THE OPEN GLOBE

SURGICAL TECHNIQUES FOR THE CLOSURE OF OCULAR WOUNDS

Paul Sullivan

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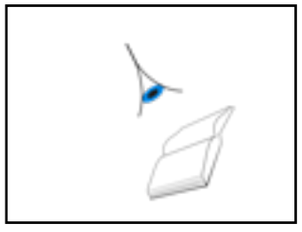

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DEDICATION

This book is dedicated to all the residents and fellows at Moorfields Eye Hospital who have taught me so much over the last 20 years.

Paul Sullivan

London June 2013

FOREWORD

This is a brief overview of the primary management of ocular wounds for general and comprehensive ophthalmologists. It started as a learning resource for trainees in my own hospital. The style of the book reflects the strong visual learning preferences possessed by most ophthalmologists.

The iPad version is designed to be dipped into and skimmed through rather than read end to end. The dots at the bottom of the screen in chapter view allow navigation between chapters. The videos are of sufficient quality to be played full screen. This can be done with a spreading touch. Many of the illustrations are also interactive. To navigate you can tap to maximize and use a pinching touch screen gesture to minimize.

For a more extensive review of microsurgical techniques in ophthalmology the reader is referred to Georg Eisner's 'Eye Surgery: An Introduction to Operative Technique' or Marian Macsai's 'Ophthalmic Microsurgical Suturing Techniques'. For a comprehensive review of all aspects of ocular trauma the reader is referred in particular to Ferenc Kuhn's 'Ocular Traumatology'.

To anyone reading this a a pdf: an interactive book with many more interactive features is available from the Apple iBookstore.

This book is very didactic in tone. This is because the target audience is ophthalmology trainees. Some controversial aspects of penetrating ocular trauma have been glossed over and any experienced ophthalmologist is likely to find at least one statement they disagree with.

I would like to thank my colleagues at Moorfields Eye Hospital for some of the videos and illustrations in this book particularly Mr Bill Aylward and Mr Julian Stevens.

A web site is currently in development which will host educational material which may be of interest if you enjoy this book as well as details of further

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, Fight For Sight or the Halo Trust which work in various ways to reduce the burden of avoidable blindness due to trauma.

CHAPTER 1

INTRODUCTION

Movie 1.1 The human cost of severe ocular trauma

Bilateral enucleation following laceration by a broken windscreen during a road traffic accident

Eye injury is an important cause of visual loss. The quality of the primary repair is a major determinant of the final visual outcome. This in turn requires a good understanding of some quite basic surgical principles.

Classification of Ocular Trauma

The Ocular Trauma Classification Group has proposed a system for the classification of mechanical ocular trauma.

This is based on:

The type of injury, based on the mechanism of the injury.

The grade of injury, defined by the presenting visual acuity in the affected eye.

The presence of a relative afferent pupillary defect.

The zone of injury, based on the anteroposterior extent of the injury.

Classification of Ocular Trauma

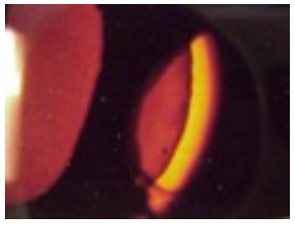
Type of injury

This is based on the mechanism of injury as shown in the diagram below. Clicking on the images will give the definitions of each type. Note in particular the distinction between penetrating and perforating trauma.

OCULAR TRAUMA

CLOSED GLOBE

CONTUSION

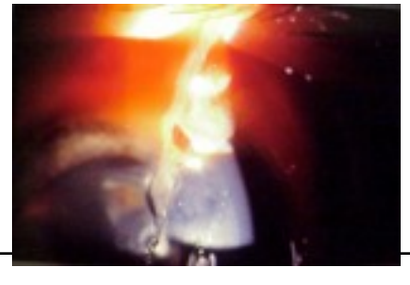


LAMELLAR LACERATION

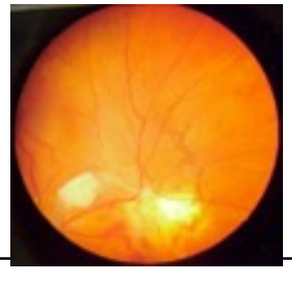
OPEN GLOBE

LACERATION

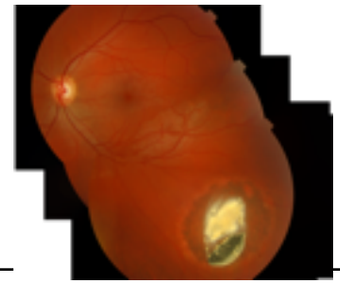
PENETRATING



PERFORATING



INTRAOCULAR FOREIGN BODY



RUPTURE

Classification of Ocular Trauma

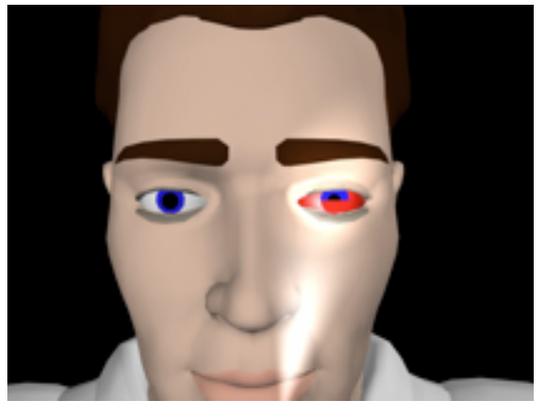
The visual acuity

The presenting visual acuity is a good predictor of final visual acuity and should be assessed as completely as practically possible. It should not overly influence management decisions (such as removal of the eye), however. Some eyes that present without light perception can eventually recover useful vision. When the lids cannot be opened (in the presence of gross hematomas, for example) perception of light can be confirmed by holding the tip of a pen torch against the closed eyelids.

The pupil

In the setting of trauma the presence of a relative afferent pupillary defect (RAPD) can be elicited by observing the pupil reaction of the uninjured eye as the light is moved between the eyes.

Movie 1.2 RAPD in trauma

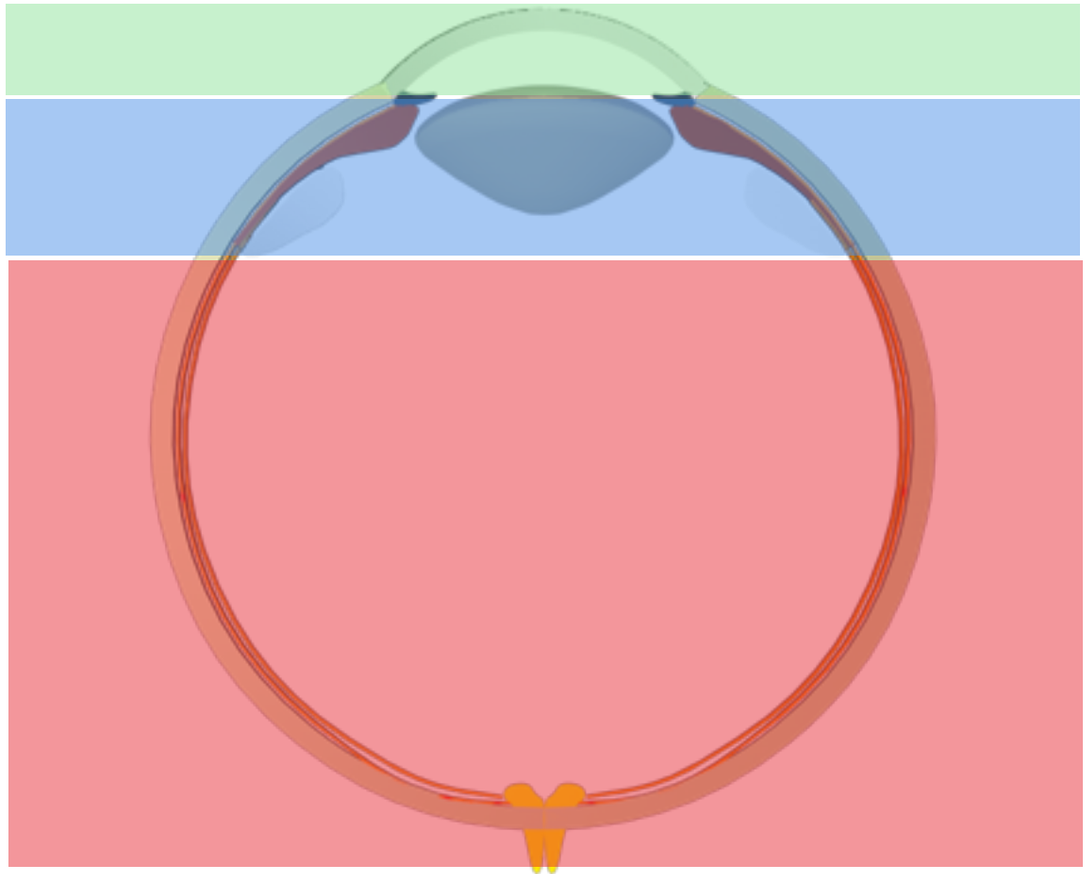


The RAPD is detected by observing the uninjured eye.

Classification of Ocular Trauma

The Zone of Injury

ZONE	EXTENT
1	Cornea/Limbus
2	Anterior 5 mm Sclera
3	Posterior Sclera



Preoperative Management

Assess the patient adequately while avoiding pressure on the globe. In particular no effort should be made to open the eye forcibly. This is particularly important in children who may not be able to cooperate with an examination and in whom examination under anesthesia may be required if the history and limited examination suggest that a penetrating injury is present. Non ocular injuries may also be present (e.g. orbital blow out fracture in a globe rupture) so examine structures around the globe. Life threatening injuries may be present which take priority over ocular injuries.

Patients may be in considerable pain and should receive adequate analgesia. If opiates are required they should be accompanied by an antiemetic to prevent vomiting.

A careful history may give clues regrading the nature of the injury. For example use of a hammer and chisel should raise the suspicion of an intraocular foreign body.

Visual function, including the presence of a RAPD, should be noted if possible.

Findings on examination should be comprehensively documented in the patient chart in case there is subsequent legal action.

A Cartella shield (without a pad) should be applied and systemic antibiotic therapy initiated. Tetanus prophylaxis should also be administered in patients who may not have previously received a complete course.

The history should guide the need for radiological investigation to exclude an intraocular foreign body (IOFB). MRI scanning should never be performed in this situation.

Preparation for Surgery

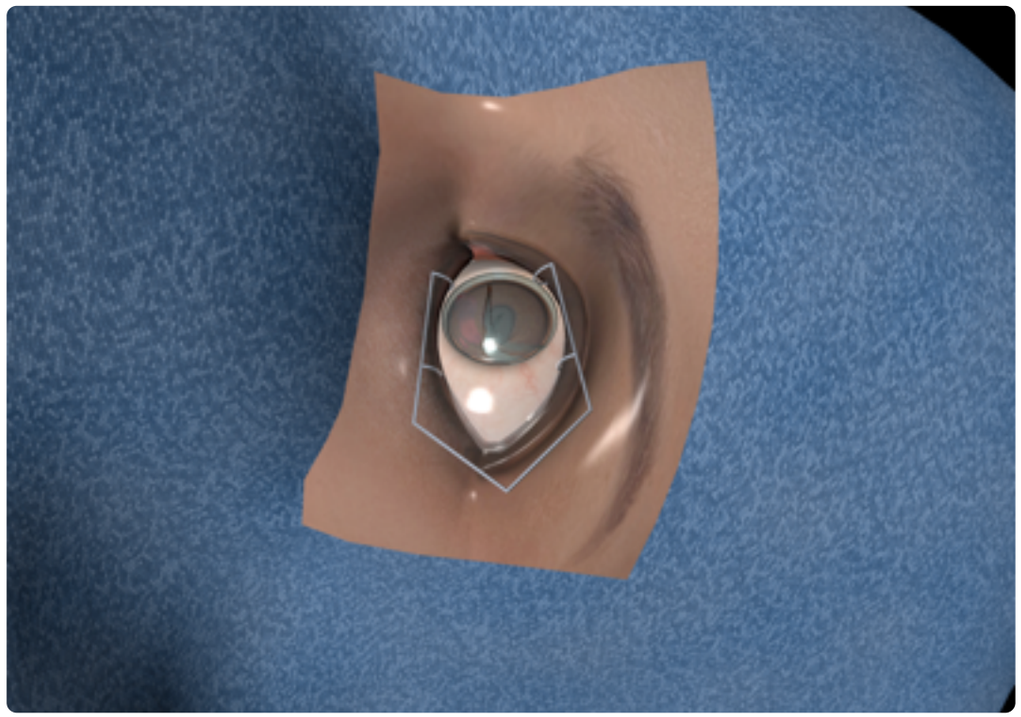
The patient should be taken to the operating room as soon as practically possible.

General anesthesia is preferable to local anesthesia in severe ocular trauma. The anesthesiologist should be aware of the presence of a penetrating eye injury. There is little evidence for the long held belief that succinylcholine is contraindicated.

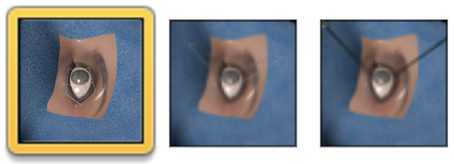
The skin around the eye and lashes should prepped and draped. Minimal pressure should be exerted on the eye while doing this.

Conventional lid specula may compress the globe. A Jaffe speculum or lid sutures can be used to open the lids without placing pressure on the globe.

Gallery 1.1 Specula



A conventional lid speculum may place pressure on the globe.



Knowledge Review

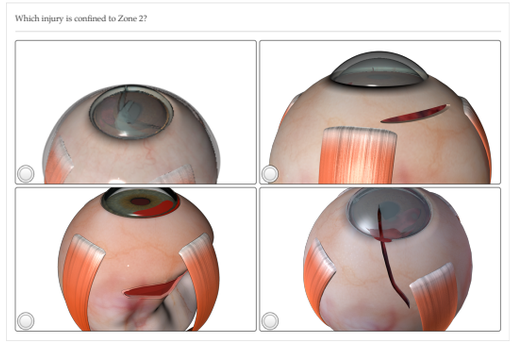
Review 1.1 Injury Classification

A patient has been stabbed in the eye with a pair of scissors. There is a corneal laceration and a posterior scleral laceration, the scissors having traversed the globe. The correct term for this injury is:

- **A.** Penetrating injury
- **B.** Double penetrating injury
- **C.** Double perforating injury
- **D.** Perforating injury
- **E.** Rupture

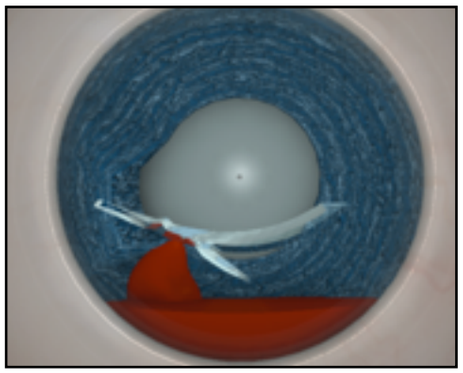
Review 1.2 Classification of trauma

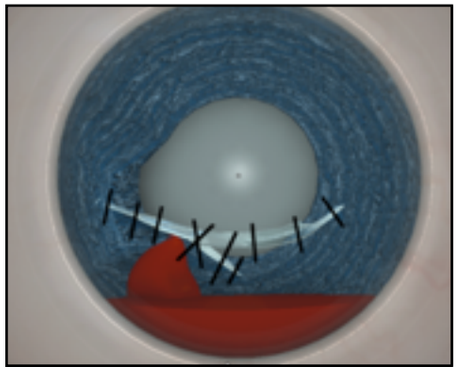
Which injury is confined to Zone 2?



CHAPTER 2

SURGICAL PRINCIPLES





The principal goal of surgery is watertight wound closure while minimizing collateral damage such as induced astigmatism.

These goals are achieved by appropriate choice of suture material, correct suturing technique, respect for tissue planes, correct knot tying and tension and understanding how the 3 dimensional structure of the wound affects its behavior.

Sutures and Needles

A monofilament non-absorbable material such as nylon is used in all corneal and most scleral trauma.

The ultrastructure of the cornea is a well organized system of layers (or lamellae). The sclera has a less well organized but still distinctly lamellar structure.
Spatulated needles are used for suturing both corneal and scleral wounds. The spatulated tip is flat on the upper and lower surfaces. It can be made to dissect its way in a flat plane between lamellae. This allows very precise control over the depth to which it penetrates sclera and cornea.

Interactive 2.1 Spatulated needle

This is an interactive three dimensional model. Note the flattened (spatulated) needle tip profile.

Figure 2.1 Spatulated needle dissecting between lamellae

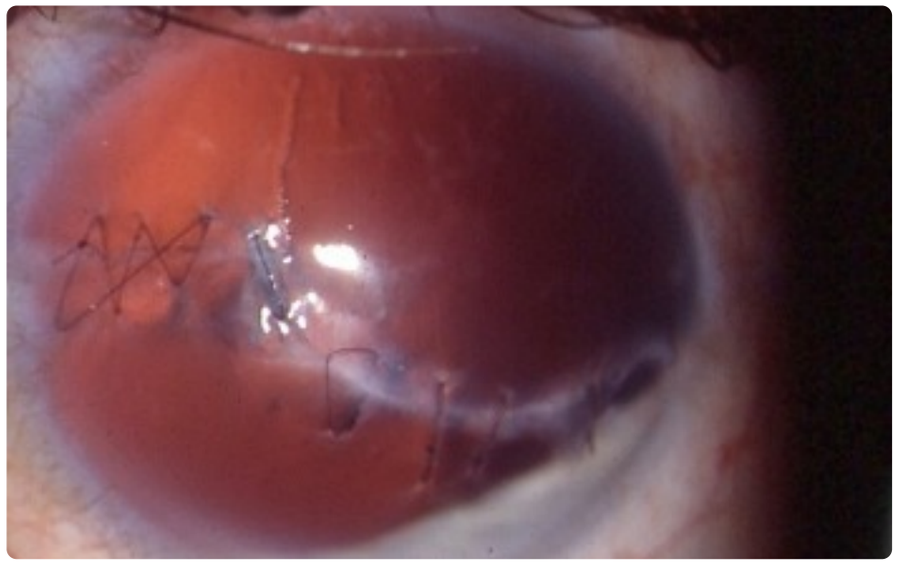
The flattened upper and lower surfaces of the needle tip and mid section allow it to stay in a plane between lamellae. This allows very precise control of the needle depth.

Knots

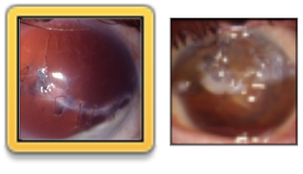
The properties of a knot depend upon the manner in which it is tied.

Knots that may be useful in trauma including surgeon's knots, slip knots and locking knots.

