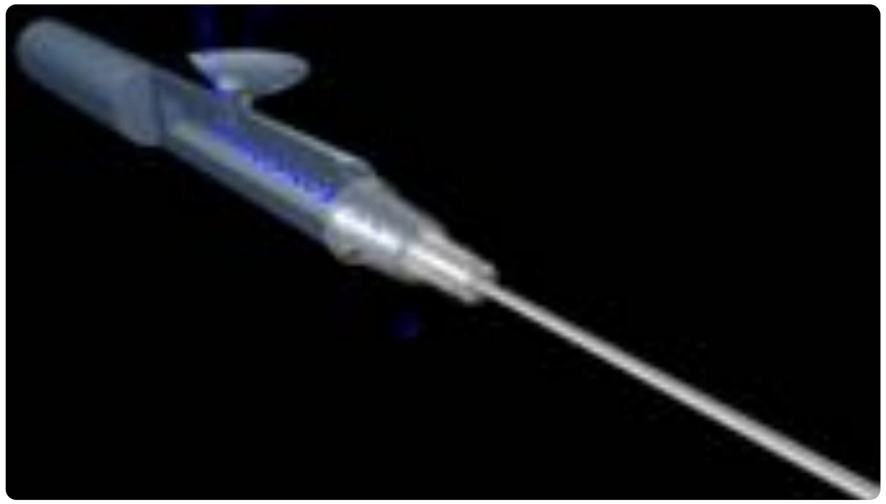
Active aspiration can be performed with the cutter or by attaching a separate extrusion line to the vitrectomy machine.

Aspiration of viscous fluids such as silicone oil requires very high pressures and a special aspiration line may be required to prevent the tube collapsing.

During aspiration the tip of the cannula may be very close to the retina. Cannulas with soft silicone tips are available to reduce the likelihood of retinal trauma if the cannula touches the retina

Passive aspiration can be achieved using a flute needle. The fluid vents from an aperture which may be occluded digitally. Passive aspiration is less effective than active aspiration in MIVS because of the high resistance to flow through the narrow tube. The creator of this instrument, Steve Charles, has stated that he no longer uses passive aspiration (S Charles, personal communication).

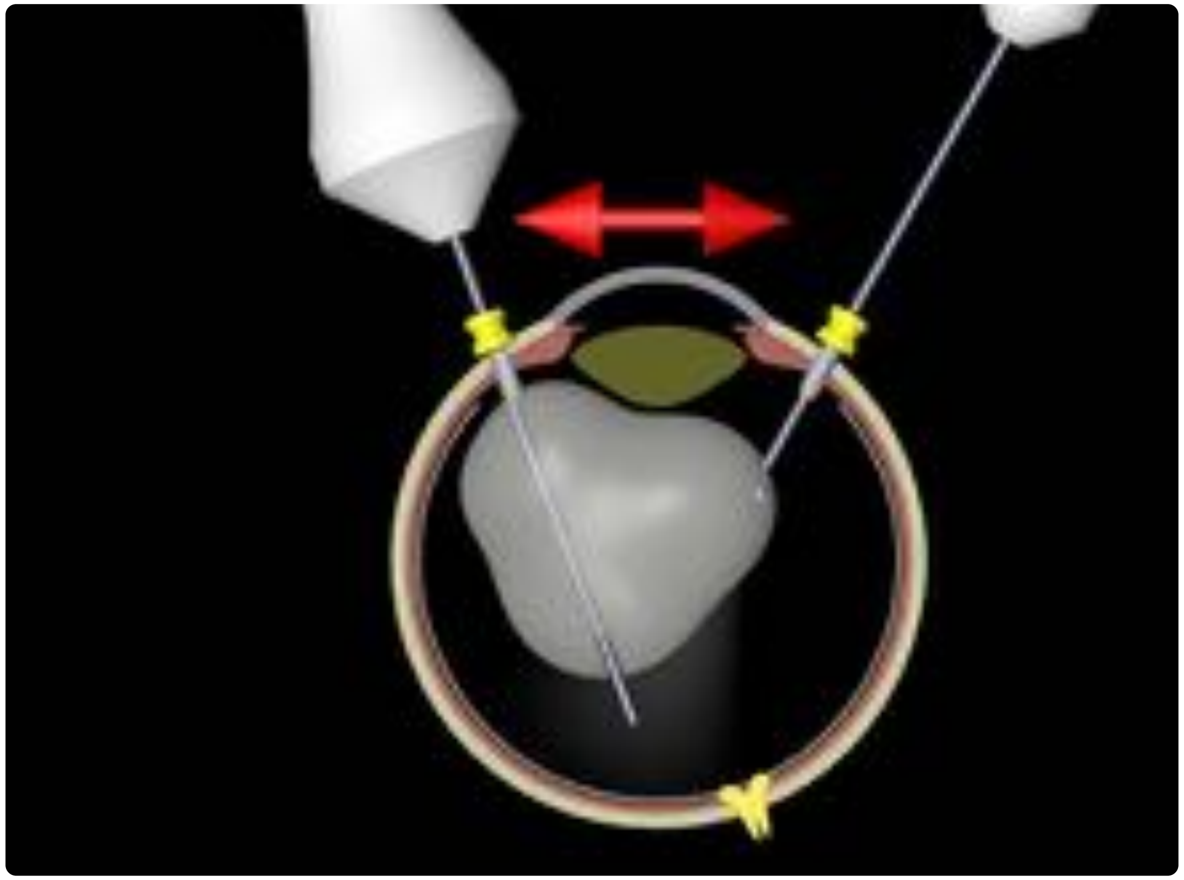
Figure 6.11 Aspiration devices



The Charles flute needle. Fluid vents through an aperture on the side which can be occluded with a finger or thumb.

The intraocular pressure should be monitored continuously during surgery. A fall in intraocular pressure may be detected by gauging the resistance to apposition of the instruments in the eye. If the eye starts to collapse aspiration should be stopped immediately and the cause established and rectified. This is one of the most important rules in the whole of vitreoretinal surgery.

Figure 6.12 Monitoring the intraocular pressure.



The resistance of the eye to inward pressure of the instruments is an indicator of the intraocular pressure. If the pressure drops and the globe starts to collapse the instruments can be pressed together easily. In this case a fluid-oil exchange is being performed (the instruments seen are the light pipe and the aspiration cannula) but this is true in all vitreoretinal procedures.

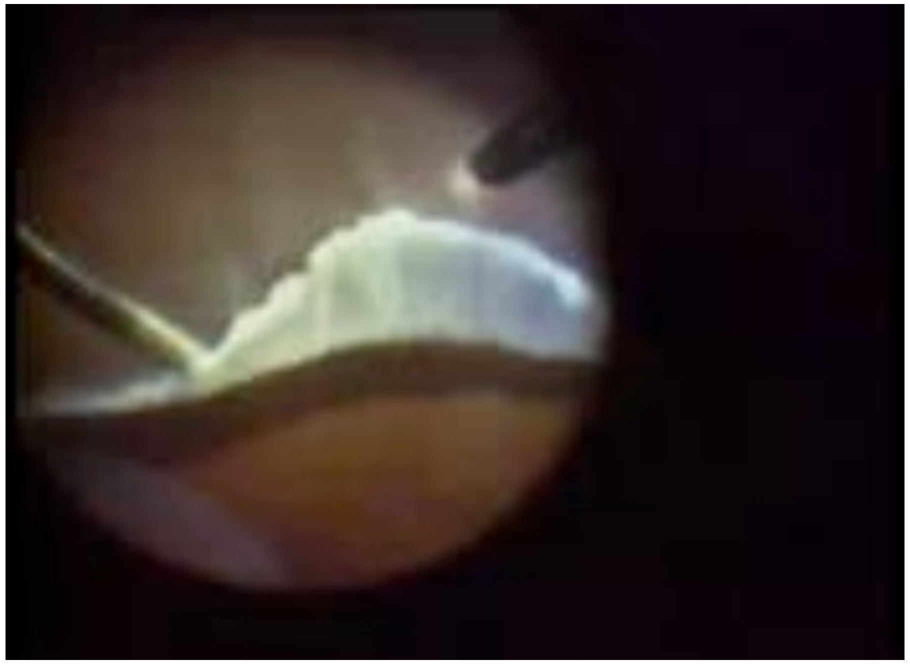
Reflux is useful in many situations including:

- Disengagement of tissue incarcerated in the cutter tip.
- To create fluid currents within the eye, for example to stir up blood sitting on the posterior retina.

A backflush needle is a variety of flute needle with a reservoir of fluid adjacent to the fluting aperture which can be squeezed digitally to reflux fluid. The tip of the needle is prone to large movements as this is done.

Reflux is an integrated function, controlled by the foot pedal, in most vitrectomy machines.

Movie 6.12 Reflux of incarcerated tissue



In the absence of an integrated reflux on the vitrectomy machine this can be achieved by pinching the aspiration line.

The Fragmatome

Movie 6.13 The Piezoelectric phenomenon.

The change is size of a piezoelectric crystal with an electric current - if an alternating current is used the vibration frequency is that of the alternating current.

Soft lens matter can be removed with the cutter. Hard lens matter may be too rigid to conform to the cutter port. Removal with the cutter alone, even with 20-gauge instruments, is then very difficult.

The **fragmatome** uses the Piezoelectric effect to generate vibrations at the tip of the fragmatome probe.

The principle is the same as phacoemulsification. Unlike a phacoemulsification probe there is no sleeve of water flowing around the probe to cool the tip down. The fragmatome relies on the aspirated fluid in the cannula to cool it and is prone to overheat if it blocks. If it starts to overheat (which is indicated by denatured lens material turning white around the tip - 'lens milk') or appears blocked it should be removed from the eye and cleared by injecting fluid through the aspiration line.

The energy of the fragmatome tends to dispel free floating lens fragments. This may be overcome by keeping the energy relatively low, the aspiration high and using it in pulsed mode. The fragmatome is generally controlled by the foot pedal with linear aspiration control.

Illumination

Endoillumination probes consist of fibreoptic cables attached to light sources. Conventionally metal halide or halogen bulbs have been used. The advent of MIVS has seen the development of new light sources to compensate for reduction in illumination due to the reduced instrument gauge. These include xenon and mercury vapor lights and light emitting diodes.

A variety hand held **light pipes** are available for routine use during vitrectomy. There are also other ways of illuminating the retina during surgery:

- **Chandeliers** use separate self retaining fibreoptic cables to allow bimanual intraocular surgery.
- Various multifunction instruments with an integrated light source such as illuminated picks are available.
- Transscleral illumination may be particularly useful. Narrow gauge instruments may be reinforced with specially designed collars when this is done. There is a theoretical risk of contamination by commensal bacteria if a naked light pipe is used. The author has never seen a case of endophthalmitis following this.

There is a danger of phototoxicity with bright endoillumination and some systems incorporate filters to reduce the more hazardous shorter wavelength light.

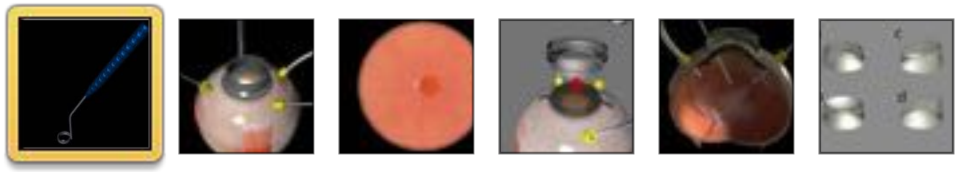
Figure 6.13 Endoillumination options

A conventional 50^0 light pipe.

Viewing systems

Figure 6.14 Contact Vitrectomy lenses

The Machemer lens



CONTACT LENS SYSTEMS

Robert Machemer designed a planoconcave lens with an integrated infusion that was held by an assistant on the cornea. This gives an excellent view of the posterior pole. Some view of the periphery can be obtained by tilting the lens which induces a prismatic effect. The lens is exchanged for a biconcave (Landers) lens when an air exchange is performed to compensate for the shortened focal length of the air filled eye.

A major disadvantage of the Machemer lens system is the requirement for a skilled assistant. A variety of solutions have been found for this problem. The Landers system consists of a ring that is sutured to the sclera inside which various lenses can be placed securely. Disposable contact lenses made of silicone are stable without a sutured ring if used in conjunction with a viscoelastic coupling gel.

The major advantages of planoconcave contact lens viewing system is the elimination of spherical aberration and the excellent z axis (depth) discrimination.

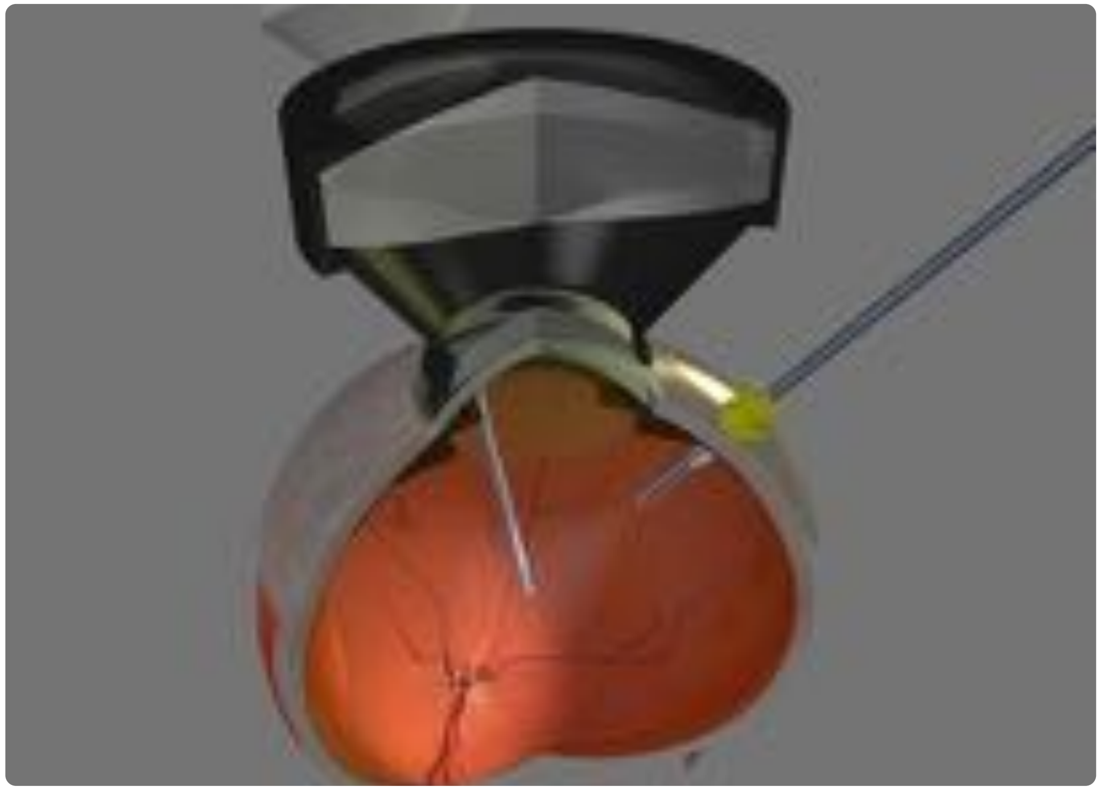
Wide angle lenses supplanted contact contact lenses in routine clinical assessment many years ago. The advantages of slip lamp indirect fundus biomicroscopy (much wider field of view, lack of corneal micro-trauma) heavily outweighed the disadvantages (slightly greater spherical aberration, slightly less stereopsis). Psychological adjustment to the inversion of the image is easy in clinical assessment but much more difficult in surgery where this adds to the significant cognitive load on the surgeon.

The invention of the stereoscopic diagonal inverter by Spitznas was therefore a major advance as it facilitated the translation of wide angle viewing techniques from the clinic to the operating theatre.

Several types of wide angle viewing system are currently is use. Most require a separate image inverter to be placed in the body of the operating microscope.

Wide field vitrectomy contact lenses work on the optical principles developed for retinal photocoagulation i.e. a meniscus lens and a high power spherical lens. Most require an assistant to hold the lens securely.

Figure 6.15 Wide angle contact lens

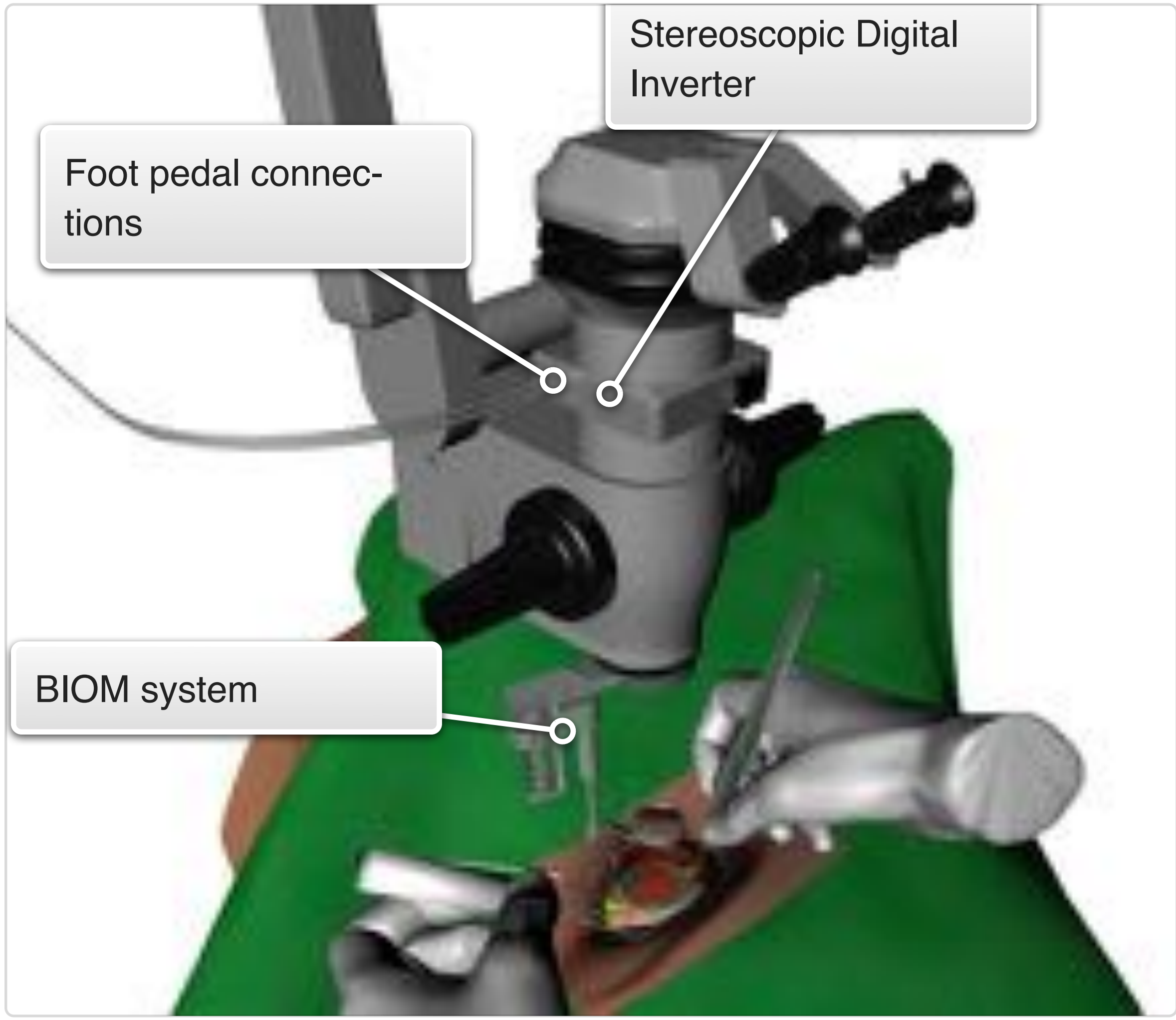


This produces a very wide field of view with no spherical aberration. A skilled assistant is usually required to hold the lens.

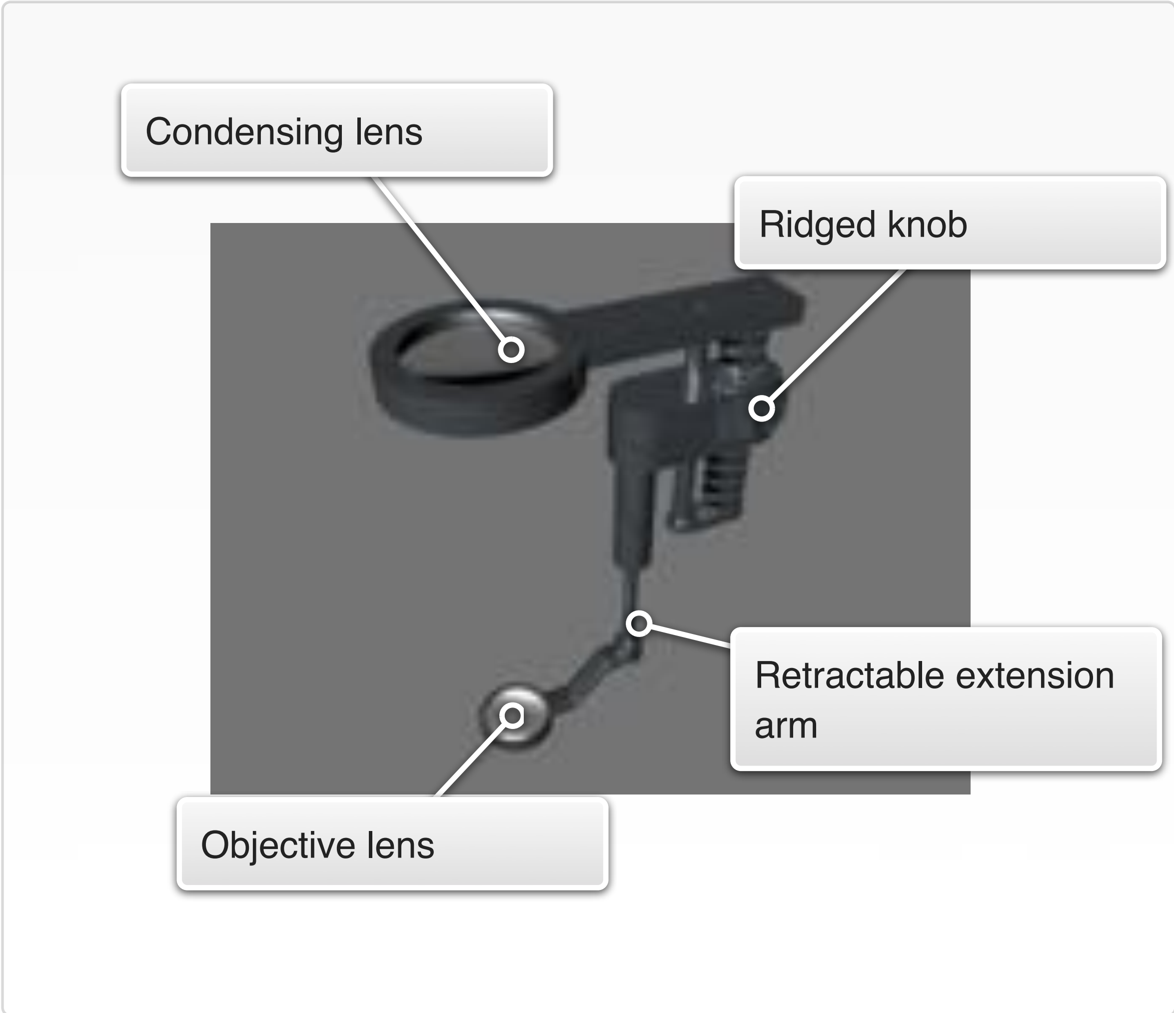
Non contact systems such as the BIOM are widely used. The field of view is maximized by positioning the BIOM lens as close to the cornea as possible without fogging of the objective. Viewing of the retinal periphery is facilitated by rotating the eye (following which the viewing system must be realigned using the microscope foot pedal). Focussing is achieved by focussing the BIOM only. The focus function of the operating microscope moves the microscope and the BIOM up and down together. This affects the field of view but not the focus.

When using non contact viewing systems the cornea is prone to dry out - this can be prevented by coating it with a dispersive viscoelastic such as methylcellulose.

Interactive 6.2 BIOM system and Inverter



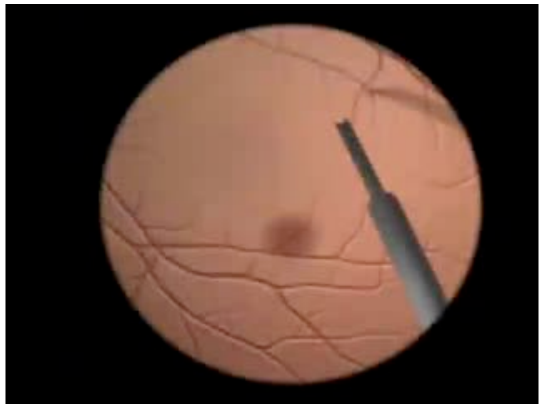
Interactive 6.3 The BIOM system.



SETTING UP THE BIOM

- The three ports are introduced into the eye.
- The BIOM is attached to the microscope using the appropriate mount.
- The cornea is coated with methylcellulose or some other wetting agent.
- The BIOM is rotated into position. The lenses are now aligned with the operating microscope.
- A light pipe is introduced into the eye
- The focussing knob is rotated until the retina is clearly focussed.
- If media opacity obscures the retina the BIOM is focused on the light pipe. The focus can be readjusted later in the case.
- Once the BIOM has been set up it is not normally necessary to readjust it unless an air fluid exchange is undertaken in a phakic eye. Following gas air exchange the knob is rotated counterclockwise to refocus the BIOM. The microscope may then bow lowered to compensate for the increased distance from the cornea. While performing an internal search for small breaks it may be helpful to focus down very slightly (a fraction of a clockwise turn of the knob) to move the plane of focus from the posterior retina to the ora serrata. To remember which way to focus consider the skin diver who goes DOWN to LOOK around and then comes UP for AIR.
- To view the periphery it often helpful to use low magnification (zoom out). The eye is also rotated, using the x-y pedals on the microscope to track the movement of the eye and preserve optical alignment.

Movie 6.14 Vignetting



This is avoided by keeping the microscope aligned with the biome when rotating the eye.

TROUBLESHOOTING

If condensation forms on the objective lens fogs raise it slightly using the focussing pedal of the operating microscope.

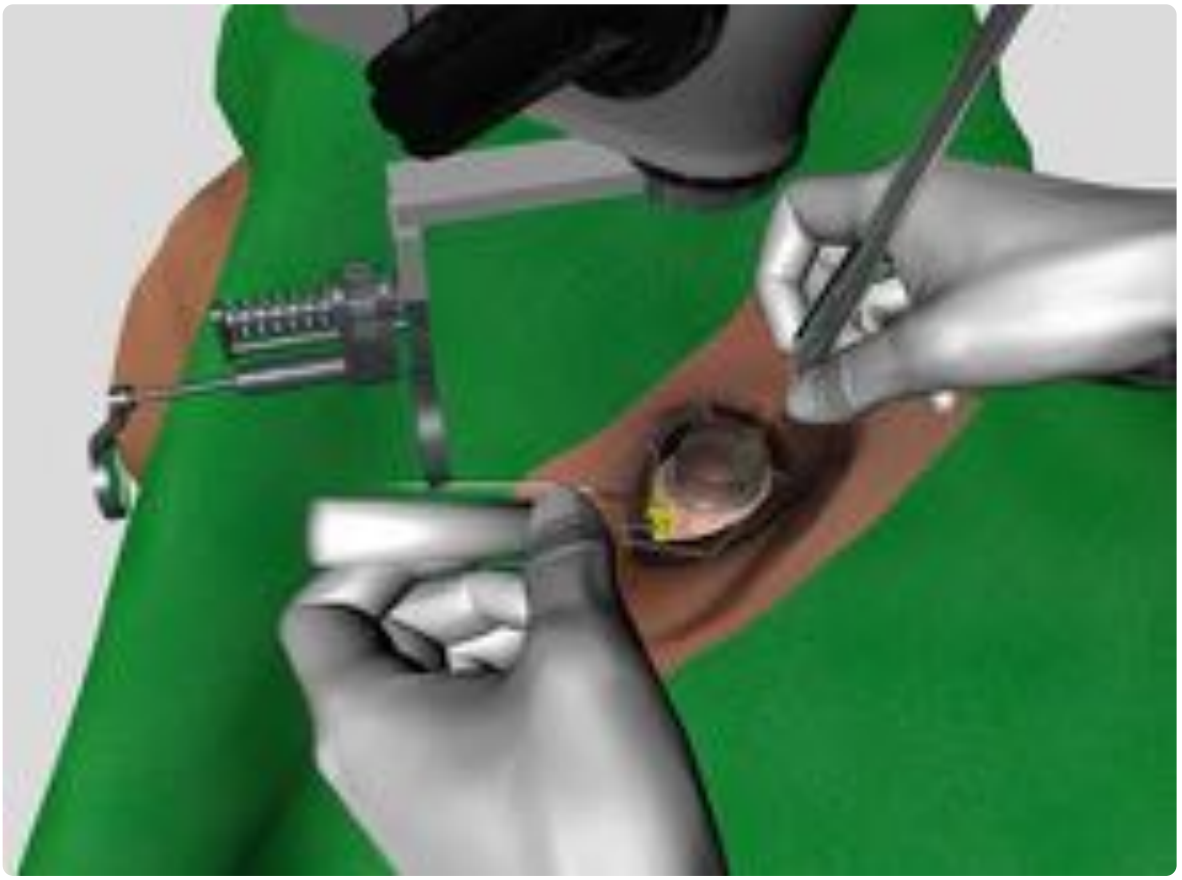
Vignetting is due to malalignment of the BIOM with the microscope.

A variety of objective lenses are available for non contact viewing systems.

In the case of the BIOM these are:

- A wide field lens (120^0 field of view). This is useful when a peripheral view is required, for example when performing vitrectomy for retinal detachment.
- A 90 Dioptre lens (90^0 field of view). This lens gives some z axis (depth) discrimination. The author finds this particularly useful when performing diabetic delamination surgery.
- A macular lens (60^0 field of view). This is designed for macular surgery. The author's current preference is to switch to a disposable contact lens for peeling (having used a wide field lens for the rest of the case) to eliminate some of the optical aberrations associated with contact lens use.

Figure 6.16 Switching viewing systems

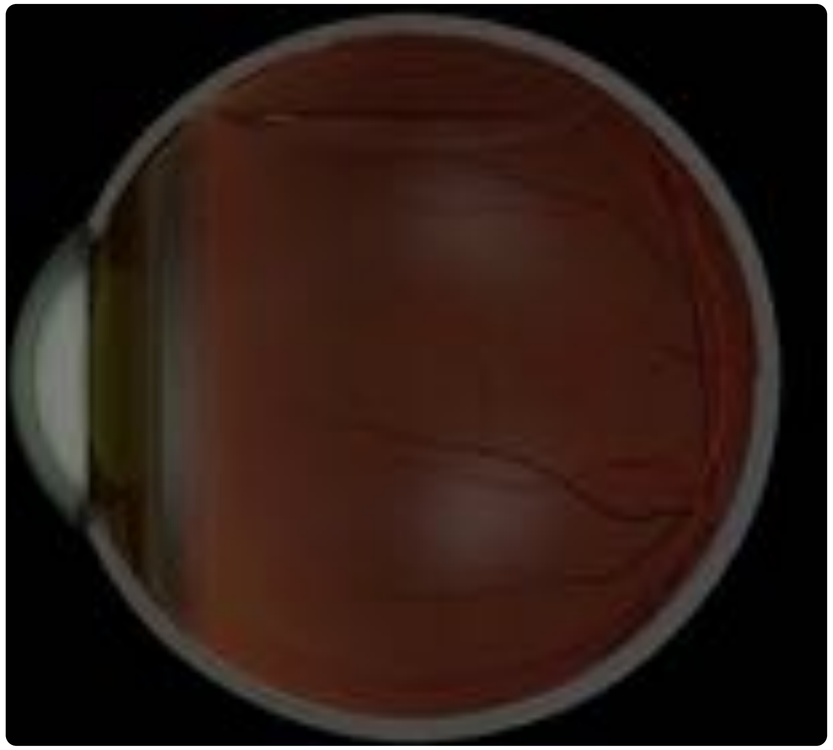


The BIOM can easily be swung out of the way and the inverter switched to allow use of a disposable contact lens.

Air and gas tamponade

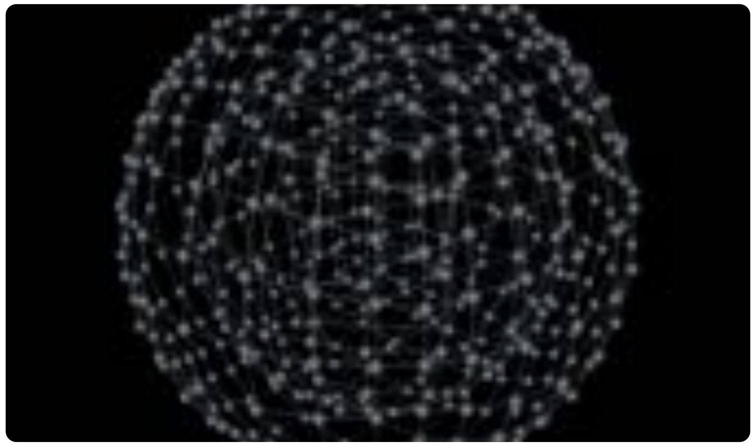
Interfacial surface tension and buoyancy are important physical properties of air and gas bubbles in fluid.

Figure 6.17 Contact arc and buoyancy of gas



Because gas is much less dense than fluid the bubble adopts a capped spherical profile. Consequently a small bubble covers a greater arc of the retina than its size (expressed as a percentage of ocular volume) would suggest. Harvey Lincoff demonstrated that a bubble 0.28 ml in volume would be in contact with a 90^0 arc of retina. This is the basis of pneumatic retinopexy.

Figure 6.18 Surface tension



Van Der Waals' forces are weak attractive forces between adjacent molecules in a matrix. The molecules in the centre of this matrix are under the influence of Van Der Waals forces from every direction. The molecules at the surface are under the influence of Van Der Waals forces from inside the matrix only. The resultant force (surface tension) tends to reduce the total surface area of the matrix.

Laplace law is a consequence of surface tension. It describes what occurs when 2 bubbles of different size are connected. Surface tension forces the bubbles to coalesce unless there is an opposing force of greater magnitude.

Buoyancy produces apposition of the break and the bubble. The flotation force of a bubble is greatest at the top of the bubble. Tamponade is a consequence of surface tension and works so long as a bubble is in contact with a break. This is why small bubbles, which have a smaller flotation force, can be used to tamponade breaks in pneumatic retinopexy.

It follows that tamponade is effective whether the break is at the top of a large bubble (where the flotation force is greatest) or at the side (where the flotation force is smaller). This has important implications for posturing after surgery as it implies that tamponade is equally effective whether the break is at the top or the side of an intraocular bubble.

Recently a study of fluid currents in the partially gas filled vitrectomized eye suggested that break closure could occur independently of direct contact of gas with the retina. This may explain the success of vitrectomy with gas in cases with inferior breaks (where compliance with posturing is difficult) and in cases with breaks in multiple meridia (where simultaneous contact of the tamponade agent with all the breaks simultaneously is impossible).

Figure 6.19 Laplace law and tamponade

When 2 bubbles are in contact Laplace law describes the tendency of the smaller bubble to coalesce with the larger bubble.

Surface tension of tamponade agents.

SUBSTANCE	SURFACE TENSION IN SALINE
Air (includes dilated gases e.g. SF6)	73 mN/m
Silicone Oil	35-40 mN/m
Perfluoro - n - octane	55 mN/m

The onset of vitreoretinal adhesion after retinopexy is of the order of 10-14 days. A vitreous air bubble usually dissolves within 5 days. For this reason air is usually mixed with a gas with low solubility and low coefficient of diffusion.

Post operative changes in the volume of intraocular gas bubbles are determined by the difference between the rate at which nitrogen diffuses into the bubble and the rate at which the gas diffuses out. A bubble of 100% gas passes through an expansion phase as the concentration of Nitrogen (which is soluble in water and has a high diffusion coefficient) exceeds rises. The rate of expansion then slows as an equilibrium in the concentration of Nitrogen is achieved. The bubble finally diminishes in size as the added gas diffuses out. The isovolemic concentration is the highest concentration of gas that can be left in the vitreous cavity without subsequent expansion. Various estimates have been derived for this using experimental and theoretical models.

Higher molecular weight gases have lower solubility in water and diffusion coefficients. They therefore remain in the eye for longer and expand more.

EXPANSION OF INTRAOCULAR GASES

NAME	FORMULA	EXPANSION	ISOVOLEMIC CONCENTRATION
Sulfur Hexafluoride	SF_6	2 X	20% - 25%
Perfluoroethane	C_2F_6	3.5 X	16%
Perfluoropropane	C_3F_8	4 X	14% - 18%

Patients undergoing surgery using Nitrous Oxide anesthesia while a gas bubble is in the eye are at high risk of very severe glaucoma. Rapid diffusion of Nitrous Oxide into the gas bubble produces significant volume expansion with exceedingly high intraocular pressures (sufficient to stop all intraocular blood flow) and a very high risk of total blindness. Postoperative glaucoma due to gas bubble expansion is also seen if there is a reduction in atmospheric pressure, for example due to air travel or ascension significantly above sea level. Patients should therefore be advised to inform anesthetists that they have a gas bubble in situ and avoid air travel until the gas bubble has absorbed.

Perfluorocarbon Liquids

The perfluorocarbons are a group of synthetic chemicals containing carbon and fluorine atoms. The names of individual members of the group derives from the corresponding organic chemicals so that (for example) the term perfuoropropane (C_3F_8) derives from propane (C_3H_8). The lower molecular weight members of the group are gases and the higher molecular weight members ones liquids. They are inert owing to the strength of the carbon - fluorine bond. They have several uses in medicine including artificial respiration.

Perfluorocarbon liquids (pfcl) were first used in ophthalmology by Stanley Chang. Liquid perfluorocarbons currently used in ophthalmology are: perfluoro-n-octane (Perfluoron), perfluorodecalin and perfluoroperhydrophenanthrene (Vitreon). All have acceptable safety profiles - there is some evidence that rates of retained pfcl may be higher with Vitreon than Perfluoron, possibly due to differences in refractive index.

The physical properties that make them useful in vitreoretinal surgery are:

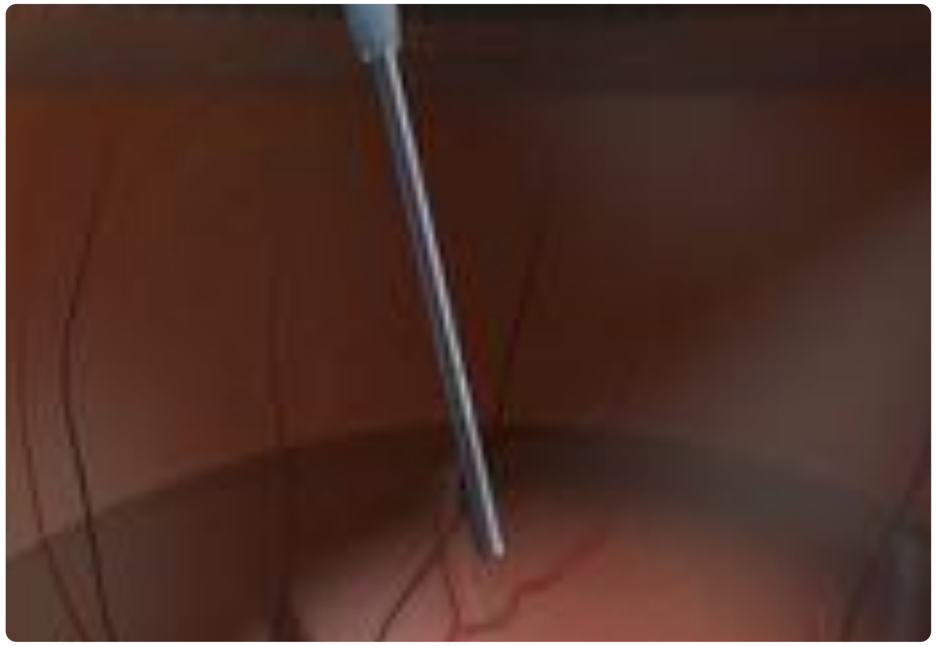
- Transparency. Their refractive index varies between 1.27 (Perfluoron) and 1.31 (Perfluorodecalin). It follows that Perfluoron is the most visible pfcl in water.
- Density (they are approximately twice a dense as water). They therefore displace saline from under the retina, causing reattachment.
- Low viscosity. This allows injection through narrow tubes.
- High interfacial surface tension in air and water. This is usually sufficient (unless disturbed by excessive fluid currents) to maintain a single bubble.

Their principal intraoperative use is to reattach the retina intraoperatively. They may also be used to displace objects (such as dislocated IOLs or lens fragments) anteriorly. They have also been used for short term postoperative tamponade of retinal breaks.

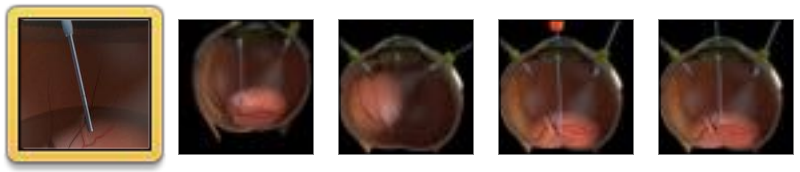
When injecting pfcl:

- Injection is initiated over the disc with the eye in the primary position and the tip of the cannula close to the disc.
- The tip of the injection cannula is kept inside the expanding pfcl bubble to maintain a single bubble.
- Bubbles may also form if the pfcl meniscus approaches the tip of the infusion, particularly if non valved ports are used. This is because intermittent jets of fluid from the infusion when a port is open cause the bubble to break up. This can be avoided by limiting the size of the pfcl bubble and using valved cannula hubs.
- If an attempt is made to inject a significant amount of perfluorocarbon (or any other liquid) into a closed eye the intraocular pressure will quickly rise. This is particularly dangerous as vitreous or even retinal incarceration may occur if an instrument is removed (if non valved ports are used). The infusion pressure should be reduced while injecting so that the excess fluid refluxes up the infusion line. This only works if the vitreous base has been shaved around the infusion port, otherwise vitreous may incarcerate in the infusion and block it. Stanley Chang devised a dual bore cannula with an aperture in the stem to allow fluid can leave the eye as the pfcl is injected. This is kept above the pfcl meniscus.

Figure 6.20 Use of perfluorocarbon liquids



The Chang injection cannula - note the fluting aperture on the side of the shaft. This is kept above the pfcl meniscus and below the tip of the cannula.



Although generally well tolerated perfluorocarbon liquids may cause complications:

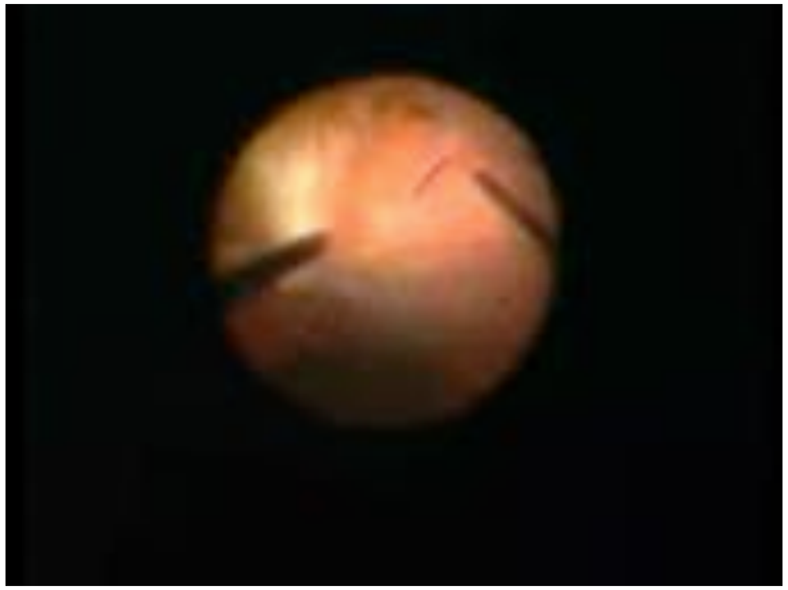
- Traction on the retina in the presence of a break may result in subretinal perfluorocarbon. Bubbles of perfluorocarbon will stay under the retina indefinitely and if located under the fovea vision is seriously compromised. They may be removed using a 39-gauge subretinal (Thomas) cannula.
- Small bubbles of residual pfcl in the vitreous cavity may be apparent to the patient but appear to do little harm.
- Bubbles of pfcl in the anterior chamber may be well tolerated but sometimes cause inflammation and corneal endothelial decompensation.

Because of these complications many surgeons reserve pfcl for more complex cases (such as giant retinal tears and pvr surgery).

Figure 6.21 Retained perfluorocarbon in the anterior chamber

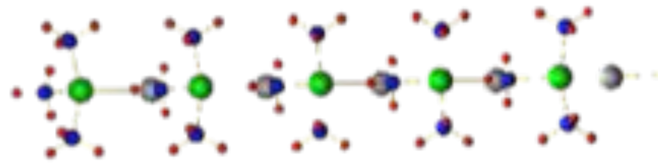
These may be removed postoperatively at the slit lamp using a fine needle. This may have to be repeated on several occasions to remove all the visible pfcl.

Movie 6.15 Aspiration of submacular pfcl



The pfcl was at the inferior border of the fovea so the cannula is passed from below.

Interactive 6.4 Conventional silicone oil (polydimethylsiloxane)



Polydimethylsiloxane consists of a backbone of repeating silicon (green) and oxygen (white) atoms. Each silicon atom is attached to 2 methyl groups. The chain length determines the viscosity. The alternation of silicon and oxygen makes the backbone quite flexible and long chains can intertwine. This accounts for the viscosity of silicone oil, which increases with increasing chain length.

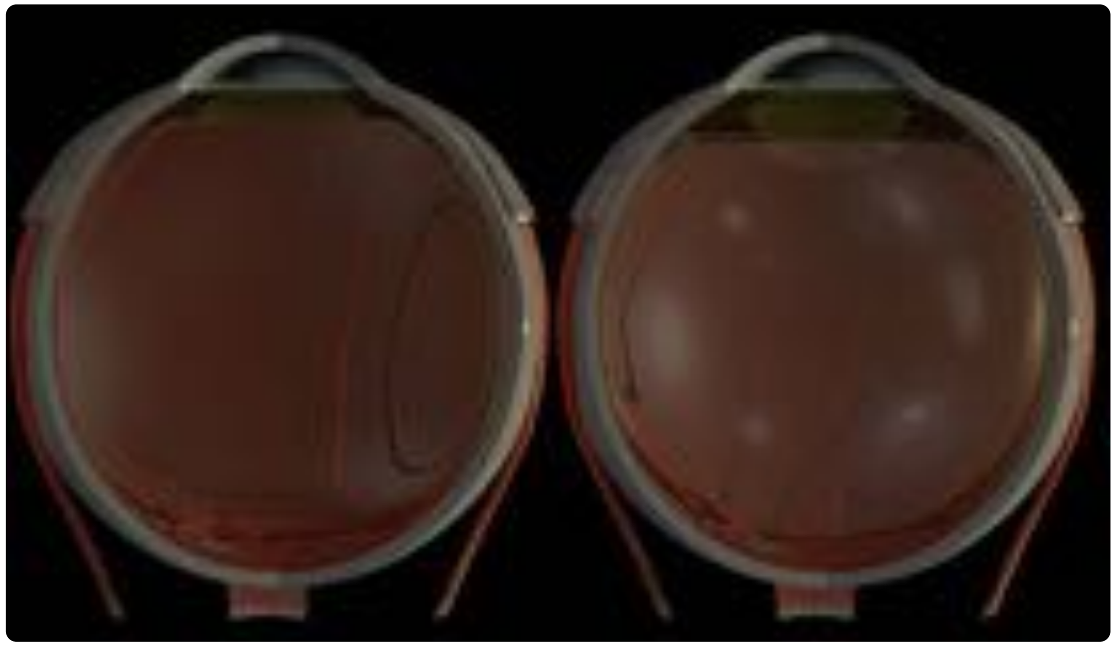
The properties of silicone oil that are relevant in vitreous surgery are:

- Transparency.
- Viscosity. This is a function of the length of the polymer chains. It is measured in centistokes (cs) and is used to classify silicone oils which are typically in the range 1000-5000 c. (Saline has a viscosity of 1 cs at room pressure).
- Biocompatability.
- High interfacial surface tension in water so that it can act as a tamponade agent
- Positive buoyancy.

Polydimethylsiloxane is often mixed with other chemicals to change its physical properties. For example silly putty consists of 65% polydimethylsiloxane combined with thixotropic agents to help it maintain its shape. In ophthalmology various chemicals may be added to polydimethylsiloxane to alter its buoyancy ('heavy oils'). For example perfluorohexyloctane (which has a specific gravity of 1.35 g/ml) may be combined in this way with polydimethylsiloxane (which has a specific gravity of 0.97 g/ml). The resulting compound, Densiron, has a specific gravity of 1.06 g/ml - i.e. it is slightly negatively buoyant.

Because it less buoyant than gas a bubble of silicone oil does not conform to the wall of the eye as well as a bubble of gas does. Oil is therefore a less effective tamponade agent than gas notwithstanding its high surface tension.

Figure 6.22 Air vs gas tamponade



The eye on the left has a 90% gas fill, the eye on the right a 90% oil fill. The oil is in contact with a smaller area of retina than the gas. Notice also the difference in refractive index. The eye on the right has some functionally useful vision.

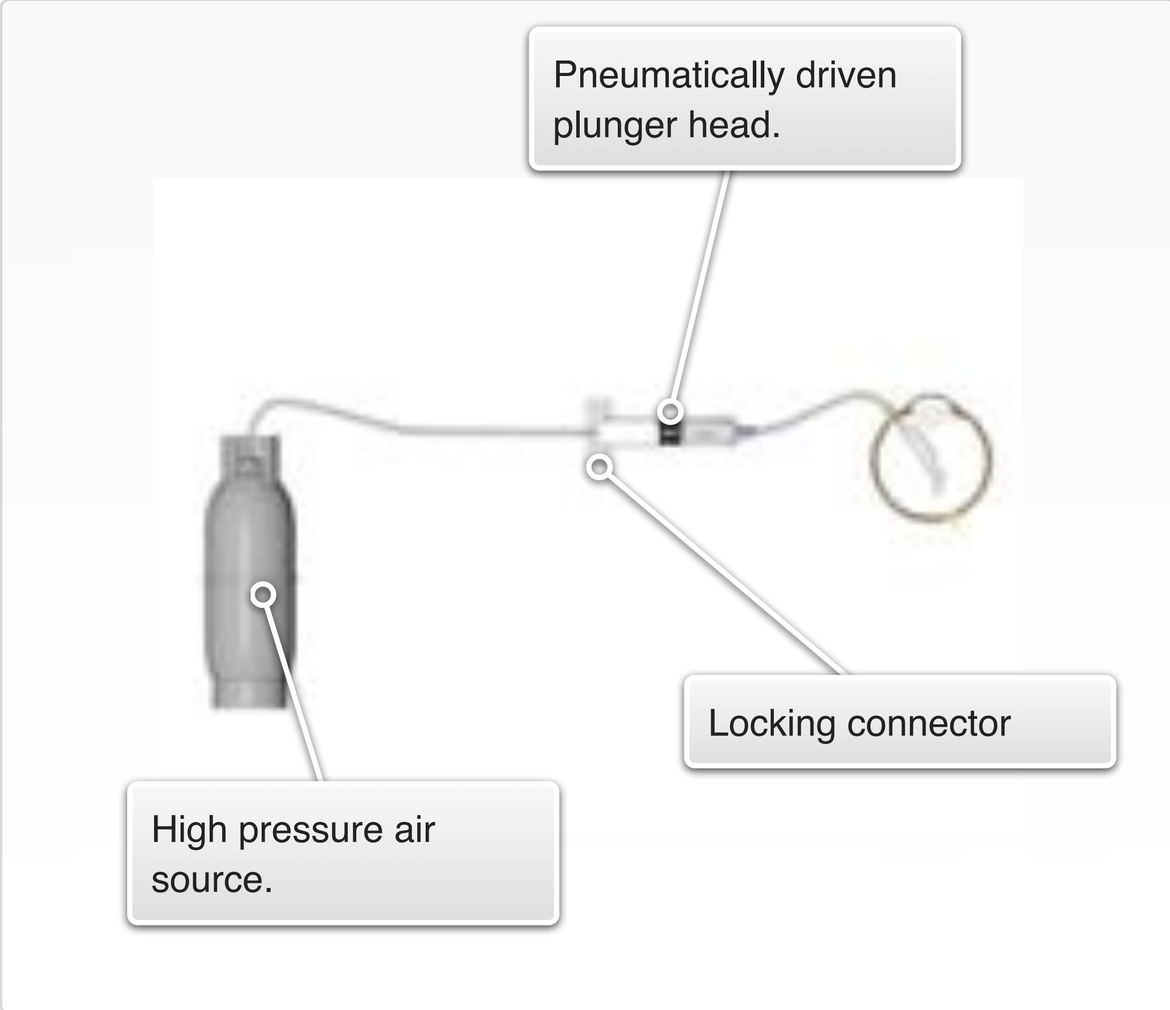
The major advantages of silicone oil over gas are:

- The tamponade effect will not diminish with time. It can last as long as the surgeon requires (indefinitely if absolutely necessary, although with the risk of long term vision loss from complications).
- The refractive index of silicone oil is 1.5. The refractive index of air or gas is 1.0. The refractive index of water is 1.33. As the refractive index of the saline is closer to that of oil than air functional vision is possible through an oil bubble.

Heavy silicone oils displace residual aqueous and the associated 'soup' of growth factors to the superior retina. This may shift the problem of recurrent PVR from the inferior to the superior retina. If a superior retinectomy is required rather than an inferior retinectomy the corresponding visual field loss will be inferior rather than superior and its functional impact on the patient's everyday life greater. The interim results of a randomized controlled study failed to show any benefit from the use of heavy silicone oil in PVR (40% success rate with conventional silicone oil vs 28% success rate with heavy silicone oil).

Because of its high viscosity silicone oil is injected using a high pressure infusion line coupled pneumatically to the plunger of a syringe containing silicone oil. All of the connections interlock to prevent accidental disconnection. When using 1000 centistoke silicone in a MIVS system a pressure of 80 pounds per square (psi) may be required. The conversion ratio from psi to mmHg is 50:1 so a pressure of 4000 mmHg is used. If the injection is accidentally carried out in a closed system (for example when oil is blocking the extrusion port or cannula) the intraocular pressure may rise to dangerous levels which may even rupture the globe, particularly if recent cataract wounds are present.

Interactive 6.5 Schematic oil pump



SILICONE OIL - AIR EXCHANGE

In most situations oil should only be injected after the eye has been filled with air and the retina attached. The air infusion line remains connected and acts as a pressure regulator.

This allows control of the pressure during injection and reduces the likelihood of oil entering the anterior chamber.

The oil fills the eye from the bottom up. It is easy to appreciate when the oil has filled the eye as the oil/air meniscus reached the lens.

Figure 6.23 Oil-air exchange

The oil fills the eye from the bottom upwards. Under air the oil bubble has a capped spherical profile.

Movie 6.16 The end of oil - air exchange

In a phakic eye the end point is indicated by an alteration in specular reflection as the top of the oil bubble comes in contact with the posterior capsule.

Movie 6.17 Oil-air exchange in an aphakic eye

The end point here is a complete anterior chamber oil fill. The anterior chamber is subsequently reformed with saline through a paracentesis while letting a little oil escape to prevent an overfill of oil.

Sometimes it is better to exchange silicone oil with fluid than air.

For example a giant retinal tear that is attached under perfluorocarbon may slip if an air exchange is performed. If silicone oil is planned in such a case it is often better to exchange the perfluorocarbon directly with oil rather than performing an intermediate exchange with air.

When performing a fluid-oil exchange the intraocular pressure (IOP) is carefully monitored in order to match the rates of aspiration of fluid and injection of oil. Closure of the choroidal and retinal vessels indicates that the IOP is too high. The IOP can also be assessed from the degree of resistance encountered while attempting to press the instruments together. If the pressure drops during oil-fluid exchange the infusion may tilt anteriorly and oil may pass through the zonules into the anterior chamber.

Movie 6.18 Oil-fluid exchange

Note that the tip of the extrusion needle is kept below the meniscus of the oil bubble.

Figure 6.24 Oil-fluid exchange

Because the oil is buoyant it fills the eye from the top downwards. Fluid therefore has to aspirated under direct view from behind the oil/fluid interface.

USE OF OIL IN APHAKIC EYES

If silicone oil is infused into an aphakic eye a form of pupil block may develop. The oil bubble blocks the physiological flow of aqueous through the pupil from the ciliary body in the posterior segment to the trabecular meshwork. The oil bubble is pushed into the anterior chamber and the anterior chamber fills with silicone which exacerbates the pupil block. A peripheral iridotomy prevents this. This can be performed with the vitrectomy cutter. If this is done with oil in the anterior chamber quite high cutter aspiration has to be used. If the anterior chamber is reformed with saline normal aspiration pressures are used.

Figure 6.25 Peripheral iridotomy

The mechanism of aphakic silicone pupil block. Aqueous from the ciliary body forces the oil into the anterior chamber. A peripheral iridotomy prevents this by creating an alternative route for aqueous to enter the anterior chamber.

Movie 6.19 Peripheral iridotomy

Usually only one iridotomy is performed. This case was a patient with uveitis - the second iridotomy was performed in the anticipation that a post vitrectomy fibrin syndrome might develop causing an iridotomy to become blocked.

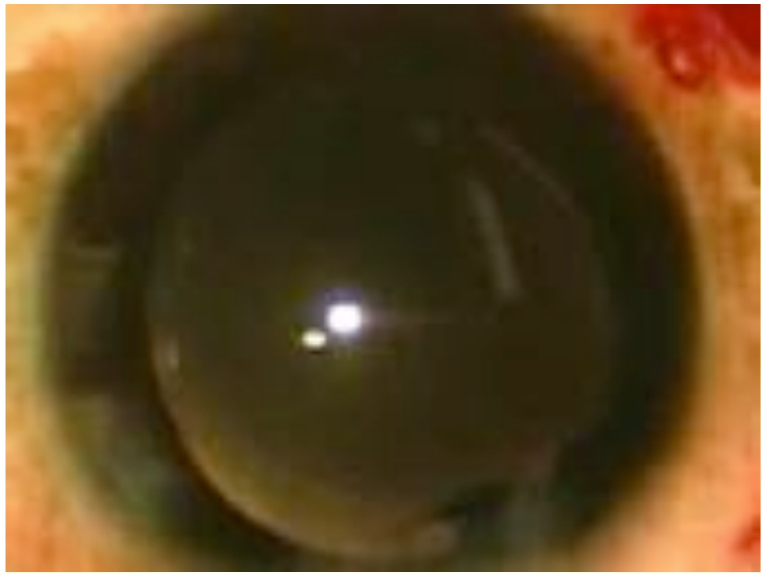
Oil in the anterior chamber.

Oil may enter the anterior chamber during surgery if the infusion tilts forward. This may occur due to hypotony during silicone oil exchange or if the infusion line is not properly secured. It is particularly likely to occur in the presence of a large zonular dialysis.

If the cause is easily remediable (e.g. an unsecured infusion) the oil can be removed by making 2 paracenteses. Viscoelastic is injected through one of these while the other is gently opened to allow the oil to escape.

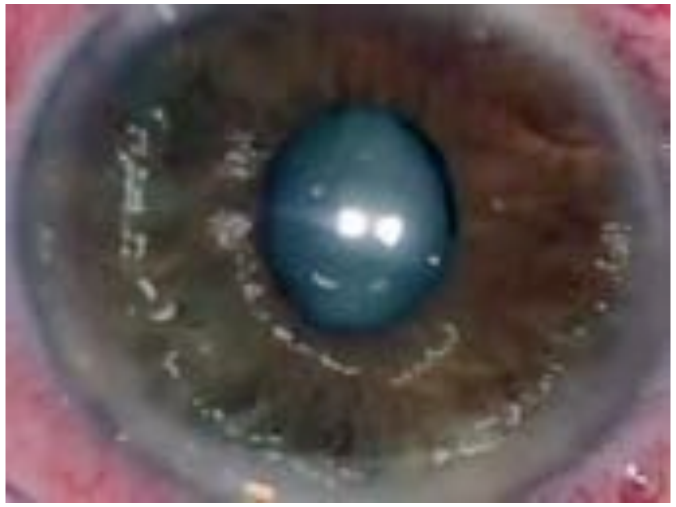
If this occurs in a phakic or pseudophakic eye with zonular deficiency serious consideration should be given to removing the lens or IOL along with the capsular bag as the problem may recur postoperatively.

Movie 6.21 Oil entering the anterior chamber



A zonular dialysis was present in this case and there was a leaking corneal section.

Movie 6.20 Oil removal from the anterior chamber



Two paracenteses are used: saline or viscoelastic are injected through one and oil is released from the other.

INTRAOPERATIVE COMPLICATIONS OF SILICONE OIL INJECTION

Suprachoroidal oil.

This may occur if the tip of the infusion slips into the suprachoroidal space during infusion. It may be avoided by avoiding too oblique entry with the entry site alignment system, avoiding hypotony and properly securing the infusion line. If discovered during surgery the infusion may be re-sited and a scleral cut down performed. If discovered post operatively it may be observed.

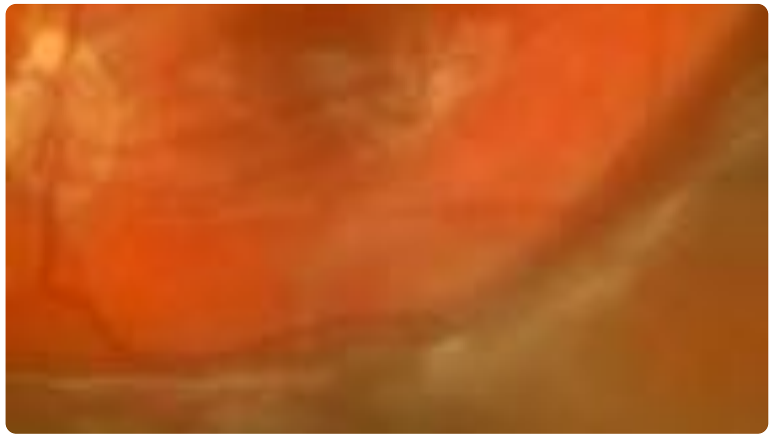
Subretinal oil.

Oil only enters the subretinal space if there is unrelieved traction on the retina. The presence of oil in the subretinal space indicates the need for a retinectomy both to remove the oil and to relieve the traction.

Retinal slippage.

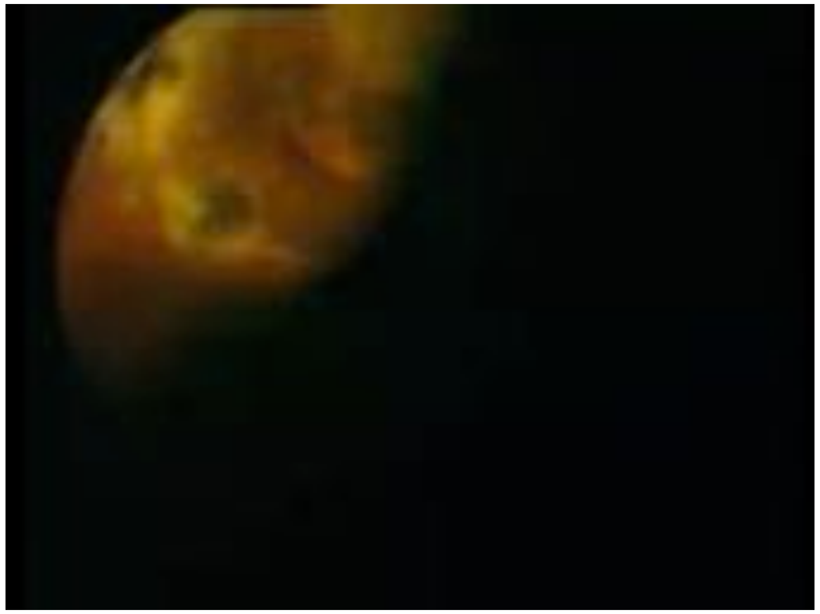
Slippage of the edge of large tears is discussed in the giant retinal tear section.

Figure 6.26 Suprachoroidal oil



B scan ultrasound confirmed the presence of oil in the suprachoroidal space.

Movie 6.22 Subretinal silicone



This was managed with a retinectomy

POSTOPERATIVE COMPLICATIONS OF SILICONE OIL INJECTION

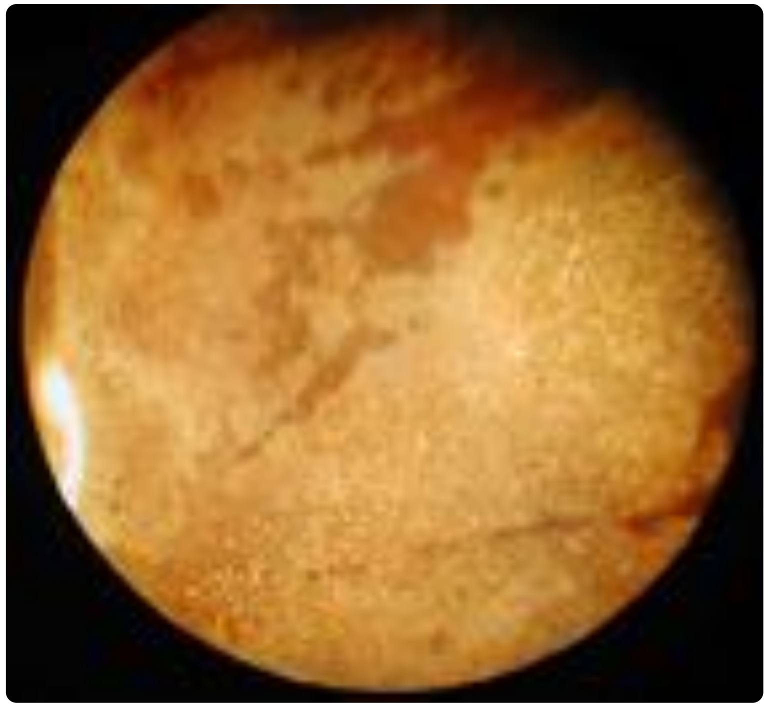
Emulsification

The breakdown of a large single bubble to an emulsion seems to be promoted by:

- Ocular movements, which provide the energy required. Factors which increase the shear rate at the bubble meniscus such as oil underfill and nystagmus seem to promote emulsification.
- Biological proteins, which reduce the surface tension and therefore as surfactant agents. This may account for an increased frequency of emulsification in the presence of post operative inflammation.

The emulsified oil droplets may migrate throughout the eye where they give rise to a variety of complications. Gonioscopy of eyes that have had silicone oil in place for long periods usually reveals the presence of small droplets in the upper angle. Sometimes these are clinically visible - a hyperoleon. Passage of oil into the trabecular meshwork has been implicated in the pathogenesis of open angle glaucoma due to silicone oil.

Figure 6.27 Silicone oil emulsification

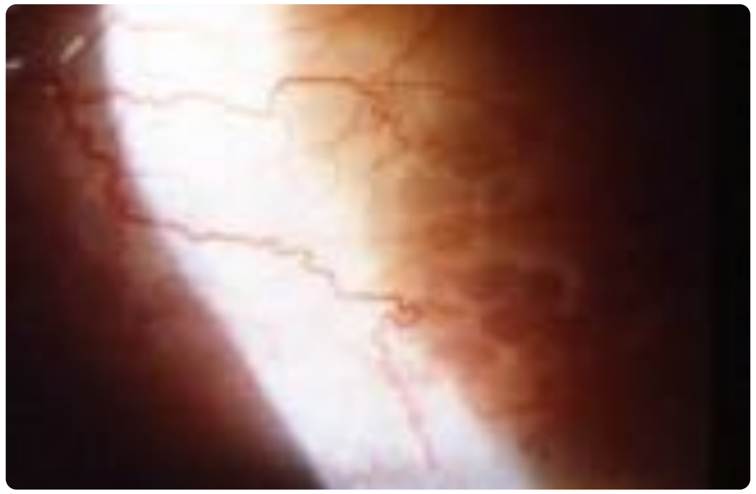


Emulsified oil on the retinal surface.

Subconjunctival silicone oil droplets

Leakage from a sclerotomy postoperatively leads to the accumulation of silicone oil droplets under the conjunctiva. These cannot always be drained as they become compartmentalized within episcleral tissue and can only be removed, if necessary, by block excision of the affected episcleral tissues. It is important to have a very low threshold for suturing sclerotomies when oil is infused, even when using minimally invasive vitrectomy.

Figure 6.28 Subconjunctival oil



Oil in the anterior chamber

As well as emulsified oil large bubbles of oil may also appear in the anterior chamber post operatively.

Blockage of a peripheral iridotomy may result in post operative aphakic pupil block.

Oil may also enter the anterior chamber postoperatively in a phakic eye through a zonular defect. The treatment of this is to either remove the oil or to make the eye aphakic and perform an iridotomy.

The signs of oil in the anterior chamber are:

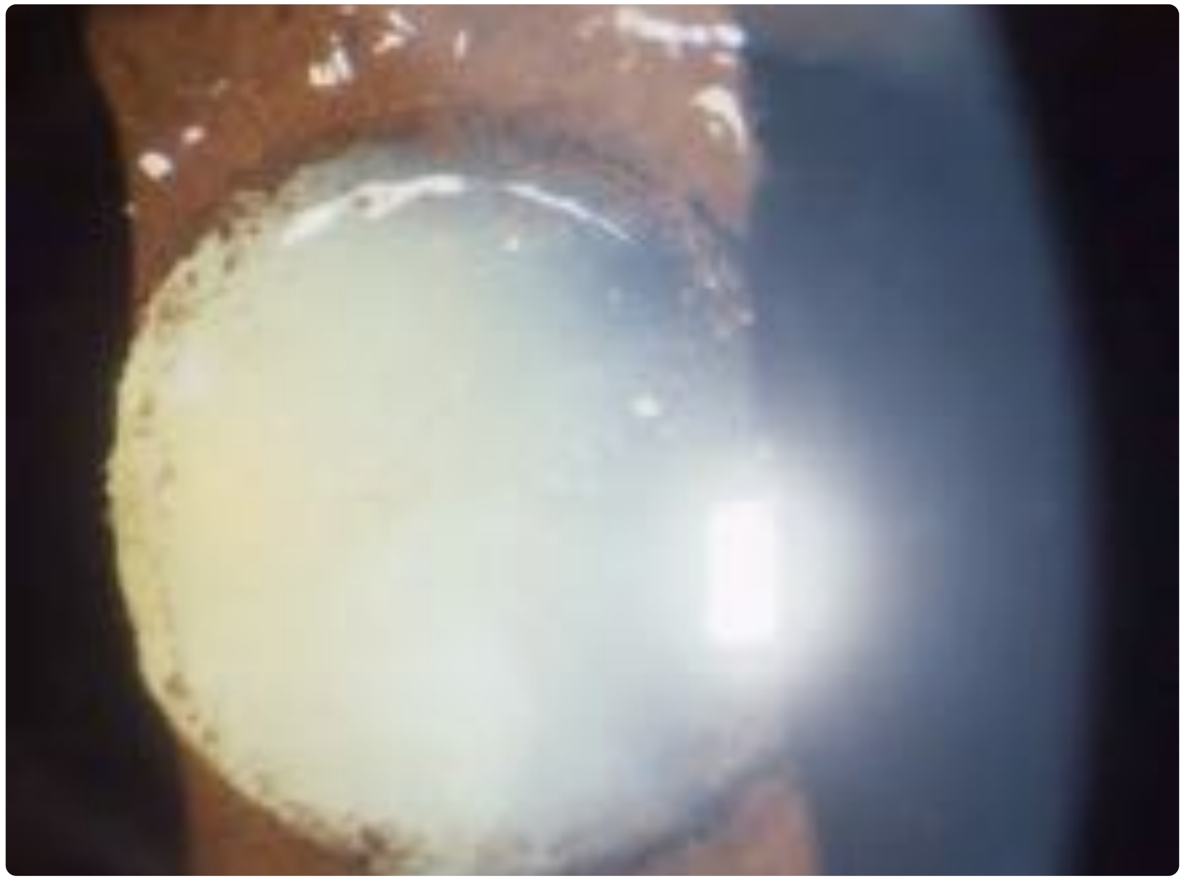
- Very high IOP with a clear cornea (as there is no aqueous behind the corneal endothelium to hydrate the cornea).
- Lack of circulating cells and flare in the anterior chamber.
- The presence of a specular sheen on the iris.

Oil may also enter the anterior chamber if there is ciliary body failure as no aqueous is produced to fill the anterior chamber.

Cataract

Nuclear cataract is virtually universal in phakic eyes with silicone oil and is frequently dealt with when the oil is removed.

Figure 6.29 Oil in the anterior chamber



Oil is present in the anterior chamber of this phakic eye. The intraocular pressure is 50 mmHg but the cornea is clear. A specular sheen from the interface can be seen on the iris and lens. This was treated with lensectomy and iridotomy.

SILICONE OIL REMOVAL

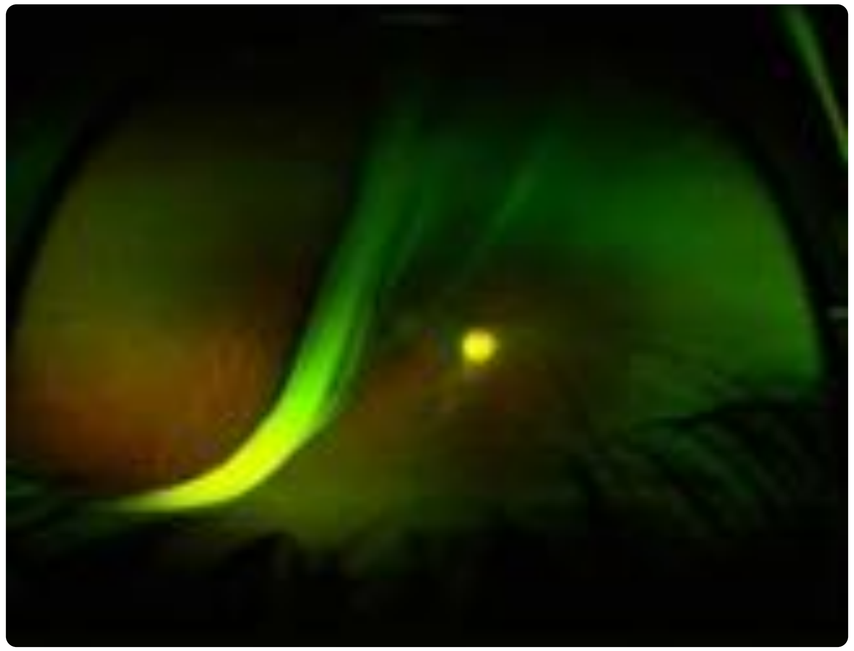
Logically silicone oil may be be removed when a mature chorioretinal adhesion is present at the retinopexy sites - i.e. approximately 2 weeks after the initial surgery.

In practice silicone oil is often left in the eye for longer than this, particularly in PVR cases. This allows the retina to be observed over several months for evidence of reproliferation.

There are some circumstances in which oil may be retained indefinitely:

- Ciliary body failure. An IOP of less than 10 mmHg is a relative contraindication to silicone oil removal.
- Extensive necrotising retinitis. The risk of redetachment is particularly high in cases of cytomegalovirus retinitis and the conventional teaching has been to leave oil in situ indefinitely in this group. The normalization of life expectancy in patients with cytomegalovirus-related detachment has prompted a review of this practice. Silicone oil is removed in selected cases.
- Patients reluctant to undergo further surgery. Patients must be prepared to accept the risk of recurrent retinal detachment and the possible need for further surgery.

Figure 6.30 Development of PVR under silicone oil



A child with Sticklers syndrome presented with a giant retinal tear.

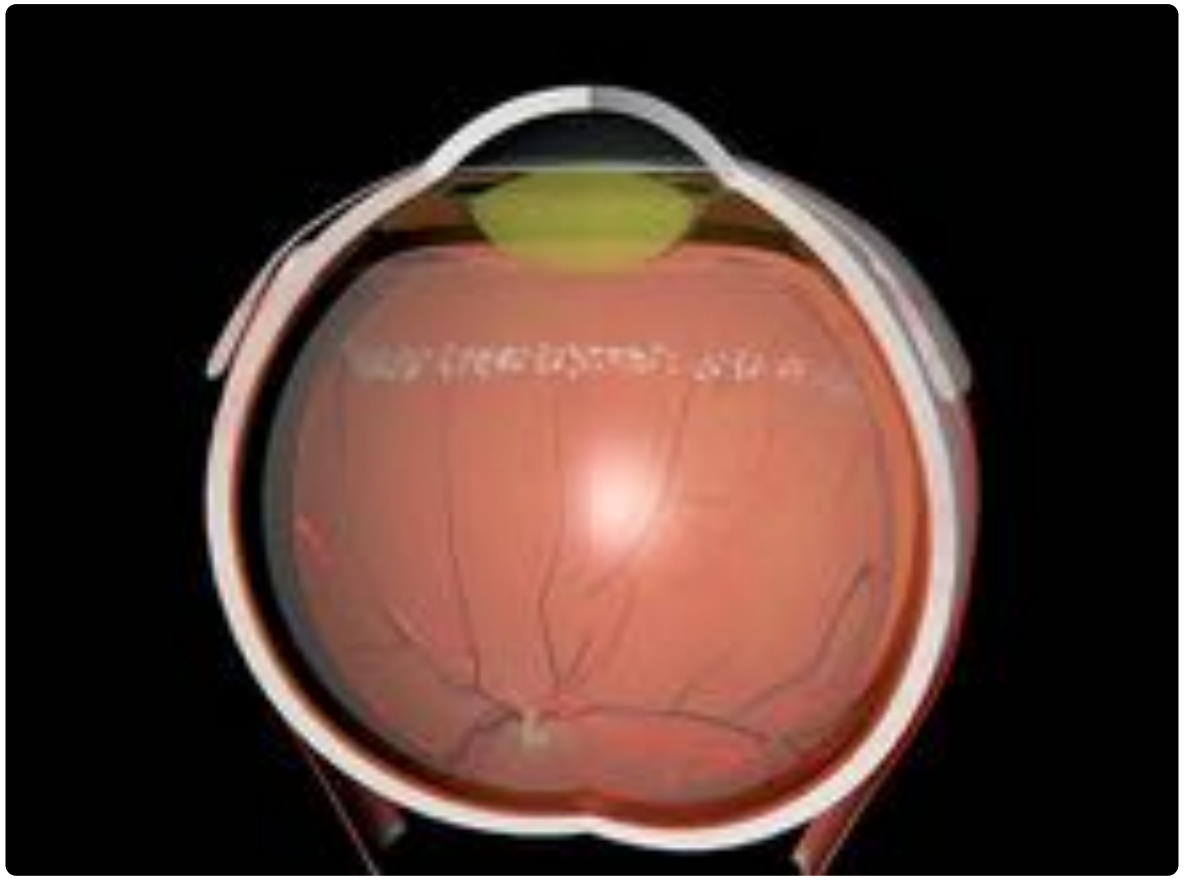
ASSESSMENT AND INTERVENTIONS PRIOR TO SILICONE OIL REMOVAL

Prior to silicone oil removal the retina is assessed for:

- Evidence of recurrent proliferation or epiretinal membrane.
- Adequacy of the retinopexy.

If there is any uncertainty about the adequacy of retinopexy supplementary laser may be delivered prior to silicone oil removal. Completion of a ring of retinopexy around the entire peripheral retina (360^0 photocoagulation) before oil removal may reduce the risk of posterior detachment following oil removal (although annular detachments anterior to the ring of retinopexy may occur).

Figure 6.31 Supplementary retinopexy before oil removal



This retina is attached under silicone oil. 360^0 retinopexy has been performed.

TECHNIQUES FOR REMOVING SILICONE OIL

There are several ways of removing silicone oil. The choice depends on:

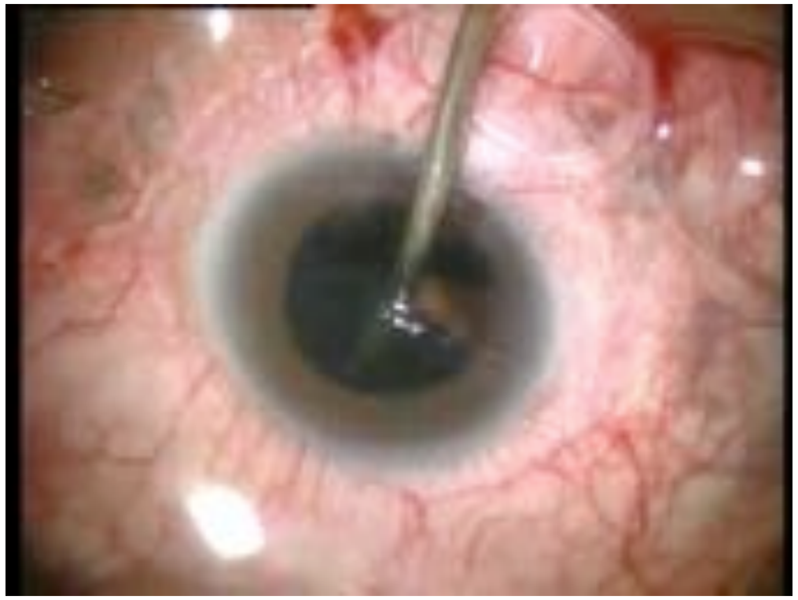
- The phakic status. Most phakic patients will inevitably develop cataract so combining cataract surgery with silicone oil removal is logical. In aphakic eyes the oil may be quickly and easily removed through a corneal incision.
- The need for further posterior segment surgery. If further posterior segment surgery is required a 3 port approach is used.
- The viscosity of the oil. Even high viscosity (5,000 cs oil) can be removed through a 25-gauge cannula.
- The buoyancy of the oil.

In an aphakic eye the oil may quickly be removed by making a corneal pocket and infusing saline into the eye. This is particularly useful when removing viscous oils. The major disadvantage of this technique is that oil covers the operative field. Silicone oil is an excellent lubricant and its presence on surgical gloves makes microsurgery challenging. The amount of oil may be reduced by irrigating the eye with copious amounts of fluid so that most of the oil flows into the fluid collection pouch of the surgical drape.

Movie 6.23 Removal of oil from an aphakic eye

In this case there is a separate 20-gauge pars plana infusion.

Movie 6.24 Dealing with the final bubbles



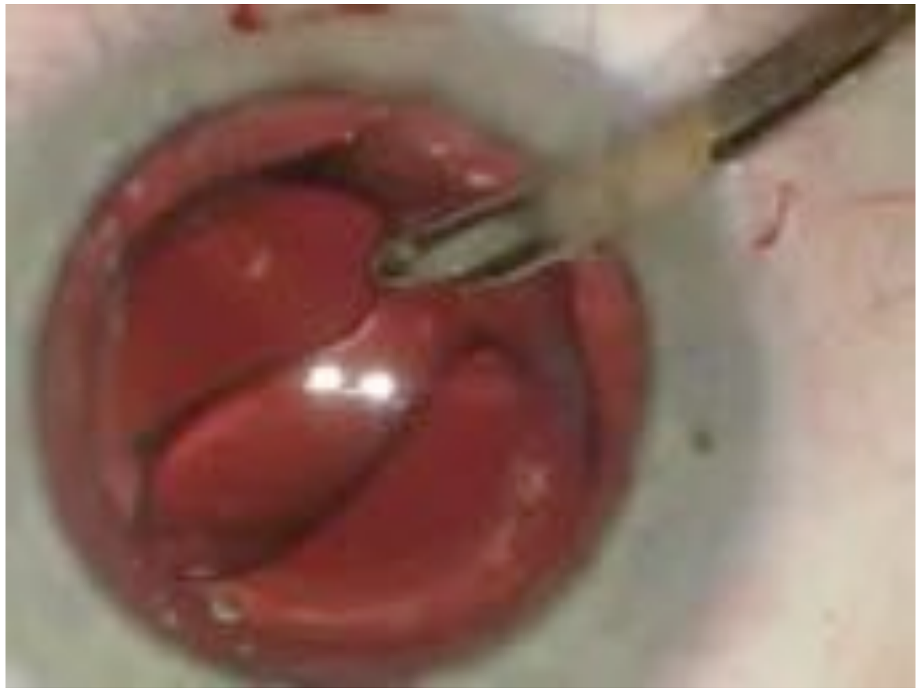
When an infusion through the cornea is used there may be some difficulty removing the last few bubbles as they are blown away with the jet of the infusion. Possible solutions are to use a plastic cannula to which the oil adheres or the technique employed in this video. The infusion is removed from the eye. When the oil bubble has floated to the level of the pupil the cannula is re-introduced without infusing. As the anterior chamber starts to fill with oil the tip of the infusion is placed behind the oil meniscus and infusion recommenced. This may have to be done several times.

Combined cataract surgery with oil removal may be performed on phakic eyes.

Figure 6.32 Combining oil removal with phacoemulsification

Silicone oil is to be removed from this phakic eye. It has minimal lens opacity but progression of this is inevitable.

Movie 6.25 Removal of silicone oil through a posterior capsulorrhexis

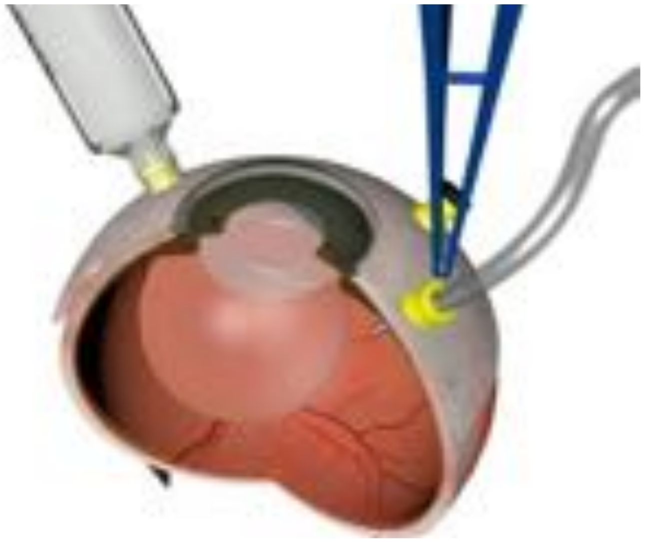


When conventional oil is removed from a pseudophakic eye a pars plana aspiration line is inserted. With high aspiration pressure it is possible to remove silicone oil through a 23-gauge cannula.

Placing 3 ports has 2 major advantages:

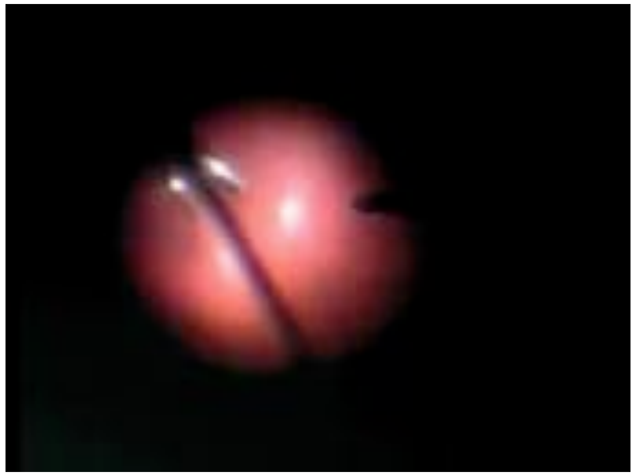
- The retina can be carefully inspected for reproliferation and epiretinal membranes. Further peeling, retinopexy and tamponade can be performed as required.
- Repeated air-fluid exchange may be carried out to remove small bubbles of residual oil. Patients often find these quite troublesome.

Figure 6.33 Active aspiration of silicone via the pars plana



The aspiration syringe is connected directly to the cannula hub. The intraocular pressure is being monitored using pressure from the forceps. The aspiration pressure is reduced as the bubble gets smaller to prevent post occlusion surge with collapse of the globe.

Movie 6.26 Air exchange following oil aspiration



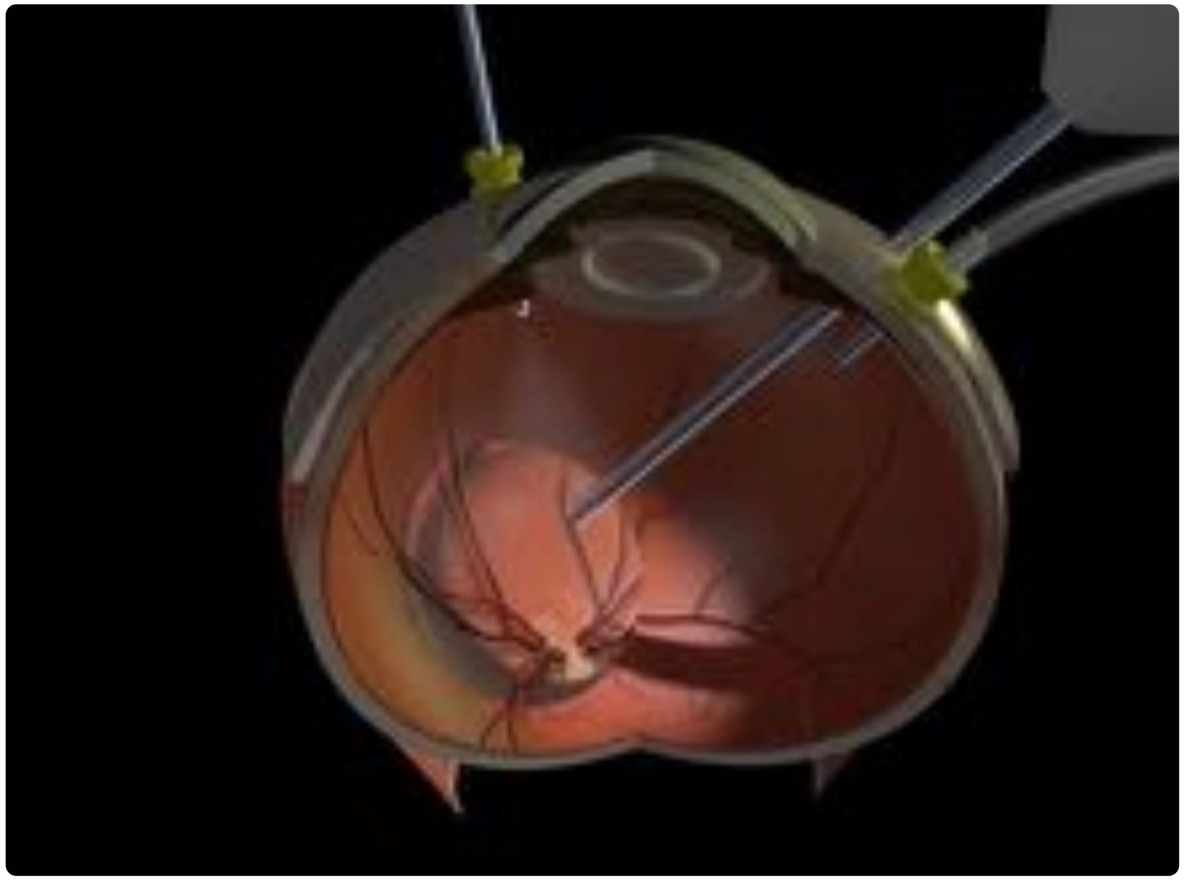
Note the numerous small bubbles of oil which sit at the air-fluid meniscus and are removed with the saline. The vitreous cavity may have to be 'washed' with several air-fluid exchanges to remove all the bubbles of oil

Movie 6.27 Post occlusion surge during active aspiration of oil.

Hypotonous episodes carry the risk of suprachoroidal hemorrhage. The linear aspiration should be carefully controlled especially as the oil bubble diminishes in size.

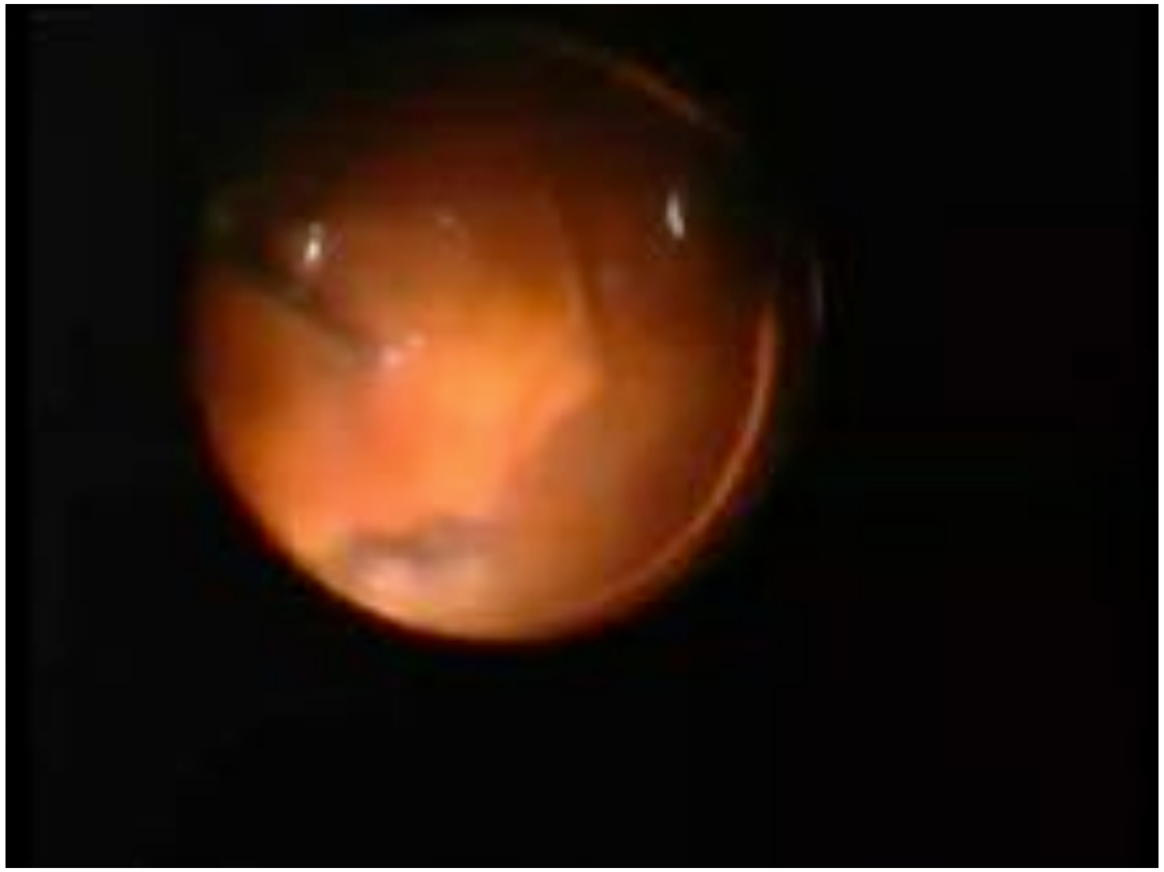
Heavy silicone oils are removed under direct view using a pars plana approach. A short 23-gauge cannula may be used combined with aspiration to draw the oil to the cannula. Some difficulty may be experienced removing the oil from the retina. Perfluorocarbon injection resolves this problem.

Figure 6.34 Removal of heavy oil.



Removal of heavy oil conventionally requires active aspiration through an 18G extrusion cannula. It is possible to remove the oil by aspirating using a shorter 23 gauge cannula so long as aspiration is maintained.