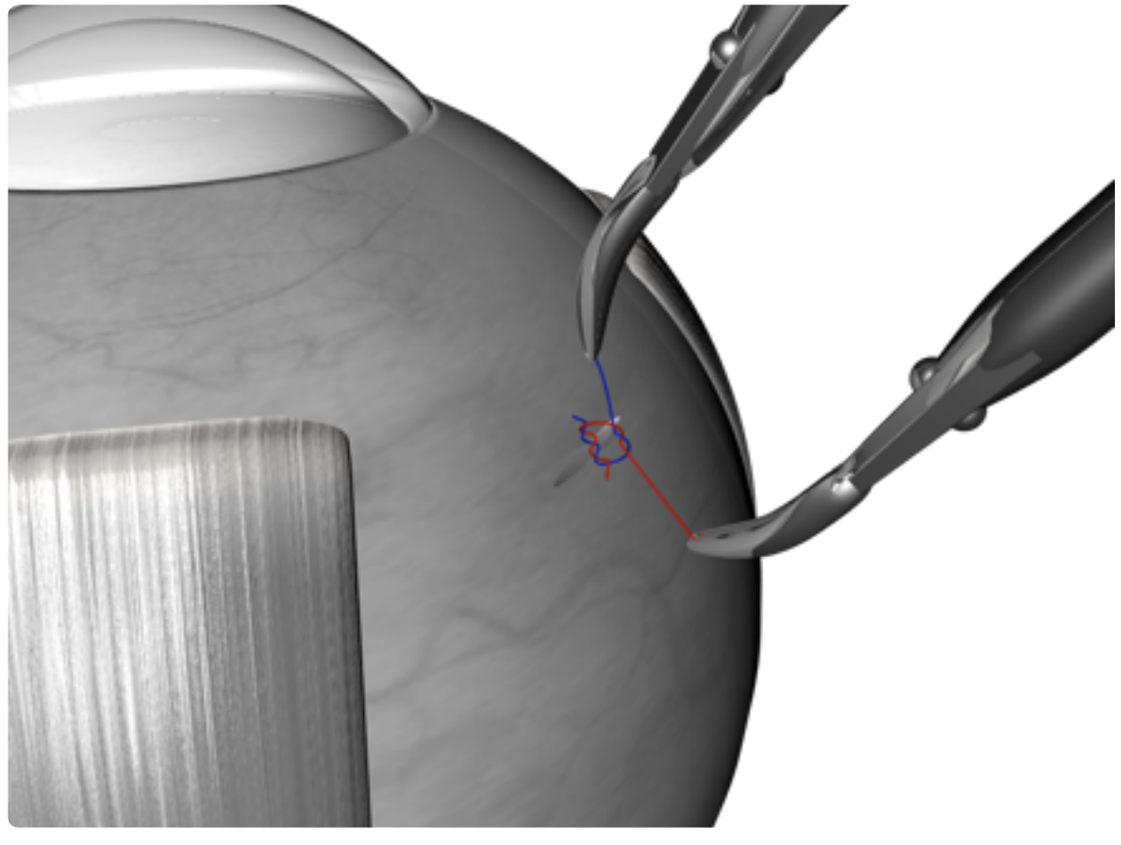
Diagram 2.1 The consequences of poor knot tying



Loose sutures.



Gallery 2.1 Knots in trauma overview



Surgeon's knot

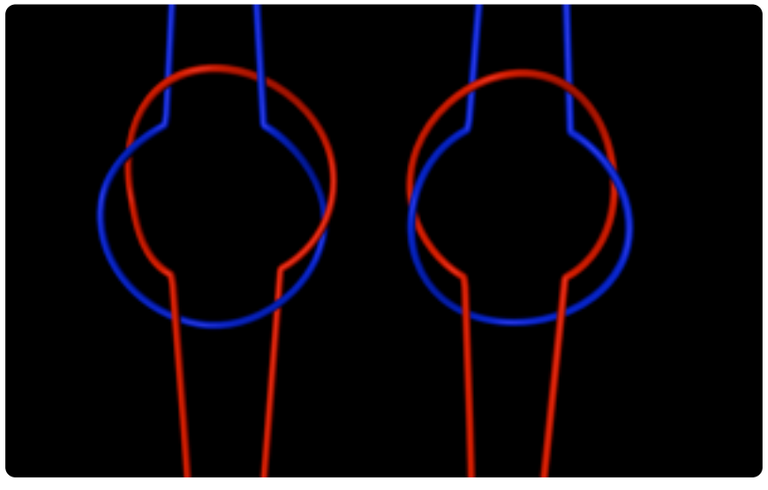
Reef Knots and Slip Knots

Understanding the difference between simple reef and slip (or granny) knots is the key to understanding and tying most of the other knots used during surgery. Both reef and slip knots are composed of two single throws of the suture (1-1 knots).
In a reef (or square) knot the orientation of the loop and direction of pull alternate between throws. This compact knot is composed essentially of two loops that interlock so that after the second throw attempts at further tightening simply make the knot more compact without tightening the suture.
A slip knot arises by default whenever an error (e.g. looping or pulling in the wrong direction) is made while attempting to tie a reef knot. These knots will slip under tension particularly if a monofilament material such as nylon is used.

Gallery 2.2 How to tie a reef knot

Note how the orientation of the loops and direction of pull alternate (forward throw, short end towards then backward throw, short end away). This gives the knot its structure.

Diagram 2.2 Reef versus Slip Knot

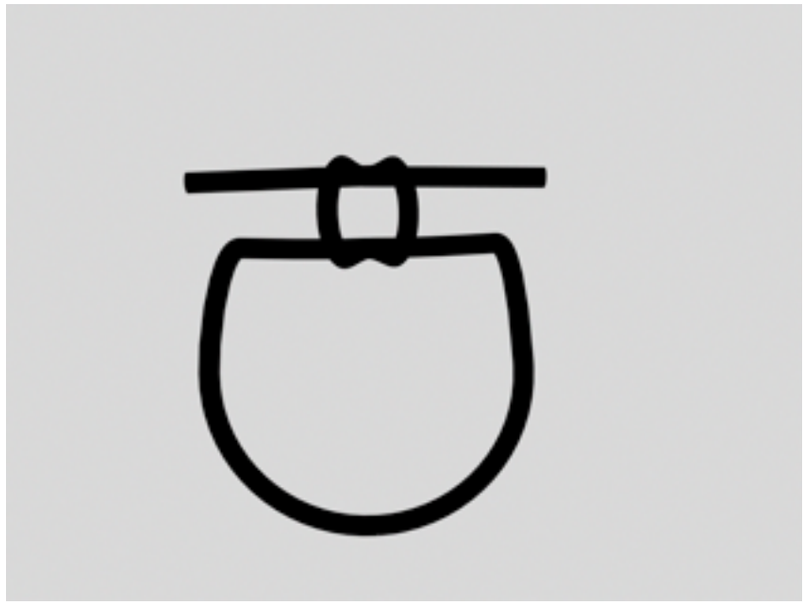


The knot on the right is a reef (or square) knot. Note that it has a plane of symmetry in its main axis unlike the granny knot on the left. The two loops of the reef knot interlock in a way that prevents slippage when tightened. The slip knot on the left will slip under tension.

The Difference Between Slip Knots and Reef Knots

Reef knots and slip knots behave differently under tension.

Movie 2.1 Reef knot



A reef knot becomes more compact but does not slip under tension.

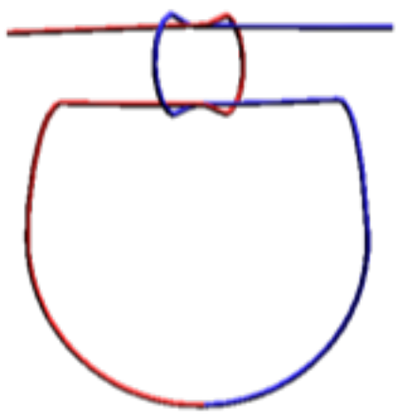
Movie 2.2 Slip knot

A slip knot slips under tension.

The Difference Between Slip Knots and Reef Knots

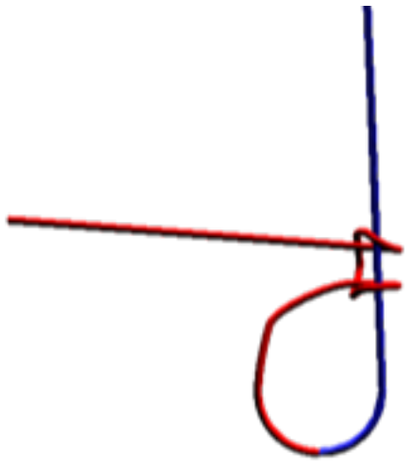
The difference between reef and slip knots arises from the basic symmetry of the reef knot which arises from the strict alternation of pull orientation (forwards then backwards) and direction of pull.

Interactive 2.2 Reef knot



The reef knot can be thought of as 2 interlocking loops as a result of its basic symmetry. The greater the tension in the knot the more the 2 loops interlock preventing slippage.

Interactive 2.3 Slip Knot



In a slip knot the loops do not interlock. As a result when placed under tension it tends to adopt this configuration allowing slippage (in this case the blue end will slip through the red loops).

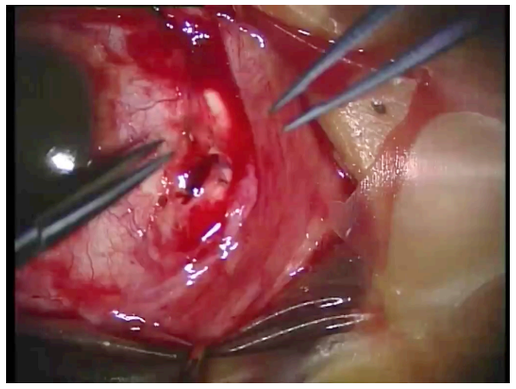
Surgeons' Knots

Reef knots are rarely used in ophthalmic surgery. Surgeons' knots are variants of the reef knot using an initial double instead of a single throw. The direction of looping and the direction of pull alternate between throws as in a reef knot. The only difference is that the number of throws (or loops) of the suture is greater. A reef knot can be described as 1-1 knot and a surgeon's knot as a 2-1 knot.

They are described according to the number of loops in each direction (e.g 2-1-1; 3-2-1). A surgeon's knot is the 2-1 sequence. Because of the low friction in nylon a triple throw is often used followed by alternating single throws (3-1-1).

The resulting knot is compact and does not slip. As a result surgeons' knots are the among the most commonly used knots in most areas of surgery, hence their name.

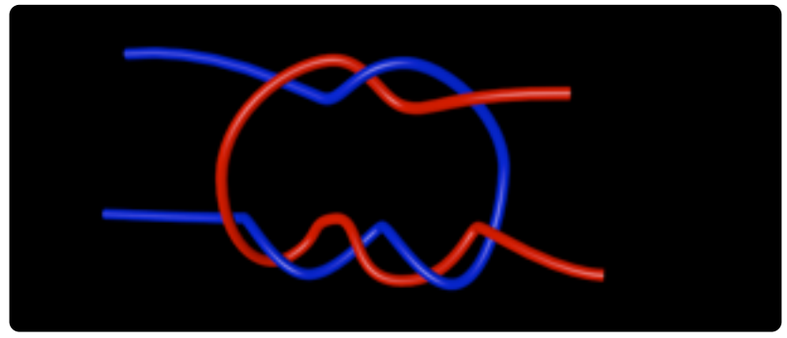
Movie 2.3 Surgeon's Knot



Note the alternating throws (forward and backward) and direction of pull.

Surgeons' knots have two major disadvantages. It is not possible to alter the tension in the knot after the second throw has been tightened. It is also difficult to tie them under tension unless several throws are made on the first loop as they tend to loosen between the first and second throws. This produces a very bulky knot. For this reason other knots are more commonly used in trauma.

Diagram 2.3 Surgeon's knot



A 2-1 surgeon's knot. Note that the orientation of the throws alternates in the same way as a reef knot. The only difference from a reef knot is the number of throws (2-1). As a result surgeons' knots do not slip.

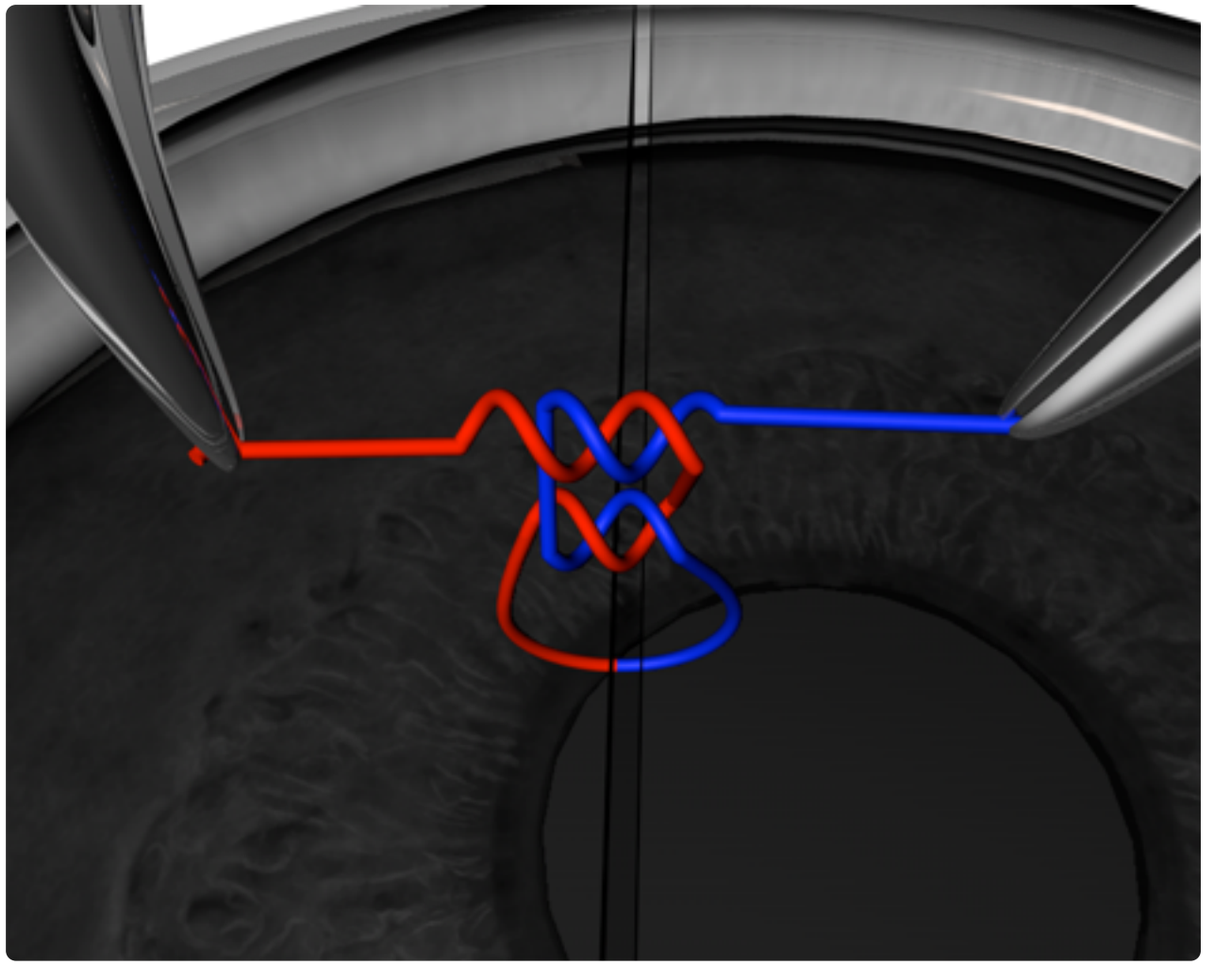
Slip Knots

Sailors and Scouts are discouraged from tying Granny Knots because they are 'unstable' and therefore 'should never be used for any purpose' and the same attitude in most areas of surgery. This is because they easily slip but it is precisely this property which can make them useful to the ophthalmic surgeon so long as an extra throw is added in the opposing direction afterwards (the 'Dangel knot').

Slip knots allow the surgeon to control the tension in a suture. The suture tension can be adjusted after the second throw has been tied. If necessary the tension can be increased to produce wound compression. While wound compression is not always appropriate it is necessary under certain circumstances.

The ability of a knot to slip is determined by the friction in the knot which is a function of the number of throws and smoothness of the suture material. Single throws of monofilament synthetic sutures tend to slip most easily.

Figure 2.2 Slip knot

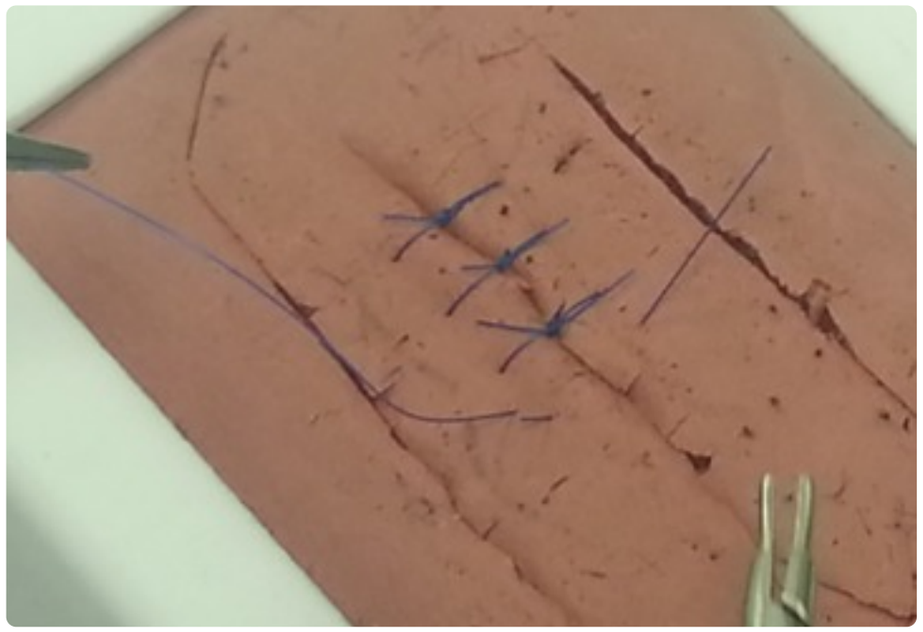


Note the lack of symmetry, this will slip under tension.

The Dangel Knot

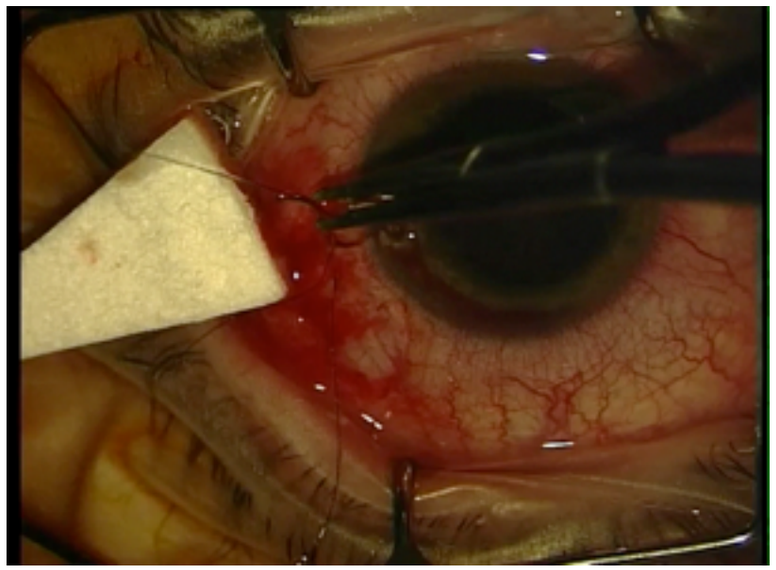
There are many ways of tying a slip knot. It will usually happen by default when tying a reef knot unless care is taken with the throws.
Probably the most frequently used slip technique in ophthalmology is the one described by Matthew Dangel. It is a 1-1-1 knot in which the first 2 throws are made in the same direction. The result after the first 2 throws is essentially a slip knot whose tension can be adjusted. Once the tension is satisfactory an opposing throw in the opposite direction secures the knot. This can be performed at the end of the case - this allows suture tension to be adjusted once the eye is closed without the need to replace sutures.

Image 2.1 Tying a Dangel knot (right handed surgeon)



The starting point - you have taken a bite and have a long and a short suture end. From this point your left hand holds the long end without letting go.

Movie 2.4 Dangel Knot



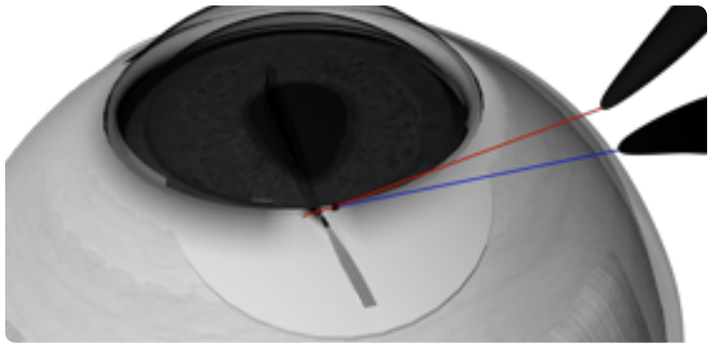
A Dangel knot is used here to close a wound under tension. Wound compression is desirable here because this eye is about to undergo vitrectomy for IOFB. Note that the direction of the throw and the direction pull is the same during both throws. A final throw, not shown here, was made in the opposite direction to secure the knot.

Locking Knots*

A knot can be locked under tension after the first throw by pulling both ends forcefully in the same direction and holding them in this position for a second. It is usually necessary to use at least 2 loops in the first throw (i.e. 2-1-1 for polyglycate or 3-1-1 for nylon). The tension in both ends of the suture must be maintained while pulling them in this way otherwise they will not lock. The knot keeps its tension while the second throw is prepared so long as it is not inadvertently tugged on.

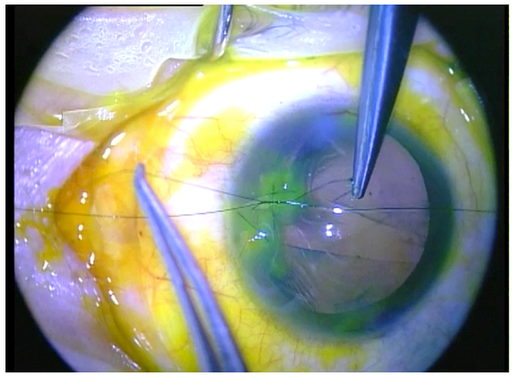
After the second throw the knot anatomy is still essentially unstable (like a large granny knot) so a third opposing throw must be made to secure it or it may loosen or unravel especially when turned. Even after this extra throw the knot is less stable than a surgeon's knot and may unravel when turned.

Figure 2.3 Locking knot



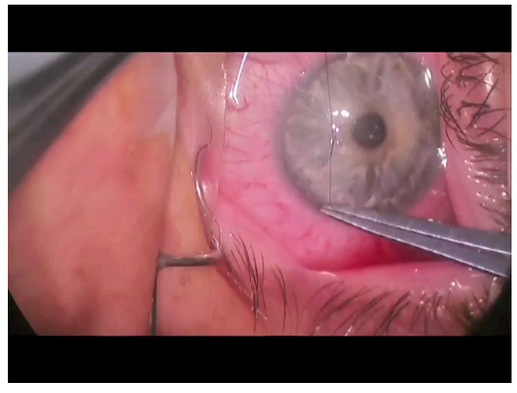
Tension must be maintained in both suture ends while locking.

Movie 2.5 Locking knot.



After 2 or 3 throws pull both ends firmly to one side of the wound. The tension achieved will be maintained so long as the first throw is not disturbed.

Movie 2.6 Poor locking technique



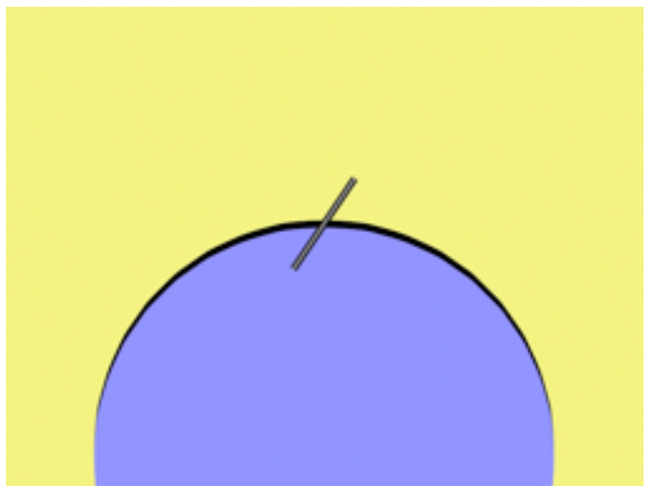
Failure to maintain equal tension on both ends of the suture while pulling.

* Not to be confused with the term locking as applied to a form of continuous suture

Wound Alignment: Basic Principles

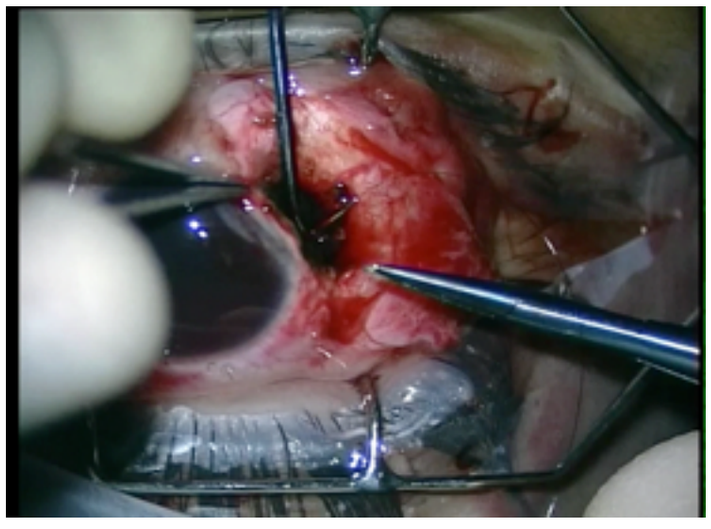
The cornea and sclera are inelastic so correct placement of sutures to realign wound edges anatomically is essential. This is true both vertically (the suture depth) and horizontally (along the wound).

Movie 2.7 Incorrect horizontal wound alignment



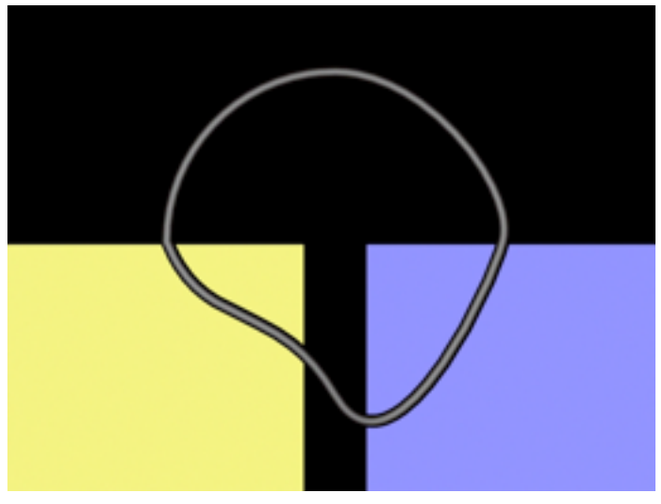
Oblique suture: as the suture is tightened lateral shift of the wound edges occurs (top view). Sutures should be oriented perpendicular to the wound.

Movie 2.8 Incorrect horizontal wound alignment, lateral shift



Lateral wound shift due to poor alignment resulting in a tag of sclera. Poor visualization due to failure to clear adherent clot was a factor here.

Movie 2.9 Incorrect suture depth, poor vertical alignment

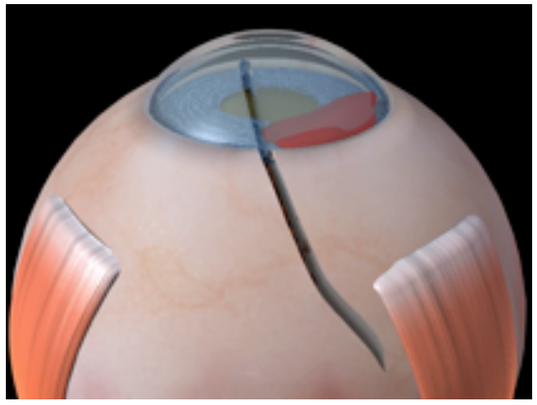


Asymmetric suture depth leads to vertical shift on tightening (lateral view).

Lateral Alignment

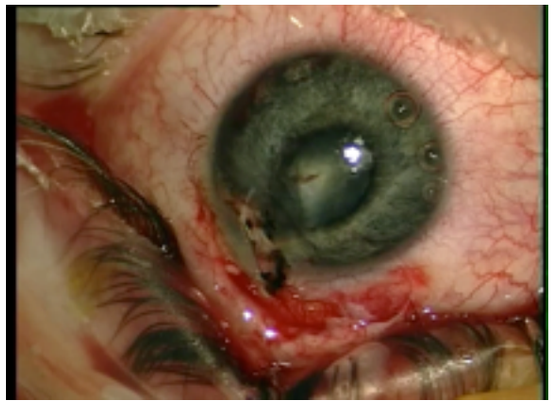
The limbus is a useful landmark for correct alignment of corneoscleral wounds. Placement of a suture here first tends to align the rest of the wound. Doglegs in the wound can be used in the same way.

Movie 2.11 Corneoscleral laceration



Placement of 'cardinal' suture.

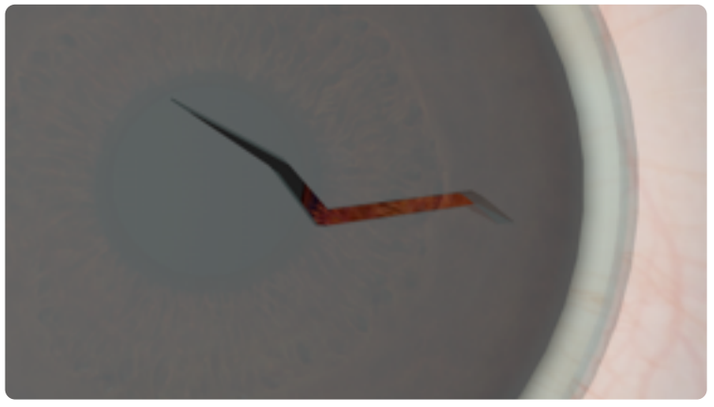
Movie 2.12 'Cardinal' suture at the corneoscleral limbus

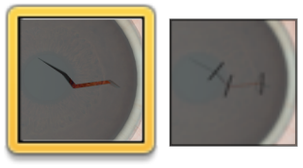


This aligns the rest of the wound.

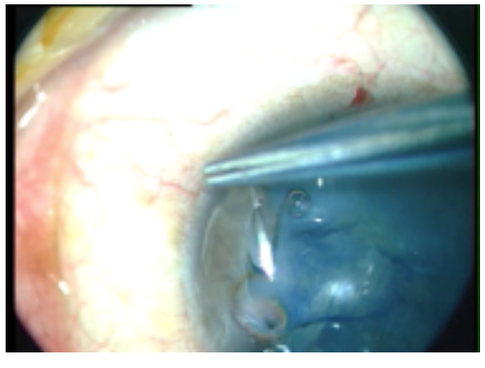
Gallery 2.3 Use of wound angles for alignment

Sutures placed at wound angles ('doglegs') first allow the rest of the wound to be correctly aligned





Movie 2.10 Aligning a corneal wound

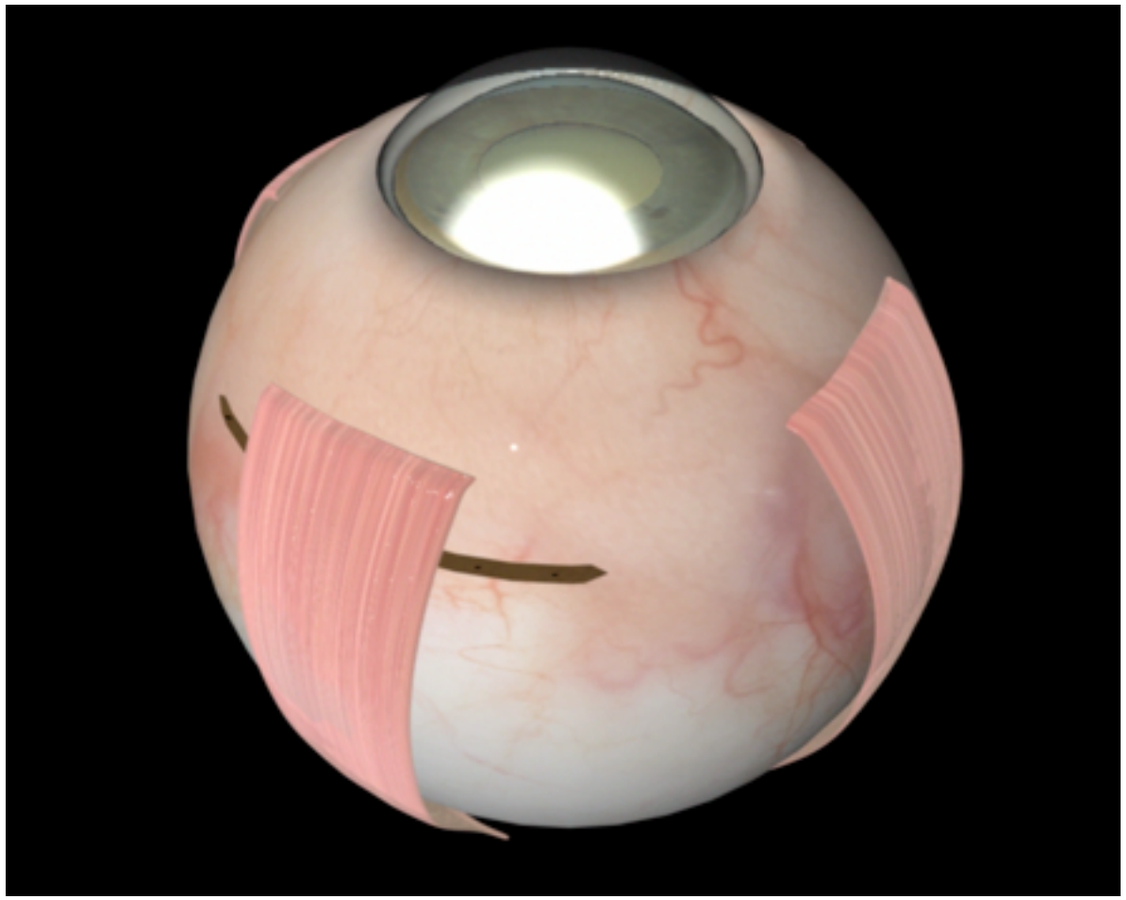


Using a dogleg (or zigzag) in the wound for wound alignment.

The rest of the wound is aligned in most cases by using the 50% rule. In special cirumstances (discussed later in the book) the wound is closed by suturing from one end and placing sutures evenly.

The '50%' rule relies on the fact that the human brain is good at gauging symmetry so it is easy to judge the halfway point of a line.
It is particularly useful for large circumferential wounds.
A suture is first placed halfway along the wound. The rest of the wound is then treated as 2 separate wounds and sutures placed halfway along each. This is repeated until the wound has been closed.

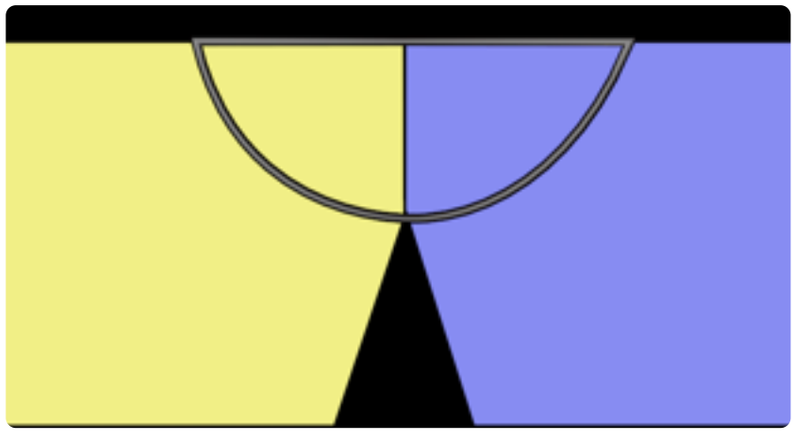
Movie 2.13 The '50%' rule



Placing sutures successively at the mid point giving good alignment and even spacing.

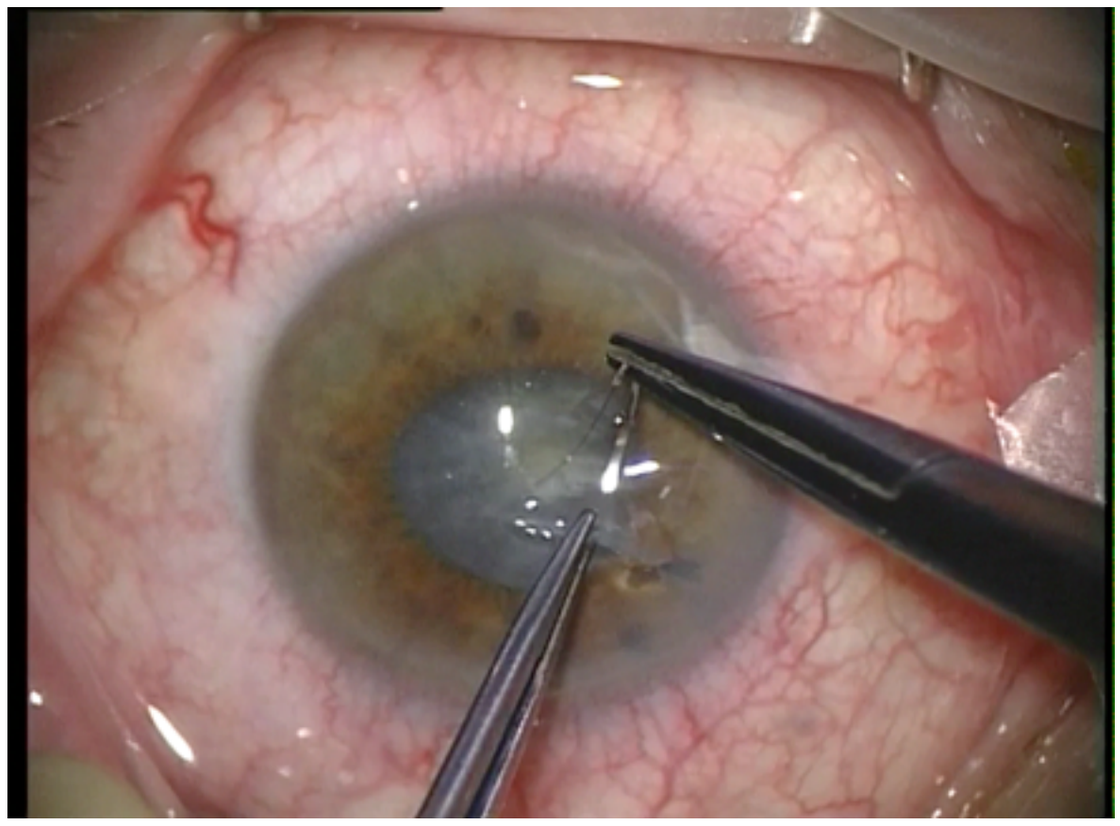
Vertical Alignment

Gallery 2.4 Suture depth



The sutures are not deep enough. The wound gapes internally.

Movie 2.14 Suture depth

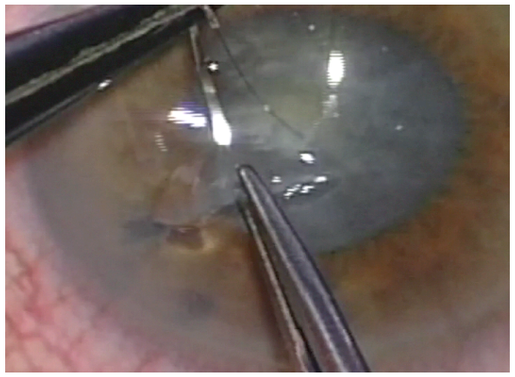


The ideal suture depth is about 90% of the corneal thickness.

Vertical Alignment

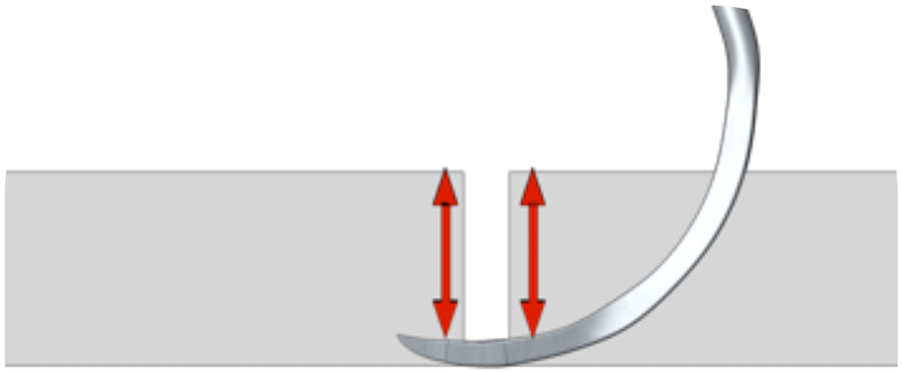
In a non-shelving corneal section eversion of the wound edges allows sufficiently deep suture passage.
Vertical symmetry of the bites is ensured by opposing the wound flaps while pushing the needle across the wound - while this could be done with a forceps it is usually done with the needle alone to try to reduce trauma to the flaps as shown in the movie below.