Movie 6.28 Removal of Densiron HD from the retina



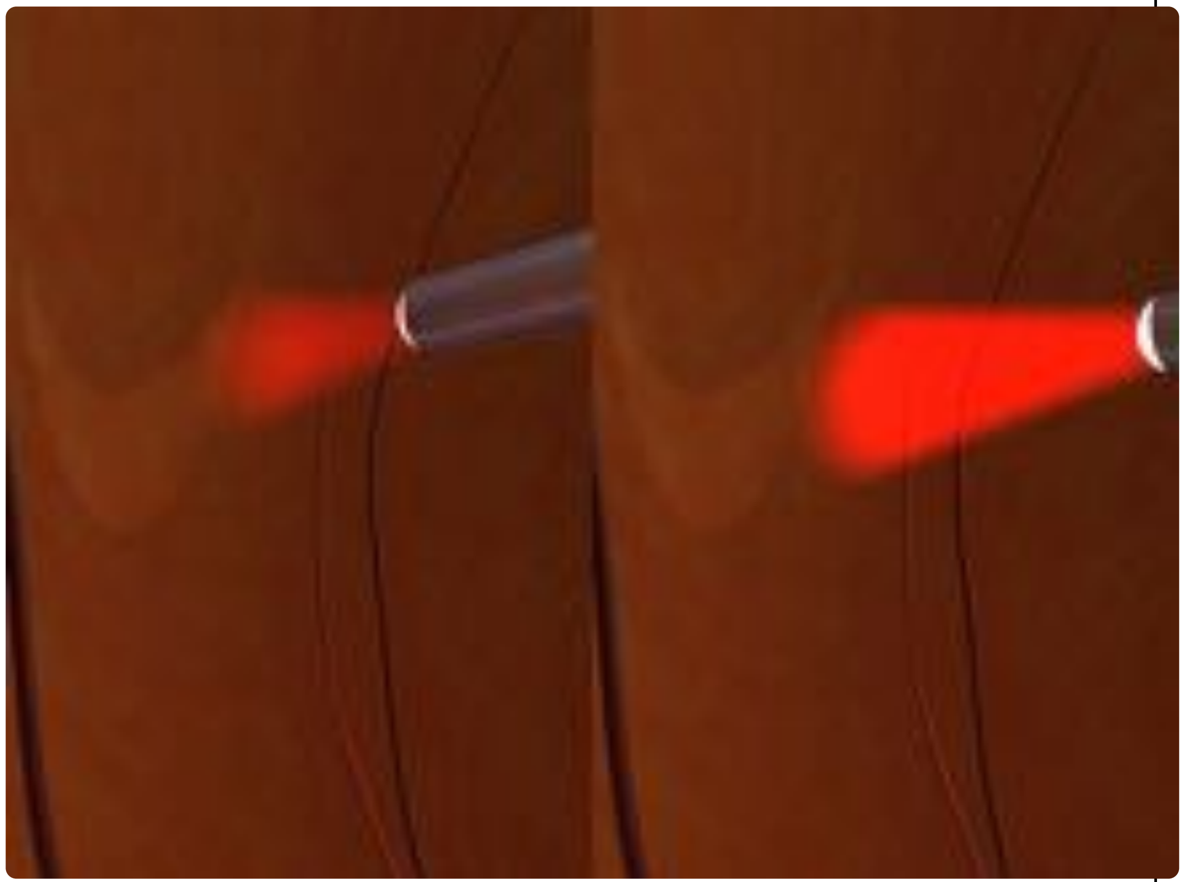
Note the oil appears to adherent to the retina. This arises from differences in interfacial surface tension and is resolved by injecting pfcl.

Endolaser.

A variety of lasers are available for vitrectomy surgery. The absorption peak for melanin is 550-600nm. Solid state lasers producing laser light using wavelengths greater than 500 nm (i.e. avoiding blue light because of fears over phototoxicity) are therefore used. The laser is delivered to the eye via flexible fibreoptic cables with convex tips to produce a diverging beam. The spot size is governed by the distance of the retina from the tip. There is a corresponding reduction in flux with distance. The distance from the retina and optimum laser energy output are therefore both modulated to give burns of the optimum size and intensity.

The angle if incidence of the laser should be as close to 90^0 as possible to give round burns of uniform intensity. Otherwise oval spots of non uniform intensity are produced. This is best achieved by treating across the eye. Curved laser probes allow this to be performed in phakic eyes.

Figure 6.35 Endolasers



The laser spot size varies with distance of the probe tip from the retina. Note the power has been increased as this distance increases.

Laser energy is absorbed in the retinal pigment epithelium. Here it is converted to thermal energy which is conducted to the retina. Laser treatment is therefore ineffective if the retina is detached. Areas of detached retina should be reattached (with air or perfluorocarbon) prior to laser. Attempts to achieve visible laser reaction in the presence of subretinal fluid may lead to excess energy uptake in the choroid and post operative inflammation. Chronic tractional detachment reattached pneumatically during surgery often have a thin layer of persisting viscous subretinal fluid. Extensive panretinal photocoagulation to areas of retina that were detached before surgery is therefore inadvisable.

A laser filter to protect the surgeon is placed in the microscope. The aiming beam is usually a low power laser of different wavelength to the therapeutic laser. It is therefore visible through the laser filter.

The optimal laser reaction is a faint blanching. This may be difficult to appreciate through the laser filter and there is a tendency to apply excessive laser energy. Very high energy levels may cause choroidal burns and retinal necrosis. Judging the appropriate laser reaction is particularly problematic in an air filled eye due to specular reflections from the retinal surface. The air acts as a thermal insulator so lower energy levels may be needed.

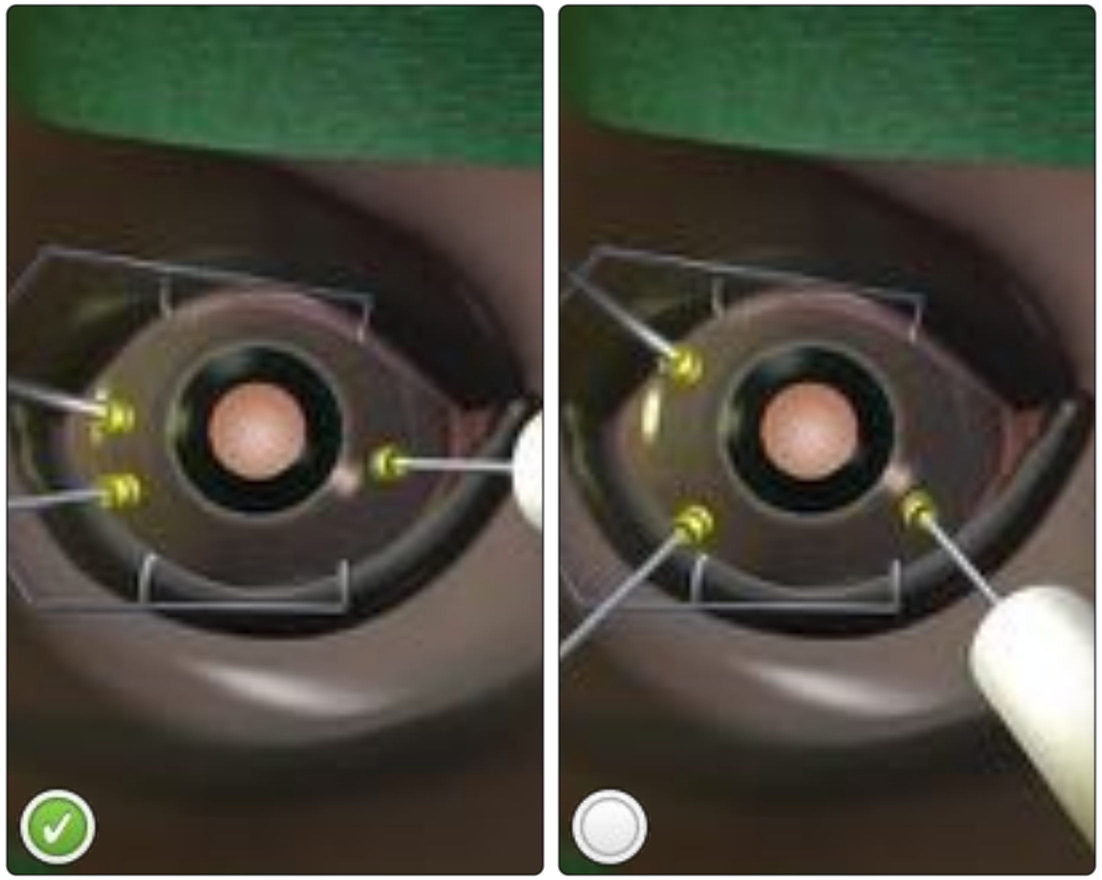
Treatment of retinal and preretinal hemorrhage should be avoided as it destroys the adjacent nerve fibre layer causing large arcuate scotomas.

Knowledge review

Review 6.1 Placement of entry site system

Question 1 of 2

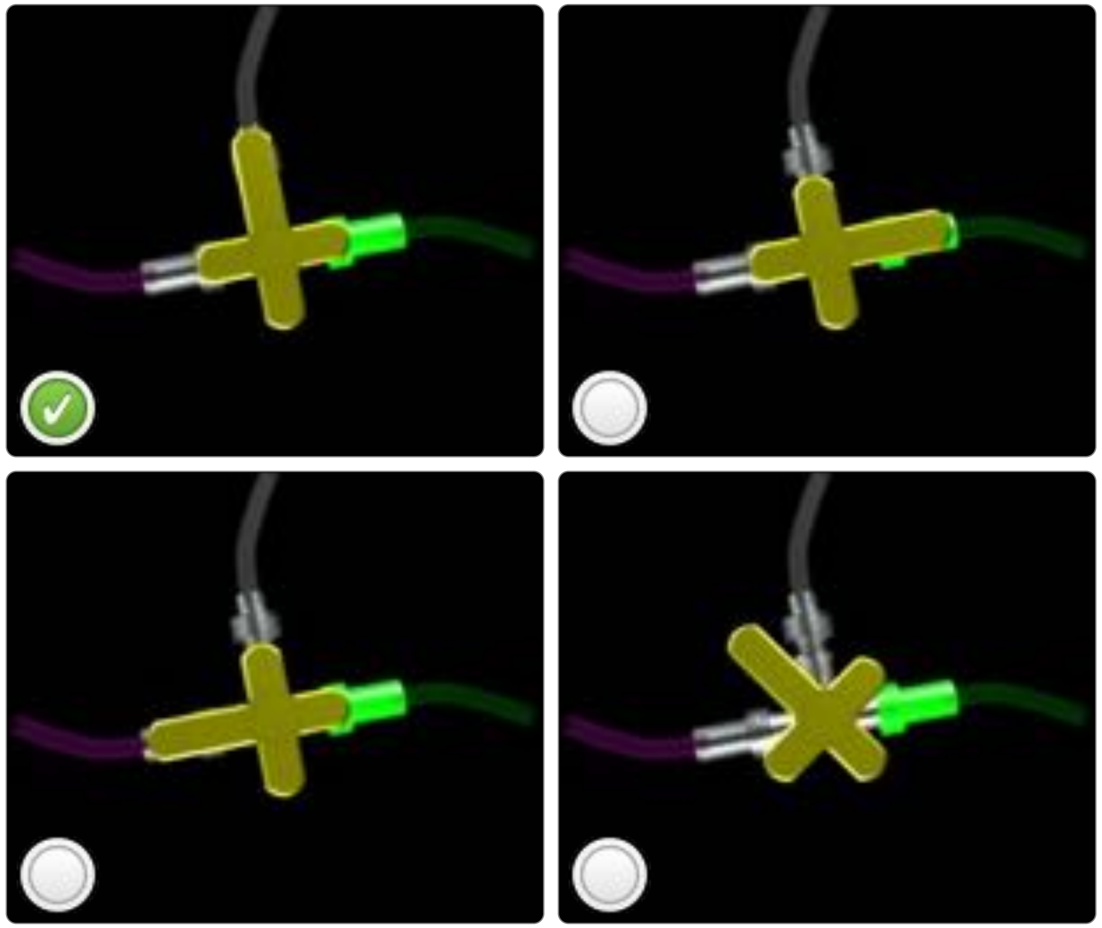
Which case has the optimum placement of the entry site system?



Check Answer

Review 6.2 Stopcocks

Which turn of the 3 way tap/stopcock handle allows fluid to flow between the purple and green infusion lines?



Check Answer

Review 6.3 Intraocular tamponade

Question 1 of 5

Tick the correct statement

- **A.** The tamponade effect at the top of an air bubble is greater than it is at the side.
- **B.** The isovolemic concentration of SF_6 is 14%.
- ✓ **C.** A 0.28 ml bubble of air in an eye of normal volume (5.5ml) tamponades a 90^0 arc of retina.
- **D.** Laplace law describes the tendency of a larger bubble to empty into a smaller one until both have an equal volume.

Check Answer

Review 6.4 Viewing systems

When using the BIOM

- **A.** Lowering the lens on the focussing ratchet moves the focal plane downwards.
- **B.** In order to visualize the retina under air the lens on the focussing ratchet is moved downwards.
- **C.** Focussing down with the microscope pedal reduces the field of view.
- **D.** The image is laterally but not horizontally inverted.
- ✓ **E.** The system includes a condensing lens which may have to be changed if the system is moved to a different microscope.

Check Answer

Review 6.5 Infusion systems

Question 1 of 2

Which statement is incorrect

- **A.** In a gravity fed infusion a bottle height of 38 cm above the eye produces an intraocular pressure of 21 mmHg if there is no flow.
- **B.** The resistance to flow in an infusion tube is proportional to the square of the radius of its lumen
- **C.** Luer locks should be used at all connection junctions.

Check Answer

Review 6.6 Illumination during surgery

Which statement is correct

- **A.** The maximal beam divergence available is 90^0.
- **B.** Modern illumination systems filter out harmful longer wavelength light.
- **C.** May use Xenon and Mercury vapor lamps.
- **D.** May use Light Emitting Diode sources
- **E.** All the above
- **F.** C and D only

Check Answer

Review 6.7 Cutters.

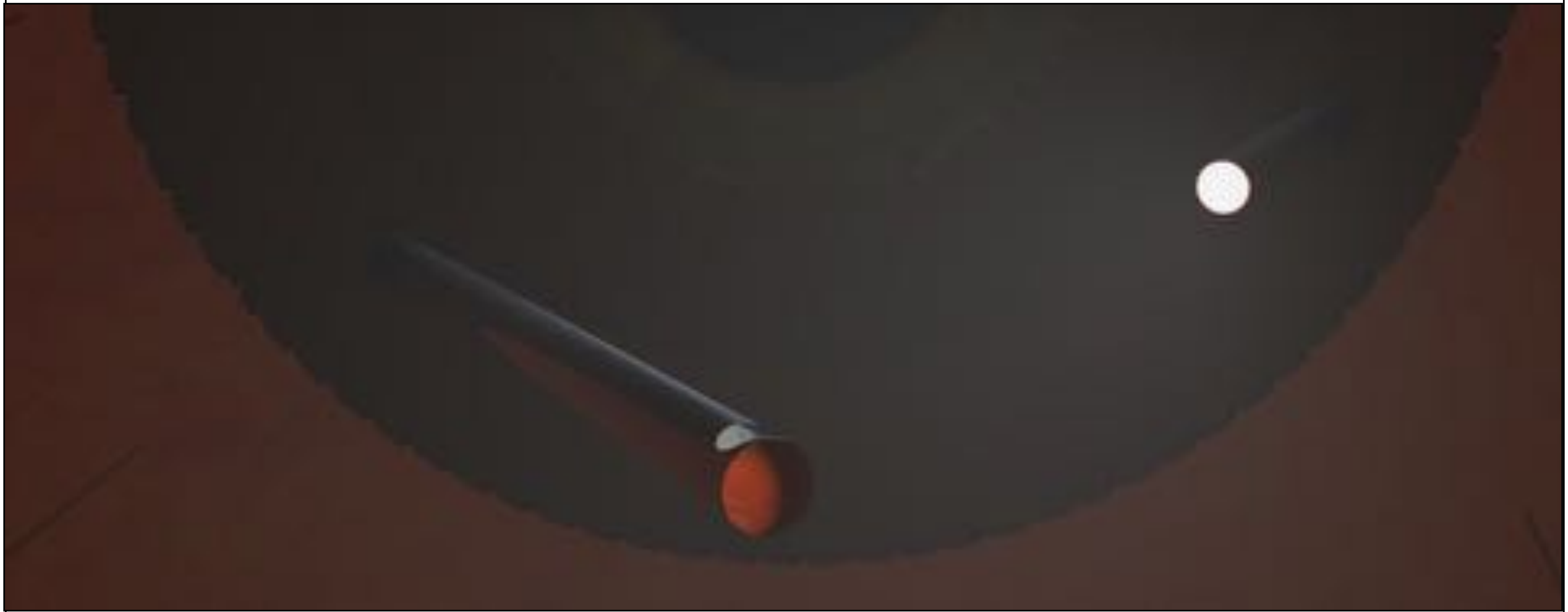
Which statement is correct:

- **A.** When using an electric cutter the duty cycle cannot be altered.
- **B.** When using a peristaltic pump the aspiration pressure is the controlled variable, with flow changing as a result.
- **C.** When using a Venturi pump the flow rate is the controlled variable, with aspiration pressure changing as a result.
- **D.** Pneumatic cutters with a single actuator line allow control over the proportion of time the cutter is open (duty cycle)

Check Answer

CHAPTER 7

Basic techniques



In this chapter some basic techniques which may be employed in a variety of situations are described.

Preparation

Thorough preparation of the patient and equipment at the start of the case increases both safety and efficiency.

Some form of local anesthesia is generally used. Children and patients who are unable to lie still may require general anesthesia. Sedation may be helpful when operating on anxious patients. It may also lead to patients becoming uncooperative and moving however.

The patient is positioned so that the eye can easily be placed in the primary position. The orbital rim should be flat - i.e. the superior and inferior orbital rims should be level. This may require some flexion or extension of the neck. As the orbital rim has a 30^0 lateral slant the neck may be slightly rotated towards the opposite side. This should be minimal to prevent fluid pooling at the inner canthus.

Figure 7.1 Positioning for vitrectomy

The neck is slightly extended and rotated to flatten the plane of the orbit.

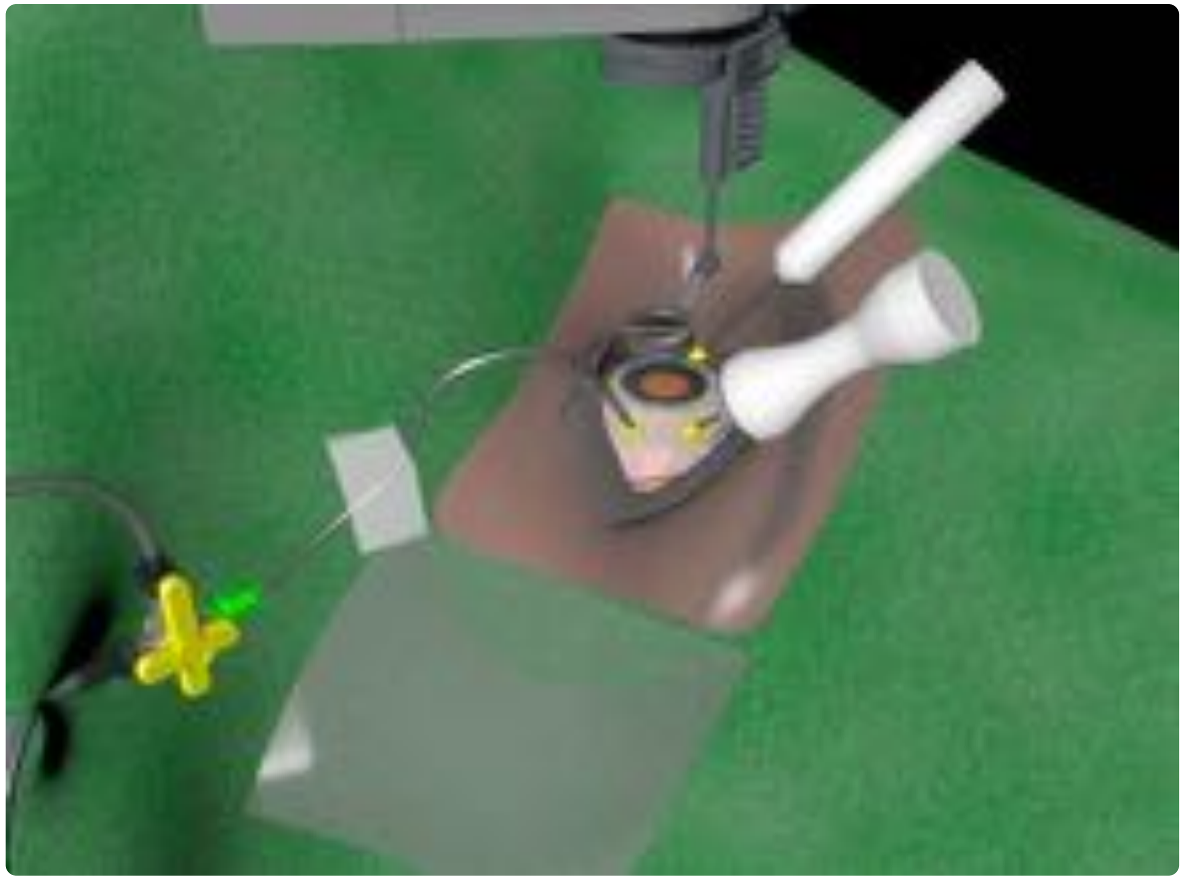
A drop if aqueous iodine is placed in the conjunctival fornix after the eye has been anesthetized. The skin around the eye is prepared by cleaning the eye with a disinfecting solution such as aqueous iodine. The skin is dried thoroughly before applying a surgical drape. These drapes have pouches to collect any infusion fluid that may spill out of the eye. The drape is orientated so that the pouch lies temporal to the eye. A horizontal slit and one or more vertical slits in the drape allow the speculum to be inserted between the lids. The eyelashes should be tucked out of the way underneath the lids along with the cut edges of the drape. The eyelashes house commensal bacteria such as Staphylococcus Epidermidis which cannot be fully eradicated with iodine and are a potential source of infection.

The microscope should be correctly set up with all necessary adjustments to the eyepieces performed before scrubbing.

The height of the operating table, the chairs and the operating microscope are adjusted so that the surgeon can easily access the vitrectomy and microscope foot pedals while looking through the microscope.

Some surgeons favor a wrist support such as the Chan wrist rest. This is a horseshoe shaped bar which is set up around the patient's head at the level of the orbital rim. Others prefer to rest their hands directly on the patient's forehead.

Figure 7.2 Errors in preparation of the patient



Correct preparation.

Entry Sites

During MIVS an entry site alignment system is used.

When performing 20-gauge vitrectomy sclerotomies are created. Many of the principles already discussed regarding the placement of trochars also apply to sclerotomies.

1. A conjunctival peritomy is performed. The surgical principles are the same as peritomy for scleral buckling but the extent somewhat smaller.
2. A suture is preplaced in the inferotemporal quadrant for the infusion. The infusion should be 3.5 mm (non phakic eye) or 4 mm (phakic eye) behind the limbus. It should be at the level of the lower border of the lateral rectus.
3. A sclerotomy is created for the infusion using the mvr blade. The blade is vertically orientated (i.e. directed towards the centre of the globe).
4. The infusion cannula is passed through the sclerotomy. Its location is checked and it is switched on.
5. Two superior sclerotomies are created at the level of the upper border of the horizontal recti.

Figure 7.3 Extent of peritomy for 20-gauge vitrectomy

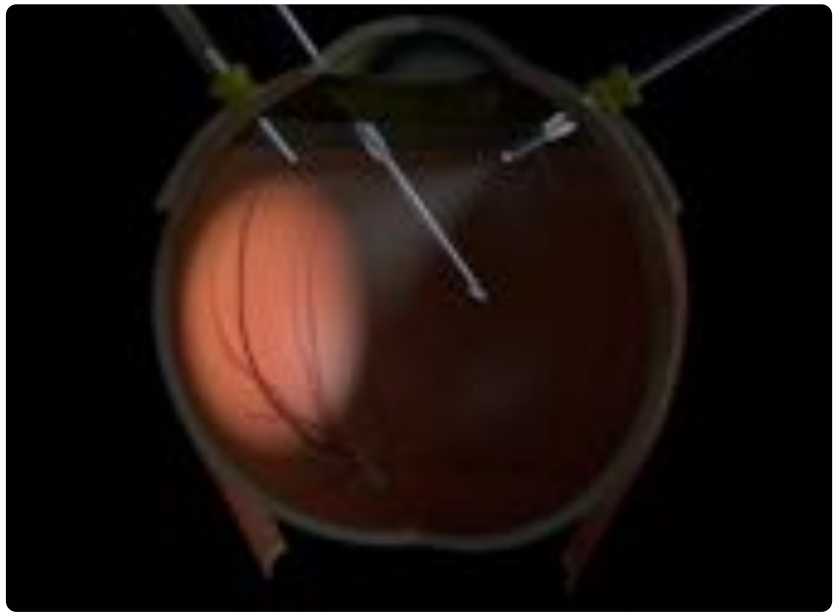
Core Vitrectomy

The viewing system is set up. If a non contact wide angle viewing system such as the BIOM is to be used a light pipe is inserted through one of the ports and the viewing system is focussed on the retina.

The cutter is then introduced into the eye and the central (core) vitreous removed. If the posterior hyaloid is detached it is easily removed along with the central vitreous. Cutting starts centrally with the eye in the primary position and progresses peripherally as the vitreous is removed. The goal of this part of the surgery is to remove the vitreous efficiently and safely without undue traction on the retina.

In order to remove vitreous safely a good view of both the cutter and the adjacent retina is required. This is achieved by orientating the light pipe towards the cutter and changing its direction so that the field of illumination follows the cutter. If the light pipe is held too close to the cutter tip the retina behind the cutter is not clearly visible.

Figure 7.4 Errors in illumination



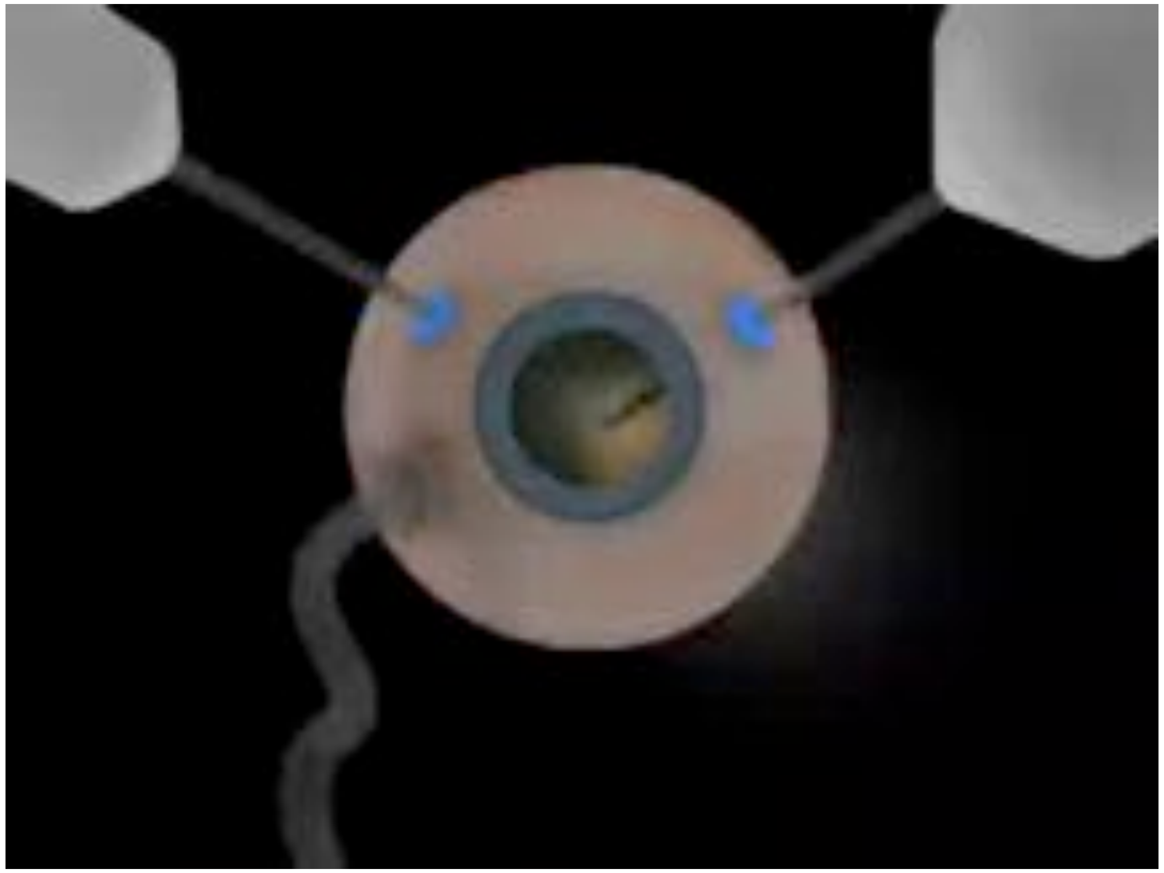
The light pipe is not following the cutter.

Wide angle contact lenses with a very wide field of view allow most of the vitrectomy to be performed with the eye in the primary position. In order to remove peripheral vitreous while using a non contact wide angle viewing system the eye has to be moved out of the primary position. This is achieved with pressure of the instruments on the ports. It can be more difficult to do this effectively with 25-gauge instruments because of instrument flexion.

Movement of the instruments without moving the eye is achieved by using a port as the fulcrum of movement.

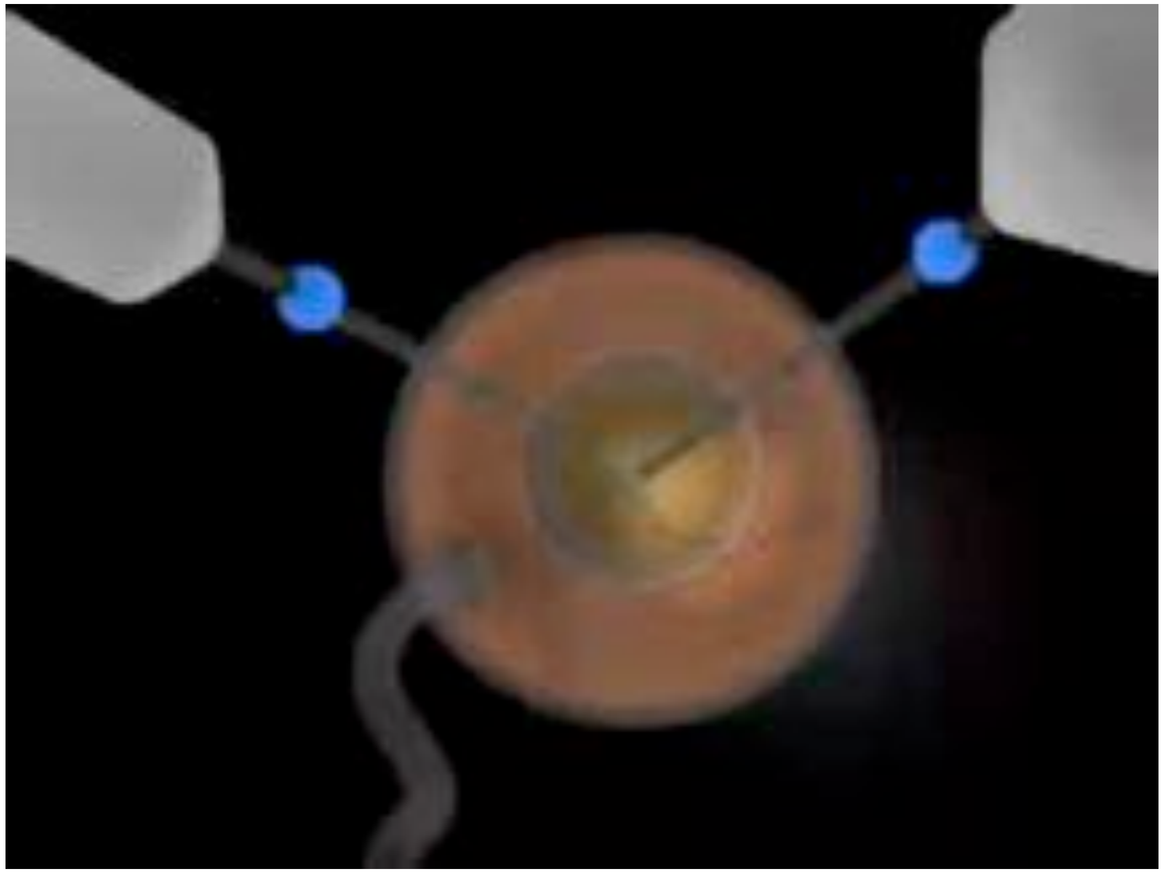
Both types of movement are used at different stages during vitrectomy, depending on whether rotation of the globe is required or not.

Movie 7.1 Movement of the instruments without moving the eye



The fulcra of movement (blue spheres) are at the instrument ports.

Movie 7.2 Rotation of the eye



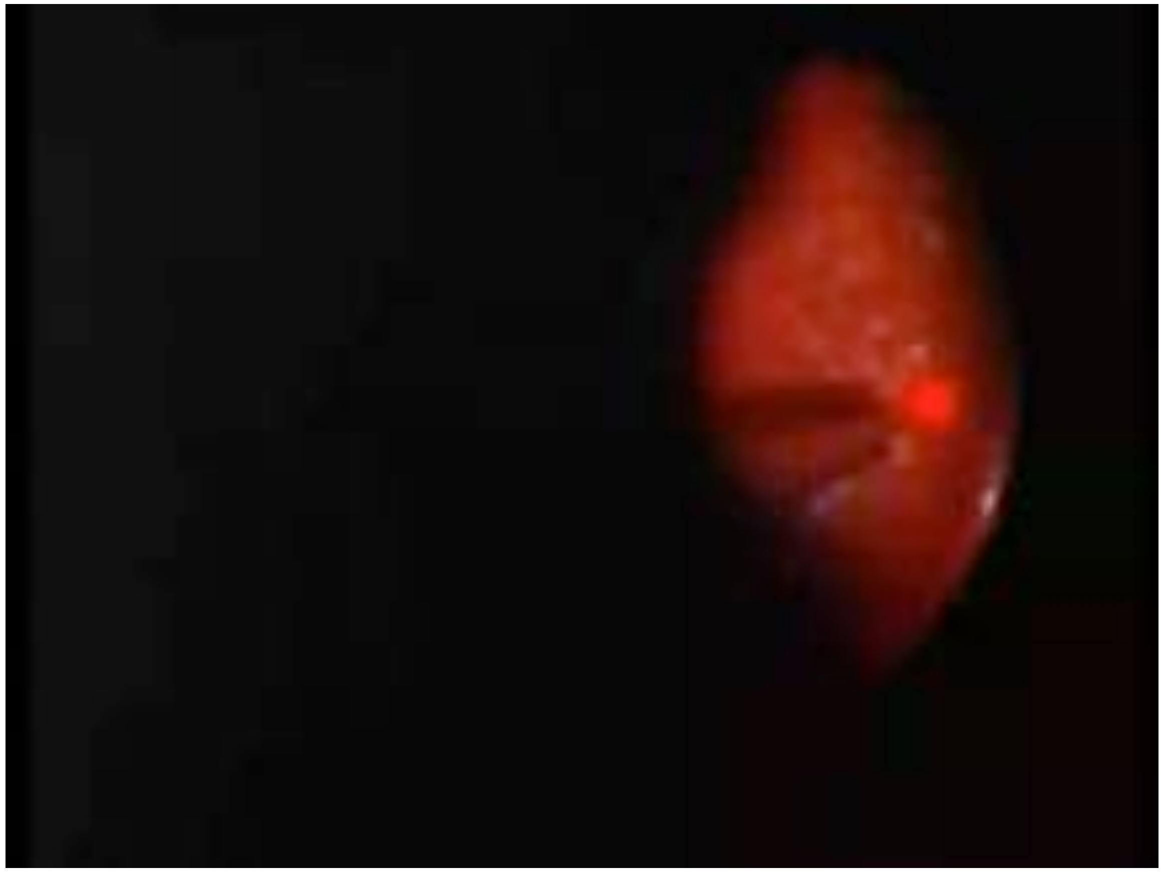
Any movement of the instruments that does not pivot at the port moves the eye.

Optimization of the view also requires correct alignment of the viewing system. If the eye, the viewing system and microscope are out of alignment vignetting (black crescents at the edge of the field of view) are seen. Movements of the eye away from the primary position should be gradual and should be accompanied by corresponding realignment of the microscope using the x/y controls on the microscope footpedal.

Figure 7.5 Poor alignment of the viewing system

The eye has been rotated but the BIOM has not been realigned.

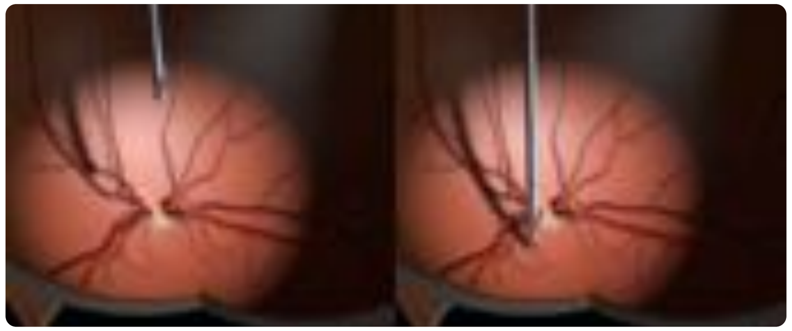
Movie 7.3 Vignetting and rapid movements



There are several errors here. The eye has been rotated in order to perform peripheral photocoagulation. The BIOM has not been realigned resulting in repeated vignetting. Additionally the movements are too quick and darting close to the retina and the laser gouges the retina (yellow arrow) as a result

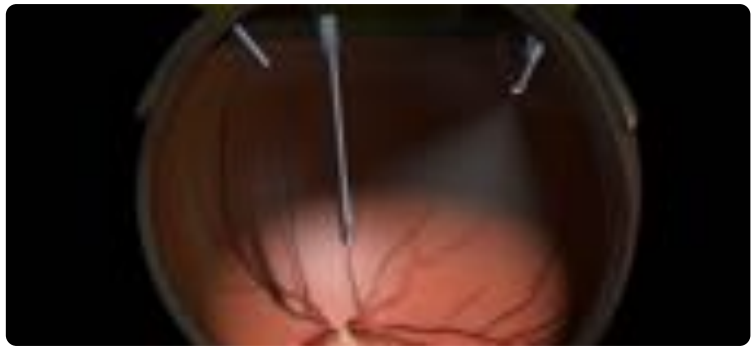
The panoramic view of the retina achieved by wide angle viewing systems comes at the cost of reduced stereopsis. Monocular clues allow orientation of the instruments within the eye.

Figure 7.7 Use of shadows to orientate instruments



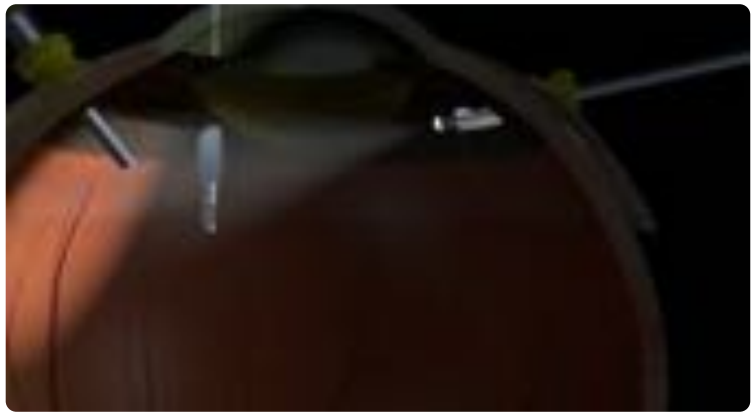
The closer an instrument is to the retina the closer its shadow is to its tip (provided the light pipe is appropriately positioned anterior to the cutter).

Figure 7.8 Position of the light pipe (1)



Even illumination of the field of view indicates that the light pipe is pointing in the correct direction.

Figure 7.6 Position of the light pipe (2)



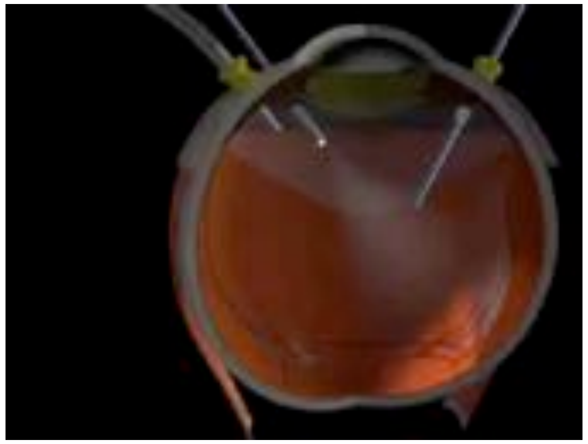
Lens flare is a warning that the light pipe is too close to the lens when focal illumination is used.

Movie 7.4 The appearance of lens flare

In order to remove vitreous safely:

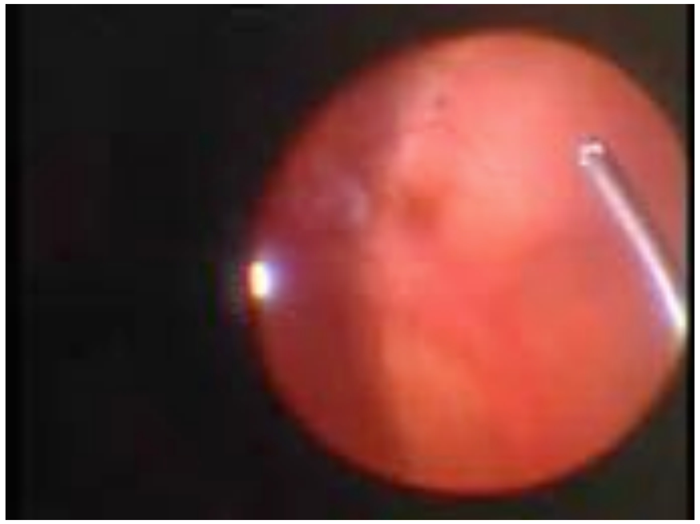
- Aspiration and infusion must be appropriately balanced to prevent hypotony as described in the preceding chapter.
- The cut rate should be very high when using the latest generation of vitrectomy machines (Constellation, Stellaris or Eva). When using older machines (such as the Accurus) the cut rate may be reduced to increase efficiency of core vitrectomy.
- Movements of the cutter should be slow and methodical working outwards from the centre of the vitreous cavity towards areas of visible vitreous. Older machines used the currents generated by high flow to move vitreous towards the cutter. Newer machines with very high cut rates generate less movement of the vitreous. The cutter is therefore moved towards the vitreous rather than vitreous being aspirated from a wide area towards the cutter. This reduces vitreous traction.

Movie 7.5 Core vitrectomy



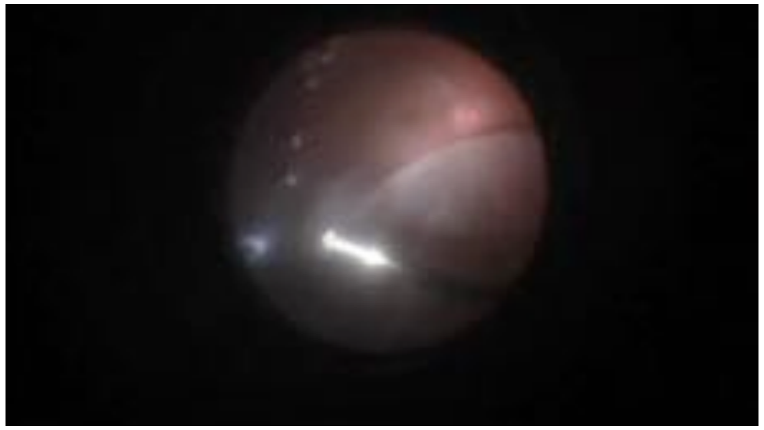
Vitrectomy working from the core outwards. The vitreous should be removed with minimal traction, as indicated by oscillation of vitreous distant from the cutter and retinal fluttering.

Movie 7.6 20-gauge vitrectomy (1998)



Note the degree of movement of the vitreous and retina.

Movie 7.7 23-gauge vitrectomy (2010)



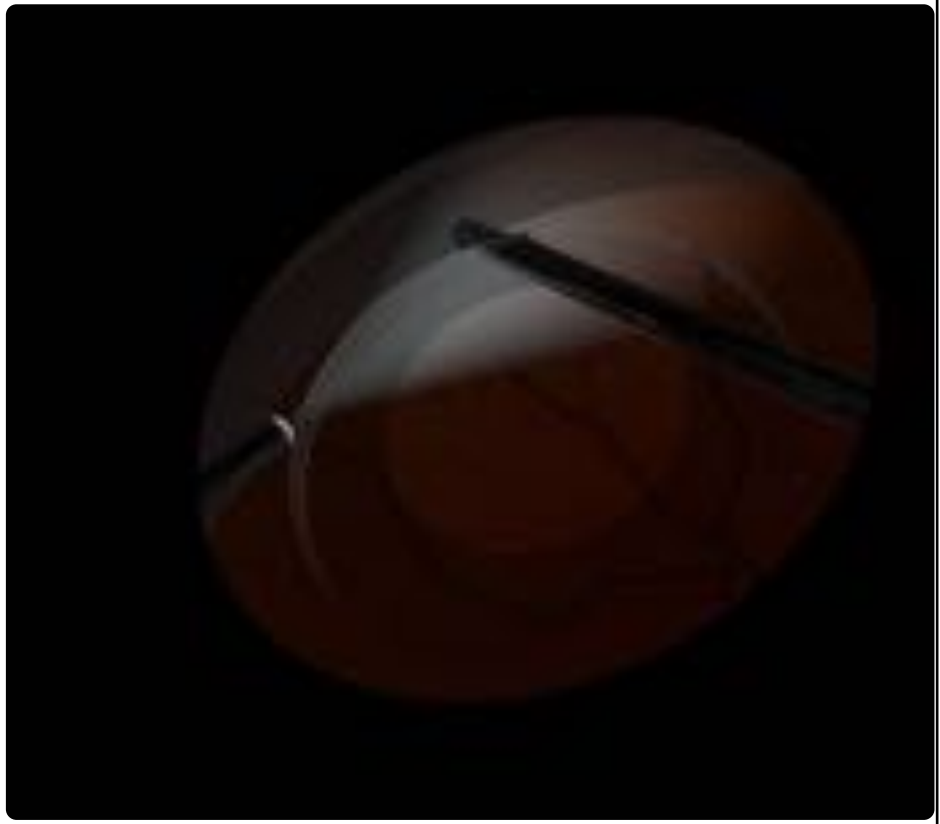
Pseudophakic retinal detachment. Note that there is much less movement of the retina and vitreous. The cut rate is much higher and the vacuum much lower.

Although vitreous is functionally translucent its visibility may be enhanced in a number of ways:

- Intravitreal injection of triamcinolone acetate
- Tangential illumination to retroilluminate or side illuminate vitreous utilizing light scatter from vitreous fibers.
- The vitreous is much easier to visualize on the side of the eye with the light pipe. In non phakic eyes the cutter can cross the midline to cut the vitreous on the opposite side. This can also be done in phakic eyes to a limited extent superiorly and inferiorly but there is a risk of lens trauma if the cutter crosses the centre of the lens.
- When using diffuse illumination (for example with the light pipe on the opposite side of the eye) vitreous is often easier to see when it is moving. The impression of movement around a cutter while it is cutting is therefore an indication that vitreous is present and is being cut.

In practice several of these techniques may be used at different stages in a single case. Although the light pipe should be directed towards the cutter it does not have to be exactly aligned with it. Continuous small movements of the light pipe, both towards and away from the cutter and radially, may help to illuminate the vitreous. A particularly common error among trainees is to cut too anteriorly, concentrating on the vitreous base while large sheets of posterior hyaloid remain posteriorly.

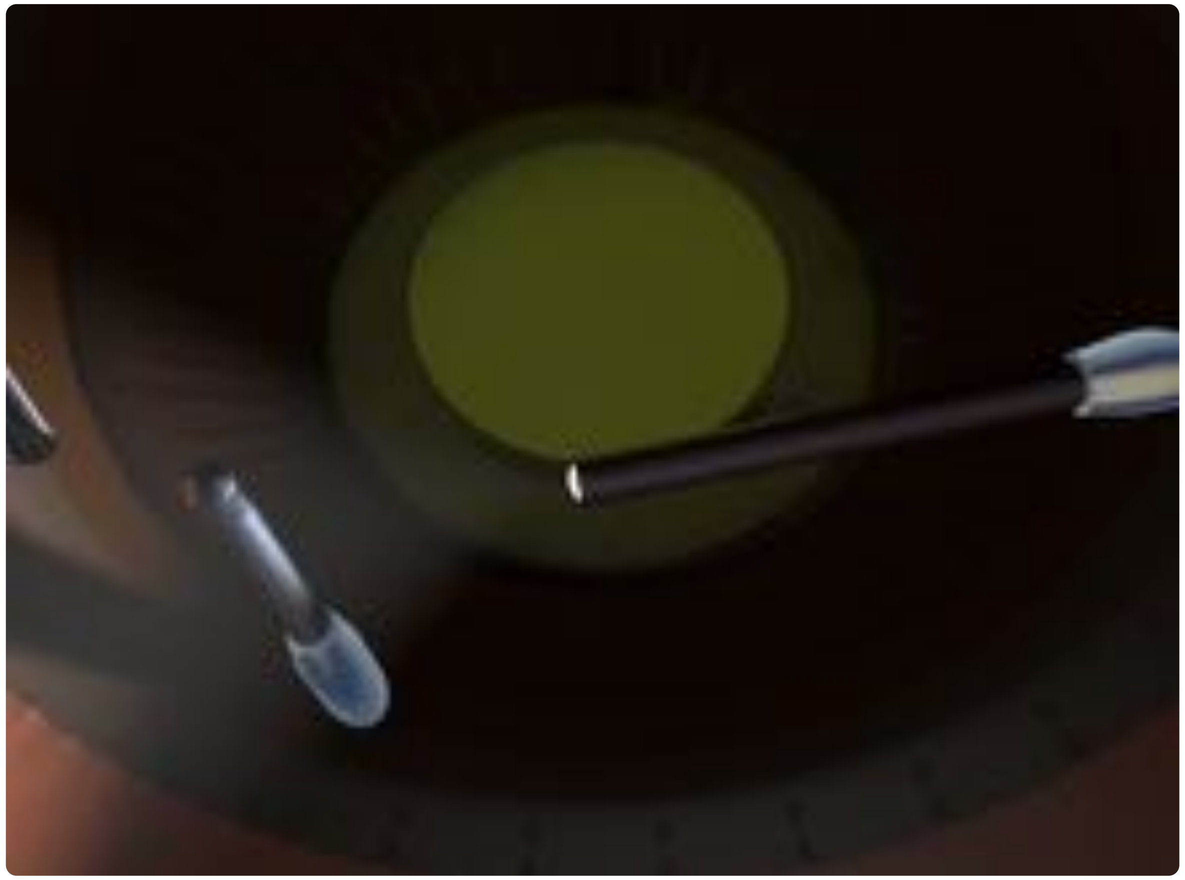
Figure 7.9 Seeing the vitreous



The vitreous is best seen on the side of the eye holding the light pipe. In a pseudophakic eye the cutter can cross the midline to cut it. Not also that the eye has been rotated to bring the peripheral vitreous into view.

In phakic eyes undergoing vitrectomy there is a risk of posterior capsular trauma if an instrument crosses the centre of the lens. The risk is particularly high when performing indented examination of the peripheral retina. The surgeon's attention is so focussed on finding peripheral retinal breaks that the light pipe touches the posterior capsule. This may be sufficient to rupture the lens capsule. Even minor indentation may cause a linear wedge in the lens which degrades the fundal view.

Figure 7.10 Lens touch



The light pipe has been moved across the posterior pole of the lens to illuminate of the peripheral vitreous better.

Movie 7.8 Lens touch

A lens capsule defect occurs as the cutter trims anterior hyaloid.

Detachment of the posterior hyaloid

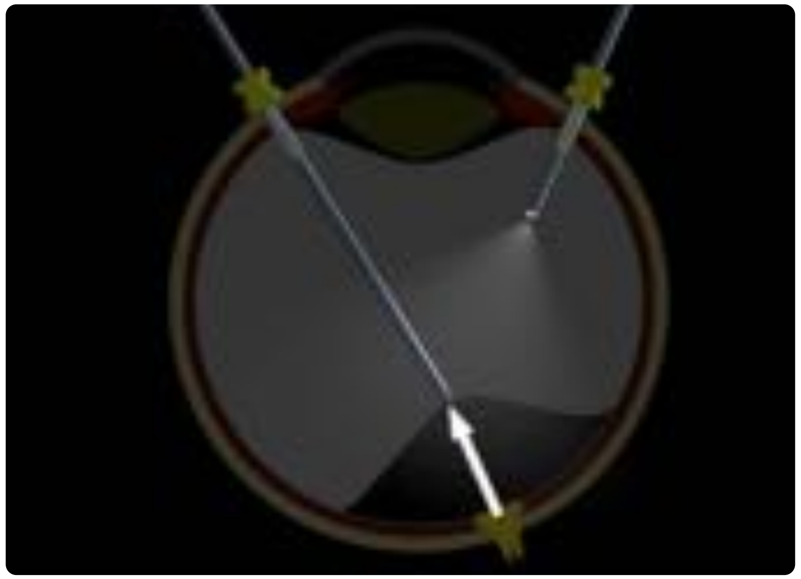
Removal of the posterior hyaloid is an important surgical goal in vitrectomy.

Initiation of detachment of the posterior hyaloid usually requires significant traction. This can only be achieved if there is occlusion of the cutter port by cortical vitreous gel. High aspiration without cutting are used initially. The fluidics are therefore analogous to the quadrant removal stage of phacoemulsification.

Aspiration without cutting engages the cortical gel in the port. When using a peristaltic pump the machine may confirm occlusion audibly. With a Venturi system cessation of infusion flow (as indicated by drops in the drip chamber) is seen despite high aspiration pressure.

When initiating posterior vitreous detachment non tangential movements of the cutter may be useful as it is possible to encounter an area with thicker vitreous cortex in this way. Once the hyaloid starts to separate the cutter is moved anteriorly to strip the hyaloid from the retina. The axis of movement remains axial (i.e. perpendicular to the disc) at this stage to prevent rapid progression of the detachment to the vitreous base as this increases the probability of retinal tears.

Figure 7.11 The axis of movement when detaching the posterior hyaloid



Axial movement of the cutter (i.e perpendicular to the disc) achieves predictable and symmetric detachment of the hyaloid face.

VISUALIZING POSTERIOR VITREOUS DETACHMENT

Progressive detachment of the posterior hyaloid membrane manifests as an expanding dark ring due to altered specular reflections resulting from focal annular tractional elevation of the retina. This is best seen by using focal illumination from a light pipe rather than diffuse chandelier illumination. The ring is only visible while traction is maintained. Stripping of the hyaloid by aspiration alone is usually stopped once this ring extends past the vascular arcades. At this point conversion to combined cutting and aspiration is sufficient to overcome the weaker mid peripheral vitreoretinal adhesions. No attempt should be made to strip the hyaloid anteriorly using aspiration alone.

Movie 7.9 Signs of posterior hyaloid detachment

The expanding dark ring (yellow arrow) indicates the extent of the posterior vitreous detachment.

PROBLEMS DURING INDUCTION OF POSTERIOR VITREOUS DETACHMENT

The vitreoretinal adhesions may be very strong in younger patients. In addition to the layer of cortical vitreous overlying the posterior hyaloid may be too thin to occlude the port because of its location on the side of the cutter. An aspiration line with an opening on its end achieves occlusion more effectively. A silicone tipped cannula is particularly useful as it can be placed very close to the optic nerve and retina. Deformation of the silicone cannula with small sideways movements (the 'fish strike sign') confirms that the tip is occluded.

The vitreous may be stained with triamcinolone. This makes it easier to appreciate the presence and extent of hyaloid detachment.

Very rarely these maneuvers are unsuccessful. Hyaloid detachment can then be initiated using a diamond dusted silicone tip cannula. In exceptionally adherent cases a bent needle or pick attached to an infusion line may be used. Once hyaloid detachment has been initiated it can easily to be propagated using the cutter.

Movie 7.10 Triamcinolone and silicone tip cannula in the induction of posterior vitreous detachment

Note the deformation of the tip of the silicone cannula - the fish strike sign.

Figure 7.12 Difficulty achieving occlusion

If the layer of cortical vitreous is very thin occlusion in the side opening port of a cutter may be difficult. A soft tip cannula has an end opening port and may be easier to occlude.

DETACHING THE POSTERIOR HYALOID IN THE PRESENCE OF RETINAL DETACHMENT

Detachment of the posterior hyaloid in eyes with mobile retina is difficult and frequently impossible. For this reason scleral buckling surgery is generally preferable for repair of these cases.

There are situations however in which a vitrectomy has to be performed. A typical example is an eye with severe trauma, lens capsule rupture and retinal dialysis.

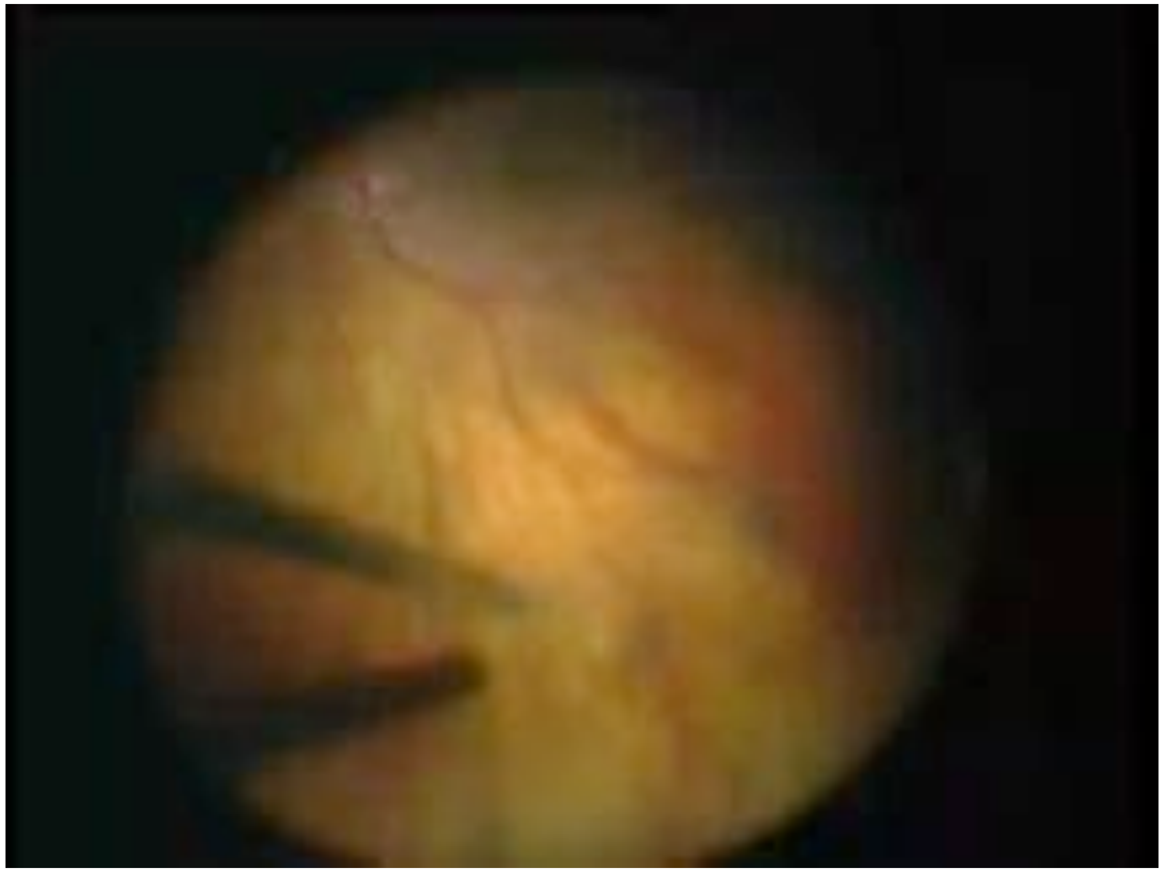
If the retina is only partially detached the hyaloid is initially detached over an area of attached retina. Once the hyaloid is detached here the hyaloid may be gently peeled off the detached retina.

Movie 7.11 Detaching the posterior hyaloid in the presence of retinal detachment

After a nearly disastrous attempt to initiate detachment of the hyaloid from detached retina the PVD is successfully initiated over attached retina and subsequently detached from the retina.

However it is achieved posterior hyaloid separation carries a very significant risk of iatrogenic retinal breaks. These may involve any part of the peripheral retina. A particularly thorough examination of the entire peripheral retina is therefore performed whenever the hyaloid is detached.

Movie 7.12 Tear during induction of posterior vitreous detachment



Shaving the vitreous base.

Complete removal of the vitreous base is impossible because of the strong vitreoretinal adhesions in this area.

Reducing the volume of the vitreous base is desirable in a number of situations:

- In cases of vitreous hemorrhage residual blood trapped in the vitreous base is a reservoir for post vitrectomy vitreous cavity hemorrhage.
- In cases with anterior PVR membranes in and around the vitreous base are removed, either en bloc (during retinectomy) or by vitreous base dissection.
- Reducing the volume of the vitreous base increases the size of intraocular gas bubble that can achieved.
- Some surgeons believe that reducing the volume of the vitreous base reduces the incidence of postoperative anterior PVR following vitrectomy for retinal detachment repair.

There are a number of potential risks including lens touch and retinal breaks. The degree of vitreous base shaving that is carried out in any individual case requires a judgement of the balance of these risks against the benefits of shaving. For example in a phakic eye undergoing surgery for a simple idiopathic epiretinal membrane minimal shaving is required. In more complex cases as much as possible of the vitreous base should be removed.

A degree of indentation is usually required to trim the vitreous base. There a several ways of doing this. The indentation may be performed by an assistant with a squint hook. Use of a chandelier or transscleral illumination allows the surgeon to perform bimanual indentation.

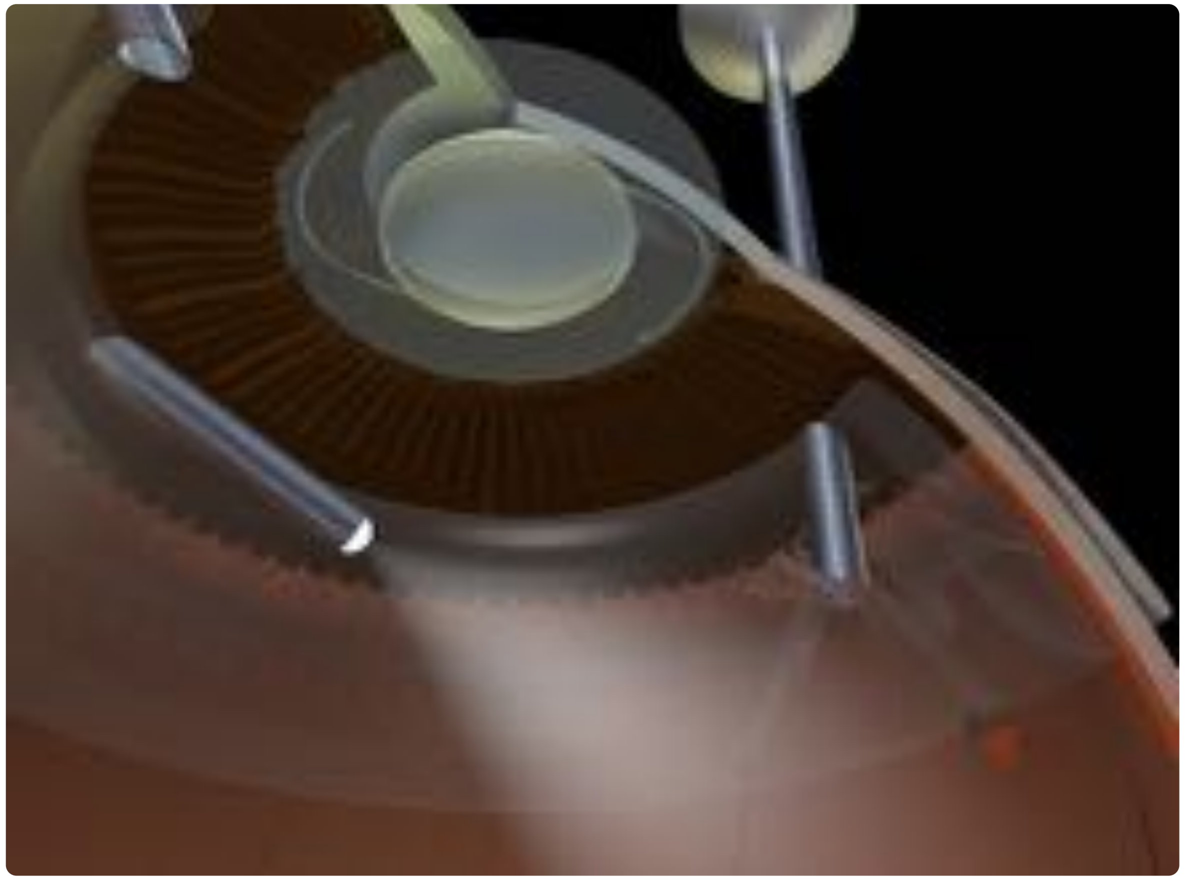
Internal search

At the end of every vitrectomy the retina should be examined for the presence of iatrogenic retinal breaks. Any breaks should be treated. If, as is usually the case, they are small and anterior cryotherapy is easier to perform than laser retinopexy.

IATROGENIC BREAKS DUE TO VITREOUS INCARCERATION

In eyes with a preexisting vitreous detachment breaks occur as a result of vitreous traction by instruments passed through the sclerotomy. They tend to be close to the sclerotomies and are sometimes call entry site breaks. The search for iatrogenic breaks is therefore focussed on the retina around the sclerotomy. The incidence of these breaks has decreased with the use of MIVS systems.

Figure 7.13 Entry site break

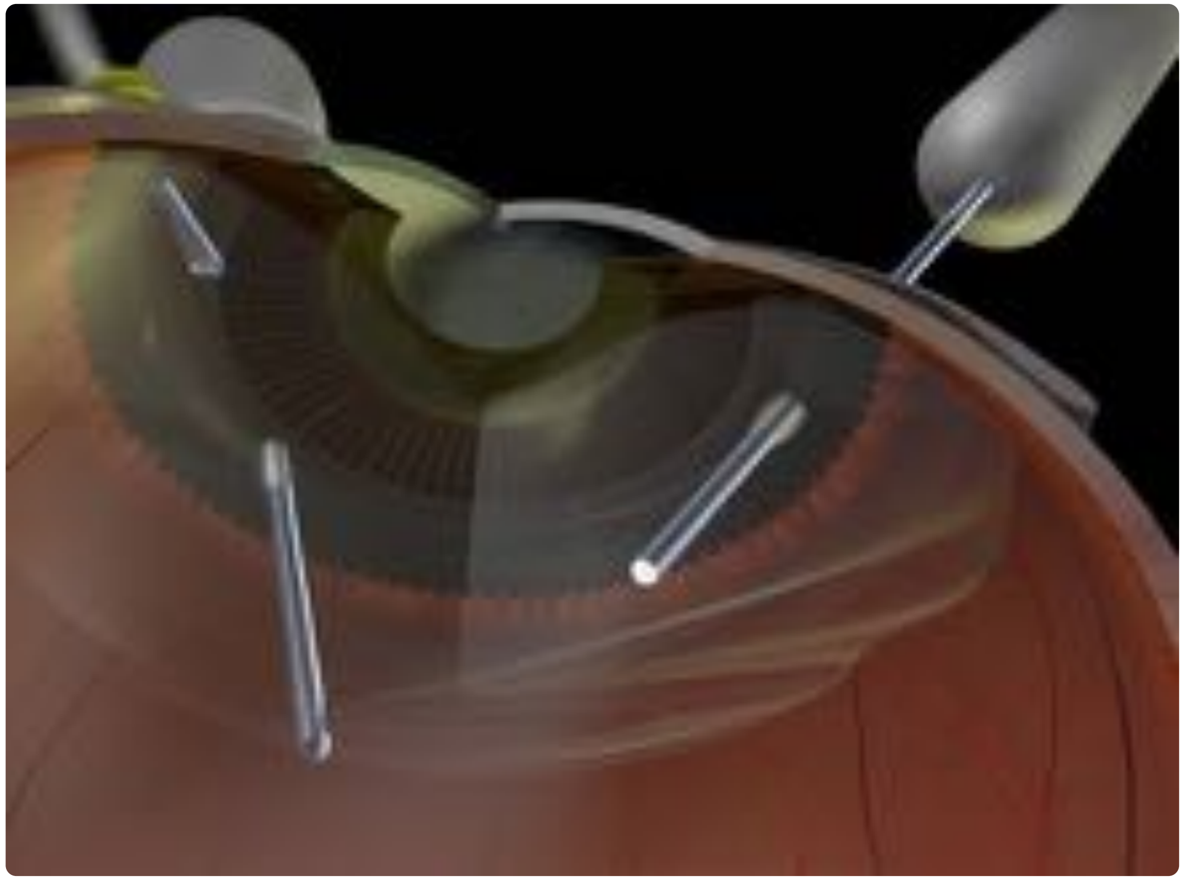


These are particularly common in 20-gauge vitrectomy when irregular instruments such as this delamination scissors are introduced or withdrawn.

IATROGENIC BREAKS DUE TO POSTERIOR VITREOUS DETACHMENT

When there is no preexisting vitreous detachment breaks may be created at the posterior border of the vitreous base in any meridian and a 360^0 search is therefore needed. Because of the traction exerted in their creation these breaks frequently have associated subretinal fluid which is often the first indicator of their presence.

Figure 7.14 Tear during posterior vitreous detachment



These may occur, as in this case, even during minimally invasive vitrectomy. They may be distant from the sclerotomies so a 360^0 search is required to exclude them.

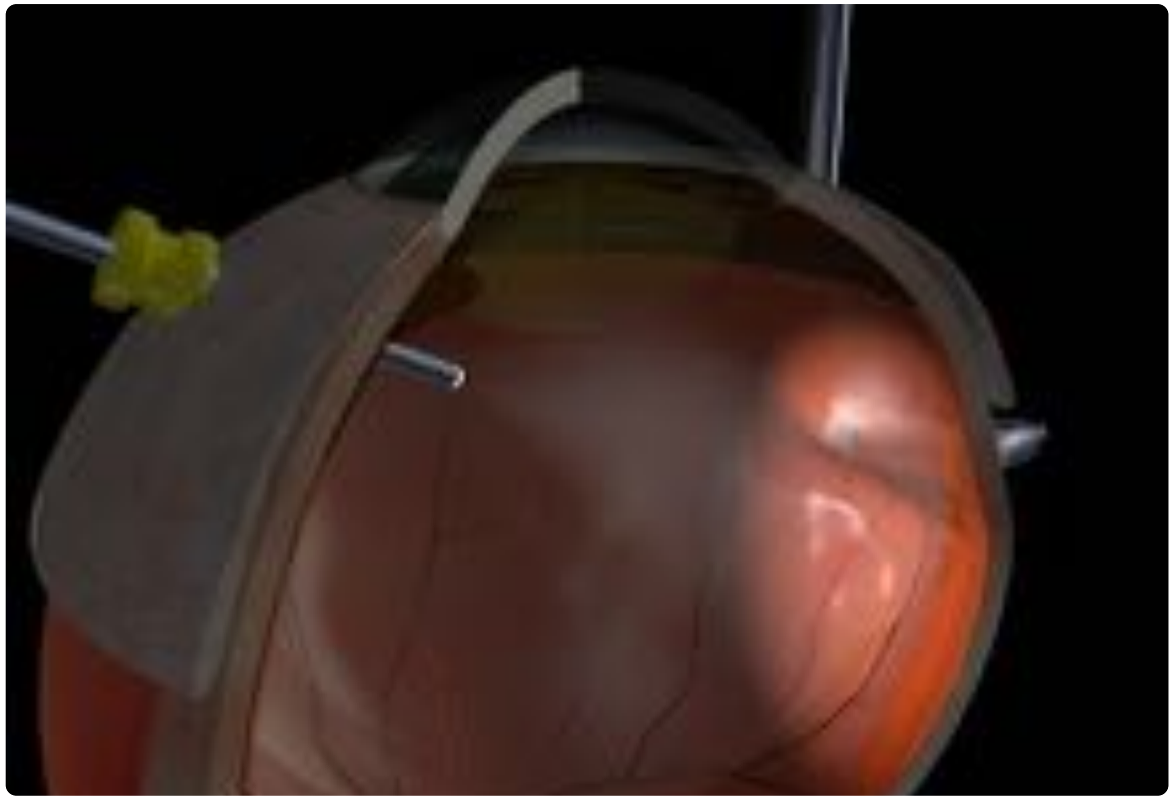
PERFORMING AN INTERNAL SEARCH

The intraocular pressure is lowered and a squint hook used to indent the peripheral retina. Fluid from the vitreous cavity refluxes up the infusion line. The aim is to indent in the zone of the posterior border of the vitreous base. This causes the opercula of small tractional tears to stand up against the profile of the indent.

Movie 7.13 Internal search

Note that the break is at the posterior border of the vitreous base, which can be seen around the operculum. Not also that the operculum stands up on indentation.

Figure 7.15 Indented internal search



Indentation at the level of the posterior border of the vitreous base causes the operculum of the tear to stand up.

Air and gas exchange

A two stage technique is used to fill the eye with gas: the saline is exchanged for air which is subsequently exchanged for gas.

Air exchange may also be performed routinely, even in cases when no tamponade of the retina is required. This has a number of advantages:

- The incidence of post operative endophthalmitis may be reduced.
- It is very easy to see when a sclerotomy is leaking as bubbles are seen under the conjunctiva.

Air is injected through the infusion line and vitreous cavity fluid aspirated actively or passively. Active aspiration is much more efficient than passive aspiration in MIVS surgery.

Because of its buoyancy the air fills the vitreous cavity from the top downwards. The eye is in the primary position unless the gas exchange is combined with internal drainage of subretinal fluid. The tip of the aspiration cannula remains below the meniscus and has to be very close to the optic nerve to complete the air exchange. Altered specular reflections from the disc indicate that the exchange is complete. Use of a silicone tipped cannula reduces the risk of injury to the disc or retina.

The view may be lost transiently during air exchange:

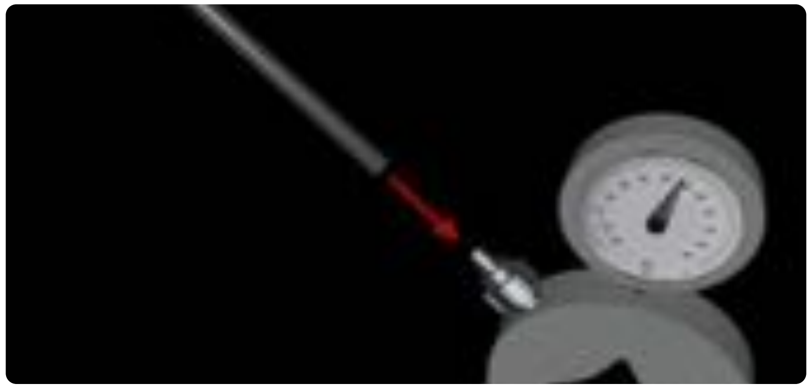
- Gas behind the convex back surface of the lens increases its focal power. This can be compensated by refocussing the viewing system or exchanging a planoconcave lens for a biconcave (‘Landers’) contact lens.
- Vitreous covering the tip of the infusion cannula may cause the air to enter the eye as a stream of bubbles. These quickly coalesce as air fills the eye and the view returns.
- Pseudophakic eyes with posterior capsulotomies develop condensation on the intraocular lens. This can be wiped off with an instrument or blown off by directing the jet of air from the infusion anteriorly but quickly recurs. A thin layer of methylcellulose applied to the posterior surface of the implant prevents this.
- Bright reflections of the light pipe from the fluid meniscus may dazzle the surgeon. Slight reorientation of the light pipe reduces these.

Exchange of air for gas is carried out at the end of the case immediately before removal of the cannulas. The gas should be drawn up into a 50ml syringe which is then injected into the vitreous cavity to give a precise gas concentration. Injection of a small volume of pure gas into an air filled eye to achieve a diluted gas mixture is unsafe because the volume of the air in the vitreous cavity cannot be determined with sufficient accuracy.

The intraocular pressure during gas exchange is under the total control of the surgeon. Very great care is taken to prevent hypotony at this stage at this may cause severe intraocular hemorrhage.

Errors in determining the correct gas concentration may lead to under or overfills in the postoperative period. The concentration of gas drawn up can be checked by holding the syringe up to a light. A faint ring is seen on the inside of the syringe which corresponds to the point to which the syringe plunger had been advanced when purging excessive pure gas. This can be used to re-check the concentration.

Figure 7.17 Drawing up and injecting gas



A sterile flexible silicone cannula is attached to the gas cylinder.

Figure 7.16 Checking gas dilution

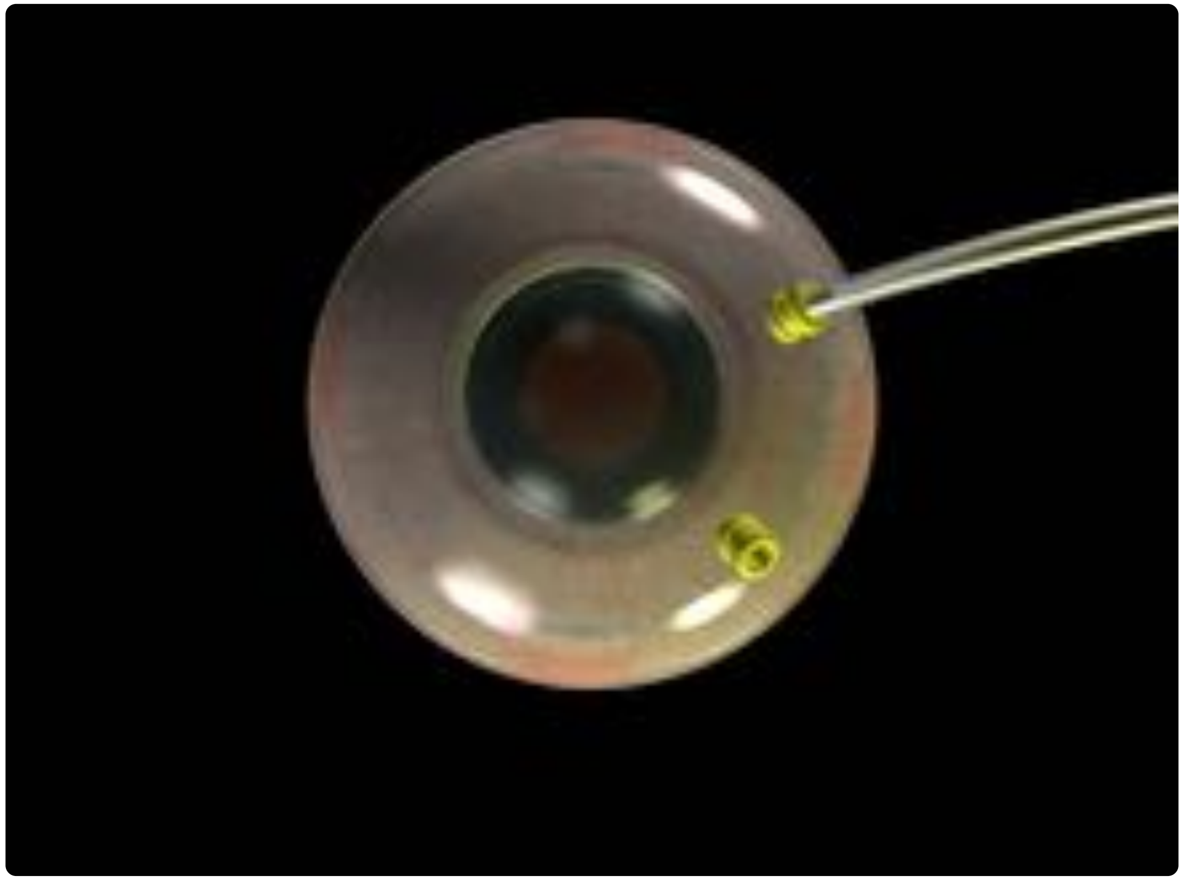
The vapor ring is at 9.5 ml, confirming that 20% gas will be injected (allowing for the 0.5 ml gas in the filter).

Closure

The cannulas removed from the eye as illustrated. Use of the light pipe as a guide may reduce the likelihood of a vitreous wick at the sclerotomy site.

Leakage may be seen if a 23-gauge vitrectomy is performed. It is less commonly seen with 25-gauge vitrectomy.

Figure 7.18 Removing a cannula



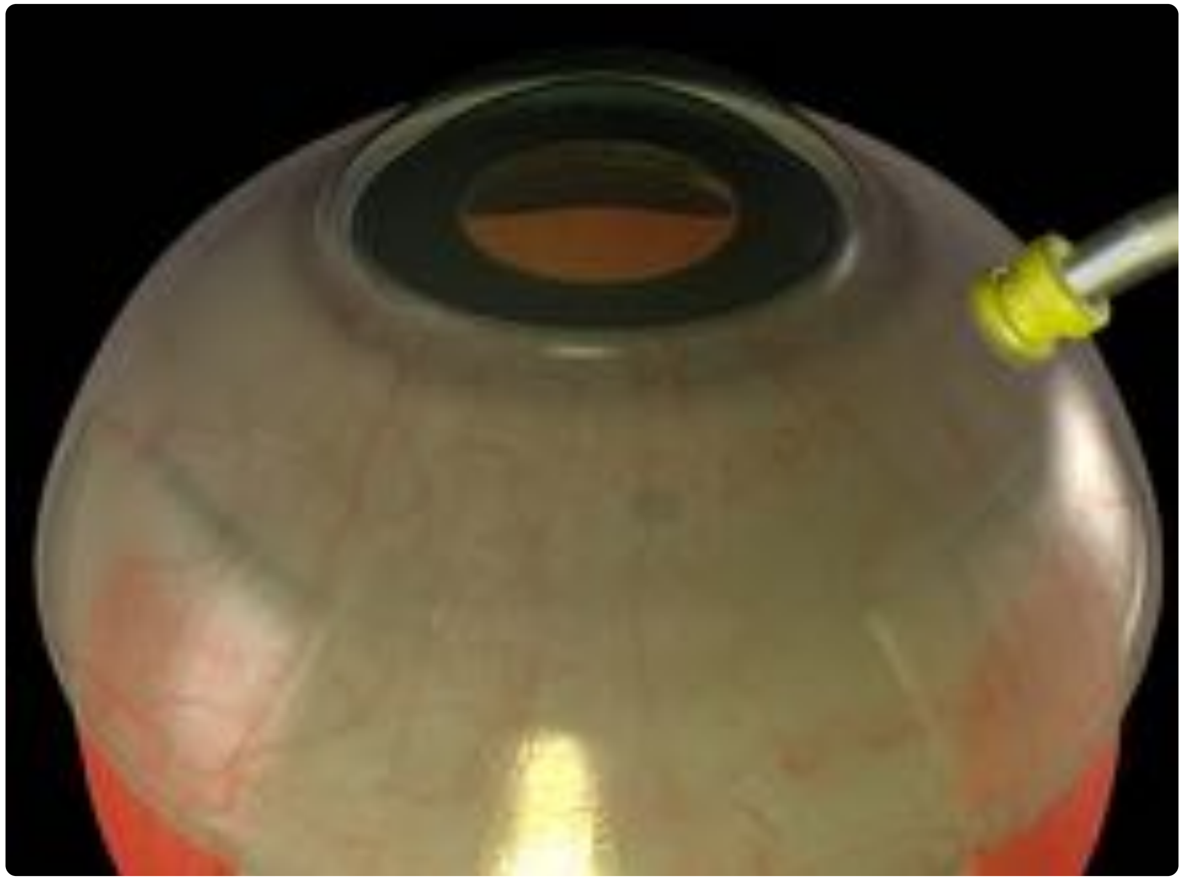
The nasal cannula has already been removed.

When the cannula is initially removed the sclerotomy gapes slightly. Over the course of 1-2 minutes the deformation of scleral tissue induced by the cannula resolves. This is accompanied by a visible change in the appearance of the sclerotomy from a gaping hole to a dark slit. At this point the incision has valved self sealing properties and leakage stops. This may be accelerated by gentle pressure or massage of top of the scleral tunnel.

Persistent leakage may be managed using a single 8/8 vicryl suture to the sclerotomy site. The threshold for placing a suture should be particularly low when the eye is filled with silicone oil.

Finally a broad spectrum antibiotic such as cefuroxime is administered subconjunctivally. The injection site should be as far as possible from the sclerotomy sites if, for any reason, an aminoglycoside antibiotic such as gentamicin is administered.

Figure 7.19 Sealing of a 23-gauge sclerotomy.

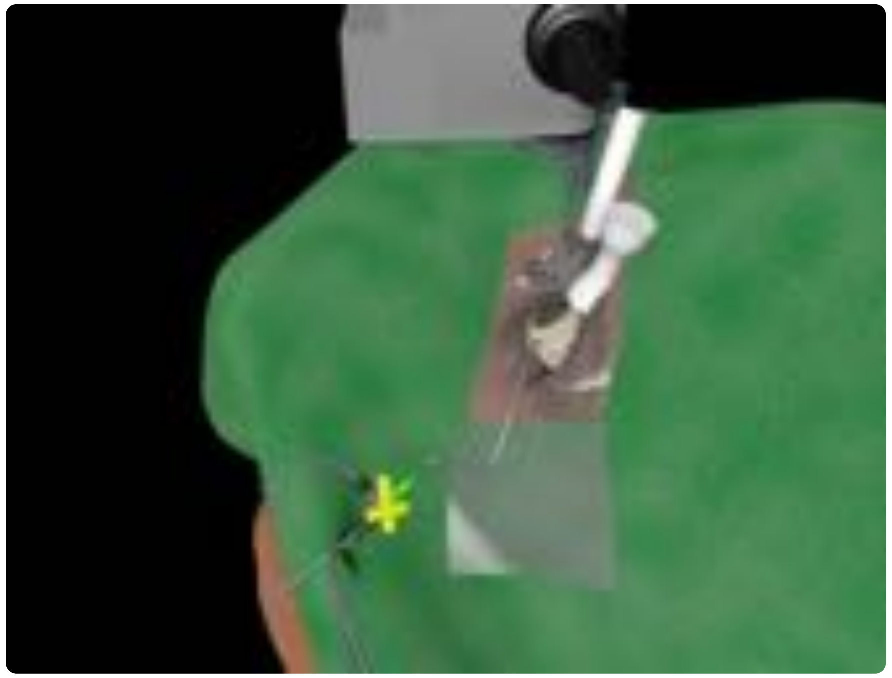


The wound gapes initially.

Twenty gauge sclerotomies are closed with 7/0 absorbable sutures. The suture that secures the infusion line may be tied using a bow which can be undone at the end of the case to release the infusion and retied to close the sclerotomy.

Knowledge review

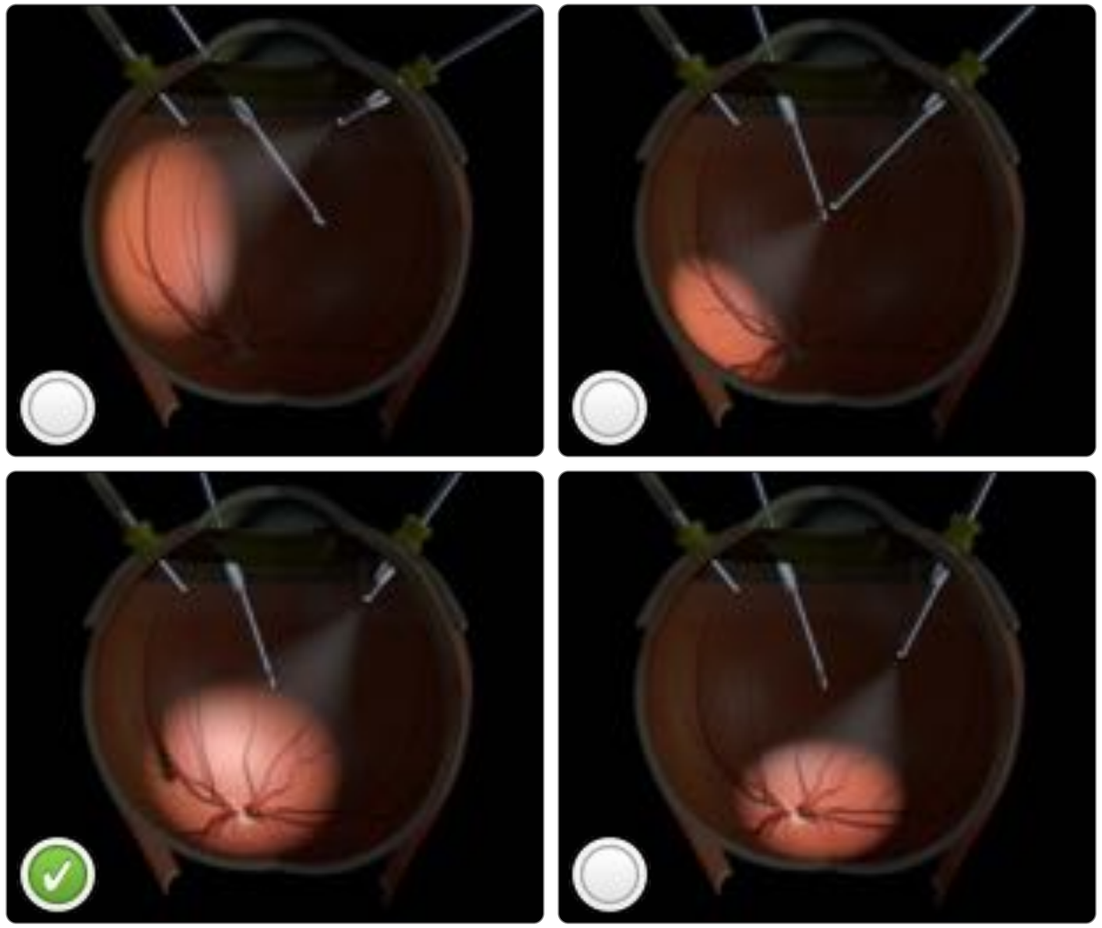
Figure 7.20 Errors in preparation of the patient



The surgeon has just started the vitrectomy. How many errors are there in the preparation of this patient?

Review 7.1 Light pipe orientation

Which position of the light pipe will give the best view of the vitreous being cut and the retina behind it?



Check Answer

Review 7.2 Vitrectomy

Question 1 of 3

Which statement is correct?

- **A.** Detachment of the posterior hyaloid is performed at the end of the case.
- **B.** Moving an instrument by pivoting at a sclerotomy causes the eye to rotate.
- **C.** Poor alignment of the viewing system causes dark arcs at the edge of the field of view(vignetting)

Check Answer

Review 7.3 Internal search

When performing an internal search

- **A.** The infusion pressure should be raised to prevent hemorrhage.
- **B.** The tip of the infusion line should be clear of vitreous.
- **C.** The infusion line stopcock should be switched off.
- **D.** Attention is focusses on the posterior border of the vitreous base.
- **E.** A and C only.
- **F.** B and D only.

Check Answer

Review 7.4 Checking the gas

You are finishing a PVR case and ask for some 14% C_3F_8. It is drawn up into a 50 ml syringe through a gas filter that that holds 0.5 ml gas. You decide to check the gas concentration by holding it up to the light to see where the plunger was advanced to by the position of the vapor line on the inside of the syringe. Which of these is consistent with the gas having been drawn up correctly?

Check Answer

CHAPTER 8

Vitrectomy for retinal detachment

An internal approach is increasingly used for primary retinal detachment repair.

Indications

There is little high level evidence on the optimum technique for repair of uncomplicated retinal detachments. The SPR study was a multicenter clinical trial which randomized patients with medium complexity detachments to scleral buckling or primary vitrectomy. The study found a higher success rate with vitrectomy in pseudophakic patients. The success rate among phakic patients was equivalent in the two groups. The authors concluded that scleral buckling should be performed to avoid the need for subsequent cataract surgery. Several other trials have been carried out with similar results. Despite this there is a trend towards use an internal approach in an increasing proportion of cases. Currently in the USA approximately 75% of retinal detachments undergo vitrectomy, 15% scleral buckling and 10% pneumatic vitrectomy. Several factors may be responsible for this:

- While there have been no major refinements in scleral buckling techniques in the past 30 years the techniques for vitrectomy are improving rapidly. For example the introduction of MIVS with valved cannulas has reduced the incidence of entry site breaks since the SPR study was carried out.
- Increasing use of ambulatory care in retinal detachment. Meticulous preoperative assessment is less important when performing a vitrectomy than when performing a conventional retinal detachment repair.
- Improved phacoemulsification techniques, such that post vitrectomy cataract is less of a concern than it used to be.
- A change in the skill set of the new generation of retina specialists. They are extremely comfortable, from residency experience with phacoemulsification, performing bimanual bipedal intraocular surgery. Some are less familiar with the skills required for scleral buckling, especially in complex cases.

Many surgeons' practice is to perform vitrectomy in all cases with PVD and tractional tears while scleral buckling is used in eyes with non-PVD related breaks (retinal dialysis and atrophic retinal holes).

Surgical techniques

Cannulas are placed and core vitrectomy is carried out. Particular care must be taken when placing the infusion in bullous detachments to ensure that the tip of the infusion cannula is not in the subretinal space.

Movie 8.1 Subretinal infusion in a bullous retinal detachment

The detachment becomes rapidly more bullous when cutting aspiration is initiated. Attempts to reduce the height of the detachment by cutting over the break are ineffective. The infusion is then rechecked and found to be in the subretinal space.

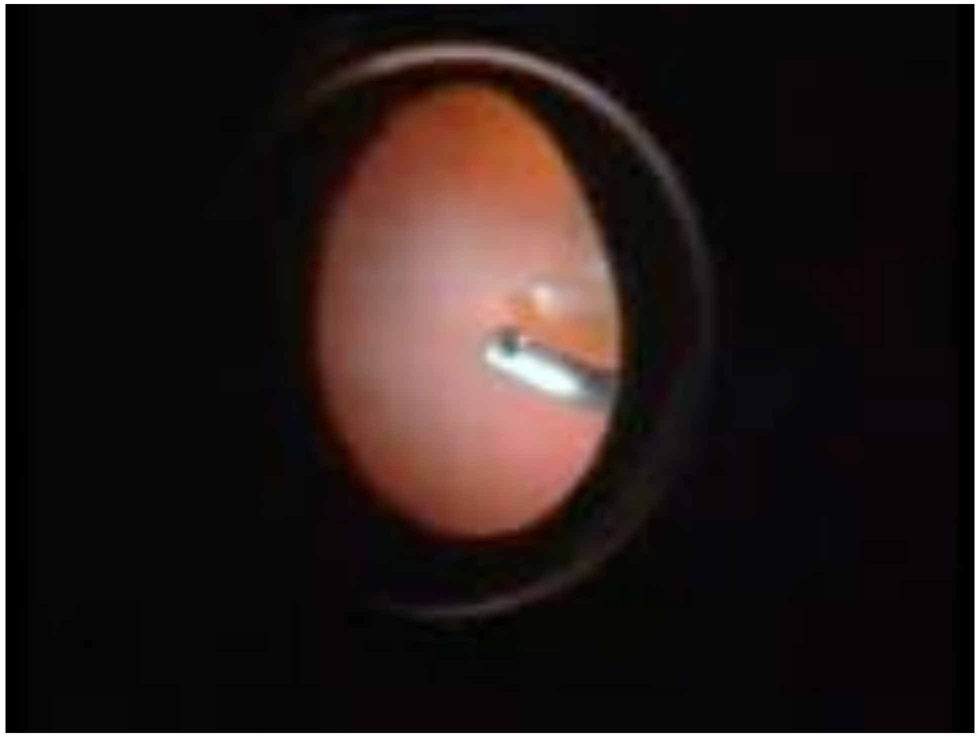
Movie 8.2 Management of subretinal infusion in 23G vitrectomy

The infusion cannula is first re-sited is one of the other hubs to maintain the intraocular pressure. A new entry site is created inferonasally which is used for the rest of the case.