Movie 2.15 Suture passage



Getting a deep enough bite in a non-shelving section.

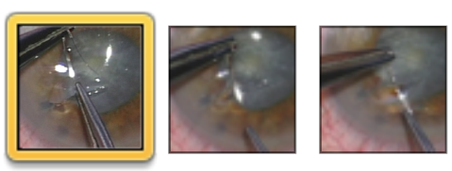
Figure 2.4 Vertical alignment



If the needle crosses the wound while the edges are apposed it follows that the needle depth will be the same on both sides of the wound - i.e.the wound will be aligned vertically. This apposition can be achieved with the force of the needle alone to minimise tissue maceration.

Figure 2.5 Suture passage

The needle entry. Here the wound is non-shelved and a perpendicular entry is achieved by everting the wound edge.



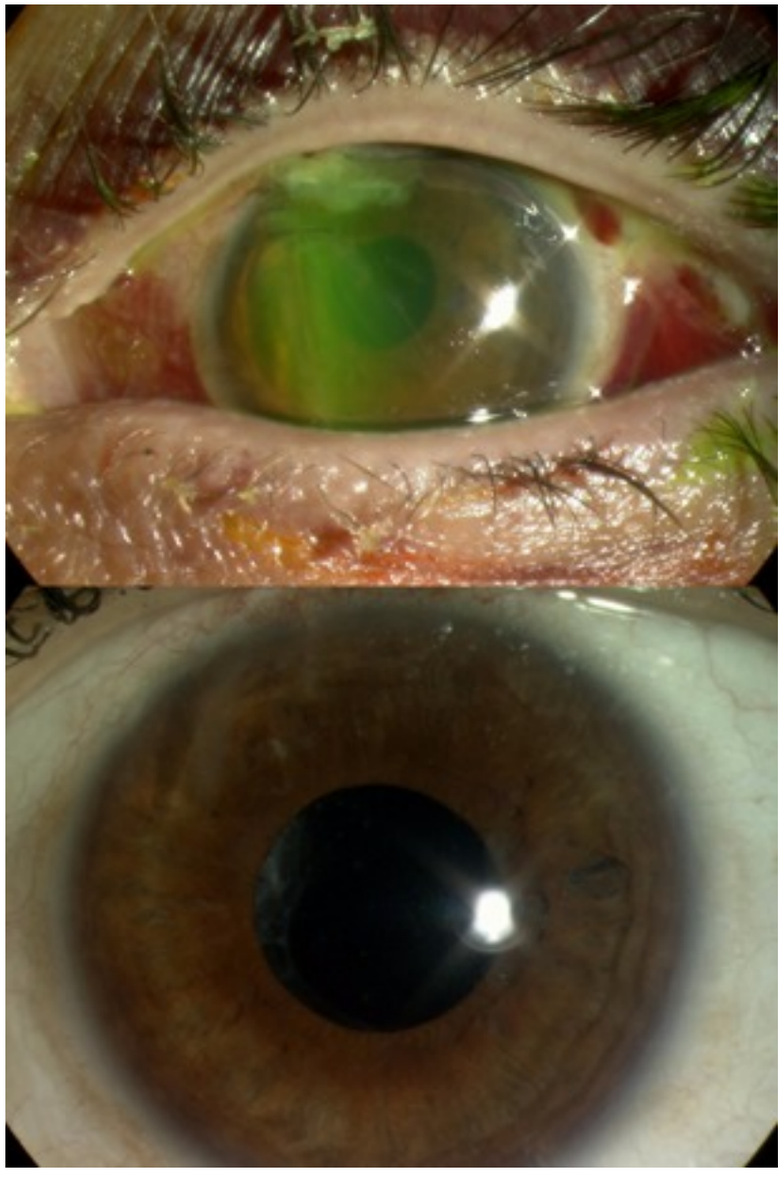
Suture Tension

Tension in the sutures should be sufficient for watertight apposition of wound edges without inducing excessive astigmatism.

Judging suture tension in a collapsed globe is very difficult. A suture that seems to simply appose wound edges may be too tight once a watertight wound has been achieved.

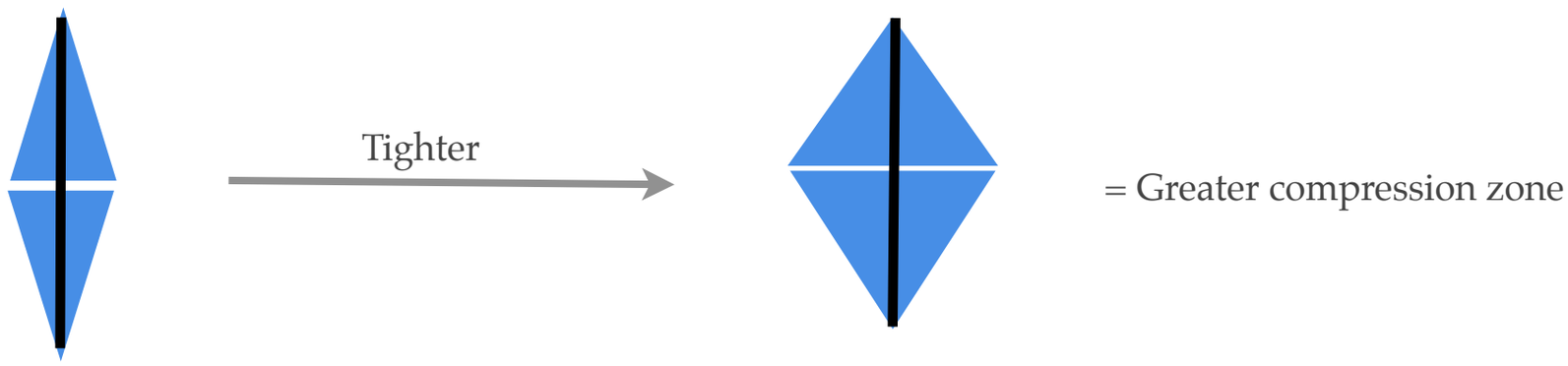
This can be judged by the appearance of stress lines in the cornea radiating away from the suture and bunching of tissues.

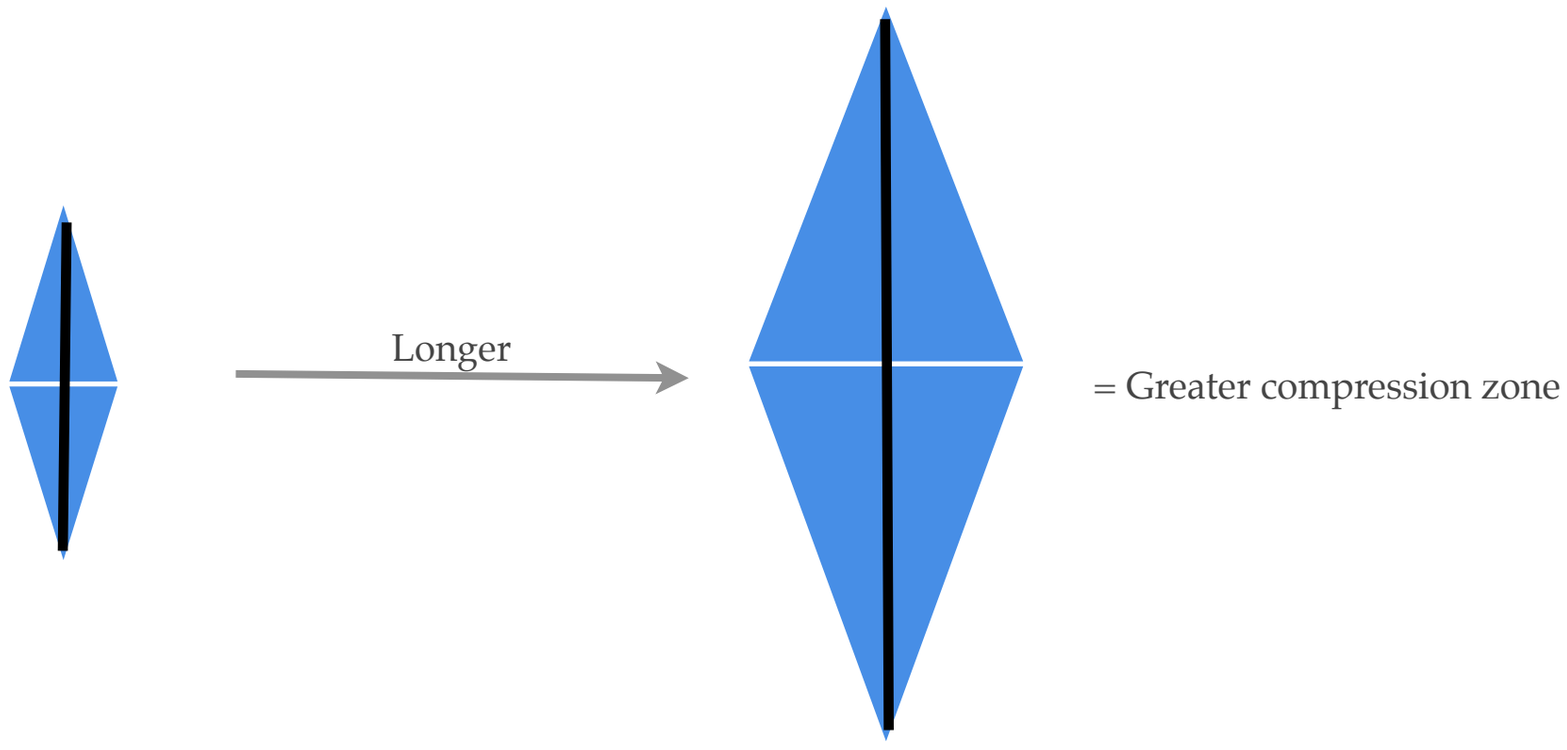
It is often necessary to replace tight sutures at the end of the case once the eye is reformed.



Compression Zones

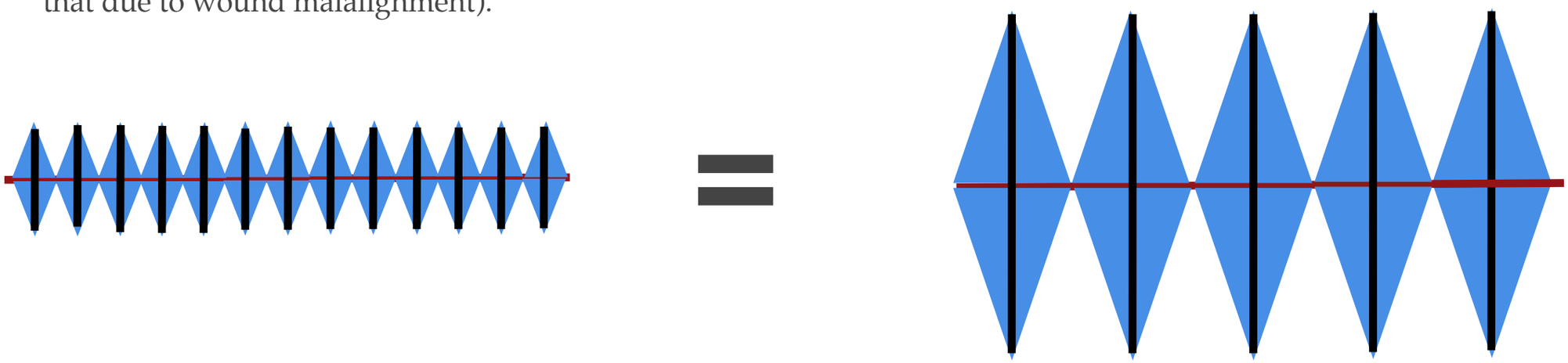
The compression zone of a suture is the area of the wound that is closed by the suture.
This is a function of the length and tension in the suture. In other words the longer and tighter the suture the greater the length of the wound the suture will appose effectively.





Compression Zones

From this it follows that less sutures are required to close a wound if the sutures are longer. Shorter sutures may induce less astigmatism but are more difficult to turn when burying the knots. Furthermore astigmatism induced by tissue compression disappears when the sutures are removed (unlike that due to wound malalignment).



Continuous Sutures

Running (or continuous) sutures have some advantages over interrupted sutures:

1. They produce tissue compression in multiple meridia and even tension along a wound.
2. They can be placed relatively quickly.

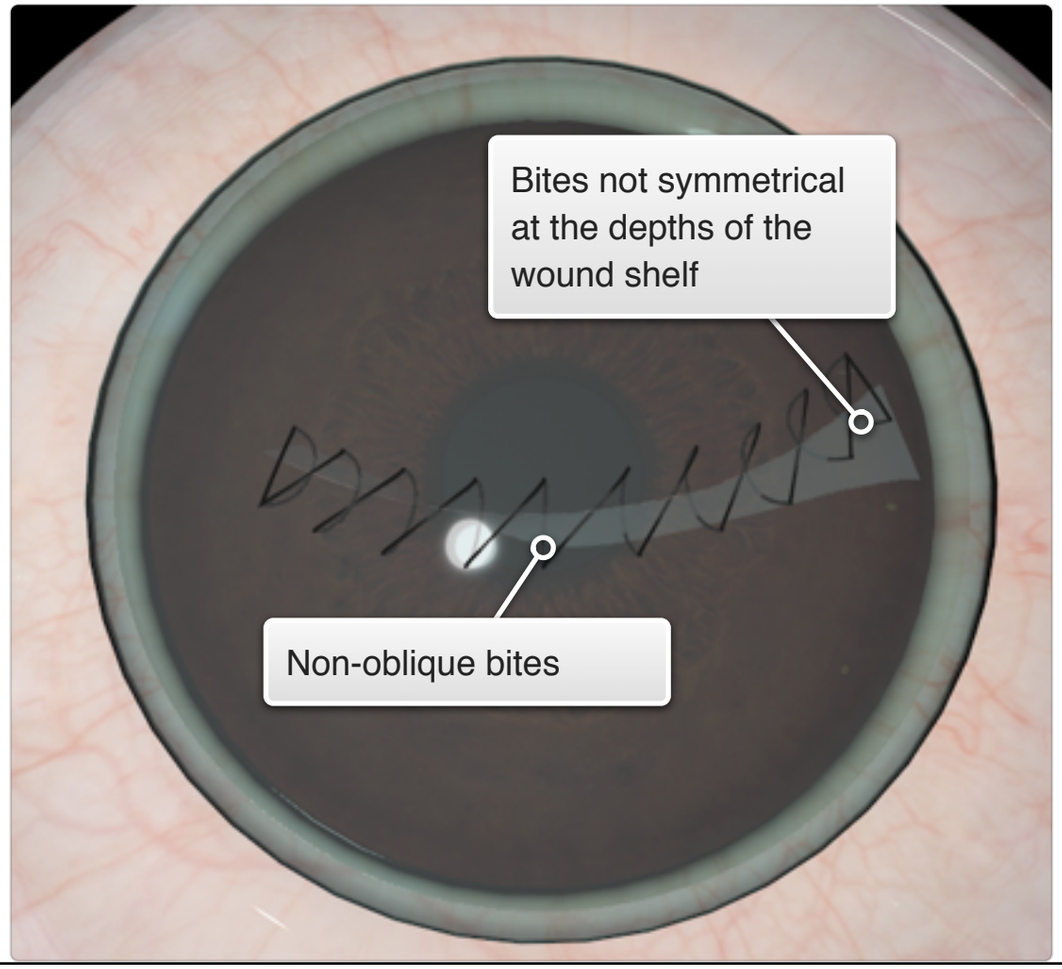
Running sutures have a number of disadvantages. In particular it is not possible to replace individual sutures if the alignment or tension is incorrect or to vary the wound tension with the wound architecture (i.e. degree of shelving).

There are a number of other caveats in the use of running sutures to reduce induced astigmatism:

They should be linear (even if the wound is not) as otherwise they will tend to straighten when tied inducing astigmatism.

The suture bites should be oblique rather than perpendicular to avoid inducing lateral wound shift when the suture is tightened.

Gallery 2.5 Badly sutured section.There are many errors in this repair. The wound has variable shelving but the tension in a running suture cannot be varied. The running suture is non linear. The bites are not oblique. In addition some of the bites are not symmetrical at the depth of the wound (arrow). This wound is not really suitable for a continuous suture and it would have been better closed with interrupted sutures.

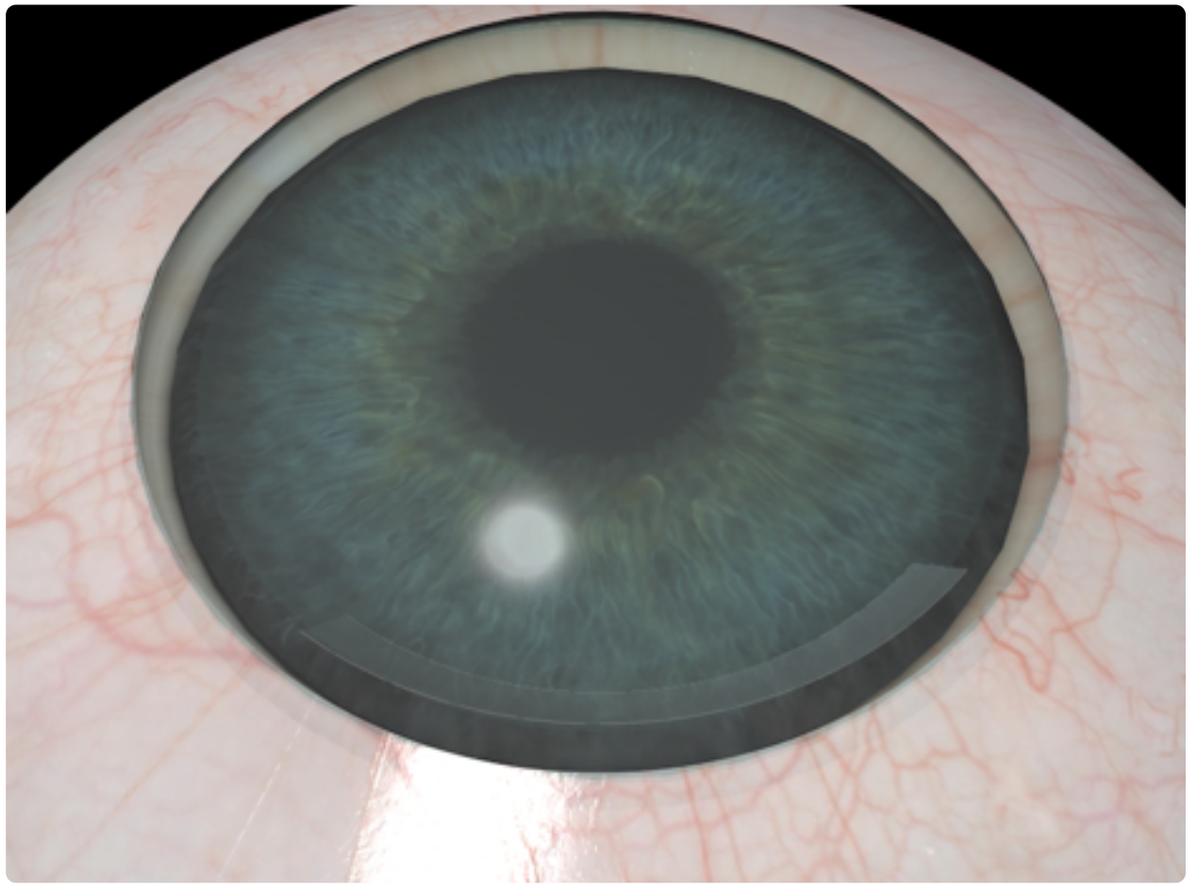


Running Sutures

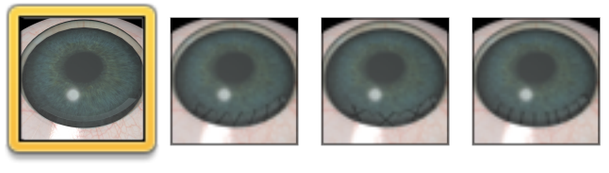
Running sutures are best used for circumferential linear wounds with relatively little shelving Suture bites should be obliquely oriented to reduce lateral wound shift. This may be achieved with either:

1. A boot lace suture.
2. A single running suture tied to loops to bury the knots at either end.

Gallery 2.6 When to use a continuous suture

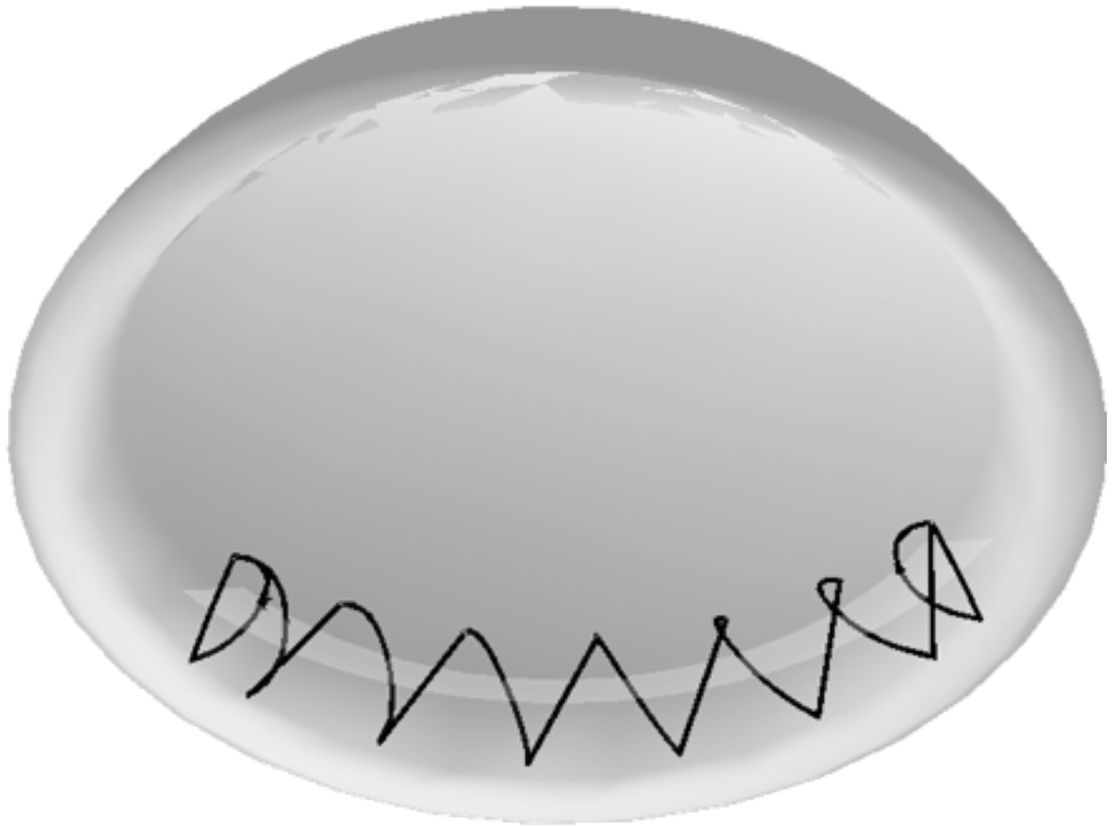


Peripheral linear circumferential wound suitable for a continuous suture.



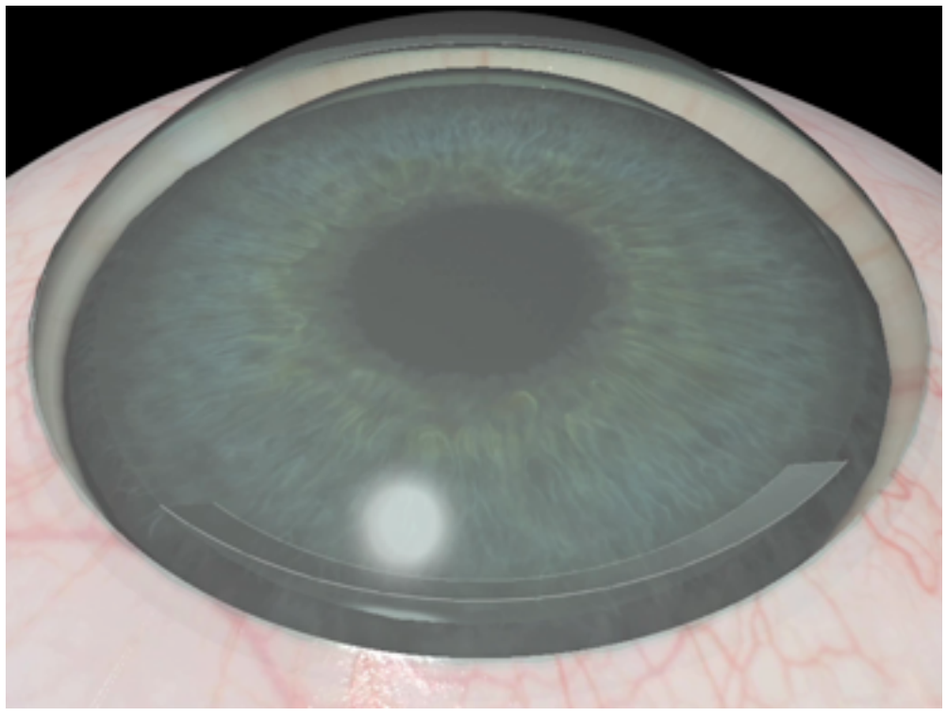
Single Running Suture

Interactive 2.4 The anatomy of a running suture



Interactive three dimensional model. Note the oblique bites.

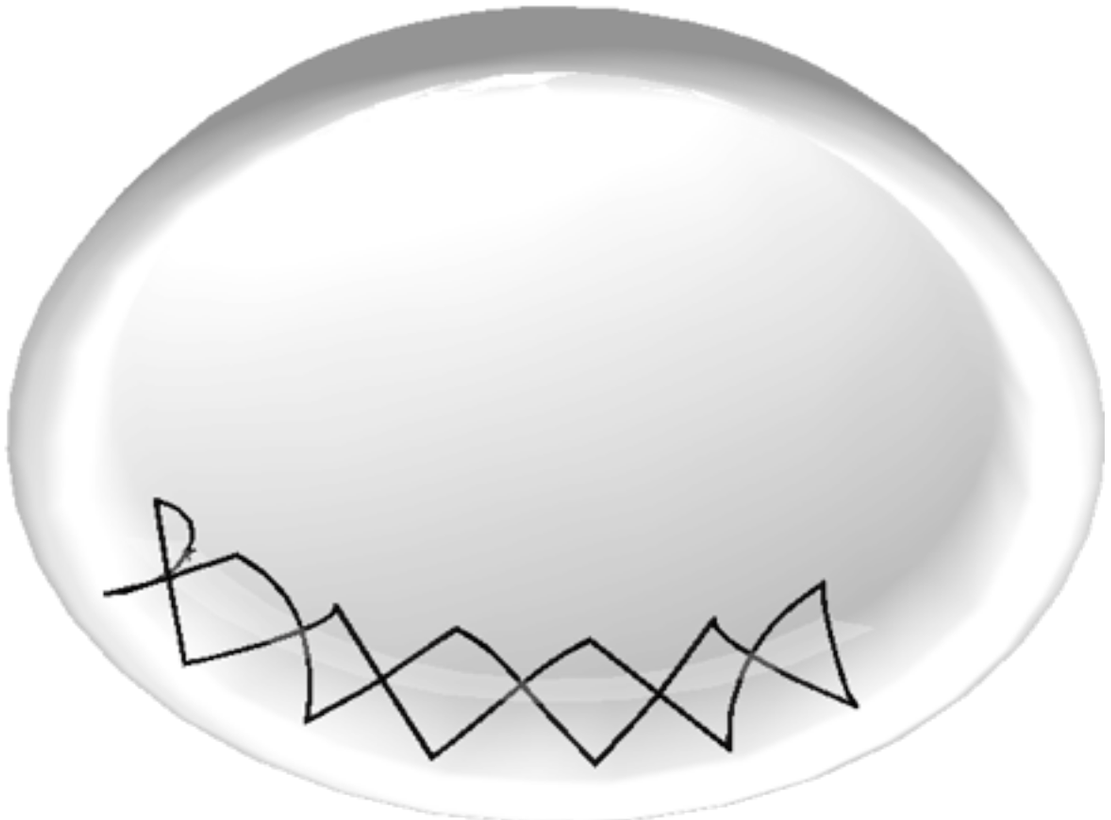
Movie 2.16 How to place a single running suture



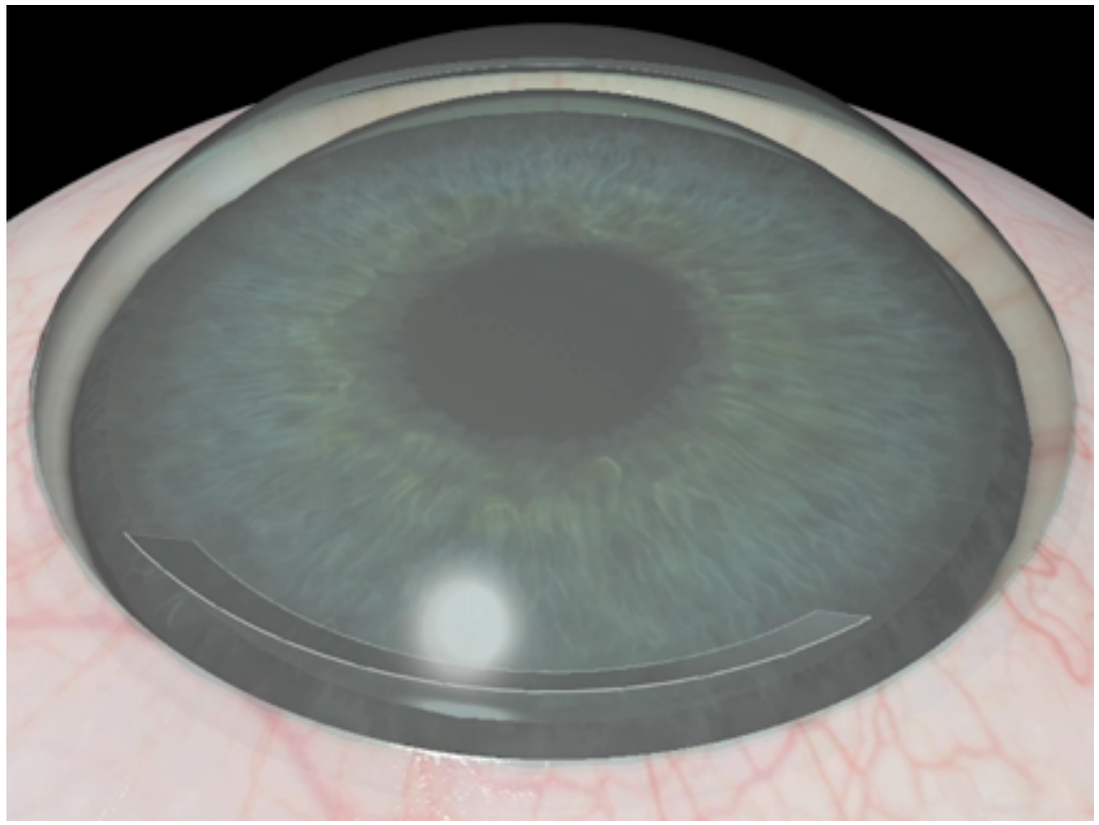
The process for tying off the ends is not accurately depicted here. A loop from the neighboring bite is pulled out of the wound and tied onto the end giving a buried knot.

Bootlace Suture

Interactive 2.5 Anatomy of a bootlace suture



Movie 2.17 How to place a bootlace suture.



Notice that the suture starts and ends in the wound. It is usually necessary to pull on the loops starting at the distal end of the wound before tying the knot, just as one does when tying bootlaces.

Knowledge Review

Review 2.1 Knots

The following statements are true of knots tied during repair of ocular trauma

- **A.** A surgeon's knot is the most difficult to turn and bury
- **B.** Slip knots and locking knots may both be used to tie knots under tension
- **C.** While tying a surgeon's knot the short end is pulled in the same direction after each throw.

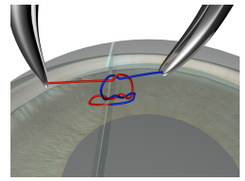
Review 2.3 Continuous Sutures

The following statement is true of running or continuous sutures.

- **A.** Lateral wound shift is minimized by placing the suture bites perpendicular to the wound
- **B.** They do not induce straightening of a curved wound.
- **C.** A bootlace suture has a knot at each end
- **D.** Continuous sutures compress tissues in more than one meridian

Review 2.6 Knots

Which term best describes this knot?



- **A.** Surgeon's knot
- **B.** Dangel knot
- **C.** Granny knot
- **D.** Reef knot

Review 2.2 Wound Alignment

Which of the following statements is correct?

- **A.** Corneal and scleral elasticity are sufficiently high that wound alignment is unimportant
- **B.** The 50% rule is useful in lateral alignment of circumferential wounds
- **C.** Internal wound gape due to insufficient suture depth does not affect corneal transparency
- **D.** It is important to avoid eversion of wound edges while placing corneal sutures.

Review 2.4 Wound Alignment

In a corneoscleral laceration the first suture should be placed in:

- **A.** The corneoscleral limbus
- **B.** The cornea
- **C.** The scleral

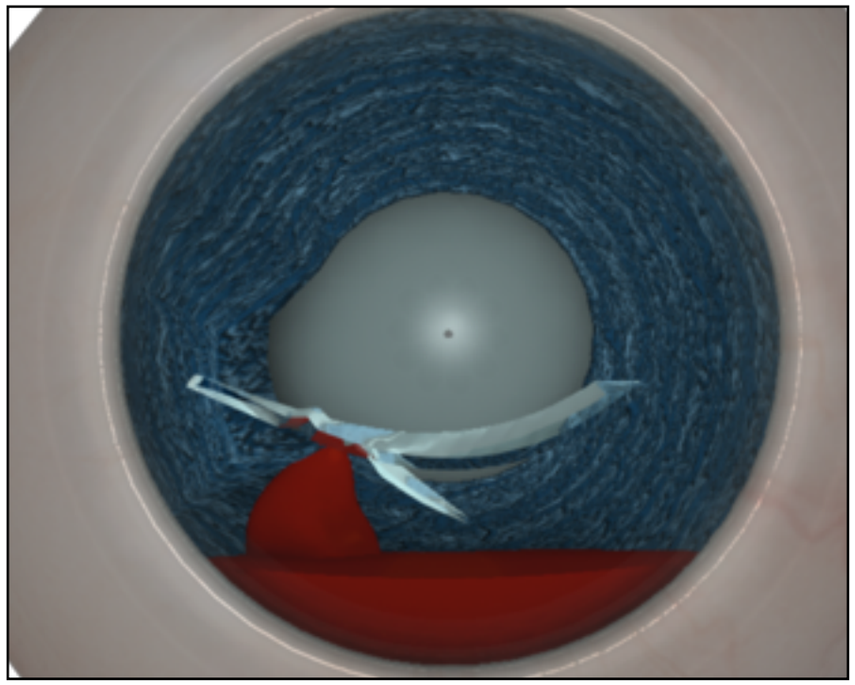
Review 2.5 Suture tension

Which of the following is NOT an indication for increasing tension in sutures

- **A.** Shelving section
- **B.** Non-shelving section
- **C.** Wound edema
- **D.** Combined primary repair and vitrectomy removal of intraocular foreign body.

CHAPTER 3

CORNEAL WOUNDS



Corneal lacerations may be very simple but often have a star shaped appearance with a complex series of forks and a configuration which is shelving in some areas, non-shelving in others. Each part of the complex wound illustrated above presents different challenges and the suturing technique is modified accordingly.

Use of Viscoelastics

Viscoelastic is used to reform the anterior chamber:

A paracentesis site is chosen away from the wound.

The eye is grasped with a toothed forceps near the paracentesis site (not 180^0 away as one would generally in a non trauma case).

A sharp blade such as a diamond blade or MVR blade is used to create the paracentesis.

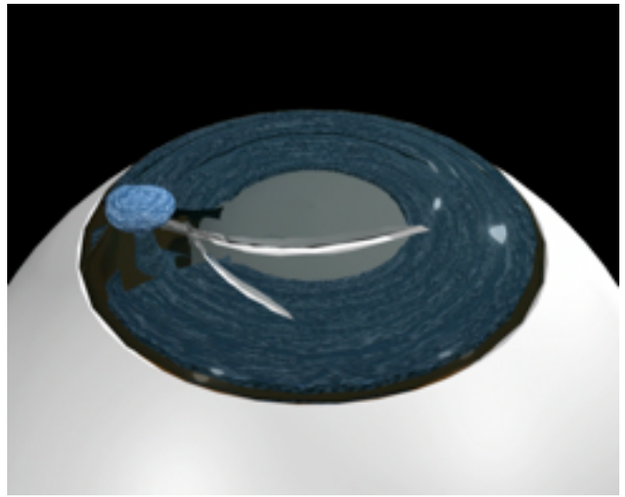
Cohesive viscoelastics maintain intraocular chambers more effectively than dispersive viscoelastics. They are therefore more useful in trauma cases.

The viscoelastic is injected in front of the iris to reform the anterior chamber. Iris trapped in the wound can be freed with a sweeping movement while injecting.

Excessive injection of viscoelastic can result in a firm globe which may be difficult to close.

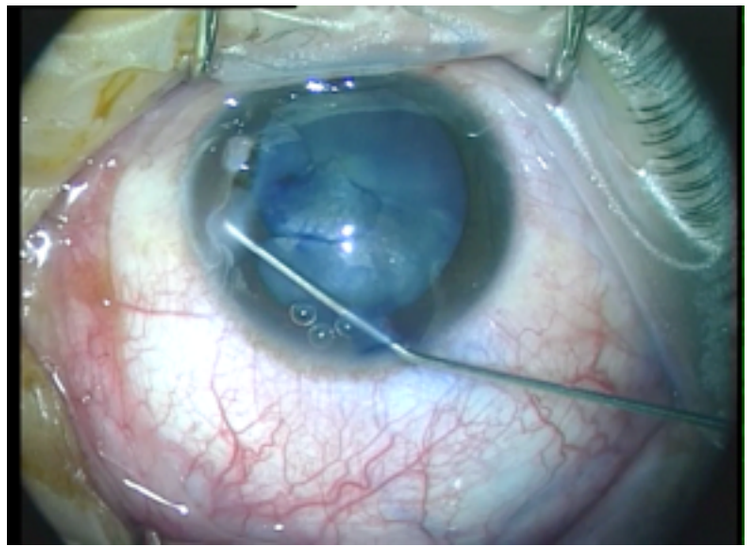
Excess viscoelastic may spill out of the wound onto the surface of the eye. This can make suturing difficult. Irrigate the cornea with saline to remove excess viscoelastic before suturing.

Movie 3.1 Creation of paracentesis



A sharp blade is used while grabbing the limbus near the entry point.

Movie 3.2 Viscoelastic injection

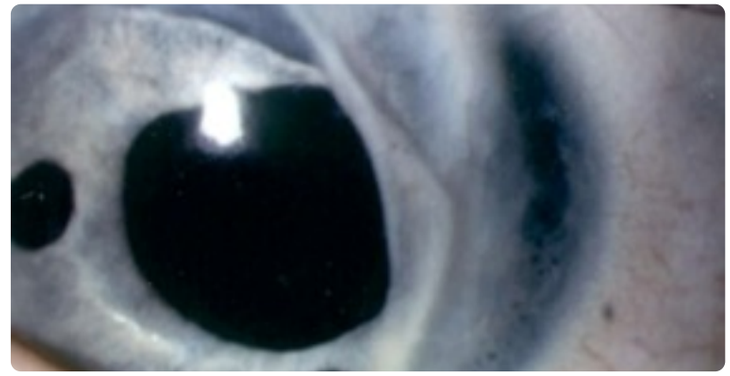


Sweeping movements of the cannula can be used to disengage incarcerated iris.