INADVERTENT RETINOTOMY

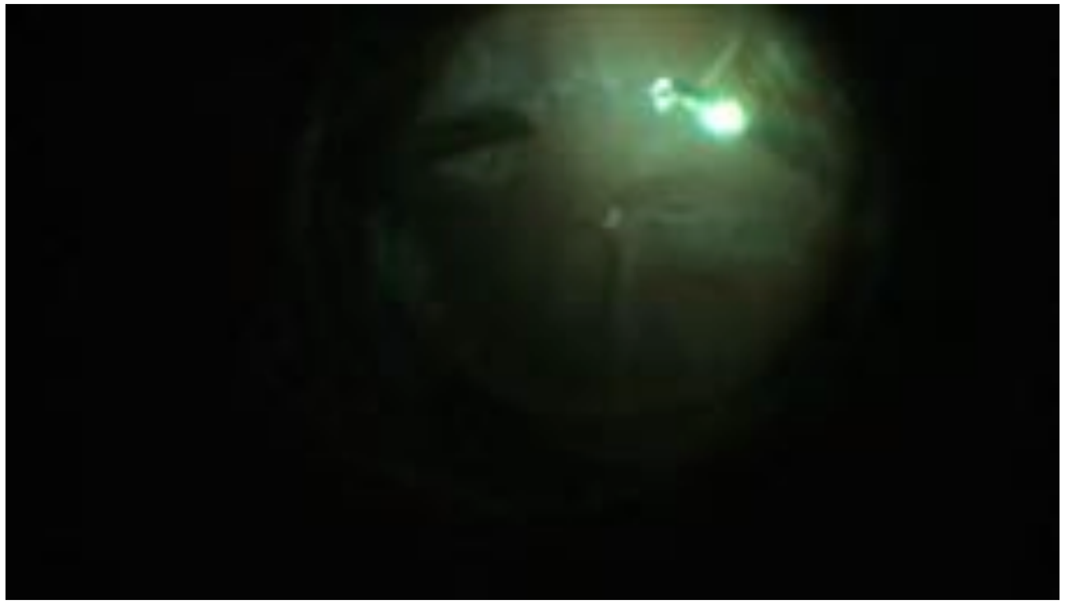
When performing vitrectomy in the presence of a mobile retinal detachment there is a risk of inadvertent retinotomy. Reducing the height of the detachment by cutting aspiration over a break reduces the height and mobility of the retina. Traditional teaching has been to face the cutter port away from the retina. This does not always allow adequate shaving of the posterior hyaloid around the vitreous base. Furthermore it is not always effective in preventing iatrogenic breaks. Careful control of the cutter settings with the footswitch is the key to safely trimming vitreous over mobile retina. Quite low levels of aspiration combined with very high cut rates are used. Some modern vitrectomy machines may be configured to perform this more safely by having the port open for only a short period of time (closed biased duty cycle). Some surgeons advocate routine use of perfluorocarbon to fixate mobile retina. Many others regard routine use of perfluorocarbon as unnecessary. There are however several situations in which is extremely helpful.

Movie 8.3 Reducing the height of the detachment



Cutting aspiration over a break reduces the height and mobility of the retina.

Movie 8.4 Inadvertent retinotomy



The retina may move very quickly when the cutter port is occluded by vitreous if inappropriate aspiration is used. Note that the cutter port is facing away from the retina when this occurs.

VITREOUS INCARCERATION

Vitrectomy for retinal detachments may cause vitreous incarceration in sclerotomies. This may in turn lead to peroperative incarceration of retina and retinal breaks. This was a major problem when using 20-gauge vitrectomy in cases of bullous detachment. Use of MIVS with valved cannulas is highly effective in preventing this.

Strategies for prevention of vitreous incarceration during 20-gauge surgery include:

- Minimizing the number of instrument changes.
- Turning the infusion off between instrument changes.
- Minimizing axial (i.e. in and out) movements of the instruments to prevent vitreous being drawn into the sclerotomy.
- Reducing the height of the retinal detachment by cutting over the break or performing an early drainage retinotomy.

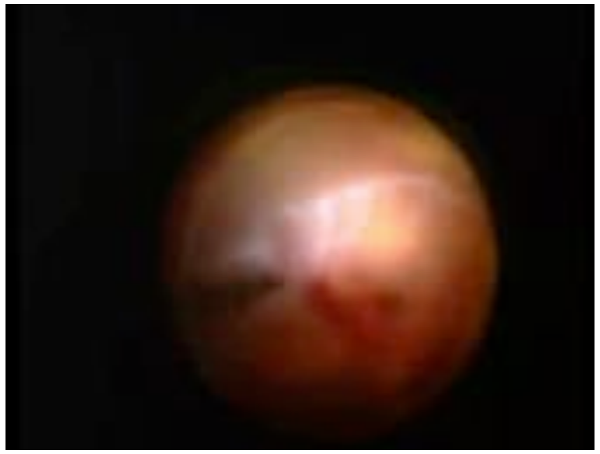
Vitreous incarceration is indicated by linear folds of retina radiating to a sclerotomy and movement of the retina when an instrument is partially withdrawn from the eye.

Vitreous incarceration in 20-gauge sclerotomies also causes post operative retinal breaks around the entry sites.

Movie 8.5 Vitreous incarceration

This was a case of retained lens matter and retinal detachment managed by 20-gauge vitrectomy.

Movie 8.6 Vitreous incarceration (20-gauge vitrectomy)



Linear folds of retina radiate to the sclerotomy. These increase as the instrument is withdrawn.

MANAGEMENT OF VITREOUS INCARCERATION

Attempts to surgically excise incarcerated vitreous from the sclerotomy with the cutter are usually unsuccessful in 20-gauge vitrectomy.

The incarceration can usually be freed by fluid gas exchange. As the retina is reattached the incarcerated vitreous is drawn out of the sclerotomy into the vitreous cavity. Unfortunately the problem often recurs when fluid is re-infused.

Perfluorocarbon may be used provided there is a sufficiently large anterior break for the subretinal fluid to drain through easily. If the breaks are very small an anterior ring of subretinal fluid may persist and the incarceration will not be relieved.

If incarceration occurs late in the procedure (after all the breaks have been marked) persistent incarceration may be a cue to move to complete air exchange and retinopexy.

Extreme cases with incarceration of the retina may require a local retinectomy around the affected sclerotomy.

Movie 8.7 Management of vitreous incarceration

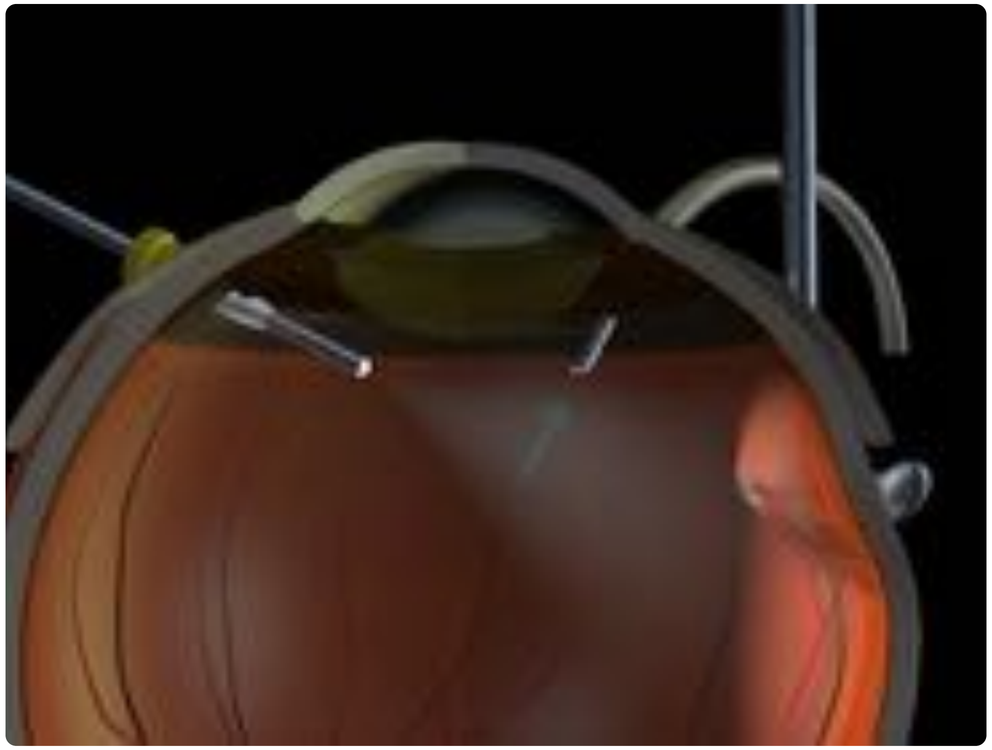
Vitreous incarceration often becomes manifest during the internal search, as in this case of 20-gauge vitrectomy. It is managed by performing an air-fluid exchange and draining subretinal fluid internally. Simply aspirating over the break (fluid-fluid exchange) is ineffective.

INFUSION CANNULA INCARCERATION

The introduction of MIVS with valved cannulas has largely eliminated vitreous incarceration in the active instrument ports. Incarceration of vitreous into the infusion may still occur during internal search. During internal search the infusion pressure is reduced to allow intraocular fluid to reflux up the infusion line so that an indent is created. Vitreous plugging the infusion cannula makes it impossible to create this indentation. Increased pressure on indentation is a cue to stop indenting and inspect the infusion cannula.

This problem is avoided by clearing basal gel around the tip of the infusion cannula and reducing the height of the detachment (by cutting over a break) before indentation. A bubble of perfluorocarbon may be used to reattach the retina which releases the incarceration and allows indentation.

Figure 8.1 Vitreous incarceration in the infusion cannula



Internal search in a MIVS system requires reflux of fluid up the infusion cannula to create space for the indent.

RELIEVING TRACTION ON RETINAL BREAKS

Relieving traction on the retinal tears is an important surgical goal of vitrectomy in retinal detachment repair. This is achieved by removing the operculum. This is also required for internal drainage of subretinal fluid through the break.

It is also desirable to trim the posterior hyaloid membrane as close as possible to the vitreous base. Because of its composition it transmits traction effectively. Residual posterior hyaloid may therefore cause secondary breaks after surgery.

Reducing the volume of the vitreous base by shaving it is also desirable. This reduces the risk of vitreous incarceration in the infusion cannula and increases the volume that can be occupied by a tamponade agent. It has also been hypothesized, but not proved, that vitreous base shaving reduces the incidence of post operative PVR.

Movie 8.8 Relieving traction

Removal of the operculum relieves the traction on the break

INTERNAL SEARCH

A major advantage of vitrectomy for retinal detachment repair is the ability to examine the peripheral retina under the operating microscope while indenting the sclera. This allows very small breaks to be identified and treated.

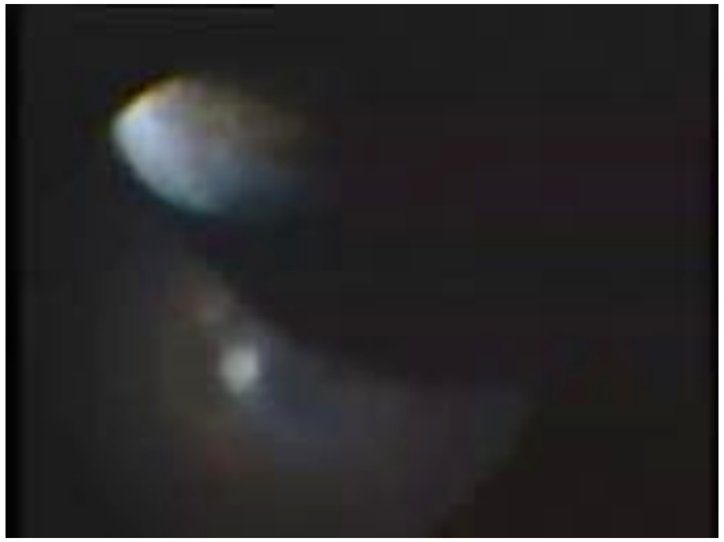
The vitreous gel around the infusion should be shaved and the height of the detachment reduced to avoid vitreous incarceration in the infusion cannula. The infusion pressure is then lowered to allow scleral indentation. Slow steady pressure on the globe with a squint hook allows the intraocular fluid to reflux up the aspiration line. An advantage of using a squint hook is that, once this indent has been created, the squint hook can be moved circumferentially while maintaining the pressure on the globe. In this way the indent can be moved and new areas of the peripheral retina examined without fluctuations in the intraocular pressure.

The eye is kept in the primary position while the search is performed, relying on the indentation to bring the peripheral retina into view.

If an indirect viewing system such as the BIOM is used it may be refocussed slightly to view the anterior retina.

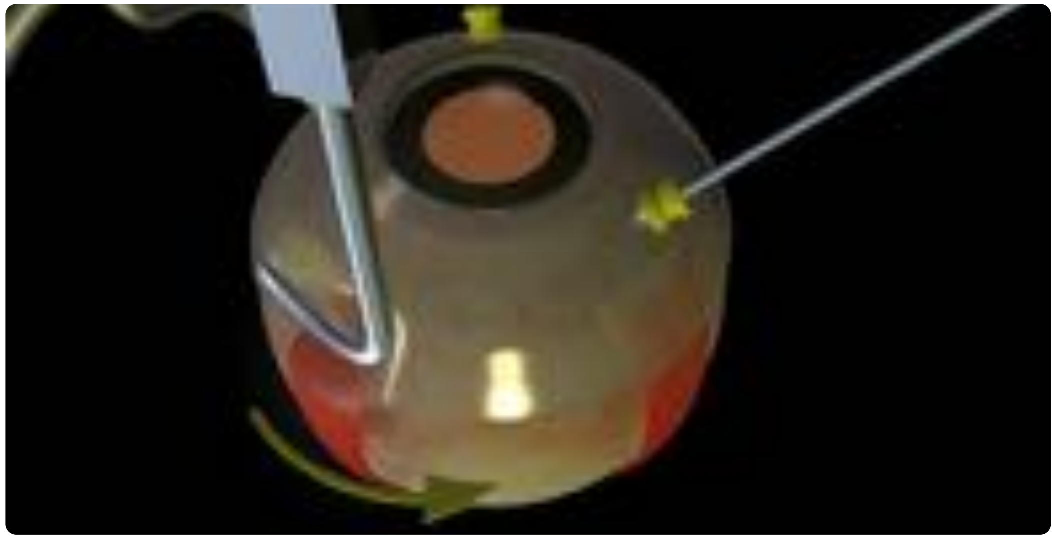
Small anterior breaks identified during internal search may be treated with cryopexy at this stage. More posterior breaks are marked with endodiathermy so that they remain visible after air-fluid exchange.

Movie 8.9 Cryotherapy during internal search



The break is small and anterior - it is easier to see and treat at this stage rather than marking and treating under air later.

Figure 8.2 Internal search using a squint hook.



The squint hook may be slid around the globe to move the indent without fluctuations in intraocular pressure. Note that the eye is kept in the primary position.

Flap tears (tears with an attached operculum) occur at the posterior border of the vitreous base so the internal search is focussed on this area. The operculum of the tear may be seen to stand up during indentation. Rolling the indent anteriorly and posteriorly is useful in confirming the presence of a retinal break. The posterior border of the vitreous base may be visible as an irregular circumferential white line in detached retina.

Movie 8.10 Location of the posterior border of the vitreous base

A white line in detached retina indicates the location of the posterior border of the vitreous base. This is not always visible but when seen is useful in finding flap tears as they are located along this line.

Movie 8.11 Identification of small breaks during internal search

Indented internal search allows tiny breaks to be identified. The indent is moved to the posterior border of the vitreous base (which may be seen on the indent). The opercula stand up in profile. The indent may then be rolled posteriorly to confirm the presence of a break by observing it en face.

Indentation may cause subretinal fluid to pass through retinal breaks into the vitreous cavity. This often has a slightly different refractive index from the infusate due to its higher protein concentration. The subretinal fluid causes visible streaks (Schlieren) within the vitreous cavity. The location of Schlieren may aid in the detection of retinal breaks.

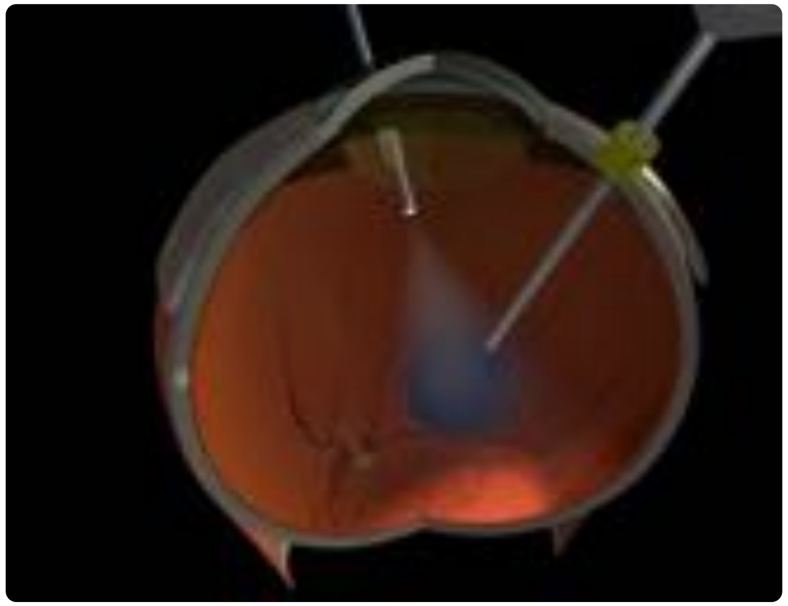
Movie 8.12 Schlieren

This is a case of rhegmatogenous retinal detachment due to a macular hole. Schlieren can be seen around the macular hole.

ENHANCED SEARCH WITH SUBRETINAL TRYPAN BLUE

Occasionally retinal breaks cannot be confirmed on internal search, particularly in cases of reoperation with multiple cryotherapy scars. The Dye-Extrusion technique is particularly useful in these cases. It is very successful in detecting small and anterior breaks. These may be treated by cryotherapy. This is followed by removal of the perfluorocarbon, drainage retinotomy, air exchange with internal drainage, laser to the retinotomy and injection of a tamponade agent. Although it may seem quite invasive it is not difficult to perform and is less invasive than encirclement, laser encirclage, silicone oil tamponade or 'cryosearching'.

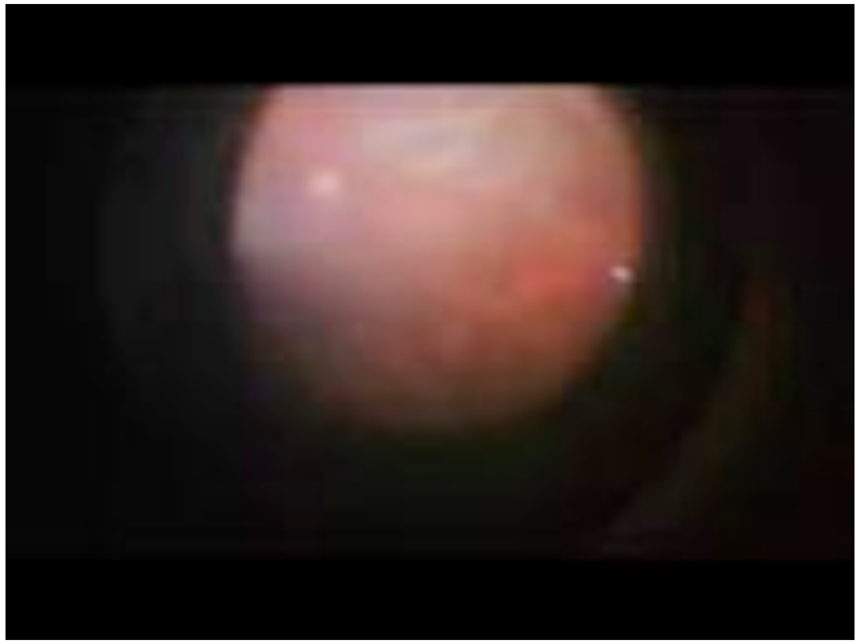
Figure 8.3 The Dye Extrusion Technique



Subretinal trypan blue injection commences.

An alternative approach is to inject the dye transsclerally using a 30 gauge needle.

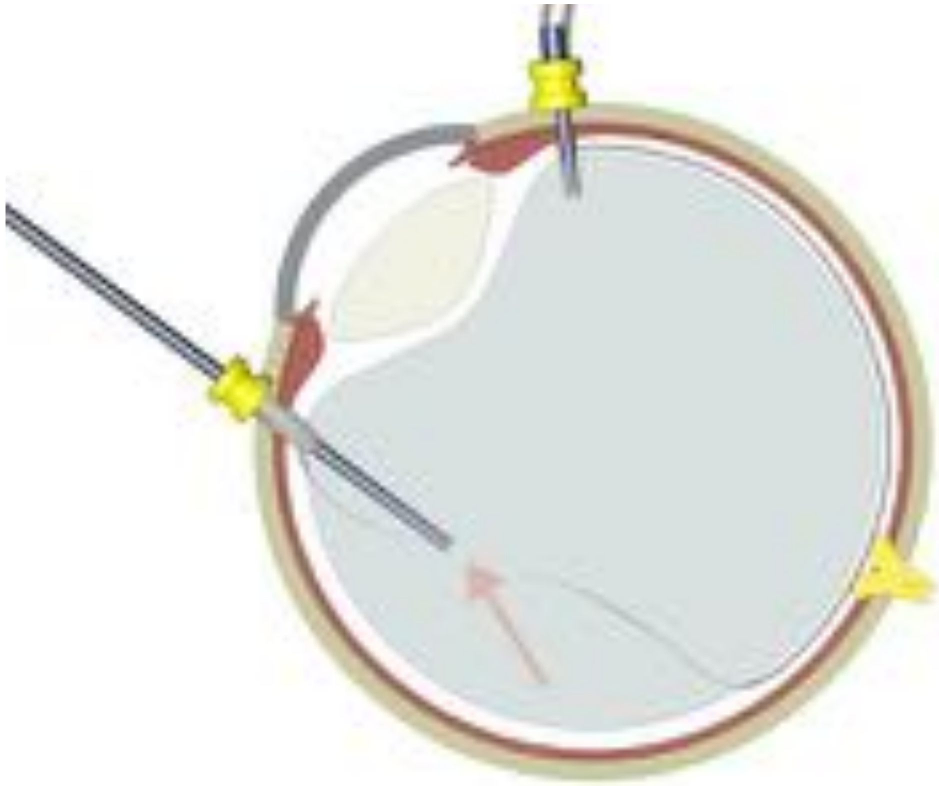
Movie 8.13 The Dye Extrusion Technique (DE-TECH) for identifying small retinal breaks.



The break was very small and not seen on indented internal search. A single application of cryotherapy to the break was performed followed by a posterior drainage retinotomy and a fluid air exchange to remove the dye and subretinal fluid. Laser to the retinotomy was followed by 20% SF_6 gas exchange. No retinopexy was applied to the 41-gauge entry site. The retina remained attached after the gas disappeared.

Air-fluid exchange is combined with internal drainage of subretinal fluid. The eye is tilted so that the break is dependent. The tip of the extrusion needle is placed over the break so that the subretinal fluid is aspirated. Once the break is attached the any residual fluid anterior to the retina is removed by returning the eye to the primary position and aspirating over the disc.

Figure 8.4 Air fluid exchange and internal drainage



Initially aspiration over the break is carried out. This is done to reduce the likelihood of trapped posterior subretinal fluid after air injection.

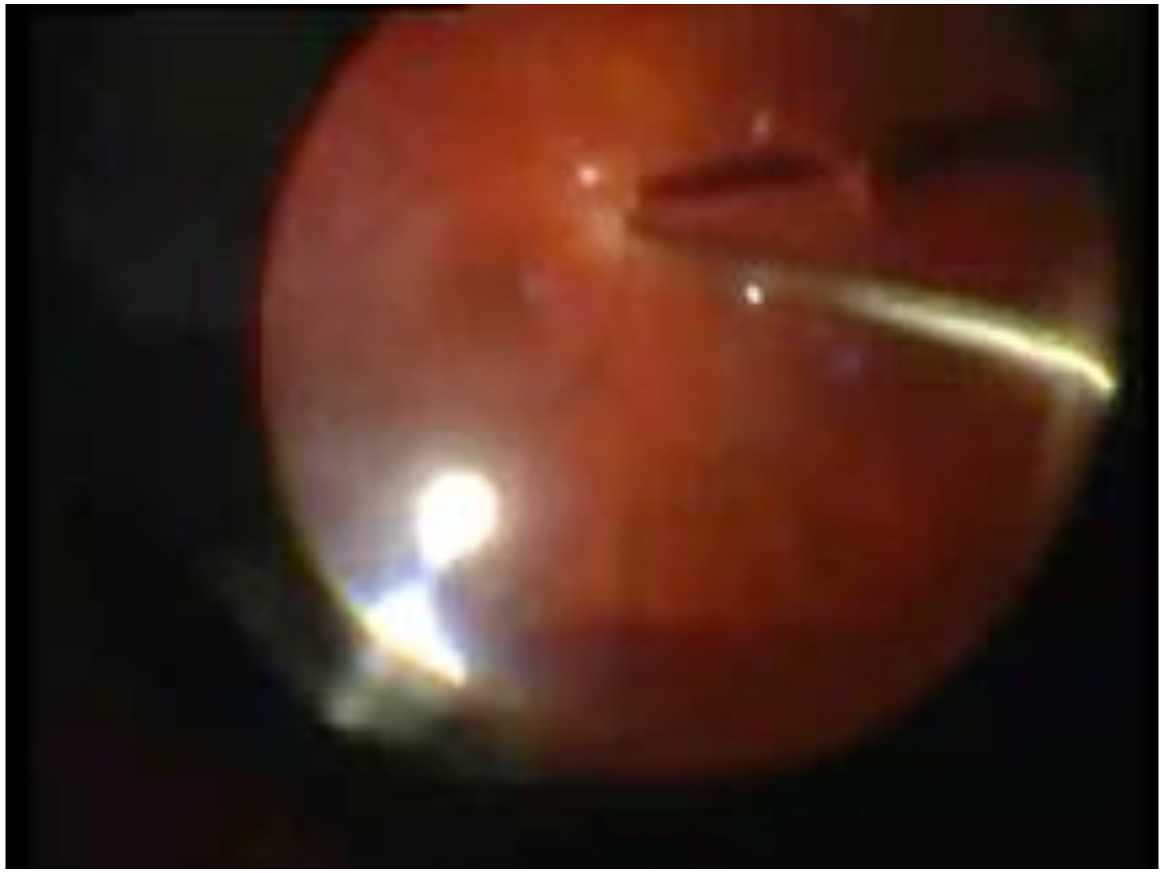
Movie 8.14 Air fluid exchange and internal drainage

Note the point at which fluid-fluid exchange is changed to air-fluid exchange.

If the retinal break is anterior it may not be possible to remove all the subretinal fluid through the break. An area of posterior sequestered subretinal fluid remains.

This does not affect break closure. Eventually this subretinal fluid is pumped out of the subretinal space by the RPE. It may have a significant effect on visual recovery however. The buoyancy of the gas bubble may displace this subretinal fluid towards the fovea. Associated retinal displacement may leave a fold through the macula. This causes severe metamorphopsia which patients find very troublesome.

Movie 8.15 Sequestered posterior subretinal fluid.



Following drainage through a very anterior break residual fluid is aspirated over the disc. This results in displacement of residual subretinal fluid to the macula.

Figure 8.5 Sequestered fluid and macular folds.

Because the break is quite anterior it has not been possible to drain all of the subretinal fluid.

MANAGEMENT OF POSTERIOR SEQUESTERED SUBRETINAL FLUID

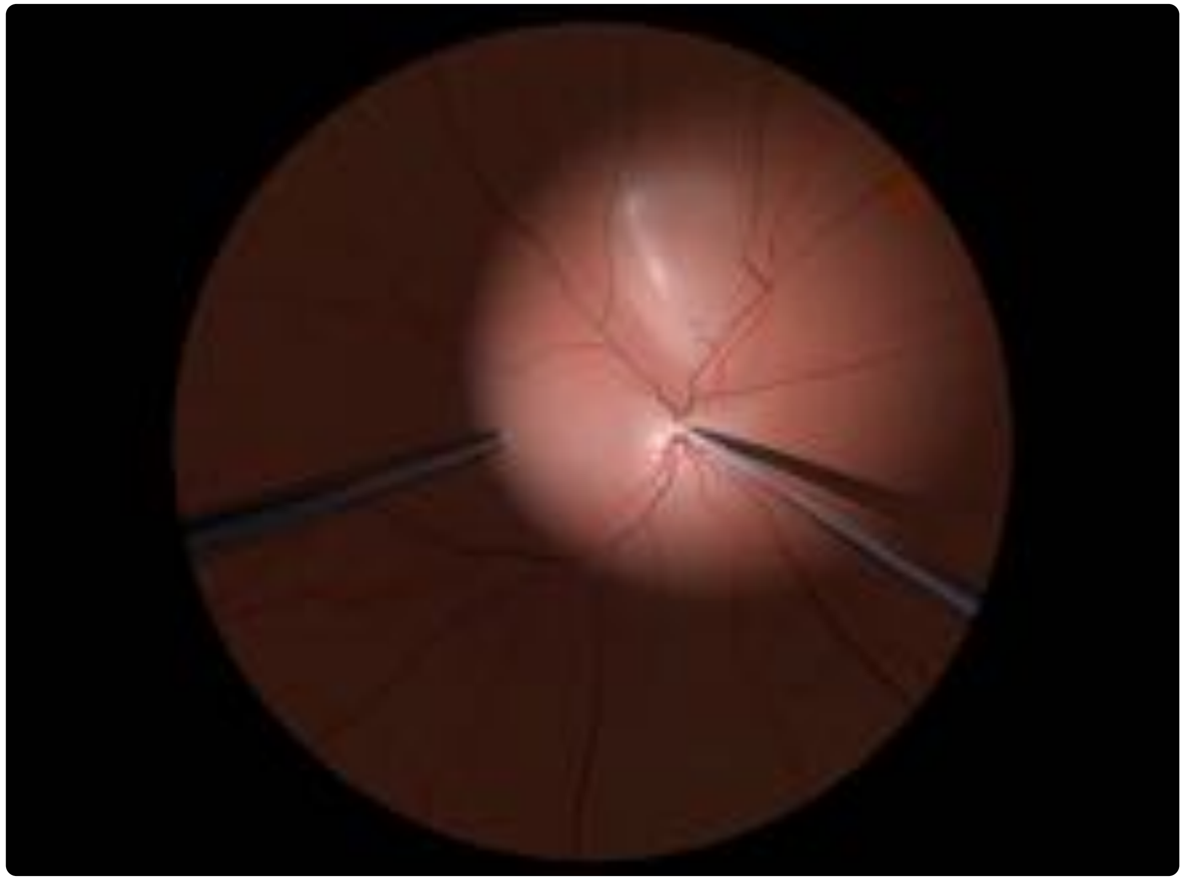
There are 3 approaches to posterior sequestered fluid:

- A conservative approach: the fluid is left and the patient asked to posture if necessary to prevent a compression fold.
- Drainage retinotomy.
- Use of perfluorocarbon liquid to displace the fluid anteriorly so that it may be drained through the retinal break.

Conservative Approach

Under certain circumstances a small amount of residual subretinal fluid may be safely left alone.

Figure 8.6 Conservative management of residual subretinal fluid



There is a small bleb of residual inferior subretinal fluid following air exchange in this vitrectomy for inferonasal tear. The probability of this extending to the macula and causing a compression fold is small and this could be left to resorb.

Drainage Retinotomy

Residual posterior subretinal fluid may be removed using a drainage retinotomy. A spot of diathermy is applied to the retina. Aspiration over the diathermy produces a full thickness break which is used to drain subretinal fluid. Retinopexy should be applied to the retinotomy once the retina is attached.

In cases where incomplete drainage is deemed likely the drainage retinotomy is usually performed before air-fluid exchange. This is particularly advisable if the macula is attached preoperatively.

Retinotomies produce absolute peripheral arcuate scotomas due to nerve fibre loss but are otherwise safe in relation to their benefits. The break created is very small and treated with laser under air so produces little additional pigment dispersion or risk of PVR.

When deciding where to create a drainage retinotomy:

- A superior site allows more effective tamponade.
- More posterior retinotomies allow more complete subretinal fluid drainage but create larger visual field defects.
- Superotemporal retinotomies create an inferonasal scotoma. An inferonasal scotoma 40^0 from fixation has limited functional impact because of the physiological field restriction arising from the nose.
- Creating a retinotomy in the same meridian as a retinal break may simplify postoperative posturing.

Movie 8.16 Drainage retinotomy

Diathermy produces retinal necrosis. Aspiration over this point produces a retinotomy. This may also be performed under air.

Perfluorocarbon liquid

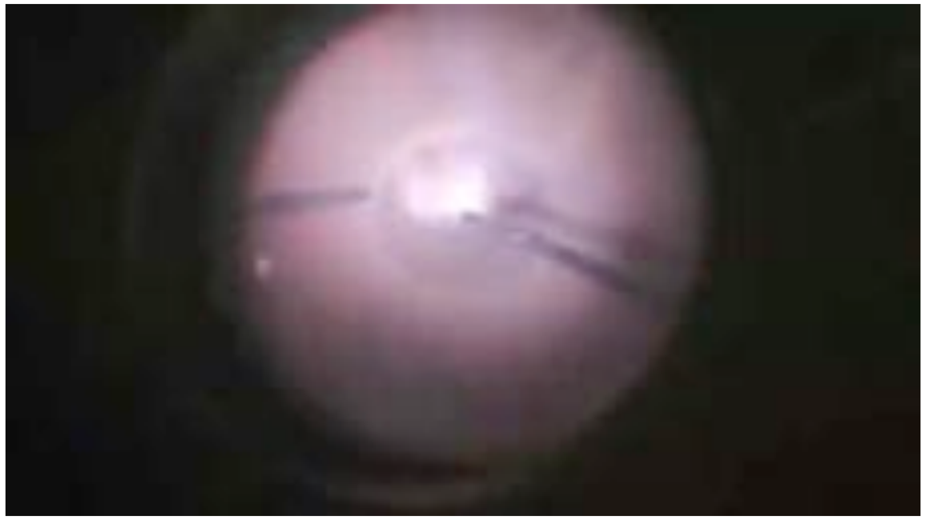
Perfluorocarbons may be used to displace posterior sequestered fluid towards a peripheral break or retinotomy.

If the breaks are small or posterior a ring of subretinal fluid may persist anterior to the tear.

This may be managed by injecting perfluorocarbon to the posterior margin of the tear and then performing a fluid gas exchange with internal drainage through the tear. Laser retinopexy is then applied to the retinal breaks.

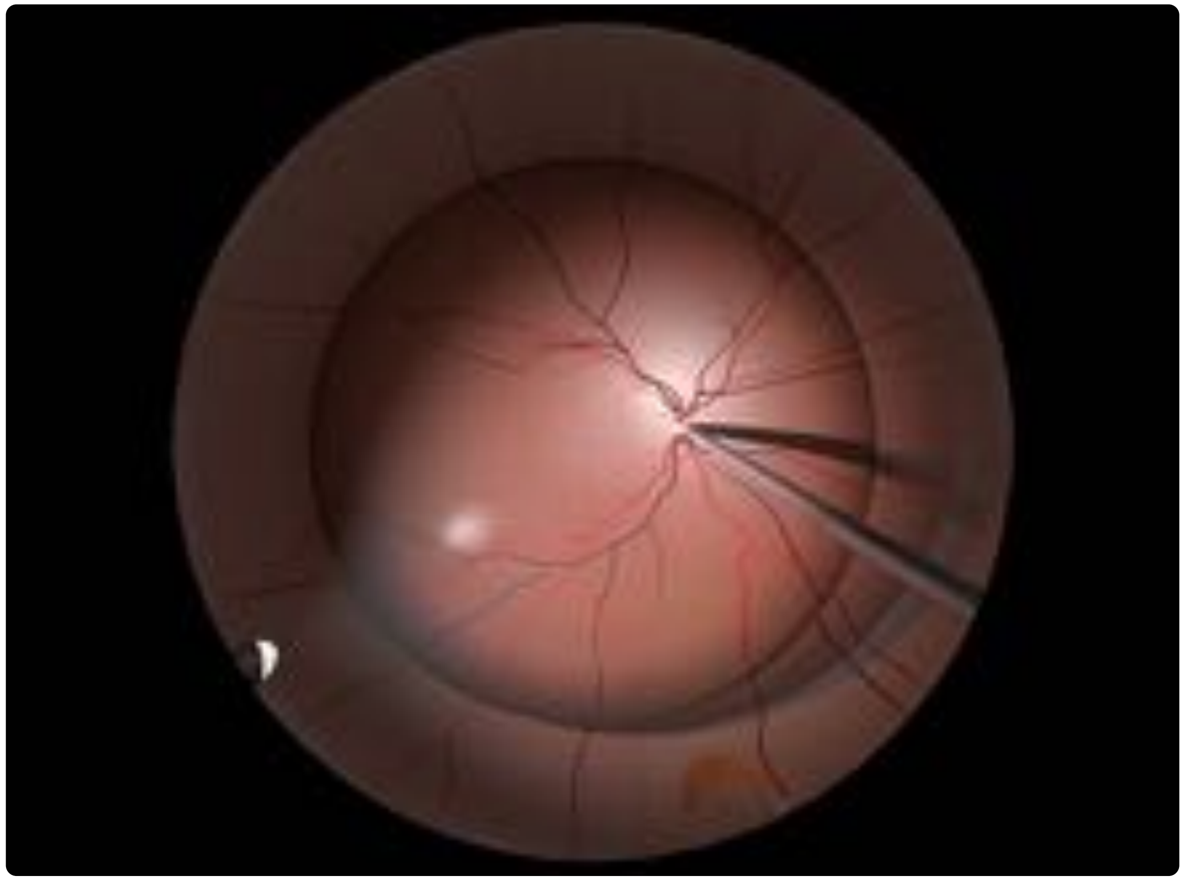
Alternatively a very large bubble of perfluorocarbon liquid may be injected having enlarged the anterior part of the tear with the cutter so that the subretinal fluid ring can drain through the tear. There are significant disadvantages to the use of large bubbles of PFCL however.

Movie 8.17 Anterior subretinal fluid



Following perfluorocarbon injection an anterior rim of subretinal remains.

Figure 8.7 Reattachment with perfluorocarbon



Perfluorocarbon has been injected. The posterior retina is attached but there is an anterior ring of subretinal fluid.

MANAGEMENT OF COMPRESSION FOLDS

Macular compression folds are usually horizontal. Autofluorescence imaging used to assess the associated macular translocation indicates that the retina is inferiorly displaced. This is unsurprising given that the displacement is a consequence of flotation force. Initial post operative posturing on the operated side may reduce the risk of compression folds as the ability of the macular to translocate temporally is constrained by its attachment at the disc.

Small juxtafoveal macular folds are are not uncommon following vitreoretinal surgery and may be observed. Large folds involving the fovea have a severe impact on vision and carry a poor prognosis. Surgery may normalize retinal morphology and improve the functional outcome. A variety of approaches have been advocated including induction of a macular detachment, tamponade and posturing as described above.

RETINOPEXY

Cryotherapy and laser retinopexy are both used during vitrectomy for retinal detachment. The time course of chorioretinal adhesion differs. Maximal adhesion is present 5 days following laser and 10 days following cryotherapy.

Cryotherapy is particularly useful for the treatment of small anterior breaks. These may be treated prior to fluid air exchange. Other breaks are treated after internal drainage.

Cryotherapy may cause pigment dispersion, particularly if indentation is subsequently performed. This may increase the risk of postoperative PVR. These observations were made on giant retinal tears treated before air-fluid exchange. It is possible that the risk of pigment dispersion is less if cryotherapy is performed following air-fluid exchange.

Laser endophotocoagulation is particularly useful for large or posterior breaks.

Movie 8.18 Endolaser retinopexy

This is a giant retinal tear treated under perfluorocarbon tamponade

Movie 8.19 Cryotherapy under air

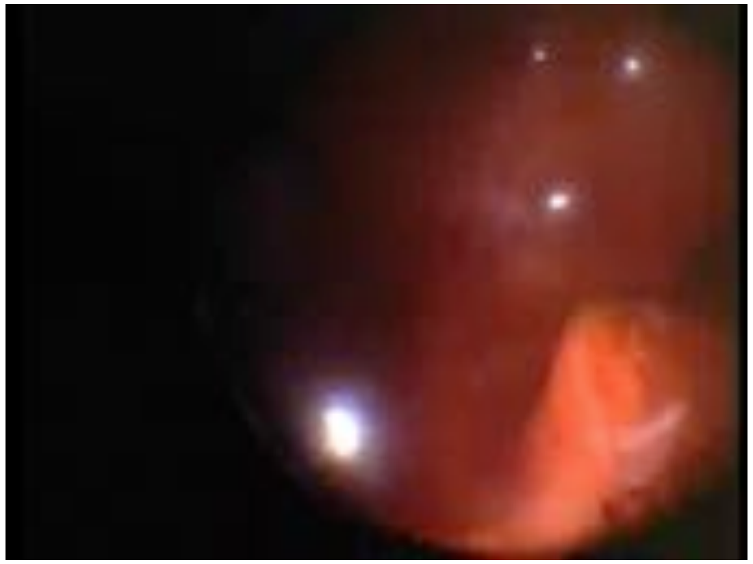
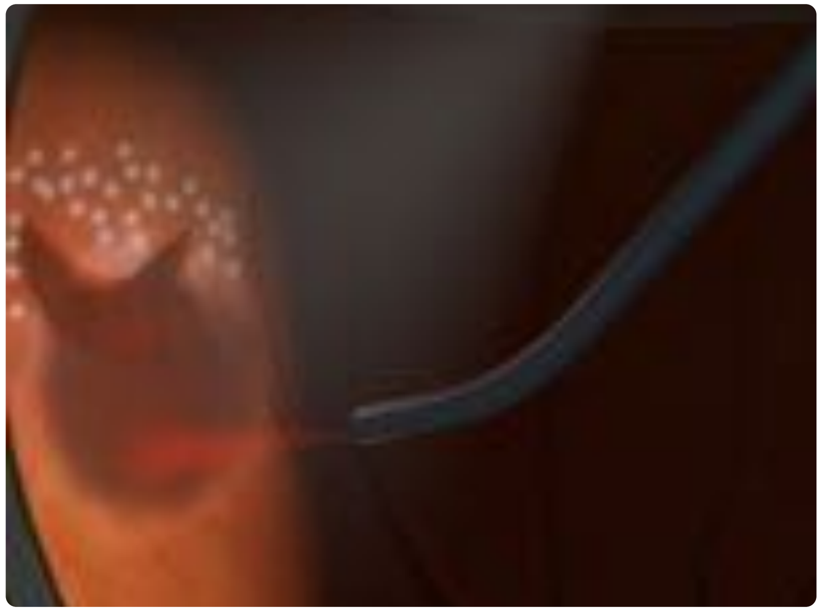


Figure 8.8 Attempted laser under air: re-accumulation of subretinal fluid



Laser retinopexy is being performed in an air filled eye. Some subretinal fluid has re-accumulated in the preretinal space and also under the posterior margin of the break. This impairs retinal laser uptake and is managed by aspirating the fluid then quickly reintroducing the laser before more fluid accumulates (an end-aspirating laser may be helpful).

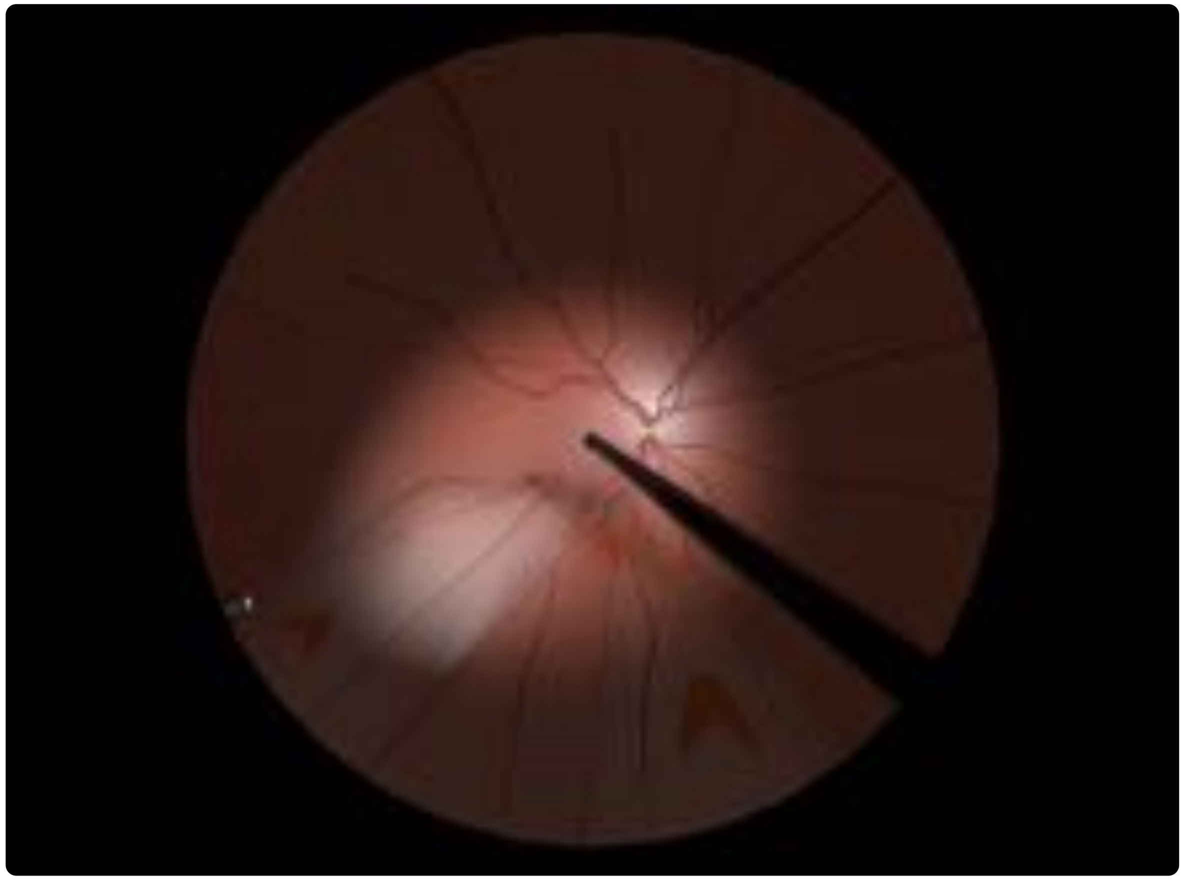
CHOICE OF TAMPONADE AGENT

Intraocular gases are preferable to silicone oil in uncomplicated cases because:

- They have greater surface tension.
- A bubble of gas of a given volume tamponades a greater area of retina.
- Their use has less long term complications than silicone oil.
- They resorb without the need for further surgery.

The choice between gas tamponade agents is made on the basis of the desired longevity of the intraocular gas bubble which is influenced by the number and distribution of retinal breaks.

Figure 8.9 Choice of tamponade agent



This eye has a bullous superior detachment with 2 superior tears. Sulphur hexafluoride (10-14 days) should give adequate tamponade.

USE OF ADJUVANT SCLERAL BUCKLE

The use of adjuvant scleral buckles with vitrectomy was common in the early days of vitrectomy. There is little evidence that they confer any benefit in uncomplicated retinal detachments and their routine use seems to be declining.

POSTOPERATIVE POSTURING

The objectives of postoperative posturing are:

- To avoid early postoperative pneumatic displacement of residual subretinal fluid towards the macula.
- To prevent or minimize contact of the gas bubble with the posterior capsule.
- To appose the gas bubble to to the retinal break until a strong chorioretinal adhesion has developed.

Apposition is necessary if the mechanism of break closure is a surface tension effect of the gas bubble. The surface tension is the same at every point on the surface of the bubble. It is not necessary that the break be at the highest point of a bubble. It is therefore unnecessary for a patient with a 70% gas fill to posture in order to close a break at 2 o'clock. Conversely posturing is clearly necessary if a 70% gas bubble is to have contact with a break at 6 o'clock. The time taken to achieve a chorioretinal adhesion and the effect of the progressive reduction in size of the gas bubble on the contact arc also need to be considered. Advice on the position and duration of postoperative posturing is therefore individualized.

The importance of postoperative posturing has recently been challenged. Good results have been achieved using vitrectomy, laser and short acting tamponade without posture in eyes with inferior retinal breaks.

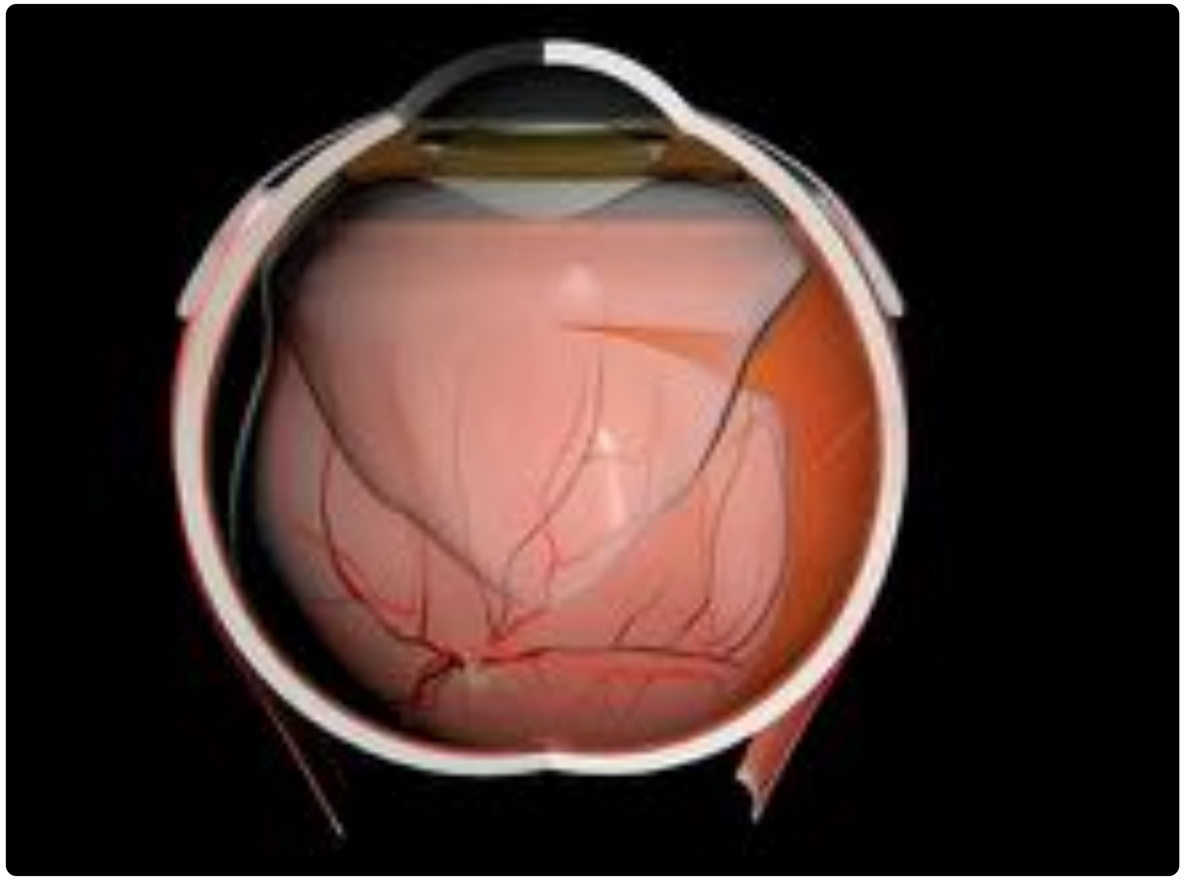
Giant retinal tears

A giant retinal tear (GRT) is a tear with a circumferential size greater than 90^0.

Giant retinal tears are differentiated from retinal dialyses by the presence of a PVD. This allows greater mobility of the flap than is seen in a dialysis. There is a large area of bare RPE. Dispersed RPE cells have direct access to the retinal surface and vitreous base. Giant retinal tears therefore have a high incidence of PVR.

They may arise spontaneously, following trauma (including surgery) or in association with other eye pathology (typically Marfan and Stickler syndromes). Traumatic GRTs may have associated vitreous base avulsion.

Figure 8.10 Features of giant retinal tears



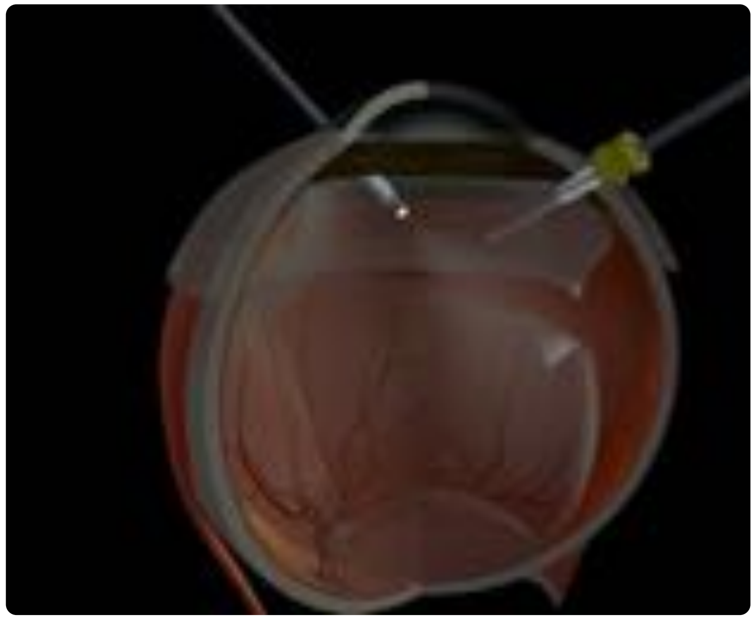
A giant retinal tear. There is a PVD. The vitreous base remains attached to the anterior flap of the tear. The posterior flap is free of vitreous and mobile. It may roll over as in this case. There is no barrier to RPE migration onto the retinal surface.

The major problem of GRT surgery - the mobility of the posterior flap - was solved by the introduction of perfluorocarbon liquids.

These are introduced after a thorough vitrectomy (including trimming of the anterior flap and vitreous base shaving). They stabilize the posterior flap and allow endolaser retinopexy. If non valved cannulas or 20-gauge vitrectomy are being used a small bubble of perfluorocarbon may be helpful earlier in the case (after core vitrectomy but before vitreous base shaving) to prevent incarceration of the mobile retinal flap in a sclerotomy.

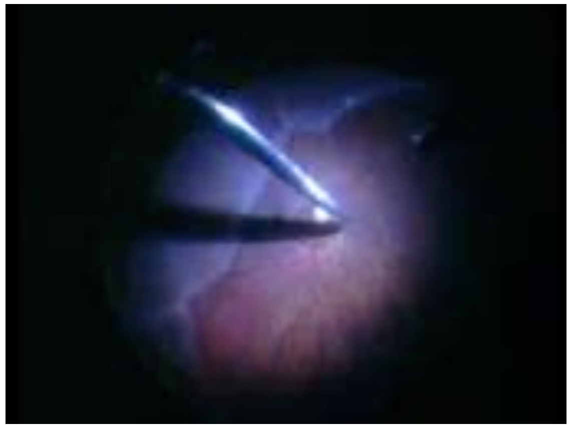
Two or three rows of interrupted contiguously spaced laser burns laser are applied along the edge of the tear. Some surgeons advocate 360^0 laser.

Figure 8.11 Vitreous base shaving



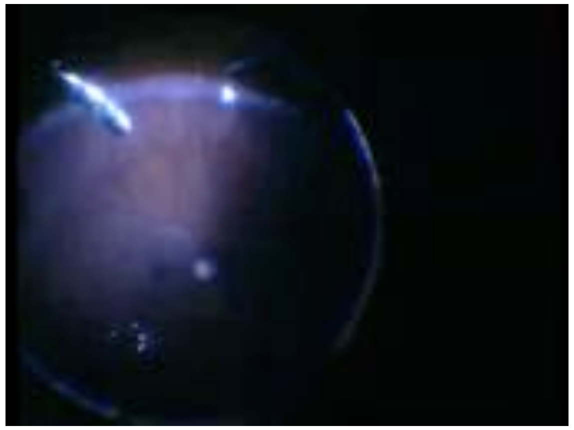
The vitreous base and anterior retinal flap are removed. Note the use of a small bubble of perfluorocarbon the stabilize the posterior retinal flap and prevent incarceration. It is particularly important to remove vitreous at the horns of the tear.

Movie 8.20 Injection of perfluorocarbon



Note that the eye is initially rotated away from the detachment so that the pfcl unrolls the flap.

Movie 8.21 Manipulation of the flap



A folded flap edge may be gently unfurled under PFCL with a blunt instrument such as a dusted silicone scraper

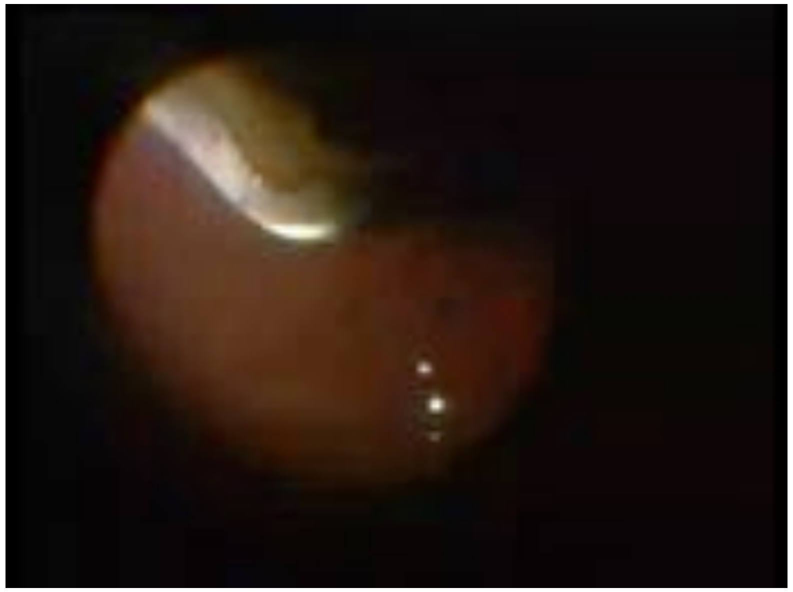
Movie 8.22 Laser to the edge of a GRT

Perfluorocarbon liquid is in place.

Retinopexy to the horns of the tear may be challenging because a rim of residual subretinal fluid is present anterior to the perfluorocarbon meniscus. There are a number of strategies for dealing with this:

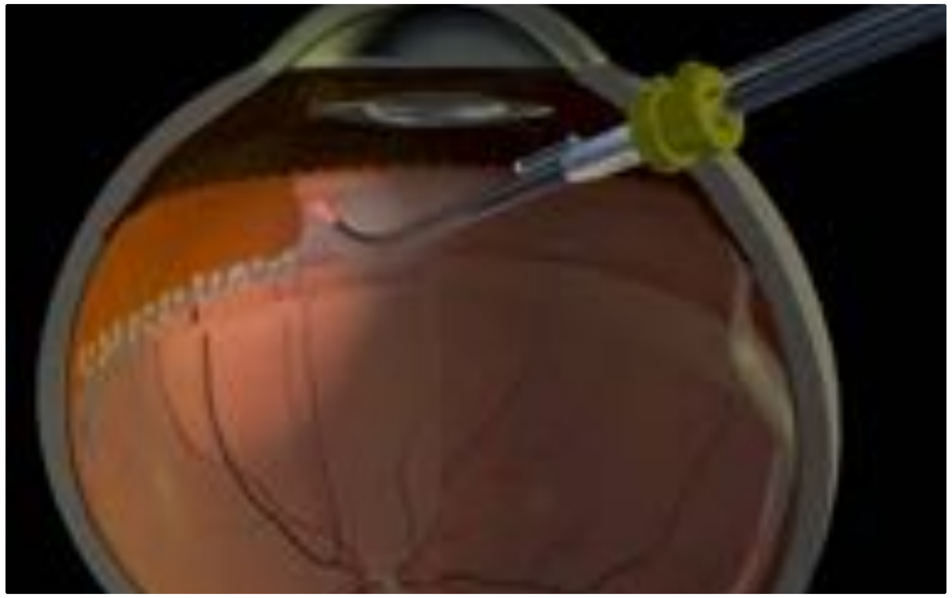
- Tilting the eye slightly displaces the perfluorocarbon anteriorly which allows more anterior laser.
- Additional perfluorocarbon may be injected. If the meniscus approaches the tip of the infusion jets of water from the infusion provide sufficient energy to overcome surface tension. Bubbles form on the surface of the pfcl. These may become subretinal during air exchange.
- Laser to the anterior retina may be performed after the perfluorocarbon has been exchanged for air. This is the author's preferred technique. It has the added advantage that the field of view tends to increase due to a prismatic effect at the edge of the air bubble.
- An accessory light source may be used to allow anterior indented laser, usually in combination with one of the above techniques.
- Cryotherapy to the horns of the tear may be used (laser retinopexy being performed elsewhere). Unlike laser, cryotherapy is effective through a thin rim of subretinal fluid. The use of cryotherapy in GRTs should be extremely judicious due to the risk of pigment dispersion.

Movie 8.23 Cryotherapy to the horn of a GRT



The retina is attached under perfluorocarbon. A single application of cryotherapy was made to each horn - the rest of the posterior flap was treated with laser.

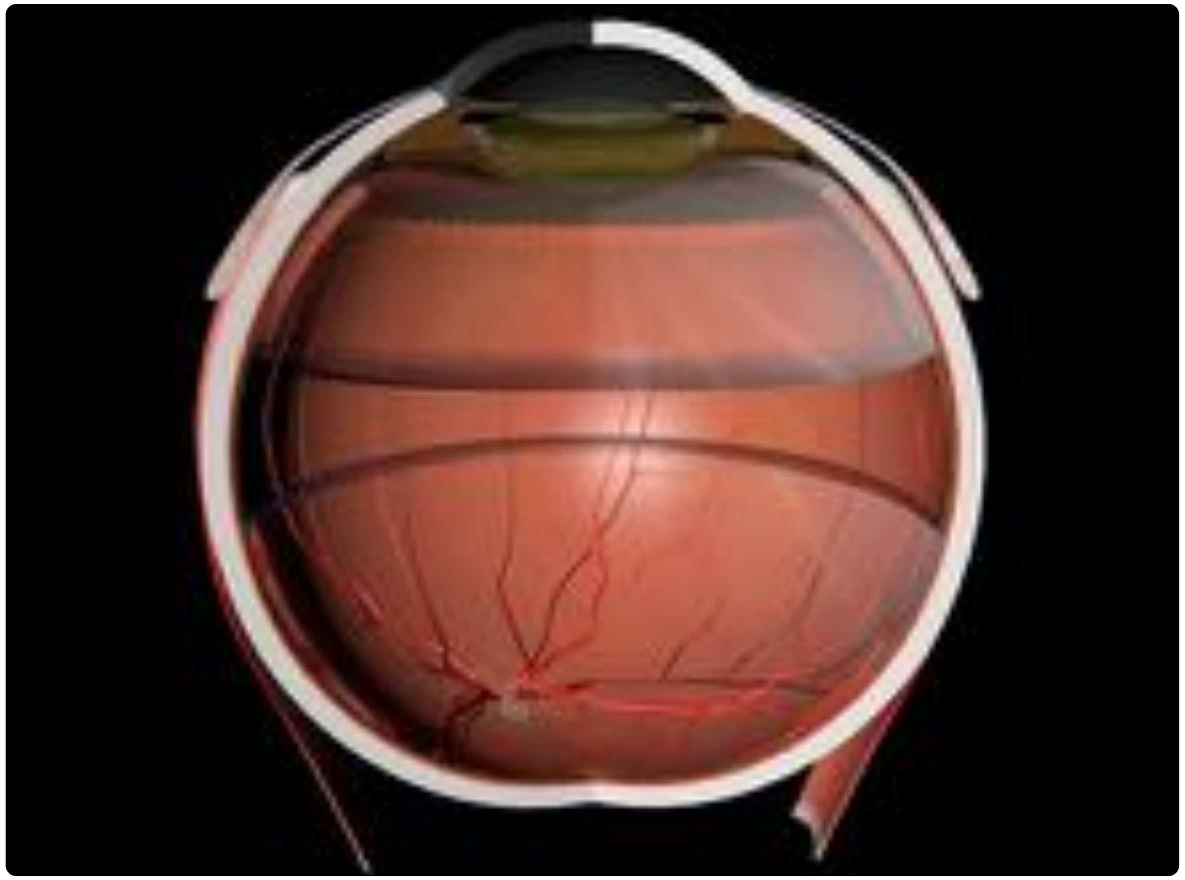
Figure 8.12 Laser to the horns of a grt



The edge of the posterior flap has been treated. Anteriorly laser uptake is poor because of a donut of subretinal fluid.

The major technical challenge in GRT repair is avoiding slippage of the posterior flap when the perfluorocarbon is removed.

Figure 8.13 Slippage



This eye has an air bubble superiorly and a perfluorocarbon bubble inferiorly with a thin layer of saline sandwiched in between.

Movie 8.24 Slippage during GRT repair

This occurred during air-perfluorocarbon exchange.

There are 3 strategies for avoiding slippage:

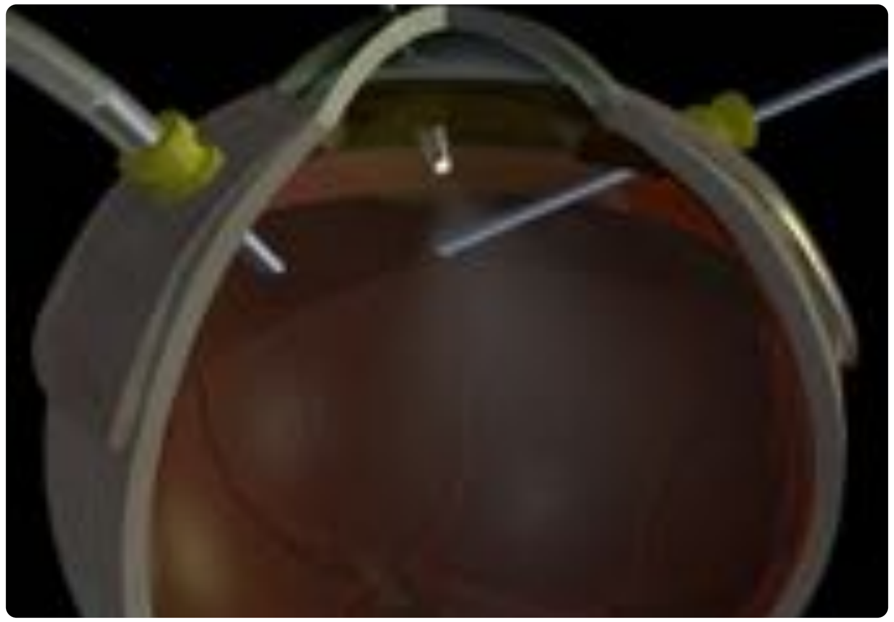
- Obsessional drying of the edge of the perfluorocarbon-air meniscus.
- Direct perfluorocarbon-oil exchange.
- Total perfluorocarbon fill.
- Short term post operative perfluorocarbon tamponade.

Perfluorocarbon-air exchange is most suitable for smaller GRTs (less than 180^0). As slippage is a consequence of a peripheral ring of aqueous it may be prevented by repeatedly aspirating just outside the edge of the perfluorocarbon bubble.

Initial aspiration is over the centre of the perfluorocarbon. Following this the tip of the aspiration needle is moved to a point just beyond the dark ring which indicates the perfluorocarbon-fluid interface. This is very peripheral and may be difficult to visualize even with wide angle viewing systems. In smaller (90^0) GRTs it may be helpful to tilt the eye slightly. There will be a corresponding peripheral movement of the pfcl-aqueous interface which displaces aqueous away from the edge of the tear. It allows some perfluorocarbon to be removed without slippage so that the aqueous ring is more posterior and easily visible. This is often unhelpful in very large GRTs as it simply shifts the problem of the aqueous rim to another (out of sight) portion of the tear.

The process of gradual aspiration and repeated drying must be done repeatedly to avoid slippage and typically takes several minutes.

Figure 8.14 Air-perfluorocarbon exchange

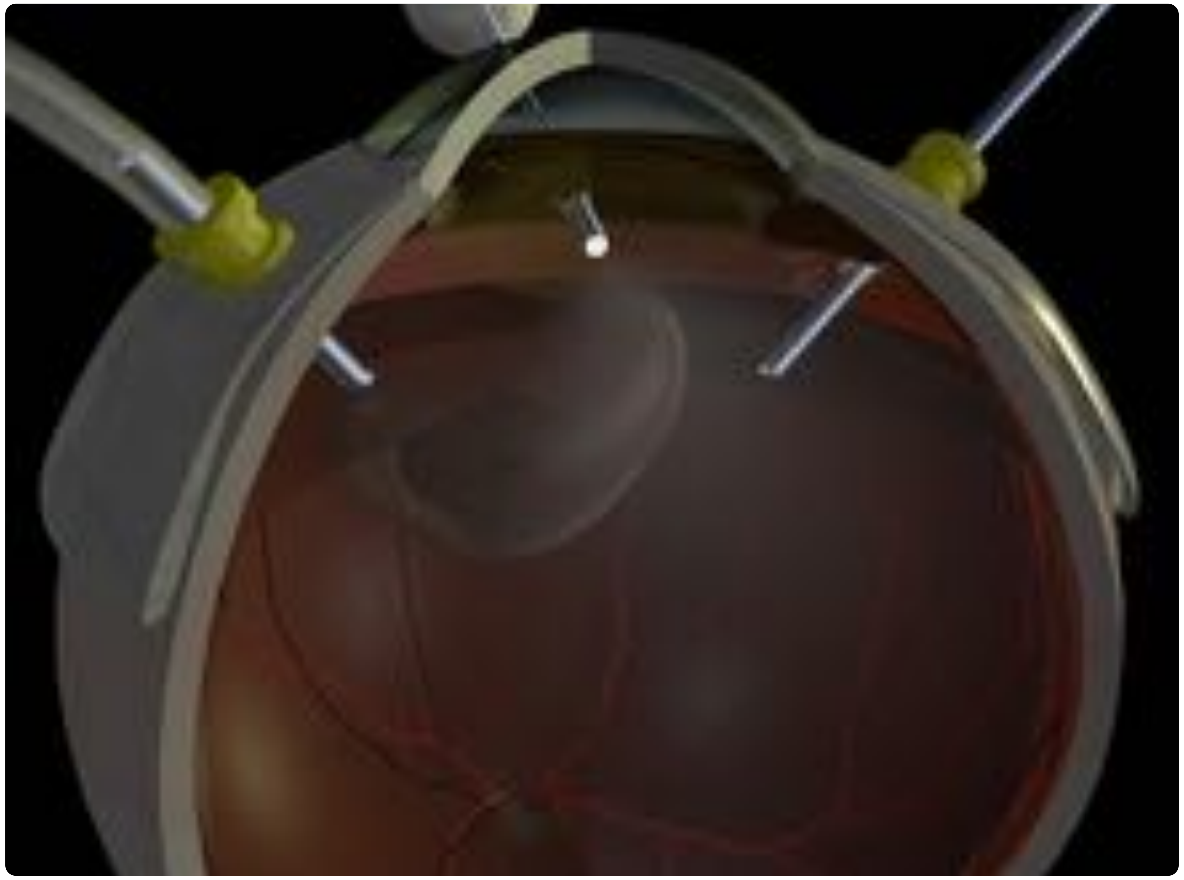


The aspiration cannula tip is placed centrally just above the perfluorocarbon bubble - the meniscus is easily identified by the change in specular reflection when it is touched.

Movie 8.25 Air-perfluorocarbon exchange

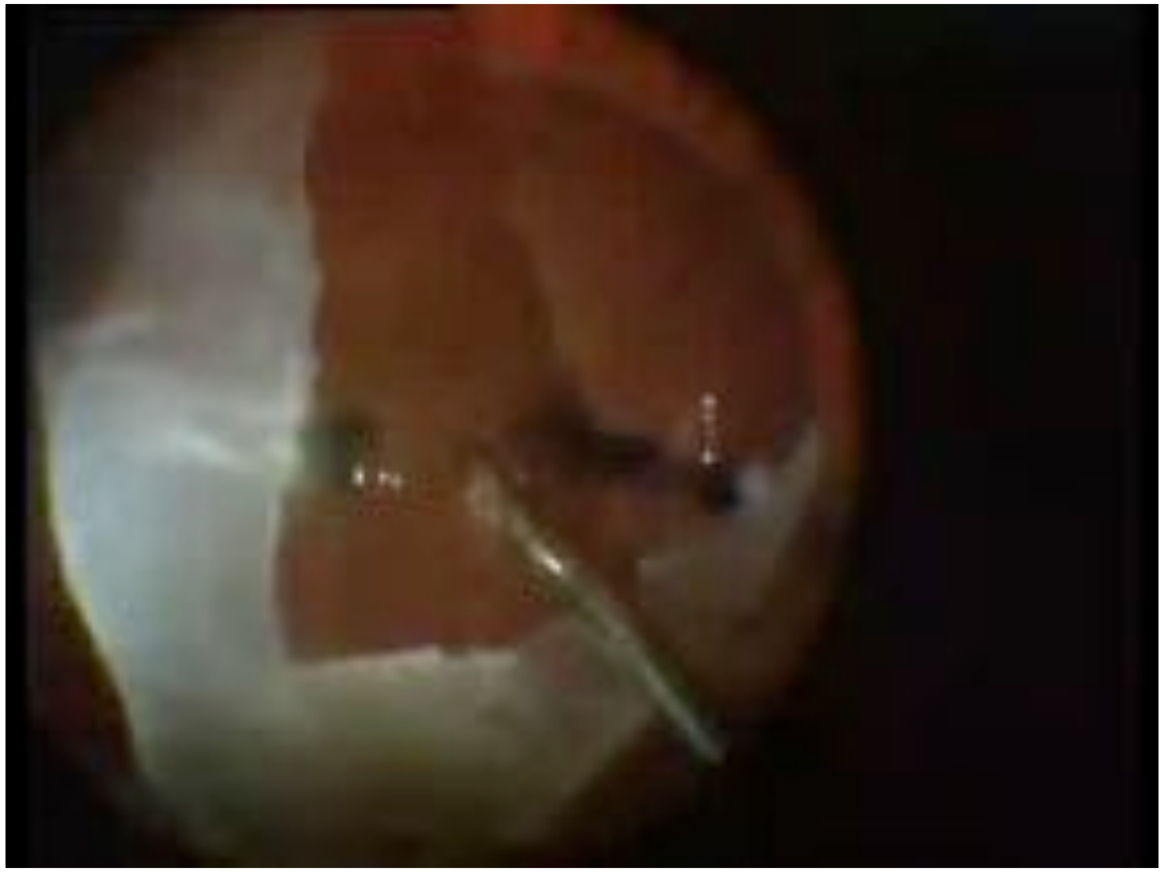
Direct perfluorocarbon-oil exchange is helpful in cases where silicone tamponade is planned. As oil and perfluorocarbon are both hydrophobic they can be made to adhere creating, in effect, a single bubble while the aqueous is displaced anteriorly and peripherally. Although peripheral aqueous remains this avoids the problem of a single air-perfluorocarbon meniscus traveling across the break (which gives rise to slippage).

Figure 8.15 Oil-perfluorocarbon exchange



Oil infusion is initiated with the aspiration cannula in aqueous.

Movie 8.26 Oil perfluorocarbon exchange

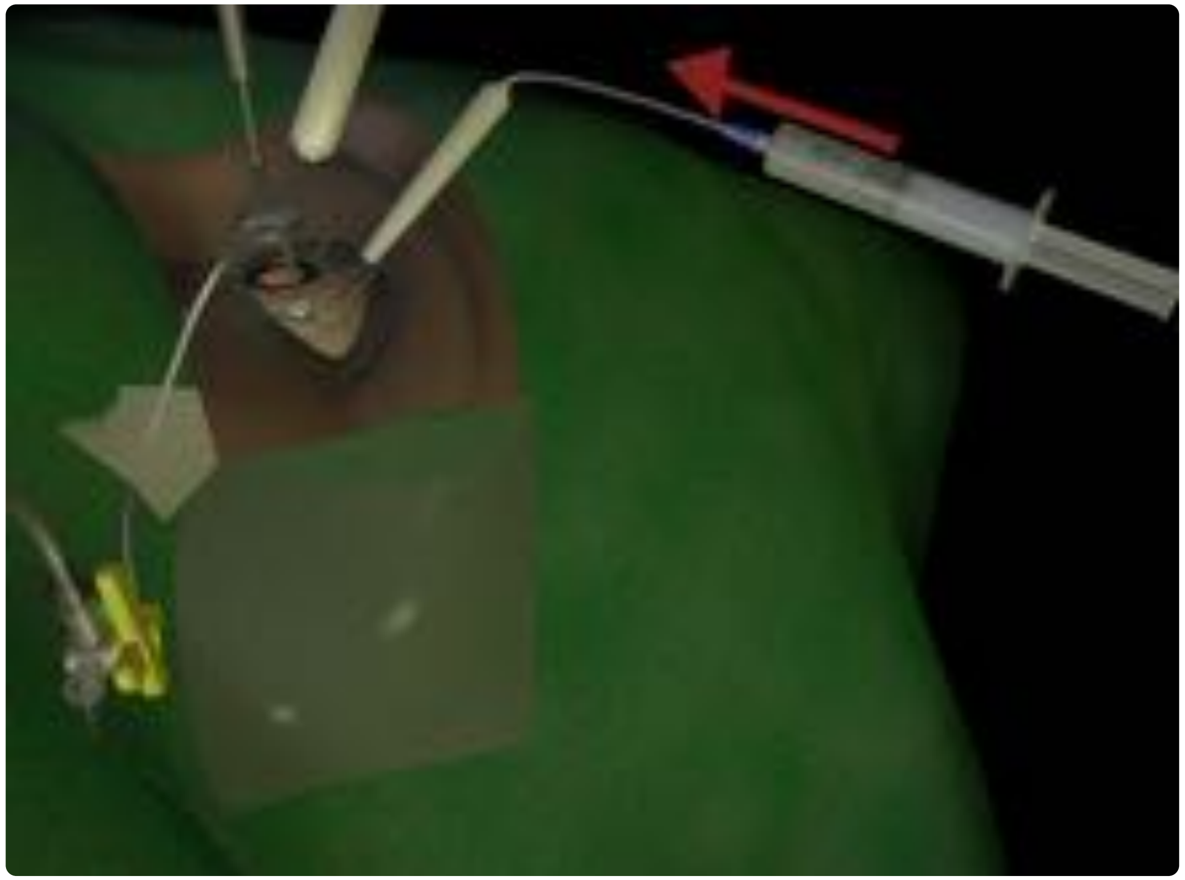


This was a very large tear with a high risk of slippage so silicone oil was used as a tamponade agent. Note that the tip of the aspiration cannula stays below the oil-perfluorocarbon interface.

Totally filling the eye with perfluorocarbon eliminates slippage by removing all aqueous from the eye.

Slippage can also be avoided by leaving the perfluorocarbon in situ while a chorioretinal adhesion develops. The perfluorocarbon may be exchanged for gas after 10-14 days.

Figure 8.16 Perfluorocarbon overfill



Perfluorocarbon is injected into the eye and allowed to reflux up the infusion line until a little emerges from the stopcock. The stopcock is immediately closed. In this case a 20-gauge infusion is being used to reduce resistance to the perfluorocarbon reflux up the infusion line. Getting a complete pfcl fill is a little more difficulty when cannulas are used because their tips protrude into the vitreous cavity.

Giant retinal tears are particularly prone to develop PVR. These are complex and difficult cases to manage. Removal of the lens, vitreous base dissection and other techniques described in the PVR section of this book are required to deal with them.

Movie 8.27 Giant retinal tear with anterior PVR

This eye had lensectomy followed by vitreous base dissection. Residual perfluorocarbon from a previous operation is present.

Detachments due to macular holes

Macular holes rarely cause retinal detachments. Most cases of macular hole detachment occur in highly myopic eyes. Optical coherence tomography examination may reveal coexistent foveoschisis.

High success rates have been reported using macular buckling techniques. Most surgeons are more comfortable using an internal approach however. Vitrectomy relief of traction on the hole and internal tamponade gives good anatomical closure rates. Success rates seem to depend on the technique used. Removal of all epiretinal membranes and internal limiting membrane following complete removal of the posterior hyaloid seems to be particularly important. This ensures removal of all contractile elements from the retinal surface and may also increase retinal elasticity.

Detachment of the posterior hyaloid and internal limiting membrane removal can be challenging in these cases. Vitreoschisis is often present - triamcinolone may be helpful in detecting it. Vital staining of the internal limiting membrane is very helpful in visualizing the membrane in cases with extensive chorioretinal atrophy. The dye may be introduced after air-fluid exchange to prevent it migrating under the retina.

Figure 8.17 Macular holes and retinal detachment

In this case the macular hole is secondary to a detachment resulting from a peripheral break. If the detachment is fixed this will resolve in about 30% of cases.

Peeling under perfluorocarbon may be performed if the detachment is very mobile but in most cases is unnecessary and may cause subretinal displacement of perfluorocarbon. If perfluorocarbon is injected the eye should be tilted nasally and the perfluorocarbon injected over the optic disc.

Air-fluid exchange is performed with subretinal fluid drainage through the macular hole. Both long acting gas and silicone oil have been used as tamponade agents. The author's current practice is to reserve the use of silicone oil for redetachments. No retinopexy is applied to the hole.

Movie 8.28 Drainage of subretinal fluid

The subretinal fluid may be drained with air exchange through the macular hole.

Knowledge Review

Review 8.1 Vitrectomy

Which statement regarding vitreous incarceration in entry sites is incorrect

- **A.** The incidence is reduced by the use of valved cannula hubs.
- **B.** May be managed by air infusion.
- **C.** In 20-gauge vitrectomy can usually be released by indented trimming of incarcerated vitreous. ✓
- **D.** Is indicated by radial folds of retina radiating to a sclerotomy
- **E.** Is more likely to occur if the infusion is left on when instruments are removed from the eye

Check Answer

Review 8.2 Internal search

When performing internal search with external indentation

- **A.** Flap tears are found within the vitreous base.
- **B.** Care must be taken to prevent fluid refluxing out of the eye up the infusion line.
- **C.** The location of the vitreous base cannot usually be determined.
- **D.** Very small breaks may be identified using the dye extrusion technique.

Check Answer

Review 8.3 Internal drainage of subretinal fluid

Which statement is incorrect>

- **A.** Internal drainage of subretinal fluid is usually combined with air-fluid exchange.
- **B.** Macular detachment and folds result from incomplete drainage of subretinal fluid.
- **C.** The postoperative posture has no effect on the incidence of macular folds.
- **D.** Macular folds are more likely to occur following surgery for superior detachments.

Check Answer

Review 8.4 Retinopexy

Regarding retinopexy during vitrectomy for retinal detachment:

- **A.** The chorioretinal adhesion is maximal 5 days after cryotherapy.
- **B.** The chorioretinal adhesion insignificant until 10 days after laser retinopexy.
- ✓ **C.** Difficulty achieving laser uptake along the posterior border of a tear in an air filled eye may be managed by aspirating pre and subretinal fluid.
- **D.** Laser retinopexy is thought to induce more pigment dispersion than cryotherapy.

Check Answer

Review 8.5 Giant retinal tears

Question 1 of 4

Causes of giant retinal tear include

- **A.** Marfan's syndrome.
- **B.** Blunt ocular trauma.
- **C.** Sticklers syndrome.
- **D.** Penetrating ocular trauma.
- **E.** Attempted removal of intravitreal lens fragments with a phacoemulsification probe.
- ✓ **F.** All of the above.

Check Answer

Review 8.6 Macular hole detachments

Which statement is INCORRECT regarding management of a retinal detachment with a macular hole

- **A.** When managing a case in which the macular hole is not the primary break it is reasonable to treat the primary break in the first procedure and perform a secondary procedure if the macular hole fails to close.
- **B.** If the macular hole is the causative break every effort should be made to peel any epiretinal membranes.
- **C.** Retinopexy to the macular hole is mandatory.
- **D.** If the macular hole is the causative break macular buckling is usually successful.
- **E.** Internal limiting membrane is easily visualized without staining in eyes with myopic chorioretinal atrophy.
- **F.** Many eyes have associated staphylomas and myopic foveoschisis.

Check Answer

CHAPTER 9

Epiretinal Membranes

Epiretinal membrane (ERM) is a common cause of unilateral visual impairment. When ERMs have a significant impact on visual function and quality of life vitreoretinal surgery may be very beneficial.

Pathology and pathogenesis

Figure 9.1 PVD and ERM

Most eyes with idiopathic epiretinal membrane have a PVD

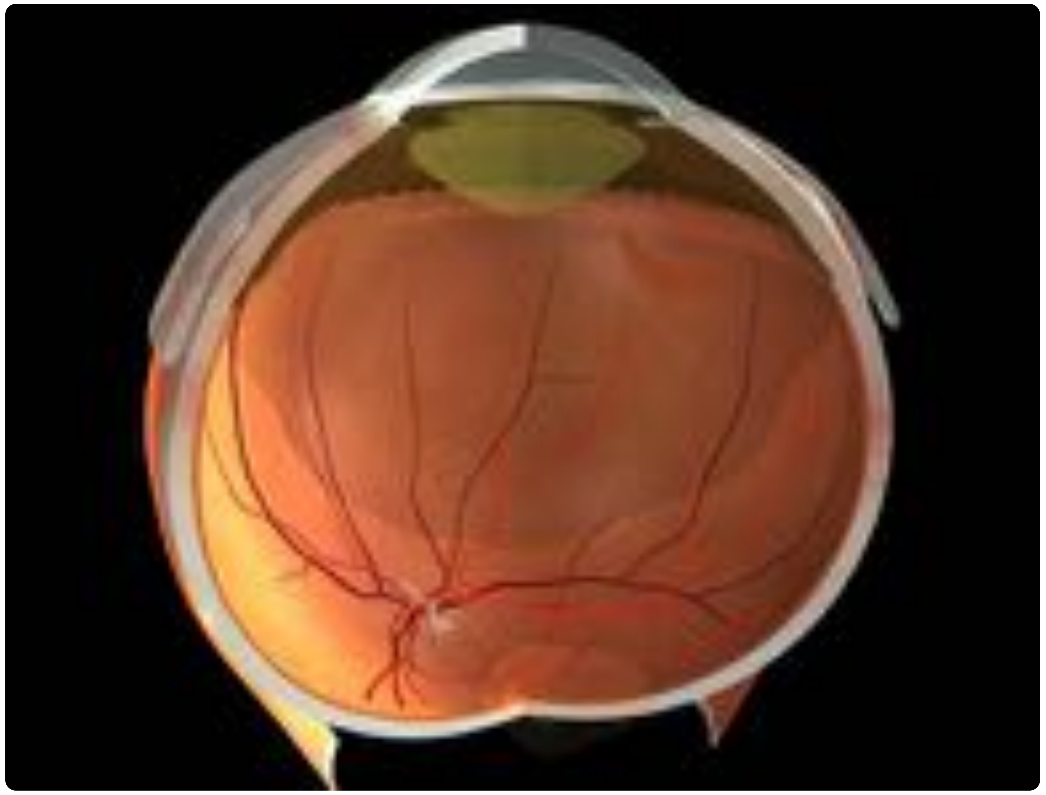
The strong association between PVD and ERM implies that vitreous separation plays a role in the pathogenesis of ERM. **Anomalous PVD** may leave residual hyalocytes on the internal limiting membrane. Alternatively small breaks in the internal limiting membrane may result in Muller cell migration, proliferation and transformation to fibroblasts.

In some cases with peripheral retinal breaks the cells in the ERM seem to originate in the RPE. These membranes behave differently from other idiopathic ERMs. They develop very quickly, contract more and have a very profound effect on vision. They are probably focal PVR at the macula.

The association with PVD has an important clinical implication: the peripheral retina should be checked for retinal breaks.

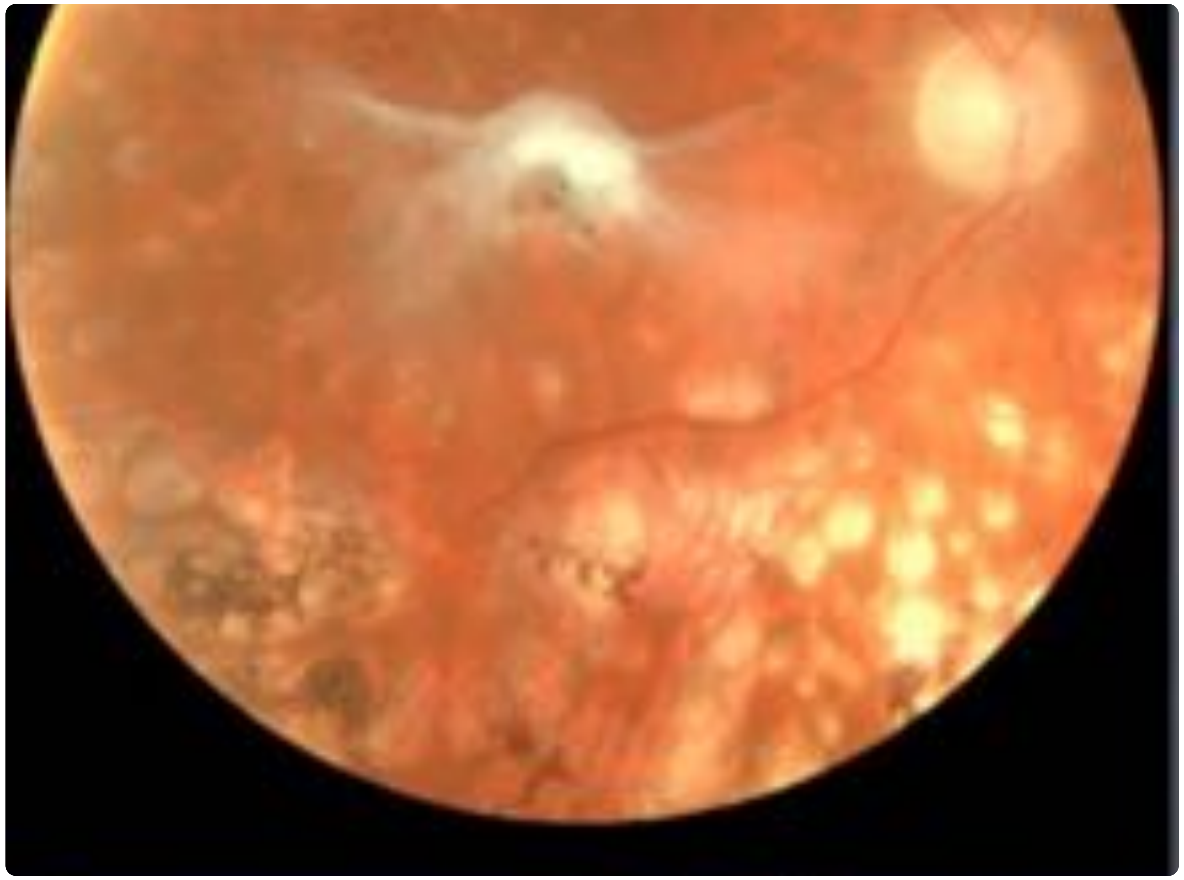
Given the association with PVD and ERM it follows that any condition that causes PVD may also cause ERM. There are very few pathological conditions in the posterior segment which are not associated with ERM.

Figure 9.2 ERM and tear



The peripheral retina should be examined in any eye with a PVD.

Figure 9.3 Many conditions are associated with epiretinal membrane



Proliferative diabetic retinopathy.

EPIDEMIOLOGY OF ERM

Epiretinal membranes are very common in population based studies - as many as 11.8% of the older population with a 2.4% bilateral incidence. The incidence is 39% in certain ethnic subgroups. The vast majority of these do not affect visual function

This fact has important implications for clinical practice. Not every patient with an ERM requires surgery. Furthermore not every patient in whom an ERM is discovered while undergoing work up for cataract or age-related macular degeneration requires surgery.

Clinical features of epiretinal membranes

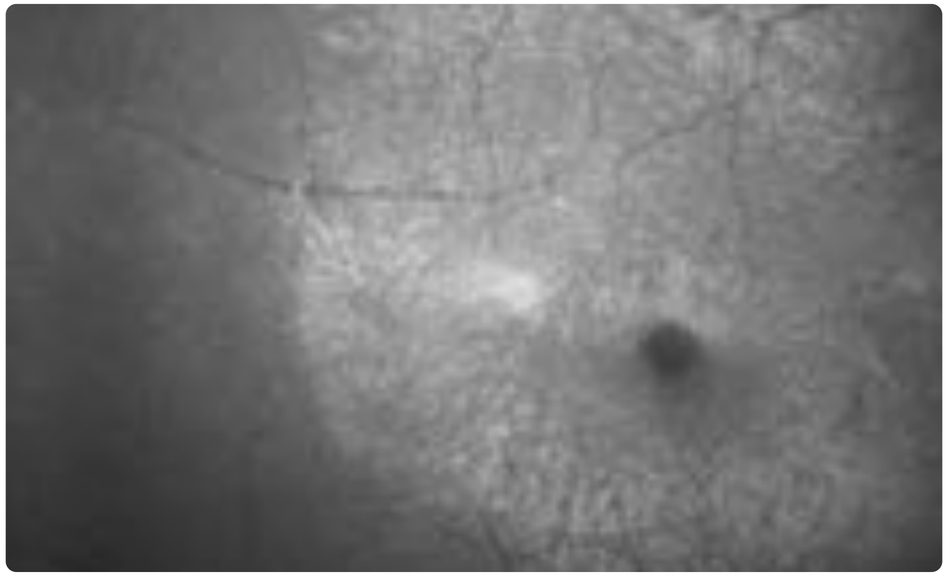
The clinical appearance of epiretinal membranes depends on their opacity, the degree of contraction and the degree to which this affects other structures in the retina.

Centripetal contraction may cause retinal tissue to become bunched around the fovea giving the false impression of a macular hole - a pseudohole. These do not develop into full thickness holes and their presence does not influence management.

Movie 9.1 Development of a macular pseudohole

Pseudoholes arise from centripetal contraction with tissue bunching. The foveal thickness remains normal.

Figure 9.4 Appearance of epiretinal membranes

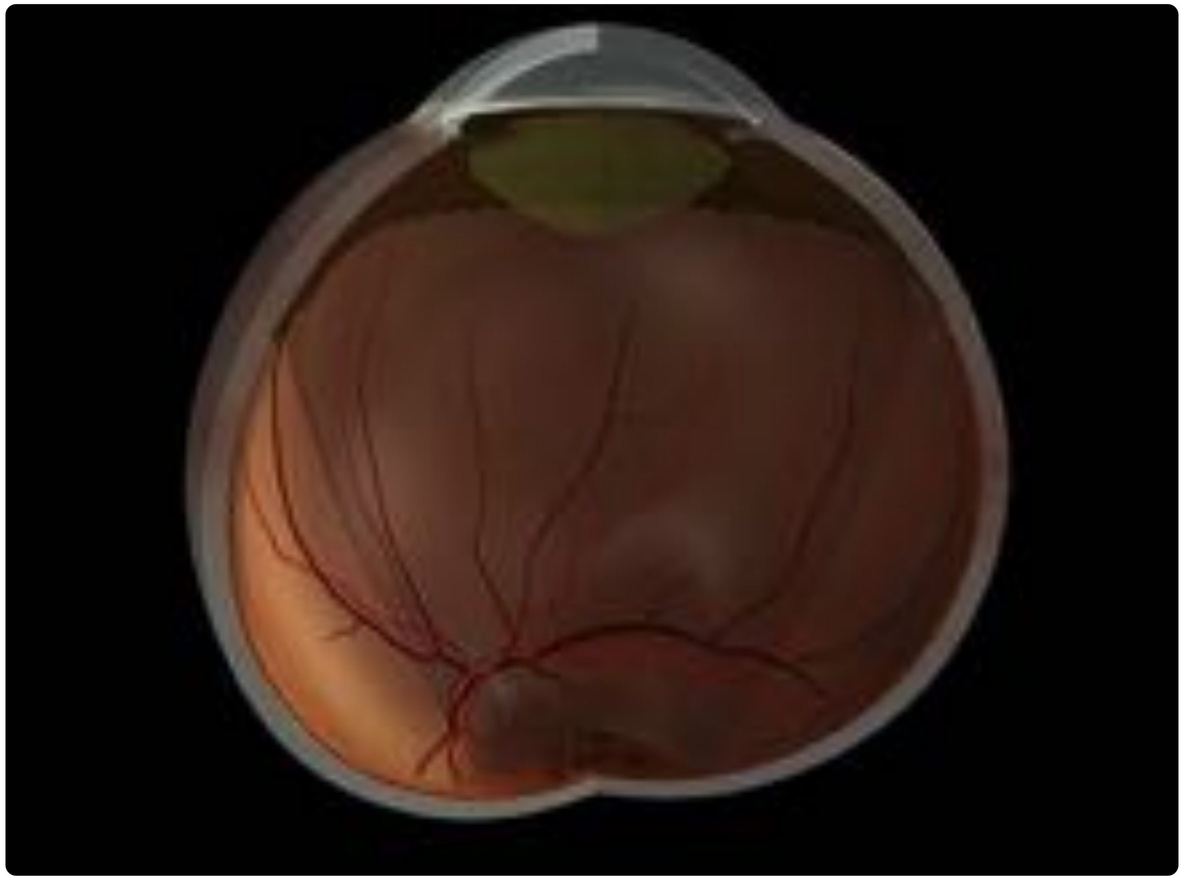


A specular sheen is present in mild cases which has been termed ‘cellophane maculopathy’

Differential diagnosis of ERM

The essential distinction between ERM and vitreomacular traction syndrome (VMT) is the presence of anteroposterior traction in the latter. Both conditions seem to be part of a spectrum of disorders -anomalous PVD - characterized by varying degrees of vitreomacular adhesion, epiretinal proliferation and vitreous separation. This spectrum includes impending and full thickness macular holes and symptomatic vitreomacular adhesions.