Preserving Iris

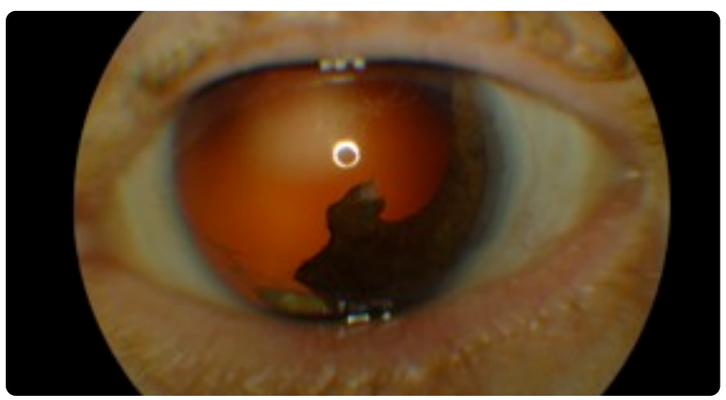
Preservation of the iris diaphragm is an important goal in trauma repair.
It is rarely appropriate to excise prolapsed iris. The exception to this is long standing prolapse with epithelialisation of the iris.
Iris vitality can be confirmed in most cases by observing fasciculation with very low power diathermy.
The technique for iris reposition was described in the previous section.
Recurrent iris prolapse can occur if excessive viscoelastic accumulates behind the iris.
Iris reconstruction is dealt with in Chapter 7.

Image 3.1 Preserving iris



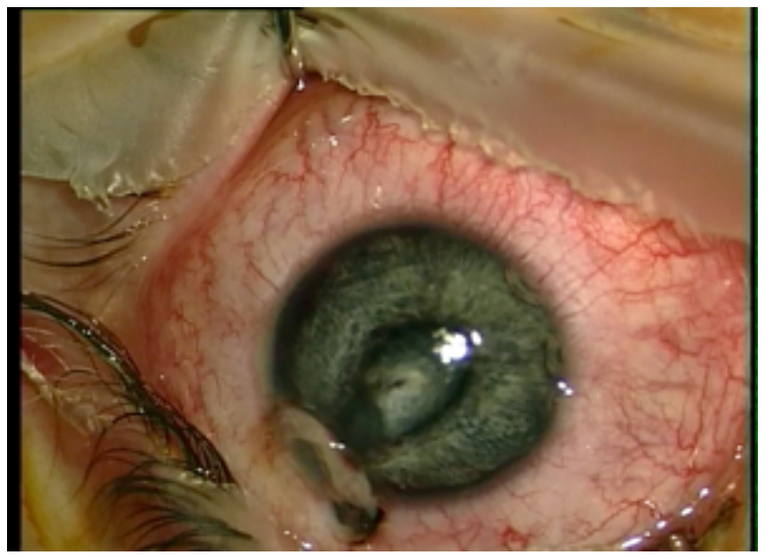
Preservation of iris diaphragm. In this case protecting the cornea from contact with silicone oil in the vitreous cavity.

Gallery 3.1 Traumatic iris defects



Major defect in the iris diaphragm.

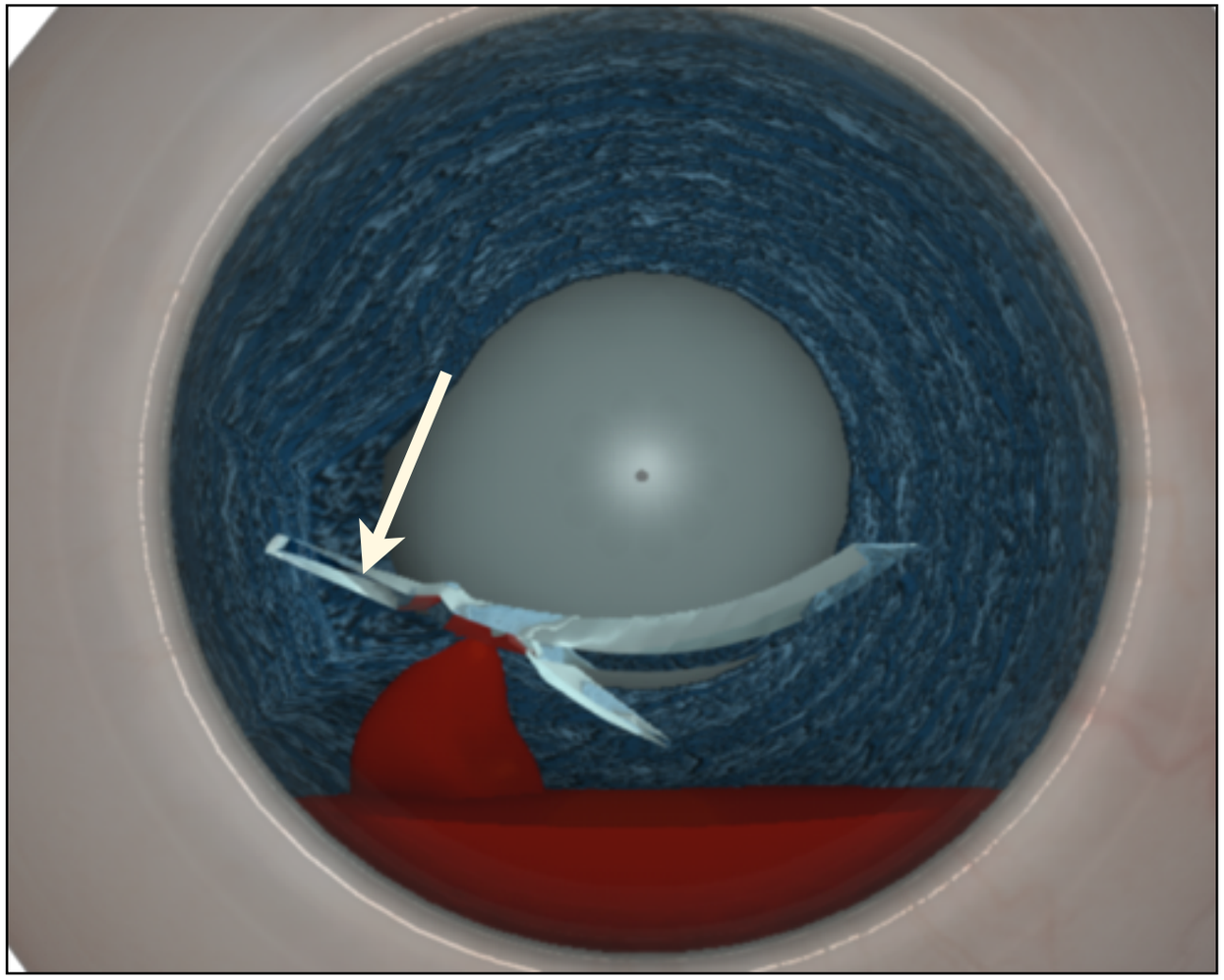
Movie 3.3 Preserving the iris



Reposition of iris to preserve iris diaphragm.

Non-Shelved Wounds

Non-shelved areas of the wounds have no self sealing properties. Some compression is required to close the wound so the sutures have to be tied under a little tension.
Sutures can be tied under tension using slip and locking knots as described in the previous section.

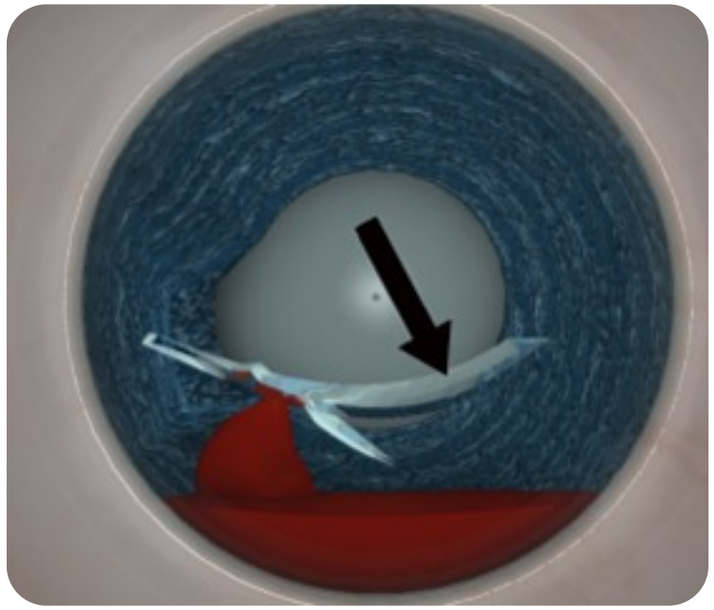


Shelved Wounds

Shelving wounds tend not to leak and require minimal suture tension. The role of the suture is simply to produce and maintain wound apposition. Care needs to be taken however with suture placement to prevent wound override.

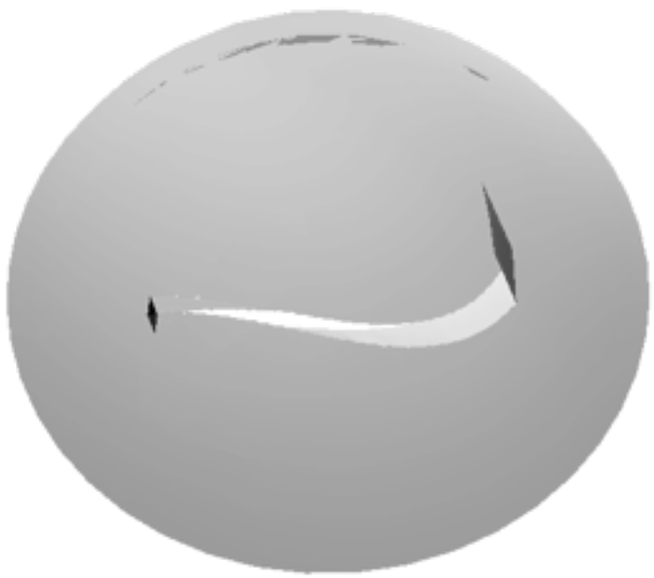
A shelved corneal wound

Image 3.2 Shelved corneal laceration



The arrow indicates the shelved section.

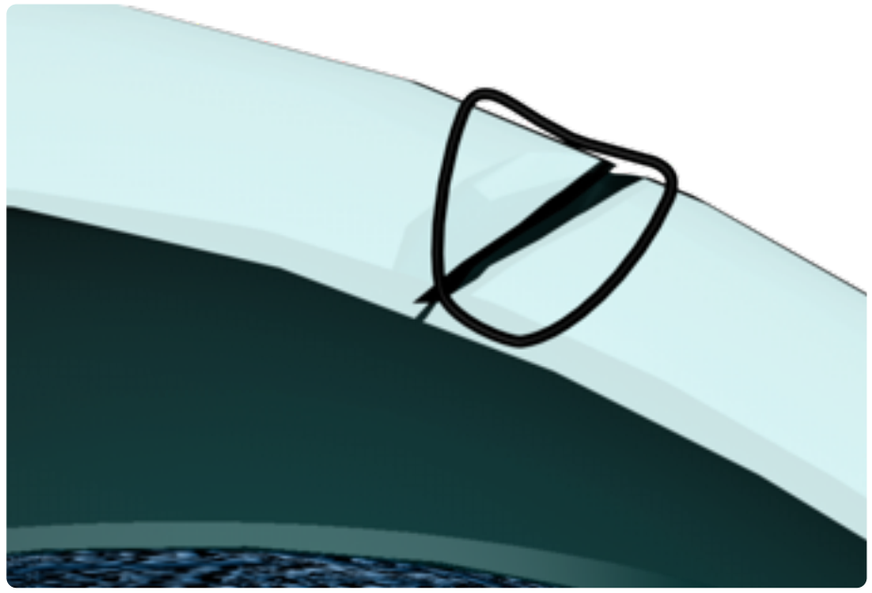
Interactive 3.1 Wound shelving



Shelved Wounds: override

To avoid wound override ensure the bites are symmetrically placed at the deeper parts of the wound.

Gallery 3.2 Correct and Incorrect suturing of shelved laceration

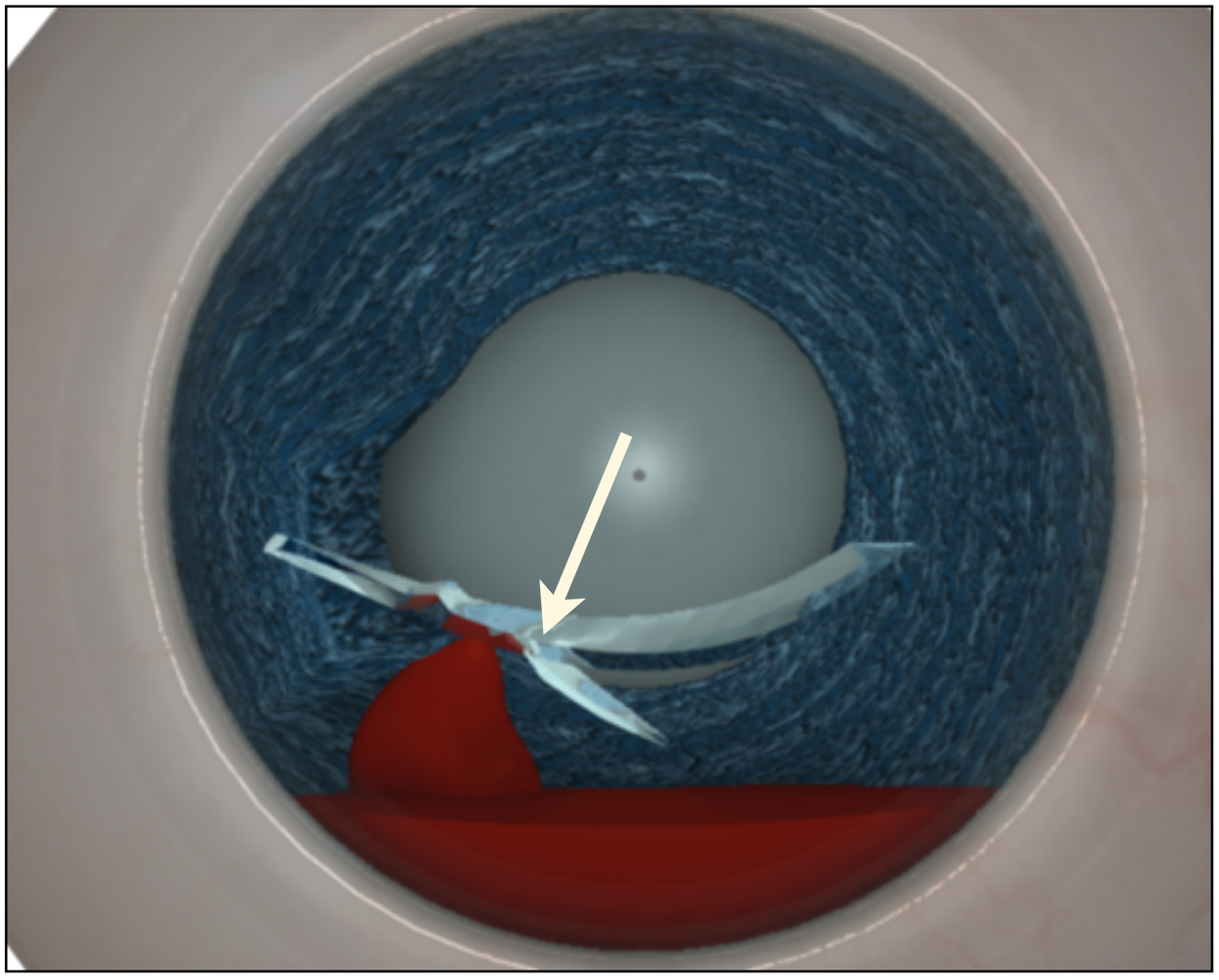


Incorrect suture placement: although the suture seems symmetrically placed with respect to the surface of the wound the deeper asymmetry may result in override when the suture is tightened

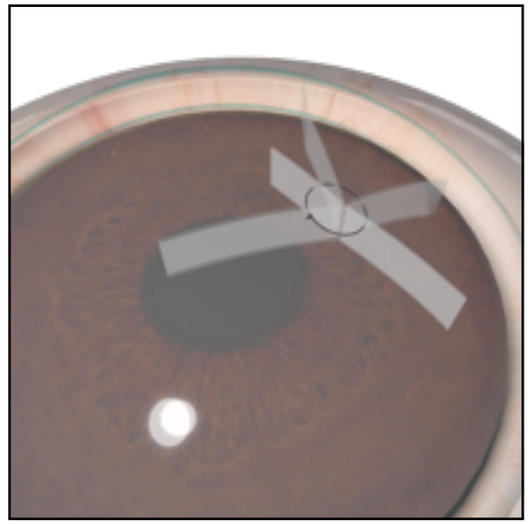
Stellate Lacerations

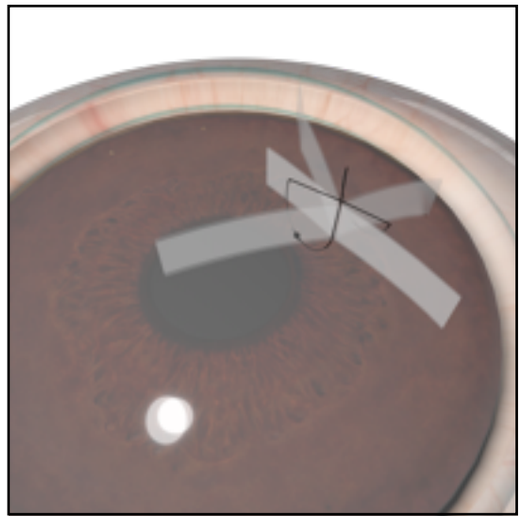
Corneal lacerations often have irregular forks producing a star shaped (stellate) configuration.

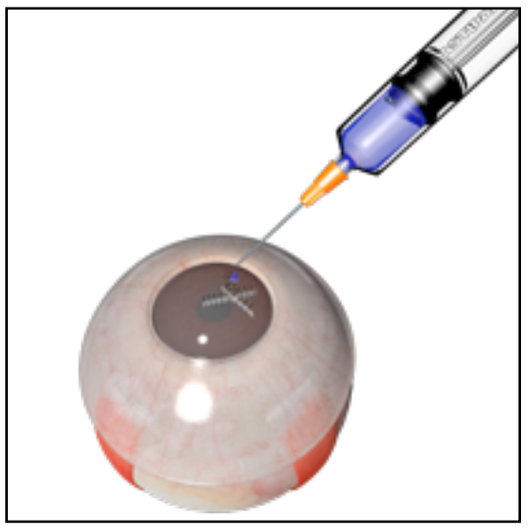
These forks in the wound can be difficult to close particularly if they are also non-shelving.



Stellate Lacerations







There are many approaches to the problem of wound forks including running sutures, purse string sutures, overlay sutures, butterfly sutures and multiple linear sutures.

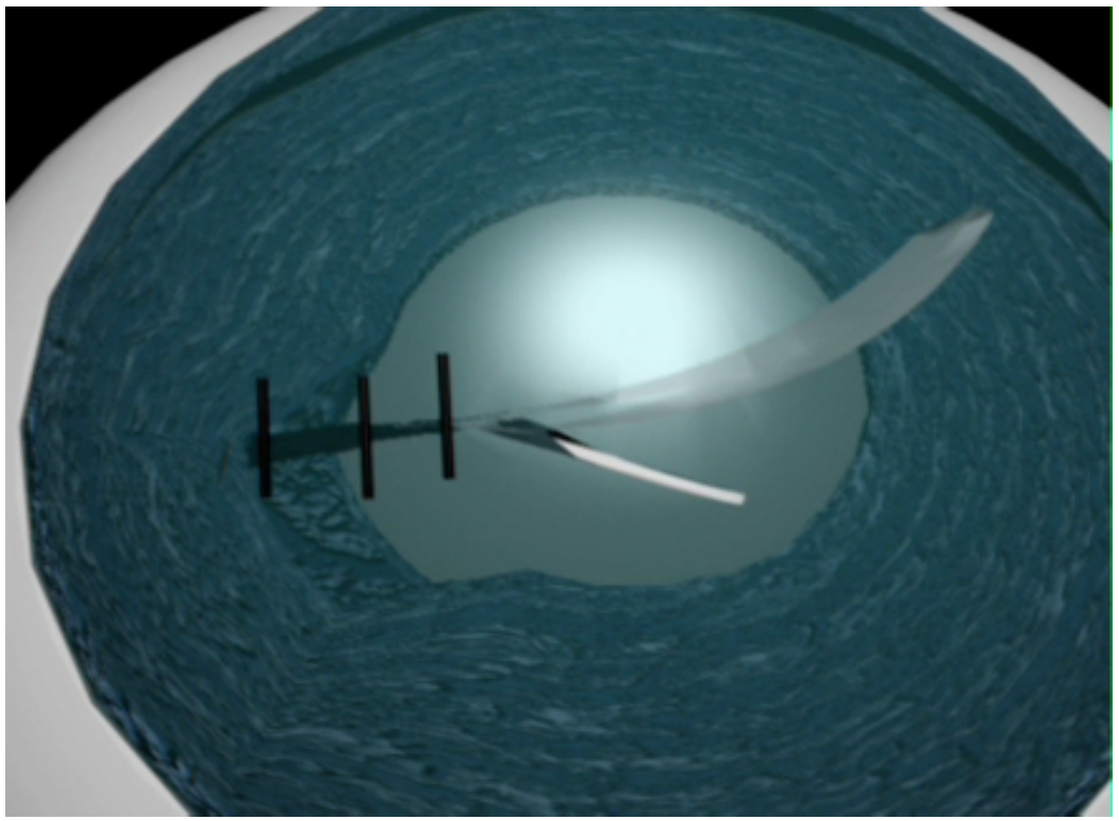
The choice depends partially on the degree of shelving but also on individual surgeon preference.