Figure 9.5 Differential diagnosis of epiretinal membrane



Anteroposterior traction is the distinguishing feature of VMT.

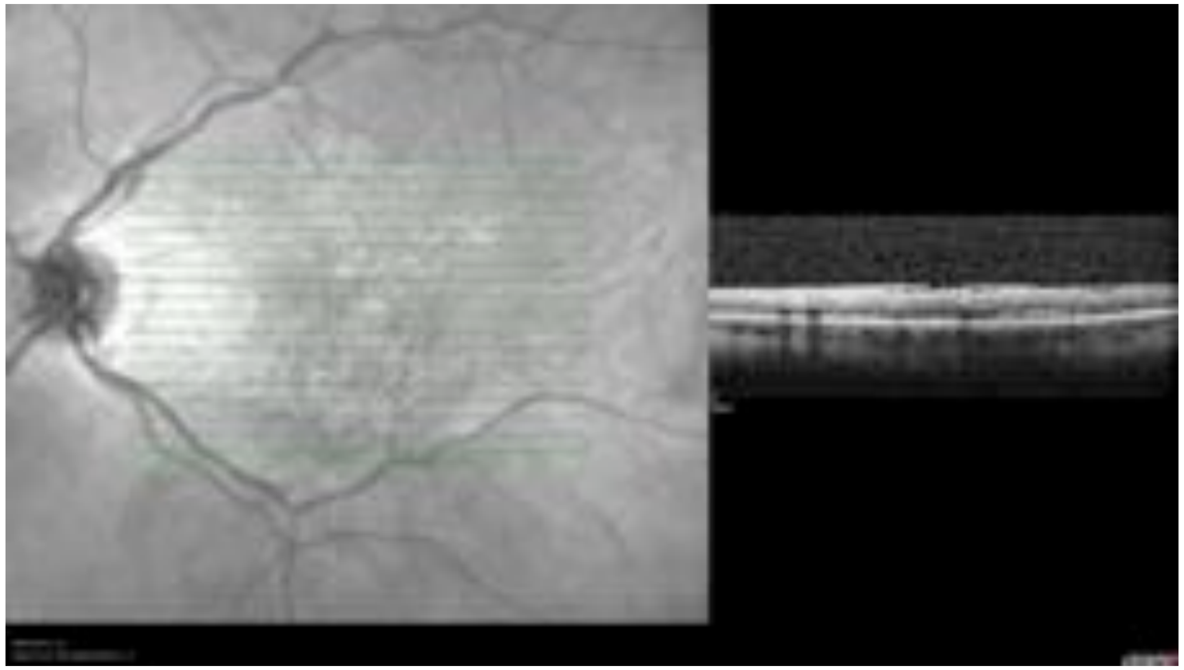
Clinical assessment of ERM

A comprehensive assessment should focus particularly on:

- The symptoms experienced by the patient.
- The effect of these symptoms on the patient's quality of life.
- The presence of a PVD and associated tears.
- The presence of an underlying cause for the ERM.
- Exclusion of significant copathology.

Optical coherence tomography (OCT) is particularly helpful in excluding other causes of visual loss but also gives some indication of the likely outcome of surgery.

Movie 9.2 The value of OCT in ERM assessment



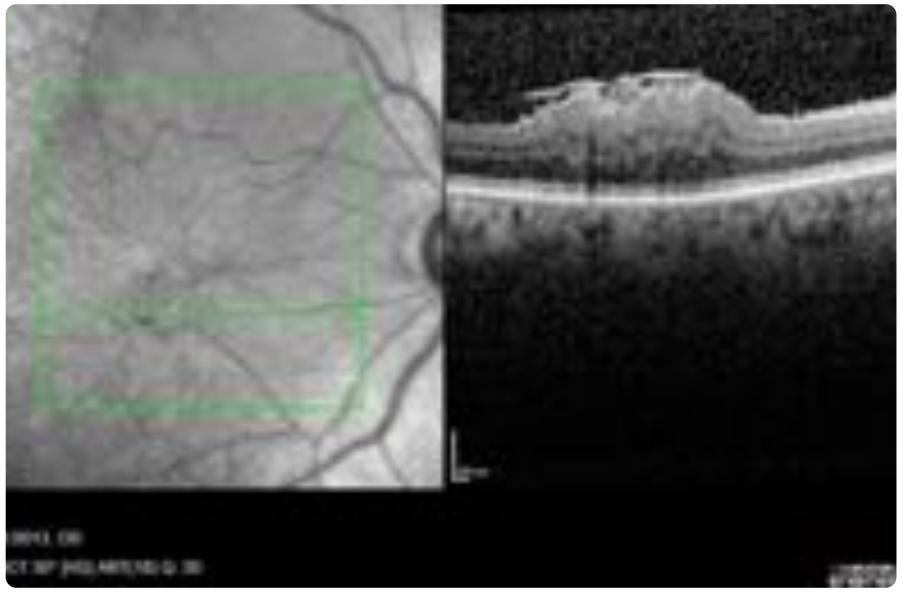
This patient complained of distortion and was referred for surgery. OCT confirmed the presence of an ERM but also demonstrated the presence of a choroidal neovascular membrane.

OCT FEATURES OF ERM

The features of ERM on OCT are:

- Visible reflective layer above the retina.
- Hyperconvolution of the internal limiting membrane.
- Varying degrees of retinal thickening.

Figure 9.6 OCT features of epiretinal membrane



Epiretinal membrane. Note the IS/OS junction is well preserved - this patient did well with surgery.

In long standing cases the following changes may be seen on imaging which may indicate a poorer prognosis following surgery:

- Submacular pigment changes.
- Discontinuity in the inner segment/outer segment layer.
- Reduced autofluorescence.

Surgical techniques for epiretinal membrane

In the past surgery was offered only when visual acuity declined to an arbitrary point.

As epiretinal membrane surgery has become progressively safer and more effective the functional threshold for surgery has become lower. Many patients with relatively good visual acuity in the affected eye are very disturbed by binocular diplopia arising from metamorphopsia and aniseikonia. These patients generally appreciate the improved vision and experience a substantial improvement in their binocular visual function and quality of life with surgery.

Patients who present with long standing epiretinal membranes often have few binocular symptoms even if the visual acuity in the affected eye is poor. Although vision may improve after surgery, sometimes quite dramatically, the positive impact on the patient's overall quality of life may be small. This should be taken into account when discussing the risks and benefits of intervention with patients.

Although the results of surgery are better with early intervention surgery on asymptomatic ERMs is not justified. This is because relatively few of these progress. For this reason there is also no indication for operating on incidental ERMs in a cataract patient with no symptoms attributable to the ERM. It has been argued that combined surgery should be routinely undertaken in case cataract surgery exacerbates the ERM but there is no evidence that this occurs.

MICROSURGICAL ERGONOMICS

When operating on the surface of the retina movements of the tips of the instruments must be very precise (with a tolerance of a fraction of a mm). There are a number of ways of facilitating this:

- A precision grasp should be used to hold the instruments. Precision grasps are those are those in which the distal interossei predominate in controlling movements, in contrast to power grasps which employ the proximal interossei. There are several variations of precision grasp which may be useful in manipulating microsurgical instruments. These include the writing tripod and the prismatic 3 finger grasp. Trainees will have developed preferred precision grasps in early development as they learn cursive script so the trainer should not be unduly proscriptive regarding individual preferences between them. It is also important that the instruments are not grasped too firmly as this reduces the ability to perform small controlled movements.
- The operating hands should rest on the patient's forehead or a wrist rest such as the Chan ring. One advantage of resting directly on the forehead is that any movement of the patient's head is transmitted to the instruments and is less likely to result in retinal injury from the tip of the instruments.
- There must be as little tension in all the muscles of the arm, from the deltoid down to the interossei, as possible. The surgeon's elbows rest on the arms of a surgical chair and the wrists on the forehead (or the wrist rest). The chair and operating table height are adjusted so that the surgeon is comfortable.

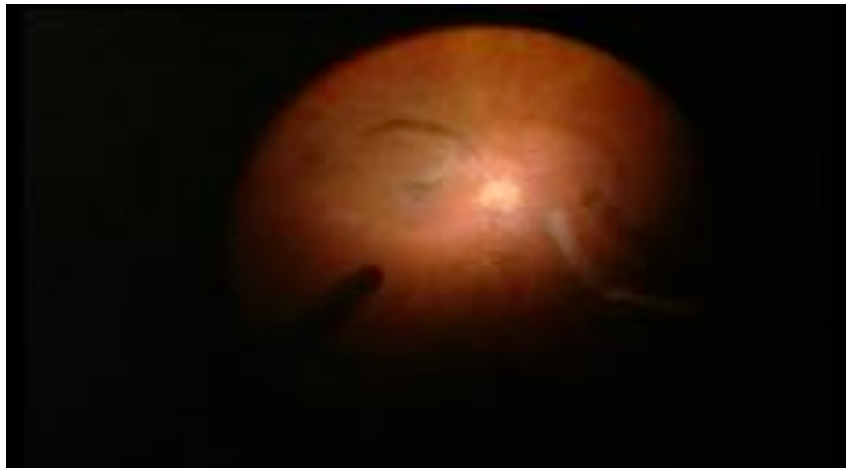
Figure 9.7 Microsurgical ergonomics

A prismatic 3 finger grasp.

A pars plana vitrectomy is carried out. If the hyaloid is attached a PVD is induced. Sometimes the ERM separates when this is done.

Peeling the internal limiting membrane seems to reduce recurrence rates. This may be because it removes glial remnants after the initial peel. The techniques for internal limiting membrane peeling are similar to those for epiretinal membrane peel so these will be considered together.

Movie 9.4 Separation of epiretinal membrane with posterior hyaloid



STAINING THE EPIRETINAL MEMBRANE AND INTERNAL LIMITING MEMBRANE

There are a variety of vital stains which can be used to enhance the visibility of epiretinal tissue. These make surgery technically easier and increase the likelihood of complete clearance of epiretinal tissue. Trypan blue is particularly effective in staining epiretinal membranes. Other dyes such as indocyanine green or brilliant blue are more effective in staining internal limiting membrane. At the time of writing brilliant blue is not available in all countries. Whichever dye is used care should be taken not to create a jet which drives the dye through the hole. Some dyes are negatively buoyant and can be gently trickled onto the posterior pole from the mid vitreous cavity. Failure of dye to stain the retina may indicate the presence of a residual layer of cortical vitreous which may be stained with triamcinolone.

Movie 9.3 Injecting trypan blue and the result

Modern dyes are negatively buoyant. They can be injected in the centre of the vitreous cavity and allowed to trickle down to the posterior pole.

ENGAGING THE EPIRETINAL MEMBRANE

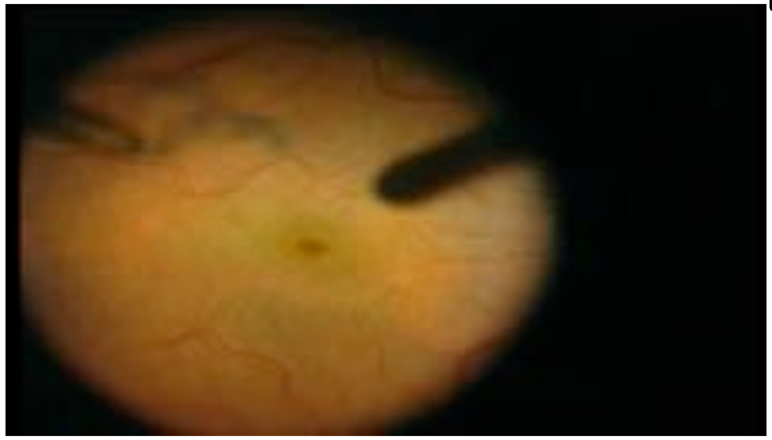
The wide angle viewing system is exchanged for one giving greater magnification and z axis resolution at the macula - either a planoconvex contact lens or a special macular lens for the wide angle viewing system.

When operating near the retinal surface vigilance is required for subtle signs that the surface of the retina is being touched.

The instrument shadows that are seen during vitrectomy are actually cast on the pigment epithelium, not the retina. This means that although they may be used to indicate when one is approaching the retina they cannot be used to determine when the surface of the retina is touched. A very subtle alteration in specular reflection from the retinal surface indicates that the instrument is in contact with, and very lightly indenting the surface of, the retina.

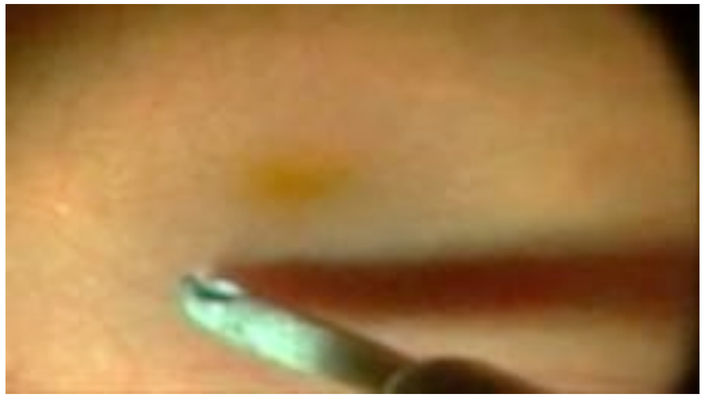
If excessive force is used a much less obvious whitening is seen as blood is forced out of the choriocapillaris.

Movie 9.5 Retinal shadows



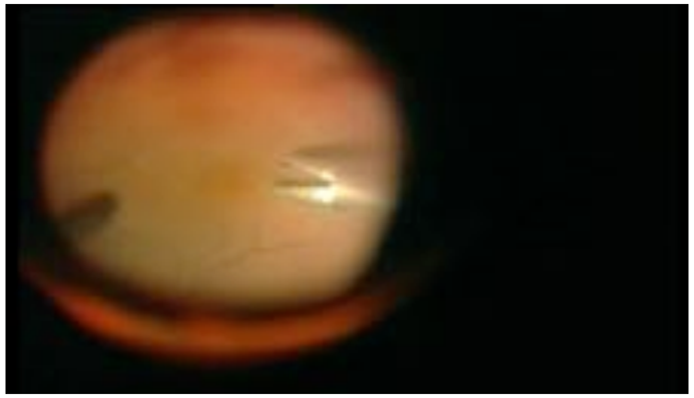
Note the shadows of retinal vessels on the pigment epithelium

Movie 9.6 Specular reflection from the internal limiting membrane



After a pause this movie clip plays twice, the second time at 50% speed. The reflections are seen above the tip of the forceps.

Movie 9.7 Excessive force - blanching of the choriocapillaris



Blanching of the choroid is an indication that the pressure is too great. The changes are more widespread and less subtle than the specular reflections.

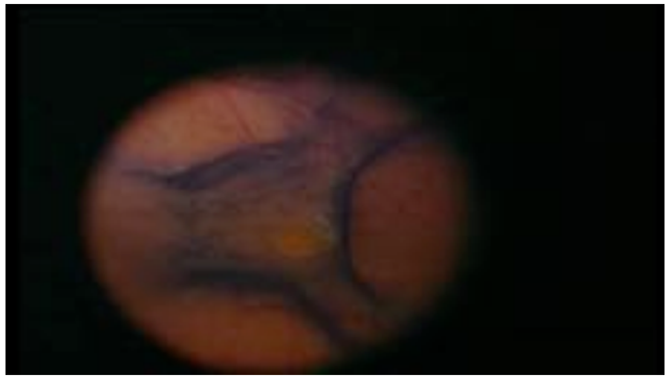
Sometimes as an epiretinal membrane contracts its edge spontaneously separates from the retina. It then rolls up (like a roller blind) to give a circumlinear slightly raised edge. This may be engaged with a pick or, more commonly, grasped with end gripping forceps.

More commonly no such edge is present. There are a number of ways of elevating part of a membrane.

The tip of a pick my be advanced into the membrane and then lifted. The flattened area on the top of the pick lifts the membrane.

Alternatively the edge of the tip of the pick, rather than the very tip itself, may be used to engage the membrane and tear it. This may be particularly useful when peeling membranes off detached retina.

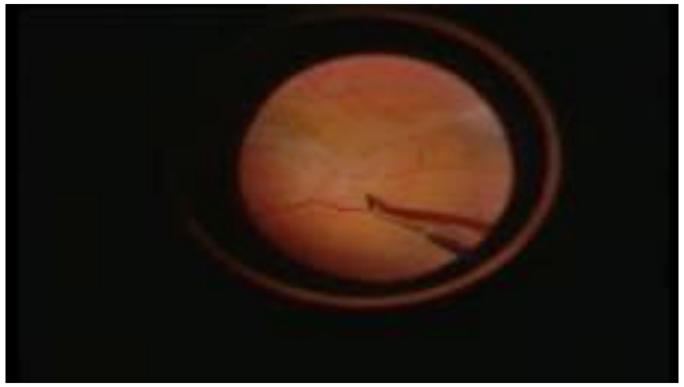
Movie 9.8 Grasping the edge of the membrane



Grasping a visible rolled edge with forceps

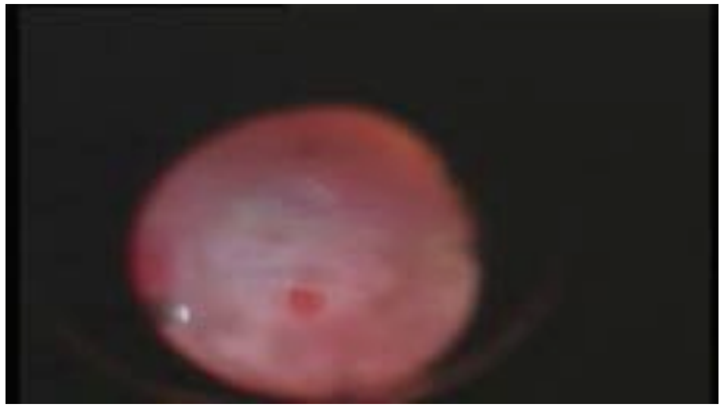
Many experienced surgeons dispense with the pick and do the whole peel using only

Movie 9.9 Engaging with the tip of the pick and lifting.



Engaging the membrane with the tip of a pick, then lifting. The flattened upper surface of the pick is used during lifting to avoid laceration of the membrane. Note the specular reflections from the membrane as it tears and lifts.

Movie 9.10 Engaging with the edge of the tip



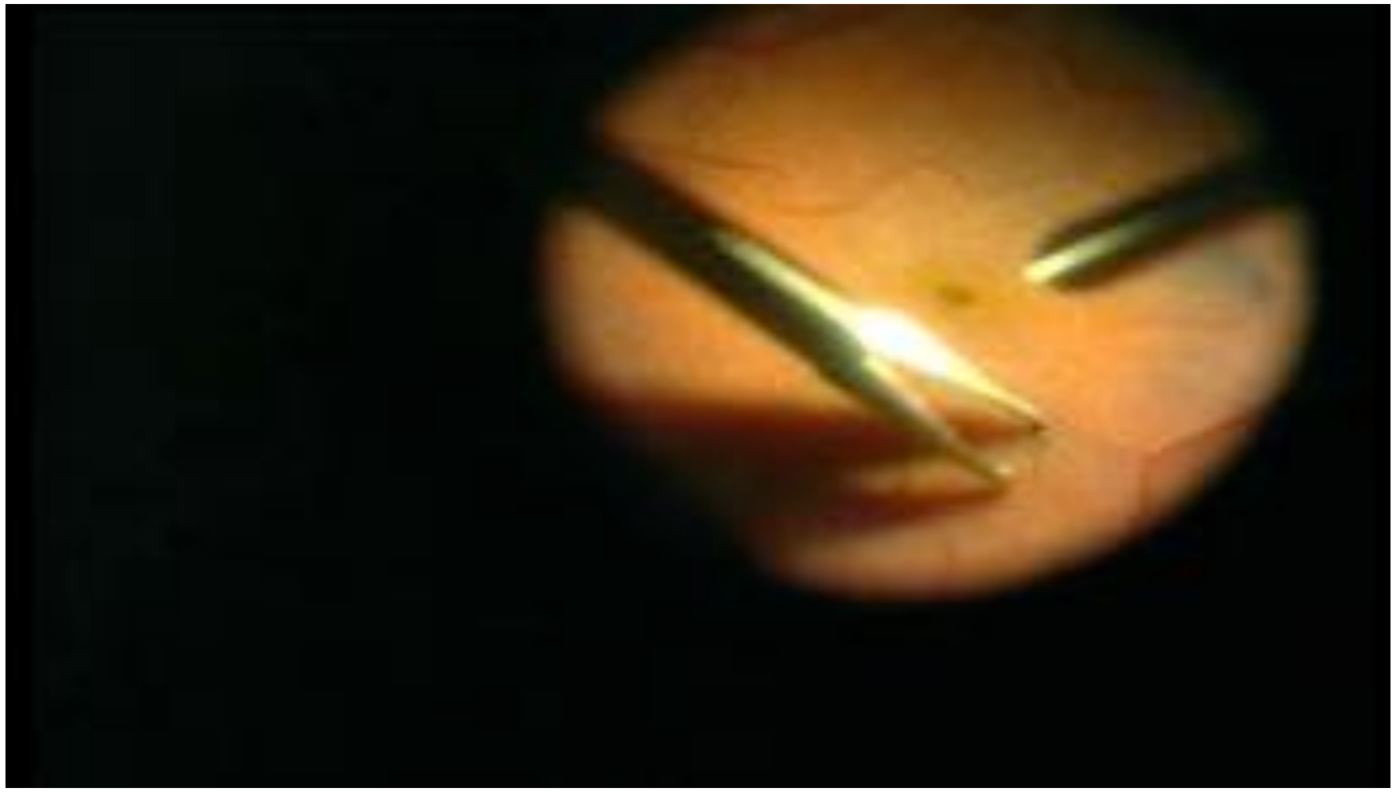
This technique is particularly useful in cases like this where the retina is detached. It may also be used in attached retina cases.

and end gripping forceps using a pinch and lift technique.

The forceps are placed on the membrane with the jaws slightly open. As they are closed a pinch of membrane is engaged. The forceps are then lifted. The membrane separates from the retina but tears if its elastic tolerance is exceeded.

If the forceps are opened too wide before closing retinal tissue may be inadvertently included in the pinch. This may not become apparent until the membrane is lifted. If this happens the forceps are opened to allow the retina to fall back a little. The membrane will then have separated enough to allow an edge to be grasped separately from the retina.

Movie 9.11 Pinch and lift using a forceps



AVULSION OF THE MEMBRANE

Once an edge has been lifted the manner in which it delaminates depends upon:

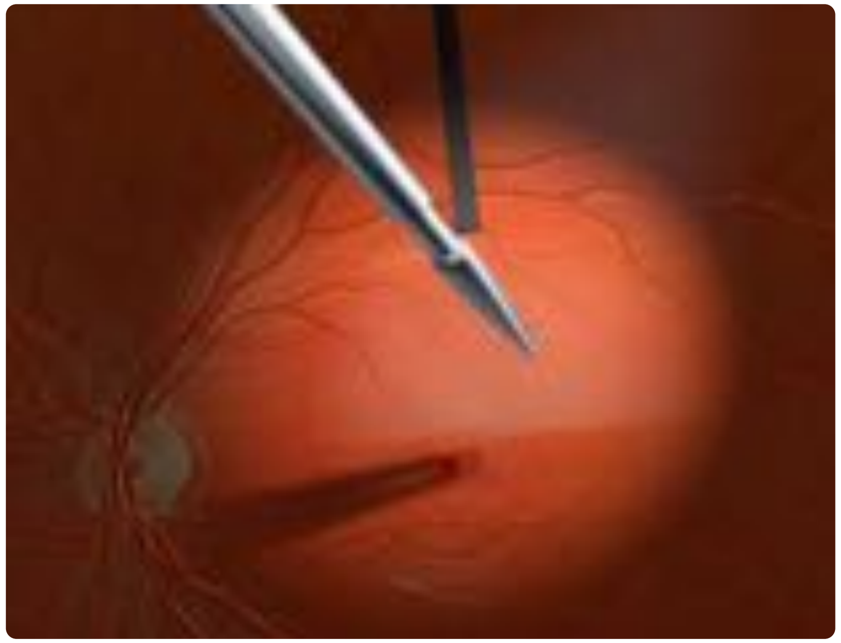
- Its adhesion to the retina.
- The elasticity of the membrane.
- The vectors of pull, both vertically and horizontally.

As the membrane delaminates it should be regrasped often so that both forceps and delamination point can be visualized simultaneously.

PEELING INTERNAL LIMITING MEMBRANE

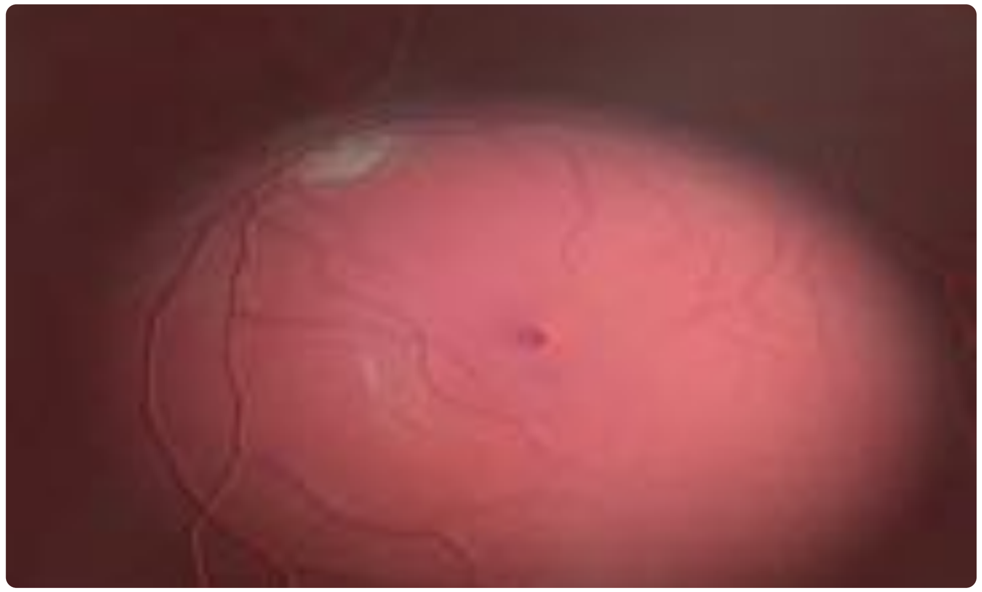
The general principles of peeling internal limiting membrane (ILM) are the same as those of peeling epiretinal membrane. Because it is particularly inelastic and adherent to the nerve fibre layer the direction of pull should be perpendicular to the initial tear. The physics of tearing thin inelastic films off an adherent substrate has been analyzed. The tear has a tendency to narrow as it is peeled. This seems to be exacerbated by pulling too vertically. Once the tear has a right angle bend at one edge it may be grasped near this bend and controlled in the same manor as a capsulorrhexis. It is often necessary to perform this 'maculorrhexis' in two steps - initially tearing off a thin radial strip and then grabbing one edge of this to tear around in a circle. As with epiretinal membrane peeling many experienced surgeons perform the whole maneuver using forceps only but trainees may find it helpful to perform it as described here.

Figure 9.8 Direction of pull



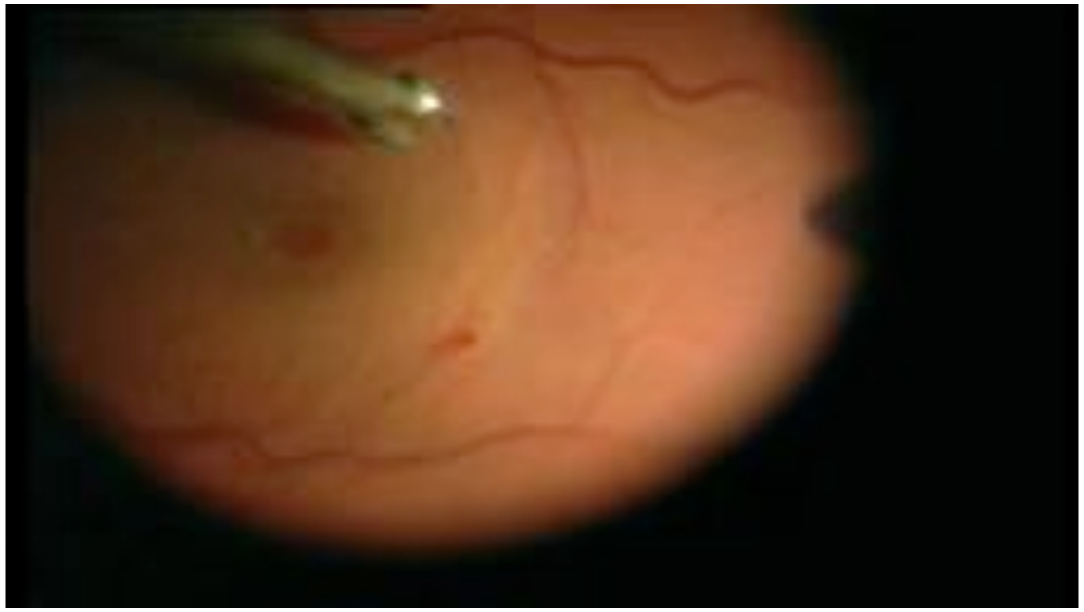
The initial direction of pull should be perpendicular to the line of the tear.

Figure 9.9 'Maculorrhexis'



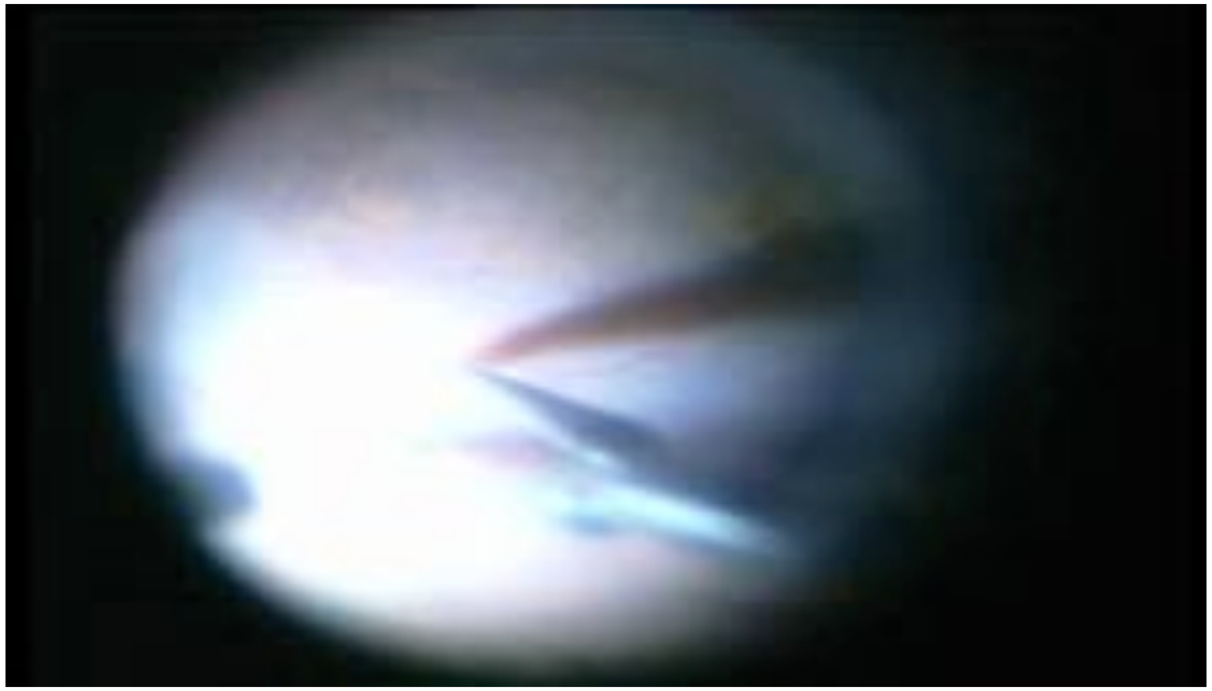
In this case the retina was stained with brilliant blue

Movie 9.12 Adjustments to the microscope while peeling



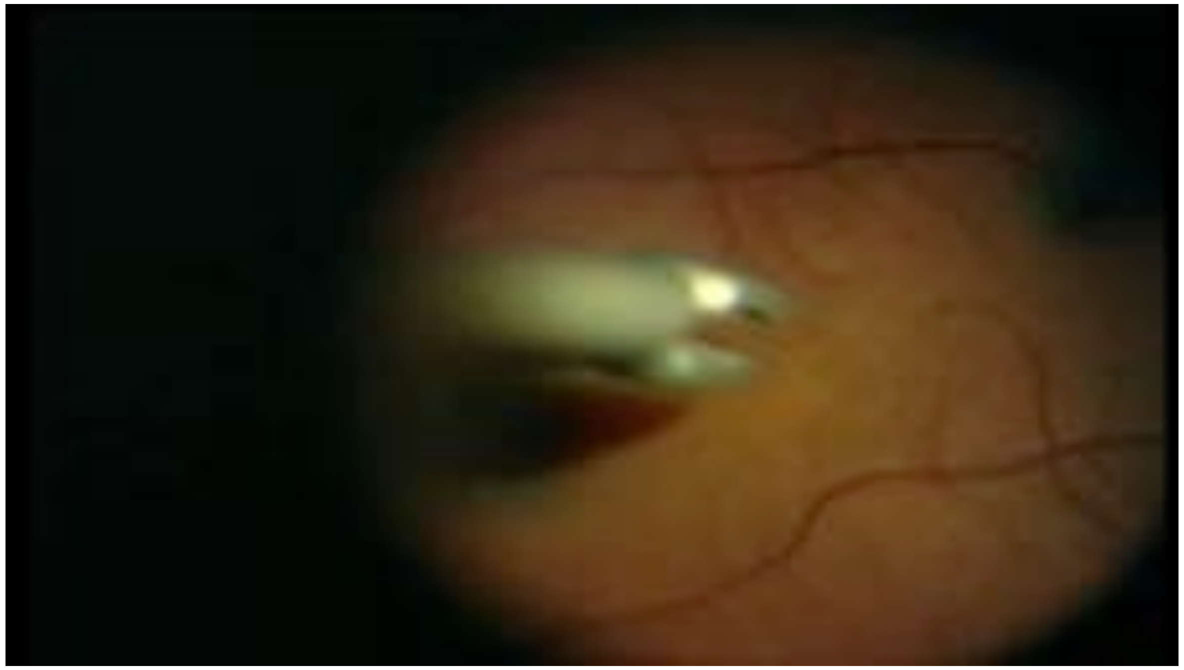
There are many mistakes here. The flaps are not regrasped often enough. The microscope foot pedal x-y control is adjusted while instruments are near the retinal surface. The tips of the instruments move in an uncontrolled way when this is done. This is very dangerous and may lead to retinal laceration. The instruments should be withdrawn slightly from the retina surface before any adjustment is made to the microscope.

Movie 9.13 Retinal laceration.



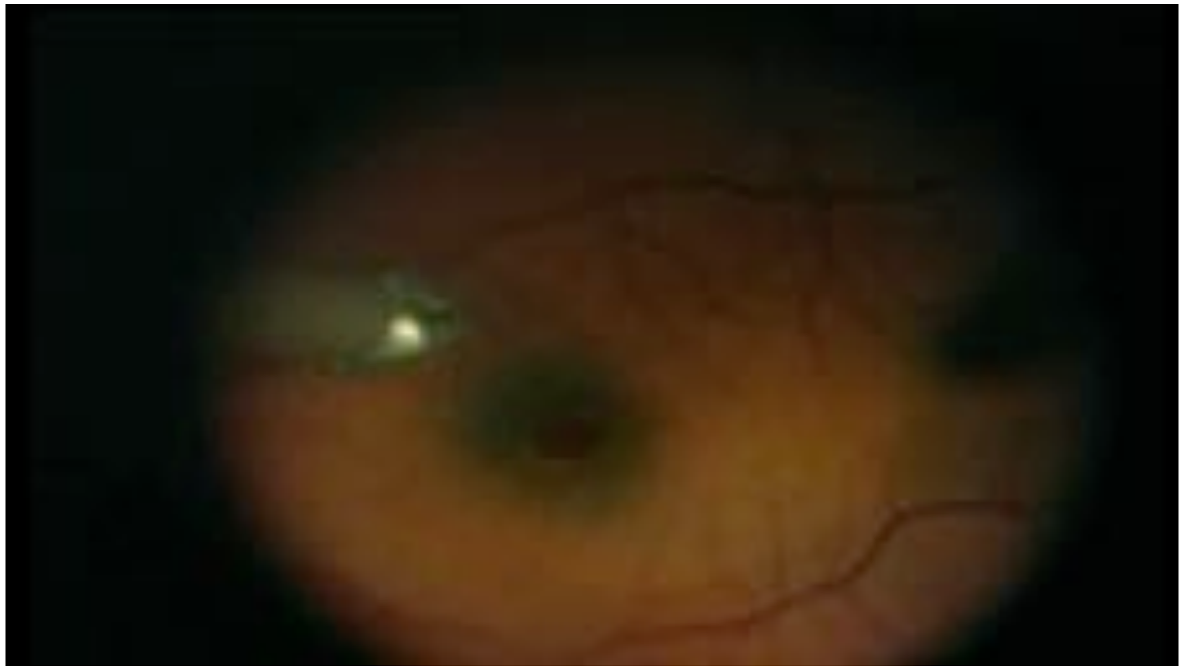
Failure to regrasp resulting in a very large flap. The surgeon cannot visualize the delamination point and the forceps simultaneously. The forceps disappear out of view and lacerate the retina.

Movie 9.14 Forceps closing progressively



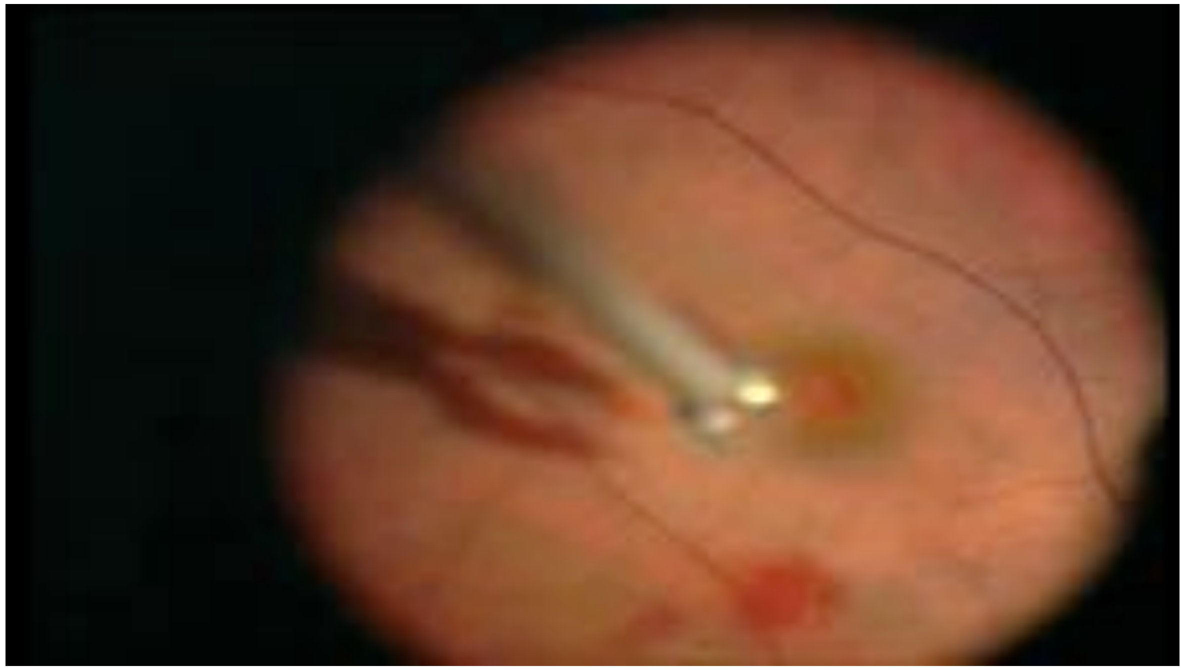
The forceps are being closed progressively as they approach the retina. By the time they touch the retina they are closed. This is a surprisingly common error among trainees. The cause is uncertainty regarding the point at which the retina is touched. The forceps should be held slightly open as they approach the retina, then closed when a subtle change in specularity is seen. This change is seen on this video just after the tips have closed.

Movie 9.15 Avulsing the ILM flap



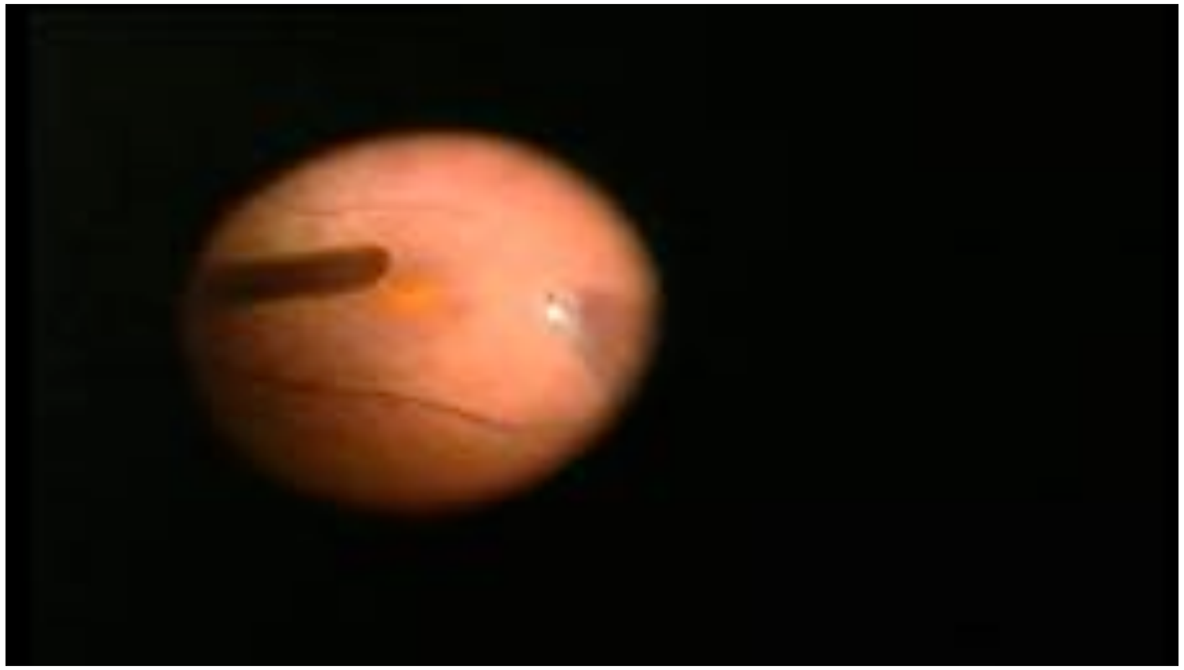
This happens because an attempt is made to turn the rhexis by pulling tangentially while grasping the centre of the ILM flap. This works with epiretinal membranes. Internal limiting membrane is less elastic and may tear if this is done. The direction of pull needs to be altered more gradually or the membrane grabbed at one end of the tear to turn it.

Movie 9.16 Movement of the tip of the forceps while closing



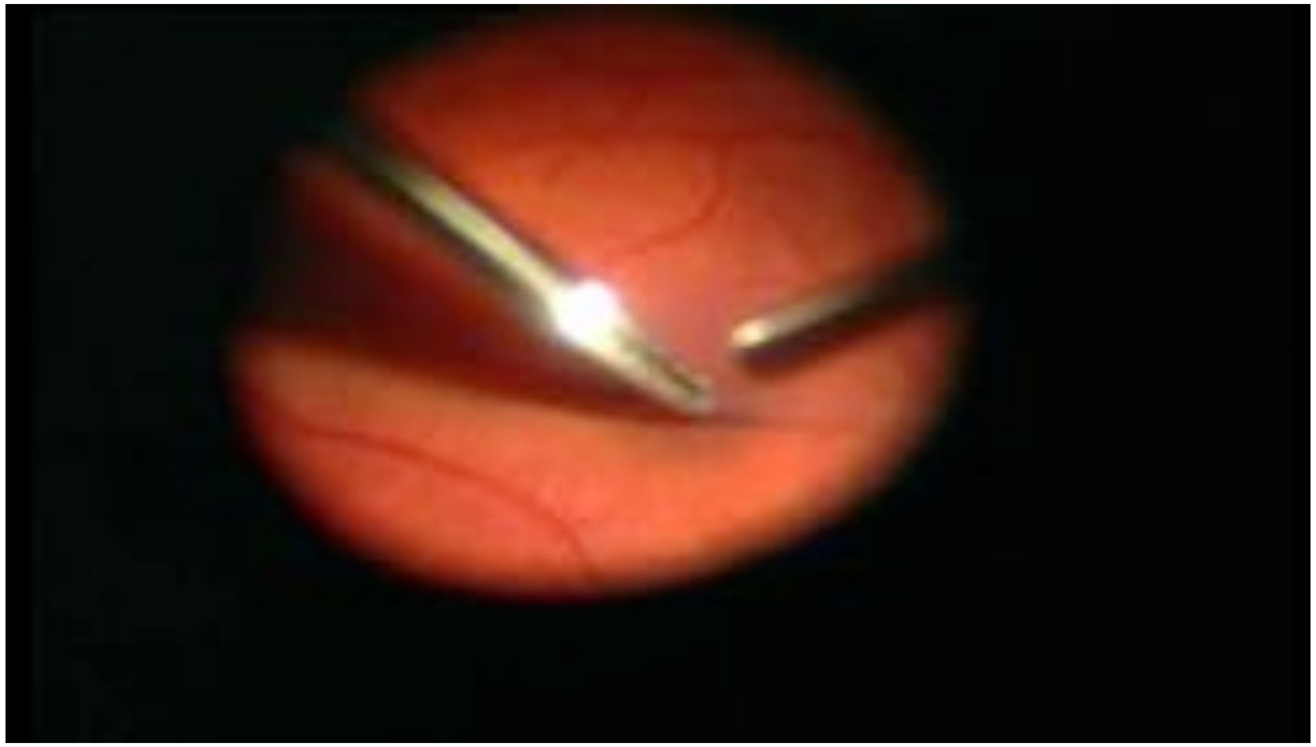
Trainees should demonstrate outside the eye that they can close a forceps without moving the tip. Failure to manage this usually indicates that the forceps are not being grasped properly.

Movie 9.17 Undue tremor



This surgeon was using an inappropriate power grip and his chair and arm rests had not been adjusted.

Movie 9.18 Iatrogenic macular hole



Signs of foveal stress such as undue deformation should not be ignored - the tissue should be peeled centripetally from several points and the foveal attachment delaminated rather than avulsed.

Myopic foveoschisis

Myopic foveoschisis is a fascinating condition which is probably under diagnosed.

It is caused by tangential traction on the surface of the retina.

Whenever tangential traction occurs between two points on a curved surface the resulting forces can be resolved into 2 vectors, one parallel to and one perpendicular to the surface. The perpendicular component increases as the radius of the curved surface decreases. For a simple illustration consider what happens when one puts on a pair of surgical gloves and slightly clenches one's fist. The rubber on the back of the hand (which is convex) is forced against the skin by the elasticity of the glove while the rubber on the other side is forced away from the palm. These forces are increased if one puts on a tighter pair of gloves (increasing the traction) or makes a tighter fist (reducing the radius of curvature).

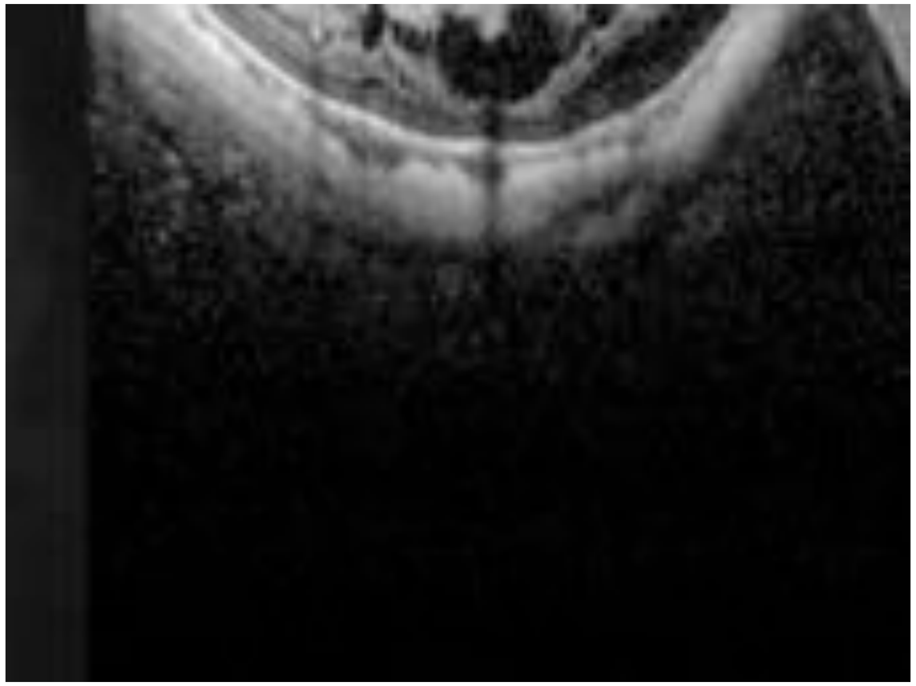
Contraction of membranes on the retina therefore generates forces that pull the retina inward. If the reattachment force generated by the RPE pump is exceeded the retina detaches. This is the basis of some tractional retinal detachments. Significant contraction is required to produce a retinal detachment. In a highly myopic eye the presence of a posterior staphyloma reduces the radius of curvature so that smaller amounts of contraction produce significant inward vectors. The RPE pump is relatively strong in the posterior pole. The fovea is therefore subject to a strong inward force on its inner side and a strong outward force on its outer side. As a result it may split - foveoschisis. The membranes that contract to produce the foveoschisis seem to be composed of both posterior hyaloid and epiretinal membrane.

Because there is often no retinal detachment the retina retains its transparency. Consequently this condition is difficult to diagnose on slit lamp examination. Unless a macular hole develops (which leads to localized retinal detachment) all that can be seen is a general impression of a gap between the retinal vessels and the RPE. Only since the advent of OCT has the frequency with which this condition occurs in myopic eyes been fully appreciated.

Figure 9.10 Myopic foveoschisis

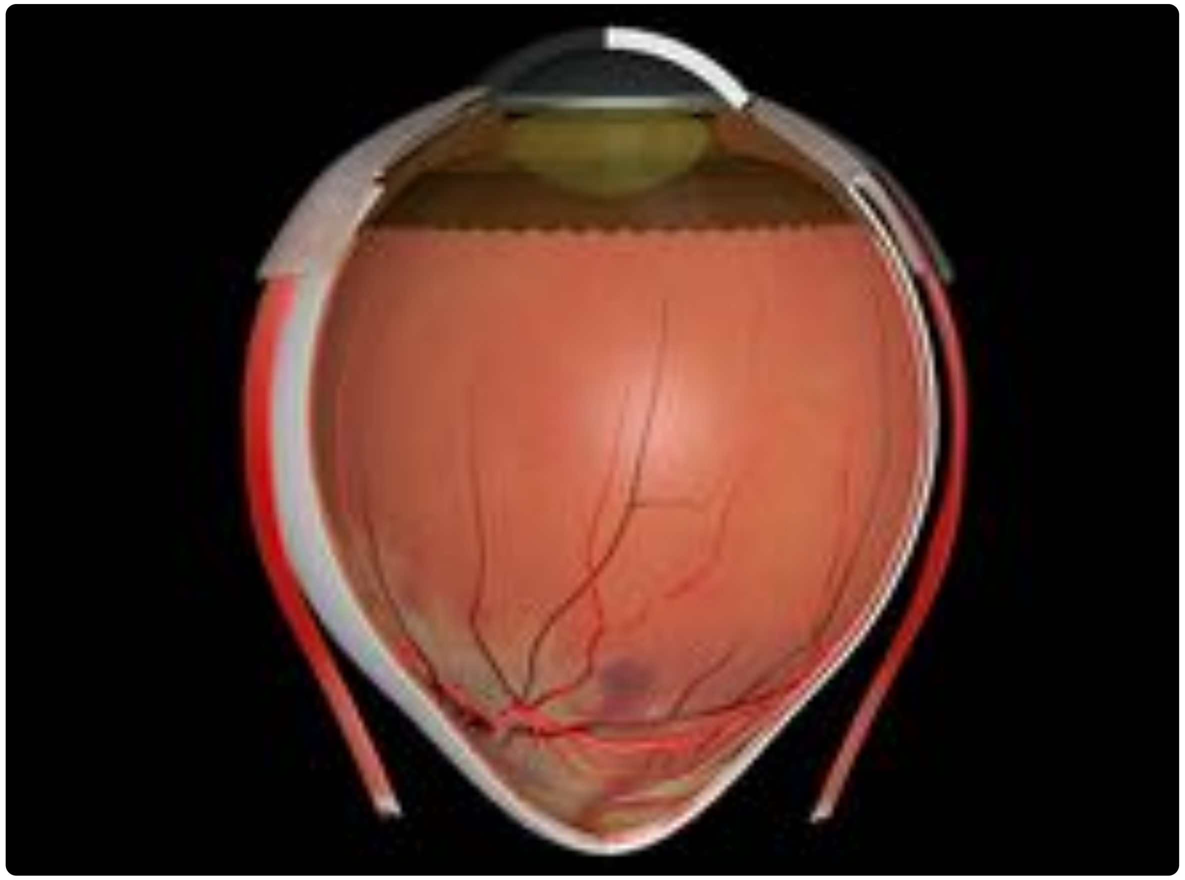
This is quite a mild case. The visual acuity had deteriorated to 20/60 for no obvious reason. The cause was only evident on OCT (next picture)

Movie 9.19 Myopic foveoschisis



Severe myopic foveoschisis. As well as schisis a macular hole is present. The preretinal membrane is also visible.

Figure 9.11 Myopic foveoschisis



This highly myopic eye has a posterior staphyloma and foveoschisis.

TREATMENT OF MYOPIC FOVEOSCHISIS

No intervention is indicated in asymptomatic cases of MFS as the visual function may remain stable. Once the vision starts the deteriorate the natural history is quite poor.

Earlier surgical intervention seems to give better surgical results in patients with reduced vision. Many eyes get progressive foveal detachment or macular hole. Early surgery should therefore be considered in symptomatic patients.

One surgical approach is the reduce the curvature of the scleral staphyloma with a macular explant. Most surgeons are more comfortable with an internal approach however.

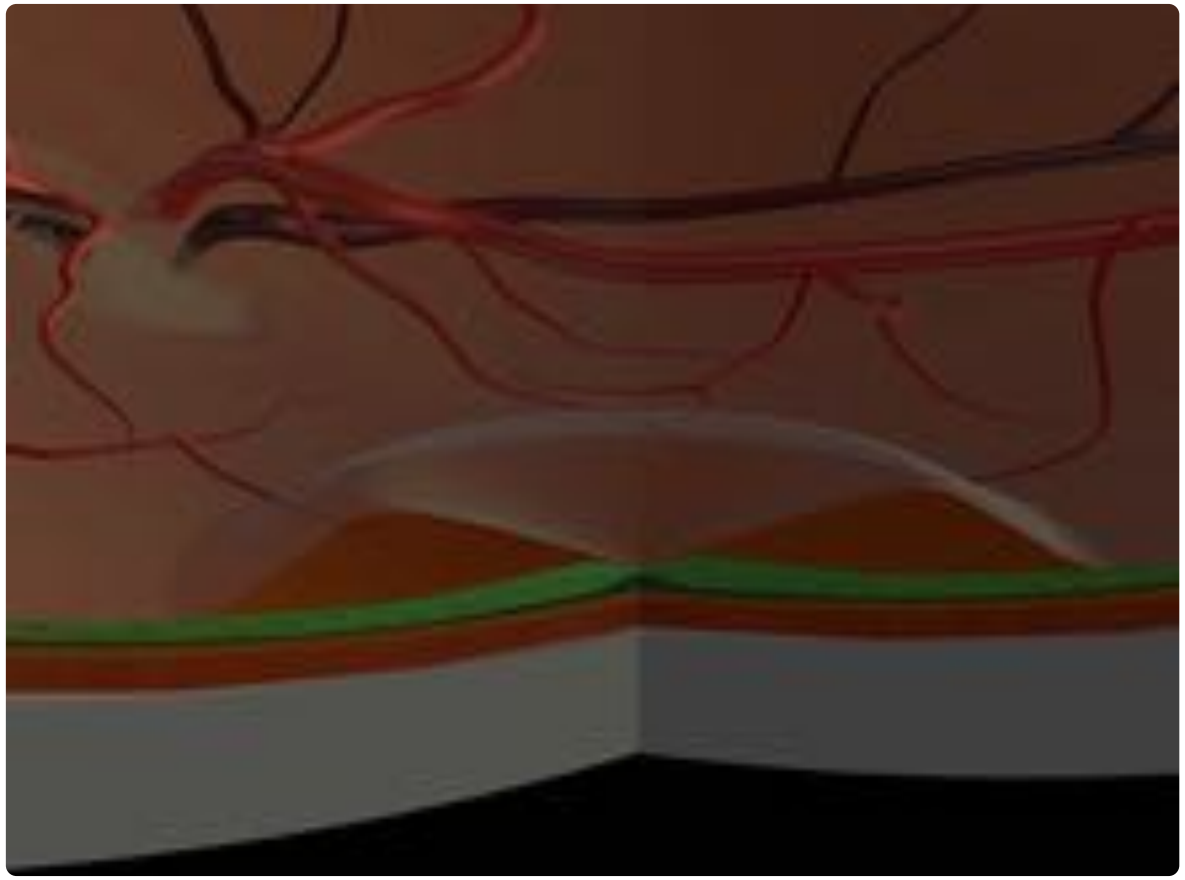
Relief of traction on the retina requires removal of the posterior hyaloid and any epiretinal membranes that may be present. Internal limiting membrane removal has also been advocated to increase the elasticity of the retina to allow it to stretch and conform to the contours of the staphyloma. The risk of iatrogenic macular hole during peeling seems to be reduced by using a fovea sparing technique. Internal tamponade is necessary in the presence of macular hole but may not be required otherwise (although some surgeons dispute this). Internal limiting membrane removal may be exceptionally challenging in these cases unless a dye is used.

Vitreomacular traction syndrome

Vitreofoveal traction is quite a common pathological mechanism which has been implicated in many posterior segment disease processes. It results from an anomalous posterior vitreous detachment in which partial vitreous separation in combination with vitreomacular adhesion generates traction on the macula. The resulting mechanical stress distorts macular structures resulting in vision loss which is preventable in the earlier stages of the process.

The work of the Vitreomacular Traction Study Group has brought some much needed clarity to this condition by establishing a classification based on the OCT appearance.

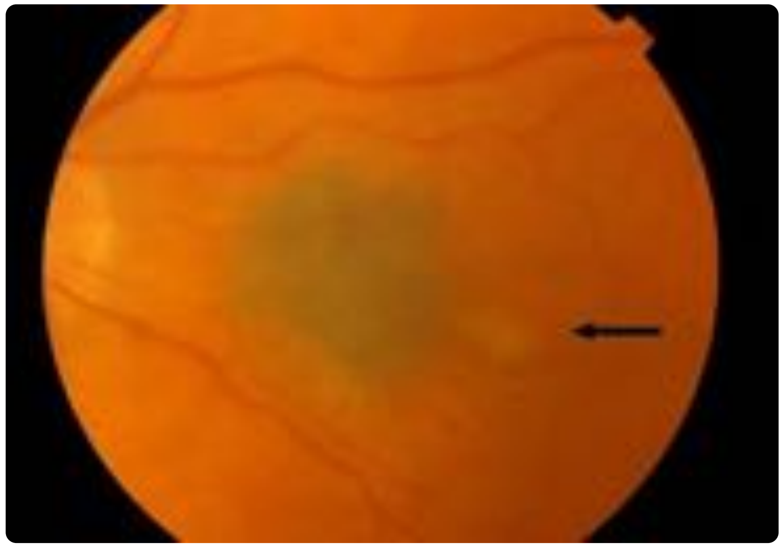
Figure 9.12 Classification of vitreomacular traction.



Focal vitreomacular adhesion. The area of vitreoretinal attachment is $< 500\mu m$ *and the macula is not deformed.*

On slit lamp examination retinal cysts are usually the most prominent feature. The presence of subretinal fluid may be difficult to appreciate as is is a late feature associated with retinal atrophy. Epiretinal membranes and sheets of partially detached vitreous over the macula may be visible. These features may be seen with contact lens examination but are best appreciated on OCT examination

Figure 9.13 Vitreomacular Traction syndrome



The slit lamp appearance - note the large cyst. the choroidal nevus is probably coincidental.

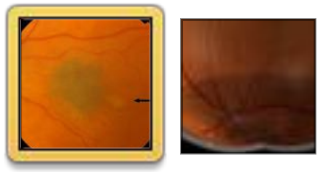
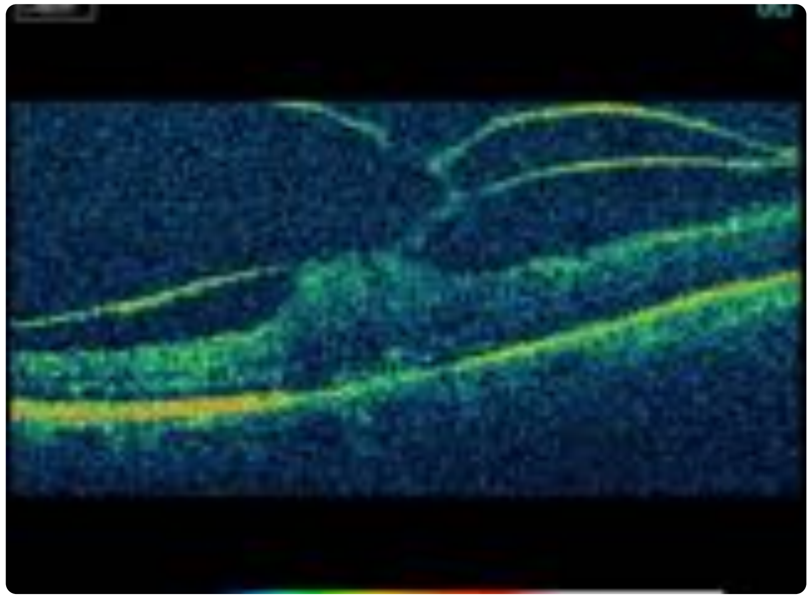


Figure 9.14 Epiretinal Changes in VMT



As well as partial vitreous detachment vitreoschisis may be present.

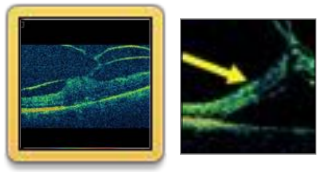
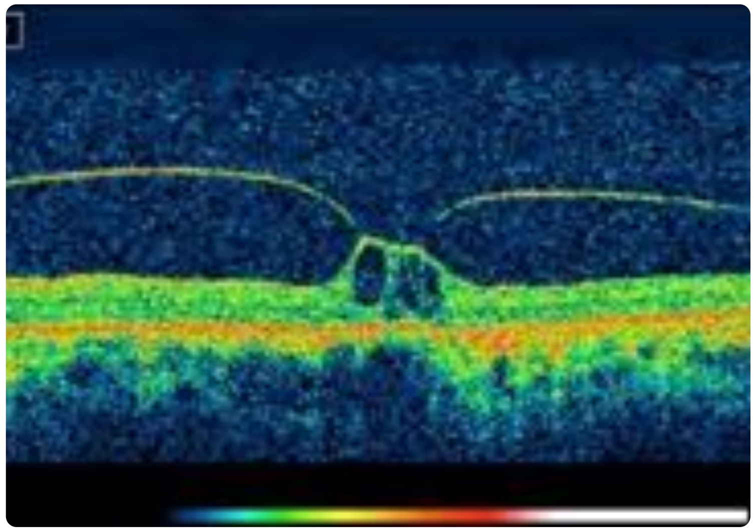
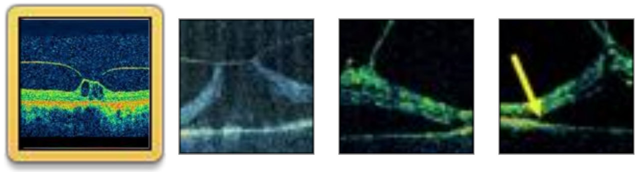


Figure 9.15 Intraretinal changes on OCT



Focal VMT with intraretinal cysts.



NATURAL HISTORY VITREOMACULAR TRACTION SYNDROME

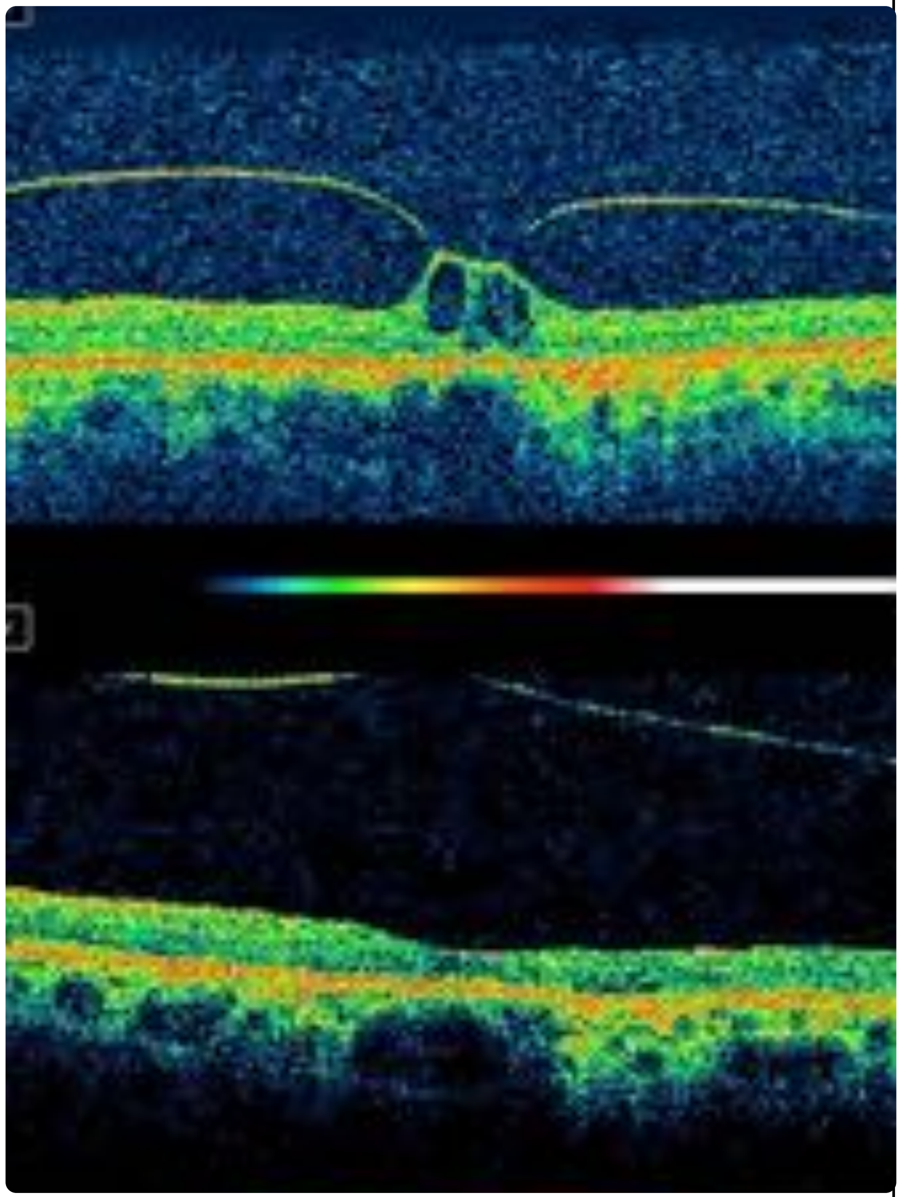
In some cases of focal vitreomacular traction syndrome the area of adhesion is exceedingly small. These cases are sometimes classified separately as vitreofoveal traction. Because the area of attachment is small the force per unit area is large. These cases may therefore spontaneously resolve but may also progress to full thickness macular hole. Focal Vitreomacular traction may be clinically indistinguishable from Stage 1 macular hole.

Cases with broad vitreoretinal and vitreopapillary adhesions are much less likely to spontaneously resolve.

Overall a significant proportion of 'fresh' cases of VMT resolve.

Where resolution does not occur most cases experience a gradual decline in vision.

Figure 9.16 Spontaneous Resolution of vitreofoveal traction



There was a complete recovery of vision and normalization of foveal architecture following spontaneous vitreous separation.

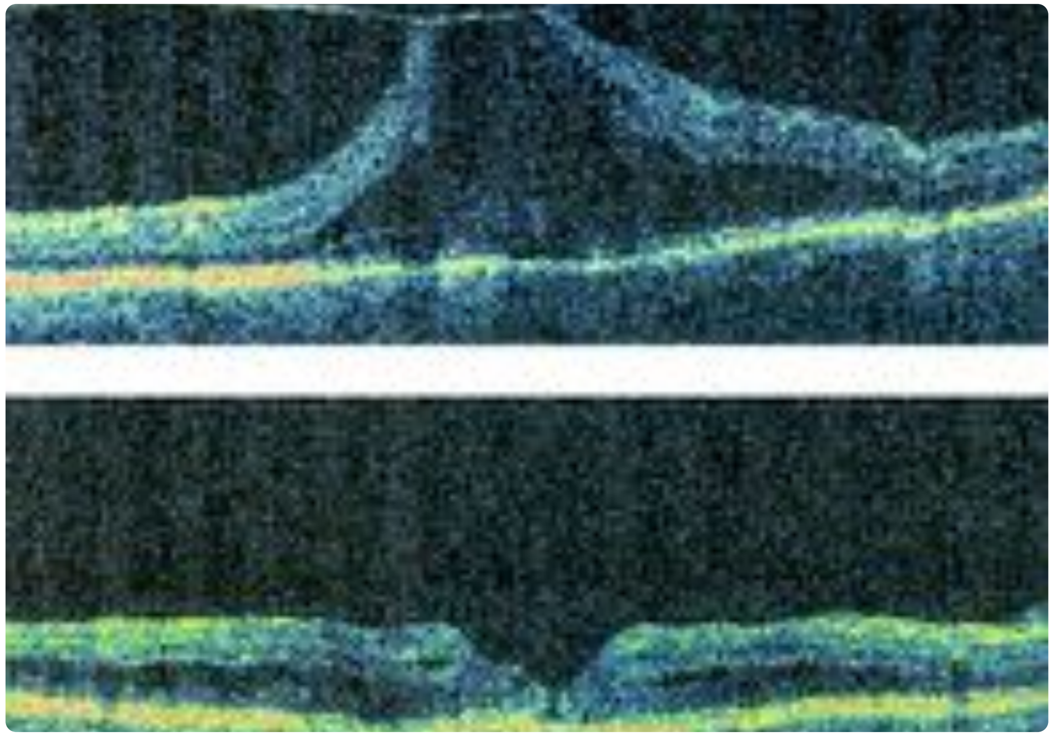
TREATMENT OF VITREOMACULAR TRACTION SYNDROME

Surgery is indicated for cases in which there is symptomatic decline in visual acuity. In early cases of focal VMT a period of observation may be indicated to determine whether spontaneous improvement will occur. The patient should be involved in the difficult decision whether to operate early or observe as in the latter case a therapeutic window may be missed.

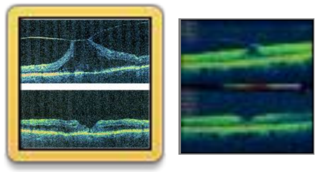
The visual outcome after surgery is best in cases with focal VMT with V shaped vitreofoveal adhesion. Factors associated with a poorer prognosis include:

- Broad vitreomacular adhesion, especially cases with vitreopapillary adhesion
- Lamellar splits within the retina.
- Chronic retinal detachment.

Figure 9.17 Results of VMT surgery



This long standing VMT with broad adhesions experienced no improvement following surgery



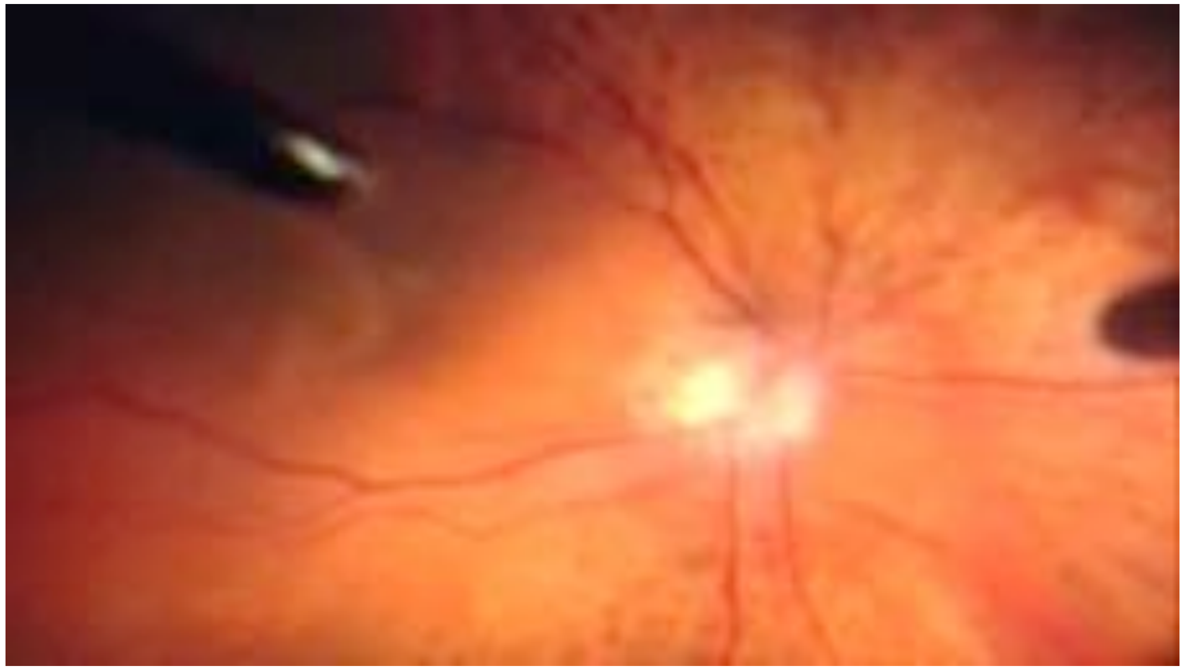
The surgical goal is to remove all epimacular contractile elements (both vitreous and ERM) using techniques previously described.

No tamponade agent is required unless a break is present or is created during surgery.

Great care should be taken peeling membranes off the fovea. Due to the strong adhesions and thin tissue here these cases are particularly likely to develop macular holes. If the fovea appears to be stretching the peel should be performed centripetally. The membrane is peeled ‘outside in’ from several points towards the fovea. The resulting floating island of tissue over the fovea may either be delaminated or trimmed cautiously with the cutter (and a small residue left).

If a macular hole does occur during peeling it can usually be closed by treating it as an idiopathic macular hole - i.e. by using gas tamponade.

Movie 9.20 Iatrogenic macular hole during VMT repair



Note how the fovea stretches before it tears - this is a danger sign that should not be ignored.

PHARMACOLOGICAL VITREOLYSIS

Ocriplasmin is a truncated form of human plasmin. It is a protease which is active against laminin and fibronectin. It has been shown experimentally to induce cleavage of vitreous cortex from the internal limiting membrane. A multi-centre randomized control study showed resolution of focal symptomatic vitreomacular adhesion in 26.5% of eyes treated with ocriplasmin compared to 10.1% of placebo treated eyes. It seems to be less effective in patients with OCT evidence of an epiretinal membrane. The only side effects (floaters, retinal tears) were an inevitable consequence of its mode of action (induction of a PVD) and unlikely to impede very widespread use of this treatment.

Knowledge review

Review 9.1 Epiretinal membranes

Question 1 of 4

Which statement is true regarding epiretinal membranes

- ○ **A.** The prevalence is less than 1% in elderly patients.
- ○ **B.** The variation between ethnic groups is insignificant.
- ○ **C.** A PVD is rarely present.
- ✓ **D.** They may be associated with any traumatic, ischaemic, degenerative, neoplastic, inflammatory or infective process in the posterior segment of the eye.

Check Answer

Review 9.2 Myopic foveoschisis

Which statement is correct regarding myopic foveoschisis:

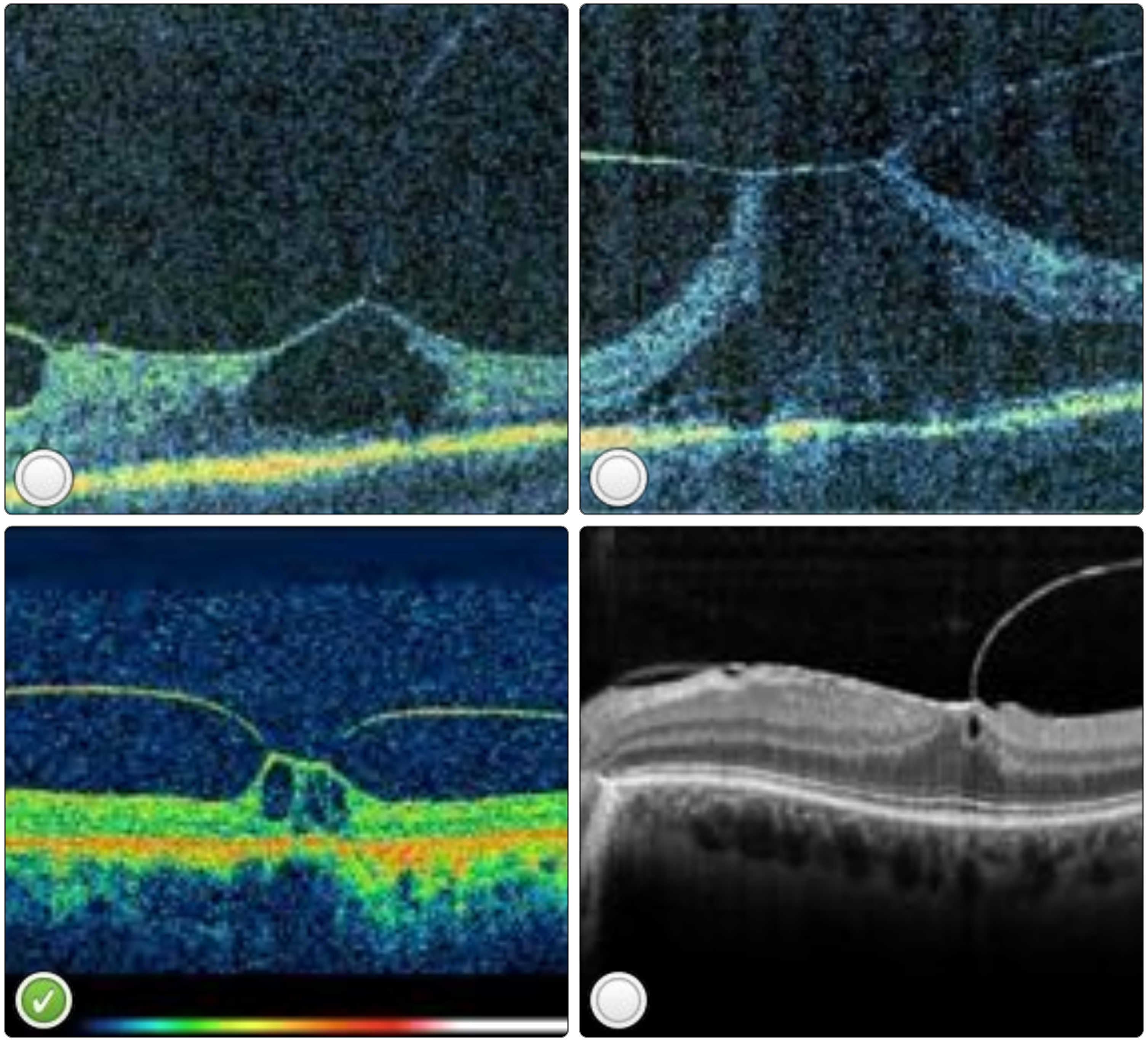
- ✓ **A.** It is usually associated with a staphyloma.
- ○ **B.** It occurs rarely in highly myopic eyes.
- ○ **C.** Visual function tends to remain stable in symptomatic cases.
- ○ **D.** It is rarely associated with an epiretinal membrane.
- ○ **E.** It is readily diagnosed without OCT.
- ○ **F.** Development of a macular hole is unusual

Check Answer

Review 9.3 Vitreomacular traction

Question 1 of 4

Which of these cases is most likely to show significant visual improvement after surgery, assuming all other factors (duration etc.) are equal:



Check Answer

CHAPTER 10

Macular Holes

Twenty five years ago macular hole was generally regarded as an untreatable condition. Today, thanks to the pioneering work of Kelly and Wendel, most cases can be successfully treated.

Pathogenesis of macular holes

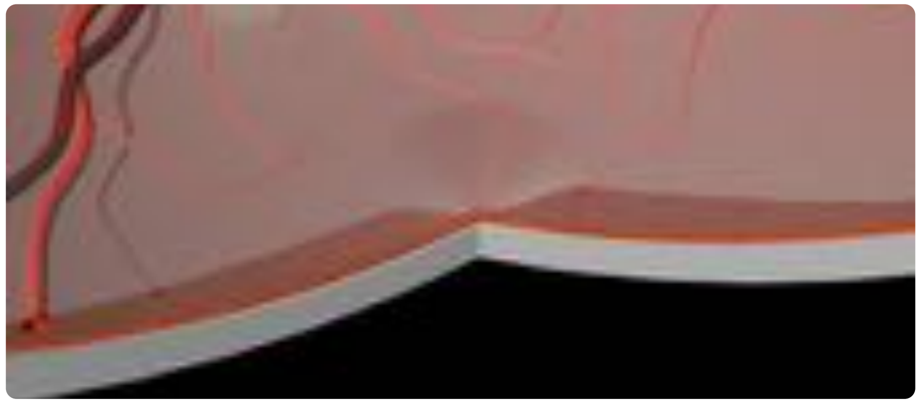
Don Gass, by closely observing idiopathic macular holes using contact lens biomicroscopy, realized the importance of the vitreous in the pathogenesis of macular holes. His hypothesis that they arose due to tangential traction at the vitreoretinal interface was confirmed histopathologically. Gass developed a classification system based on the evolution of holes from subtle early tractional changes without macular hole (Stage 1) to separation of the vitreous (Stage 4).

Optical coherence tomography subsequently also implicated anteroposterior traction due to the combination of partial vitreous separation and foveomacular adhesion. It is also the basis for the current classification system of macular holes.

Figure 10.1 The Gass classification of macular holes

Stage 1 macular hole

Figure 10.2 The role of anteroposterior traction in macular hole development.

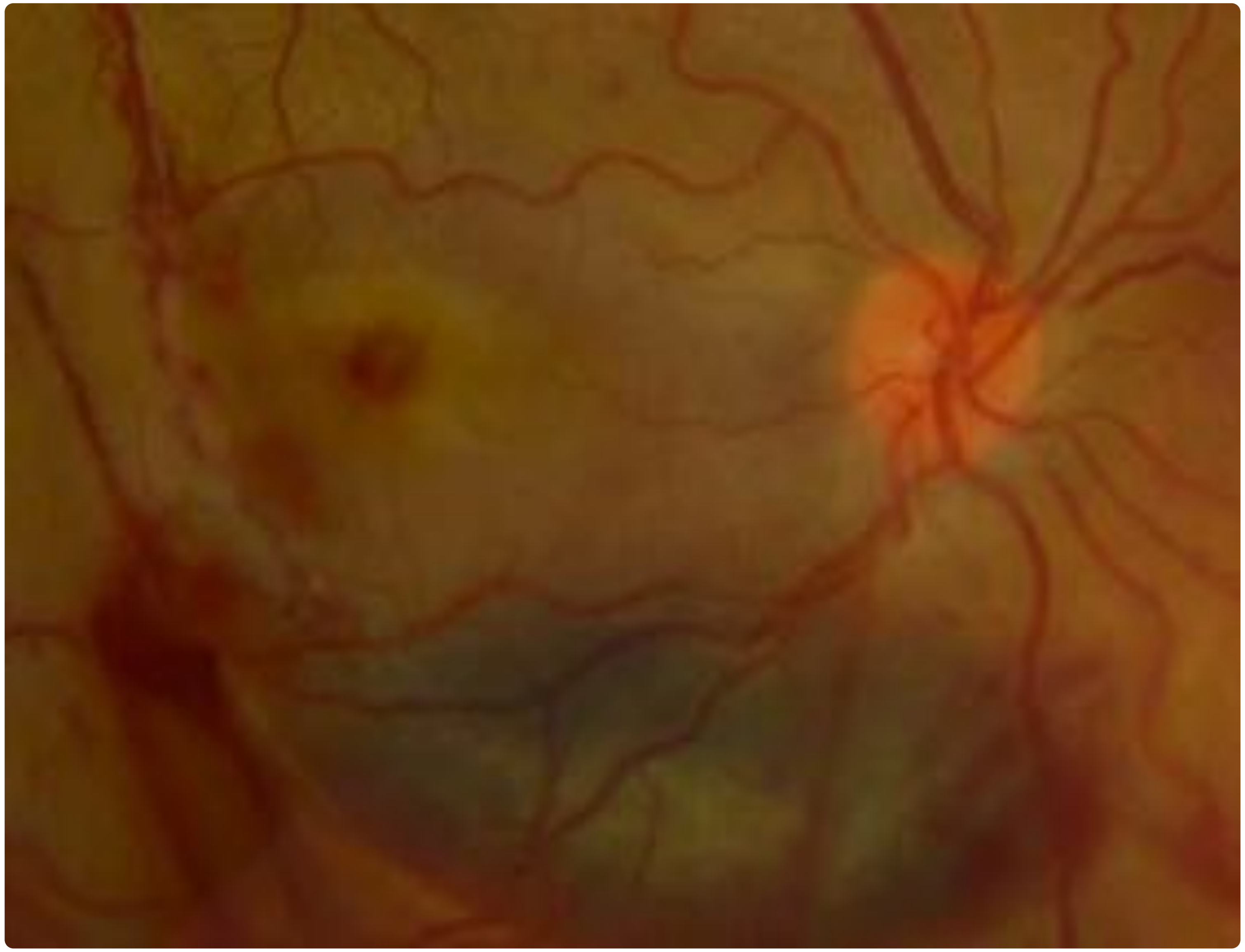


Stage 0 - the posterior hyaloid has partially detached and there is an asymptomatic vitreofoveal adhesion.

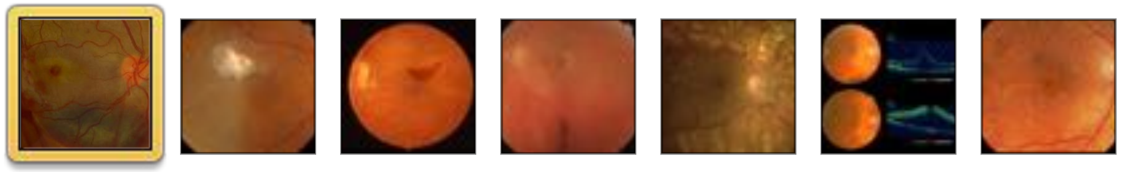
CAUSES OF NON IDIOPATHIC MACULAR HOLES.

Macular holes may arise in association with many other conditions.

Figure 10.3 Secondary macular holes



Traumatic macular hole. The traction here arises from the transient deformation of the globe during a severe blunt injury. This hole closed without intervention as is frequently the case with traumatic macular holes. The vision did not improve due to extensive outer retinal / RPE contusion.



The diagnosis of macular hole can often be made on the slit lamp, particularly if a contact lens or high resolution condensing lens is used.

There is a visible central retinal defect. A cuff of subretinal fluid is usually present. Small drusenoid deposits may be visible on the bare pigment epithelium. A large hole or the presence of pigment indicate chronicity.

Figure 10.4 Clinical appearance of macular holes

Drusenoid deposits in the base of a macular hole.

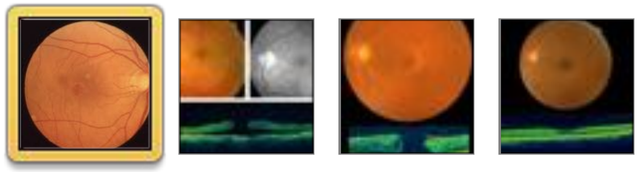
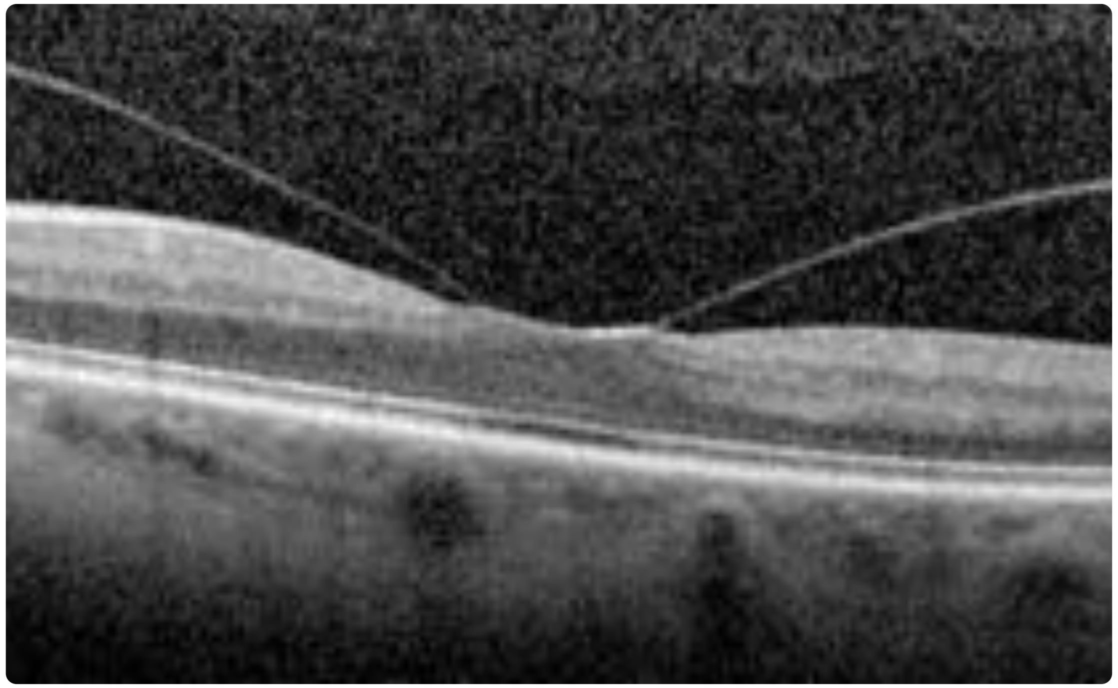


Figure 10.5 Optical coherence tomographic features and classification of macular holes

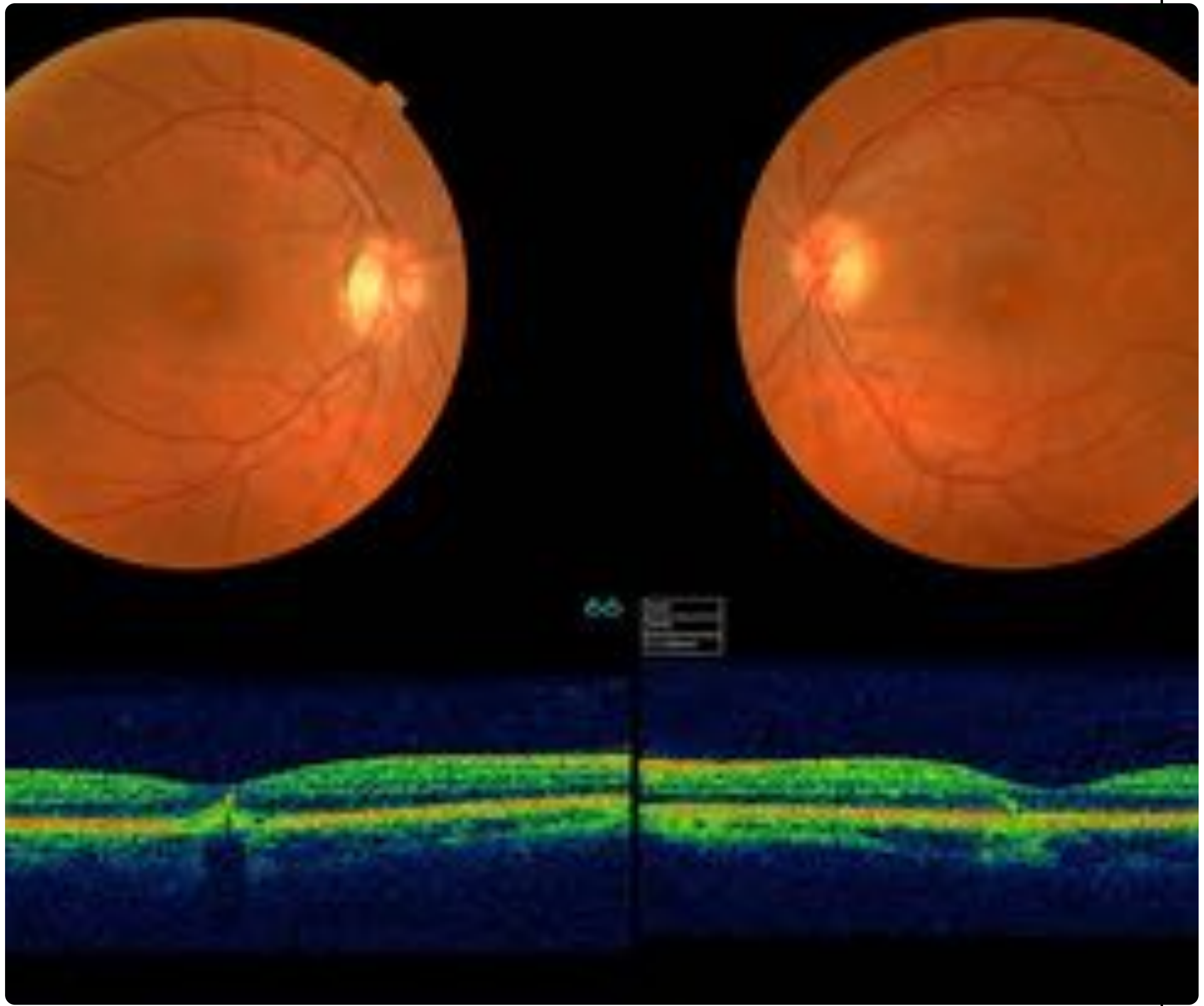


A Stage 0 macular hole. Image c/o Shyam Kodati.

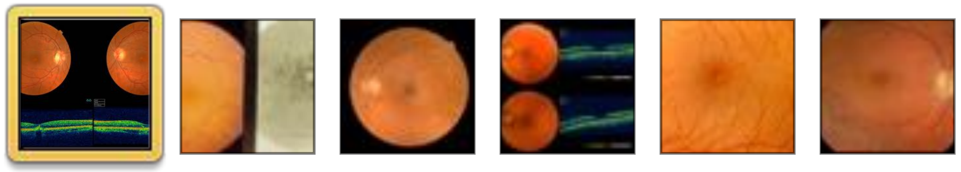
DIFFERENTIAL DIAGNOSIS OF MACULAR HOLES

Several conditions can mimic macular holes. If there is any doubt about the diagnosis OCT examination is invaluable.

Figure 10.6 Differential diagnosis of full thickness macular hole.