Corneal glue may also be employed as an adjunct to suturing.

The Problem with Stellate Lacerations

Stellate wounds are prone to leak at the forks in the wound unless these are shelved. Simply placing a very tight suture at the fork often fails to solve this problem. It produces tissue compression in a single meridian only. This may simply cause wound distortion, opening up other areas of the wound.

Movie 3.4 Effect of a tight suture on a stellate fork

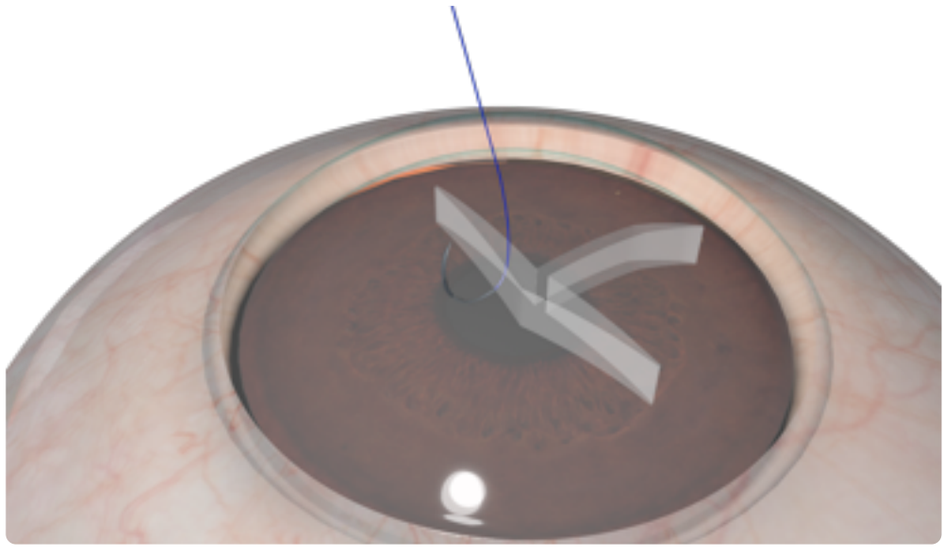


The tight suture here distorts tissues in a way that opens up other areas of the wound.

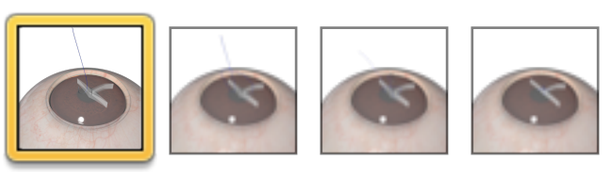
Butterfly Sutures

A butterfly (figure of 8) suture solves this problem by producing tissue compression in multiple meridia. The suture is initiated inside the wound so that the final knot is buried.

Gallery 3.3 Tying a butterfly suture

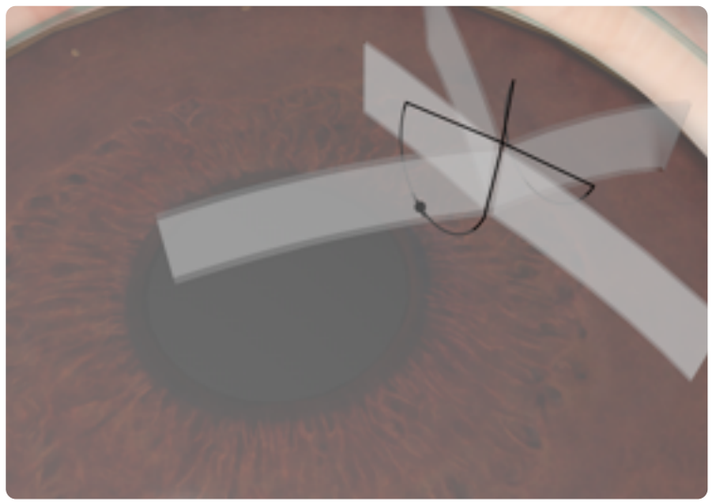


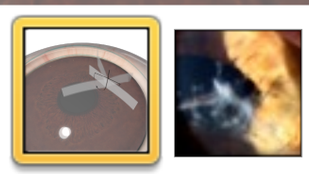
The stages of tying a butterfly suture. Note the knot is buried at the end.



Gallery 3.4 Butterfly (figure of 8) suture at wound fork.

A star shaped (or butterfly, figure of 8) suture. Note that the knot is buried inside the wound.



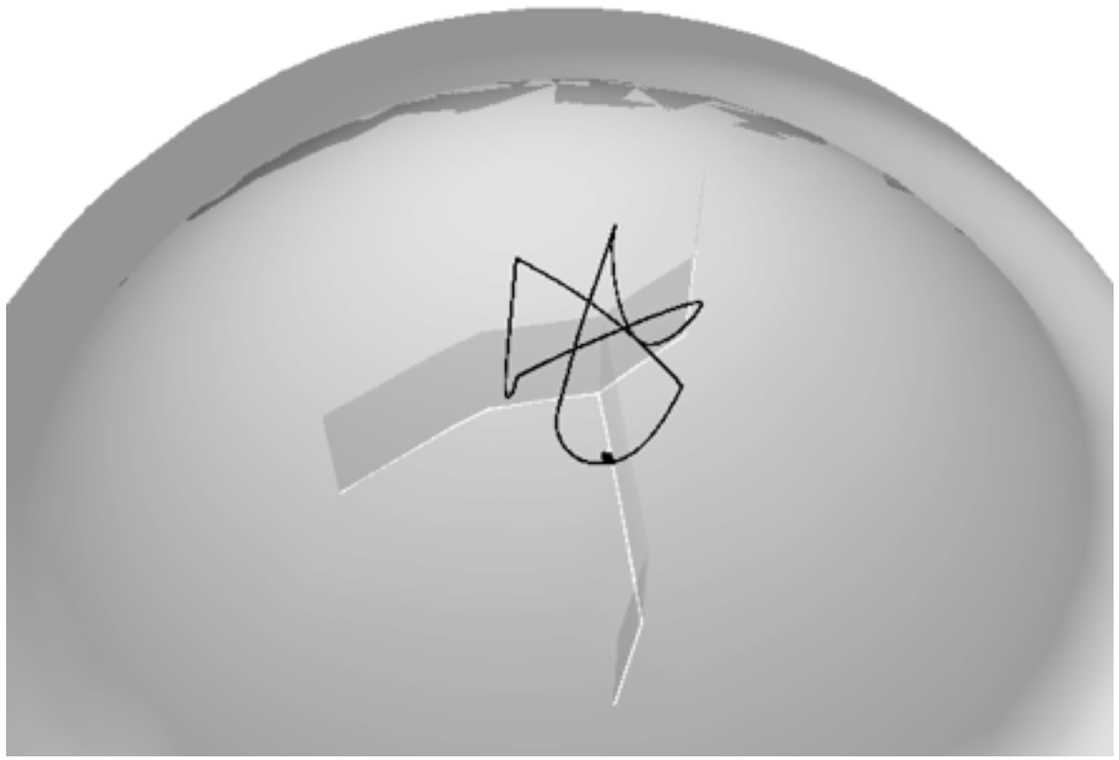


Interactive 3.2 The anatomy of a butterfly suture

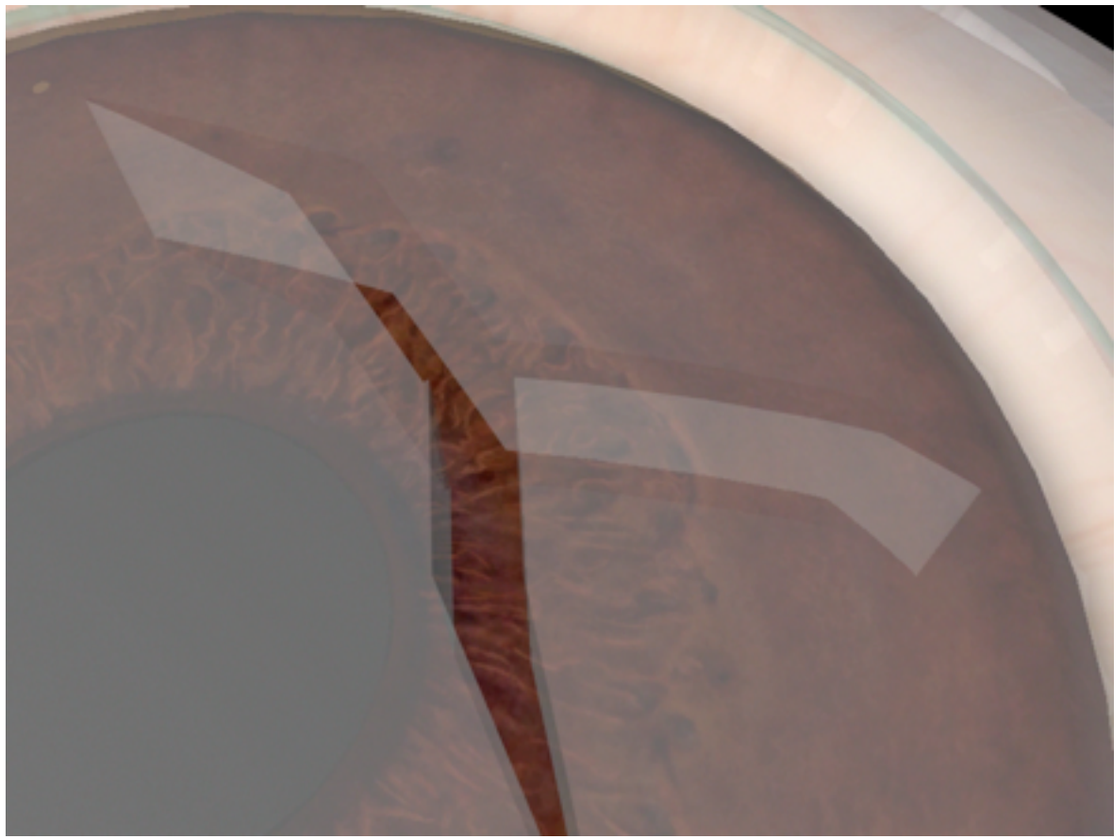
Star Shaped Sutures

Akkin and coauthors have described a more sophisticated variant of the butterfly using a star shaped suture to close stellate lacerations. The first pass starts inside the wound and the next bite is a full thickness clockwise bite across the opposing fork. A full thickness bite is then made in an opposing fork before returning to the fork next to the one originally sutured. The final bite is half thickness in the original fork to allow the knot to be buried inside the wound.
This is a relatively easy way of achieving excellent wound alignment and closure of wound fork.

Interactive 3.3 The Akkin star suture



Movie 3.5 How to tie an Akkin star suture

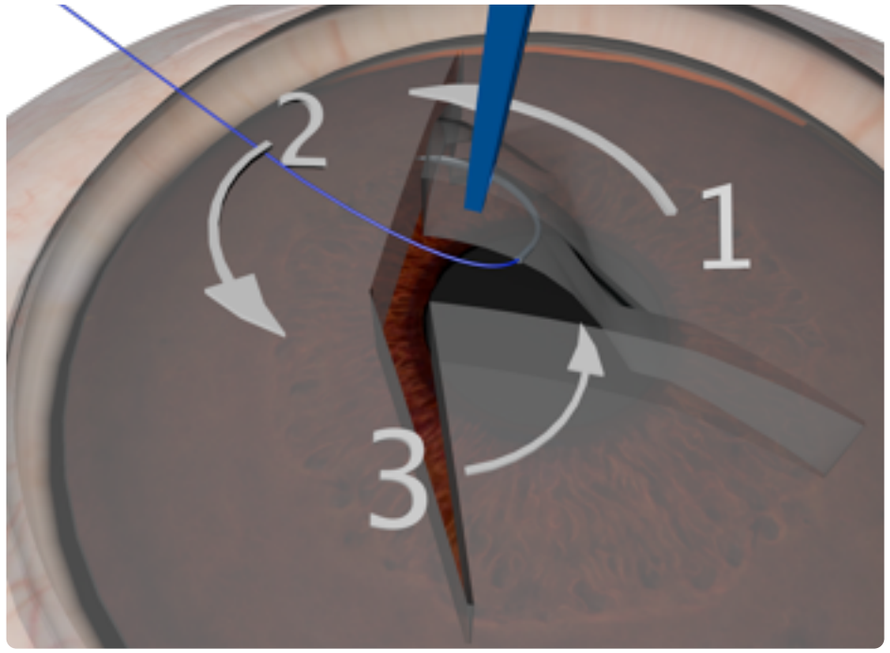


Note that the suture starts and ends inside the wound.

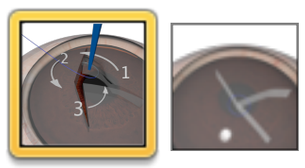
Purse String Sutures

Purse string sutures derive their name from the medieval purses which were closed with a circular drawstring in the seam. They are entirely buried and the circular profile produces even tissue compression in all meridia at the wound fork so they are highly effective in wound apposition.
Purse string sutures can be quite technically challenging to place and align correctly.
Great care must be taken to minimize trauma to the wound edges, especially the apices of the flaps.

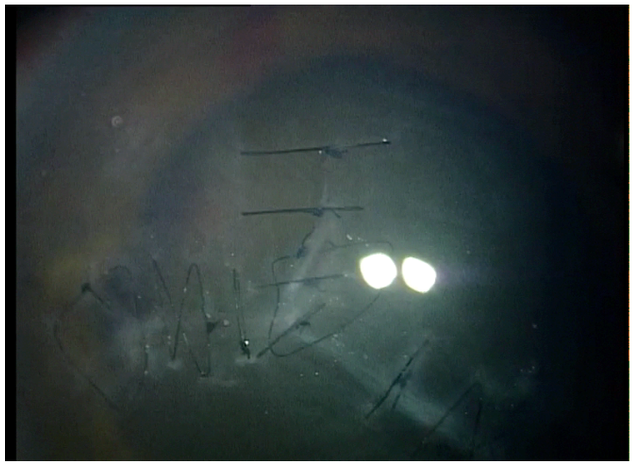
Gallery 3.5 Purse string suture



The suture bites for a purse string are made horizontally within the corneal stroma. Note that the cornea is being grasped away from the thin wound apex.



Movie 3.6 Purse string suture

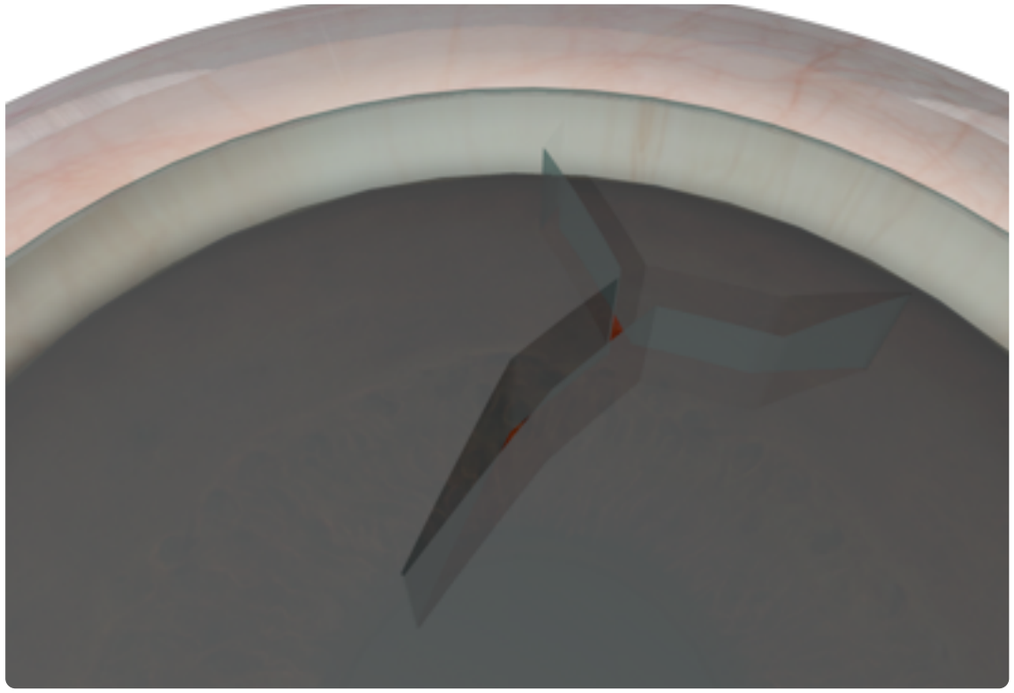


This wound has been closed with a combination of purse strings to the forks and interrupted sutures to the linear segments.

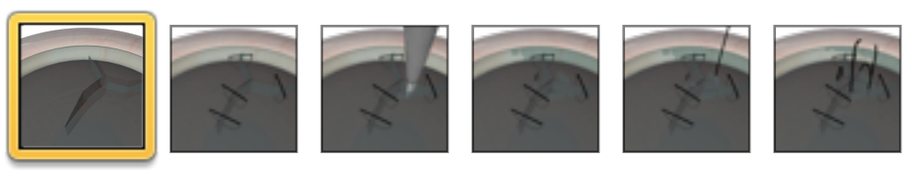
Purse String Sutures - Eisner's Modification

Georg Eisner developed a technique for placing a purse string suture through corneal incisions made around the wound fork.
This is easier if a very sharp blade such as a diamond blade is used and the wound partially closed to restore the IOP.
As with all purse string sutures judging the tension correctly is critical as over-tightening can cause central tissue to herniate forward. Use of a slip knot allows the tension to be adjusted if this occurs.

Gallery 3.6 The Eisner purse string



An open stellate wound.



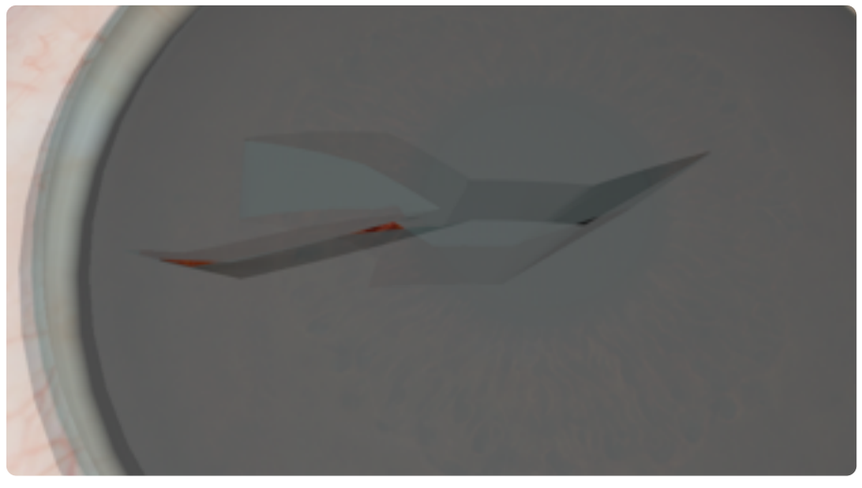
Stellate Lacerations With Thin Flaps

The flaps of shelved stellate wounds are sometimes very thin. These are vulnerable to surgical trauma if sutures are placed in them. Wound leak here is unlikely to be a problem in any case because of the shelving.
The surgical goal is simply to reappose the flap to allow healing. A bridging (or overlay) suture can achieve this taking bites either side of the flap.

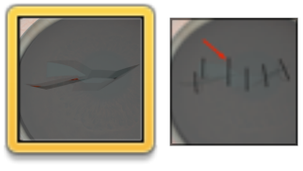
Interactive 3.4 Thin flaps in a stellate wound

Animated three dimensional model to demonstrate the thin flap apices.