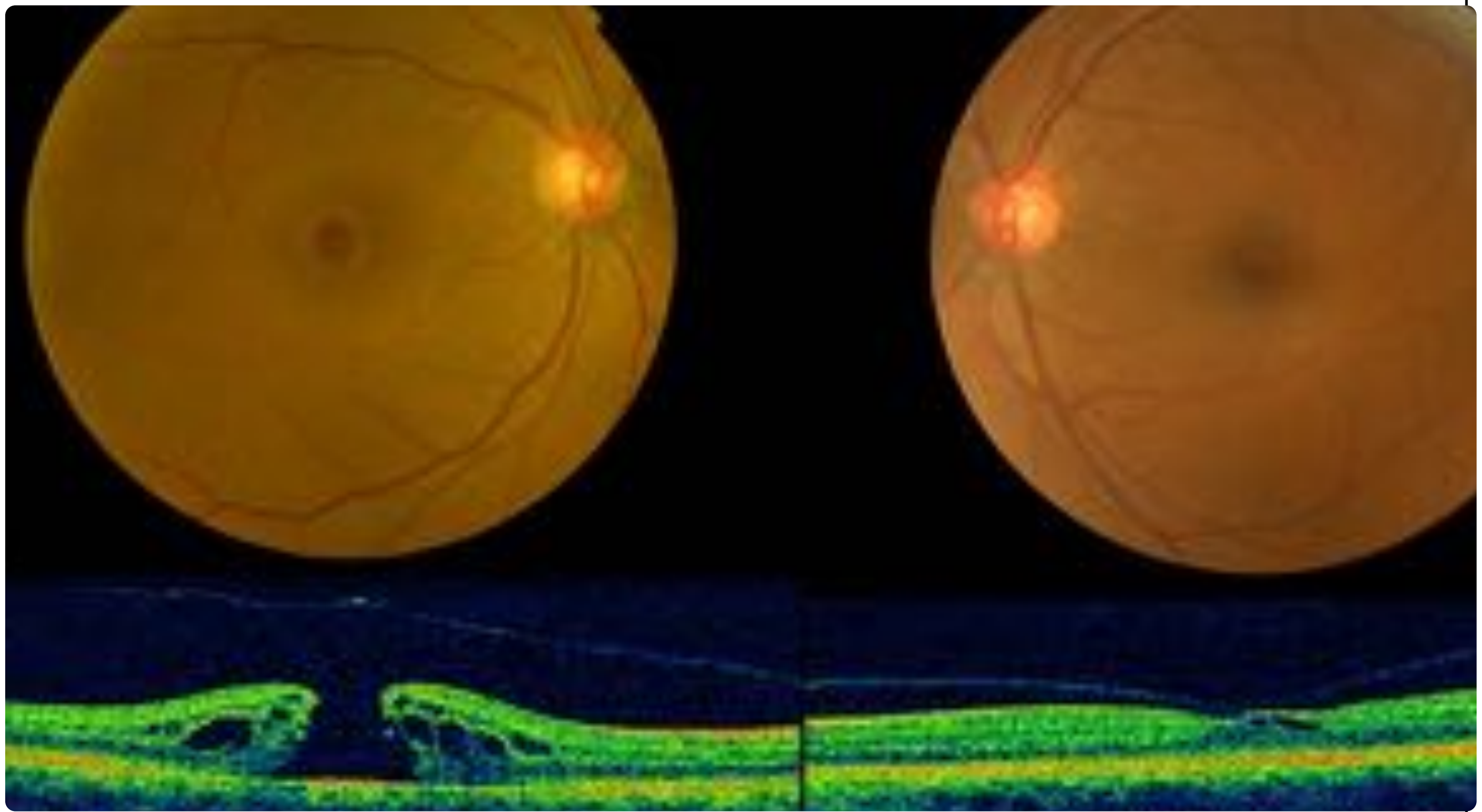
Adult vitelliform macular dystrophy



OCT examination of an asymptomatic fellow eye frequently reveals a Stage 1 lesion.

Patients are usually anxious about their fellow eye. If that eye has a PVD a they can be reassured that it will not develop a macular hole. The reported risk in eyes with an attached vitreous varies widely. One of the factors accounting for this variation may be the quality of OCT as the improved resolution of spectral domain OCT allows more subtle foveal lesions to be detected. A recent prospective study of 42 fellow eyes with stage 0 lesions found that 50% of the patients (20 eyes) developed a Stage 1 hole (foveal detachment or cyst). Five of these 20 eyes then developed a full thickness macular hole. This gives an 11% (5/42 eyes) risk of full thickness macular hole at 5 years.

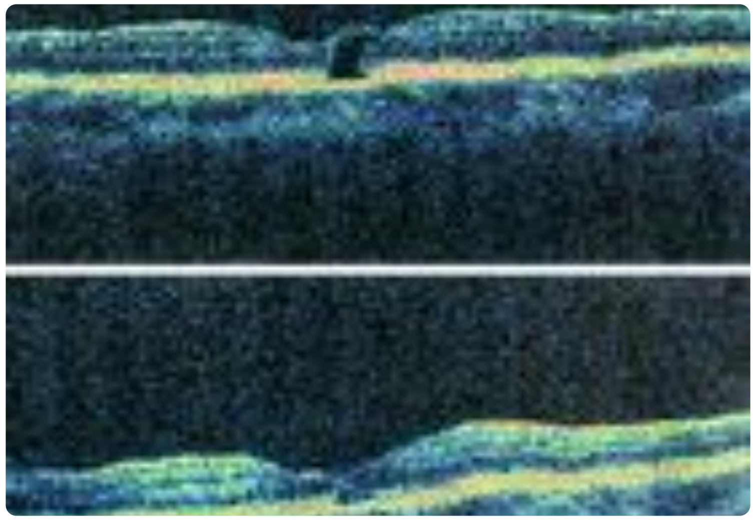
Figure 10.7 The fellow eye



This patient was referred for the right macular hole. A Stage 1 lesion was found in the asymptomatic fellow eye. In one study the risk of developing a macular hole was 30%.

Treatment of macular holes

Figure 10.8 Spontaneous closure of a Stage 1 macular hole.



NATURAL HISTORY OF MACULAR HOLES

About 40% of stage 1 macular holes progress to Stage 2 holes.

About 11% of stage 2 holes regress.

Larger holes tend to increase slowly in size with a drop in both visual acuity and potential for visual recovery after surgery.

INDICATIONS FOR SURGERY

Surgery is not indicated for asymptomatic Stage 1 macular holes.

When a patient presents with a small Stage 2 hole of recent onset the decisions has to be balanced between:

- Reluctance to miss a therapeutic window as surgery is most effective in smaller and more recent holes.
- The possibility of avoiding surgery by waiting for possible spontaneous resolution.
- The risks of surgery - a high likelihood of cataract and a small risk of iatrogenic retinal detachment.

Many surgeons wait for a short period before performing surgery as most cases that resolve do so fairly quickly. The introduction of effective vitreolysis has given surgeons less invasive treatment options in this group of patients which may lower the bar for intervention.

Treatment decisions in other groups of patients need to be individualized and discussed carefully with the patient. Surgery would probably be recommended for most patients with symptomatic holes (irrespective of size) as the resulting binocular dysfunction negatively impacts quality of life. Conversely one might be more circumspect in recommending surgery to a patient with an asymptomatic (i.e. good binocular vision) patient with an incidentally noted long standing macular hole in one eye, a PVD in the fellow eye and significant medical comorbidity.

SURGICAL TECHNIQUES IN MACULAR HOLE REPAIR.

There is universal agreement that a complete vitrectomy with detachment and removal of the posterior hyaloid followed by gas tamponade should be used.

The gas bubble seems to close the hole quickly. The mechanism by which it does so is still uncertain.

There is on going debate and uncertainty about the need to posture after surgery.

A well designed prospective randomized controlled trial showed a minimalist approach (no ILM peel, no posture) to be effective in macular holes $< 400\mu m$ diameter but that approach was less effective in larger holes.

It is possible that the need for patients with larger holes to posture may be reduced by enhancing the surgery. One approach is to increase the size of the gas fill by phacovitrectomy which gave a 90% success rate without posturing. A recent retrospective study reported 100% success without face down posturing. Many of the patients in this study had very large and long standing holes. Extensive (arcade to arcade) internal limiting membrane was used. The vitreous base was shaved and re-aspiration of vitreous fluid after 5 minutes were performed to maximize the size of the gas bubble. Patients were asked to maintain a 'reading posture' (45^0 forward inclination) but were not asked to posture prone.

The MIVI trial investigated the effect of ocriplasmin in full thickness macular holes of less than 400μm diameter.

Hole closure occurred in 40.6% treated holes compared to 10.6% in the control group. Failure to close with injection did not prejudice the final outcome. Cases that failed to close underwent surgical repair. The success rate in this group was no worse than cases undergoing primary surgical repair.

Ocriplasmin is discussed further elsewhere in this book.

The development of an effective office based procedure for macular holes is a major advance. At the time of writing the treatment is being introduced and is likely to be very widely used in future.

Knowledge Review

Review 10.1 Macular holes

Question 6 of 6

The MIVI trial showed that microplasmin injection:

- **A.** Caused closure of approximately 40% of holes less than 400μm in diameter. ✓
- **B.** Showed that repeated injection increased the success rate to 60%.
- **C.** Was associated with a 5% risk of retinal detachment.
- **D.** Caused closure of approximately 20% of holes less than 400μm in diameter.
- **E.** Is less effective in holes with a diameter exceeding 400μm.
- **F.** Showed that ocriplasmin is more effective in the treatment of vitreomacular traction than macular holes.

Check Answer

CHAPTER 11

Diabetic retinopathy

Surgery for advanced diabetic eye disease ranges in complexity from relatively straightforward to extremely technically challenging. An understanding of the pathology of the condition is the basis for successful surgery. Therapeutic advances such as preoperative administration of anti-VEGF agents and minimally invasive vitrectomy have had a major impact on the outcome in complex cases.

Pathology

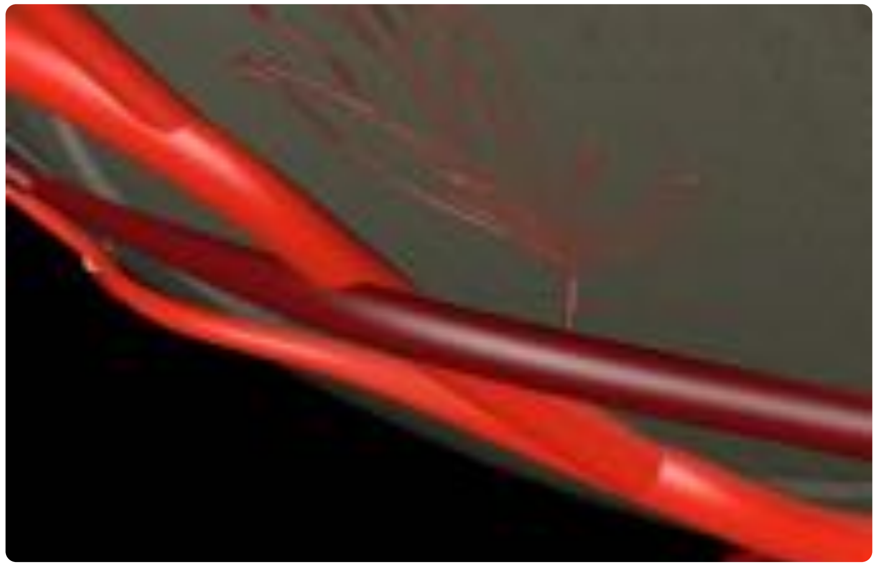
NEOVASCULAR COMPLEXES

In the early stages of diabetic retinopathy metabolic damage to the retinal vasculature. This causes widespread retinal ischaemia. The resulting hypoxia is insufficient to lead to cell death but causes release of angiogenic growth factors from glial cells. New vessels arise from retinal veins in response to these growth factors. They create and grow though defects in the internal limiting membrane along the posterior hyaloid face. Subsequently glial cells proliferation encases them in fibrous tissue. The resulting fibrous peg tethers the posterior hyaloid face firmly to the wall of the vein. Traction on the adjacent hyaloid face is transmitted directly to the vein.

Therefore:

- Neovascularisation does not develop in areas where the vitreous is detached as there is no scaffold for new vessel growth.
- Successful treatment of active neovascularisation does not eliminate the fibrous pegs. Tractional vitreous hemorrhage may persist after the new vessels have regressed. The source of the hemorrhage is the vein itself at the site of the peg.
- Traction on the pegs may cause breaks and bleeding during vitreous detachment or delamination surgery.
- The fibrous tissue associated with the neovascular complexes develops into mature fibrovascular epiretinal membranes which contract causing tangential traction on the retina.

Figure 11.1 Pathology of neovascular complexes.



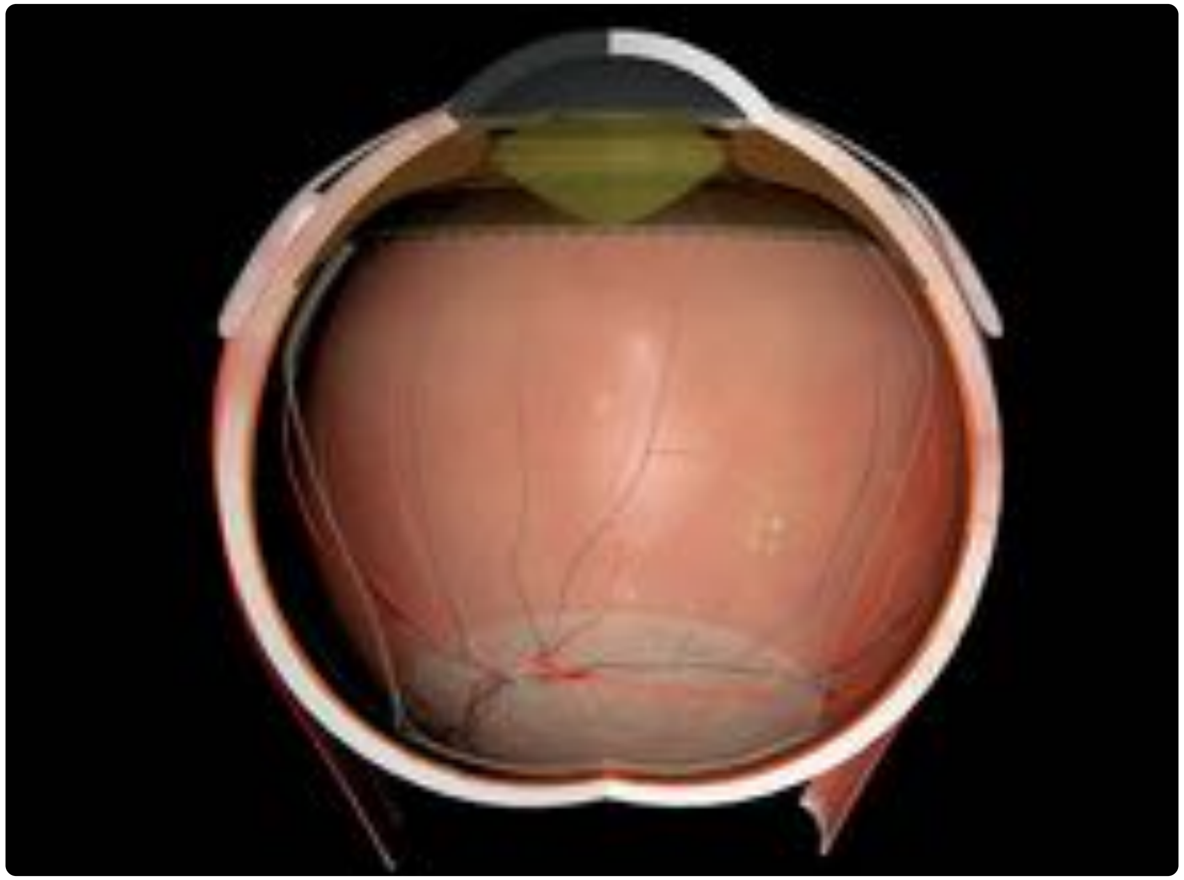
A view of a neovascular complex from the retina. Note that it is growing along the posterior hyaloid membrane and is attached to the vein by a feeder vessel ('peg').

•

VITREOUS PATHOLOGY AND TRACTION

Posterior vitreous detachment is common is diabetic eyes. Posterior hyaloid tethering to the retina at the site of neovascular complexes limits vitreous separation. This gives rise to anteroposterior traction. Splitting of the posterior hyaloid (vitreoschisis) may give rise to additional epiretinal membranes which adhere to the retina outside the fibrovascular membrane.

Figure 11.2 Vitreous changes in advanced proliferative diabetic retinopathy.



A partially detached posterior hyaloid, a fibrovascular epiretinal membrane and vitreoschisis are present in this eye.

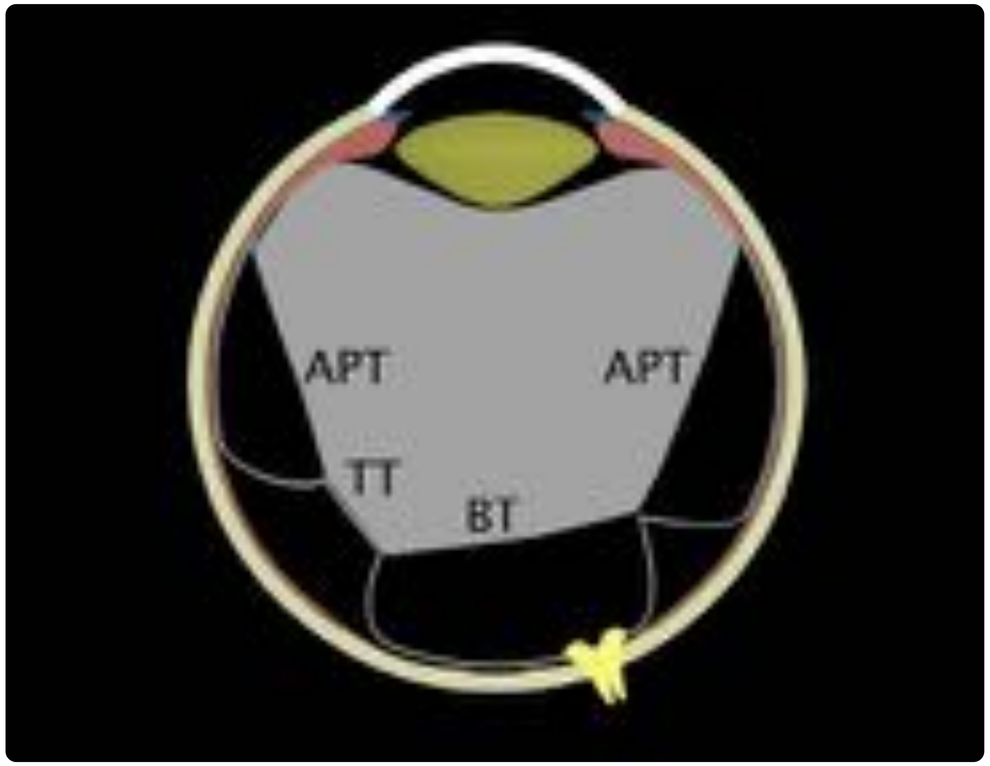
The configuration of traction retinal detachment and distortion depends upon the pattern of vitreoretinal adhesions and detachment. Static traction on the retina may be classified as:

- *Anteroposterior traction*. This arises from contraction of the detached posterior hyaloid face which is adherent at the vitreous base anteriorly and vitreomacular adhesions posteriorly.
- *Bridging Traction*. When the posterior hyaloid partially detaches from the retina the toughest fibrovascular pegs act as anchor points. This results in traction between the anchor points.
- *Tangential traction*. This occurs when there is little vitreous separation. Contraction of the fibrovascular membrane/hyaloid occurs in the plane of the retina. This may cause very extensive traction retinal detachment extending far beyond the borders of the fibrovascular membrane. These are the most surgically challenging cases.

Different types of traction are often present in the same eye.

If a retinal break develops near a site of vitreoretinal traction a combined traction-rhegmatogenous detachment may result. The detachment progresses very rapidly and has the characteristic convexity of a rhegmatogenous detachment.

Figure 11.3 Traction in proliferative diabetic retinopathy



Types of traction present in the same eye.

VITREOUS HEMORRHAGE IN PROLIFERATIVE DIABETIC RETINOPATHY

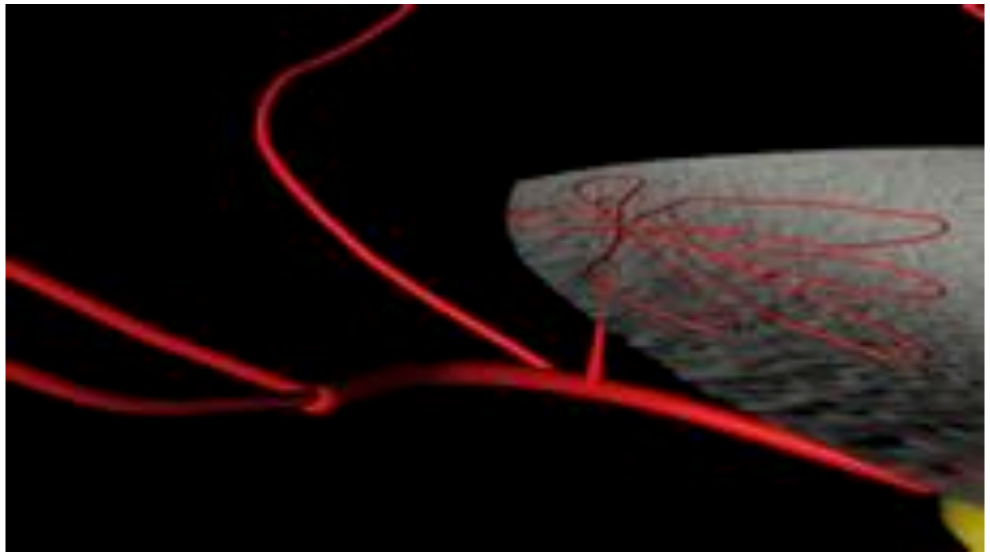
Vitreous hemorrhage arises from traction on neovascular pegs. The source of the bleeding is usually the retinal vein to which the peg is attached rather than the neovascular complex itself.

If there is a PVD the blood disperses in the retrohyaloid space. The vitreous core may initially be clear. The detached posterior hyaloid membrane with blood trapped behind it may be mistaken for a detached retina.

If there is limited PVD the blood is trapped in small subhyaloid pockets. Pre-foveal hemorrhages carry a poor prognosis due to the associated posterior fibrovascular proliferation.

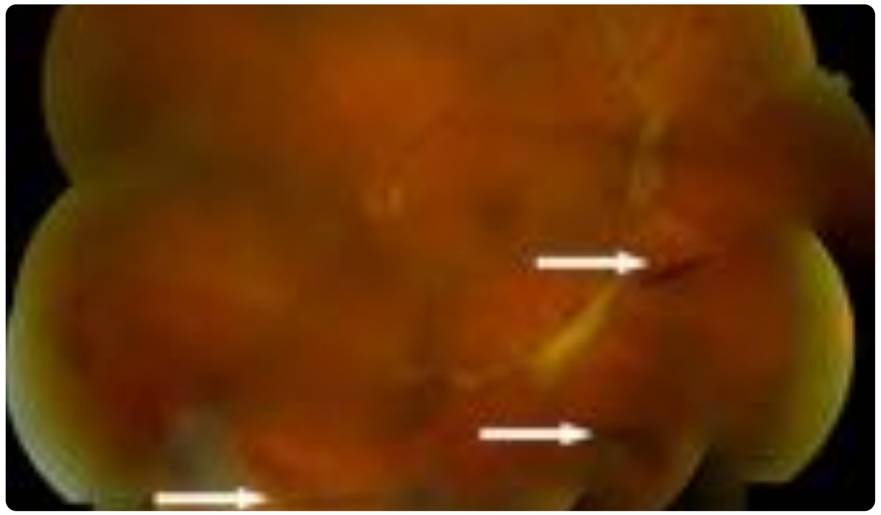
Erythrocytes are slowly broken down in the vitreous but also leave the eye through the trabecular meshwork via the anterior chamber. This occurs much more quickly after vitrectomy and in non phakic eyes. The presence of erythrocytes in the anterior chamber is therefore an indicator that the hemorrhage may clear more quickly. Passage of partially degraded erythrocytes (erythroclasts) may cause severe glaucoma as the rigidity of these cells impedes their passage through the trabecular meshwork (ghost cell glaucoma).

Movie 11.1 Origin of diabetic vitreous hemorrhage



Traction on a neovascular peg causes hemorrhage from a retinal vein.

Figure 11.4 Diabetic vitreous hemorrhage



As well as diffuse vitreous hemorrhage several areas of trapped subhyaloid blood are present (white arrows). These indicate the limits of vitreous separation.

Clinical assessment

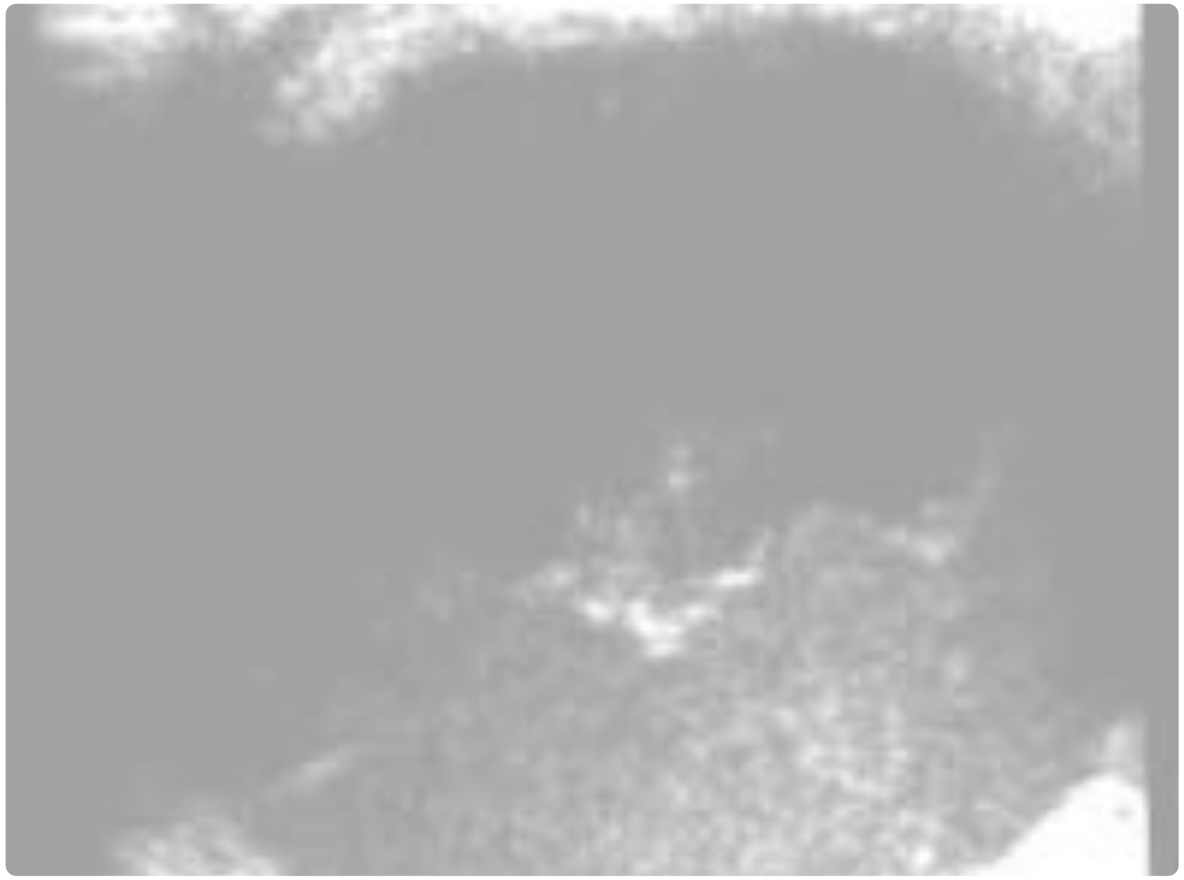
Diabetic patients under consideration for vitreoretinal surgery should be thoroughly assessed. The assessment should particularly focus on:

- Whether adequate panretinal photocoagulation has been performed.
- The frequency and duration of vitreous hemorrhages.
- The patient's medical fitness for surgery. With the advent of preoperative intravitreal anti-VEGF therapy it is important that there are no surprises on the day of surgery requiring deferral of surgery.
- A drug history including anticoagulants (in particular aspirin and clopidogrel).
- The degree of lens opacity, to determine whether combined surgery may be required.
- The presence of iris neovascularisation or signs of anterior hyaloid proliferation such as hypotony.
- The activity of the retinal neovascularisation to determine whether PRP or anti-VEGF agents should be given before surgery.
- The extent of retinal detachment and vitreoretinal adhesions, by B scan ultrasound if necessary.
- The severity of retinopathy and adequacy of treatment in the fellow eye.

B SCAN ULTRASOUND IN DIABETIC RETINOPATHY

Ultrasound is an essential part of the work up for diabetic patients with fundus obscuring vitreous hemorrhage. Use of a Doppler mode on the ultrasound may be helpful in distinguishing between a detached hyaloid face and tractional detachment of the retina.

Figure 11.5 B scan ultrasound in fundus obscuring diabetic vitreous hemorrhage



The appearance of retrohyaloid hemorrhage.

Indications for surgery

The general goals of vitreoretinal surgery in diabetes are to:

- Restore vision by removing vitreous hemorrhage.
- Deliver panretinal photocoagulation to eyes with fundus obscuring vitreous hemorrhage.
- Deal with vision affecting tractional complications of cicatricial proliferative retinopathy including recurrent tractional hemorrhage, tractional retinal detachment affecting the macula and combined traction/rhegmatogenous retinal detachment.

Vitrectomy is not an alternative to adequate panretinal photocoagulation. Although vitrectomy does improve retinal oxygenation it also allows greater diffusion of growth factors into the anterior segment which may cause rubeosis unless adequate panretinal photocoagulation is performed.

Robert Machemer suggested specific indications for diabetic vitrectomy in 1976:

- Non clearing vitreous hemorrhage with loss of useful vision.
- Traction retinal detachment involving the macula.
- Combined traction/rhegmatogenous retinal detachment.
- Bilateral vitreous hemorrhage or hemorrhage in an only seeing eye.

Vitrectomy is still carried out for all these reasons. There is a trend to intervene surgically earlier in order to prevent, and not just treat, advanced cicatricial eye disease and improve final visual outcomes.

The Diabetic Retinopathy Vitrectomy Study (DRVS) studied eyes with non clearing vitreous hemorrhage and those with useful vision. Although the study reported many interesting findings it does not dictate current management of cicatricial diabetic retinopathy. This is because many significant technical advances have taken place since it was carried out. For example many eyes in the DRVS were lost to rubeotic glaucoma, the incidence of which decreased following the advent of endolaser.

The role of vitrectomy in the management of proliferative diabetic retinopathy can be summarized with some illustrative case histories.

Case 1 - Vitreous hemorrhage, previous partial PRP

Case 2 - Recurrent vitreous hemorrhage.

Case 3 - Extrafoveal traction detachment.

Case 4 - Tractional retinal detachment involving the fovea.

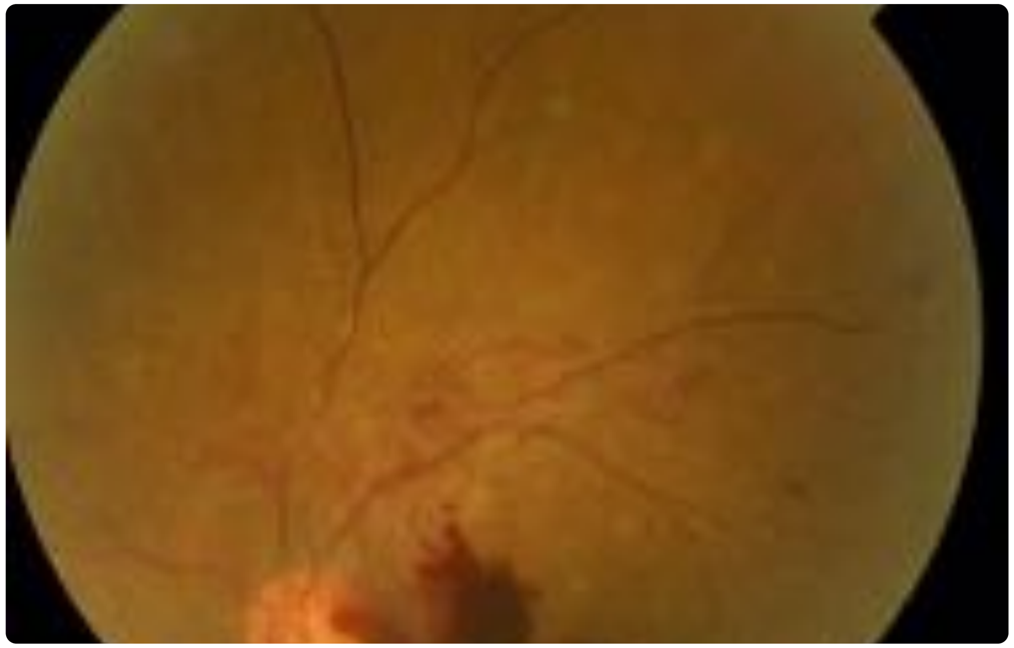
Case 5 - Dense vitreous hemorrhage in a young patient with no previous PRP.

Case 6 - Advanced cicatricial retinopathy.

Case 7 - Combined traction-rhegmatogenous retinal detachment.

Case 8 - Severe uncontrolled proliferation despite PRP.

Figure 11.6 Case 1. Vitreous hemorrhage, previous PRP.



This young patient with a vitreous hemorrhage was referred for consideration of vitrectomy.

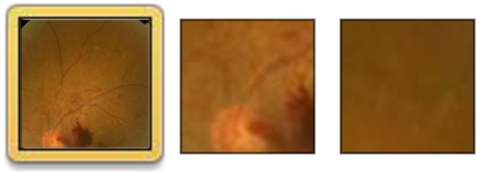
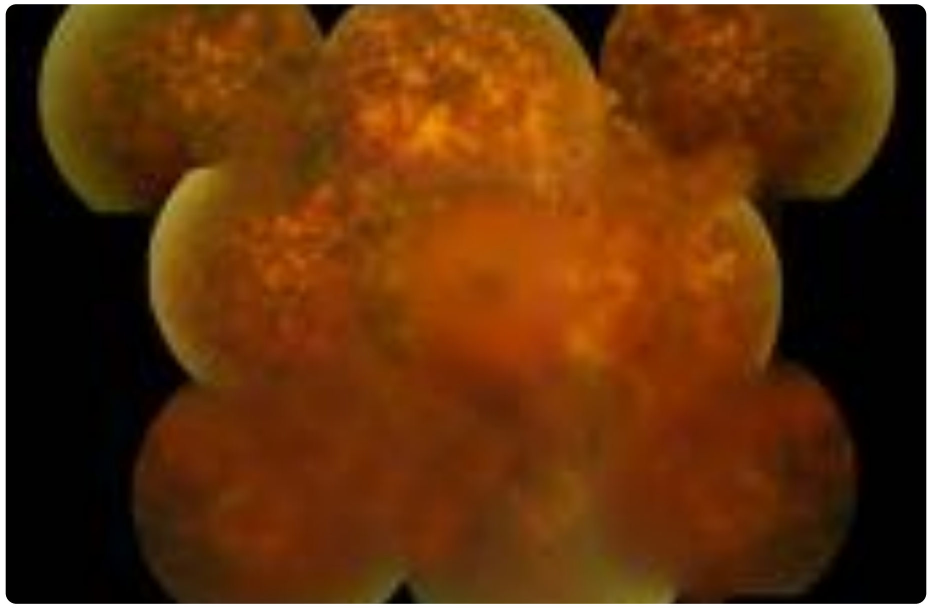


Figure 11.7 Recurrent hemorrhages, previous PRP.



This patient presented with a history of recurrent vitreous hemorrhage. He had suffered 15 previous episodes over the past 2 years. He had undergone supplementary photocoagulation on each occasion. The retinopathy appears very inactive with extensive coverage of the retina with laser burns. The narrow calibre of the retinal vessels is narrow suggests that the concentration of VEGF in the vitreous is low.

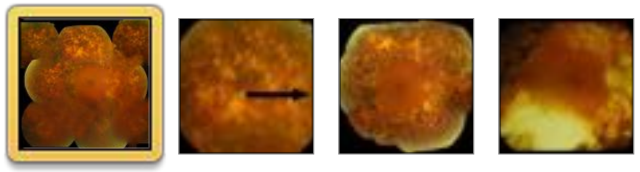
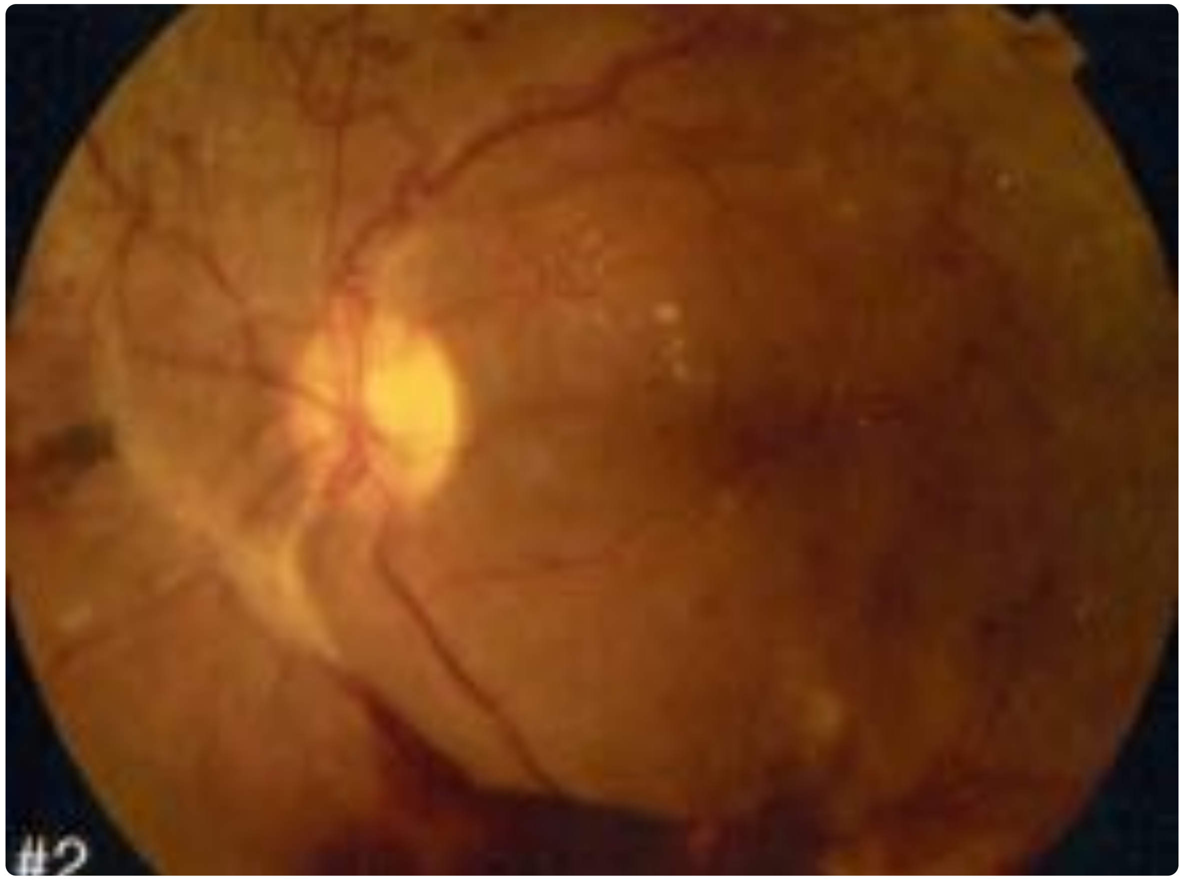
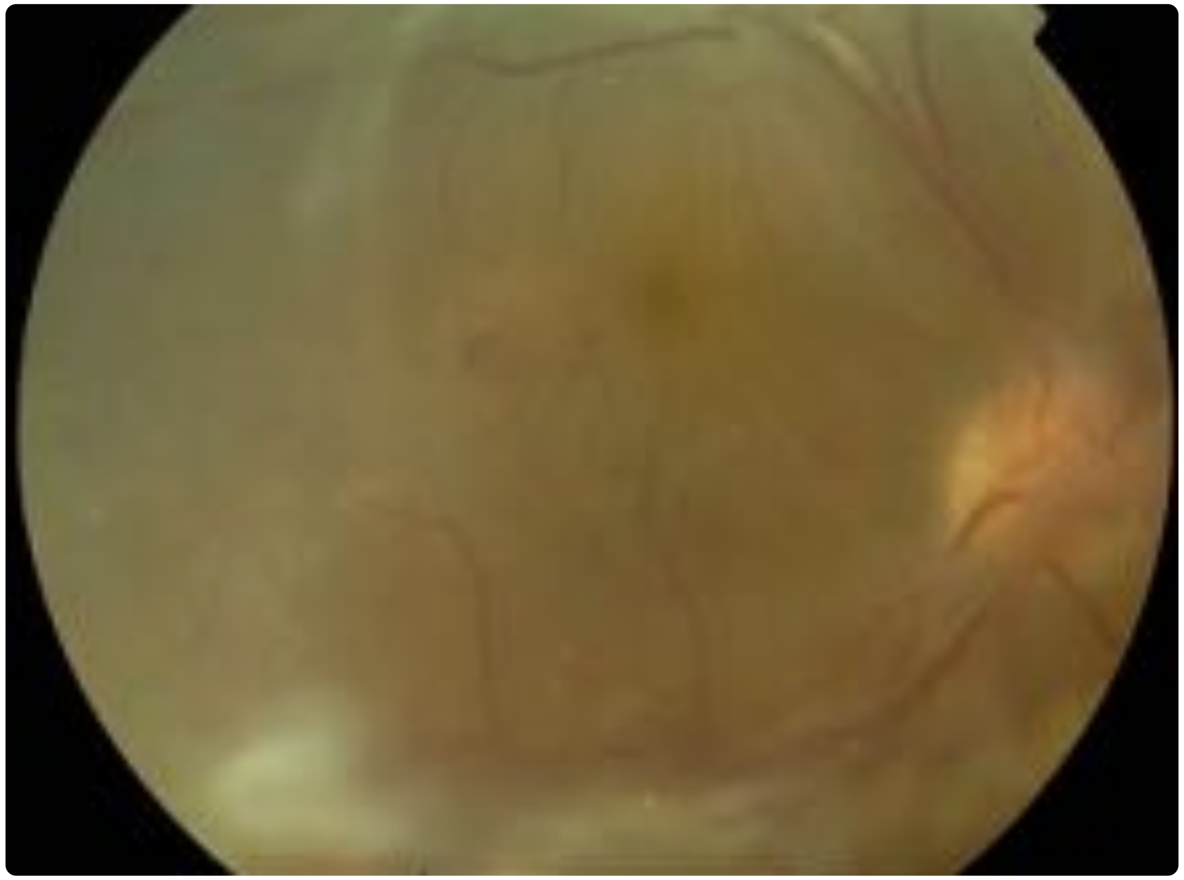


Figure 11.8 Case 3 - extrafoveal tractional retinal detachment



This patient was referred for vitrectomy with active retinopathy (see the retinal vein calibre) and an extensive nasal traction detachment. The eye had received partial PRP.

Figure 11.9 Case 4 - tractional retinal detachment involving the fovea



This patient presented with a shallow tractional retinal detachment involving the fovea. Visual acuity was 20/100.

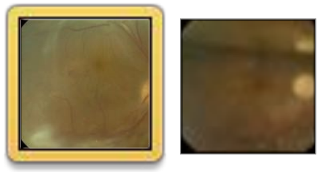
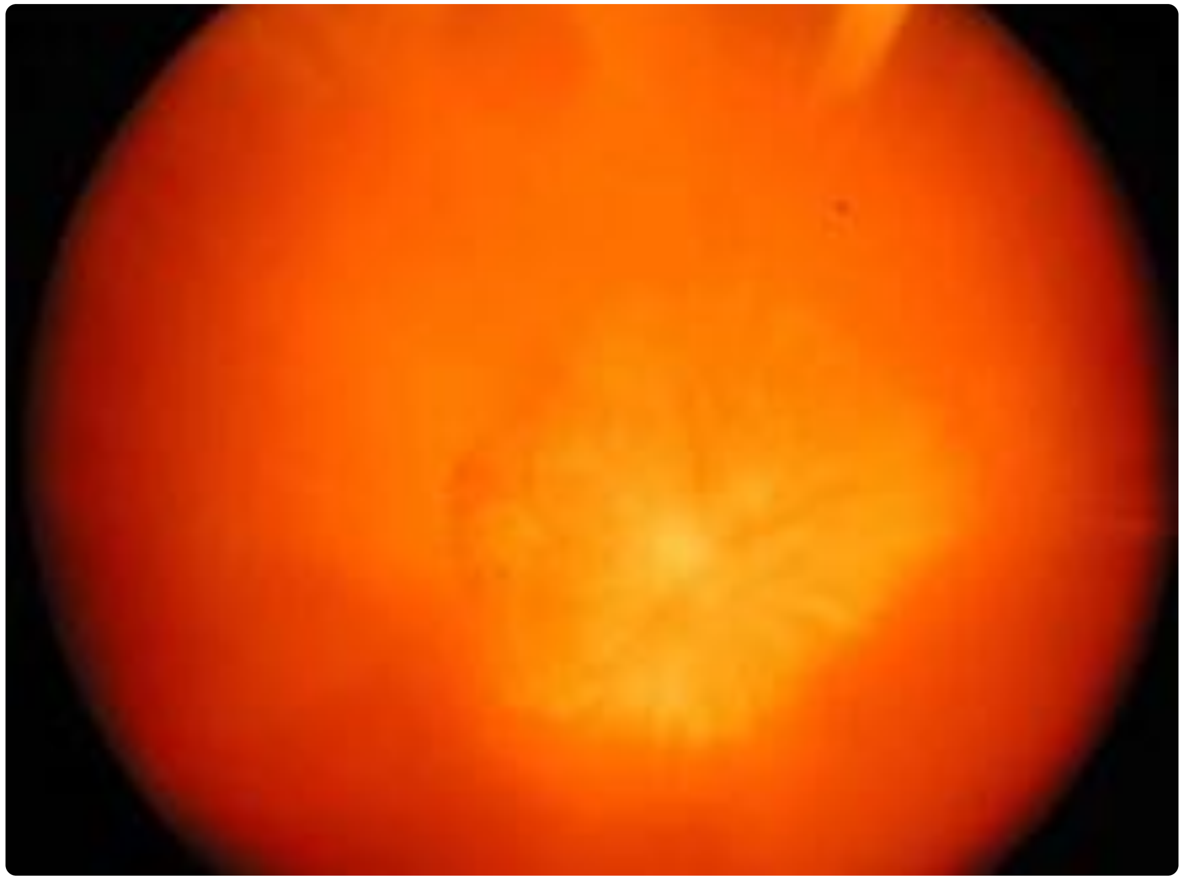
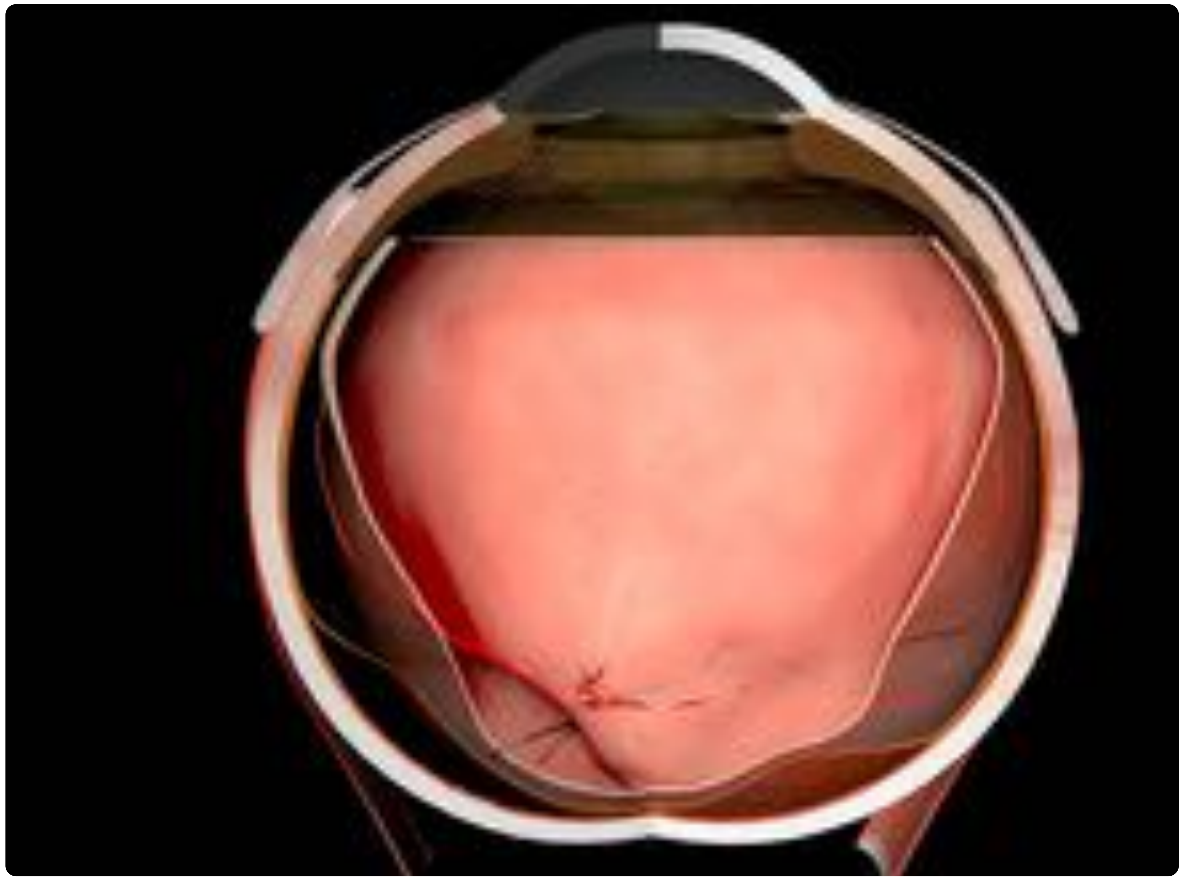


Figure 11.10 Dense vitreous hemorrhage in a young patient



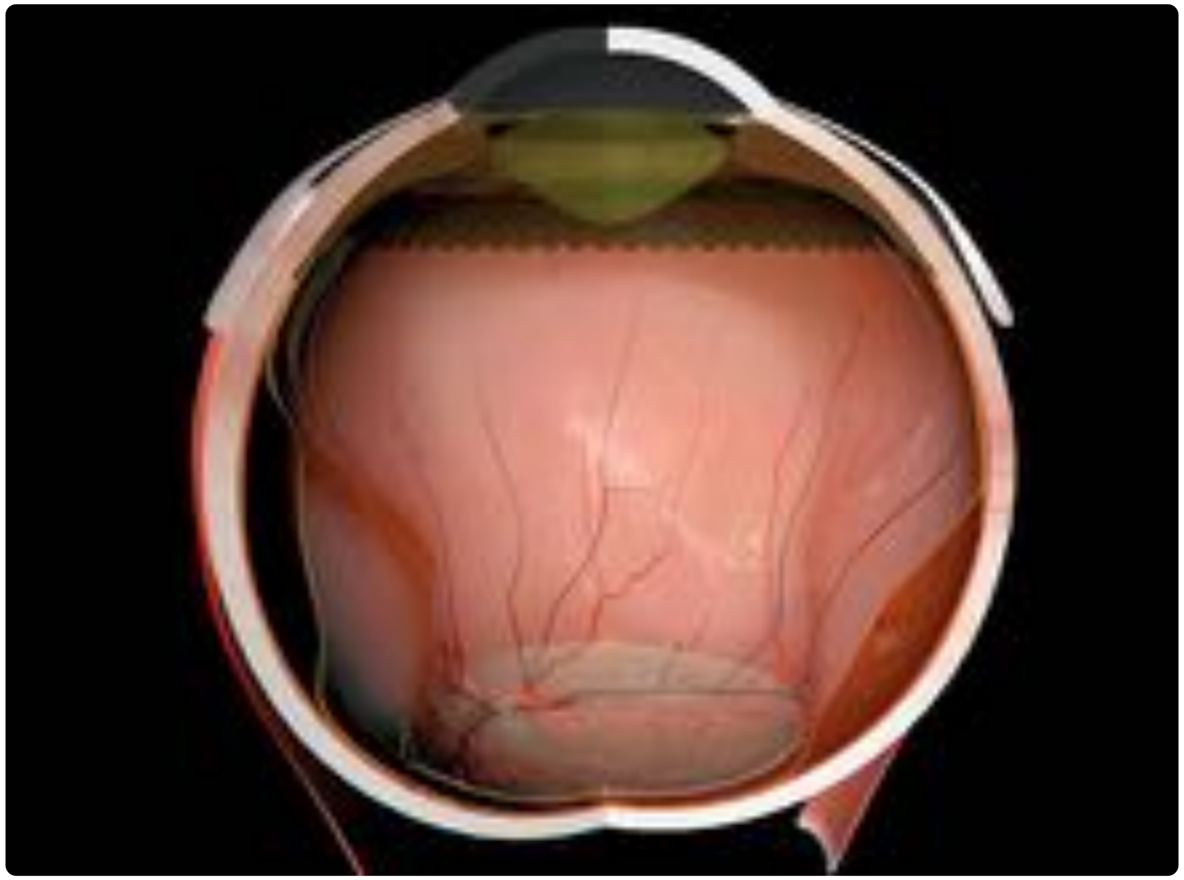
This patient presented with a vitreous hemorrhage. The eye had not undergone laser treatment. There was no clearing over a 2 week observation period. The eye underwent vitrectomy with delamination and extensive panretinal photocoagulation. The decision to operate was influenced by the DRVS findings of better outcome with earlier surgery in younger patients. Whenever possible it is desirable to administer preoperative panretinal photocoagulation. Indirect laser photocoagulation may be possible the view is too poor for treatment on the slit lamp.

Figure 11.11 Vitreous hemorrhage with traction detachment



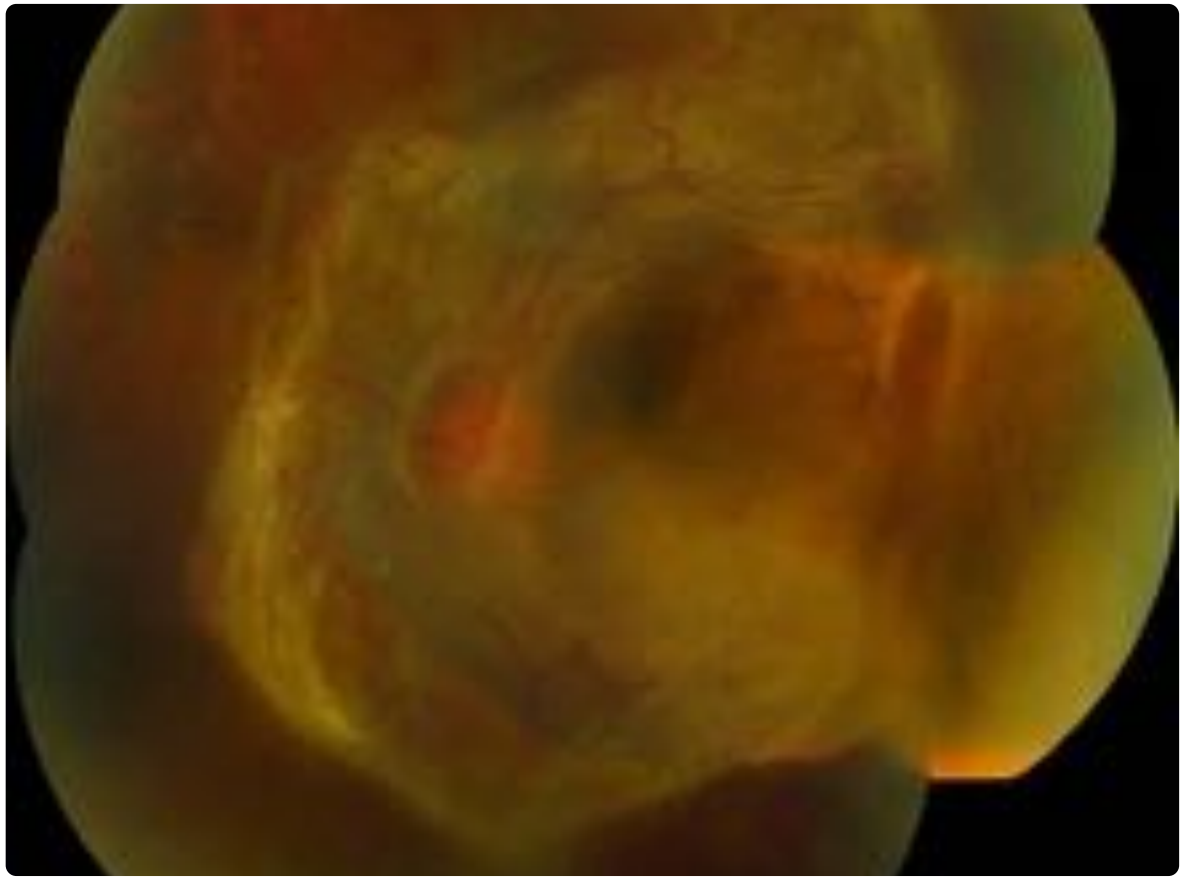
This eye has a vitreous hemorrhage and extensive tractional retinal detachment. Iris rubeosis is also present. The visual prognosis is poor but vitreoretinal surgery offers the only chance of salvaging vision and it should be carried out as quickly as possible. Intravitreal anti-VEGF agents administered preoperatively seems to be particularly useful in this group of patients.

Figure 11.12 Combined traction-rhegmatogenous retinal detachment



This patient complained of sudden visual loss. The detachment has many of the features of rhegmatogenous detachment - there is extensive subretinal fluid with a convex profile and a visible break. The break is frequently, as in this case, small and adjacent to a fibrovascular membrane. Urgent vitrectomy with delamination, tamponade and retinopexy is required.

Figure 11.13 Severe uncontrolled PDR



This young poorly controlled diabetic patient has severe uncontrolled PDR despite extensive PRP. Iris rubeosis is also present. The eye still has functional vision of 20/400 but the visual prognosis is very poor. Vitreoretinal surgery, probably following an anti-VEGF intravitreal injection, offers the only hope of vision retention.

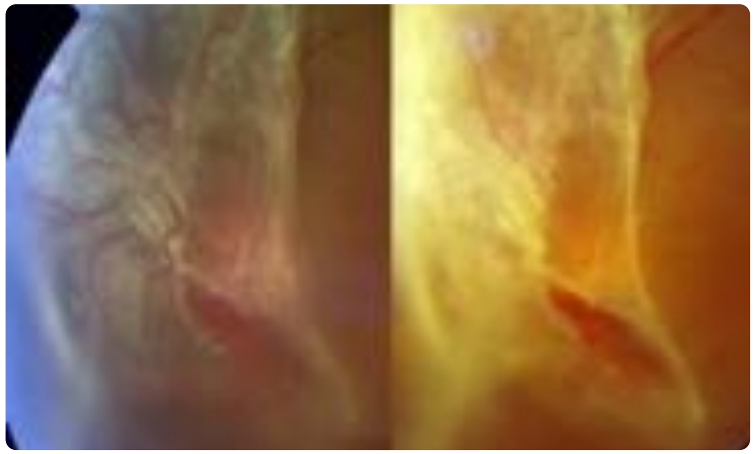
Surgical techniques in diabetic vitrectomy

PREOPERATIVE MANAGEMENT

Many diabetic patients are receiving some form of anticoagulant or anti-platelet therapy. The risk of postoperative hemorrhage may be reduced if these are discontinued in the perioperative period. This should only be done after consulting with the treating physician. Patients with drug eluting coronary stents are at particular risk and great caution should be exercised in stopping anti-platelet agents in this group. Many patients placed on long term aspirin for other indications (e.g as prophylaxis after a previous myocardial infarction) are at much lower risk from temporary suspension of treatment. In the case of warfarin therapy the international normalized ratio (INR) is checked to ensure that it is within the therapeutic range.

If the retinopathy is poorly controlled preoperative supplementary photocoagulation should be considered. If there is limited vitreous hemorrhage an indirect laser deliver system may allow treatment to be given. Alternatively a preoperative injection of an anti-VEGF agent reduces perfusion of the neovascular complexes and makes surgery technically more straightforward. The timing of this injection is quite important. A delayed cicatricial response may cause progression of detachment in some cases. The beneficial effects may be apparent as soon as 48 hours after injection. Most surgeons perform surgery within one week of injection.

Figure 11.14 Effect of intravitreal anti-VEGF agent



The reduction in perfusion of neovascular complexes is apparent.

SURGICAL PREPARATION

Most cases of diabetic vitrectomy, including complex delamination surgery, can now be performed using MIVS. The refined fluidics and proximity of the aspiration port to the tips of vitrectomy instruments allows very controlled and precise excision of fibrovascular complexes. The use of cannula entry site systems has considerably reduced the incidence of entry site breaks which were frequent when performing 20-gauge surgery. If a 20-gauge instrument such as a horizontal delamination scissors is required a single separate sclerotomy may be made for this.

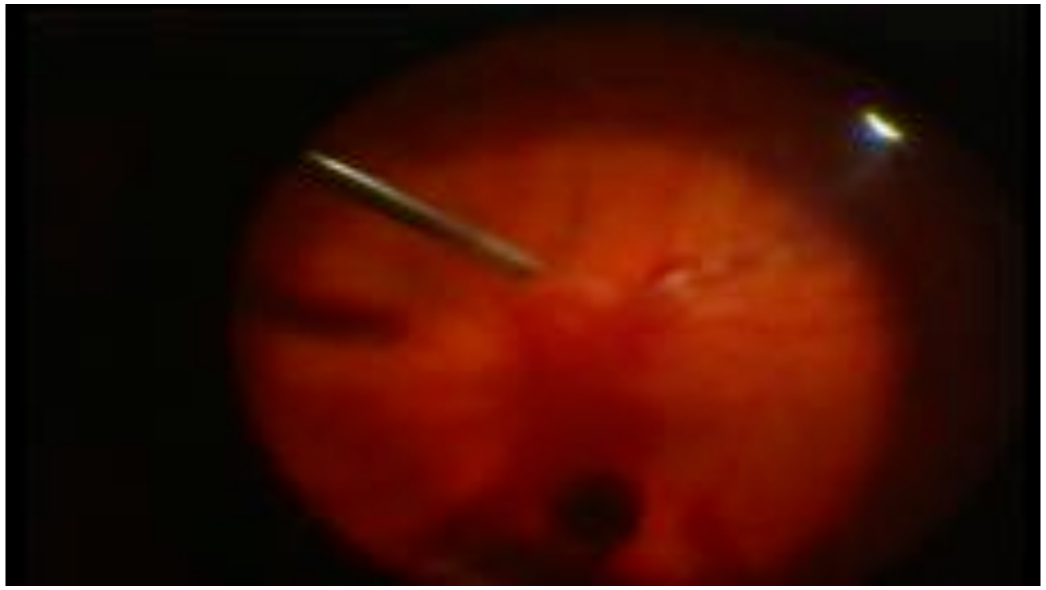
The use of non contact viewing systems reduces the probability of corneal abrasion. Switching from a wide field to a 90 Dioptre lens provides a good balance between width of field and depth of focus when dissecting posterior membranes.

VITREOUS HEMORRHAGE

In cases with fundus obscuring vitreous hemorrhage it may be difficult the check that the tip of the infusion is correctly sited in the vitreous cavity. If there is any doubt a light pipe may be passed through the infusion cannula - the light can be seen easily even in dense vitreous hemorrhages.

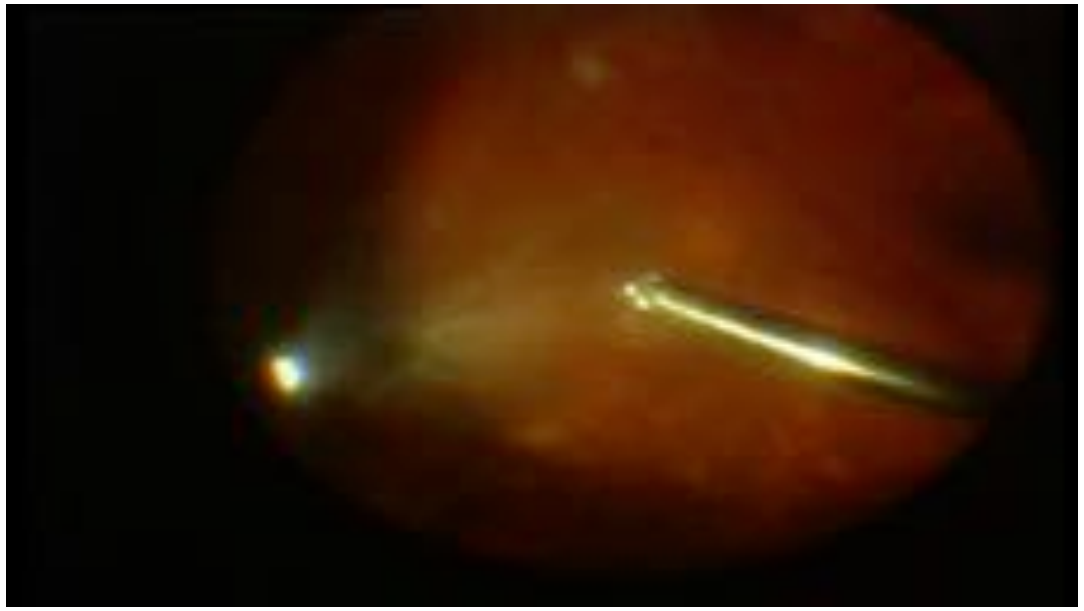
The vitrectomy should proceed cautiously initially. In time the view will start to clear and fundal details will start to appear. It will then be possible to cut more peripherally and posteriorly. The vitreous in the superior mid-periphery should be cleared first so that, if a break is inadvertently created, it is superior and easier to deal with. Another advantage of starting in the mid-periphery is that there are less likely to be strong vitreoretinal adhesion in this area. The way the vitreous moves should be observed. Detached vitreous moves freely while being cut and the impression that the vitreous movement is tethered may be a clue to the presence and location of adherent membranes behind the blood. Cutting should be performed initially where the vitreous seems most mobile.

Movie 11.2 Non mobile vitreous hemorrhage



Vitreoretinal adhesions are present which damp movement of the vitreous.

Movie 11.3 Mobile vitreous hemorrhage

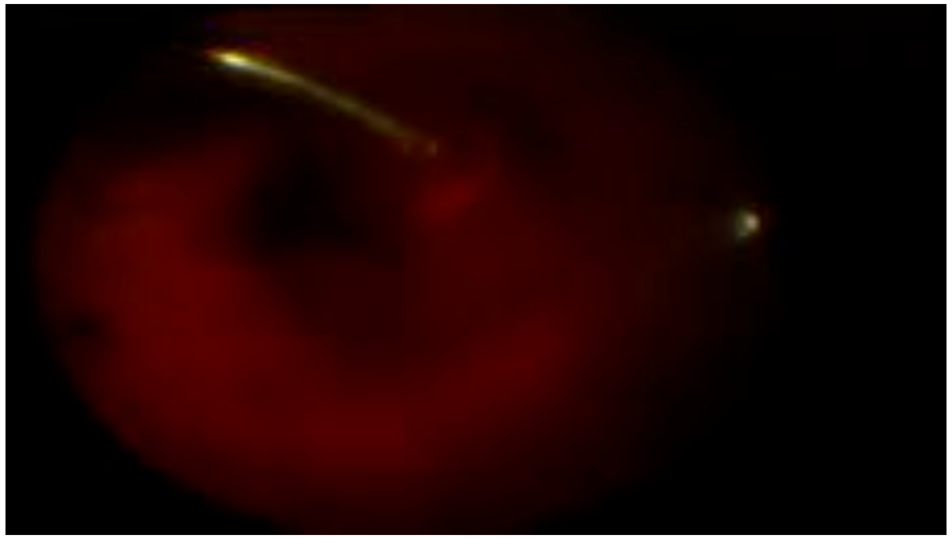


The posterior hyaloid is detached and the whole vitreous moves freely.

If there is retrohyaloid hemorrhage it will form a plume to the cutter when a hole is made in the posterior hyaloid. When this is seen the cutter should be kept in place to aspirate the blood. It is usually safest to stay in cut mode initially rather than switch to active aspiration in order to avoid vitreous traction. The liquefied retrohyaloid blood is denser than water and usually pools posteriorly and can be aspirated actively from the surface of the retina once the hyaloid has been cleared sufficiently. If fibrovascular membranes are thought to be present reflux from a backflush needle can be used to create a jet of fluid to blow blood away from the retina so that it can be safely aspirated. Areas of blood that do not move with this maneuver indicate the presence of fibrovascular membranes or attached hyaloid.

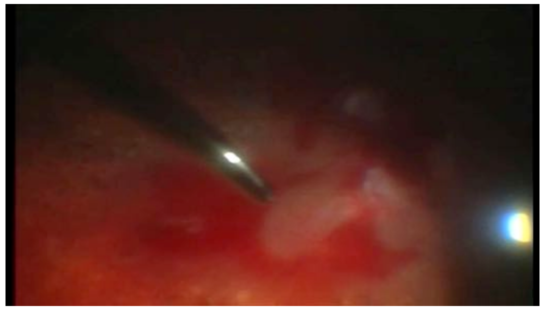
Trapped blood in the anterior hyaloid may degrade the fundal view. It can be stripped posteriorly off the lens capsule - this may be difficult to achieve in younger patients. Combining vitrectomy with cataract surgery allows this to be performed without fear of lens touch.

Movie 11.4 Retrohyaloid hemorrhage



A plume of blood comes forward to the cutter through the hole in the posterior hyaloid

Movie 11.5 Backflush disruption of preretinal hemorrhage



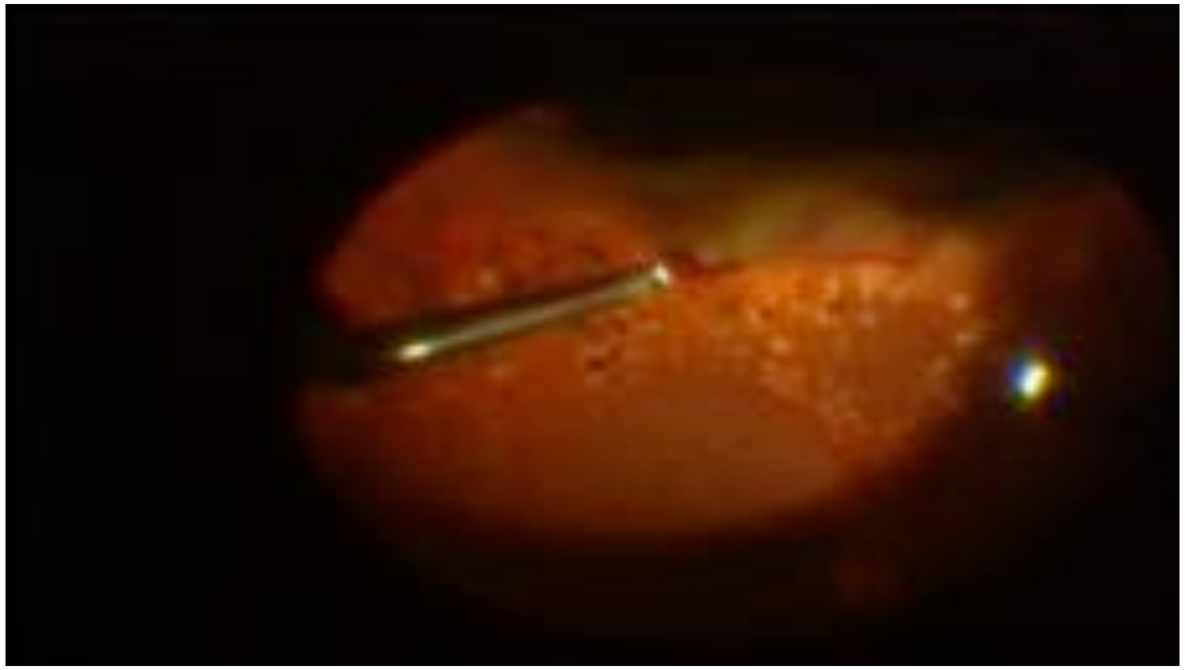
Note that the blood in the right of the picture is a slightly different color and does not move: it is trapped behind adherent vitreous. Also note the movements of the tip of this manual backflush so that it is kept some way from the retina. Automated reflux now allows more controlled disruption of the preretinal liquefied blood.

Movie 11.6 Stripping the anterior hyaloid in a phakic eye

This is best done using the microscope light. The cutter is placed behind the hemorrhage without crossing the midline. High aspiration is used to engage the anterior hyaloid which is pulled posteriorly and then the cutter activated while aspiration is maintained. Combined phaco/vitrectomy is probably a better option with this degree of anterior hyaloid hemorrhage.

Once the view is sufficiently clear indented shaving of the vitreous base is performed to reduce early vitreous cavity hemorrhage. This may be deferred to the end of the procedure in phakic patients to avoid the possibility of inadvertent lens touch degrading the fundal view.

Movie 11.7 Indented vitreous base shaving



Note the gap that appears between the basal hemorrhage and the retina (yellow arrow): the outer vitreous base remains clear. This sign allows the vitreous base to be shaved very close to the retina.

RELIEF OF TRACTION DIABETIC EYES - GENERAL PRINCIPLES

Relief of traction on the retina allows tractional detachments to resolve and reduces the risk of post vitrectomy hemorrhage. Even cases with an apparently complete vitreous detachment may have areas of adherent schitic vitreous. Triamcinolone allows these to be seen.

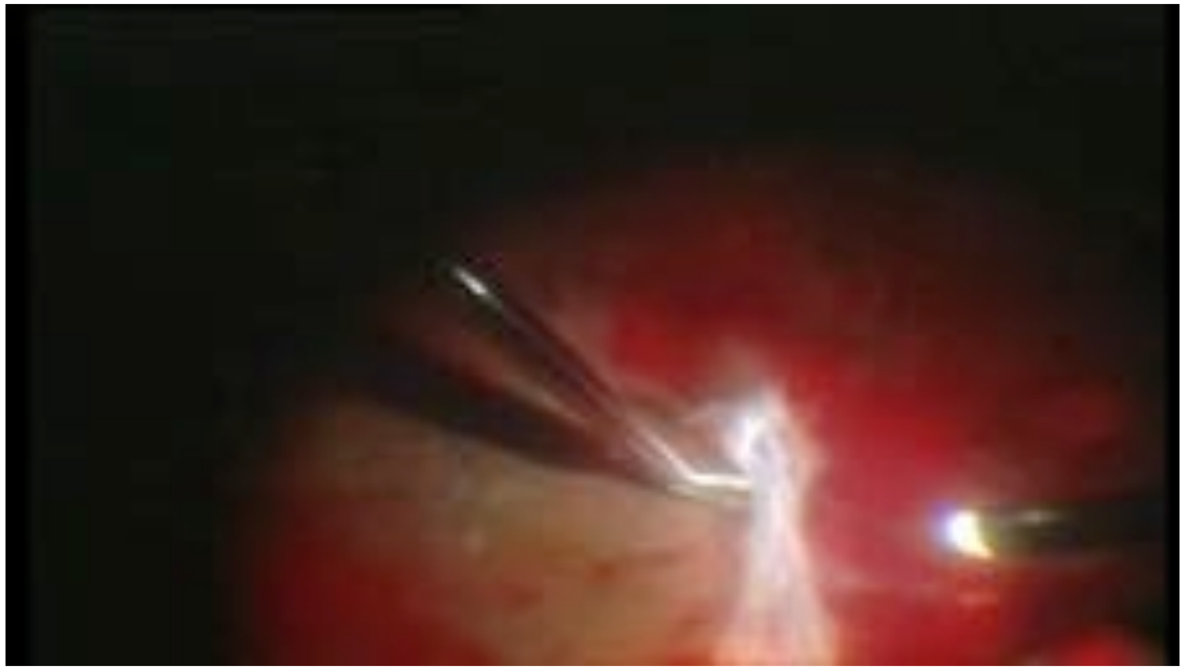
In the early days of vitrectomy only anteroposterior traction could be relieved. The development of segmentation - division of membranes with vertical scissors - was a significant advance which allowed the relief of bridging traction. The residual islands of fibrovascular tissue were particularly likely to cause post operative hemorrhage however. This problem was solved by the introduction of techniques to completely remove all the fibrovascular membranes. This relieves all traction (anteroposterior, bridging and tangential). This was initially performed with horizontal scissors. This surgical goal can now often be achieved with ultrahigh speed vitreous cutters. These can be used multifunction tools capable of segmentation, delamination and gentle elevation of non fibrovascular membranes.

SEGMENTATION

Segmentation still has a role in providing access to fibrovascular pegs. It may be carried out with scissors or a vitrectomy cutter. It is not usually an end in itself, merely a means to the end of complete excision of the fibrovascular membrane ('access segmentation').

Scissors designed for segmentation have blades which are not aligned with the shaft and so cannot be introduced through MIVS cannulas. The curved blades designed for segmentation may be used for access segmentation by tilting them slightly. Segmentation may also be achieved with MIVS cutters due to the proximity of the port to the end of the shaft.

Movie 11.8 Segmentation



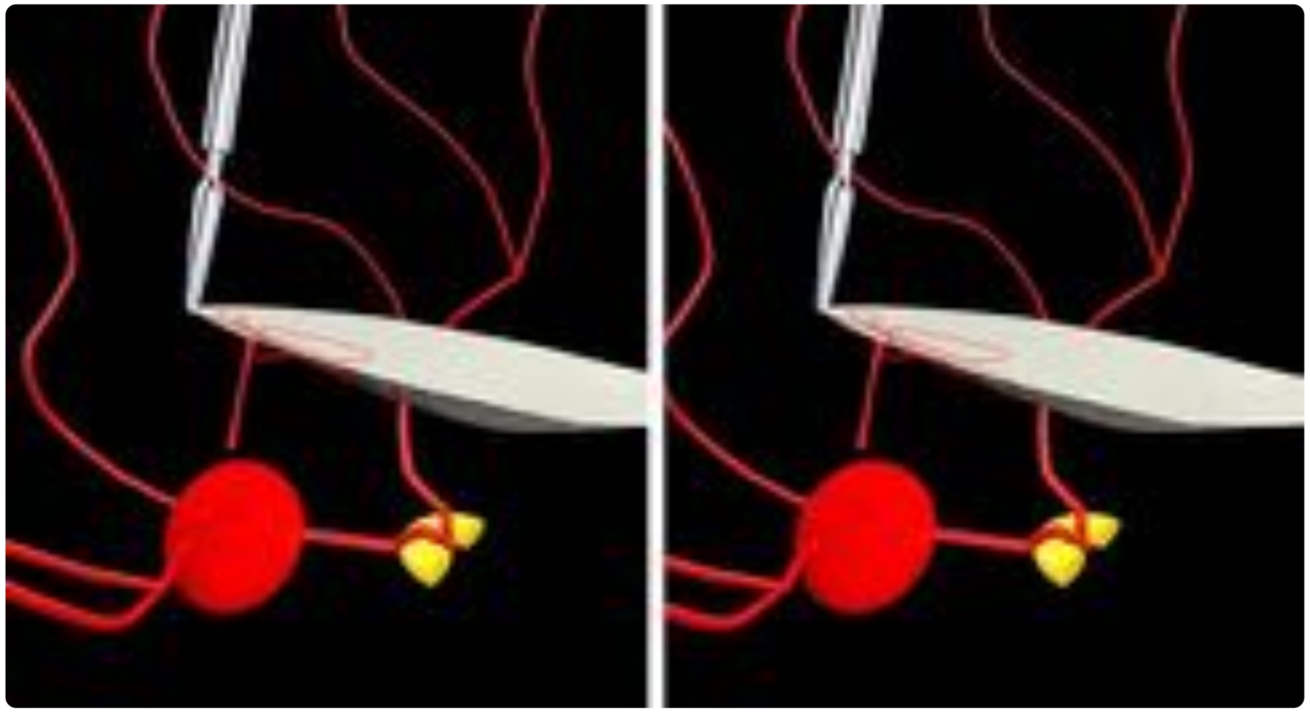
This technique is generally only used to facilitate access to fibrovascular pegs.

DELAMINATION - GENERAL PRINCIPLES

Fibrovascular pegs securely anchor the hyaloid to the retina. If these are stripped away there is a significant risk of retinal breaks and hemorrhage due to avulsion of a small plug from wall of the vein. Although the pegs may bleed slightly when transected the bleeding is far less and easier to control than the hemorrhage resulting from avulsion of the wall of the retinal vein.

The fibrous tissue that surrounds the new vessels within the fibrovascular membrane impedes the physiological vasospasm that normally follows vessel injury. The bleeding, although slow, is prolonged and may be more difficult to control than the more isolated bleeding from a divided peg. The peg should therefore be transected between its origin in the vessel wall and its entry point into the fibrovascular membrane. This is relatively straightforward in eyes with partial vitreous separation around the peg as there is a clearly visible plane between the hyaloid/fibrovascular membrane and the retina. The challenge of complex delamination surgery is that frequently no such plane exists. It has to be created without undue traction on the peg (as bleeding makes the correct plane for dissection even harder to define).

Figure 11.15 Fibrovascular peg bleeding (stereo gallery)



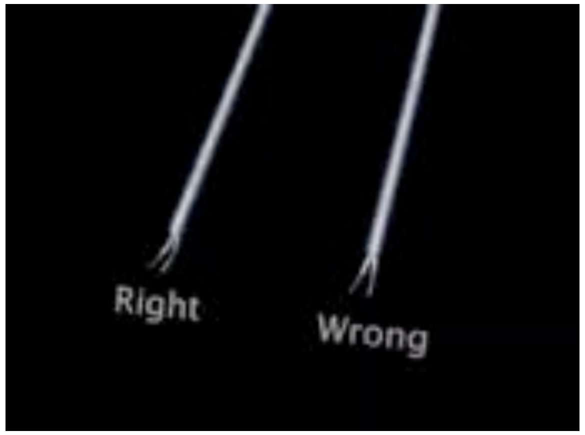
The bleeding that arises when the fibrovascular plug is torn off the vessel may be severe.

SCISSOR DELAMINATION

When performing scissor delamination

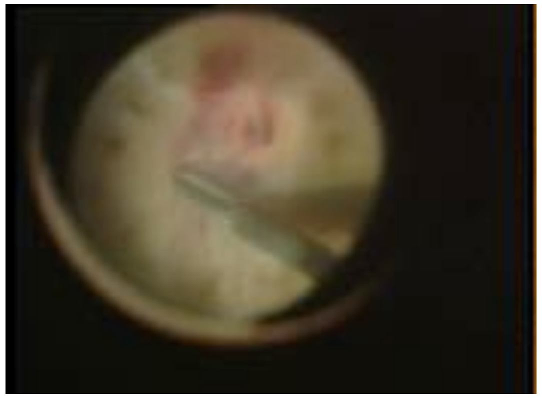
- Start dissection in the correct plane. If starting centrally ('inside out delamination') this is relatively easy to achieve. If working from the outside in (i.e. from the periphery of the fibrovascular membrane) one should look for non fibrovascular membranes ('additional epiretinal membranes') adhering to the retina which represent areas of peripheral vitreoschisis. These can be gently stripped off the retina (while being vigilant for 'arrowheads' indicating a vitreoretinal adhesion requiring delamination) and used to define the correct plane.
- Work from the edge towards the epicenter of any individual fibrovascular peg. This applies whether working 'inside out' or 'outside in'.
- Apply just sufficient traction to see areas of fibrovascular adhesion so that they may be cut transversely.
- Avoid a spreading action with the scissors under membranes as this causes traction without cutting (the aim being to cut the pegs not tear them).
- Employ a precision grip which allows closure of scissors without movement of the shaft (practicing outside the eye if necessary).
- Use scissors that are capable of cutting cleanly. Blunt scissors tear rather than cut tissues.

Movie 11.9 Using delamination scissors



The shaft should not move when the scissors are opened and closed.

Movie 11.10 Gently stripping the hyaloid around fibrovascular pegs



There is a fibrovascular peg at the disc. The hyaloid around it is elevated so that the peg is isolated before cutting it.

IDENTIFYING PEGS

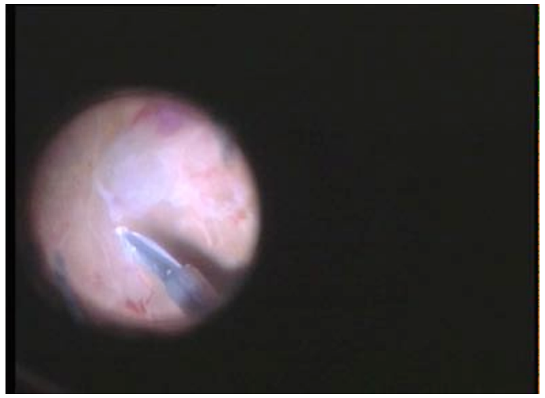
Identifying the location of the fibrovascular pegs is key to delamination surgery. This can be done in various ways:

- Observing white dots within the membrane 'en face'.
- Turning the membrane over and identifying 'arrowheads'
- Moving the closed scissors under the membrane - if a peg is encountered the membrane and retina will move slightly.

Figure 11.16 Identifying pegs

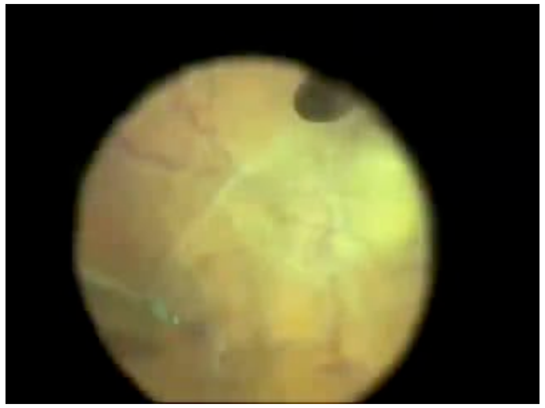
Identifying pegs (stereo). The pegs need to be clearly seen in order to be safely cut. In this case bimanual delamination is being used. Traction on the peg is minimal - just enough to see the arrowhead that points to the vitreoretinal adhesion and separate the weak non vascular adhesion around the peg.

Movie 11.11 Reflecting the membrane to visualize pegs.



Notice the minimal traction used - the aim is simply to see the pegs so that they can be cut.

Movie 11.12 Observing movements of the membrane



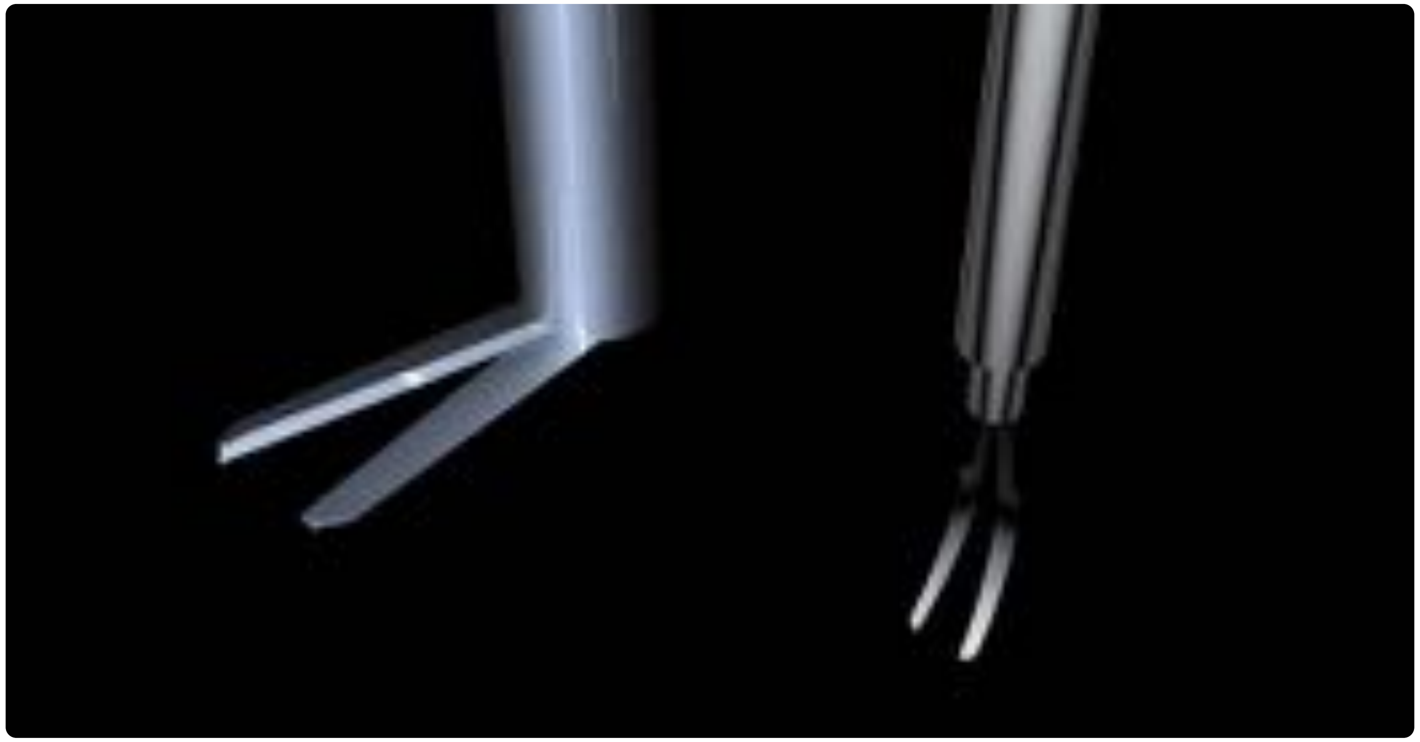
Adherent non vascular posterior hyaloid is stripped around the fibrovascular peg. Prior to cutting the peg with the scissors they are moved under the membrane - when the scissors encounter the peg the whole membrane moves confirming that there is a focal adhesion at this point (video courtesy of Zdenek Gregor).

DELAMINATION SCISSORS

The horizontal scissors used during 20-gauge vitrectomy cannot be introduced through a cannula. If required during an MIVS delamination a single 20-gauge port can be created.

Specialized scissors using curved blades that can pass through a microcannula are used during MIVS scissor delamination.

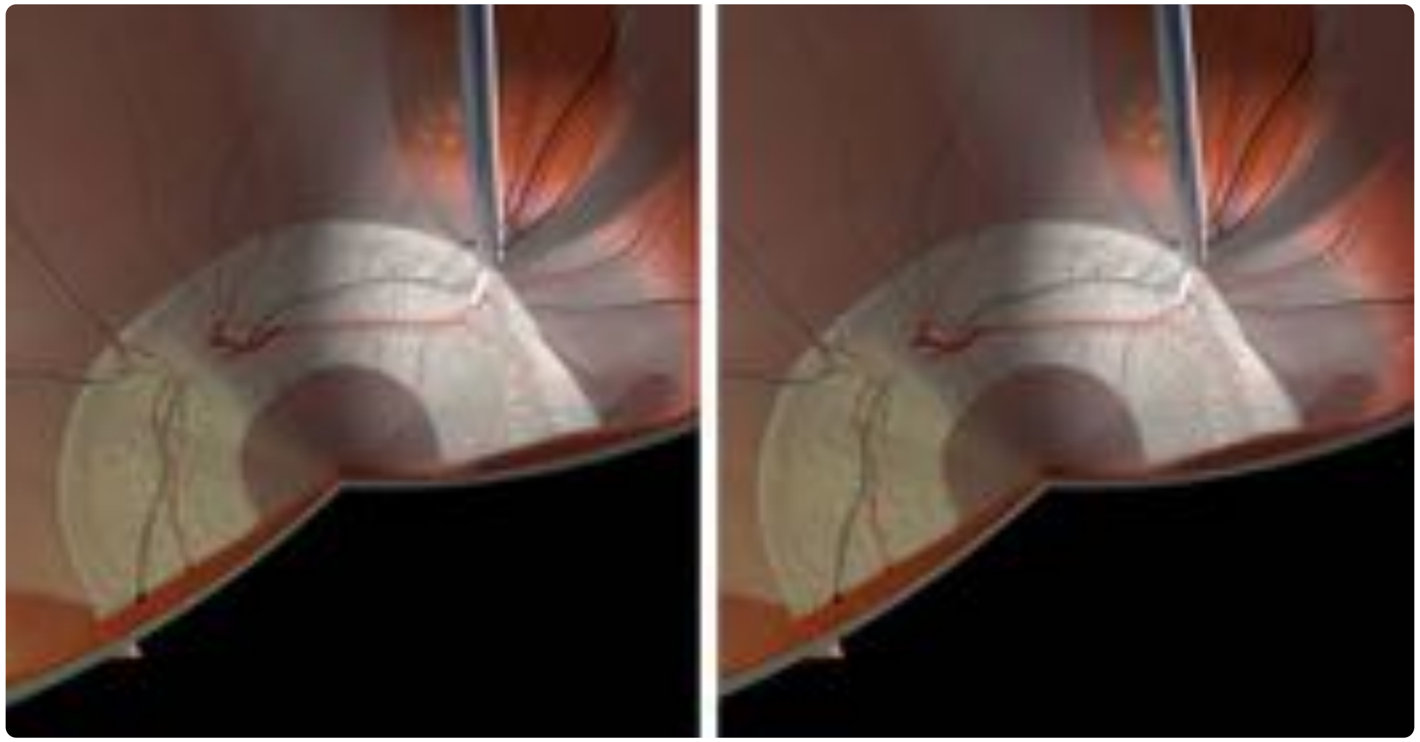
Figure 11.17 Delamination scissors



20 and 23-gauge delamination scissors. The 23-gauge scissors have curved rather than horizontal blades to allow them to pass through a cannula. 25-gauge scissors are also available.

The en bloc technique involves leaving much of the hyaloid in place initially. Vitreous around the sclerotomies is removed to avoid entry site breaks. Dissection starts at the edge of the fibrovascular membrane. The residual hyaloid elevates the fibrovascular membrane as it is dissected off the retina. Traction may be transmitted by the posterior hyaloid to the peripheral retina causing peripheral retinal breaks. For this reason many surgeons prefer to perform delamination 'inside out'. Dissection starts over the posterior pole working outwards. When starting dissection over the optic disc the fibrovascular tissue is first avulsed from the disc with forceps. This usually causes hemorrhage from the veins in the optic nerve head.

Figure 11.18 Delamination



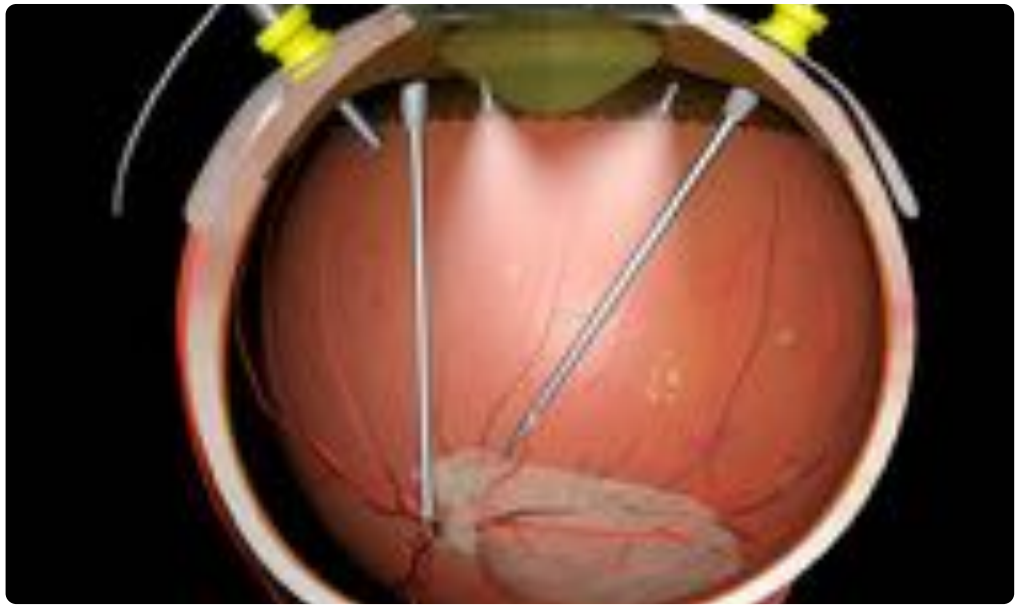
En Bloc delamination (stereo). Note that a window has been cut in the posterior hyaloid to allow the scissors access to the membrane but most of the hyaloid has been left in place. It is removed along with the fibrovascular membrane after it has been dissected free of the retina.

ILLUMINATION DURING DELAMINATION

Use of accessory light source allows bimanual delamination surgery to be carried out, with a forceps used to retract the membrane and a scissors to perform the delamination. When performing this technique:

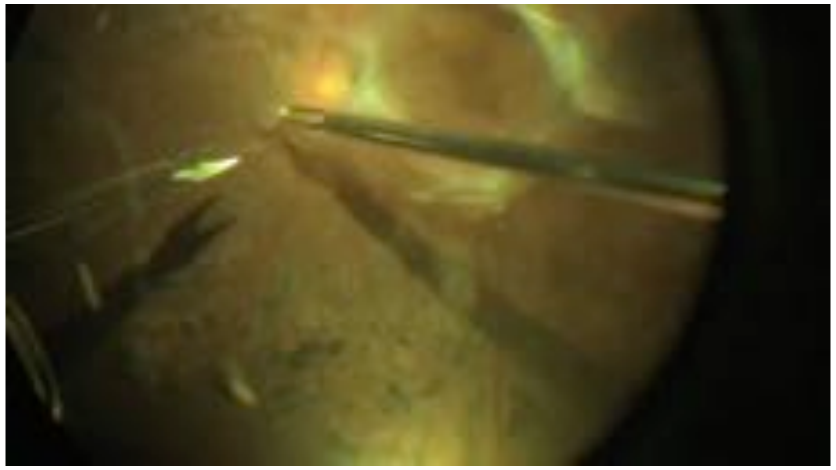
- Some of the subtle specular clues and shadows that are seen during focal illumination with a light pipe are lost and slightly greater traction has to be applied to see the pegs.
- Care has to be taken not to rotate the eye while moving the scissors, otherwise the induced movement of the forceps places traction on the membrane. This can be achieved by pivoting the scissors carefully around the sclerotomy or by grasping the membrane when the scissors are in approximately the correct position. Counterintuitively it may be easier to use the forceps in the dominant and the scissors in the non-dominant hand.
- Light sources vary enormously in quality - some are much better than others for bimanual surgery. The light should be bright and the color balance as close as possible to natural light.

Figure 11.19 Bimanual delamination set up



In this case two self retaining 27-gauge light fibreoptics are being used. The position of these should be carefully considered, especially if the palpebral aperture is narrow, to avoid tilting of the light pipes as the eye is moved due to pressure from the upper lid.

Movie 11.13 Bimanual delamination



The peripheral detached hyaloid has already been excised. Sufficient traction is being used to separate schitic vitreous around the pegs and to visualize the pegs clearly as little arrowheads when the membrane is lifted. The visible arrowheads are cut individually using the very tips of the scissors. In this case an 'outside in' approach is used but many surgeons prefer to start at the disc to reduce peripheral retinal traction. In the absence of non vascular adhesions around the pegs it is only necessary to reflect the membrane slightly to see the pegs.

Bimanual manipulation during routine delamination (i.e. without an accessory light source) can be achieved by using the light pipe to turn over the edge of the fibrovascular membrane. Light picks are fibreoptic light pipes specially designed for this purpose.

Movie 11.14 Bimanual manipulation using an ordinary light pipe

Note a frill of fibrovascular membrane has to be left in order to do this. This is less important if a light pick is used.

CUTTER DELAMINATION

Micro-incision vitrectomy cutters offer improved fluidics, faster cut rates and cutting apertures closer to the end of the end of the shaft. These properties have considerably extended the scope of the surgeon to perform surgery in diabetic eyes with the cutter alone. Steve Charles has coined the terms 'conformal delamination' and 'foldback delamination' to describe techniques used to excise fibrovascular membranes with the cutter. Both techniques rely on the membrane around the vascular pegs being mobile.

Movie 11.15 Conformal cutter delamination

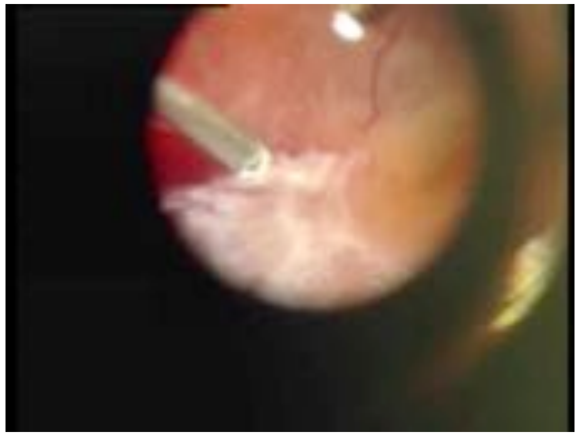
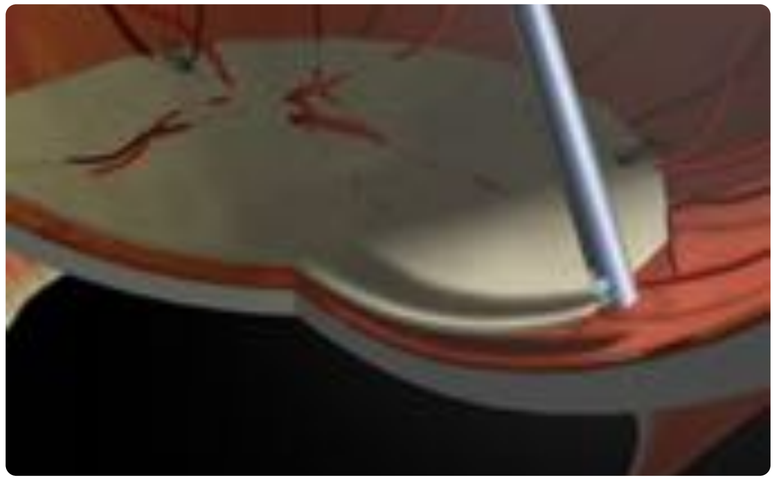
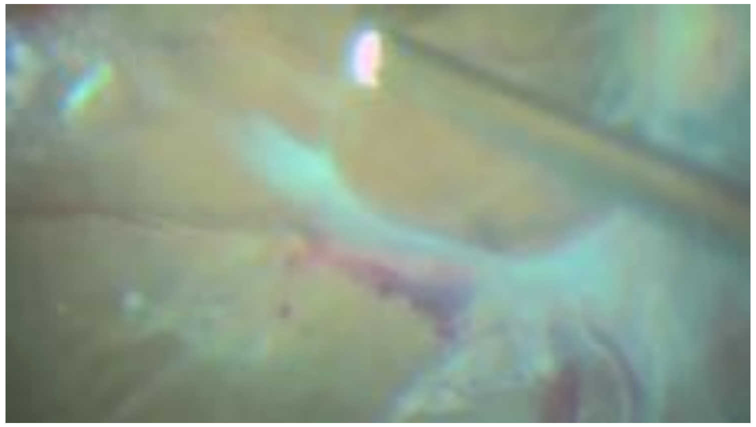


Figure 11.20 Cutter delamination



Conformal delamination. The edge of the cutter directly engages less compliant membranes. This is very controlled unless port occlusion occurs (which causes undesirable rapid aspiration)(this is less likely to occur in these less compliant membranes) or the membrane is still bound to the retina (in which case retinal breaks may occur). The angle of the cutter needs to be changed continuously to prevent retinal breaks. Generally the port should orientated slightly oblique to the membrane and away from the retina.

Movie 11.16 Cutter delamination of a single peg



The aperture of this 23-gauge cutter is close to the tip. Combined with the high cut rate this allows individual pegs to be cut quite precisely. Note there is little traction on the fibrovascular membrane as this is done.

SUMMARY OF DELAMINATION TECHNIQUES

In summary several techniques are available to the retinal surgeon for the excision of diabetic fibrovascular membranes. These include

- Access segmentation.
- Scissors delamination (inside out or outside in).
- Cutter delamination - conformal or foldback.
- Bimanual surgery - either with an accessory light source or using the light pipe to turn the membrane over.

The author uses almost all of the above, often employing more than one technique in the same case, depending on the extent of the fibrovascular membrane and the nature of the associated adhesions to the retina. Most surgeons no longer perform ‘en bloc’ dissection because of the high incidence of peripheral breaks. They are increasingly performing dissection with the cutter.

ENDOLASER

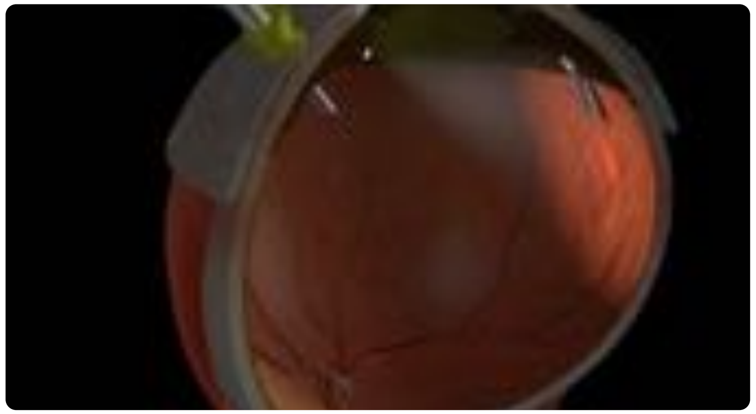
If the retina has ischaemic features supplementary PRP is performed. This reduces postoperative posterior reproliferation (around any residual membranes) and anterior vasoproliferation (rubeosis and anterior hyaloid proliferation).

When performing panretinal photocoagulation:

- Preretinal blood is removed prior to laser. Laser to preretinal hemorrhages results in inner retinal burns. Nerve fibre layer loss causes extensive arcuate scotomas.
- A curved endoprobe is used to treat the equatorial retina from the opposite side (e.g. treatment of nasal retina with the laser in a temporal port). The angle of incidence of the laser light is more perpendicular and the laser spots less oblique.
- Whenever possible the laser probe is swung in an arc at a constant distance from the retina giving uniform burn size and intensity. This is also easier when treating the opposite side of the eye.
- Only attached retina should be treated. Attempts to perform PRP in the presence of subretinal fluid lead to intense burns (as the power has to be very high to get a visible reaction) which causes energy propagation to the choroid. Chronic tractional detachments have viscous subretinal fluid which cannot be removed sufficiently to perform PRP safely. Areas of detached retina may be treated postoperatively when the tractional detachment has resolved.
- If any eye has not had previous laser a methodical approach treating posteriorly first and than in arcs outwards may be employed to reduce the risk of losing orientation and accidentally treating the fovea.

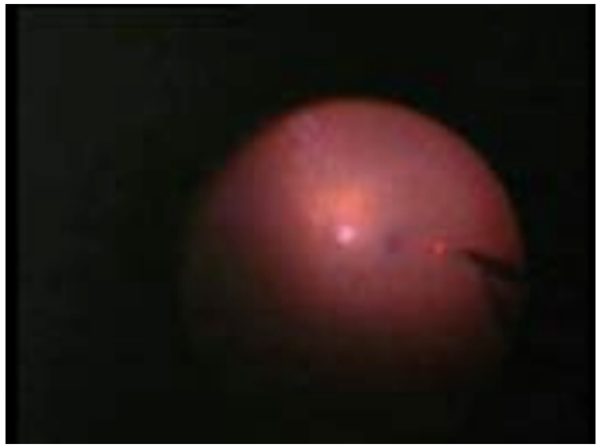
Laser should also be performed around retinal breaks (after fluid gas exchange if there is associated subretinal fluid).

Figure 11.21 Endolaser panretinal photocoagulation



Attempts to treat the equatorial retina on the same side of the laser results in oblique light incidence and non circular laser spots.

Movie 11.17 Pan retinal photocoagulation



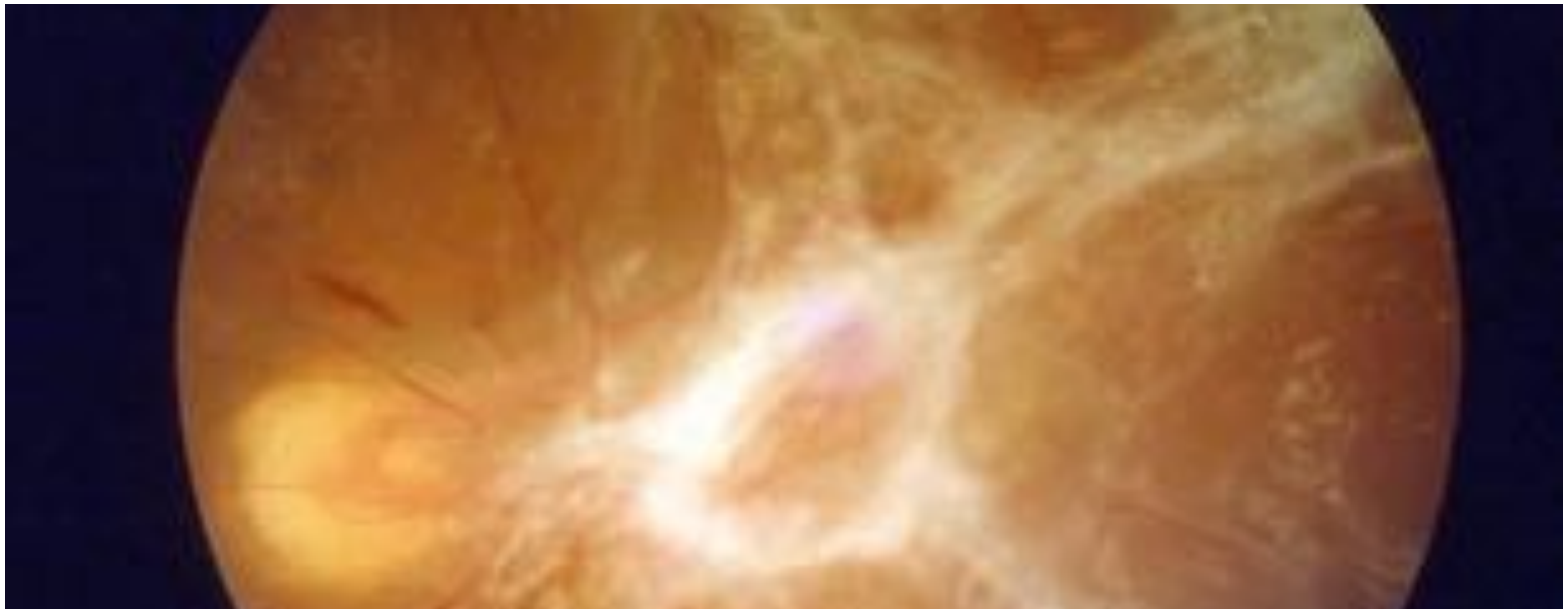
The intraoperative PRP is heavier than would normally be delivered on the slit lamp to a virgin eye. The rationale for this is that postoperative vitreous cavity hemorrhage may preclude post operative fill in PRP.

TAMPONADE

No tamponade agent is required unless a retinal break is present, in which case air or a short acting gas is usually sufficient.

Silicone oil is reserved for the more complex cases with anterior hyaloid proliferation or large retinectomies with unrelieved traction. The silicone-fluid interface seems to provide a scaffold for reproliferation. The threshold for using silicone oil in diabetic patients should be very high indeed.

Figure 11.22 Tamponade after diabetic vitrectomy



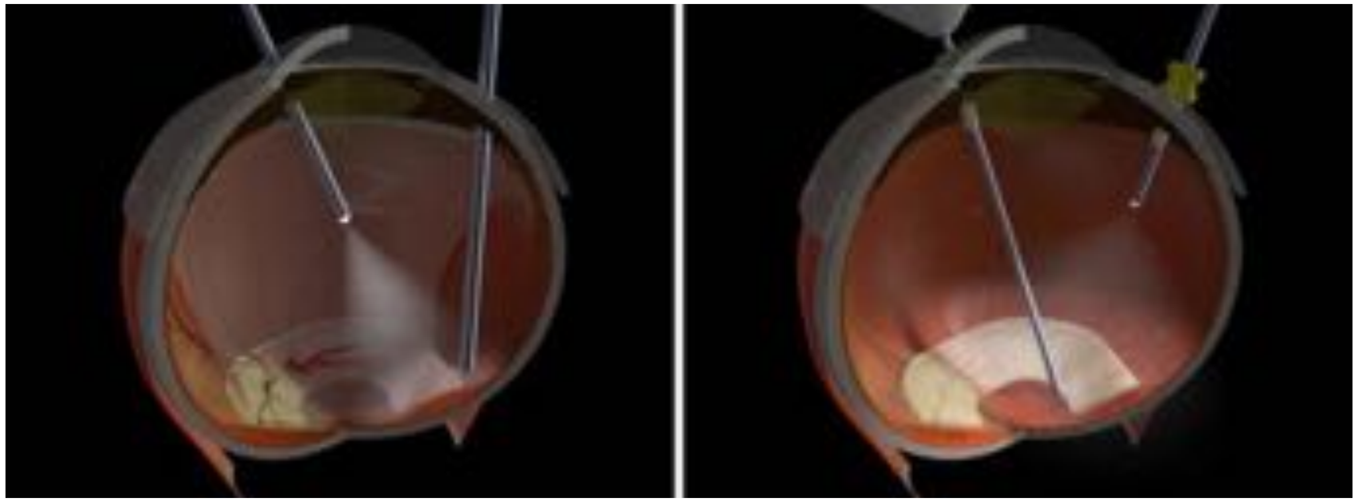
Reparative fibrosis ('perisilicone proliferation') 6 months after diabetic vitrectomy with silicone oil.

Complications of diabetic vitrectomy

The major intraoperative complications are hemorrhage and retinal breaks. These are far more likely in complex cases with little vitreous separation or in which uncontrolled proliferation is present. The two complications often go together. Uncontrolled bleeding under a fibrovascular membrane makes it more likely that a break will be made. Breaks may lead to a traction detachment becoming more mobile which makes delamination more difficult and increases the likelihood of hemorrhage.

Preoperative administration of anti-VEGF agents reduces the incidence of peroperative hemorrhage and complexity of surgery. The combination of preoperative administration of anti-VEGF agents and MIVS seems to improve visual outcomes in the most complex cases.

Figure 11.23 Advances in diabetic vitrectomy



The eye on the left is undergoing en bloc surgery with 20-gauge instrumentation. On the right the same eye is undergoing surgery 5 days after avastin injection (the peripheral vitreous has already been removed and the cutter is being used to perform inside out conformal delamination). The introduction of preoperative anti-VEGF injection and refinements in vitrectomy instrumentation have reduced the complexity of surgery and the risk of complications.

Intraoperative bleeding may arise from:

- Transected pegs. This is usually self limiting.
- Avulsed pegs. Here the traction is irising directly from the wall of the vein and may be more persistent. It may be managed by temporarily increasing the infusion pressure. Direct pressure may be applied to the bleeding point with the cutter tip for 30 seconds. Bleeding of this sort is particularly likely to occur if a fibrovascular membrane is avulsed from the disc. This may be avoided by leaving a nubbin of tissue over the disc. Bleeding from this may be managed with unimanual bipolar diathermy.
- Bleeding from the cut edges of a fibrovascular membrane. This may be managed with diathermy. The fibrovascular membrane seems to hold vessels open and, paradoxically, bleeding may stop or be easier to control if the whole fibrovascular membrane has been removed.

Solid clots are probably best left if bleeding has stopped. Stripping these off the bleeding point may cause hemorrhage to restart. If very large clots are present their edges may be aspirated free of the retina and trimmed with the cutter, leaving the centre undisturbed.

Endolaser can be applied to a persistent bleeding point on the retinal surface - this is preferable to diathermy which may stick to the surface of the retina. Quite low laser power levels are used as the blood absorbs laser energy effectively. Large retinal vessels should not be treated in this w

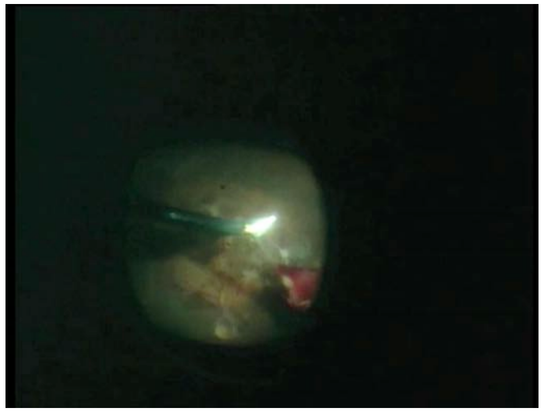
Movie 11.18 Pressure to control bleeding during diabetic vitrectomy.

This is effective for bleeding from the retinal surface. It cannot be used for bleeding from the cut edge of a fibrovascular membrane or where the origin of the hemorrhage cannot be determined.

Posterior retinal breaks usually arise from:

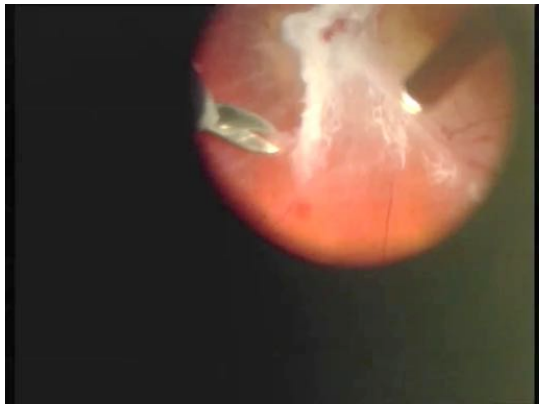
- Applying undue traction to the retina.
- Failure to isolate a single peg before cutting with scissors.
- Uncontrolled scissor cutting under a fibrovascular membrane, especially when the underlying retina is convoluted.
- Poor vitrectomy cutter delamination technique.

Movie 11.19 Iatrogenic tractional tear



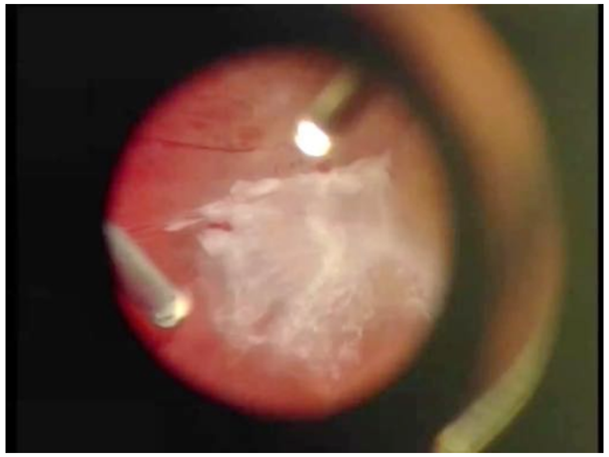
The traction on the membrane is grossly excessive here.

Movie 11.20 Iatrogenic break from scissors



Scissors should only be used to transect clearly identified pegs. Only the tip should be used and they should not be opened wide. Here the scissors are opened too wide and cut in an area of broad adhesion without pegs, resulting in a tear.

Movie 11.21 Break during cutter delamination

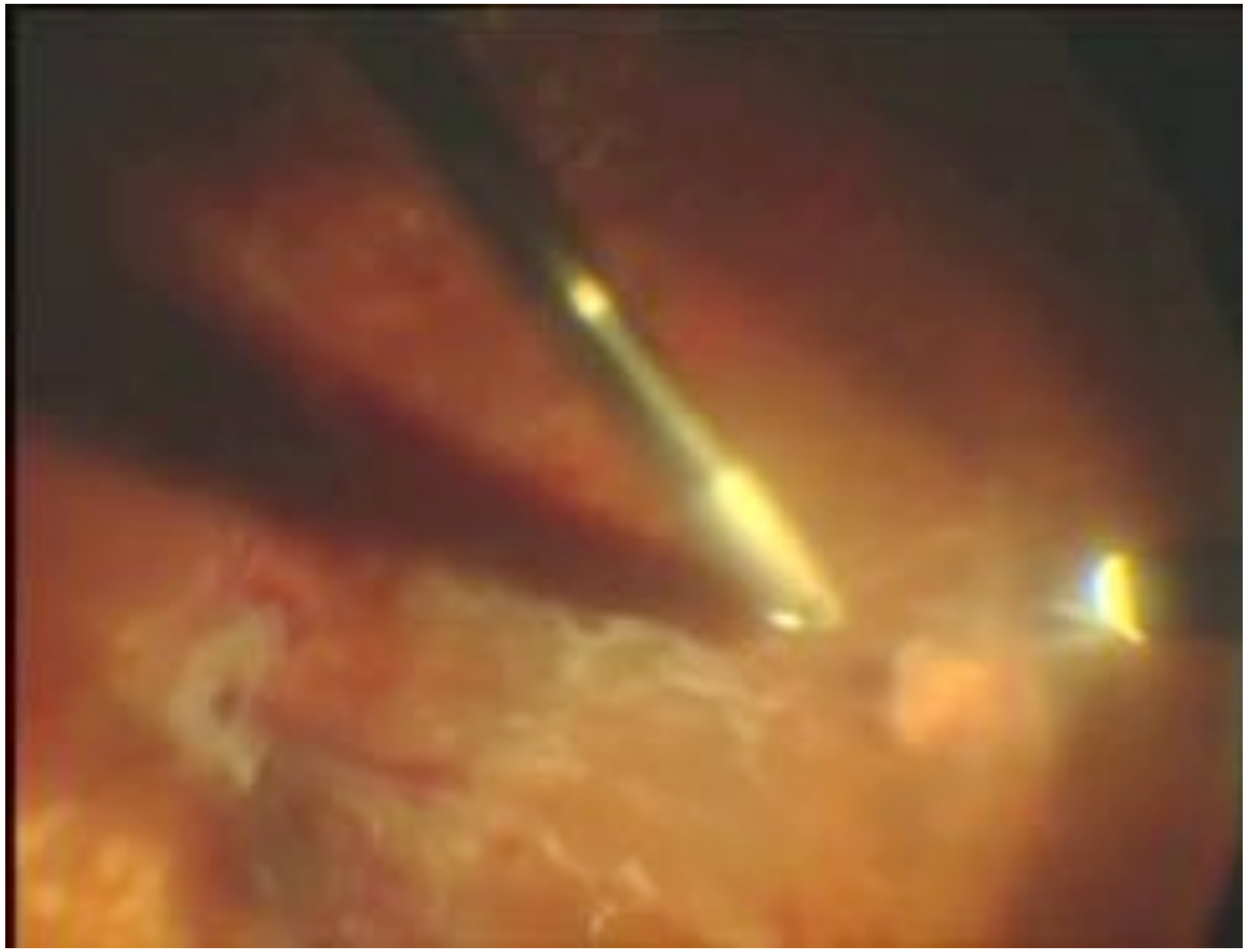


There is a broad adhesion between the retina, the fibrovascular membrane and schitic vitreous. The broad non vascular adhesions have not been peeled adequately. The membrane is compliant and occludes the cutter tip resulting in a retina break. During conformal delamination the tip of the cutter should be angled away from the retina. Conformal delamination should not be used on areas of membrane with broad non vascular vitreoretinal adhesions - these should be peeled.

Posterior breaks are managed by relieving all the traction on them, reattaching the retina with air-fluid exchange and applying retinopexy.

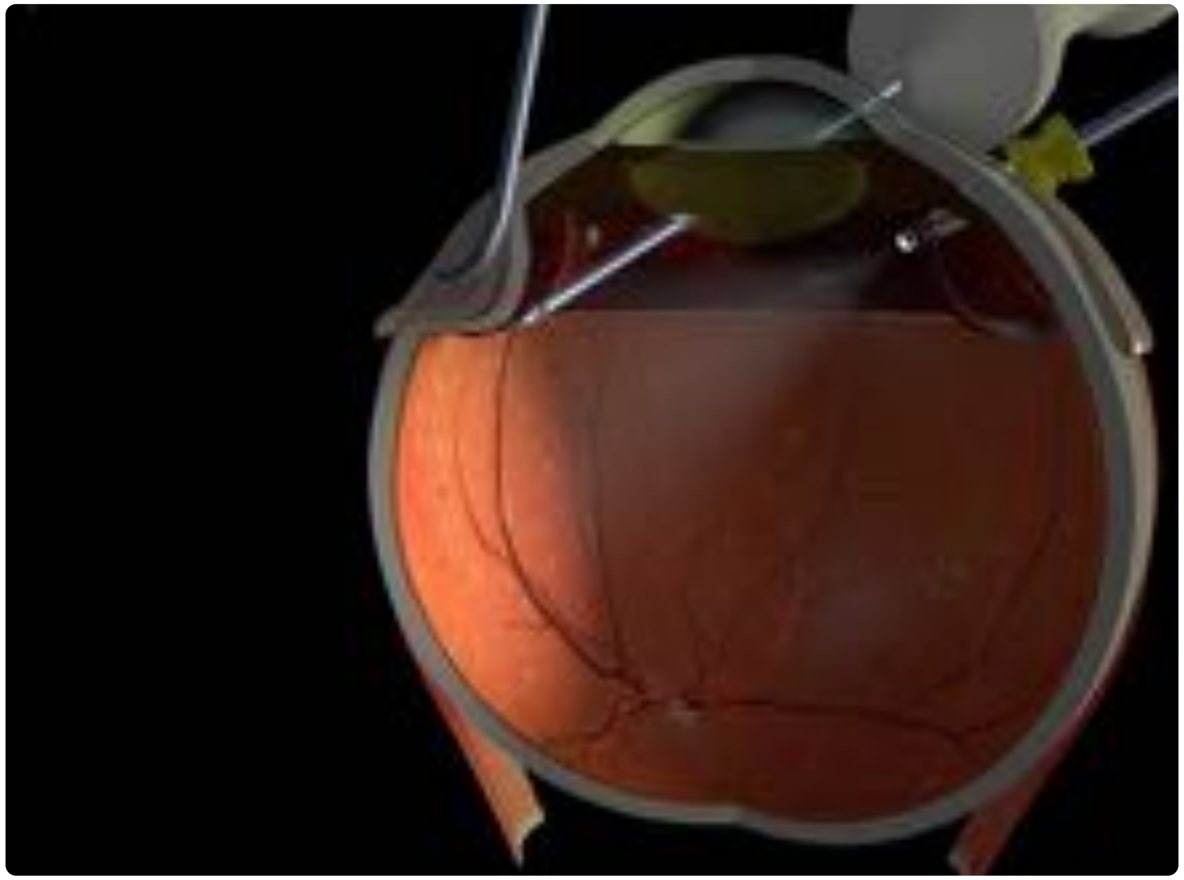
Peripheral retinal breaks arise from traction on a detached posterior hyaloid, especially around the instrument entry sites. These occur much less frequently with MIVS surgery. They are managed by retinopexy and tamponade. Scleral buckling is no longer used.

Movie 11.22 Relieving traction on a retinal break



This is a case of combined traction rhegmatogenous retinal detachment. The yellow arrow indicates the location of the break. Fibrovascular pegs are delaminated and schitic vitreous peeled away from the retina.

Figure 11.24 Steps to reduce the incidence of post operative vitreous cavity hemorrhage



Indented trimming to remove hemorrhage in the vitreous base

Post vitrectomy hemorrhages may occur due to:

- Leaching of residual blood from within the vitreous base.
- Residual membranes causing traction on posterior fibrovascular complexes.
- Anterior vascular proliferation.

These problems typically present at different times after surgery. Early hemorrhage is typically due to residual blood from the vitreous base or bleeding from residual membranes. Anterior hyaloid proliferation typically presents as delayed vitreous cavity hemorrhage.

Measures to prevent postoperative hemorrhage include:

- Indented trimming of the vitreous base.
- Panretinal photocoagulation or even cryotherapy to the anterior retina, particularly around the sclerotomies.
- Use of triamcinolone to exclude the presence of residual posterior membranes.

The presence of erythrocytes in the anterior chamber indicates a high probability that hemorrhages will clear spontaneously. Failure to clear may be managed by vitreous cavity washout, with vitreous base trimming and excision of residual membranes as required.

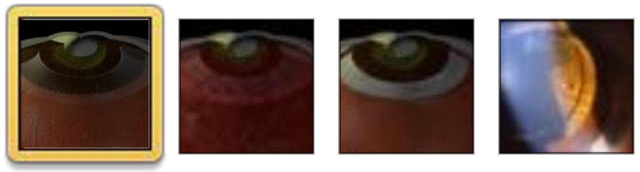
ANTERIOR PROLIFERATION.

Following vitrectomy VEGF release may drive proliferation of new vessels on the residual anterior vitreous base if the retina is ischemic. In many cases the vessels seem to arise from the extraocular ciliary vessels via the sclerotomies. These entry site new vessels may simply cause recurrent vitreous cavity hemorrhages. Occasionally they follow the same sequence of fibrosis, contraction and bleeding seen with posterior retinal neovascularisation, progressing eventually to tractional detachment of the ciliary body and pthisis.

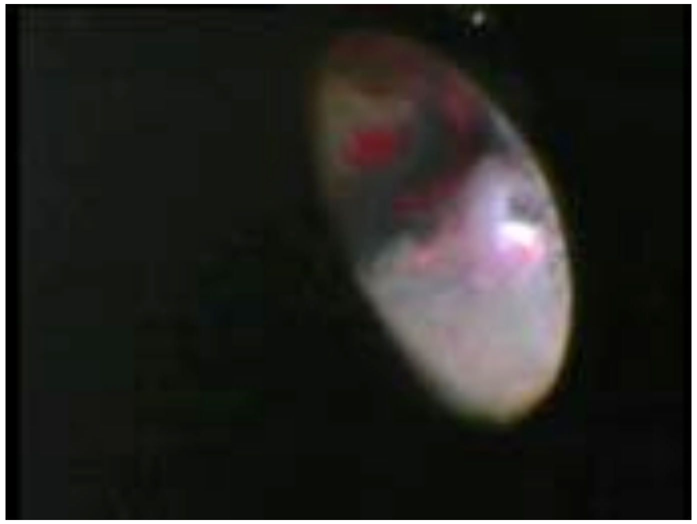
Surgical excision of advanced anterior hyaloidal proliferation is very difficult. A clean delamination plane cannot be created because of the tight vitreoretinal adhesions present in the vitreous base. Untreated it has a terrible prognosis but some cases respond to lensectomy, dissection of anterior membranes around the ciliary body and anterior photocoagulation. Retinectomies are often required as is silicone oil tamponade. Any case requiring a delayed vitreous cavity washout should be inspected for fibrovascular tissue in the vitreous base and extensive anterior photocoagulation delivered if this is present.

Figure 11.25 Anterior neovascularisation

Early entry site neovascularisation.



Movie 11.23 Entry site neovascularisation



This patient suffered recurrent vitreous cavity hemorrhages which started 4 months after vitrectomy with delamination for tractional detachment. The new vessels are at the site of a previous sclerotomy. Note the absence of anterior photocoagulation scars.

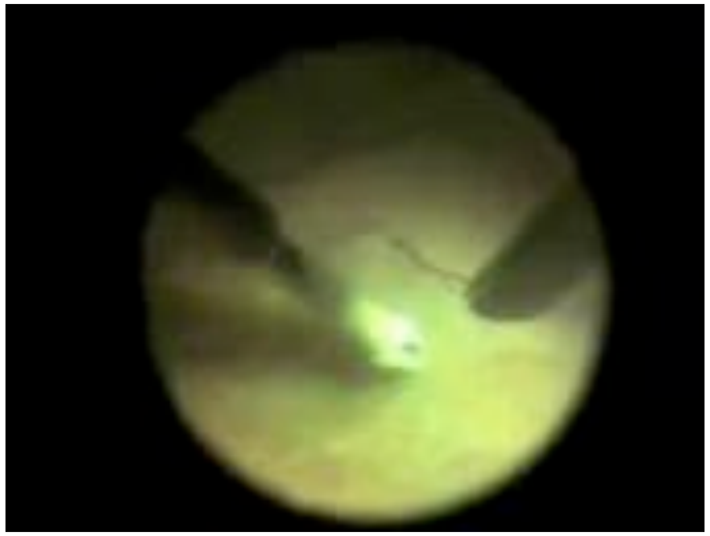
Movie 11.24 Surgery for advanced anterior hyaloidal proliferation

Trimming the vitreous base with deep indentation under the microscope.

Vitrectomy for diabetic maculopathy

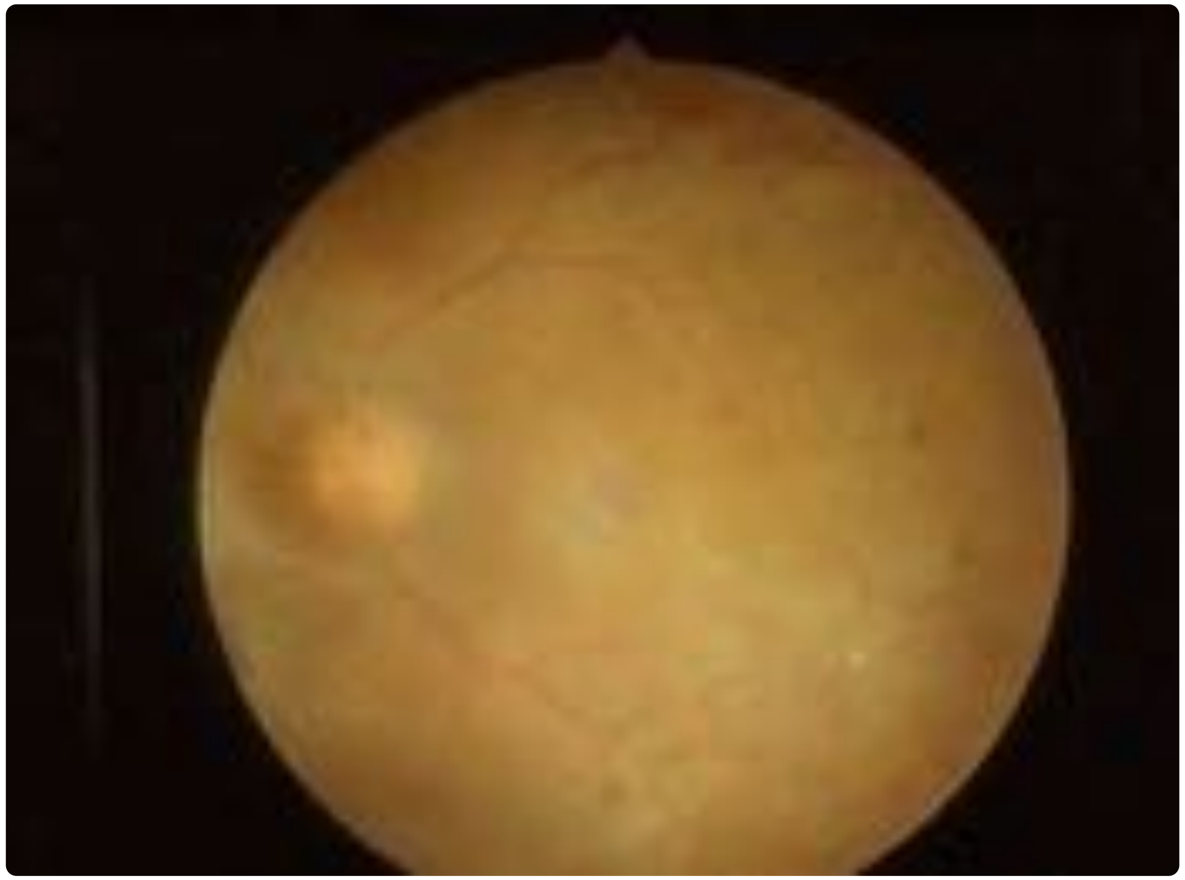
Vitrectomy with epiretinal membrane peeling has been shown to reduce macular thickening and improve visual function in diabetic patients with a visibly taut posterior hyaloid. Optical coherence tomography has made this condition easier to diagnose.

Movie 11.25 Removal of a taut thickened posterior hyaloid



This was performed in conjunction with extensive delamination of fibrovascular membranes. Video courtesy of Mr Zdenec Gregor.

Figure 11.26 Tractional diabetic maculopathy



The clinical appearance of a taut thickened posterior hyaloid is of a diffuse glistening membrane over the posterior pole of the eye. Fluoresecein angiography shows deep retinal leakage.

In theory vitrectomy surgery may be of wider benefit in patients with diabetic maculopathy even in the absence of OCT evidence of traction:

- Cross sectional and longitudinal studies have suggested that PVD protects against macular edema.
- Vitrectomy increases the rate of clearance of cytokines including VEGF.
- Vitrectomy increases the partial pressure of oxygen in the vitreous.

Over 40 uncontrolled studies have been published suggesting that vitrectomy may be beneficial in diabetic macular edema. Six prospective randomized controlled trials have been published with mixed results. Lens status and cataract surgery have been significant confounding variables in some studies. A subgroup analysis in a well conducted prospective study suggested that the benefit was confined to eyes with OCT evidence of vitreous traction. This was also the conclusion of a large study conducted by the Diabetic Retinopathy Clinical Research Network. Most surgeons do not currently perform vitrectomy for diabetic macular edema without OCT evidence of traction, especially as there is superior evidence of effectiveness of other treatments.

Knowledge Review

Review 11.1 Pathology of cicatricial diabetic retinopathy

Question 1 of 3

Regarding diabetic neovascularisation:

- **A.** New vessels develop from endothelial proliferation through the walls of small retinal arterioles.
- **B.** The neovascular buds require a scaffold such as the posterior hyaloid membrane to grow on. ✓
- **C.** Bleeding is a consequence of lack of fibrous proliferation.
- **D.** Effective laser treatment causes fibrosis to regress.

Check Answer

Review 11.2 Vitreoretinal techniques in diabetic vitrectomy

Question 1 of 8

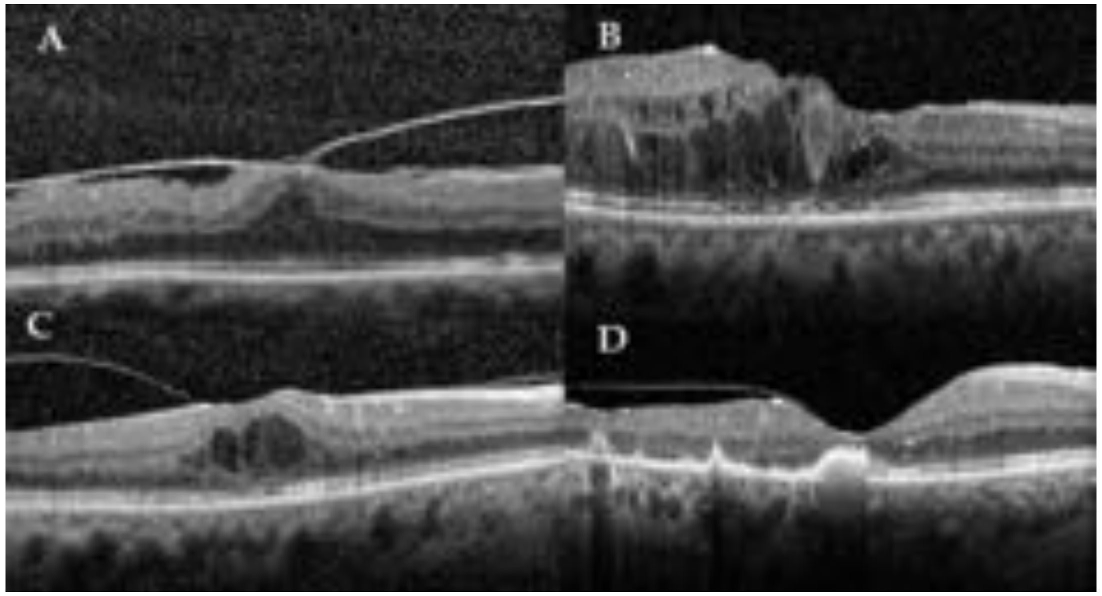
In eyes with fundus obscuring vitreous hemorrhage:

- **A.** Cutting aspiration should start just over the disc moving anteriorly.
- **B.** Movement of the vitreous gives an indication of the degree of vitreoretinal adhesions.
- **C.** The appearance of a plume of dense liquefied blood coming forward to the cutter indicates that a major vessel has ruptured.
- **D.** Areas of hemorrhage that do not move with reflux indicate the presence of long standing organized clots.

Check Answer

Review 11.3 Vitrectomy for diabetic maculopathy

Which of these diabetic eyes with macular edema is most likely to benefit from a vitrectomy?

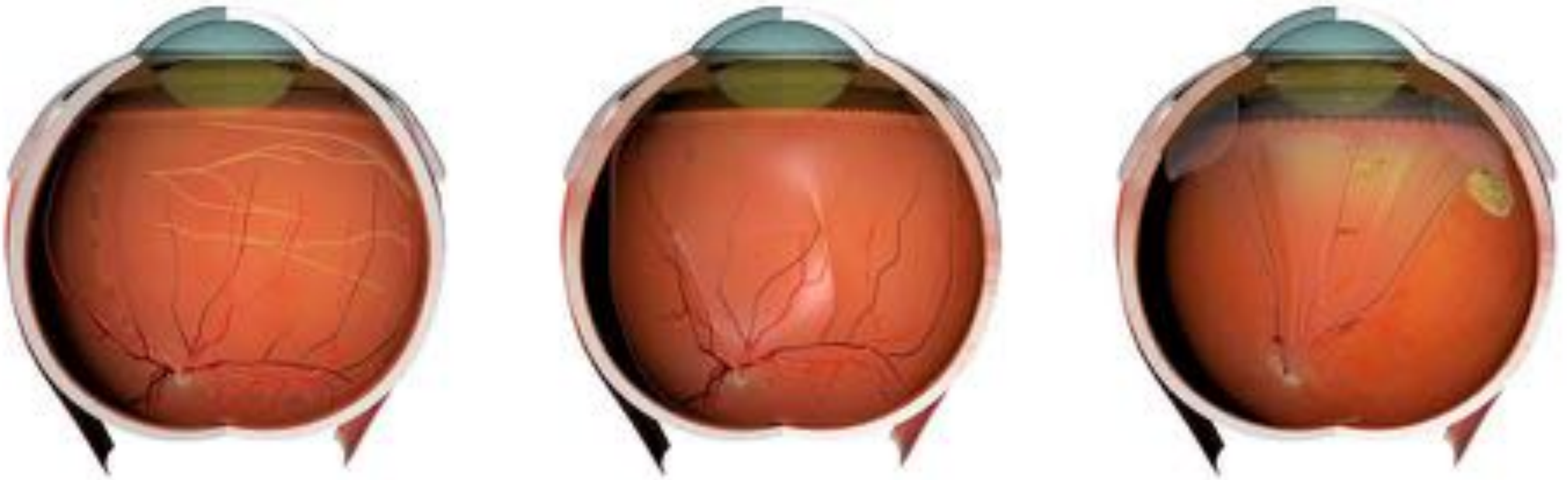


- ✓ **A.** Answer 1
- **B.** Answer 2
- **C.** Answer 3
- **D.** Answer 4

Check Answer

CHAPTER 12

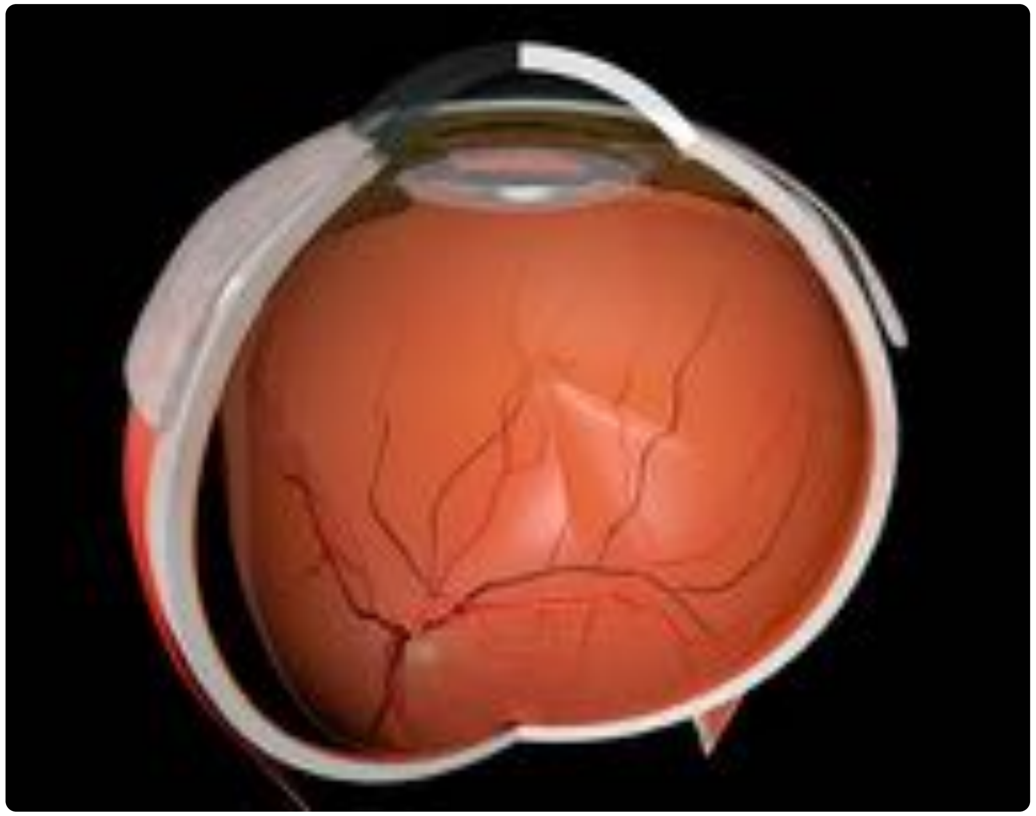
Proliferative Vitreoretinopathy



Pathogenesis of

Proliferative vitreoretinopathy (PVR) is a pathological response in which periretinal membranes develop in association with a retinal break. It is a dysfunctional wound healing response. Contraction of these membranes around retinal breaks keeps them open and may create new breaks. It is the major cause of final failure of retinal detachment repair. In the absence of PVR repeated reoperations could be carried out until all the retinal breaks had been closed. With modern vitreoretinal techniques it is usually possible to reattach the retina but the functional results of surgery for established PVR are poor. Consequently much research has been done into the pathology of this condition in the hope of developing effective medical adjuncts to treatment. At the time of writing no adjunctive treatment has been found sufficiently safe and effective for routine clinical use.

Figure 12.1 Proliferative vitreoretinopathy



Proliferative vitreoretinopathy - contraction of epiretinal membranes in the presence of a retinal break. The term PVR should not be applied to periretinal membranes without a break. Note that the membrane is keeping the break open. This may prevent repair by by scleral buckling.

DEVELOPMENT OF PVR MEMBRANES

Proliferative vitreoretinopathy membranes are composed of various cell types. Retinal pigment epithelial cells seem to be particularly important in the pathogenesis of PVR. These migrate, proliferate and metaplase into fibroblasts to form the bulk of the cells in PVR membranes. Various cytokines seem to promote this process.

RISK FACTORS

Major risk factors for PVR include:

- Factors that increase RPE dispersion:
    - Large number and size of breaks.
    - Cryotherapy, particularly when applied to large areas of bare RPE or when indentation follows cryotherapy.
- Factors that up-regulate the cytokines that promote migration, proliferation and contraction of RPE:
    - Any condition that causes blood-aqueous barrier breakdown (e.g. inflammation, hypotony).
    - Vitreous hemorrhage.

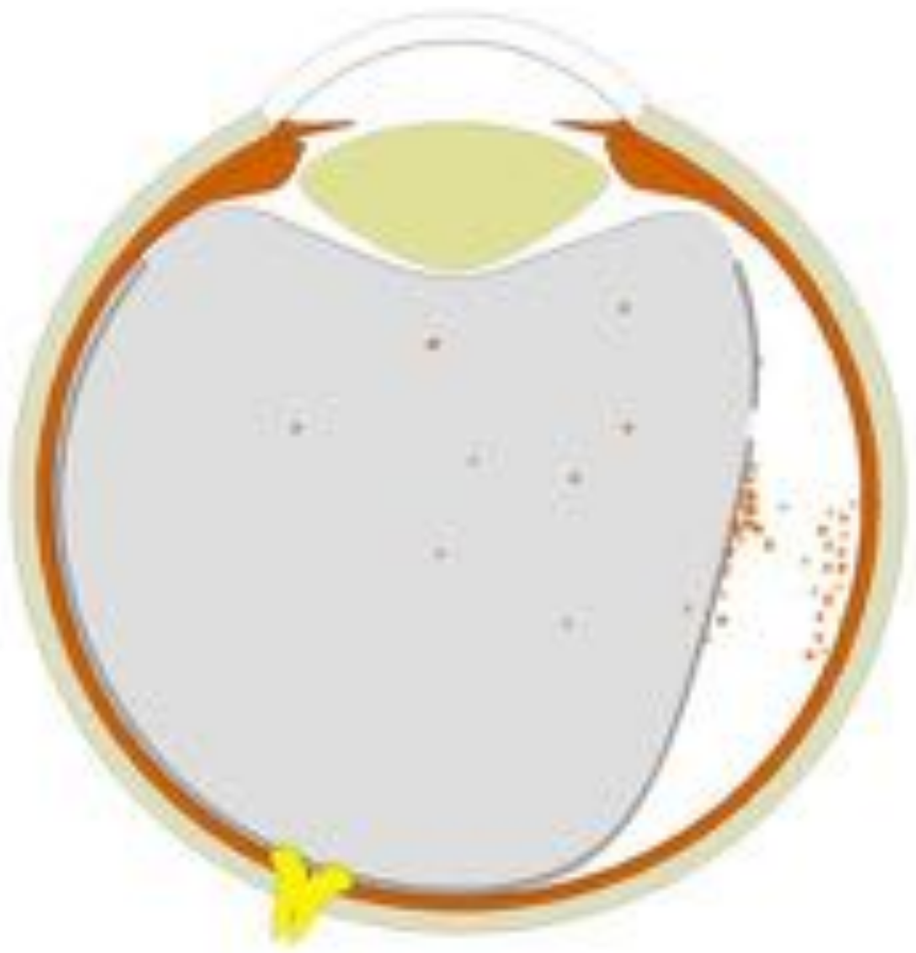
Classification of PVR

The current classification of PVR uses the location of PVR (anterior or posterior to the equator), extent of PVR (measured in clock hours, 1-12) and type of contraction (focal, diffuse, subretinal, circumferential contraction and anterior displacement).

GRADE	LOCATION	EXTENT	TYPE OF CONTRACTION	FEATURES
A				Vitreous pigment or haze
B				Inner retinal wrinkling, reduced retinal mobility, rolled edges on retinal breaks
C	Posterior (CP)	1-12	Focal	Star Folds
C	Posterior (CP)	1-12	Diffuse	Confluent star folds, may efface disc.
C	Anterior or Posterior	1-12	Subretinal	Diffuse sheets which may roll up to form linear branching bands, 'napkin ring' around the disc.
C	Anterior (CA)	1-12	Circumferential	Contraction of the vitreous base with central displacement and thinning of the peripheral retina and posterior retinal radial folds
C	Anterior (CA)	1-12	Anterior displacement	Vitreous base pulled anteriorly, 'anterior loop' traction, ciliary body traction and hypotony

The state of the vitreous has a significant influence on on RPE cell dispersion and the form of PVR which develops. The influence of gravity and intraocular tamponade agents also influence the dispersion of RPE and hence the distribution of PVR. Membranes are usually more pronounced in the inferior retina although superior PVR may occur after the use of negatively buoyant tamponade agents.

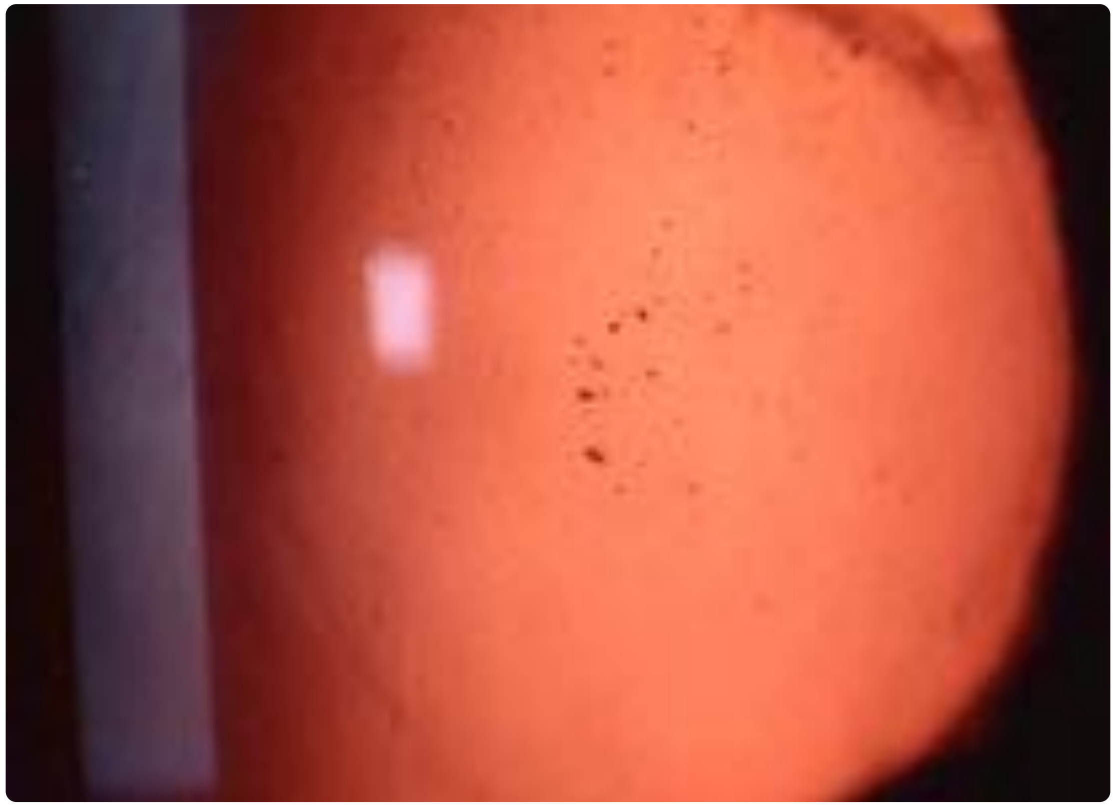
Figure 12.2 The role of the vitreous in RPE cell dispersion



In a detachment due to a round retinal hole the attached vitreous is a barrier to RPE cell migration to the retinal surface and vitreous base. Anterior PVR and star folds are therefore unlikely to develop although subretinal PVR may be present.

Clinical features of PVR

Figure 12.3 Features of PVR



Vitreous pigment (Shafer's sign) - Grade A PVR.

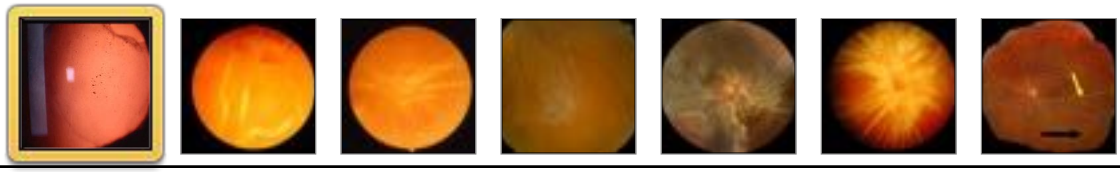
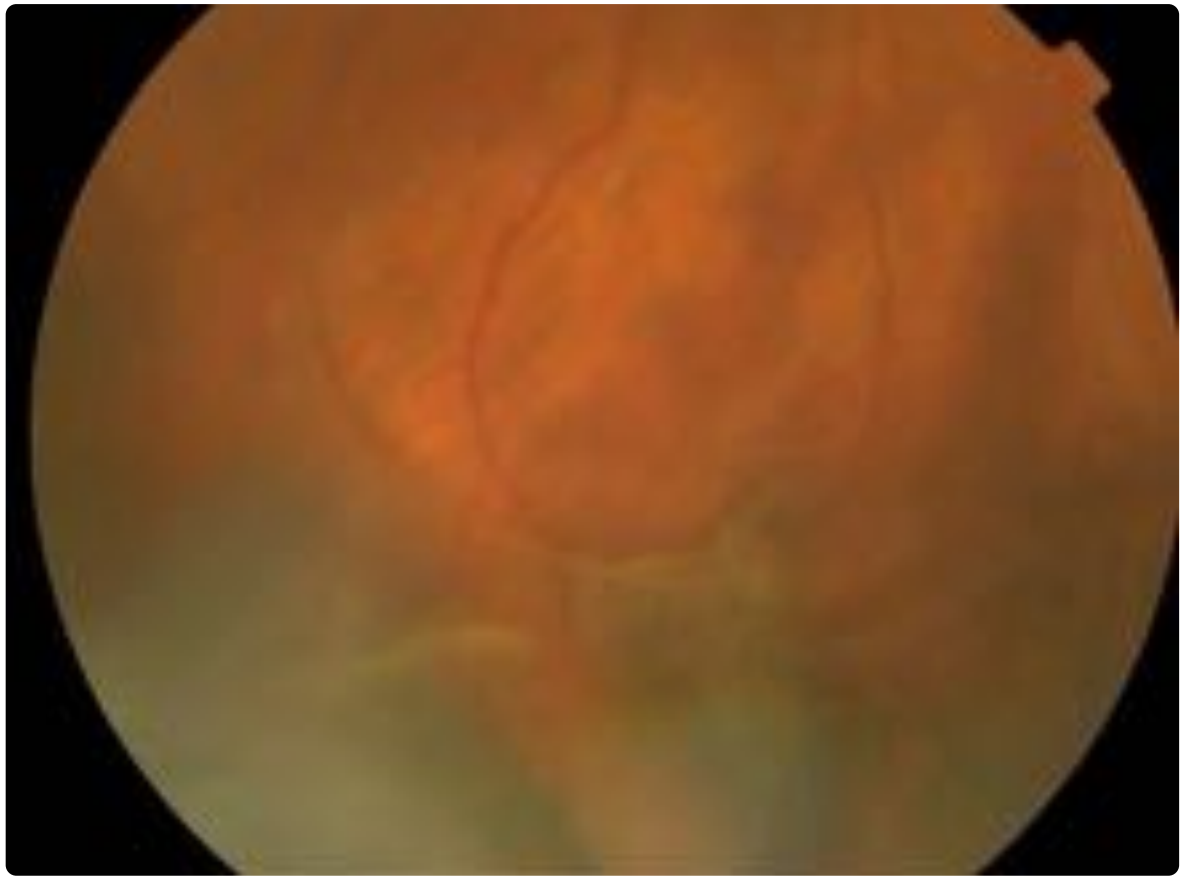


Figure 12.4 PVR and retinal breaks



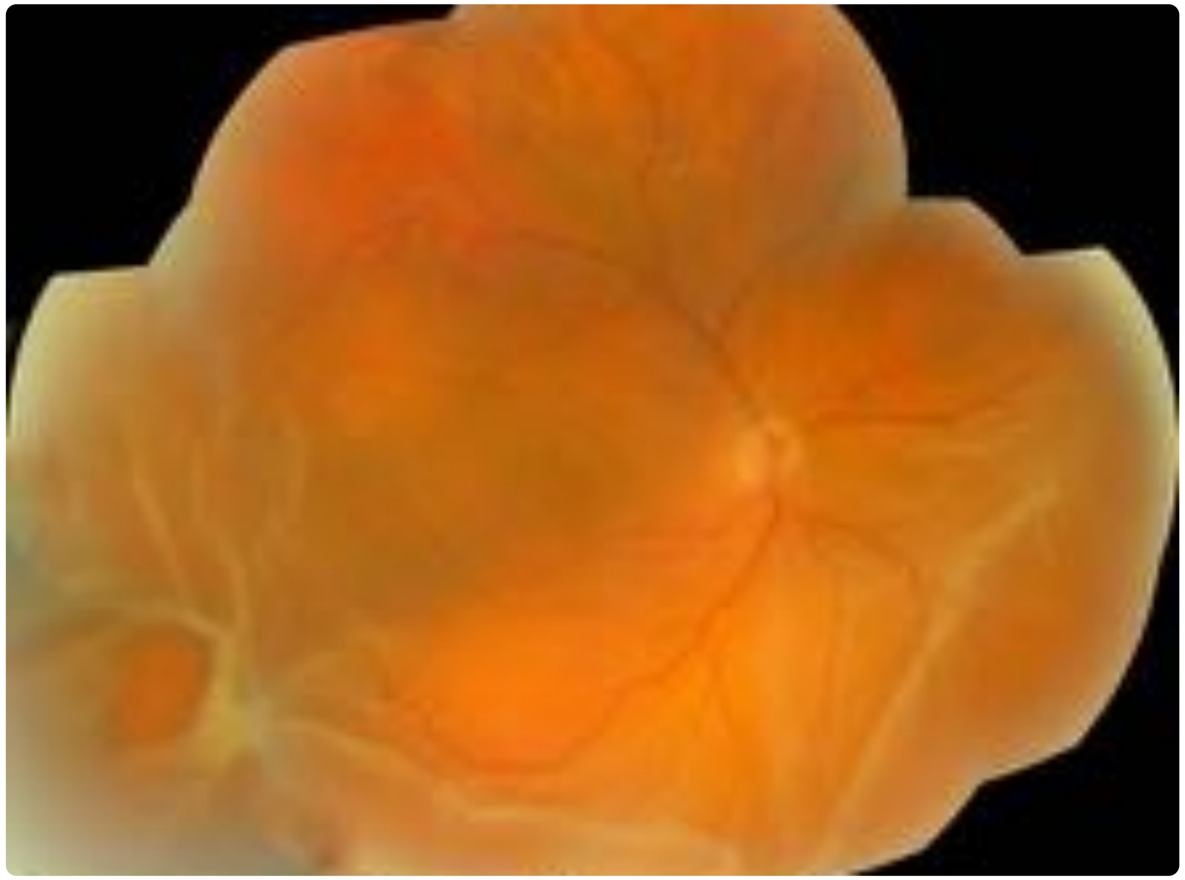
PVR with localized shallow tractional detachment. In the absence of a retinal break these may remain stable. If a break develops the retina may detach very quickly - this has been misinterpreted as acute development of PVR. This case was observed and did not progress.

Proliferative vitreoretinopathy typically develops approximately 8 weeks after the initial surgery. The appearance and nature of the membranes evolves over this period. In the early stage of contraction the membranes are transparent and their adhesion to the retina exceeds their tensile strength. Removal at this stage is difficult as these immature membranes tend to shred rather than separate cleanly. Removal of membranes is much easier once they have become very slightly opaque.

This process of maturation produces a management dilemma. Earlier intervention results in quicker reattachment of the macula but removal of significant membranes may be incomplete. Delaying intervention may allow more complete removal of functionally significant membranes with poorer macular function.

Early intervention using silicone oil as part of a planned 2-stage approach, with subsequent supplementary retinopexy (and peeling under silicone oil with retinectomy if required) is a pragmatic compromise between these considerations. It may also allow more judicious use of retinopexy when the intraocular inflammation from primary surgery has resolved (S Charles, personal communication).

Figure 12.5 PVR membrane development



The membranes in this case were quite immature and hard to remove entirely. A planned 'two stage' approach using silicone oil was used to repair this.

Treatment of PVR

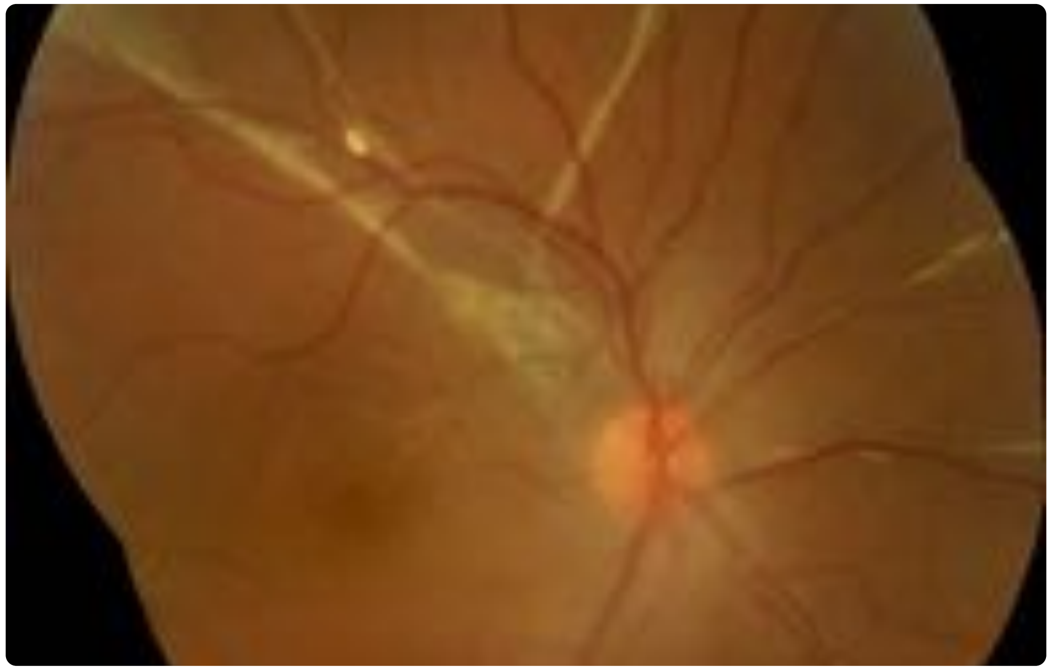
THE ROLE OF CONVENTIONAL SURGERY

Most cases of subretinal PVR can be managed with a scleral buckle, especially as it is commonly seen in chronic detachments without vitreous separation (i.e. atrophic retinal holes and retinal dialyses) which are best managed with conventional surgery. Usually the membranes cause little traction on the break and do not prevent retinal reattachment.

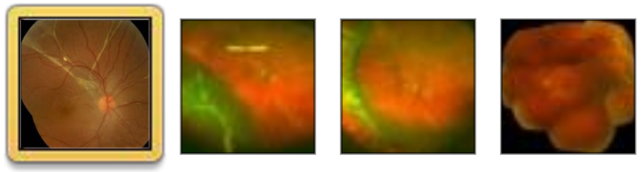
Grade B and mild Grade C PVR may also be managed with a scleral buckle especially if the PVR is some distance from the break and does not appear to be holding it open (although this may be quite difficult to judge). Many surgeons advocate encirclement when buckling Grade C PVR on the grounds that more extensive PVR may develop. Creation of an indent alters the profile of the retina so that the tangential forces arising from static traction favor reattachment rather than detachment.

The results in more severe PVR are much better if an internal approach is used.

Figure 12.6 Conventional surgery for PVR.



Post operative appearance following scleral buckling for subretinal PVR. The extensive subretinal bands are not preventing retinal reattachment.



TREATMENT OF POSTERIOR PVR

Following vitrectomy surface epiretinal membranes are peeled to relieve traction on the retina. There are a number of ways of doing this.

A pick may be used to engage and then lift the membrane at the centre of each star fold in turn. Once an edge is visibly elevated it may be grabbed and peeled using forceps.

Figure 12.7 Peeling a star fold using a pick

The pick approaches the star fold tangential with the retina between two folds

Movie 12.1 Peeling a star fold using a pick

Note the change in the angle of pull to lift the membrane from the retina.

Alternatively an end gripping forceps may be used to grasp the centre of the star fold and peel the membrane.

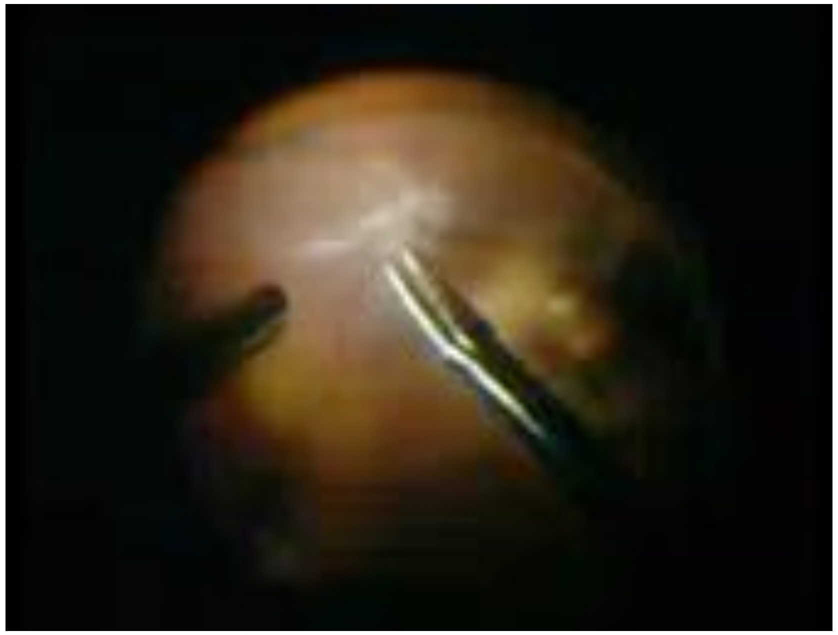
Whichever technique is used it is important to pull centrifugally and initially at an angle of about 20^0 to the retinal surface. With more peripheral star folds the angle of pull may become more vertical but tangential pulling should be avoided. It is important to pull quite slowly, allowing time for the adhesions between the membrane and retina to separate. Perflourocarbon or silicone oil may provide useful counter traction.

Dye - assisted internal limiting membrane peel may reduce the probability of secondary epimacular membranes developing.

Figure 12.8 Forceps peel

The very centre of the star fold is grasped with forceps and peeled centrifugally.

Movie 12.2 Forceps peel



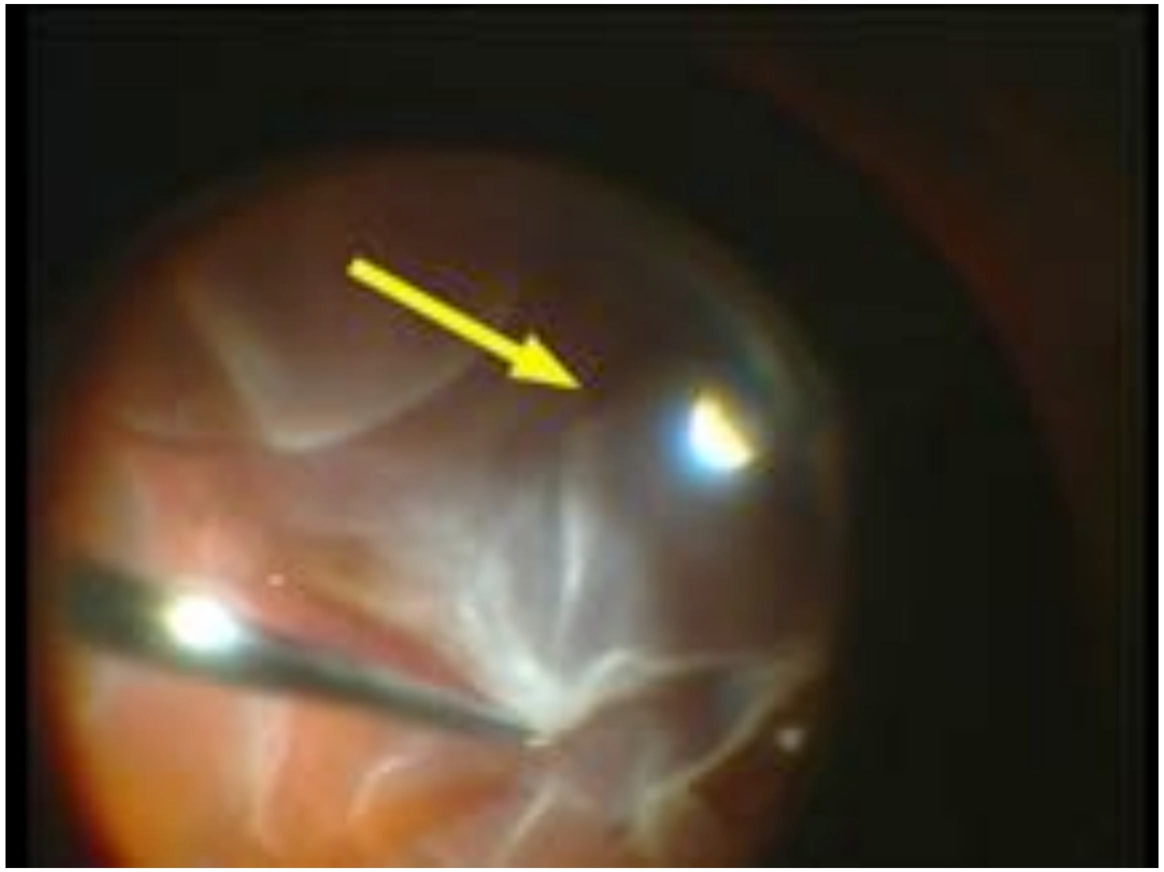
Note the slow centrifugal peel.

Movie 12.3 Iatrogenic break during peeling

The mistakes are:

- *Failure to grab an epicenter of contraction.*
- *Opening the forceps jaws too widely so that retina is grasped on closing.*
- *Ignoring the warning sign of increasing retinal translucency which precedes a break.*

Movie 12.4 Iatrogenic break during peeling 2

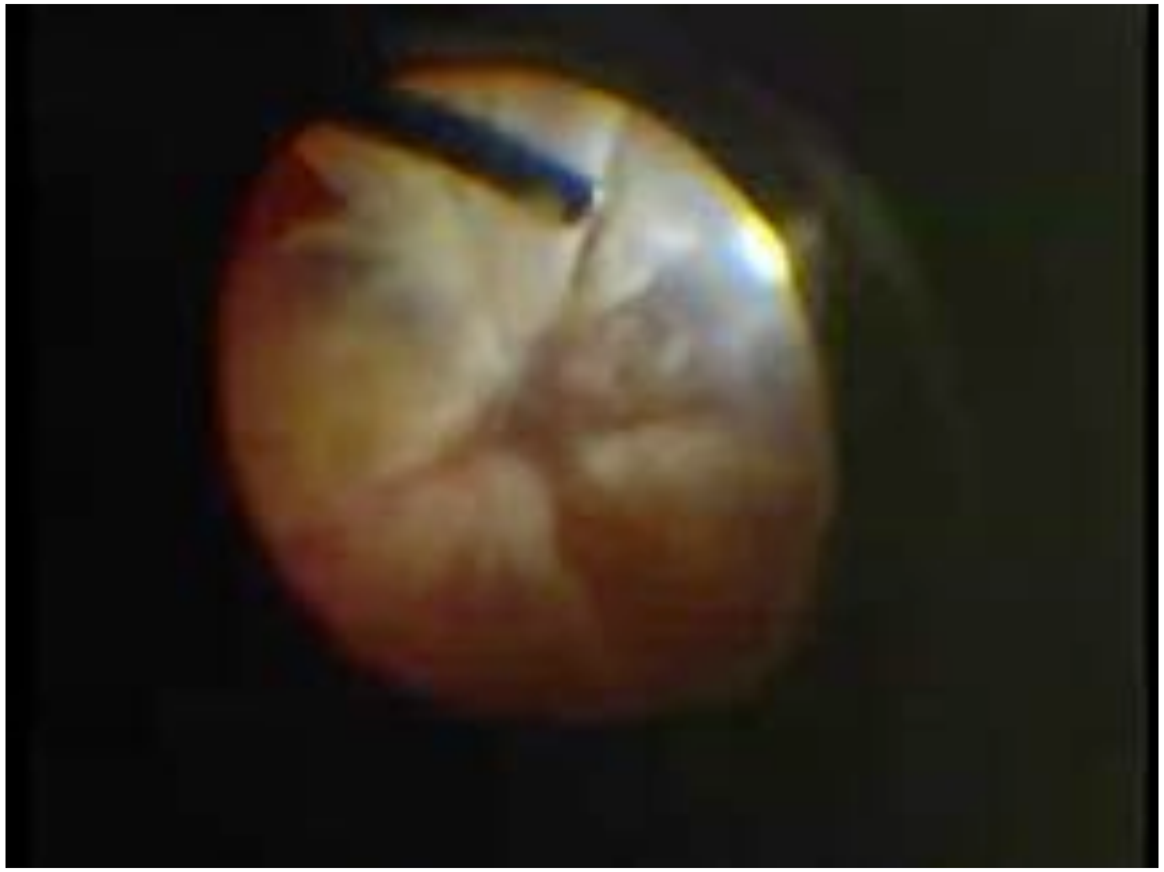


The mistake here is failure to pull centrifugally. This causes stress on thinner areas of peripheral retina. The tendency to pull laterally is often a consequence of limited space and forward movements of the underlying detached retina so that the membrane does not appear to be separating with centrifugal peeling. It is better to pull more vertically or to use perfluorocarbon counter traction than it is to pull laterally.

USE OF PERFLUOROCARBON LIQUIDS DURING PEELING

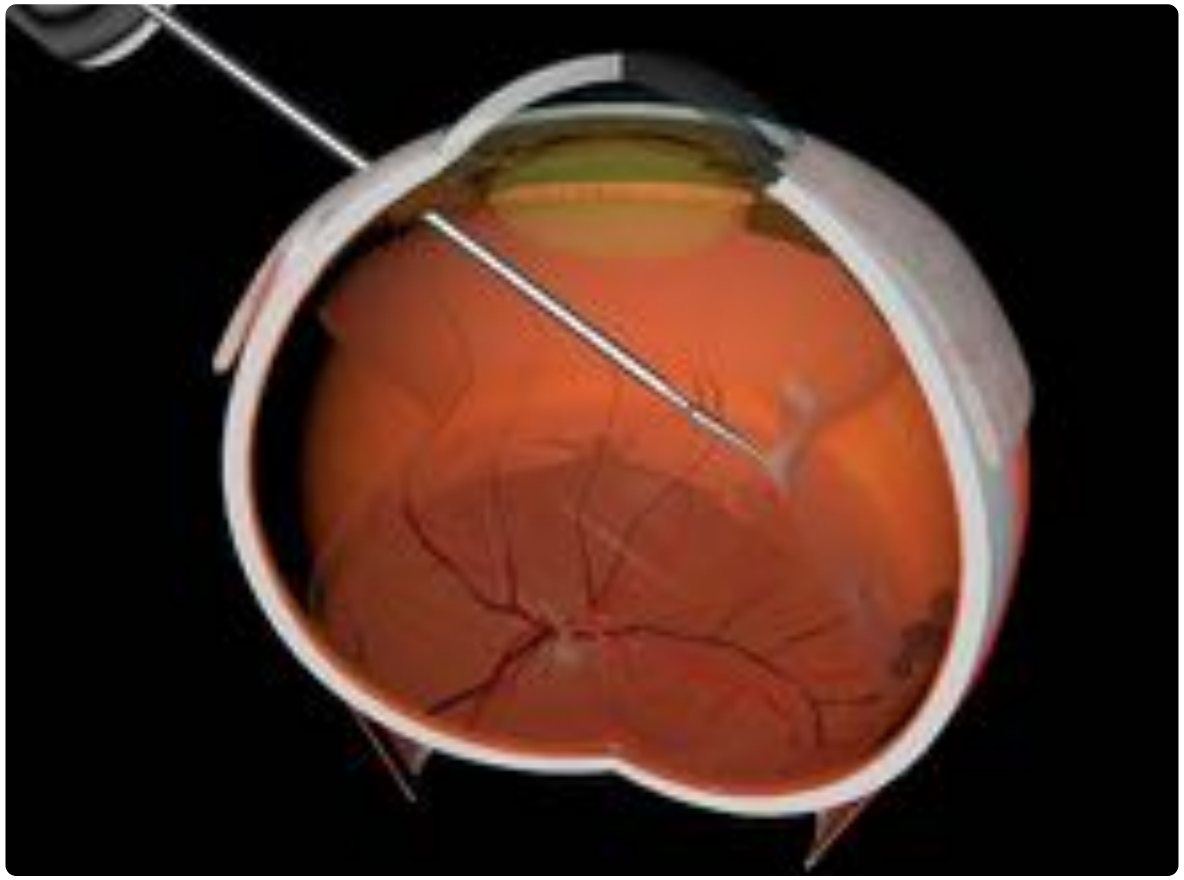
The development of perfluorocarbon liquids (PFCL) by Stanley Chang was a major advance of enormous value in PVR surgery. They are useful at several stages in the procedure. During the dissection stage they are used provide counter traction while peeling. This is particularly useful when dealing with funnel detachments. The PFCL is injected incrementally to allow peeling, starting at the optic disc and working anteriorly. It is important to avoid traction on any break below the PFCL/fluid interface as this may result in subretinal PFCL.

Movie 12.5 Dissecting an open funnel under perfluorocarbon liquid



There is a giant retinal tear with diffuse posterior PVR. Dissection starts posteriorly and the amount of perfluorocarbon liquid gradually increased. A retinectomy was performed at the end of this case to relieve anterior traction.

Figure 12.9 Subretinal perfluorocarbon



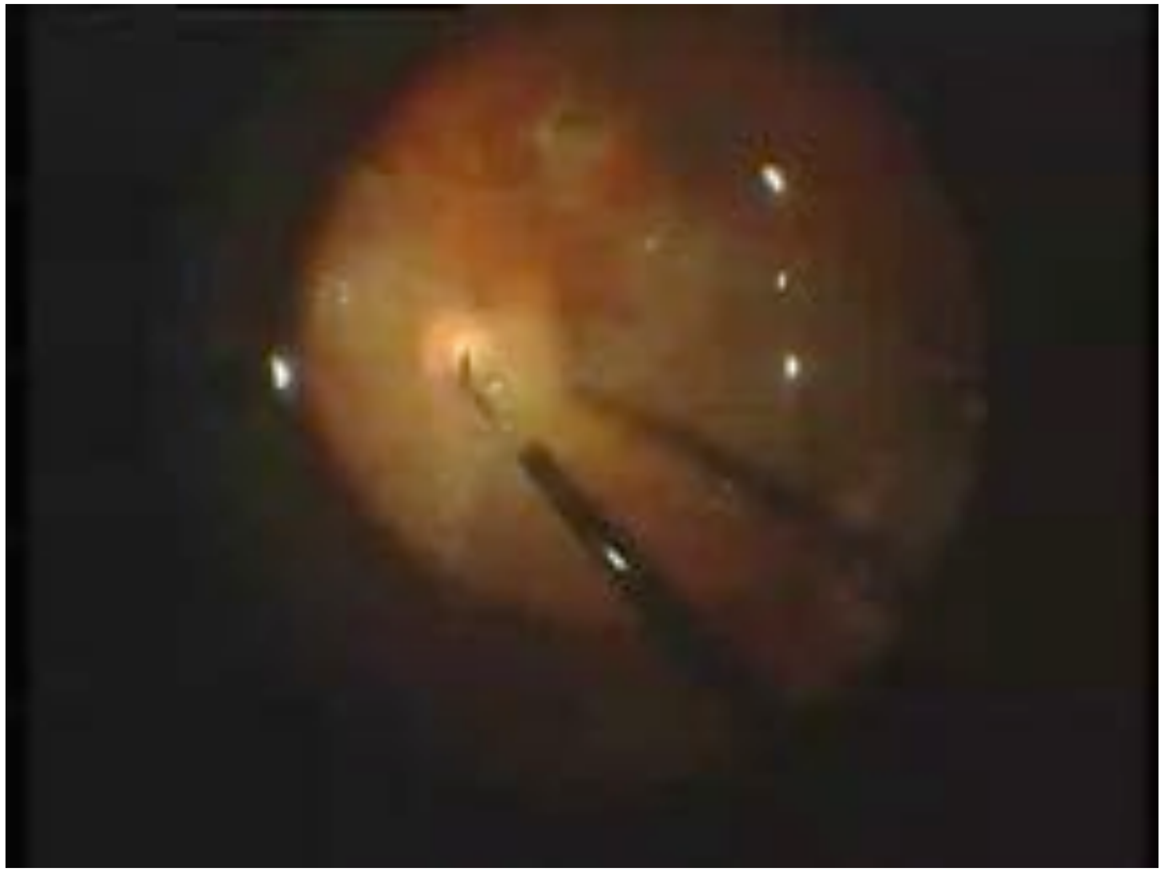
Traction on a break below the perfluorocarbon/fluid meniscus resulting in subretinal bubbles of perfluorocarbon liquid.

PEELING UNDER SILICONE OIL

In reoperations where silicone oil is already in situ posterior epiretinal membranes may be peeled under silicone oil. This provides counter traction while peeling.

As silicone oil has a greater interfacial surface tension with saline than perfluorocarbon it is less likely to migrate under retinal breaks.

Movie 12.6 Peeling under silicone oil.



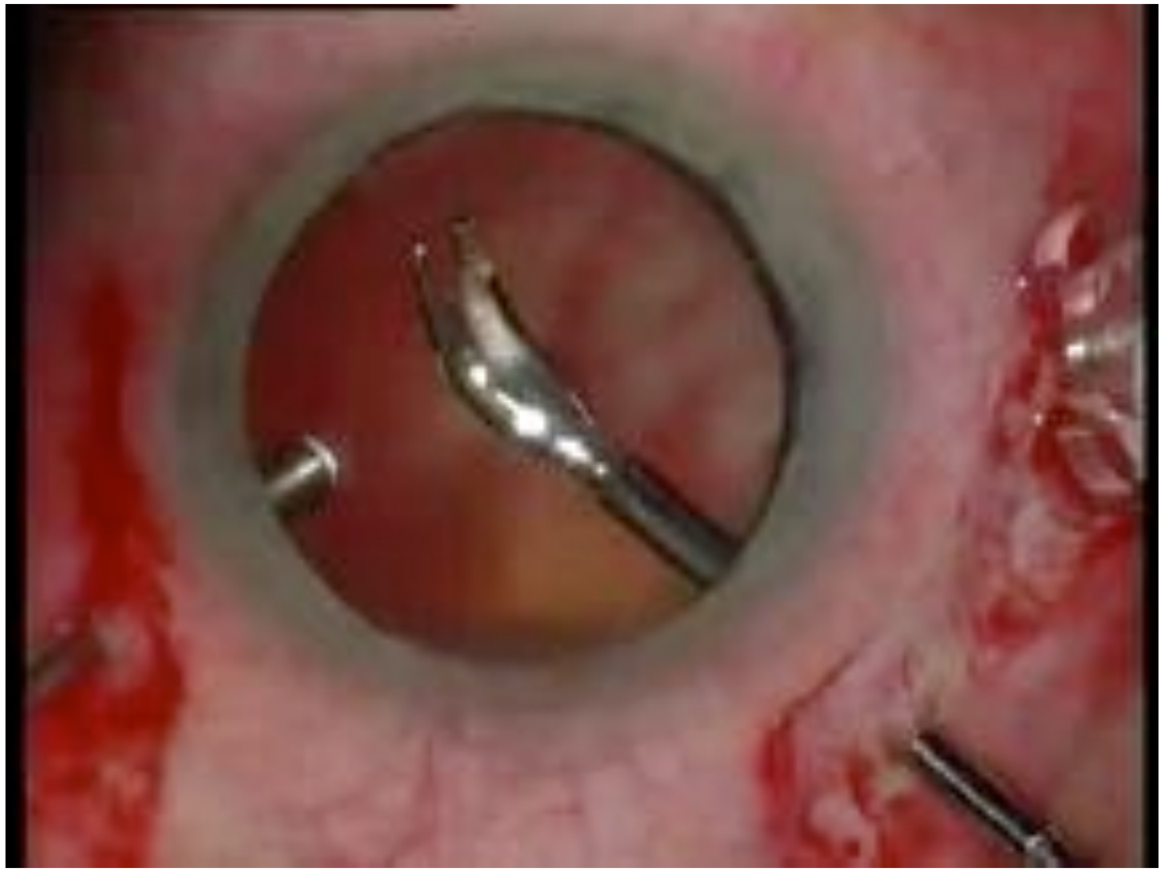
This case had previously undergone vitrectomy with retinectomy and silicone oil tamponade. Recurrent PVR developed which was peeled under silicone oil.

ANTERIOR PVR

Membranes in the vitreous base cannot be simply stripped from the retina. The vitreoretinal adhesions in the vitreous base are very strong and any attempt to strip the vitreous base off the retina creates retinal breaks. Membranes in and around the vitreous base must therefore be segmented or excised using a vitrectomy cutter or scissors.

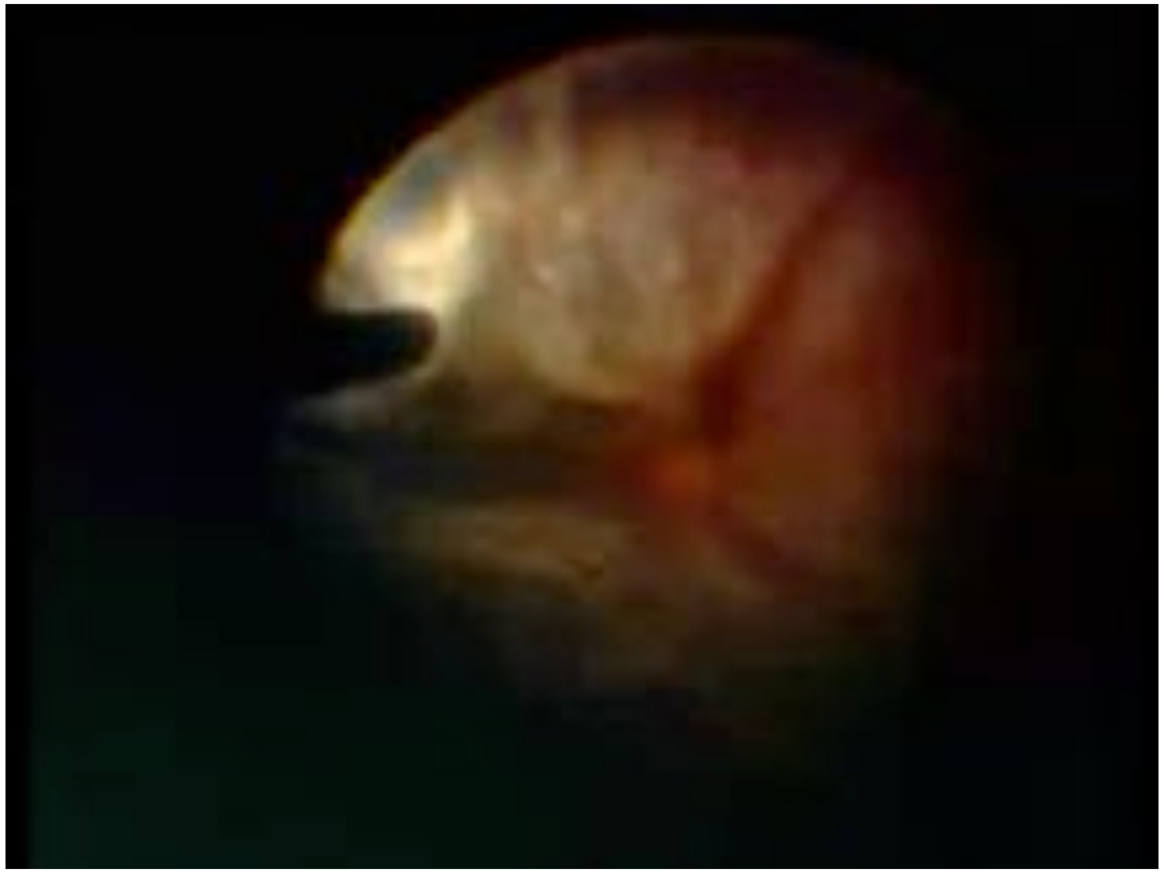
When dissecting anterior PVR in phakic eyes lensectomy with capsulectomy improves the access to and visualization of the vitreous base.

Movie 12.7 Lensectomy in PVR



The capsule is removed to facilitate access to the anterior vitreous and retina and to and remove one potential scaffold for reproliferation.

Movie 12.8 Vitreous base dissection in circumferential anterior PVR

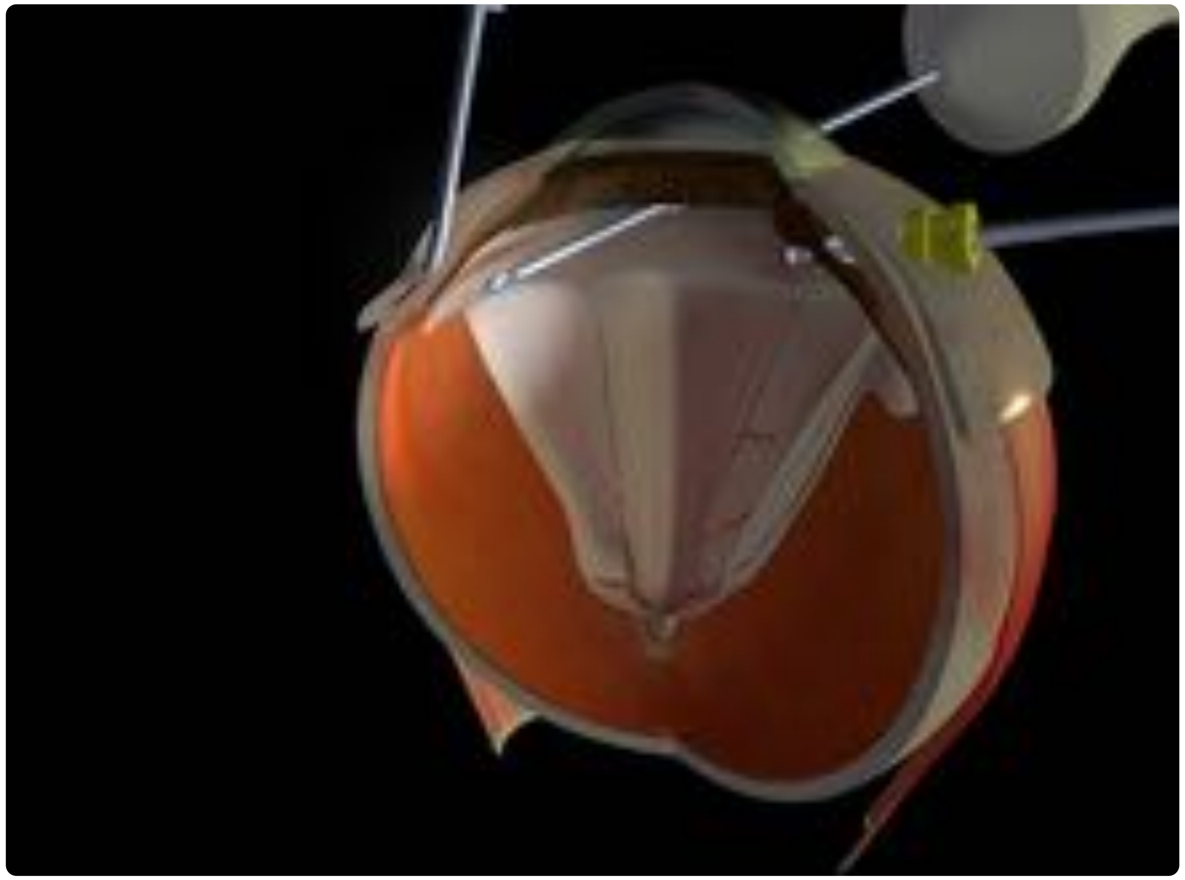


This patient was aphakic. Note the retinal folds posteriorly and the flat retina within the vitreous base, the classic features of circumferential anterior PVR.

Vitreous base dissection in anterior loop traction is particularly challenging. The goal is to dissect the scar tissue within the peripheral retinal gutter to allow the retina to relax back into its normal position. Many techniques have evolved for doing this including bimanual surgery with forceps and scissors. Improved fluidics allows much of this to be done with the cutter. Vitreous base dissection is usually combined with the use of a broad encircling scleral buckle, retinopexy to all the breaks and long acting tamponade. This is very time consuming surgery even in expert hands. In the Silicone Oil Study the duration of surgery in anterior PVR cases ranged from 1 to 9 hours with a median operating time of 4 hours. While technological advances have significantly reduced operating times this remains challenging and time consuming surgery.

Peripheral retinectomies are being used increasingly in the management of PVR. This allows removal of anterior PVR along with the rest of the peripheral retina and is quicker than vitreous base dissection without retinectomy. The use of primary peripheral retinectomy in this way seems to give acceptable results without the need for an encircling buckle. There is little evidence that use of a supplemental buckle improves outcomes.

Figure 12.10 Vitreous base dissection



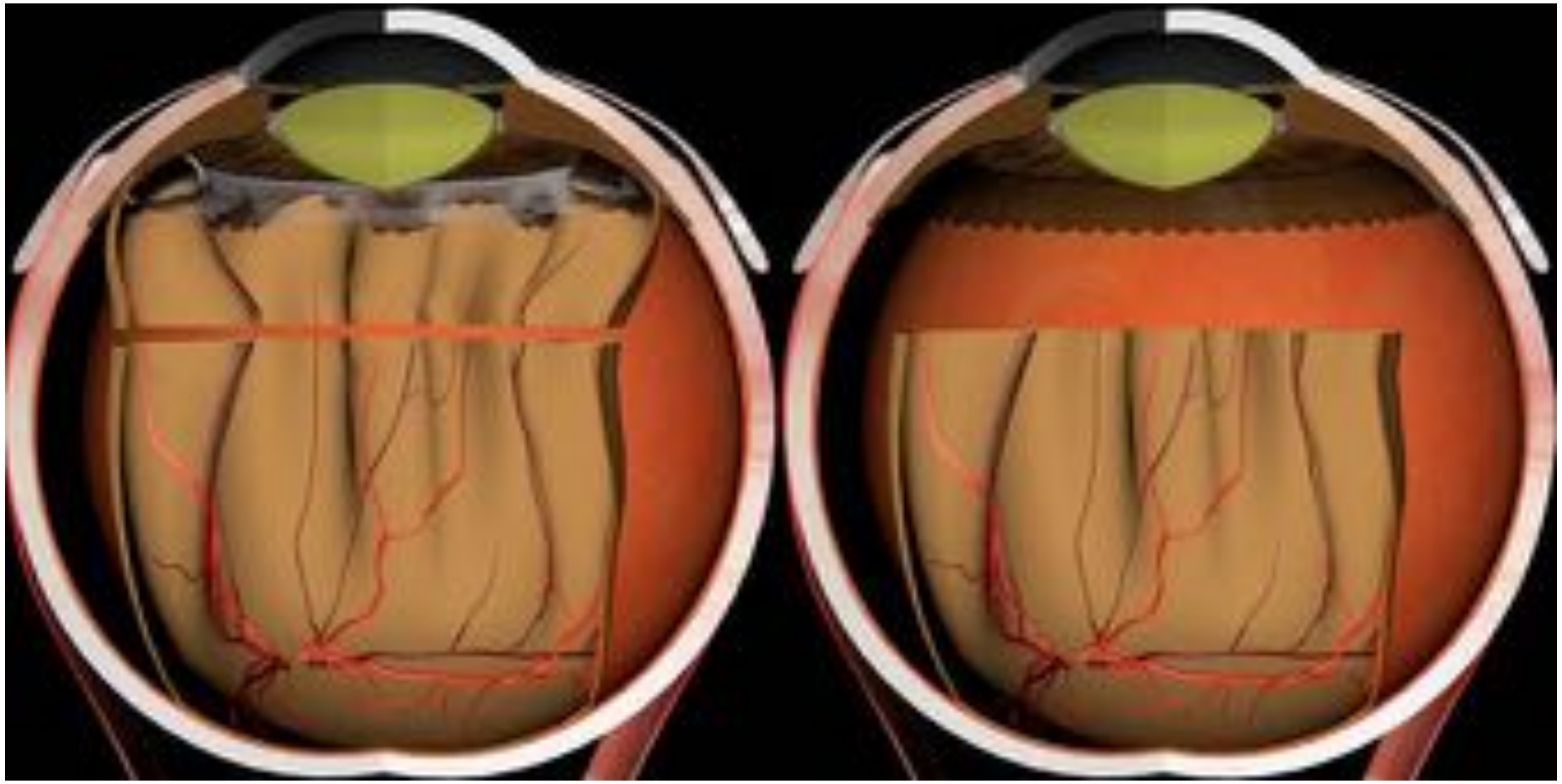
The peripheral trough is often too narrow for the tip of the cutter and a needle or scissors may need to be used to open it up.

RETINECTOMY

Linear retinotomy relieves the traction on the posterior retina from anterior PVR. It is combined with removal of all anterior devitalized retina (retinectomy) to prevent the development of rubeosis.

All posterior membranes should be peeled before retinectomy to prevent posterior retraction of the retinectomy edge when the retina is cut.

Figure 12.11 Retinotomy and retinectomy



Linear retinectomy (left) relieves traction but leaves devitalized anterior retina in place. Retinectomy removes this along with the vitreous base proliferation.

Figure 12.12 Performing a retinectomy

This pseudophakic eye has posterior and anterior PVR in the inferior retina.

Movie 12.9 Diathermy

Movie 12.10 Linear retinotomy using a vitrectomy cutter

Movie 12.11 Linear retinotomy using scissors

Movie 12.12 Removal of anterior retina - retinectomy.

Movie 12.13 Injection of perfluorocarbon

This video shows use of continuous laser. The author now uses 2 rows of interrupted laser burns.

THE SIZE OF THE RETINECTOMY

In deciding upon the size of the retinectomy the following should be considered:

- Retinectomies often fail due to recurrent proliferation at the horns. The retinectomy should be sufficiently large to avoid leaving traction at the horns. As a general rule 6 clock hours (180^0) is required. Failure to make the retinectomy large enough is a common mistake in PVR surgery. The aim should be to have healthy retina at both horns of the retinectomy.
- The anteroposterior location is determined by the location of the posterior border of the vitreous base. This may be more posterior than usual in eyes with PVR.

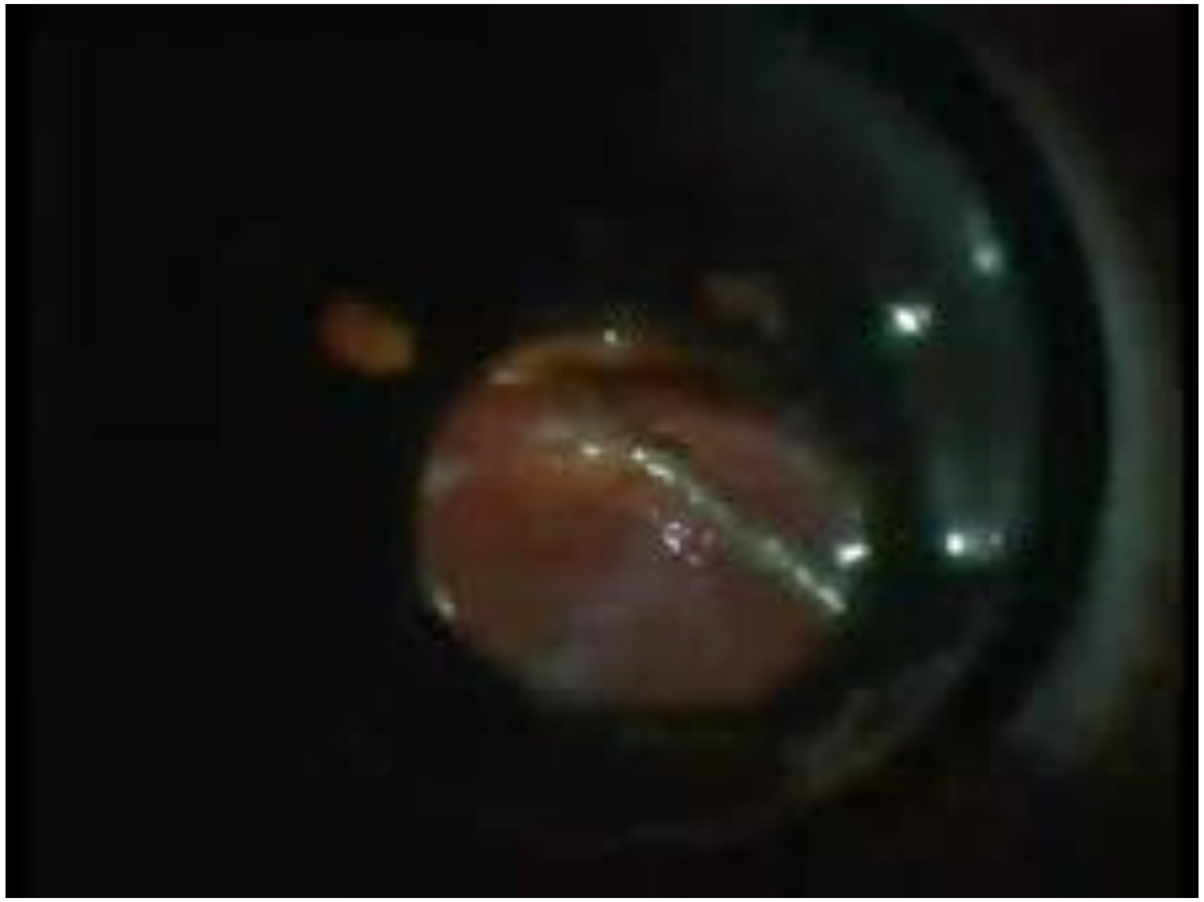
Movie 12.14 Adhesion of the diathermy to retina

This suggests the presence of membranes on the retina. Posterior hyaloid may become secondarily adherent to the retina behind the vitreous base in PVR cases. A soft tipped diamond dusted cannula may be used to strip the membranes anteriorly to the posterior border of he vitreous base. If this cannot be achieved the retinectomy should be performed more posteriorly to prevent reproliferation under oil.

THE REATTACHMENT TEST.

Persistence of retinal detachment under air, perfluorocarbon or silicone indicates unrelieved traction and the need for further peeling or a larger retinectomy. Air has a greater surface tension than oil so reattachment under air is not a totally reliable predictor of persisting attachment under silicone. Care should be taken performing a reattachment test with perfluorocarbon if posterior breaks are present.

Movie 12.15 Failed reattachment test using air.



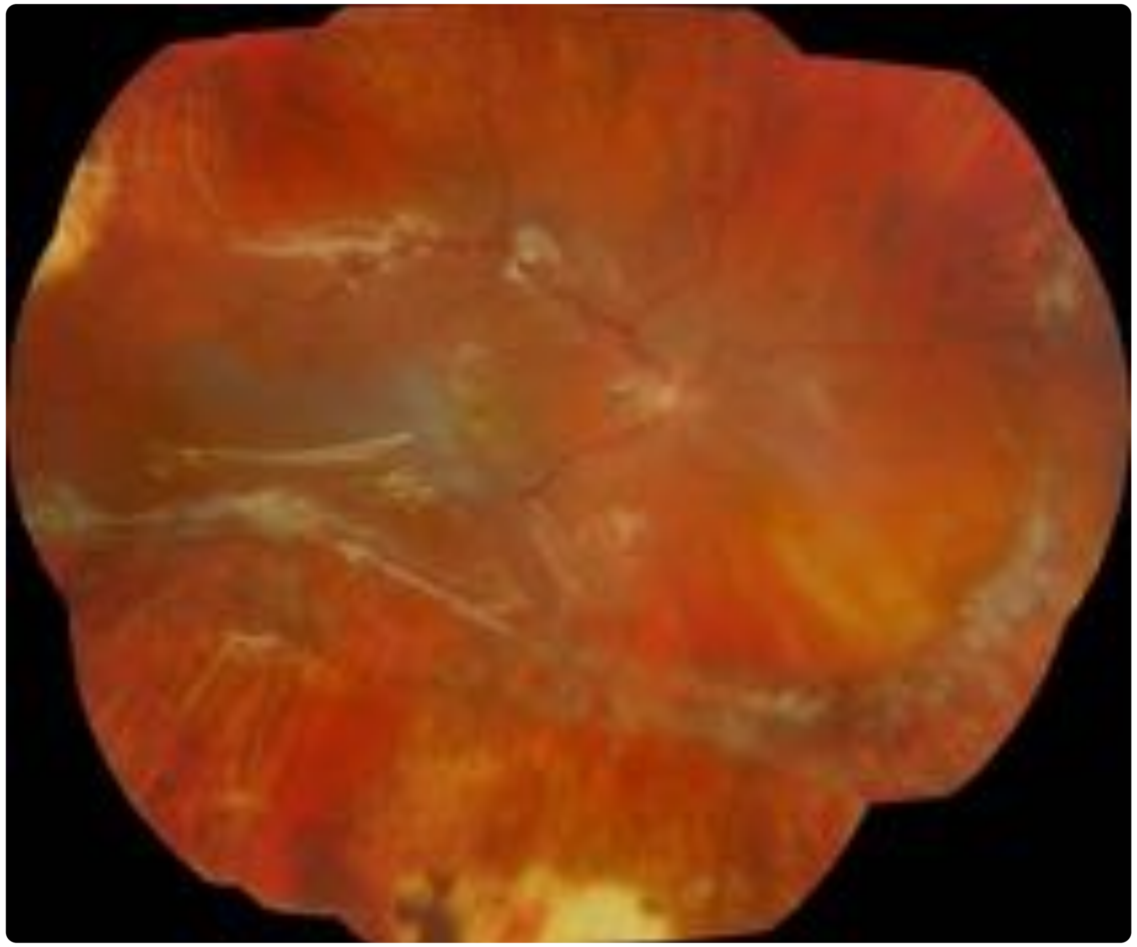
The retina folds over indicating the presence of unrelieved traction at the horns.

Redetachment after retinectomy usually occurs due to reproliferation. Retraction of the retinectomy edge is usually due to posterior membranes, recurrent/unrelieved traction at the horns of the retinectomy or bowstring contraction along the posterior border of the retinectomy.

Retinectomy is associated with postoperative hypotony. Possible mechanisms for this include enhanced uveoscleral outflow and tractional ciliary body failure. Dissection of ciliary body membranes has been used with success in some cases.

Postoperative cystoid macular edema is common after retinectomy. It is often refractory to medical treatment and is a significant cause of poor visual recovery. Some cases are tractional in origin and respond to peeling of associated epiretinal membranes.

Figure 12.13 Retinectomy failure.



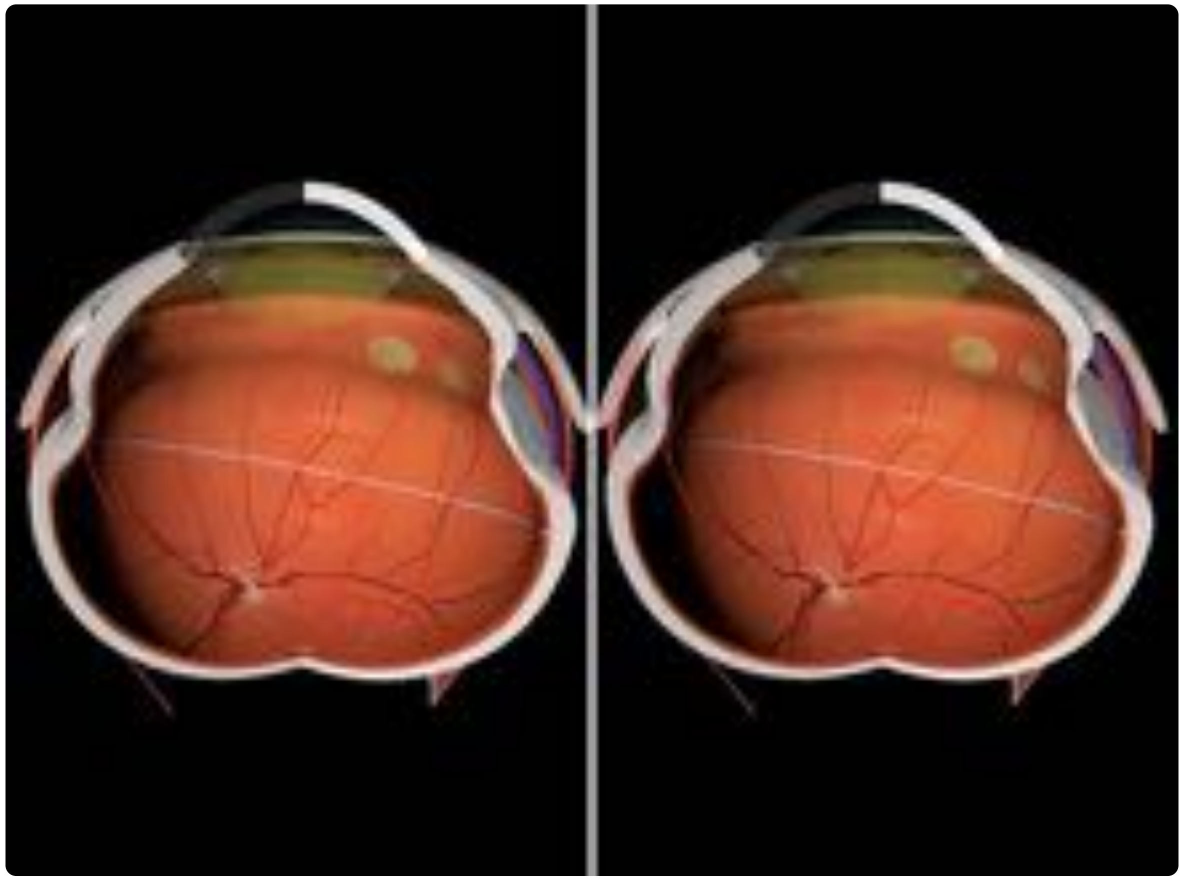
Posterior reproliferation under oil. This may be prevented by internal limiting membrane peeling.

TREATMENT OF SUBRETINAL PVR

Mild subretinal PVR, commonly found in chronic retinal detachments, generally has little effect on retinal breaks and need not influence management of the retinal break.

More severe subretinal PVR may prevent retinal reattachment despite break closure - the retina is draped over a subretinal band leading to tractional detachment. The intraoperative decision whether to remove the membranes is sometimes a difficult judgement call which may be helped by perfluorocarbon injection. A subretinal band that prevents retinal reattachment under perfluorocarbon is likely to prevent postoperative reattachment. Removal of the membrane should then be performed. This is particularly likely if the subretinal band has an annular configuration (giving a 'napkin ring' around the optic disc) but may also occur with linear bands (resulting in a 'clothesline' appearance). Napkin rings and clotheslines are only seen in longstanding detachments.

Figure 12.14 Subretinal PVR preventing retinal reattachment



'Clothesline' subretinal PVR (stereo). A linear subretinal band is causing localized tractional detachment despite break closure. This diagram simplifies the pathology - usually several interconnecting bands are present. Notice how the retina appears draped over the band like clothes on a washing line. Subretinal sheets may be quite adherent to the outer retina. Subretinal bands are not usually adherent to the retina as the process of rolling up into a band breaks the adhesions with the photoreceptors. The ends of the bands are adherent to other bands and diffuse sheets and may be adherent to choroid.

The effect of subretinal bands on retinal reattachment can be assessed using a reattachment test. If the membranes prevent retinal reattachment they can be removed through a peripheral retinotomy.

Movie 12.18 Removal of subretinal band 2

The band snaps but the traction has been relieved.

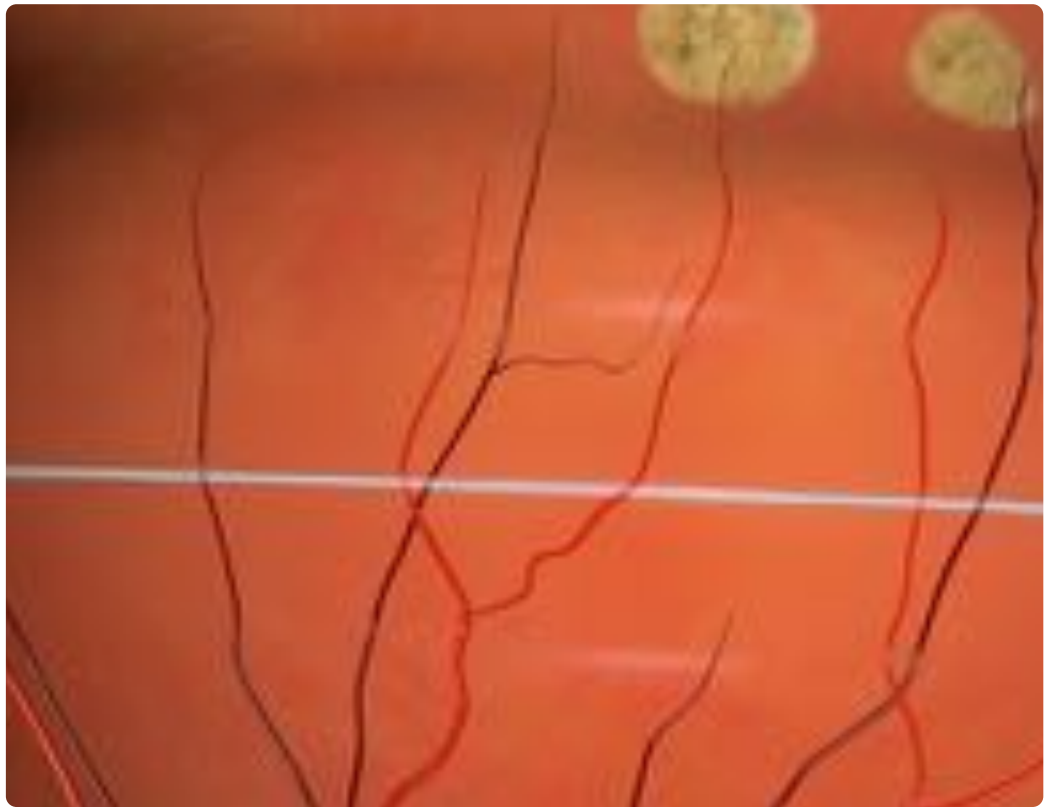
Movie 12.16 Removal of subretinal band 1

Note the tangential movements in the axis of the band to break the anchor points.

Movie 12.17 Removal of subretinal band after retinectomy

Significant subretinal proliferation is sometimes found when a retinectomy is performed on an eye with a chronic detachment. If deemed functionally significant these membranes may be removed easily.

Figure 12.15 Removal of subretinal band.



Usually subretinal bands can be left alone. This eye has an extensive tractional detachment and the band will be removed. All epiretinal proliferation should be removed before making a retinotomy.

REMOVAL OF NAPKIN RINGS

Annular bands of subretinal PVR which impede retinal reattachment may be encountered after vitrectomy or may become apparent after a reattachment test. Removal of thick membranes is safer through a large (180^0) peripheral retinectomy than attempted removal through a peripheral retinotomy. This allows the retina to be folded over so that annular membranes may be divided. Attempted avulsion of a thick annular subretinal membrane without dividing it first may cause large retinal breaks.

Movie 12.19 Surgery for annular subretinal PVR

Division and removal of annular subretinal PVR after retinectomy.

TAMPONADE AGENTS IN VITREORETINAL SURGERY

The Silicone Oil Study was a randomized controlled trial which investigated the relative efficacy of tamponade agents in vitreoretinal surgery. In this study the outcomes of tamponade with perfluoropropane and silicone oil were similar and both were superior to sulphur hexafluoride in PVR surgery. In a more recent study silicone oil seemed to give significantly better outcomes than perfluoropropane. This may be due to a change in presentation of PVR. As more primary vitrectomy is used in the repair of retinal detachment it is possible that more PVR-related failures have anterior PVR than was seen in the Silicone Oil Study (which had also found silicone oil to be superior to perfluoropropane in anterior PVR). Many surgeons now favor retinectomy with silicone tamponade in cases with significant anterior PVR.

Knowledge Review

Review 12.1 Pathogenesis of proliferative vitreoretinopathy

Question 1 of 2

Which of these is not a risk factor for anterior PVR:

- **A.** Multiple large tears.
- **B.** Giant retinal tear.
- **C.** Completely attached posterior hyaloid face. ✓
- **D.** Inflammation.
- **E.** Hypotony.
- **F.** History of cryotherapy.

Check Answer

Review 12.2 Classification and assessment of PVR

Question 1 of 2

Assuming all significant epiretinal proliferation can be seen in this image how would the PVR in this picture be graded:

- **A.** CA 6.
- **B.** CP 3.
- **C.** CP 6 (subretinal). ✓
- **D.** CP 180.

Check Answer

Review 12.3 Treatment of PVR

Question 1 of 3

When peeling star folds:

- **A.** Tangential or centripetal direction of peel is mandatory.
- **B.** The membrane should be removed quickly to avoid retinal breaks.
- **C.** The centre of the star fold is the epicenter of contraction. ✓
- **D.** Membranes tend to localized to the immediate vicinity of the star fold.

Check Answer

Review 12.4 Tamponade

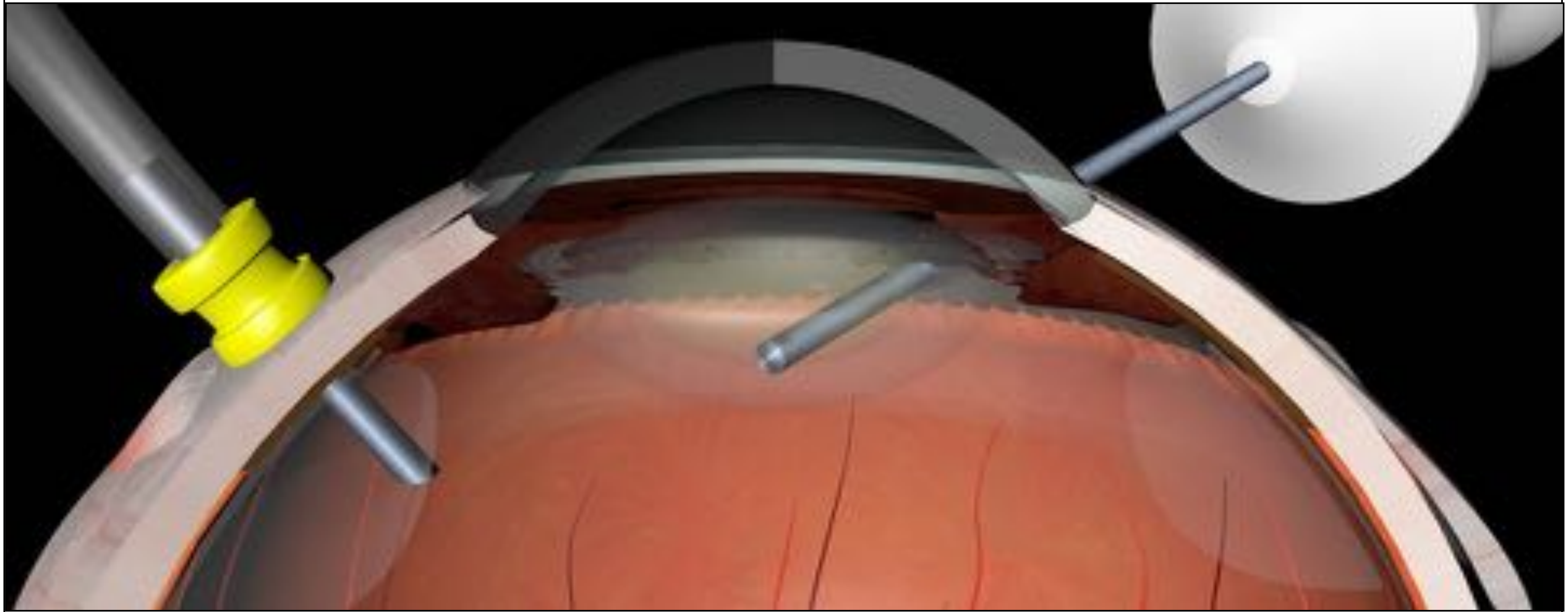
Which statement is correct regarding intraocular tamponade agents

- **A.** The interim results of the Heavy Silicone Study showed that patients with inferior PVR have better outcomes with heavy silicone oil than conventional silicone oil.
- **B.** The Silicone Oil Study showed silicone oil to be superior to perfluoropropane in all grades of PVR.
- **C.** The Silicone oil study showed that rates of hypotony were higher with silicone oil than perfluoropropane
- **D.** The Silicone oil study showed that postoperative elevated intraocular pressure was higher with perfluoropropane than silicone.
- **E.** Densiron is a mixture of perfluoron and conventional silicone.
- **F.** The surface tensions of conventional silicone and densiron are similar. ✓

Check Answer

CHAPTER 13

Lensectomy



Lens removal is frequently performed during vitreoretinal surgery. A pars plana approach using a cutter or fragmatome may be used. Alternatively the lens may be removed by anterior phacoemulsification.

Pars plana lensectomy

When lens removal is combined with vitrectomy phacoemulsification is generally preferable to pars plana lensectomy as it allows optimal (in the bag) intraocular lens placement.

Pars plana lensectomy is usually reserved for:

- Subluxed lenses with global zonular deficiency (e.g. Marfan syndrome).
- Conditions in which removal of the whole lens including the capsular bag is required (severe anterior PVR, severe anterior hyaloid proliferation after diabetic vitrectomy).
- Dislocated lenses or fragments in the vitreous cavity.
- Severe trauma with capsular rupture.

Many surgeons prefer to use phacoemulsification in almost all cases, fixating dislocated lens fragments with perfluorocarbon if necessary. Many cases that formerly required pars plana lensectomy may now be managed with phacoemulsification if a capsular tension ring is employed.

Movie 13.1 Phacoemulsification of traumatic cataract with zonular dehiscence

Use of capsular tension rings and iris hooks allows many cases to be completed with anterior segment phacoemulsification.

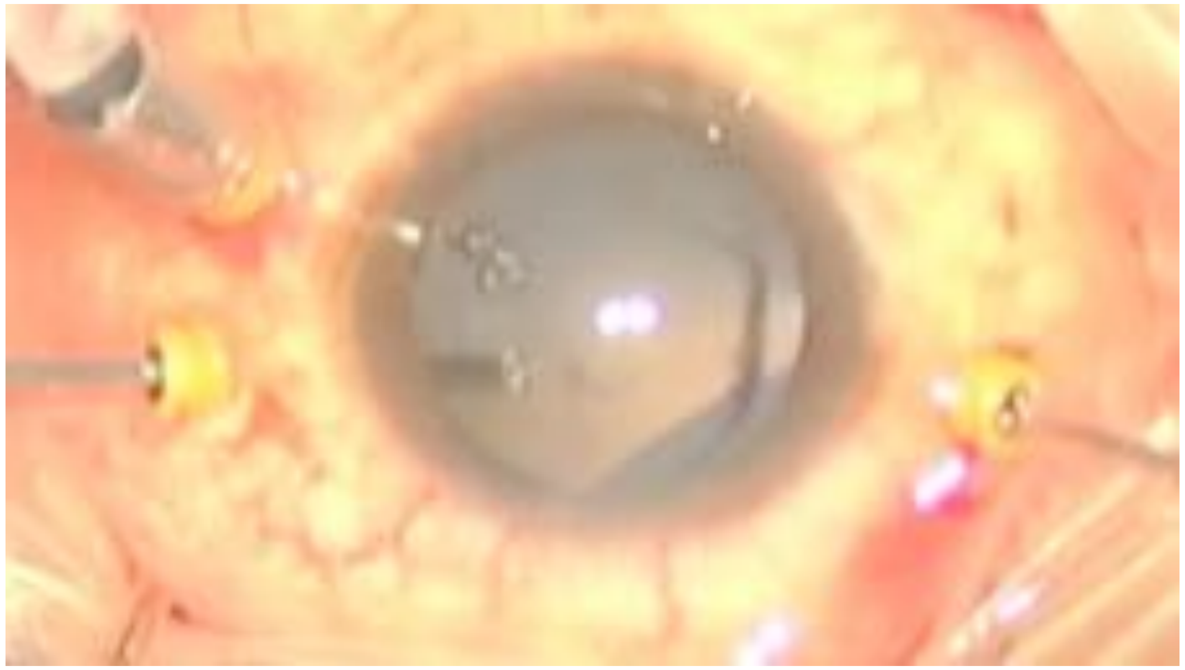
PARS PLANA REMOVAL OF NON DISLOCATED LENS.

A cutter or fragmatome may be used to remove the lens. The technique employed depends on the state of the zonules and the toughness of the lens nucleus.

In simple cases with weak zonules and a soft nucleus (e.g. most cases of Marfan syndrome) removal of the lens and capsular bag are easily performed with a routine vitrectomy setup. Coaxial illumination from the operating microscope allows the lens to be clearly seen against the lens reflex. Aspiration and cutting are both used to remove the lens material. Quite high aspiration may be required. When cutting near iris the cutter should face away from the iris whenever possible to prevent accidental iridectomy.

Once the lens has been removed a complete pars plana vitrectomy is performed to reduce the risk of late retinal detachment.

Movie 13.2 Lensectomy with soft lens and weak zonules



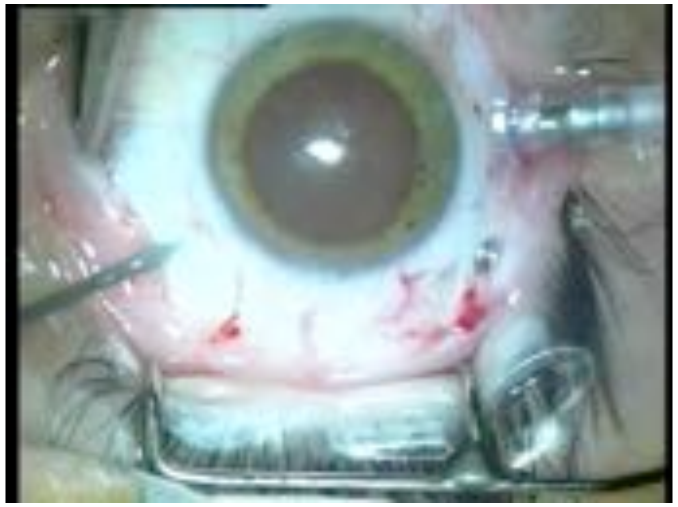
In this case of Marfan syndrome the zonules are so weak that capsulorrhexis is not possible. It is important to complete a full pars plana vitrectomy after the lens has been removed.

Pars plana removal of tough lens nuclei is most efficiently performed by phacoemulsification but may also may be performed using a fragmatome. While MIVS fragmatomes are becoming available at the time of writing many surgeons prefer a hybrid small incision/20-gauge approach. One port is enlarged to accommodate a 20-gauge fragmatome (or a separate 20-gauge sclerotomy is created). This creates a potential infusion/aspiration mismatch which may cause ocular hypotony. This is addressed by increasing the infusion pressure.

The fragmatome relies on continual aspiration of fluid to conduct thermal energy from its tip. Fluid from the infusion must have access to its tip at all times. If the posterior chamber infusion cannot be visualized this may be achieved using an intralenticular infusion. A needle is bent, attached to an infusion line and then passed horizontally into the lens through a sclerotomy 3.5 mm from the limbus.

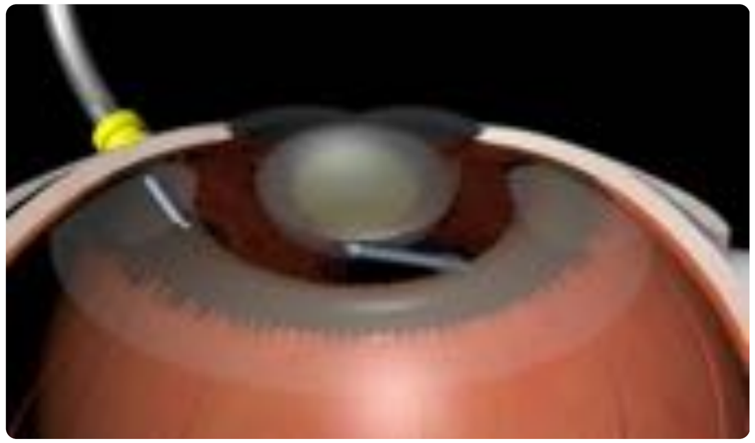
If the infusion tip is visible a different approach is used. Removal of anterior vitreous allows infusion fluid from the pars plana to pass to the fragmatome. It is not possible to create a continuous circular curvilinear capsulorrhexis from the posterior segment using forceps. This is due to hyalocapsular adhesions and the convexity of the posterior surface of the lens. A posterior capsulotomy is created using the cutter. When a posterior capsulotomy is created in this way it is better not to place an intralenticular infusion. It is unnecessary as fluid from a posterior infusion has access to the fragmatome. The irregular capsular defect created by the intralenticular infusion may enlarge and cause a large capsular tear.

Movie 13.3 Placement of an intralenticular infusion



A sclerotomy is created. A 20 G needle is bent through 30^0 and attached to an infusion. It is then passed into the lens. The lens is not particularly opaque and this case would have been better performed with a posterior capsulotomy and no intralenticular infusion.

Figure 13.1 Posterior capsulotomy with the vitreous cutter



The anterior hyaloid has also been removed to allow the fragmatome access to the lens cortex and nucleus.

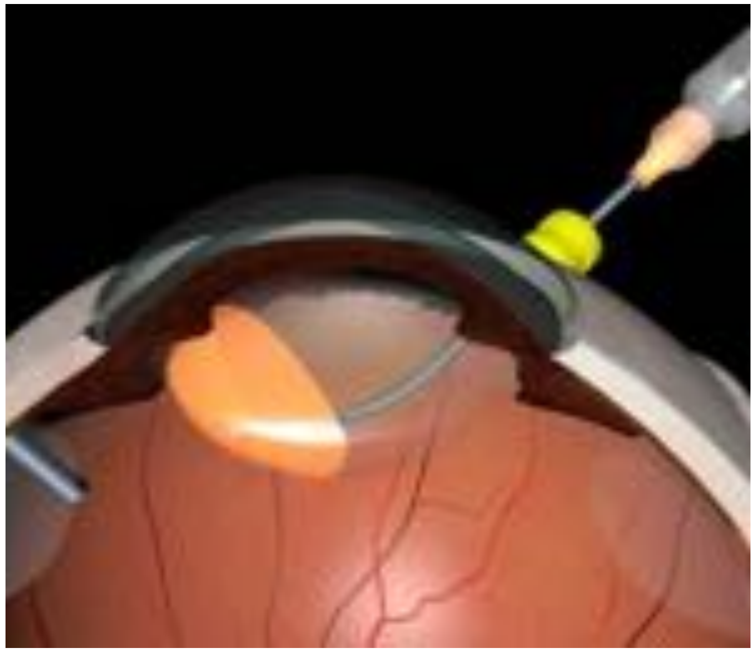
Hydrodissection may be performed using a curved cannula introduced via the pars plana through the posterior capsulotomy. The tip of the cannula is placed adjacent to the anterior capsule and the wave of hydrodissection can be observed spreading around the periphery of the lens.

A series of grooves are then made in the nucleus using the fragmatome. This is activated while advancing into the lens. Whitening of lens matter (lens milk) around the tip of the fragmatome indicates that the tip is overheating. This is due to occlusion of the fragmatome. It lacks an irrigation sleeve and relies on a constant flow of fluid through the lumen to dissipate thermal energy from the vibration at the tip. The heat may be conducted up the shaft of the probe causing a scleral burn. This is a very serious problem which must be avoided. If lens milk is seen ultrasound should be stopped immediately and the instrument withdrawn from the eye. The occluding material is refluxed by forcible injection of saline from a syringe connected to the shaft. The instrument is not reintroduced into the eye until it has been tested outside the eye. The tip is placed in a dish of saline and aspiration activated to confirm free flow of fluid. The probability of occlusion may be reduced by creating a series of shallow grooves rather than impaling the instrument in the centre of the lens (analogous to nuclear sculpting in anterior segment phacoemulsification).

Movie 13.4 Use of the fragmatome

This is a case of severe PVR. As there is no fundal view an intralenticular infusion with equatorial entry of the fragmatome was used. An MVR blade creates an entry into the lens for the fragmatome. Note the 'mining' approach as the fragmatome is successively advanced into the lens with ultrasound and aspiration activated then withdrawn to create a series of grooves. Today the author would manage a case like this with transcorneal phacoemulsification

Figure 13.2 Using the fragmatome

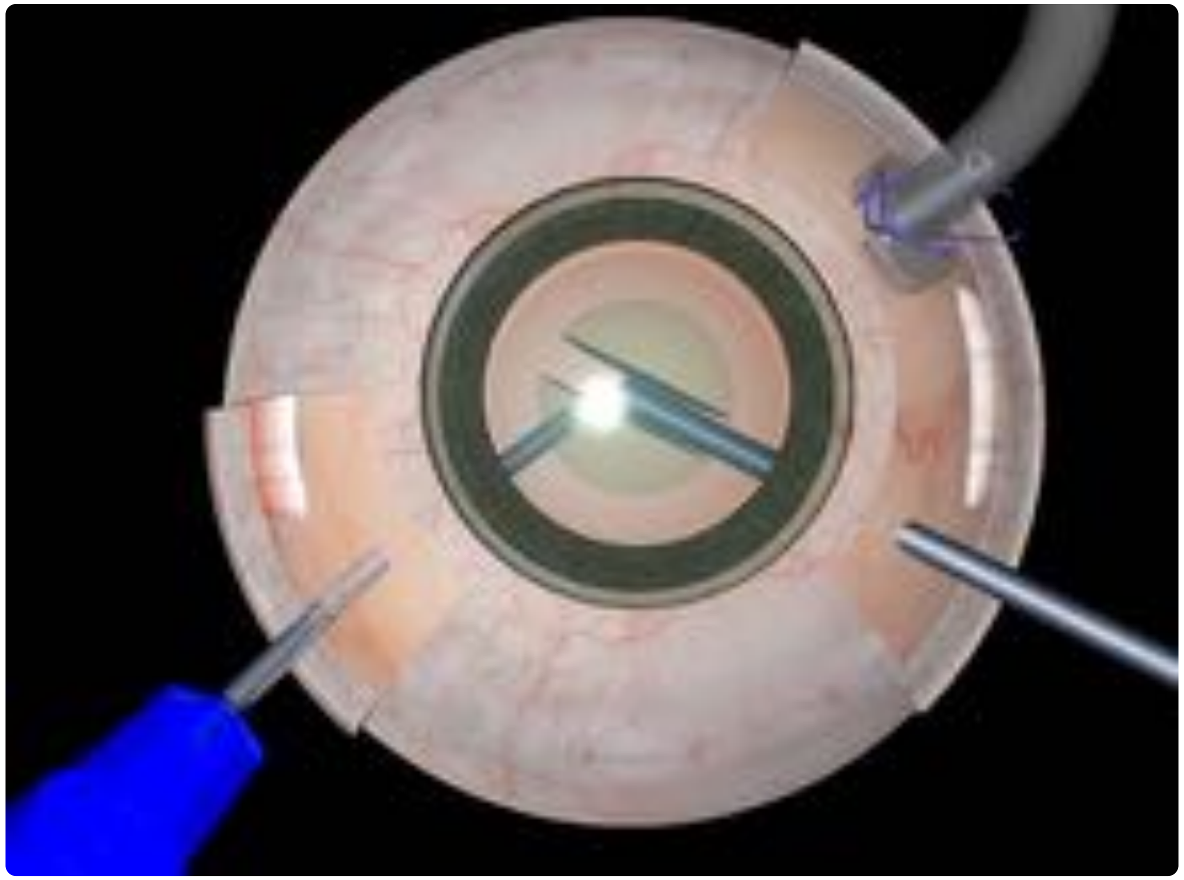


A hydrodissection made through the posterior capsulotomy. The tip of the cannula is adjacent to the anterior capsule. A further hydrodissection may be required from the opposite sclerotomy.

1. Grooving made from both superior sclerotomies results in 2 cruciate crossing grooves in the nucleus. This allows the nucleus to be disassembled by cracking. The principle is the same as the 'divide and conquer' approach to phacoemulsification. Instruments are placed within each groove and a spreading movement of each instrument pivoting at the sclerotomy is used to crack the lens. Further grooves are made if the nucleus cannot be cracked. The nucleus is rotated and the procedure repeated. This creates 4 mobile quadrants. The quadrants can then be emulsified using pulsed ultrasound with high aspiration.

The residual lens cortex is removed by engaging it peripherally using aspiration only and stripping it centrally.

Figure 13.3 Pars plana fragmatome lensectomy (20-gauge)



A series of fragmatome grooves makes a trench in the lens nucleus.

Viscodissection is used to separate the iris from the lens. The iridocapsular adhesions that develop following trauma are very strong and may require division with a blade or scissors.

Iris hooks or a Malyugin ring may be used to mechanically dilate a small pupil.

Movie 13.5 The use of iris hooks with vitreolensectomy

This is preceded by viscodissection to free the iris from the lens.

Movie 13.6 Division of iridocapsular adhesions

Following trauma the iridocapsular adhesions may be too strong for viscodissection and surgical division may be required.

PARS PLANA REMOVAL OF DISLOCATED LENS MATERIAL

Soft lens material is easily removed from the posterior segment with the vitrectomy cutter. A front to back approach is used, removing lens material from the anterior segment first to clear the view. A complete vitrectomy including induction of PVD is performed. The mobility of lens fragments on the surface of the retina is a useful indicator of the presence of a PVD. If the vitreous is detached they move freely, if it is attached they appear stuck to the retina. After the vitreous has been detached the lens fragments are engaged with aspiration alone and lifted from the retinal surface. Only when the lens fragments are safely away from the retina is cutting aspiration activated. This is done without breaking aspiration.

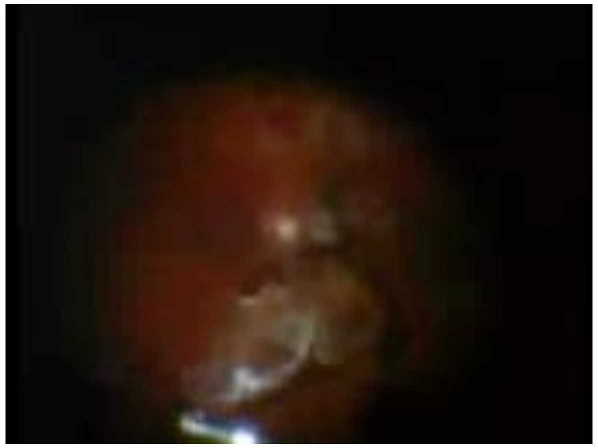
Nuclear lens matter may be too rigid to deform and occlude the cutter port. Lens fragments may be then be crushed bimanually and pushed towards the cutter using the light pipe.

Small lens fragments tend to gravitate to the inferior vitreous base which should be therefore be trimmed carefully with indentation.

Cortical clean up using aspiration should be performed while preserving as much of the capsular bag as possible.

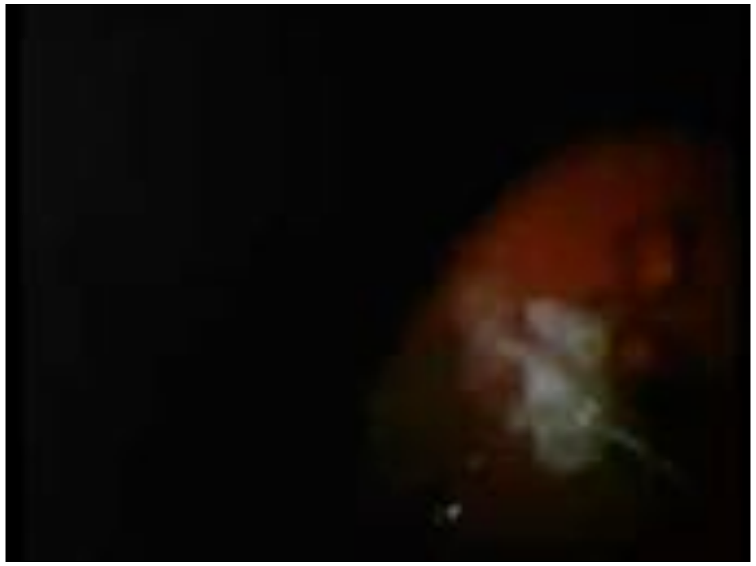
Triamcinolone may reveal the presence of vitreous strands to the corneal section which should be divided. This is best done at the end of the surgery in case the pupil constricts. Routine use of miochol at the end of surgery for retained lens matter helps to identify thin strands which may not stain with triamcinolone.

Movie 13.7 Retained lens matter and the posterior hyaloid



The lens fragments are trapped in the posterior hyaloid and do not initially move freely. As a PVD is induced the lens fragments move forward with the posterior hyaloid.

Movie 13.8 Bimanual crushing of nuclear fragments



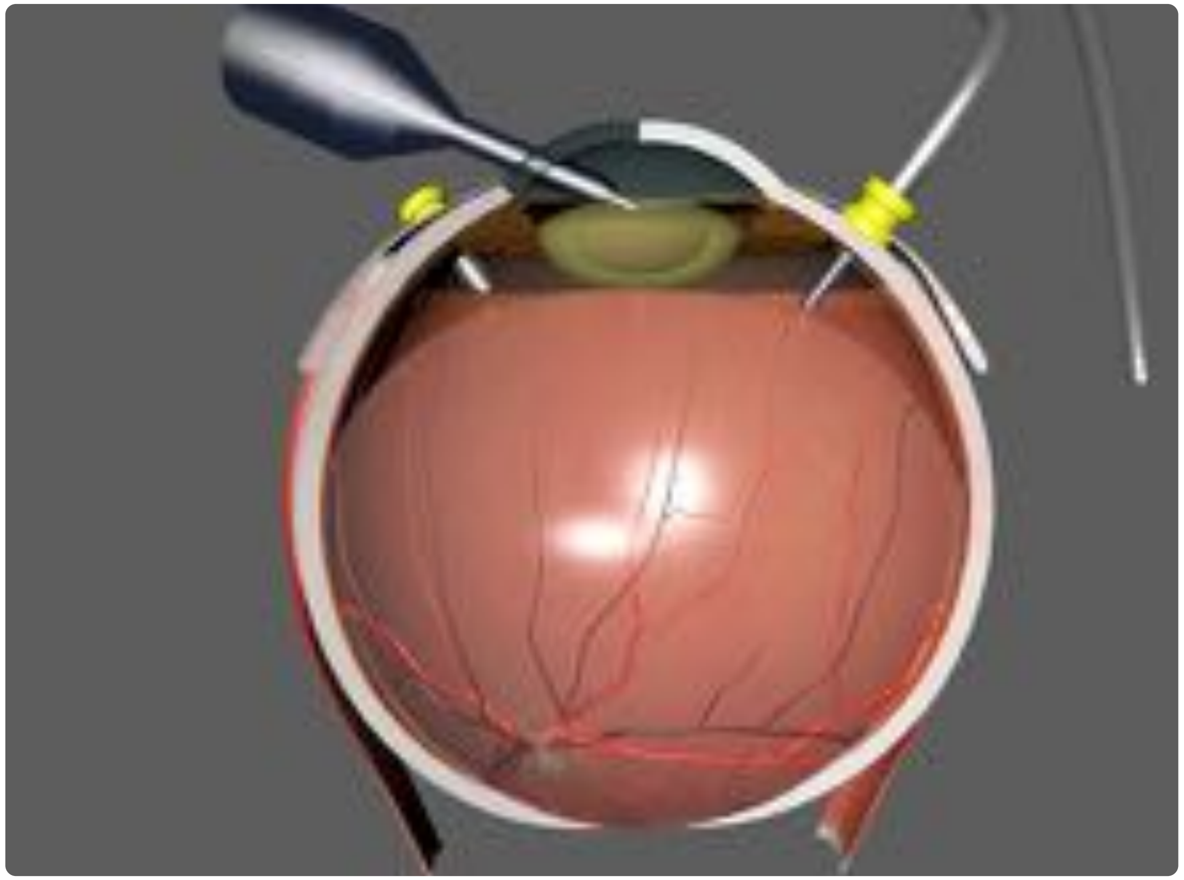
Harder lens fragments are crushed into ever smaller pieces and fed into the cutter port.

Pars plana or anterior segment phacoemulsification are performed if lens material is too hard to be removed with the vitreous cutter.

In aphakic eyes perfluorocarbon may be used to lift lens matter into the pupillary plane for phacoemulsification. The vitreous base should be shaved thoroughly before this is done. The convexity of the perfluorocarbon meniscus tends to cause the lens material to slip peripherally out of sight. As the corneal section is opened fluid currents are generated which may cause the lens to become visible if it is not trapped in peripheral vitreous, allowing phacoemulsification. Viscoelastic injection behind the lens can also be useful at this stage.

The fluid currents generated by opening the section and phacoemulsification also cause the perfluorocarbon to break up into small bubbles. These may become entangled in the residual vitreous base and can only be removed by repeating the vitreous base shaving after the perfluorocarbon has been removed.

Figure 13.4 Phacoemulsification of dislocated nucleus

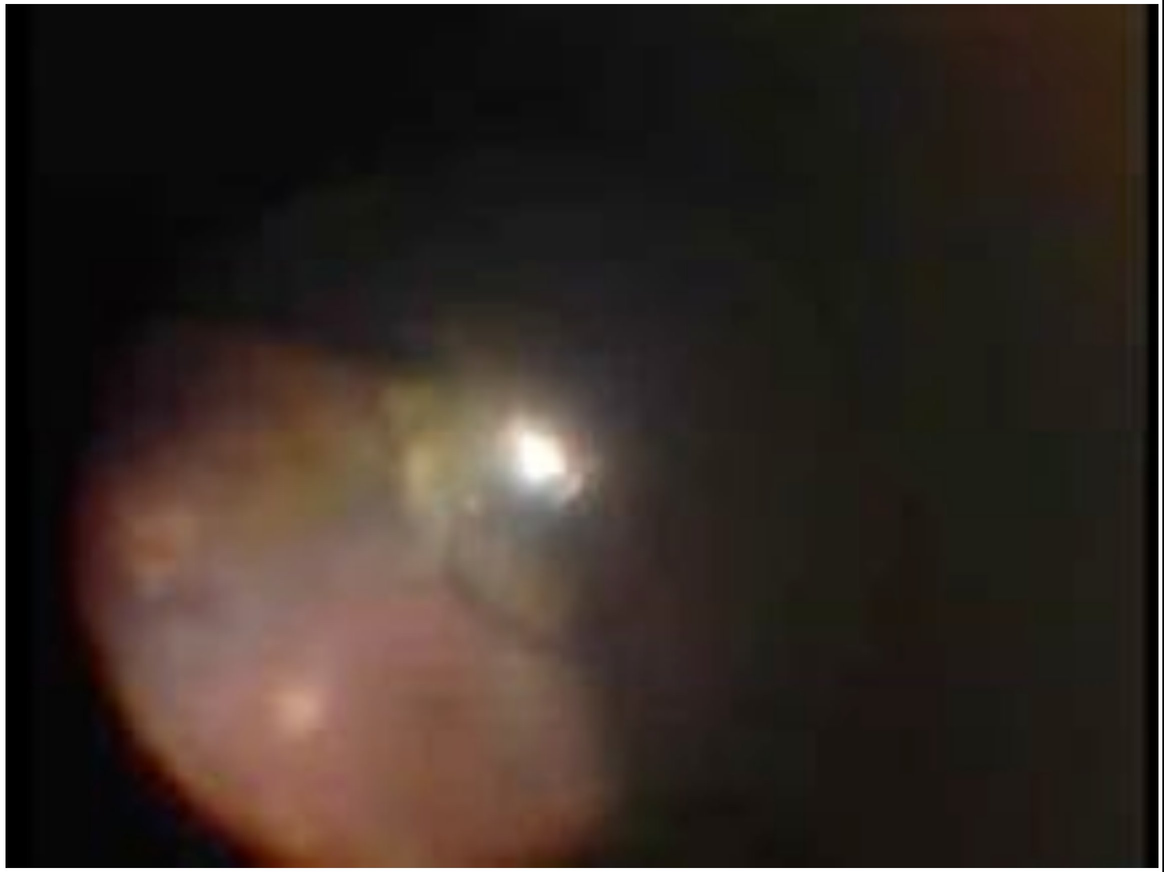


The lens is supported in the pupil plane with a large bubble of perfluorocarbon.

In pseudophakic eyes tough nuclear fragments are best removed with the fragmatome. When using the fragmatome:

- Induction of a posterior vitreous detachment is essential before the fragmatome is introduced. It is impossible to remove vitreous with the fragmatome and dangerous to try.
- Aspiration is used to engage lens fragments which are moved away from the retinal surface before ultrasound is activated.
- The problem of lens material flying off the tip of the fragmatome may be reduced by using pulsed (4 Hz) ultrasound with low power and high aspiration.
- If a 20-gauge fragmatome is used with a small incision infusion the aspiration/infusion mismatch may induce hypotony, particularly when there is an occlusion break. Elevation of the infusion pressure may partially compensate but the intraocular pressure must be carefully monitored.
- Any sign that the fragmatome does not appear to be aspirating should be taken a cue to remove the instrument from the eye and purge it before lens milk occurs.
- Lens particles flying off the tip of the fragmatome do not have sufficient inertia to cause retinal injury. Retinal trauma during fragmentation is a result of sonification of the retina due to activation of the instrument too close to the retina. Perfluorocarbon has a protective effect but may also make removal more difficult as lens particles tend to slip down the edges of the PFCL bubble and may even become trapped underneath it as the eye rolls around. Correct fragmentation technique (engaging with aspiration and only performing fragmentation when the lens is distant from the retina) allows good visual outcomes without the use of PFCL.

Movie 13.9 Use of the fragmatome

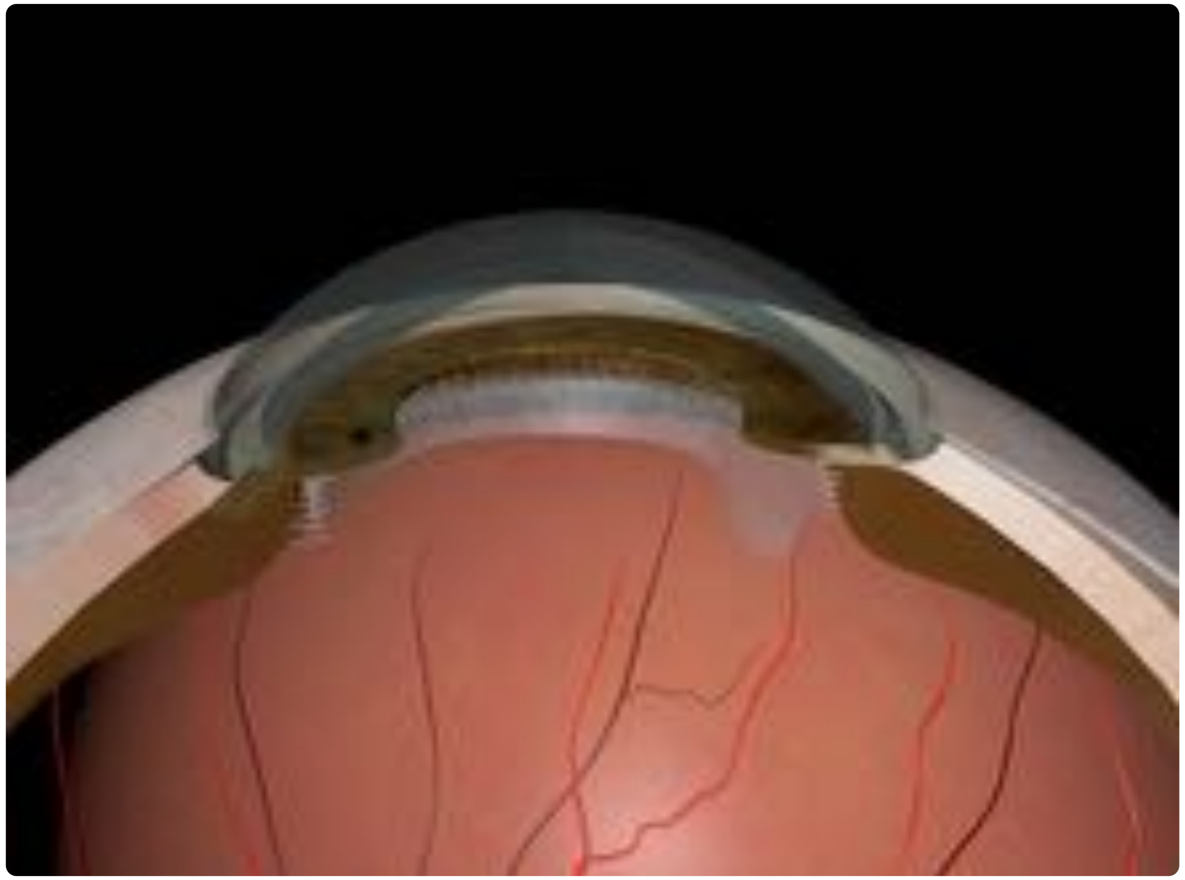


The lens particles are lifted off the retina before fragmentation. The problem of lens particles flying off the tip is reduced, but not eliminated, by the use of pulsed ultrasound with low power and high aspiration.

In aphakic eyes with an intact anterior capsule an intraocular lens may be placed in the sulcus. Rigid intraocular lenses with a large diameter optic are preferable to injectable or foldable lenses. If the capsulorrhexis is well centered and smaller than the optic an optic capture technique may be used.

If biometry is unavailable or there is any doubt about capsular integrity intraocular lens implantation may be deferred. Postoperative fibrosis of the capsular remnants often allows secondary sulcus intraocular lens placement.

Figure 13.5 Secondary intraocular lens implant



At the time of vitreolensectomy for retained lens fragments there is a large posterior capsule defect due to extension of a tear in the anterior capsulorrhexis. Attempted lens implant may damage the remains of the capsular bag.

Combined phacoemulsification with vitrectomy

SIMULTANEOUS VS. SEQUENTIAL SURGERY

Most modern vitrectomy machines are capable of phacoemulsification also. Combined surgery is therefore possible when lens opacity interferes with the fundal view. The incidence of cataract after vitrectomy is very high (approaching 100% if intraocular gas tamponade is used). There is no consensus on the management of cases with a clear lens.

Arguments for routinely performing phacovitrectomy are:

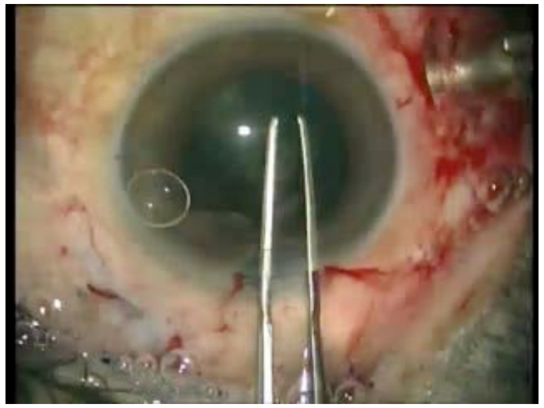
- Elimination of the need for a second procedure in many cases.
- Elimination of some of the technical problems associated with post vitrectomy phacoemulsification.
- Enhanced gas fill and easier access to the vitreous base without the risk of capsular breach.

Arguments against performing combined phacovitrectomy are:

- Pupil miosis may occur during phaco, especially if the anterior chamber collapses or the iris is touched.
- A smaller than usual rhexis is required if intraocular gas is injected to prevent intraocular lens dislocation. This may phimose and cause glare.
- Many patients seem to develop posterior synechiae which may also cause glare.
- Use of ‘premium’ (multifocal and toric) lenses may be problematic because of implant displacement by gas.

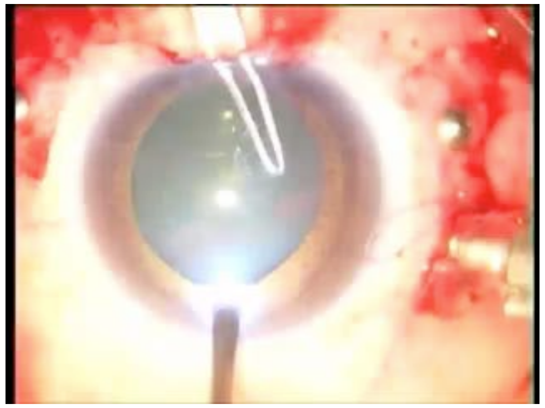
- The cannulas for the vitrectomy should be placed 3.5 mm behind the limbus before the corneal pocket is created.
- The section should be well constructed (2 or 3 step incision) to prevent leakage during vitrectomy.
- If the red reflex is absent due to vitreous opacity a capsular dye may be required to visualize the capsulorrhexis. Alternatively the light pipe may be used to provide tangential illumination.
- The size of the capsulorrhexis is critical if gas is to be used. It should be at least 1mm smaller than the implant optic.
- During phacoemulsification care is taken to prevent anterior chamber collapse or iris touch to prevent iris constriction. Even moderate miosis may impair the fundal view. Preoperative non steroidal anti-inflammatory drops such as voltarol may also help to prevent this.
- Silicone intraocular lenses are best avoided if there is a possibility that silicone oil may be required.
- The section should be sutured before the vitrectomy starts.
- If intraocular gas is injected at the end of the vitrectomy a bubble of gas may also be injected into the anterior chamber to reduce intraocular lens displacement.

Movie 13.10 Capsulorrhexis without red reflex



Trypan blue is used to enhance the view of the capsulorrhexis in this eye with vitreous hemorrhage.

Movie 13.11 Capsulorrhexis without red reflex



Alternatively a light pipe may be used to provide tangential illumination.

Figure 13.6 Phacovitrectomy

Optic capture due to a large capsulorrhexis

Cataract after vitrectomy

Nuclear cataract is very common after vitrectomy, especially if intraocular gas is used. An increase in oxygen diffusion to the lens following vitrectomy has been implicated in its pathogenesis. It typically presents as progressive myopia which may be apparent as soon as 3 months after surgery.

Contact of gas with the posterior capsule produces a feathery vacuolated appearance in the early post operative period (gas cataract) which usually resolves. Persisting diffuse posterior subcapsular cataracts may develop follow contact of gas with the posterior capsule, particularly if the anterior hyaloid was removed during surgery. Linear posterior capsular defects aligned to a sclerotomy suggest lens touch without capsular breach. A full thickness defect (for example due to the cutter removing a portion of capsule) in a soft lens may cause early hydration of the lens with the clinical features of phacolysis.

There is no single surgical technique appropriate for all post vitrectomy cataracts. Some of the techniques used in dealing with zonular instability are inadvisable if there is a posterior capsule defect and vice versa.

Figure 13.7 Posterior capsule cataracts after vitrectomy.

Gas cataract. This is due to gas contact with the posterior capsule and usually implies disruption of the anterior hyaloid face. This resolves as the gas resorbs but is often be followed by the early development of diffuse posterior subcapsular lens opacities

Figure 13.8 Nucleosclerosis after vitrectomy

This patient presented with progressive myopia two years after right vitrectomy. This had been managed by frequent changes to his spectacle prescription. He had been told that he did not have a cataract.

ANTERIOR CHAMBER DEPTH

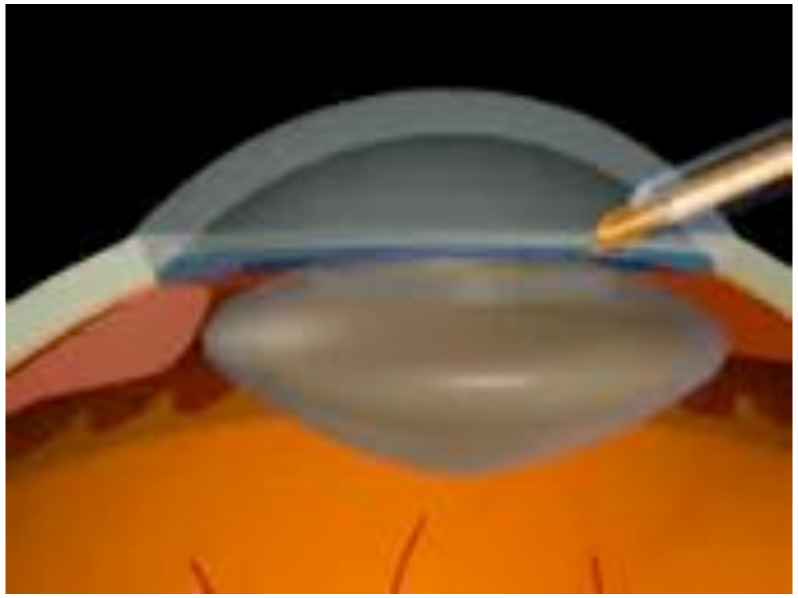
A number of technical challenges may be encountered during phacoemulsification after vitrectomy.

The anterior chamber may become very deep when the phacoemulsification probe enters the eye. This retropulsion of the lens iris diaphragm is due to reverse pupil block. The iris acts as a flutter valve preventing fluid passage around the lens to the posterior segment. Reducing the infusion pressure (and performing the phacoemulsification with low aspiration) prevents the block arising.

It may be treated very simply by elevating the iris with a second instrument or by placing a single iris hook.

Movie 13.12 Lens-iris diaphragm retropulsion syndrome

Movie 13.13 The mechanism of lens-iris diaphragm retropulsion syndrome



The pressure of the infusion forces the iris back against the lens where it acts as a flutter valve so that the lens is displaced posteriorly.

Movie 13.14 Treating lens-iris diaphragm retropulsion syndrome

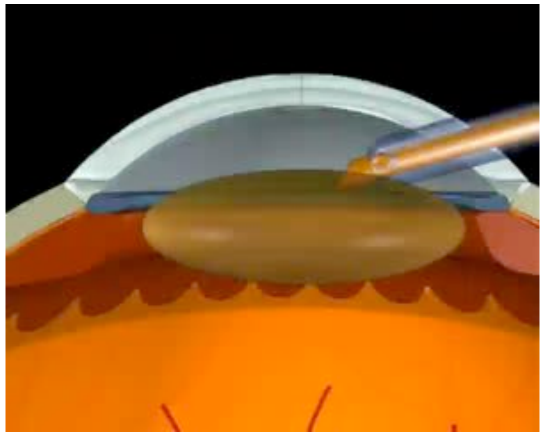
Lifting the iris to allow fluid passage around the zonules into the posterior segment. This does not usually need to be repeated unless

During nuclear grooving the anterior chamber may shallow and the pupil constrict. This is termed infusion deviation syndrome. The lens is displaced posteriorly by pressure from the phacoemulsification probe. This creates a gap between the capsule and the iris. The jet of fluid from the infusion passes through this gap causing forward displacement and constriction of the iris. Increasing the infusion pressure simply exacerbates the problem. This may be treated by simply injecting a cohesive viscoelastic into the eye (mechanical dilatation of the pupil is not required). It may also be prevented by moving the infusion sleeve up the phacoemulsification probe so that the infusion is further from the tip of the probe.

Movie 13.15 Infusion deviation syndrome

Note that the lens is displaced posteriorly immediately before the change in the iris.

Movie 13.16 The cause of infusion deviation syndrome

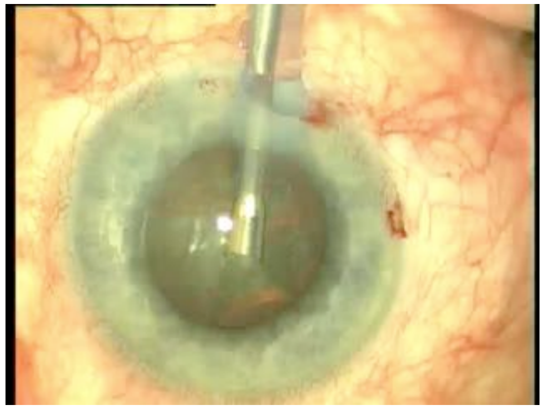


The jet of infusion fluid between the iris and the lens blows the iris forwards.

Movie 13.17 Management of infusion deviation syndrome

Viscoelastic injection without iris hooks is highly effective.

Movie 13.18 Prevention of infusion deviation syndrome



The infusion sleeve has been withdrawn a little.

LENS CAPSULE CHANGES

Full thickness capsular detects which cause a phacolytic reaction usually require lensectomy rather than standard phacoemulsification.

Posterior capsule touch causes localized plaques which occasionally split during hydrodissection or phacoemulsification.

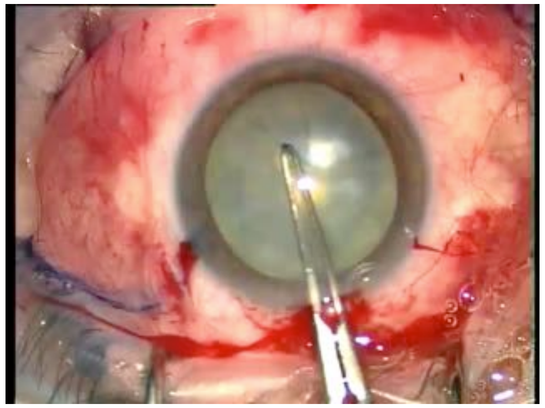
Movie 13.19 Posterior capsular rupture

This eye was known to have a posterior capsular plaque following lens touch. The pupil snap and sudden anterior chamber deepening indicate that the posterior capsule has ruptured.

When managing a posterior capsule plaque:

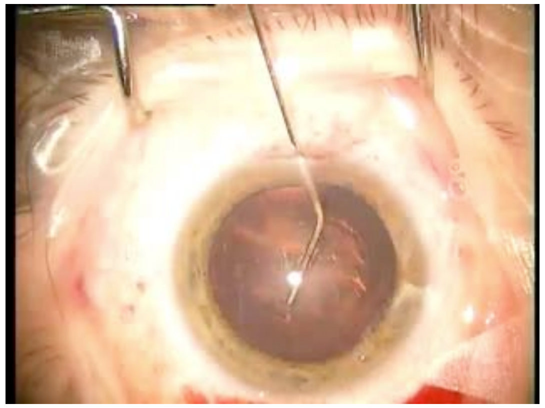
- Early cataract surgery is advisable while the nucleus is still soft.
- A large capsulorrhexis reduces the risk of capsular block.
- Hydrodelineation and removal of the nucleus before viscodelamination of the lens cortex may be helpful. This is the same technique used for posterior polar cataracts. This increases stress on the lens zonules however.

Movie 13.24 Capsulorrhexis



This case is undergoing surgery one week following vitrectomy complicated by lens capsule breach. Note the large capsulorrhexis.

Movie 13.20 Hydrodelineation

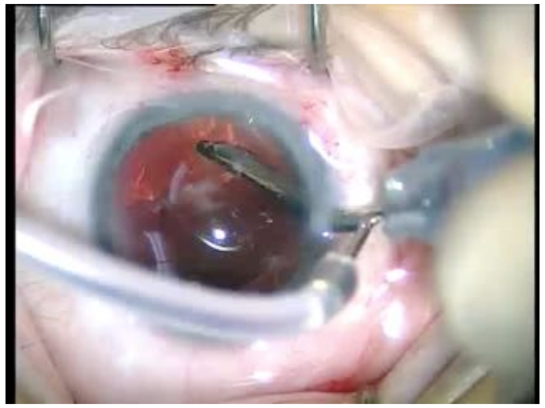


Early intervention allows hydrodelineation and removal of the nucleus. This is usually not possible after a few months as the lens nucleus is too large.

Movie 13.21 Viscodissection

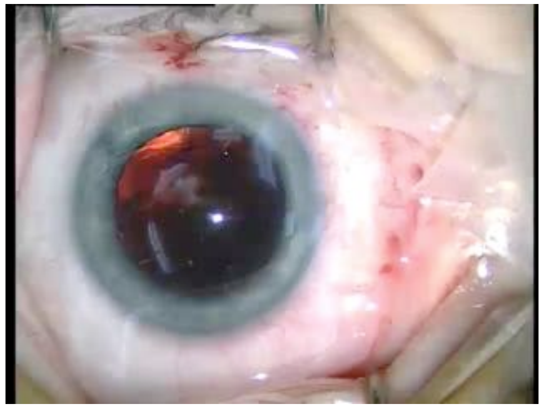
Following hydrodelineation and removal of the nucleus viscodissection and aspiration are used to remove the cortex.

Movie 13.22 Cortex aspiration



The cortex around the plaque is removed last.

Movie 13.23 Plaque management



The plaques may be very adherent and the posterior capsule mobile. They are hard to remove by polishing and may be best left with a view to subsequent yag capsulotomy.

ZONULE WEAKNESS

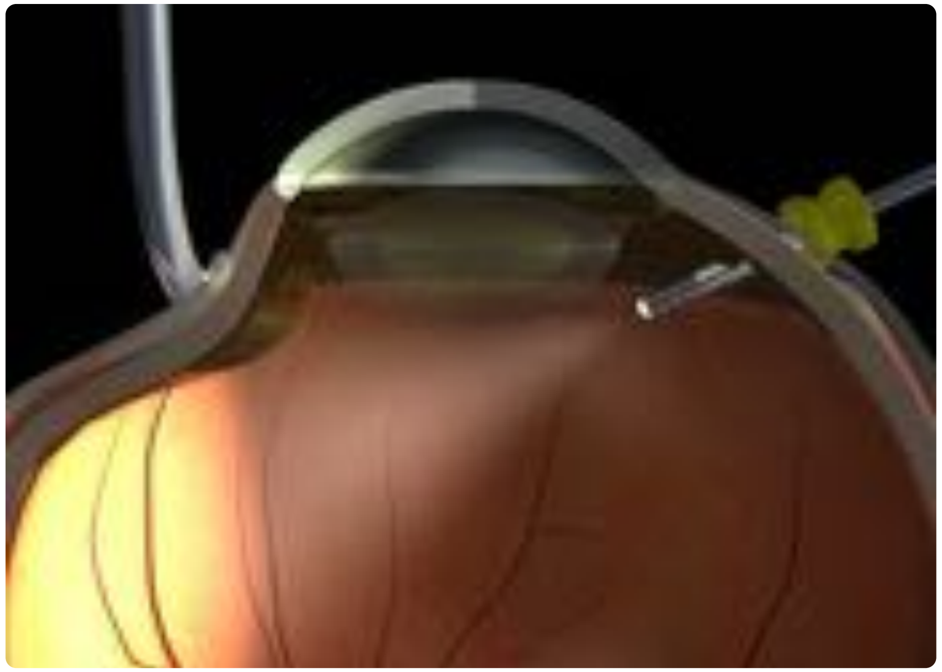
Zonules may be traumatized during vitrectomy particularly if scleral indentation has been performed. It is therefore usually often seen after complex vitreoretinal procedures. As the zonule weakness is usually focal phacodynesis may not be apparent preoperatively. It may become apparent intraoperatively as:

- Difficulty rotating the nucleus. Attempted rotation of the nucleus leads to rotation of the whole lens and capsular bag, which return to their original position once rotational forces cease.
- Mobility of the lens during grooving.
- Localized iris dilation during grooving due to lens tilting.

Useful surgical techniques include:

- Meticulous hydrodissection.
- Use of a capsular tension ring.
- Placement of iris hooks in the capsulorrhexis.
- Use of techniques for nuclear disassembly that minimize stress on the zonules (i.e. minimizing nuclear rotation).

Figure 13.9 Zonule stress during vitrectomy



Zonular weakness is typically seen after vitrectomy for complex pathology. Deep anterior scleral indentation causes mechanical stress on the zonules.

Knowledge Review

Review 13.1 The fragmatome

When using a fragmatome to perform pars plana phacoemulsification:

- **A.** The power of the fragmatome should be increased if vitreous is present around the tip.
- **B.** The appearance of lens milk indicates that the power should be increased.
- **C.** An intralenticular infusion reduces the risk of large capsular tears
- **D.** Pulsed phacoemulsification is usually more efficient than continuous phacoemulsification when dealing with mobile lens fragments.
- **E.** Dislocated nuclear fragments should be phacoemulsified close to the surface of the retina.
- **F.** The posterior capsular opening for the fragmatome should be a continuous curvilinear capsulorrhexis made with a forceps introduced through the par plana.

Check Answer

Review 13.2 Phacovitrectomy

Question 1 of 2

Which of the following is an advantage of phacovitrectomy over sequential vitrectomy then cataract surgery include:

- **A.** Reduced incidence of peripheral synechiae.
- **B.** Increased gas fill.
- **C.** Increased accuracy of biometry.
- **D.** Reduced risk of corneal edema during vitrectomy.
- **E.** The need for a larger capsulorrhexis.
- **F.** Reduced incidence of peroperative pupil miosis

Check Answer

Review 13.3 Cataract after vitrectomy

Question 1 of 2

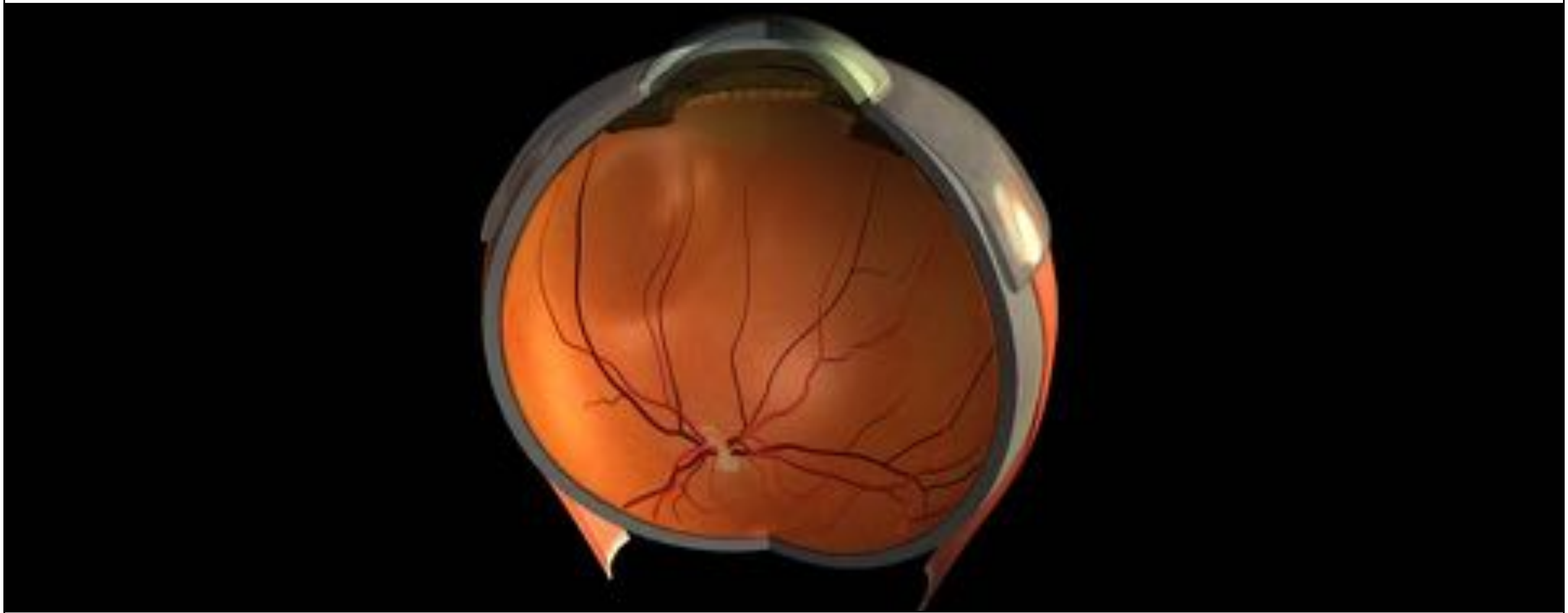
Regarding post vitrectomy cataract

- **A.** Hypoxia of the lens has been implicated in the pathogenesis.
- **B.** Increasing hypermetropia is an early symptom.
- **C.** An early diffuse subcapsular opacity usually indicates that the anterior hyaloid face is still attached to the lens capsule
- **D.** Nucleosclerosis may start to develop within 3 months of vitrectomy. ✓

Check Answer

CHAPTER 14

Retinoschisis



Retinoschisis is common and often confused with retinal detachment. It rarely causes progressive retinal detachment.

Pathology

Retinoschisis is splitting of the retina. The two layers that result are called the inner and outer leaves of the retinoschisis. The cavity between these is filed with hyaluronic acid.

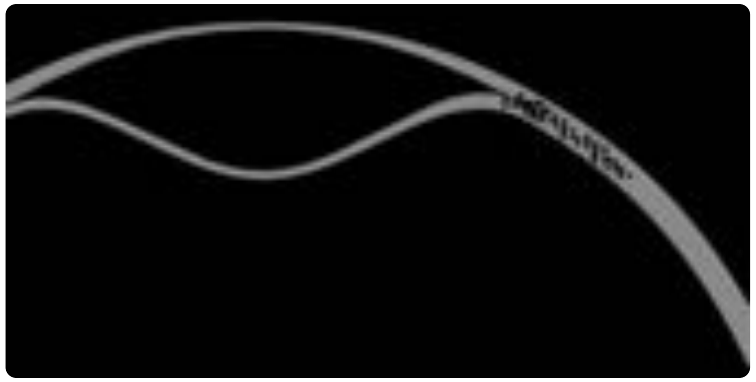
It is classified according to the etiology.

Congenital retinoschisis (X-linked retinoschisis, XLRS) is a consequence of a mutation in the RS1 gene which encodes the protein retinoschisin.

The etiology of acquired retinoschisis in unknown. It typically occurs adjacent to areas of microcystoid degeneration and is presumed to arise from coalescence of the cysts with loss of the intervening Muller cell columns. It is further classified according to the level of the split. In degenerative retinoschisis the split is at the level of the outer plexiform layer. In reticular retinoschisis it is just deep to the nerve fibre layer. This distinction does not affect clinical practice. Acquired retinoschisis is very common. In the Copenhagen Eye Study the prevalence was 3.9%. It is typically bilateral affecting the inferotemporal quadrants.

Retinoschisis may also occur secondary to other disease processes. Examples include optic disc pit maculopathy, myopic foveoschisis and tractional schisis in cicatricial diabetic retinopathy.

Figure 14.1 Retinoschisis and microcystoid degeneration



Microcystoid degeneration is seen at the borders of retinoschisis.

Movie 14.1 Retinoschisis and microcystoid degeneration

This eye is undergoing surgery for progressive retinal detachment due to retinoschisis (right side of movie). Note the pronounced microcystoid degeneration. (left side of movie).

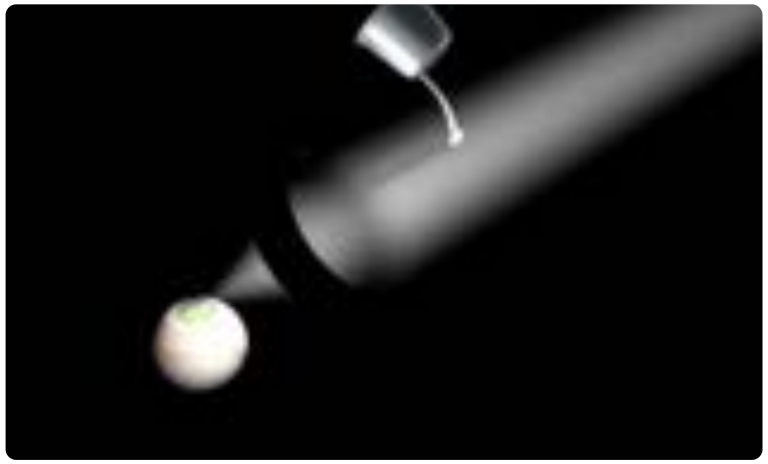
Clinical assessment

Features useful in differentiating retinoschisis from retinal detachment are illustrated in the accompanying figure.

Other features or investigations that may be useful are:

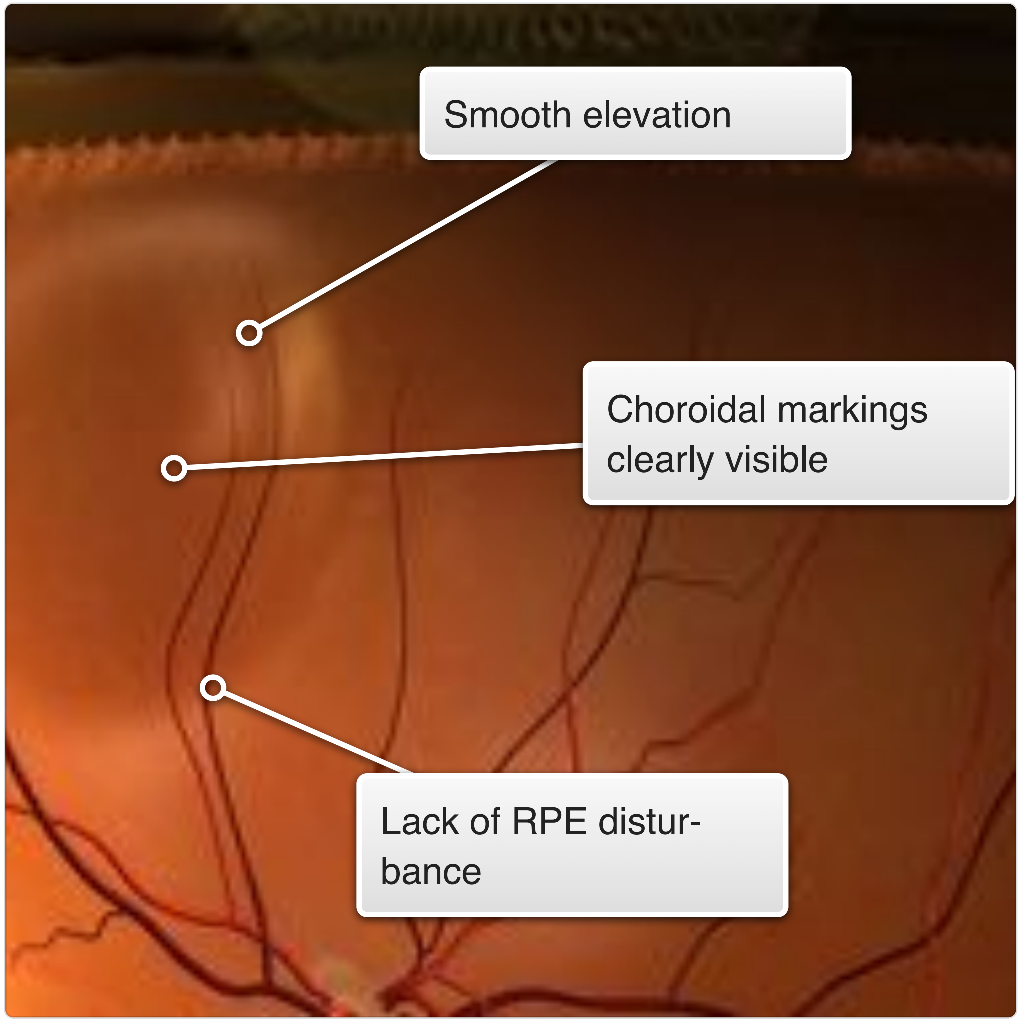
- Absolute scotoma due to interruption of the neural pathway. This may be demonstrated by indirect ophthalmoscopic perimetry.
- Patients are almost never myopic and usually hypermetropic.
- The laser uptake test is now rarely performed.
- Optical coherence tomography.

Figure 14.2 Diagnosis of retinoschisis



Indirect ophthalmoscopic perimetry. The indenter is held in front of the condensing lens so that its shadow falls on the area of retinal elevation. The patient is asked whether they can see a hammer. Failure to see this indicates an absolute scotoma.

Interactive 14.1 The appearance of retinoschisis



Retinal detachment and retinoschisis

Retinoschisis rarely leads to visual problems. One of the retinoschisis patients in the Copenhagen Eye Study developed a retinal detachment. This eye had undergone cataract surgery so the retinoschisis may have been incidental.

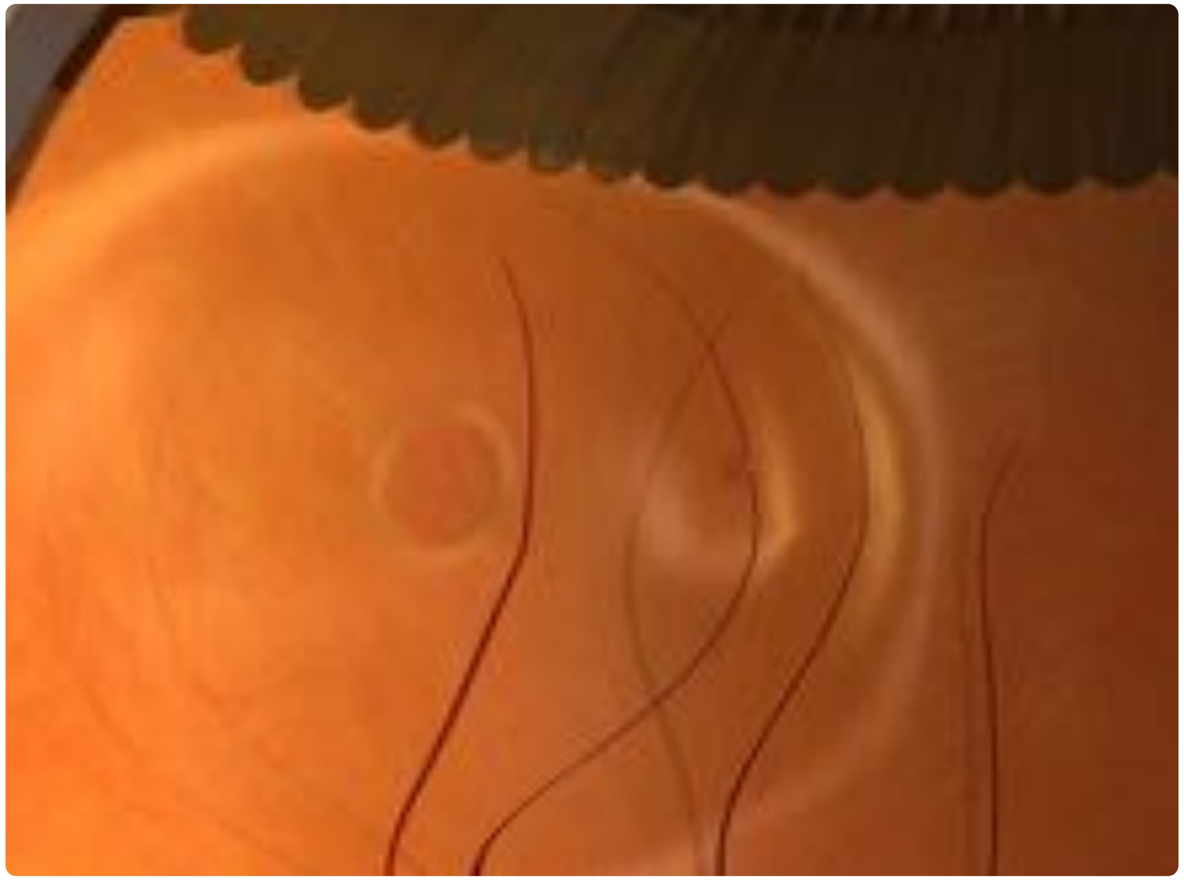
In Norman Byer's long term follow up of 123 individuals there were no cases of progressive retinal detachment requiring treatment although 12 patients had limited progression.

Macular involvement in retinoschisis is exceptionally rare unless a retinal detachment develops.

There are 2 patterns of retinal detachment in retinoschisis, depending on whether breaks are in the inner or outer leaves in both leaves of the schisis.

Outer leaf breaks tend to be large with opaque rolled edges. Inner leaf breaks are often very small and difficult to localize.

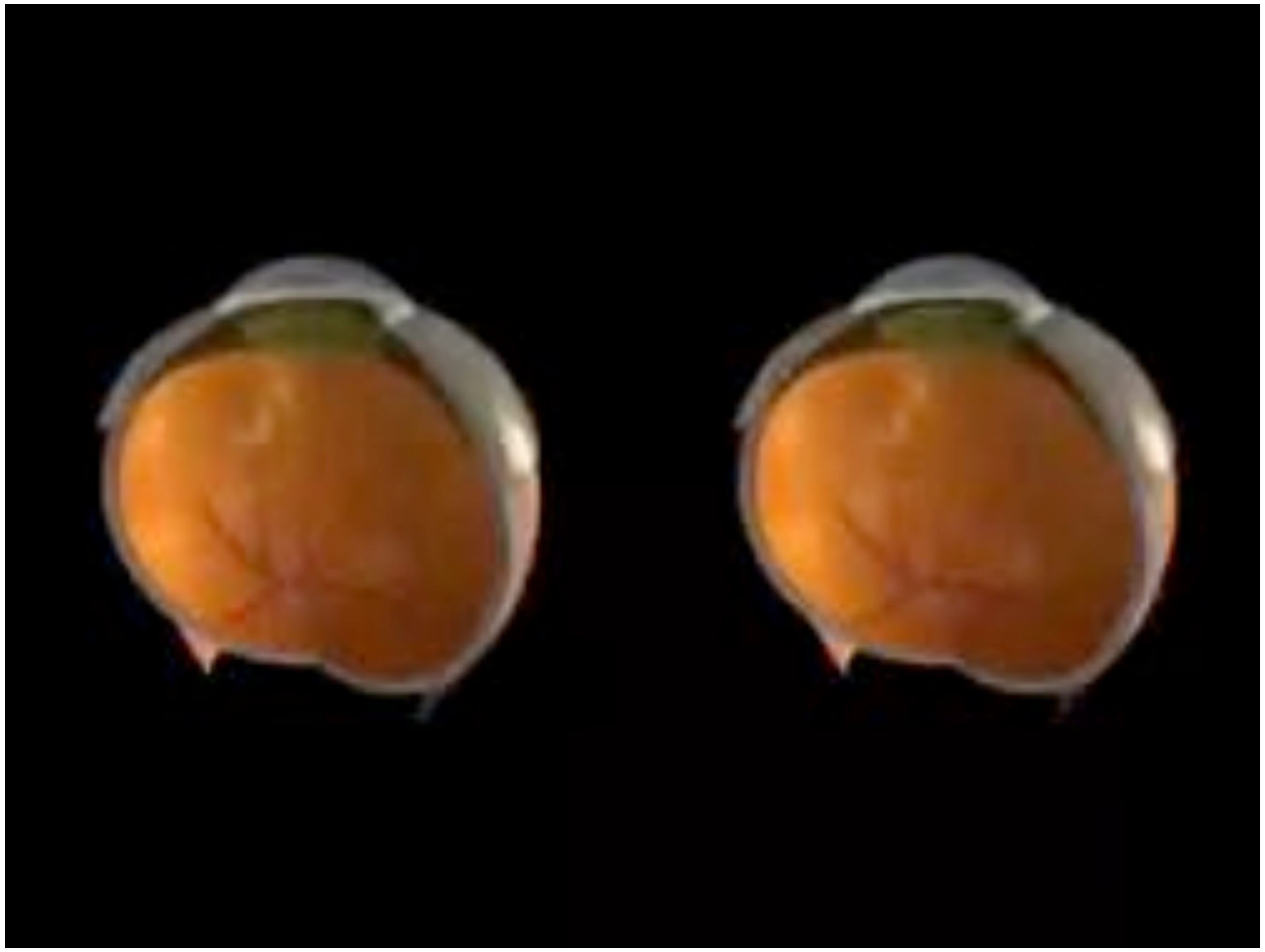
Figure 14.3 Breaks in retinoschisis



Outer leaf breaks tend to be large with rolled edges. Holes in the inner leaf are usually very small. Because the inner leaf is very thin they may be hard to see.

In non progressive 'schisis detachments' the development of an outer leaf break allows the hyaluronic acid in the schisis cavity to move to the subretinal space. Although this results in a retinal detachment this is typically limited and non progressive. Eventually the hyaluronic acid may be cleared from the subretinal space leaving an attached retina. There may some associated RPE hypertrophy due to the transient retinal detachment.

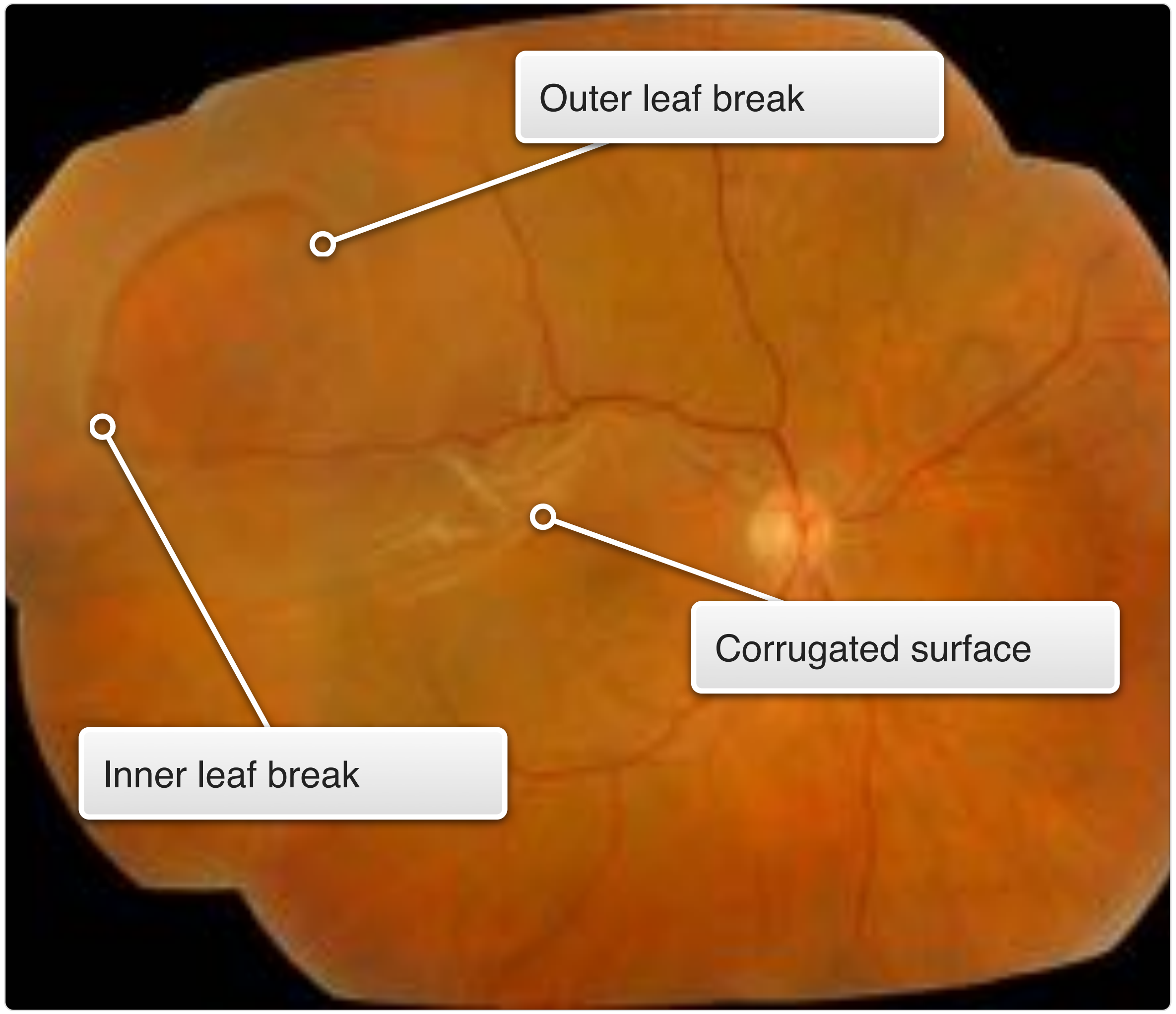
Movie 14.2 Evolution of schisis detachment (stereo)



There is a break in the outer leaf only. Redistribution of the hyaluronic acid in the schisis cavity to the subretinal space creates a localized non progressive retinal detachment. In time this may resolve leaving RPE changes which are not a feature of uncomplicated retino-schisis.

If holes are present in both inner and outer leaves of the schisis a progressive retinal detachment may develop as there is a channel from the preretinal to the subretinal space. Patients usually present with symptoms of a progressive scotoma, which is not seen in uncomplicated retinoschisis.

Interactive 14.2 Features of a progressive rhegmatogenous retinal detachment due to retinoschisis.



Management

No treatment is indicated for retinoschisis because:

- Progression to visual loss is rare.
- Retinopexy is ineffective in preventing extension of the schisis cavity.
- Retinopexy may cause outer leaf breaks and retinal detachment.

Prophylactic treatment of retinoschisis with outer leaf breaks and asymptomatic schisis-detachments is unnecessary for similar reasons.

Surgical intervention is indicated for progressive schisis-detachments.

Buckling surgery is possible where the outer leaf break is peripheral. Usually it is quite posterior however and a vitrectomy is technically easier. The most commonly performed technique is vitrectomy (with detachment of the posterior hyaloid if necessary) followed by internal drainage through the inner leaf break (this may be enlarged or a retinotomy created) followed by endolaser under air. The subretinal fluid may be very viscous and as much subretinal fluid as possible is drained under fluid (fluid-fluid exchange) before switching to air. Laser is performed to both the inner and outer leaf breaks. It is usually unnecessary to excise the whole inner leaf of the schisis cavity in uncomplicated cases. A short acting gas usually gives adequate tamponade.

Movie 14.3 Management of progressive retinal detachment due to retinoschisis

Retinoschisis detachments with PVR have a poor prognosis. Star folds are difficult to peel from the thin inner leaf without causing breaks. A large inner leaf retinectomy is therefore usually required with silicone oil tamponade.

Figure 14.4 Retinoschisis with PVR

Knowledge review

Review 14.1 Pathology

Which of the following is NOT typically associated with retinoschisis

- A. Optic disc pit maculopathy.
- B. Central serous retinopathy. ✓
- C. Myopic foveoschisis.
- D. Advanced proliferative diabetic retinopathy

Check Answer

Review 14.2 Clinical assessment

Question 1 of 2

Which of the following features is LEAST consistent with the diagnosis of retinoschisis:

- A. High myopia ✓
- B. A beaten metal appearance on the inner surface.
- C. Bilateral lesions in the inferotemporal quadrant.
- D. A visible reaction to gentle retinal photocoagulation.

Check Answer

Review 14.3 Retinal detachment due to retinoschisis

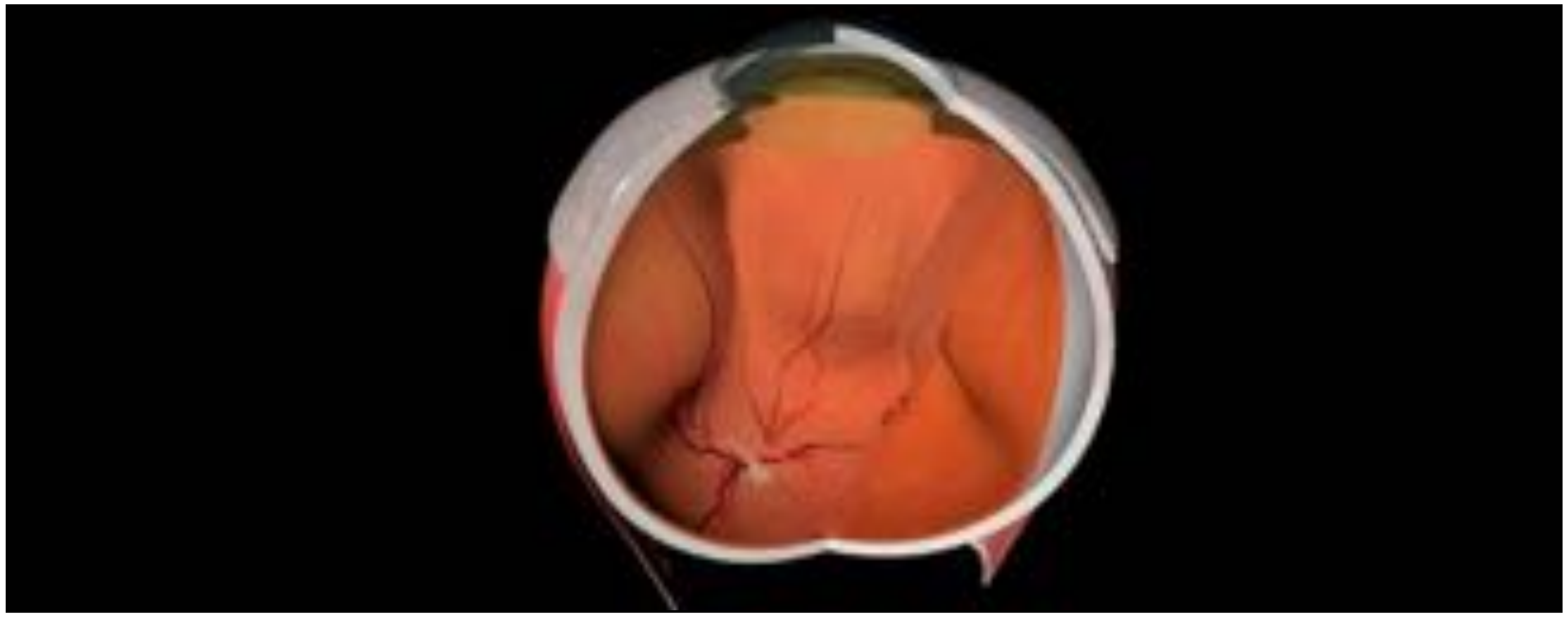
Which of the following is true:

- **A.** An asymptomatic retinoschisis with outer leaf breaks has a high chance of progressing to involve the macula.
- **B.** A retinoschisis with outer leaf breaks may develop a self limiting schisis detachment.
- **C.** Outer leaf breaks are typically smaller than inner leaf breaks.
- **D.** No adverse affects have been described following prophylactic laser to retinoschisis.

Check Answer

CHAPTER 15

Differential diagnosis of retinal detachment



Non rhegmatogenous retinal detachments are sometimes misdiagnosed as rhegmatogenous detachments and subjected to inappropriate surgery. The possibility that a detachment is not rhegmatogenous should be considered whenever atypical features are present or no retinal breaks can be seen.

Overview

Non rhegmatogenous detachments may arise as a result of fluid accumulation under the retina or traction.

In exudative retinal detachments the subretinal fluid has a high concentration of protein. This may cause visible exudation under the retina. Because the subretinal fluid is denser than vitreous the distribution of fluid is affected by posture. Typically inferior bullae are present when the patient is upright which move posteriorly when the patient lies supine (shifting subretinal fluid).

There are many causes of exudative detachment including:

TUMORS:

- Choroidal melanoma
- Intraocular lymphoma
- Choroidal hemangioma
- Choroidal metastases

VASCULAR LESIONS:

- Neovascular age related macular degeneration
- Idiopathic polypoidal choroidal vasculopathy
- Central serous retinopathy
- Uveal effusion syndrome
- Coats disease
- Retinal telangectasia
- Severe hypertension
- Optic disc pit maculopathy
- Retinal angiomas

INFLAMMATION

- Vogt-Koyanagi-Harada syndrome
- Posterior scleritis
- Post surgical exudative detachment

In tractional retinal detachments the profile of the elevation is concave. In adults the diagnosis is usually straightforward but may be less so in children where delayed diagnosis often results in rhegmatogenous detachments presenting with advanced cicatricial changes.

Common causes of tractional retinal detachment include:

<u>FIBROVASCULAR PROLIFERATION</u>

- Proliferative diabetic retinopathy
- Retinal venous occlusion
- Retinal vasculitis
- Retinopathy of prematurity
- Familial exudative vitreoretinopathy

<u>PENETRATING OCULAR TRAUMA</u>

A comprehensive account of all the conditions that may cause non rhegmatogenous non rhegmatogenous retinal detachment is beyond the scope of this book. This section contains some interactive case histories which will illustrate some of the scenarios encountered in clinical practice. The patients were referred to an emergency retina clinic for urgent surgery to repair retinal detachment.

CASE 1

An 18 year old male presented with a history of sudden visual loss in the left eye. The left eye has only had partial vision since a trabeculectomy at the age of 8 which was complicated by intraocular hemorrhage.

He had a facial port wine stain in the left frontal and maxillary area.

He had a history of greenstick fracture following a fall at the age of 6 but no other health problem.

On examination his visual acuity was 20/20 right and 20/200 left.

He has an inferior retinal detachment in the left eye with subretinal fluid extending to the edge of the macula. The fluid shifted posteriorly when he lay down.

Investigations are as shown in the accompanying figure.

What is the most likely diagnosis?

Gallery 15.1 Case 1

The fundal appearance.

Review 15.1 Case 1

The most likely diagnosis is

- **A.** Nanophthalmic choroidal effusion syndrome.
- **B.** Choroidal hemangioma. ✓
- **C.** Choroidal osteoma.
- **D.** Atypical central serous retinopathy.
- **E.** Posterior scleritis.
- **F.** Over-draining trabeculectomy bleb with suprachoroidal hemorrhage.

Check Answer

CASE 1

This was a case of choroidal hemangioma secondary to Sturge-Weber syndrome. Surgery in these cases should be avoided and they should be referred to an ocular oncologist for photodynamic therapy or radiotherapy.

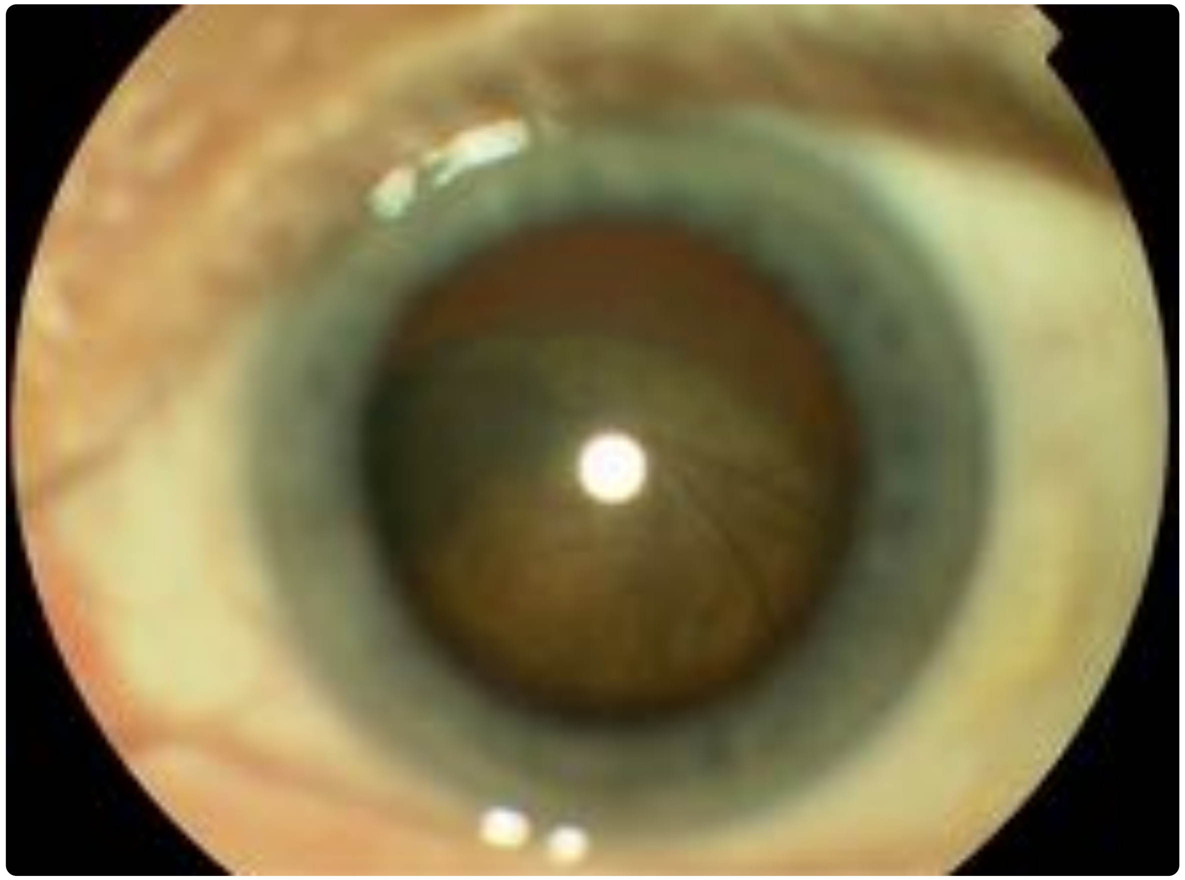
Gallery 15.2 Case 1

The fundal appearance. The shifting fluid suggests a non rhegmatogenous detachment.

CASE 2.

This patient presented with a large area of retinal elevation.

Gallery 15.3 Case 2 findings



The slit lamp view.

Review 15.2 Case 2

The most likely diagnosis is

- **A.** Choroidal metastasis.
- **B.** Ocular lymphoma.
- **C.** Amelanotic melanoma.
- **D.** Choroidal osteoma.

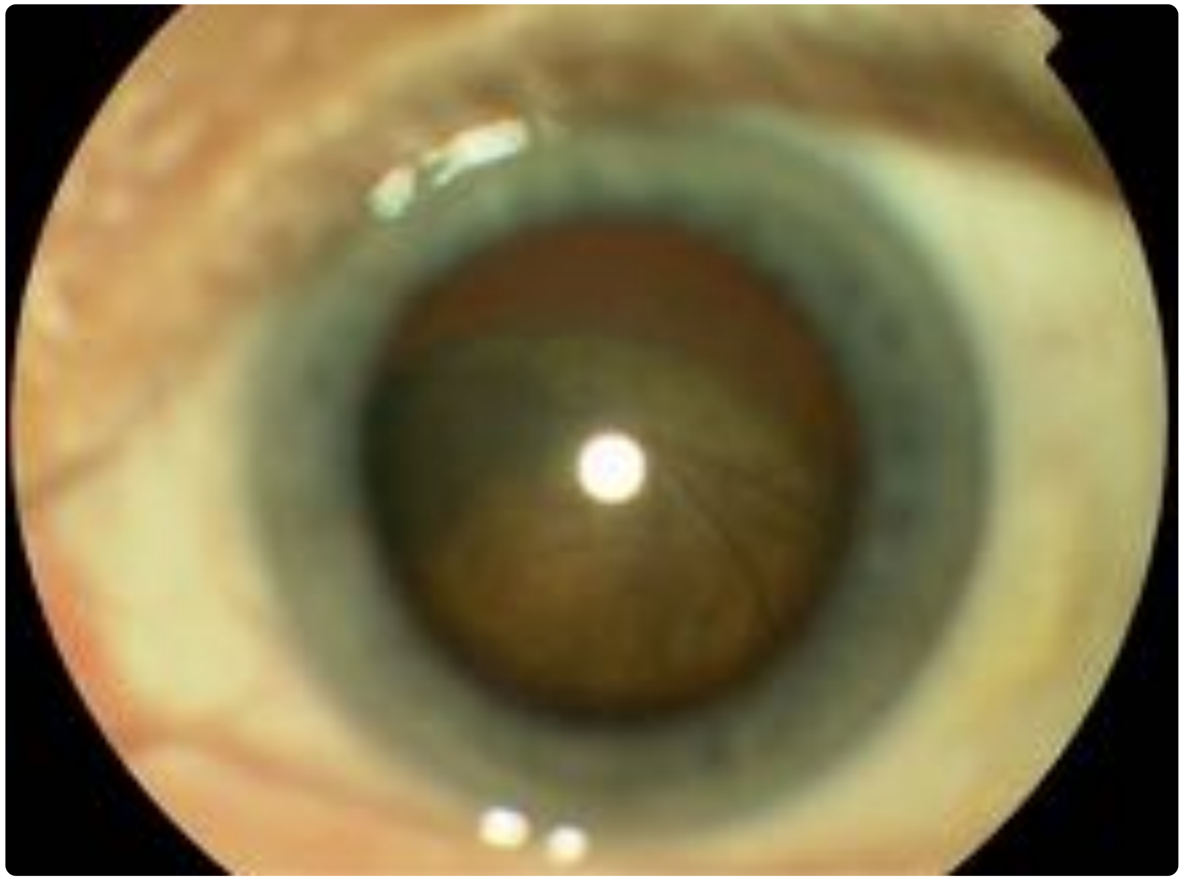
Check Answer

CASE 2.

This was an amelanotic choroidal melanoma.

Choroidal tumors may cause exudation. The subretinal fluid may mask the tumor. A high index of suspicion is required in any case with no visible retinal break and a negative Schaffer's sign. Even if the subretinal fluid does not appear to shift, unless the whole choroid can be clearly seen these patients should undergo B-scan ultrasound.

Gallery 15.4 Case 2 findings



The slit lamp view. The elevation looks solid. Detachments due to tumors sometimes have much more subretinal fluid than this.

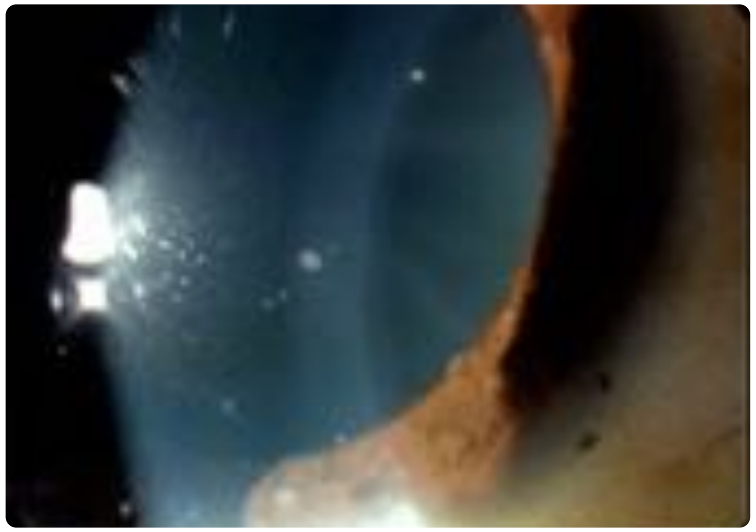
CASE 3

A 39 year old Asian female presented with loss of vision in her both eyes. She also complained of tinnitus and headache. She had no history of eye problems or ocular pain.

On examination the visual acuity was 20/100 right and 20/80 left. The intraocular pressure was 20 mmHg in both eyes.

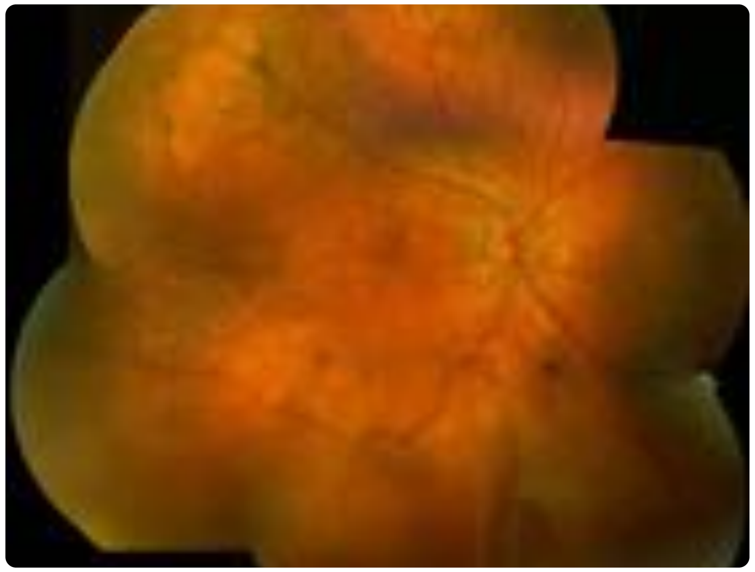
What is the diagnosis?

Gallery 15.6 The anterior segments



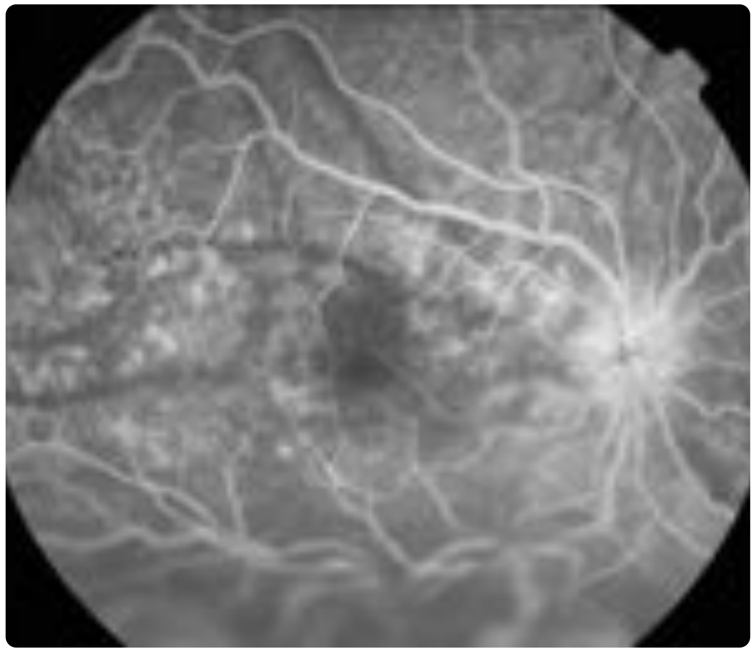
The right anterior segment.

Gallery 15.8 Fundal appearance



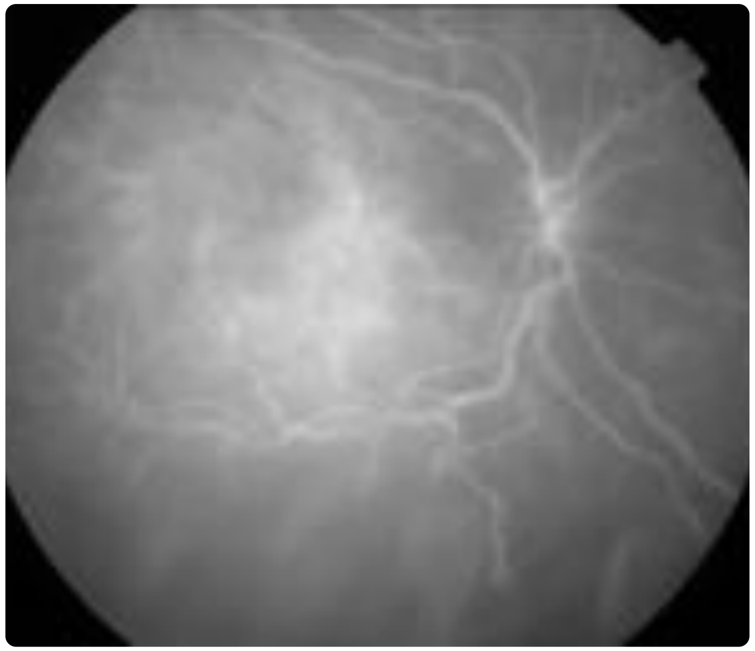
Right eye.

Gallery 15.5 The fluorescein angiogram



The fluorescein angiogram at 23 seconds.

Gallery 15.7 The indocyanine green angiogram



25 seconds.

Review 15.3 Case 3

The most likely diagnosis is

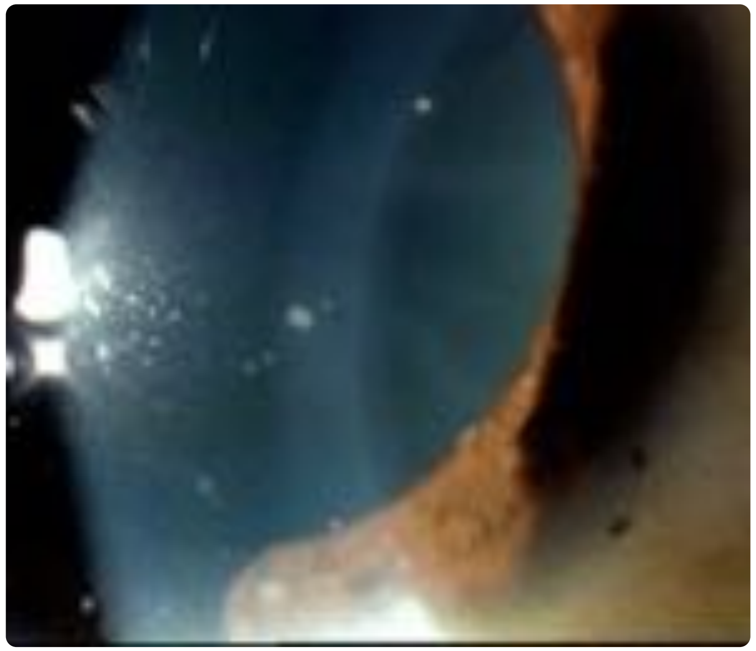
- **A.** Tuberculous choroiditis.
- **B.** Vogt–Koyanagi–Harada syndrome. ✓
- **C.** Ocular lymphoma.
- **D.** Sarcoidosis.
- **E.** Sympathetic ophthalmia.
- **F.** Posterior scleritis.

Check Answer

CASE 3

This was a case of Vogt–Koyanagi–Harada syndrome (VKH syndrome). This case highlights the importance of careful anterior segment examination in any atypical detachment to exclude intraocular inflammation.

Gallery 15.9 Findings



Granulomatous uveitis was present.

CASE 4

An 8 year old boy was referred with poor vision noted at a school eye test. He was otherwise fit and well. He was born 4 weeks prematurely and weighed 3.5 kg (7.5 pounds).

He has a maternal uncle with poor vision.

On examination his visual acuity was 20/80 right and 20/400 left.

Gallery 15.10 Case 4

The fundal appearance.

Review 15.4 Case 4

The most likely diagnosis is:

- **A.** Norrie's disease.
- **B.** Bilateral retinal dialysis with secondary chronic detachments.
- **C.** Familial exudative vitreoretinopathy.
- **D.** X linked retinoschisis. ✓
- **E.** Goldmann-Favre syndrome (enhanced S-cone syndrome)
- **F.** Retinopathy of prematurity.

Check Answer

CASE 4

The clinical diagnosis is X-linked retinoschisis. Gene sequencing confirmed a mutation in the RS-1 gene which encodes the protein retinoschisin. This is quite a common condition and the average vitreoretinal surgeon will make the diagnosis several times in his career.

Gallery 15.11 Case 4

The fundal appearance. Areas of peripheral retinoschisis are present and there was an inferior retinal detachment in the left eye. The split in XLRS is in the inner retina, like the reticular form of degenerative retinoschisis, so these patients often develop progressive retinal detachments.

CASE 5

An 88 year old male presented with a 2 week history of visual loss in his right eye.

He was hypermetropic and had patching to his left eye as a child.

He was taking a beta-blocker for mild hypertension and was a diet controlled diabetic.

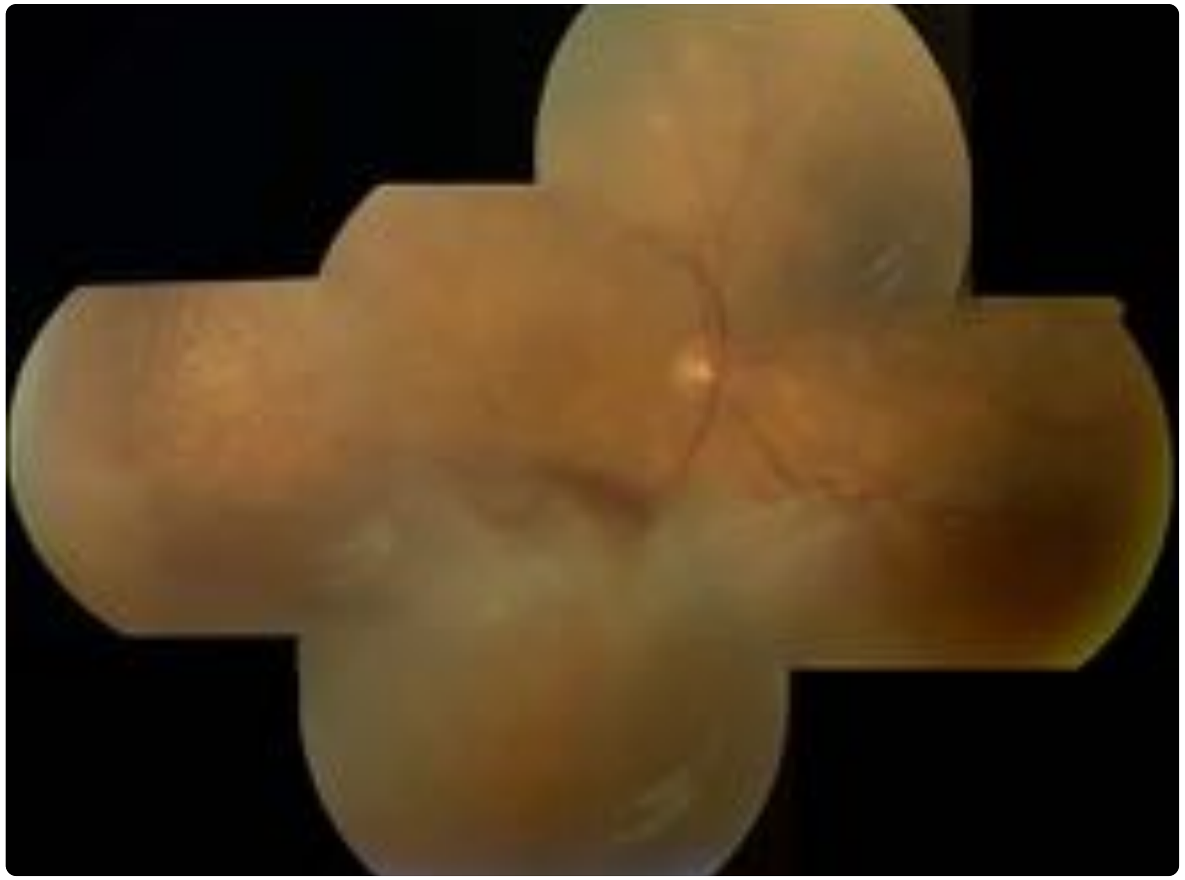
The visual acuity was 20/200 right and 20/100 left.

The intraocular pressure was 24 mmHg in both eyes.

Movie 15.1 Case 5

The appearance of the right vitreous.

Gallery 15.12 Case 5



The right fundus.

Review 15.5 Case 5

The most likely diagnosis is

- **A.** Pars planitis with retinal detachment.
- **B.** Retinal dialysis and Schwartz syndrome.
- ✓ **C.** Ocular lymphoma.
- **D.** Bullous central serous retinopathy.
- **E.** Uveal effusion syndrome
- **F.** Idiopathic polypoidal choroidal vasculopathy,

Check Answer

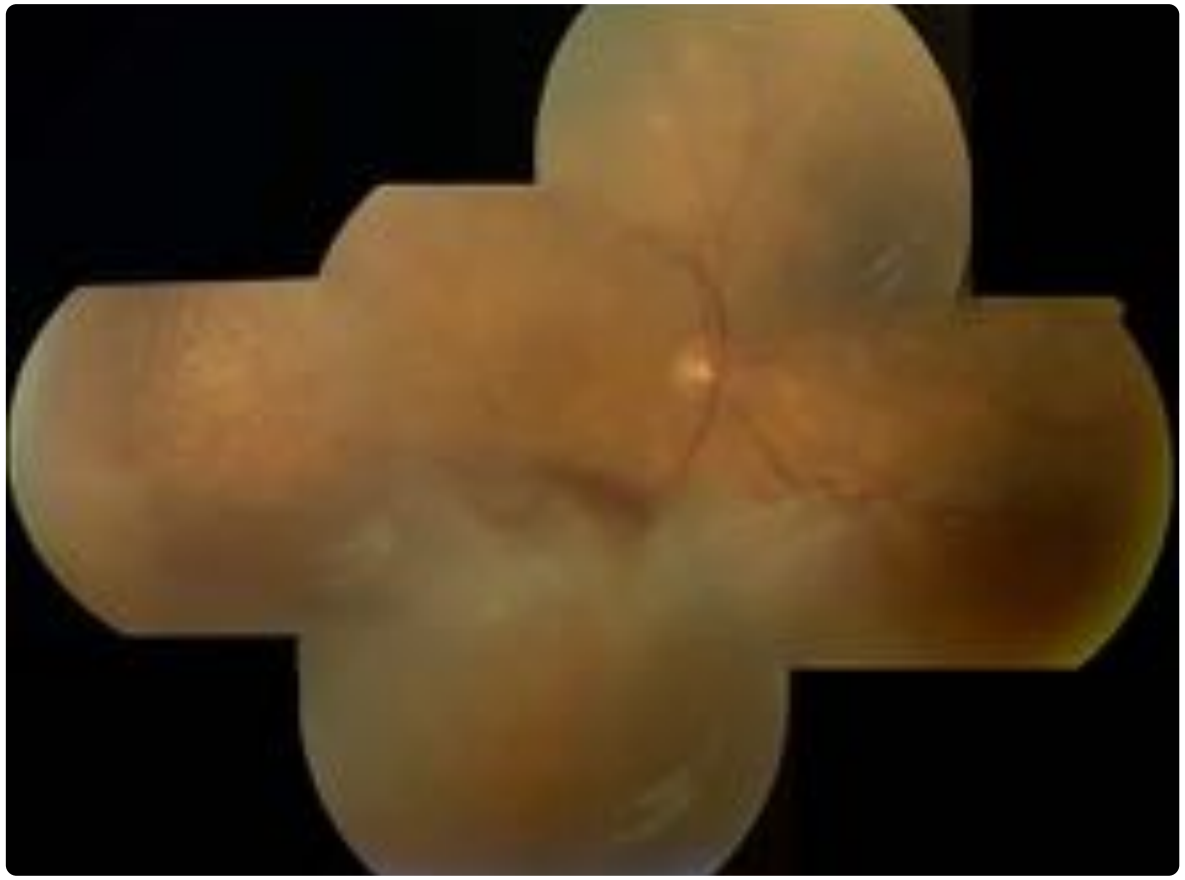
CASE 5

Vitreous biopsy confirmed the diagnosis of B cell lymphoma.

Movie 15.2 Case 5

The appearance of the right vitreous. The clusters of cells are variable in size, some small and some quite large. The variability in size is one of the pathognomic features of this condition.

Gallery 15.13 Case 5



The right fundus.

CASE 6

A 4 year old female was referred with a left esotropia.

She had multiple dental problems but was otherwise fit and well. She had been adopted at age 3 months and no details of her biological mother or father were available.

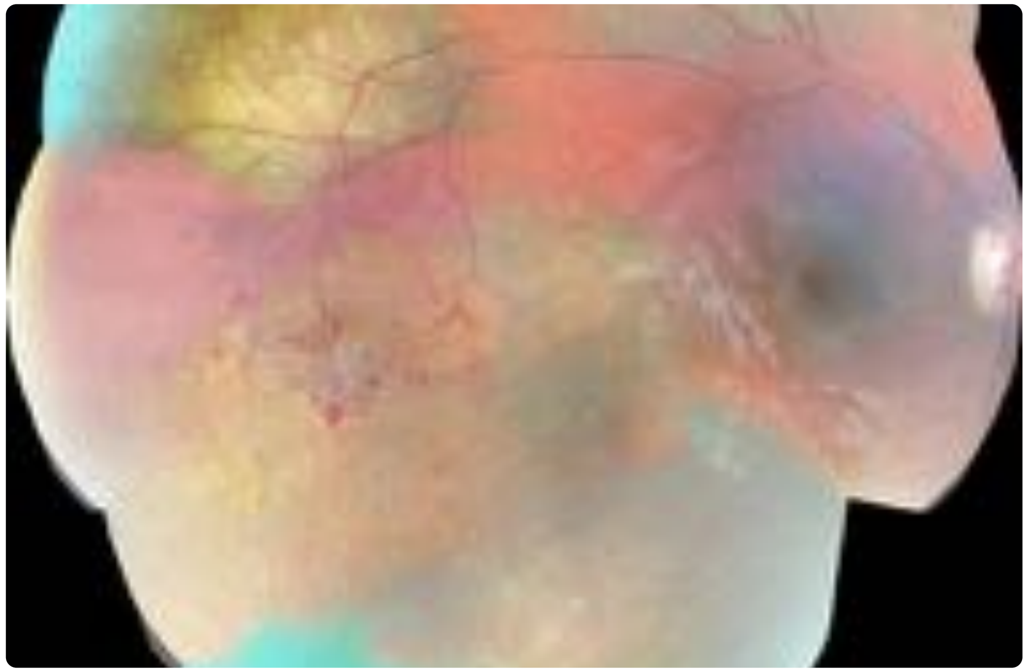
She was found to have vision of 20/20 in the right eye and bare perception of light in the left eye.

She was unable to cooperate sufficiently to allow fundal examination. B scan ultrasound suggested the presence of a total retinal detachment in the left eye.

She then underwent examination under anesthesia. She was found to have rubeosis and a total retinal detachment in her left eye.

The findings in the right eye are shown.

Gallery 15.14 Case 6



Montage of retcam images of the right eye.

Review 15.6 Case 6

The most likely diagnosis is

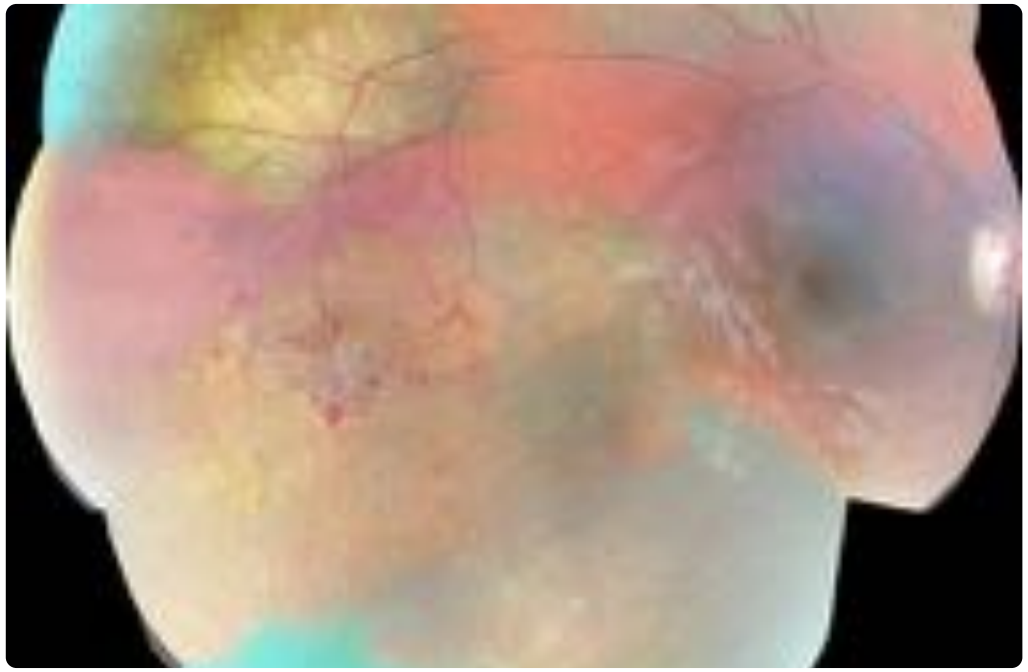
- [x] **A.** Incontentia pigmentii.
- [ ] **B.** Old retinopathy of prematurity.
- [ ] **C.** Dominant exudative vitreoretinopathy.
- [ ] **D.** Toxocara.
- [ ] **E.** Non accidental injury.
- [ ] **F.** Coats disease.

Check Answer

CASE 6

This is incontinentia pigmentii. This case illustrates the importance, when assessing children with retinal lesions, of careful assessment of the fellow (apparently normal) eye as well as the value of examination under anesthesia in uncooperative children. A proper systemic examination should also be performed. Many peripheral retinal conditions in children have associated systemic features.

Gallery 15.15 Case 6



Montage of retcam images of the right eye.

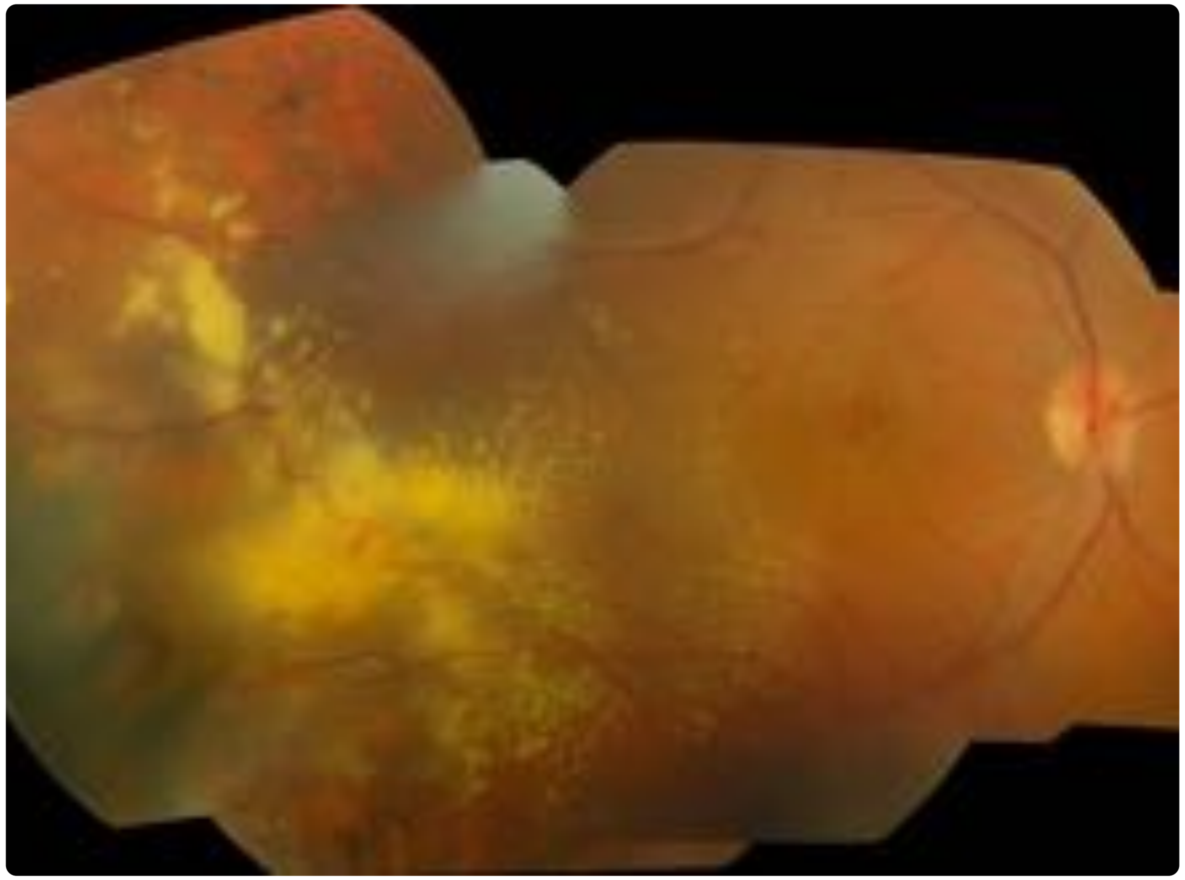
CASE 7

A 60 year old female was referred after her optician noted poor vision and a fundal abnormality in the right eye. She had not noticed the loss of vision. She had a history of depression for which she was taking prozac and had undergone hysterectomy 5 years previously but was otherwise fit and well. She was presbyopic and had worn reading glasses for 10 years but had no previous eye problems. Her last spectacle review had been several years previously and was apparently normal.

On examination her visual acuity was 20/100 in the right eye and 20/20 in the left eye. Examination of the anterior segments was unremarkable and her intraocular pressure was normal in both eyes.

The left fundus was completely normal.

Gallery 15.16 Case 7



The fundal view

Review 15.7 Case 7

The most likely diagnosis is

- ○ **A.** Chronic rhegmatogenous retinal detachment with secondary retinal neovascularisation.
- ○ **B.** Retinoschisis with secondary retinal neovascularisation.
- ✓ **C.** Adult onset Coats disease / acquired vasoproliferative tumor.
- ○ **D.** Old retinal vein occlusion with secondary retinal detachment.
- ○ **E.** Retinal angioma due to Von Hippel disease.
- ○ **F.** Idiopathic polypoidal choroidal vasculopathy.

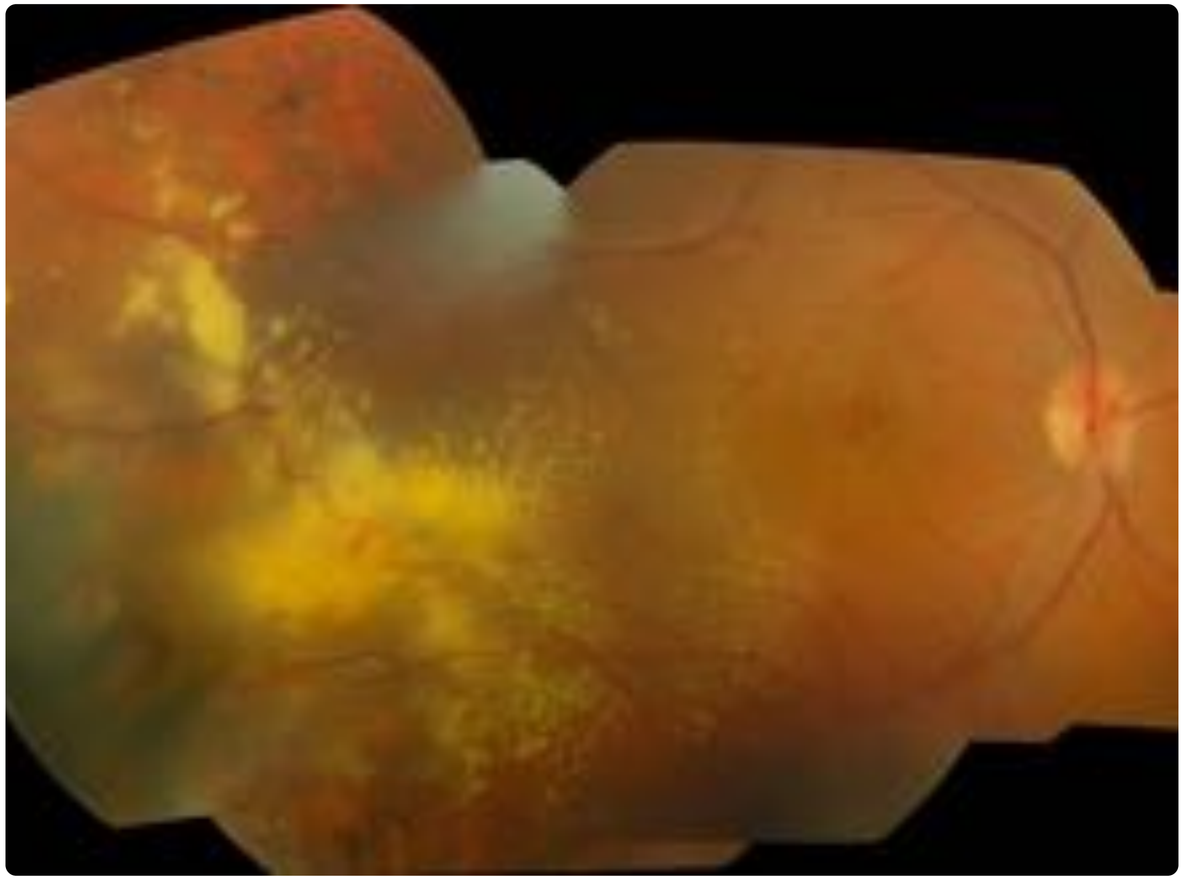
Check Answer

CASE 7

The diagnosis was adult onset Coats disease / acquired vasoproliferative tumor.

The combination of retinal telangectasia and subretinal exudation is characteristic of the condition.

Gallery 15.17 Case 7



The fundal view. Retinal telangectasia and subretinal exudation is present.

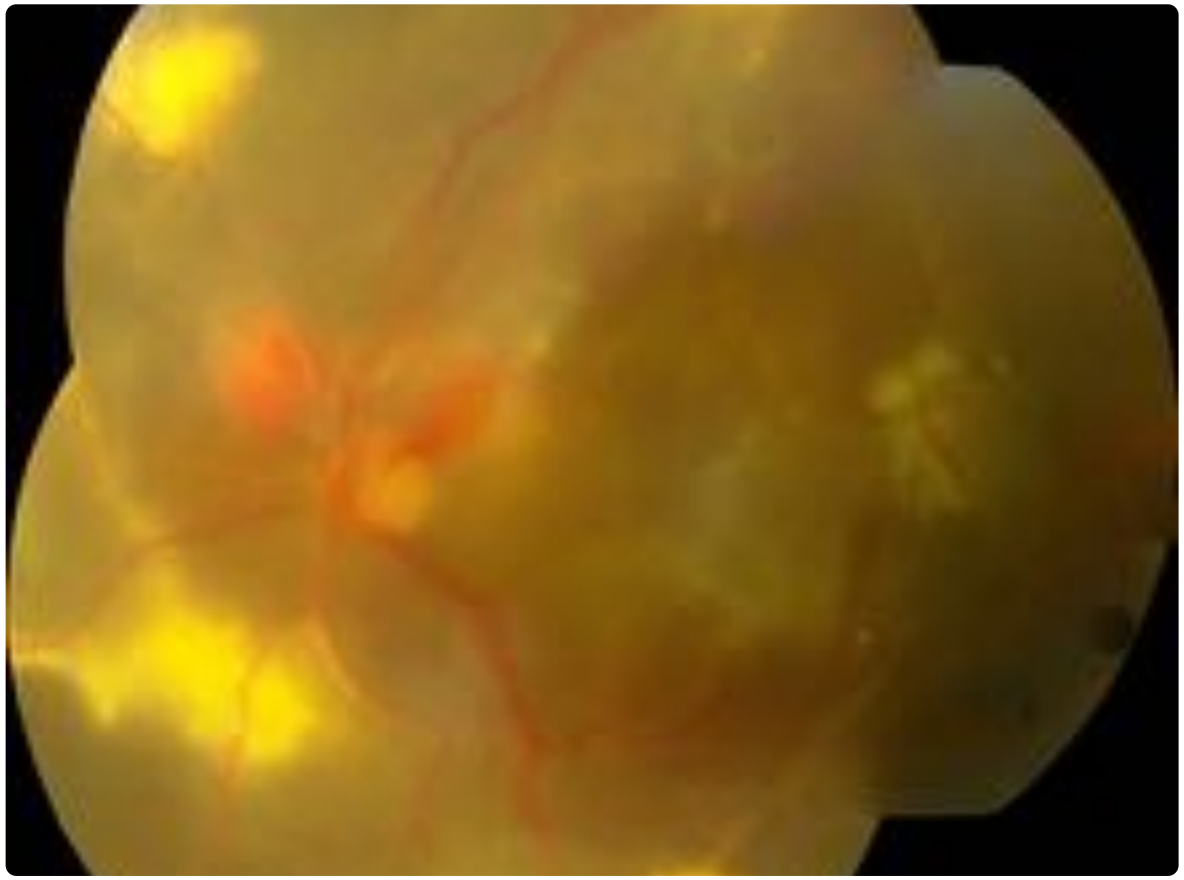
CASE 8

A 21 year old male was referred by a neurologist, who was managing his epilepsy, who noticed poor vision in the left eye. The patient had been unaware of this. He was under investigation for epilepsy. His mother had died of at the age of 40. He was unaware of the cause of her death but recalled that she had undergone abdominal surgery a year before her death. He was otherwise fit and well.

On examination the visual acuity was 20/20 in the right eye and perception of light in the left eye.

The anterior segments and intraocular pressures were normal.

Gallery 15.18 Case 8



The left retina

Review 15.8 Case 8

Which is the most likely diagnosis

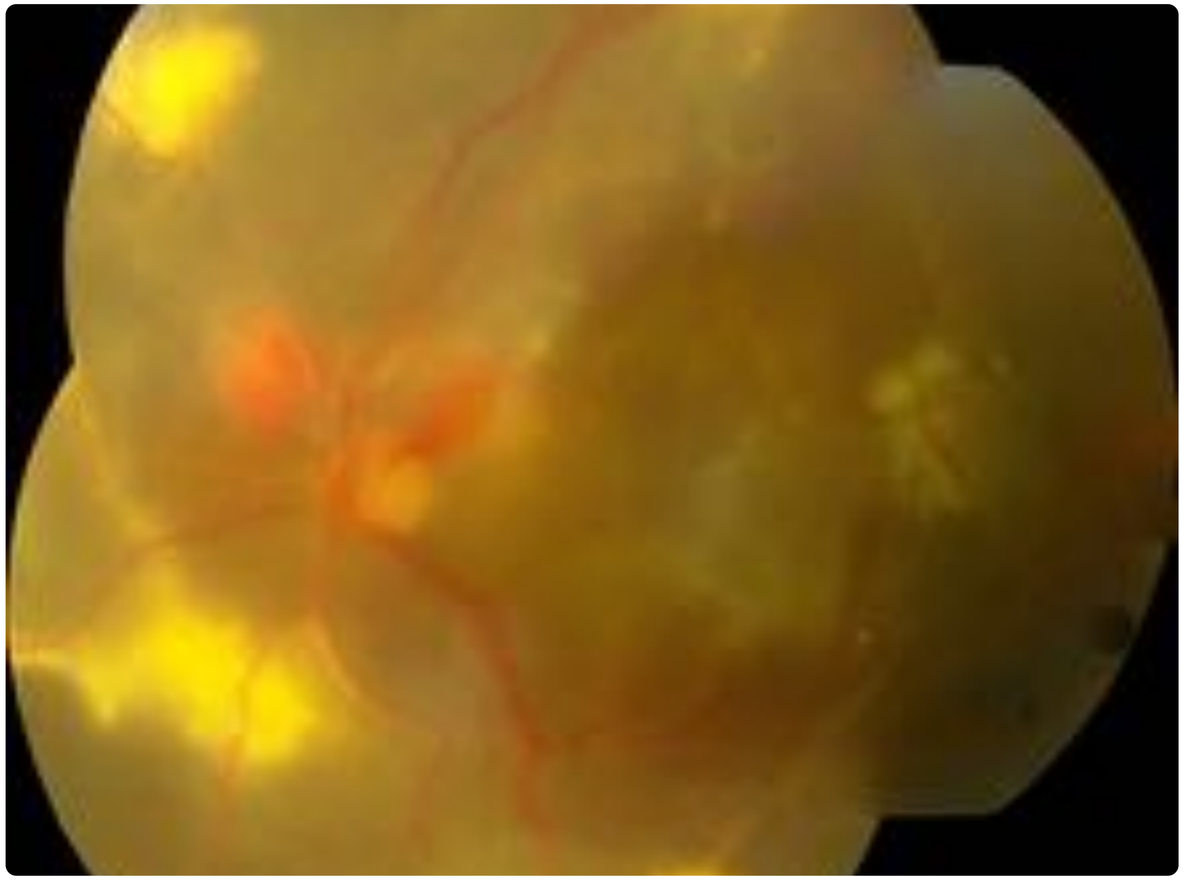
- **A.** Coats disease.
- **B.** Retinal capillary hemangioma
- **C.** Leiden mutation causing bilateral retinal venous occlusion.
- **D.** Retinal macroaneurysm.
- **E.** Familial exudative vitreoretinopathy.
- **F.** Retinal vasoproliferative tumor.

Check Answer

CASE 8

This is a case of Von-Hippel-Lindau disease with multiple retinal capillary hemangiomas in both eyes.The dilated feeder vessels distinguish the capillary hemangiomas from other peripheral retinal dilated lesions such as acquired vasoproliferative tumors. The ophthalmologist has an important role in the diagnosis of this life threatening condition.

Gallery 15.19 Case 8



The left retina is totally detached with large peripapillary hemangioma.

CASE 9

A 10 year old girl was referred by her optometrist for visual loss of uncertain duration. She was otherwise fit and well. This was her first visit to an optometrist and she had not noticed the loss of vision. She was emmetropic. She had a normal birth at full term with no neonatal problems.

A paternal uncle had been diagnosed with a lazy eye many years earlier.

The visual acuity was perception of hand movements in the right eye and 20/20 in the left eye.

The anterior segments and intraocular pressures were normal.

The parents were examined and a fundal abnormality found in her father.

Gallery 15.20 Case 9

The right retina.

Review 15.9 Case 9

The most likely diagnosis is

- **A.** Familial exudative vitreoretinopathy.
- **B.** Retinopathy of prematurity.
- **C.** Norries disease.
- **D.** Stickler syndrome.

Check Answer

CASE 9

This was a case of familial exudative vitreoretinopathy. This case illustrates the value of careful examination of the parents' retinas in any child with peripheral retinal vascular lesion. It emphasizes the importance of careful assessment of the fellow eye, under general anesthesia if necessary. The examination under anesthesia should include examination of the anterior segment with an operating microscope and 360^0 indented indirect ophthalmoscopic search and may include fluorescein angiography. If a retcam is unavailable for this indirect fluoroscopy may be performed. This should be performed with an endotracheal tube in place to protect the airway in case of vomiting following the fluorescein injection.

Gallery 15.21 Case 9

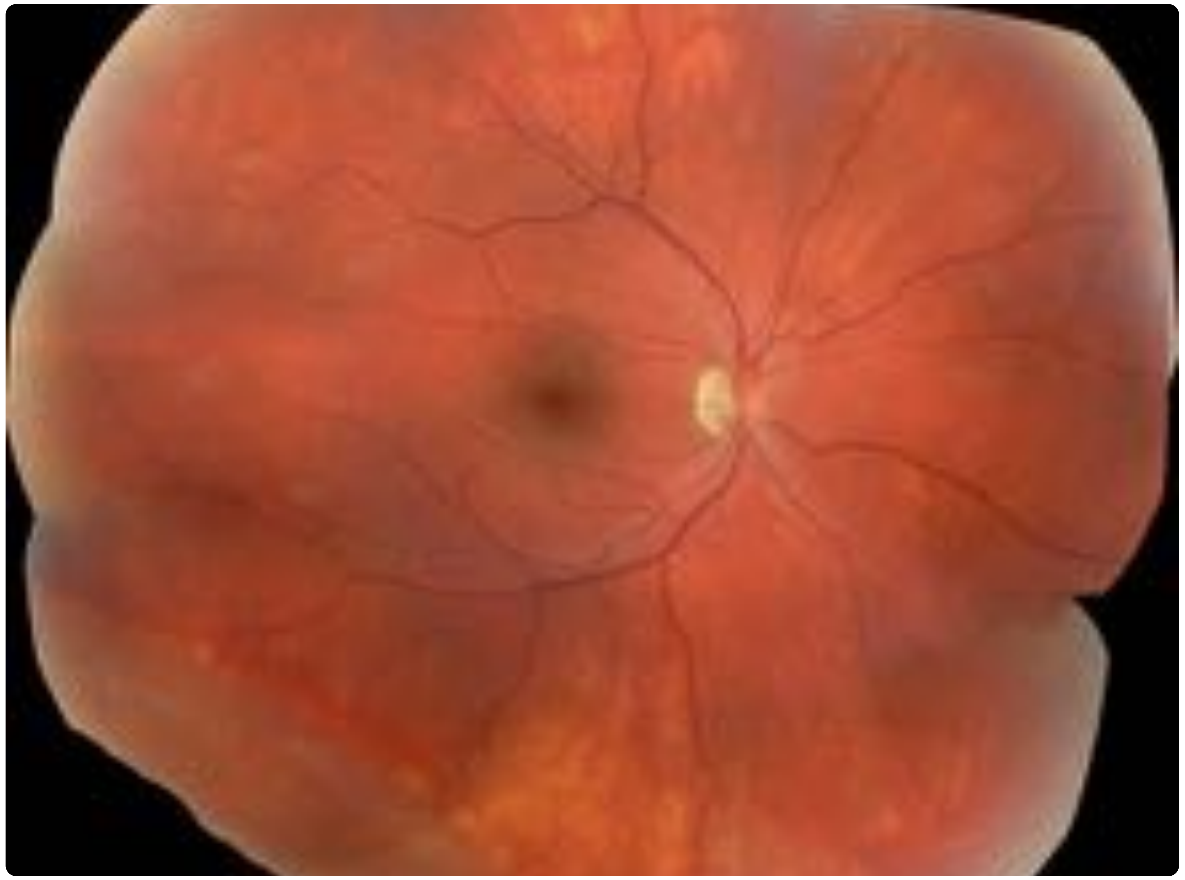
The right retina.

CASE 10

This 35 year old boxer was referred to the uveitis service with refractory glaucoma and an inferior retinal detachment. The referral letter stated that he had originally presented with visual obscurations in his right eye and an intraocular pressure of 50 mmHg. The iridocorneal angle was open. Cells were present in the anterior chamber and anterior vitreous but no keratic precipitates. The only abnormality on B scan ultrasound was the retinal detachment. There was no choroidal detachment. He had been managed with medical intraocular pressure lowering agents and systemic immunosuppression. He had no previous ophthalmic problems apart from mild (1 Dioptre) hypermetropia.

He was very intolerant of indentation in either eye. The fellow eye was completely normal as far as could be seen. The right eye at initial presentation is shown.

Gallery 15.22 Case 10



The right fundus. This was taken from another patient with the same condition.

Review 15.10 Case 10

The most likely diagnosis is:

- **A.** Ghost cell glaucoma.
- **B.** Schwartz-Matsuo syndrome. ✓
- **C.** Uveal effusion syndrome.
- **D.** Nanophthalmic uveal effusion.
- **E.** Posner-Schlossman Syndrome.

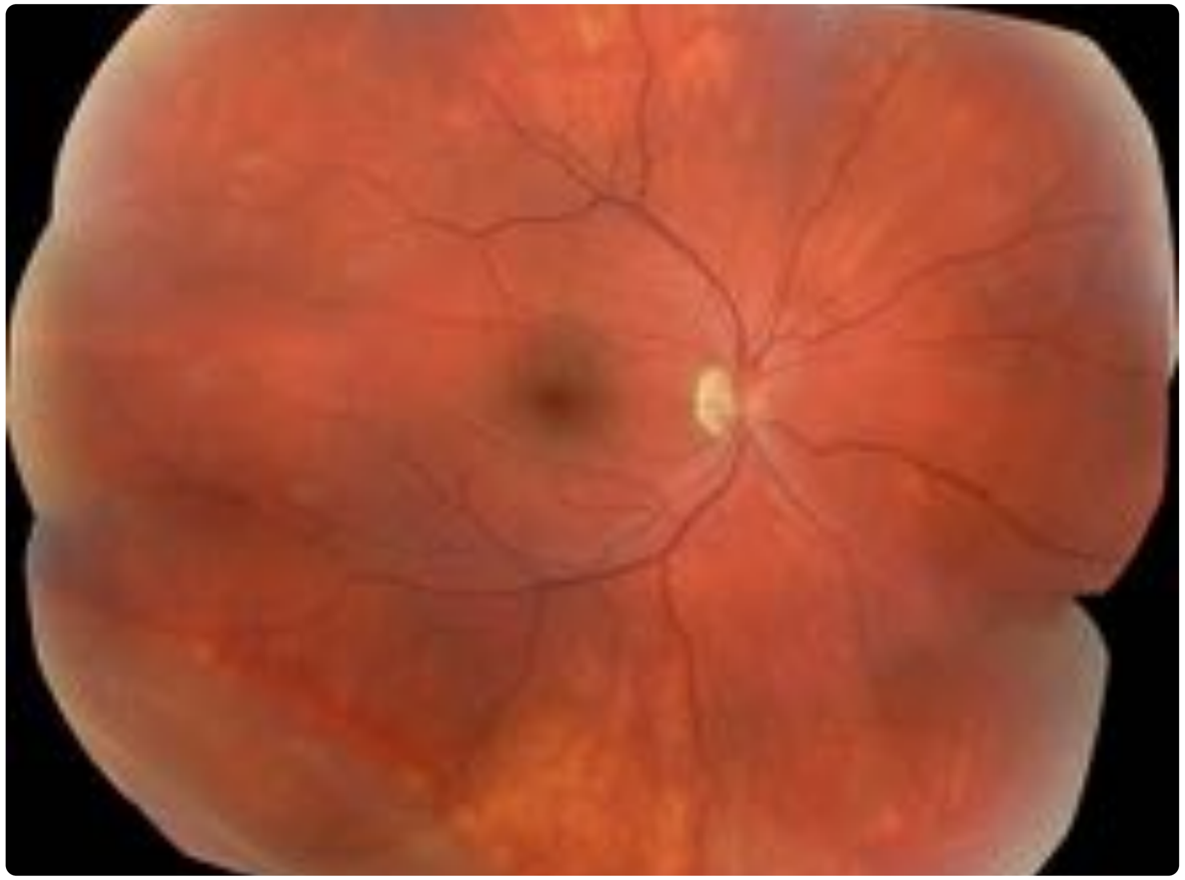
Check Answer

CASE 10

This is Schwartz-Matsuo syndrome. There was a peripheral retinal dialysis on careful indented examination. This diagnosis is often delayed. This condition should be suspected in any case with retinal detachment and elevated intraocular pressure. Non rhegmatogenous detachments are not usually associated with such elevated intraocular pressure.

Although this is a rhegmatogenous retinal detachment it has been included in this section because it illustrates a possible error in the diagnosis of retinal detachment.

Gallery 15.23 Case 10



Careful indented examination revealed a retinal dialysis (not as obvious as the case shown here).

CASE 11

This 68 year old man was referred with a 2 year history of visual loss. He gave no history of ocular discomfort. He was a low (+2.5 Dioptre) hypermetrope with no other ophthalmic history. He had a past medical history of angina and atrial fibrillation. His regular medication was aspirin and a beta blocker. He had no family ophthalmic history of note.

His visual acuity was 20/200 in the right eye and 20/30 in the left eye.

His intraocular pressure was 20 mmHg in the right and 19 mmHg in the left eye.

Both anterior chambers were completely quiet with no cells or flare.

Gallery 15.24 Lorem Ipsum dolor amet, consectetur

The anterior segment.

Review 15.11 Case 11

What is the most likely diagnosis?

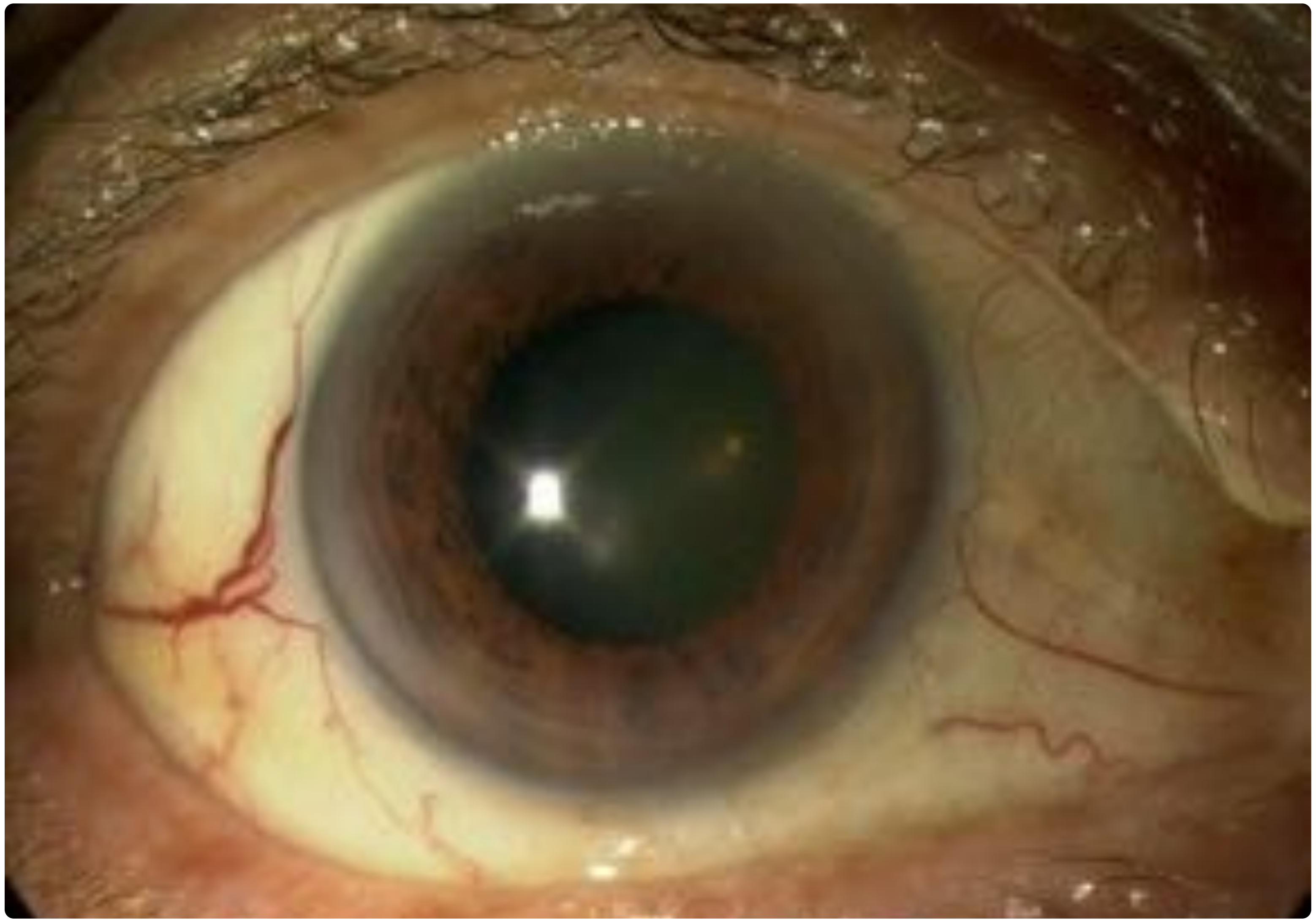
- **A.** Multifocal central serous retinopathy.
- **B.** Posterior scleritis.
- **C.** Uveal effusion syndrome. ✓
- **D.** Multifocal choroiditis.
- **E.** Choroidal folds.

Check Answer

CASE 11

This was a case of uveal effusion syndrome. This is largely a diagnosis of exclusion but the presence of choroidal detachments in a non inflamed eye with normal intraocular pressure is highly suggestive of the diagnosis. This paradoxical finding indicates that the pathogenesis of the condition is a disorder of trans-scleral diffusion of osmotically active proteins. Although often bilateral this is often sequential rather than simultaneous so the unilateral presentation does not exclude the diagnosis.

Gallery 15.25 Case 11 -



The anterior segment. Dilated episcleral veins are sometimes seen in this condition.

CASE 12

A 50 year old man presented with visual loss in both eyes for several months.

He had been diagnosed with ulcerative colitis a year previously and had developed severe sclerosing cholangitis. He had also suffered from several episodes of anterior uveitis. His gastrointestinal symptom had settled when he was started on high dose systemic steroids and the dose of these had been tapered to 20 mg/day prednisolone.

On examination his visual acuity was 20/200 right and 20/100 left.

The anterior chambers were quiet with no cells or keratic precipitates. The intraocular pressures were normal in both eyes.

Figure 15.1 Case 12

The right eye.

Review 15.12 Case 12

The most likely diagnosis is

- **A.** Retinal vasculitis.
- **B.** Central serous retinopathy ✓
- **C.** Multifocal choroiditis
- **D.** Toxoplasmosis
- **E.** Ocular lymphoma

Check Answer

CASE 12

This was a case of multifocal central serous retinopathy due to systemic steroid use.

Summary

In adults diagnostic confusion typically arises between rhegmatogenous and exudative detachments. The potentially disastrous consequences of diagnostic error may be avoided by approaching cases without a visible break or vitreous pigment with a high level of suspicion.

Exudative detachments in young children are rare. Presentation of rhegmatogenous detachment is often quite delayed so PVR is commonly established at presentation. The differential therefore usually lies between tractional detachments and long standing retinal detachments with PVR. A very careful history, examination of both eyes of family members and examination of both eyes under general anesthesia, with fluoroscopy or fluorescein angiography as required, help to make the correct diagnosis. The commonest vitreoretinal problems in children are regressed retinopathy of prematurity, X-linked retinoschisis, Stickler syndrome, familial exudative vitreoretinopathy and trauma (including self induced injury - ‘eye poking’). Together these account for the majority of cases and can usually be differentiated using this approach.

Active

When applied to aspiration indicates that fluid is being actively withdrawn from the eye by means of a Venturi or peristaltic pump.

Related Glossary Terms

Drag related terms here

Index Find Term

Angiogenesis

The physiological process whereby new blood vessels form from pre-existing vessels.

Related Glossary Terms

Drag related terms here

Index

Find Term

Anomalous PVD

A spectrum of conditions characterized by varying degrees of vitreomacular adhesion, epiretinal proliferation and vitreous separation. Includes ERM, VMT and macular holes.

Related Glossary Terms

Drag related terms here

Index

Find Term

Aspiration

Removal of fluid from the eye without cutting. Cutting aspiration implies cutting and aspiration are both occurring simultaneously.

Related Glossary Terms

Drag related terms here

Index Find Term

ATROPHIC RETINAL HOLES

Retinal breaks that occur due to atrophy of the retina, independently of vitreous detachment. Often found within the base of areas of lattice degeneration.

Related Glossary Terms

Drag related terms here

Index Find Term

Buckle

Any episcleral explant, either local or encircling.

Related Glossary Terms

Scleral buckle

Index Find Term

Bullous

A ballooning appearance of the retina. Retinal detachments have irregular mobile bullae which differ from the single smooth balloon seen in retinoschisis.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chandelier

A light with a widely diverging beam. May be used in relation to a light pipe or some form of accessory light source.

Related Glossary Terms

Light pipe, Vitrectomy

Index

Find Term

Chandeliers

Self retaining fibreoptic cables to allow bimanual intraocular surgery

Related Glossary Terms

Drag related terms here

Index

Find Term

Choroid

The vascular layer external to the retina and Bruch's membrane that supplies nutrients to the metabolically active outer retina .

Related Glossary Terms

Drag related terms here

Index

Find Term

Ciliary body

The layer of tissue internal to the sclera composed of the ciliary muscle and ciliary processes

---

Related Glossary Terms

Drag related terms here

Index

Find Term

Contiguous

Adjoining without a gap.

Related Glossary Terms

Drag related terms here

Index Find Term

Core

The central area of the vitreous where collagen fibers are widely interspersed.

Related Glossary Terms

Drag related terms here

Index Find Term

Cryonecrosis

Necrosis of tissue due to excessive cryotherapy.

Related Glossary Terms

Cryopexy, Cryoprobe

Index Find Term

Cryopexy

Production of a chorioretinal adhesion using cryotherapy.

Related Glossary Terms

Cryonecrosis, Cryoprobe

Index Find Term

Cryoprobe

An instrument designed to perform cryotherapy.

Related Glossary Terms

Cryonecrosis, Cryopexy

Cutter

Instrument used for the atraumatic removal of vitreous.

Related Glossary Terms

Vitrectomy

Encirclement

An explant that passes around the circumference of the eye forming a ring. Usually takes the form of an encircling band attached to itself by a Watske sleeve supporting a more local tire.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chapter 4 - Encirclement

Endothelial

The thin layer of cells that lines the interior surface of blood vessels.

Related Glossary Terms

Drag related terms here

Index Find Term

Entry site alignment system

The trocar, blade, hub and cannula assembly designed to introduce the polyamide cannula into the eye during MIVS.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chapter 6 - Entry Site Alignment

Floaters

Entoptic phenomenon in which opacities within the vitreous cast a shadow on the retina. They are perceived by the patient as drifting spots or specks in the visual field and may be interpreted as arising from outside the eye ('muscae volantes'). A sudden increase is an important early warning symptoms of vitreous detachment.

Related Glossary Terms

Photopsia, Posterior hyaloid, PVD, Synchysis, Syneresis

Index Find Term

Chapter 3 - Vitreous degeneration

Fragmatome

Instrument for ultrasonic disintegration and aspiration of lens matter from the posterior segment of the eye. Uses a piezoelectric crystal to generate high frequency vibrations.

Related Glossary Terms

Drag related terms here

Index Find Term

Gel

Substance possessing some properties of a liquid with the structural coherence of a solid, like a jelly on a plate

Related Glossary Terms

Drag related terms here

Index Find Term

Giant retinal tear

Giant retinal tear. A tear greater than 90^0 in circumferential extent.

Related Glossary Terms

GRT

Index Find Term

GIANT RETINAL TEAR

A large tear extending more than 3 clock hours. Unlike retinal dialysis a vitreous detachment is present so the flap of the tear is not splinted by vitreous and is very mobile.

Related Glossary Terms

Drag related terms here

GRT

Giant retinal tear. A tear greater than 90^0 in circumferential extent.

Related Glossary Terms

Giant retinal tear

Index Find Term

Hyaluronic acid

Hydrophilic glycoprotein found in vitreous and thought to be importance in maintaining its gel state.

Related Glossary Terms

Drag related terms here

Index

Find Term

Indirect ophthalmoscope

Instrument for performing indirect ophthalmoscopy.

Related Glossary Terms

Indirect ophthalmoscopic, Indirect ophthalmoscopy, Scleral indentation

Indirect ophthalmoscopic

A technique for examination of the retina devised by Charles Schepens. A head mounted light source is focussed on the retina with the help of a hand held condensing lens. Light reflected from the retina passes through this lens and a series of prisms and lenses to the observers retina.

Related Glossary Terms

Indirect ophthalmoscope, Indirect ophthalmoscopy, Scleral indentation

Index

Find Term

Indirect ophthalmoscopy

A technique for examination of the retina devised by Charles Schepens. A head mounted light source is focussed on the retina with the help of a hand held condensing lens. Light reflected from the retina passes through this lens and a series of prisms and lenses to the observers retina.

Related Glossary Terms

Indirect ophthalmoscope, Indirect ophthalmoscopic, Scleral indentation

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Index Find Term

Infusion

The system for replacing fluid removed from the eye and maintaining intraocular pressure.

Related Glossary Terms

Drag related terms here

Index Find Term

Lamellae

Layers of tissue. Usually vitreous, scleral and corneal.

Related Glossary Terms

Drag related terms here

Index Find Term

Lattice degeneration

Lattice degeneration is a peripheral vitreoretinal degeneration of unknown etiology. The appearance is variable but generally includes the criss-crossing white lines that give the condition its name and varying degrees of pigmentation.

Related Glossary Terms

Drag related terms here

Index Find Term

Light pipe

Fibreoptic probe used to illuminate the eye from within during vitrectomy.

Related Glossary Terms

Chandelier, Vitrectomy

Index Find Term

Light pipes

A hand held fibreoptic connected to a light source.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chapter 6 - Illumination

Light transduction

Light transduction occurs when a photon strikes a molecule of retinal within an opsin molecule embedded in the wall of the membranous plates in the outer segment of the photoreceptors. The resulting conformational change of the opsin molecule triggers hyper-polarization of the cell and reduction in neurotransmitter release at the synaptic terminal.

Related Glossary Terms

Lipofuscin, Opsin

Index Find Term

Chapter 1 - Photoreceptors

Lipofuscin

A by-product of photoreceptor disc phagocytosis and rhodopsin recycling between the photoreceptors and RPE. Its concentration reflects the balance between the activity of photoreceptors and RPE cells.

Related Glossary Terms

Light transduction

Index Find Term

Long ciliary nerves

The long ciliary nerves carry sensory fibers from the nasociliary nerve to the cornea. After they pierce the sclera they travel anteriorly with the long posterior ciliary artery at the 3 and 9 o'clock meridia where they are usually visible.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chapter 1 - Ciliary Nerves

Micro-incisional vitrectomy systems

Vitrectomy systems using cannulas narrower than 20-gauge. They are usually used with an Entry Site Alignment system. At the time of writing the most commonly used and 23-gauge and 25-gauge although narrower systems are starting to be used.

Related Glossary Terms

Drag related terms here

Index Find Term

Muller cells

Glial cells extending from the inner to the outer limiting membranes of the retina. They provide structural and metabolic support to the neural cells of the retina and have been implicated in several disease processes.

Related Glossary Terms

Drag related terms here

Index Find Term

Muscle hook

Surgical instrument for engaging ocular muscles. A blunt ended hook.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chapter 4 - Slinging muscles

Non pigmented epithelium

The anterior extension of the retina over the ciliary body.

Related Glossary Terms

Drag related terms here

Index

Find Term

OCT

Optical coherence tomography. A technique for imaging the eye by analyzing patterns of light scattering and reflection within the retina, choroid and vitreous.

Related Glossary Terms

Optical coherence tomography

Index Find Term

Operculum

The flap (or lid) of a tractional retinal tear.

Related Glossary Terms

Drag related terms here

Index

Find Term

Chapter 3 - Retinal breaks

Opsin

Membrane bound protein found in photoreceptor cells of the retina involved the conversion of a photon of light into an electrochemical signal (visual transduction).

Related Glossary Terms

Light transduction

Index Find Term

Chapter 1 - Photoreceptors

Optical coherence tomography

Optical coherence tomography. A technique for imaging the eye by analyzing patterns of light scattering and reflection within the retina, choroid and vitreous.

Related Glossary Terms

OCT

Index Find Term

Optical Coherence Tomography

Imaging the structures of the retina analyzing light scattered from the retinal layers.

Related Glossary Terms

Drag related terms here

Index Find Term

Ora serrata

The anterior termination of the retina. Serrata refers to the saw toothed shape of the edge.

Related Glossary Terms

Drag related terms here

Index Find Term

Passive

As applied to aspiration, fluid leaving the eye without the use of an external suction pump.

Related Glossary Terms

Drag related terms here

Index

Find Term

Pericytes

Contractile cells that wrap around the endothelial cells of capillaries.

Related Glossary Terms

Drag related terms here

Index Find Term

Peritomy

Separation of the peripheral conjunctiva and episclera from the sclera.

Related Glossary Terms

Drag related terms here

Index

Find Term

Photopsia

Flashing lights perceived by the patient.

Photopsia due to vitreous detachment are entoptic phenomena typically experienced in the temporal visual field and are more noticeable in the dark..

Related Glossary Terms

Floaters

Index

Find Term

Chapter 3 - Vitreous degeneration

Posterior hyaloid

The external layer of the vitreous. The layer of vitreous adjoining the retina when the vitreous is attached.

Related Glossary Terms

Floaters, PVD, Weiss ring

Index Find Term

Posterior vitreous detachment

Separation of the posterior hyaloid face of the vitreous from the retina. Extends anteriorly to, but does not include, the vitreous base.

Related Glossary Terms

PVD

Index

Find Term

Chapter 3 - Vitreous degeneration

PPV

Pars plana vitrectomy. Removal of vitreous through the pars plana.

Related Glossary Terms

Vitrectomy

Index Find Term

PVD

Posterior vitreous detachment. Separation of the posterior hyaloid face of the vitreous from the retina. Extend anteriorly to, but does not include, the vitreous base.

Related Glossary Terms

Floaters, Posterior hyaloid, Posterior vitreous detachment, Syneresis, Vitreoschisis, Weiss ring

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Index Find Term

RETINAL DIALYSIS

Circumferential breaks near the ora serrata. There is no vitreous detachment in contrast to a giant retinal tear.

Related Glossary Terms

Drag related terms here

Index Find Term

Retinal pigment epithelium

The layer of hexagonal cells that lies superficial to Bruch's membrane. Important in function and metabolic support of the neurosensory retina.

Related Glossary Terms

RPE

Index Find Term

Retinopexy

Therapeutic production of a chorioretinal adhesion.

Related Glossary Terms

Drag related terms here

Index

Find Term

Retinoschisis

Splits within the retina.

Related Glossary Terms

Drag related terms here

Index

Find Term

Rhegmatogenous

'Break Generated' (Gr). The adjective used to describe retinal detachments due to a retinal defect.

Related Glossary Terms

Drag related terms here

Index Find Term

RPE

Retinal pigment epithelium. The layer of hexagonal cells that lies superficial to Bruch's membrane. Important in function and metabolic support of the neurosensory retina.

Related Glossary Terms

Retinal pigment epithelium

Index Find Term

Scleral buckle

An episcleral explant, either local or encircling.

Related Glossary Terms

Buckle

Index Find Term

Scleral indentation

A technique for examining the extreme periphery of the retina while performing indirect ophthalmoscopy. Pressure applied via the lid crease to the sclera creates an indentation which brings the peripheral retina into view.

Related Glossary Terms

Indirect ophthalmoscope, Indirect ophthalmoscopic, Indirect ophthalmoscopy

Index Find Term

Sclerotomies

Incisions in the sclera through which instruments are inserted during vitrectomy.

Related Glossary Terms

Drag related terms here

Index

Find Term

Short ciliary nerves

The short ciliary nerves carry sympathetic and parasympathetic fibers from the ciliary ganglion to the iris muscles. The may be difficult to identify as their position is variable and the become visible more anteriorly than the long ciliary nerves.

Related Glossary Terms

Drag related terms here

Index Find Term

Snail track degeneration

A variant of lattice degeneration

Related Glossary Terms

Drag related terms here

Index

Find Term

Spatulated

Having flattened upper and lower surfaces (like a spatula). Spatulated needles rely on the sharpened tip and lateral edges to cut through tissue.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 4 - Scleral sutures

Specular

A mirror-like reflection of light from a surface.

Related Glossary Terms

Drag related terms here

Index

Find Term

Sponge

Explant made of silicone rubber with air pockets so that it is compressible.

Related Glossary Terms

Drag related terms here

Index Find Term

Stickler Syndrome

Mutation of genes encoding collagen leading to vitreoretinal degeneration and retinal detachment as well as extraocular manifestations such as hearing loss, arthropathy and cleft palate or bifid uvula.

Related Glossary Terms

Drag related terms here

Index

Find Term

Subtenons anesthesia

An anesthetic technique in which a conjunctival incision is made and anesthetic injected behind the posterior layer of Tenons capsule into the intraconal space.

Related Glossary Terms

Synchysis

Index Find Term

Suprachoroidal

The suprachoroidal space is a potential space between the choroid and the sclera in which fluid may accumulate. This is traversed by week connective trabeculae which break easily and by arteries and nerves supplying the ciliary body.

Related Glossary Terms

Drag related terms here

Index

Find Term

Synchysis

An early stage of vitreous degeneration. the appearance of fluid filled pockets (lacunae) within the vitreous.

Related Glossary Terms

Floaters, Subtenons anesthesia, Syneresis

Index Find Term

Chapter 3 - Vitreous degeneration

Syneresis

Liquefaction with collapse of the vitreous.

Related Glossary Terms

Floaters, PVD, Synchysis

Tenons Capsule

A fascial capsule that envelops the whole globe from the optic nerve to the limbus.

Related Glossary Terms

Drag related terms here

Index Find Term

The nerve fibre layer

Ganglion cell axons running in the superficial retina then via the optic nerve to the lateral geniculate nucleus.

Related Glossary Terms

Drag related terms here

Index Find Term

Tight junctions

A type of junctional complex. Also known as occluding junctions or zonula occludens. The closely associated areas of two cells whose membranes join together forming a virtually impermeable barrier to fluid.

Related Glossary Terms

Drag related terms here

Index Find Term

Tire

An explant made of solid silicone rubber which is incompressible.

Related Glossary Terms

Drag related terms here

Index

Find Term

TRACTIONAL TEARS

Retinal tears following vitreous detachment at points of vitreoretinal adhesion. The tearing extends to the vitreous base which gives the tear a horseshoe (or 'U') shape.. If the vitreoretinal adhesion is behind the vitreous base the operculum may detach completely (operculated tear).

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 3 - Retinal breaks

Triamcinolone

Solution used to enhance visibility of vitreous and reduce intraocular inflammation.

Related Glossary Terms

Drag related terms here

Untitled

Lorem ipsum dolor sit amet, consectetur adipisicing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat.

Related Glossary Terms

Drag related terms here

Index Find Term

Uveoscleral outflow

The alternative path of fluid out of the eye which does not leave via the iris root.

Related Glossary Terms

Drag related terms here

Index Find Term

Vitrectomy

Removal of vitreous.

Related Glossary Terms

Chandelier, Cutter, Light pipe, PPV, VMT

Index Find Term

Vitreoschisis

Splitting of the vitreous cortex. When a PVD is though to be present a thin layer of vitreous cortex may be left on the retinal surface.

Related Glossary Terms

PVD

Index Find Term

Vitreous base

Area in the anterior peripheral vitreous where the collagen fibers are densely packed and more tightly bound to each than those of the core. They insert directly into the cytoskeleton of the superficial retinal cells. Consequently the vitreous in this area cannot be detached from the retina.

Related Glossary Terms

Drag related terms here

Index Find Term

Chapter 1 - Vitreous composition

VMT

Vitreomacular traction. The presence of anteroposterior traction on the retina. When functionally significant the term vitreomacular macular traction syndrome is used.

Related Glossary Terms

Vitrectomy

Index Find Term

Weiss ring

Annular densely packed collagen fibers attached to the optic nerve which give rise to a ring of semi-opaque tissue when the vitreous detaches.

Related Glossary Terms

Posterior hyaloid, PVD

Index

Find Term