Gallery 3.7 Bridging suture



A shelving wound with thin flaps.



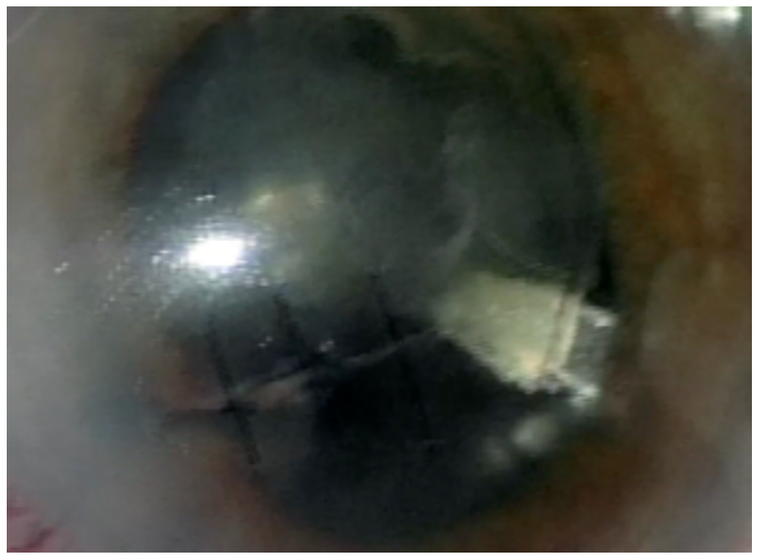
Suturing Under Tension

The importance of wound compression when closing non-shelved wounds has already been emphasized but there are two other situations in which the degree of wound compression may have to be greater than normal:

- When another procedure such as lensectomy or vitrectomy is planned as part of the primary wound repair.

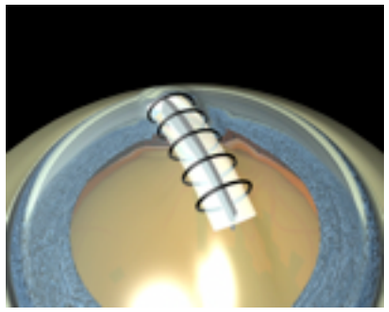
- When tissues are very edematous: otherwise sutures will loosen when the edema subsides.

Movie 3.7 Leaking wound



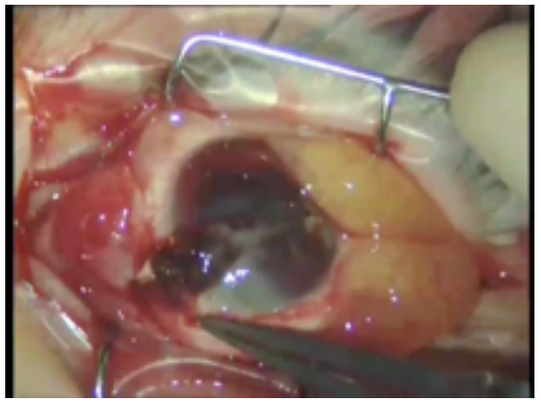
Corneal wound leaking during lensectomy due to loose sutures in non-shelving wound.

Movie 3.8 Wound edema and suture tension



As wound edema resolves sutures may become loose.

Movie 3.9 Suturing in the presence of gross edema



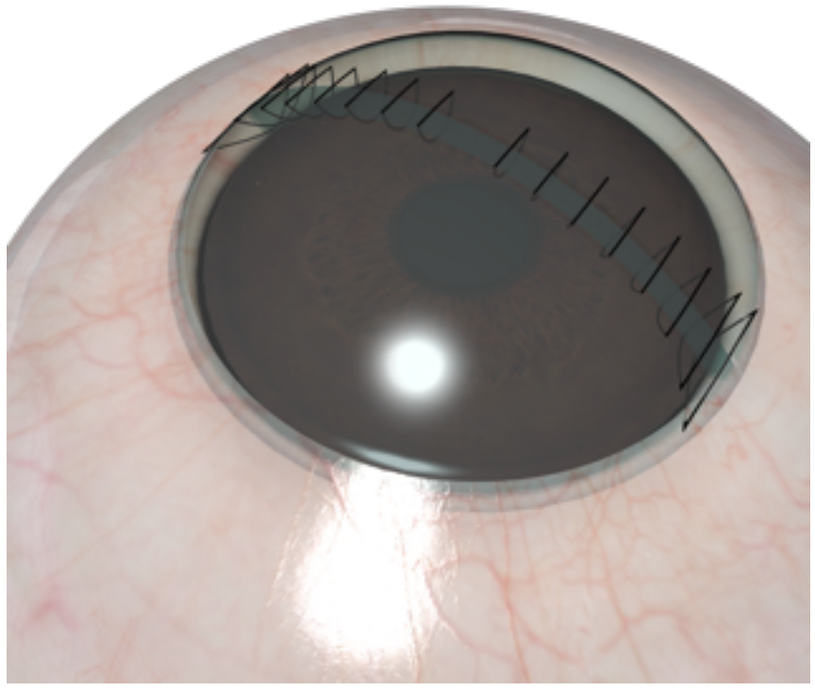
Suturing in the presence of gross wound oedma. Note the tension under which the knots are tied. Note also that there has not been adequate clearing of adherent clot before suturing. An iris repositor is being used to reposit extruded tissue.

Minimizing Astigmatism

Tension in central corneal sutures induces central corneal flattening. This can be reduced using progressively longer sutures for the more peripheral part of the wound (the Rowsey-Hays technique).

The astigmatism induced by tight sutures disappears when the sutures are removed. Astigmatism induced by poor alignment of tissues or wound override is permanent.

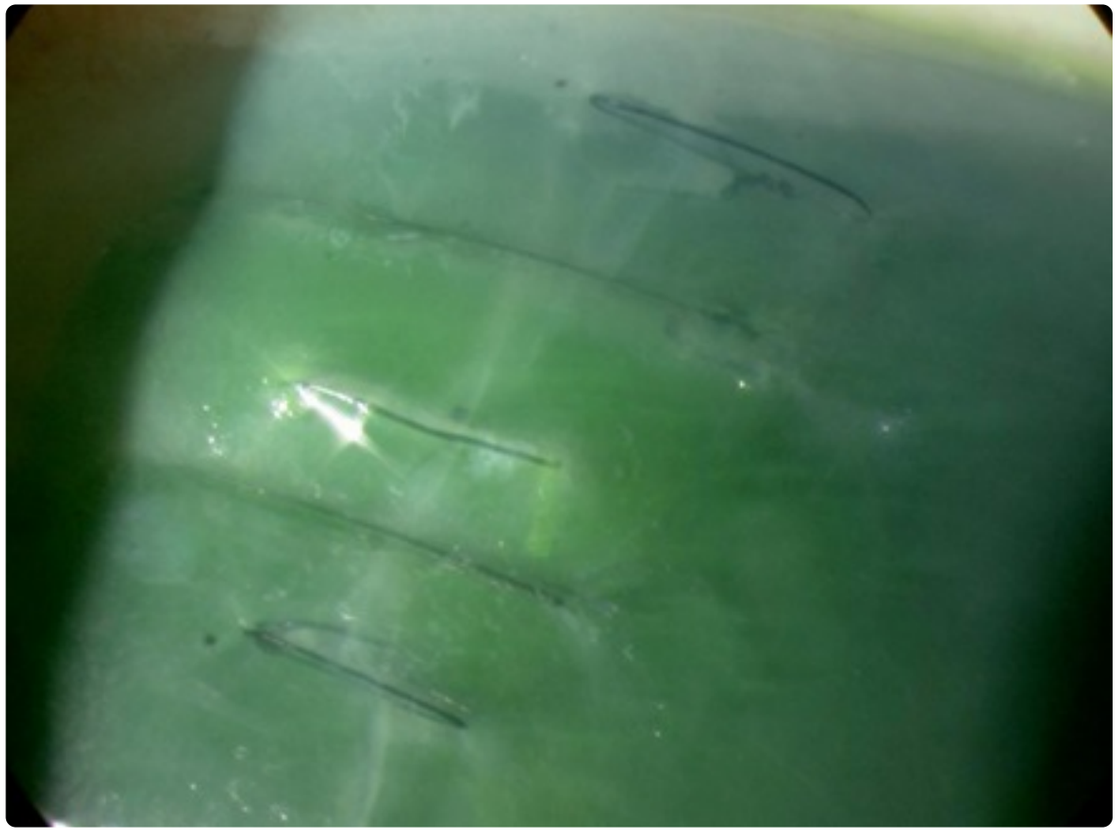
Good wound alignment with prevention of override of shelved sections is therefore the key to minimizing the degree of astigmatism induced by the repair.



Replacing Sutures

Once basic wound integrity has been restored it is often apparent that some sutures are either too loose or too tight (indicated by puckering of the wound edges and stress lines in the cornea).
It is often therefore necessary to replace sutures at the end of the case.

Gallery 3.8 Tight and loose sutures

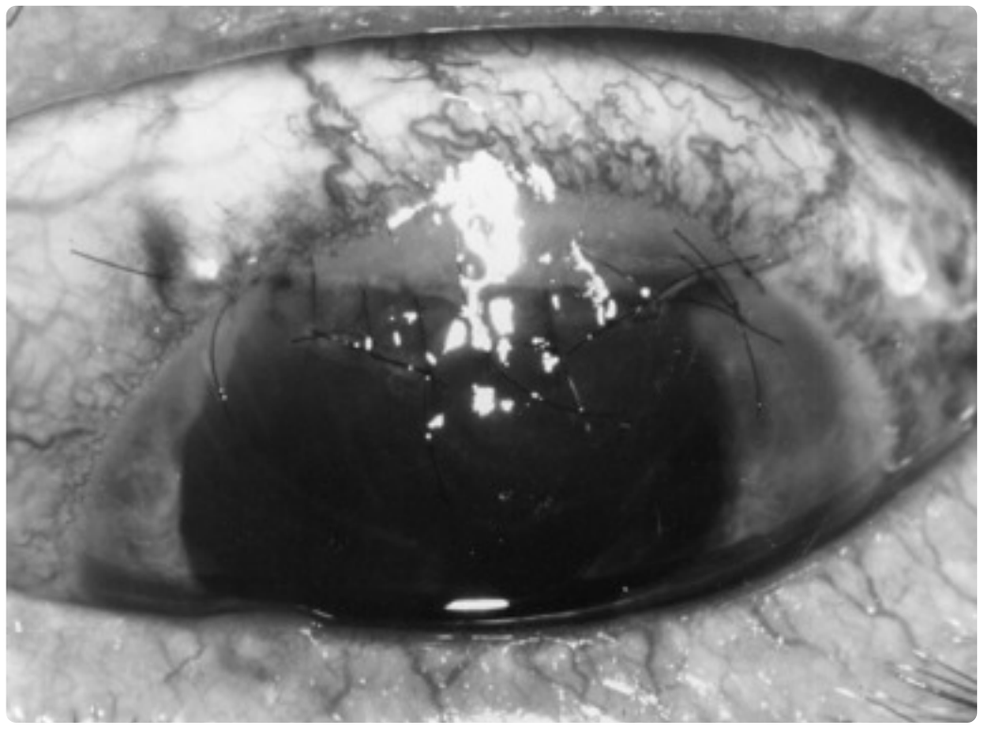


The suture in the middle is loose.

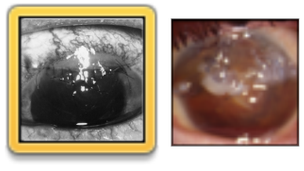
Replacing Sutures

Finally the sutures should be turned to bury the knots. This is much easier if compact knots have been tied. The knots should be buried away from the visual axis because they generally cause some corneal opacification.
Unturned sutures cause many problems including patient discomfort and mucus build up on the suture ends.

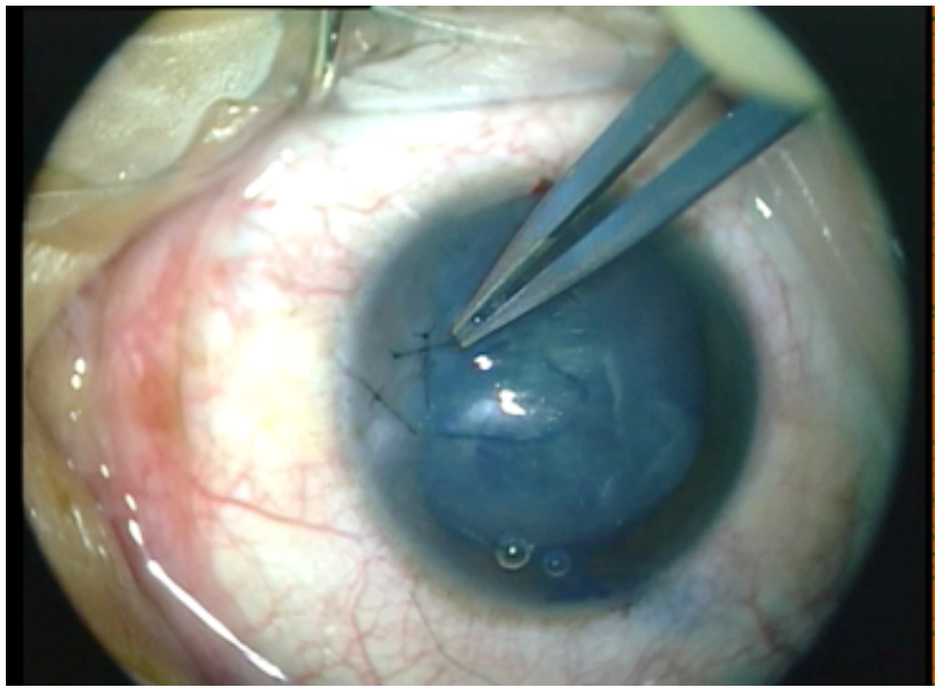
Gallery 3.9 Unturned sutures



Unturned sutures cause patient discomfort and accrete mucus.



Movie 3.10 Burying corneal sutures



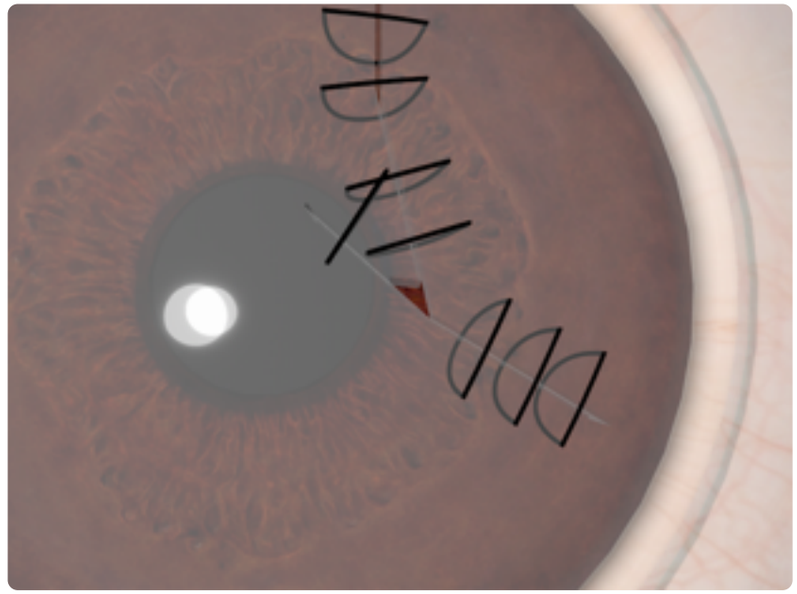
Management of Tissue Loss

Small areas of tissue loss (up to about 0.5 mm) can be managed by suturing alone. The sutures need to produce compression in multiple meridia simultaneously. The sutures employed are similar to those used in management of the apex of a non-shelved stellate laceration. This may induce gross irregular astigmatism which can be dealt with later.

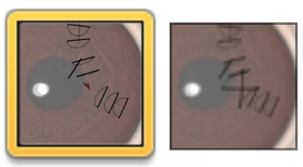
Larger areas of tissue loss generally require some form of corneal graft but this is generally best done as a secondary procedure. Cyanoacrylate and a bandage contact lens may be useful temporizing measures. This allows penetrating or tectonic keratoplasty to be carried out subsequently under optimum conditions.

If there is very extensive loss of sclera and cornea primary enucleation may be the only realistic therapeutic option.

Figure 3.1 Missing tissue



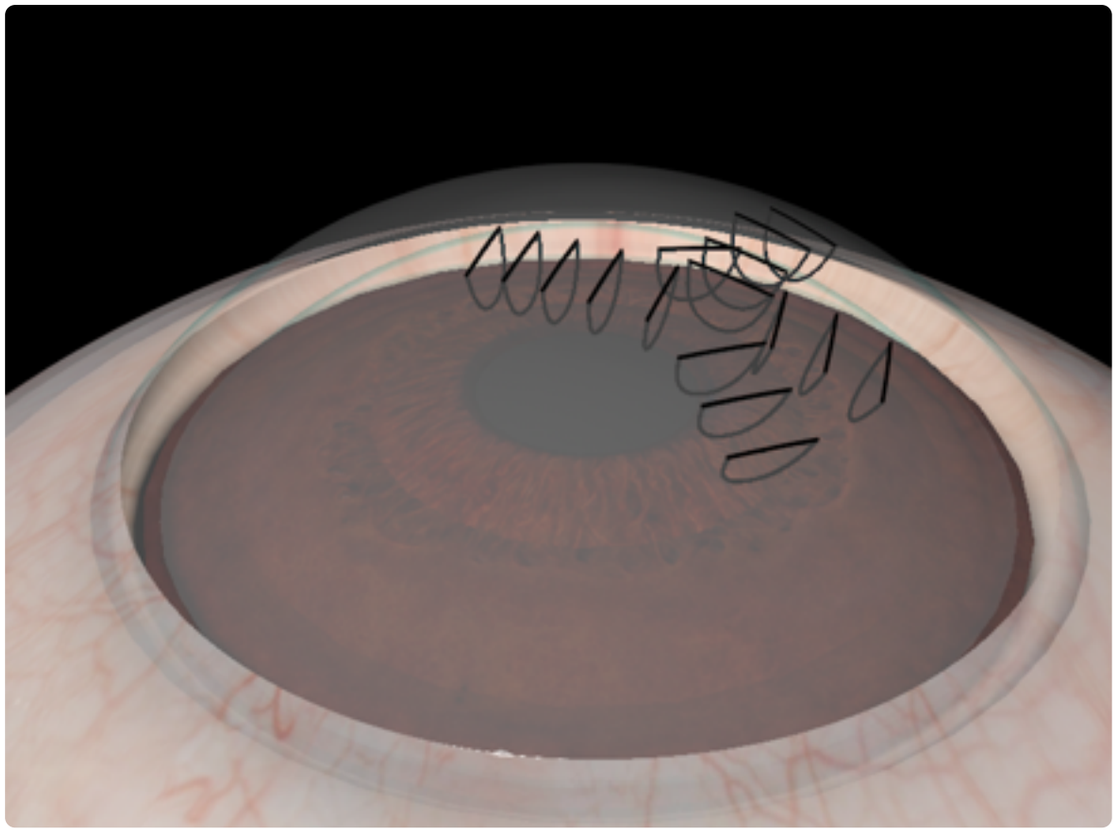
The apex of one of the stellate flaps has been avulsed and there is a small area of tissue loss.



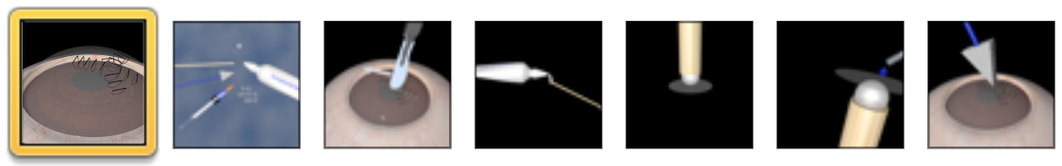
Use of Cyanoacrylate

Cyanoacrylate has bactericidal as well as adhesive properties that may be useful if it is difficult to get a watertight wound by suturing.
An elegant way of applying cyanoacrylate to wounds has been described which allows controlled application and avoids the use of excessive amounts.

Figure 3.2 Application of cyanoacrylate



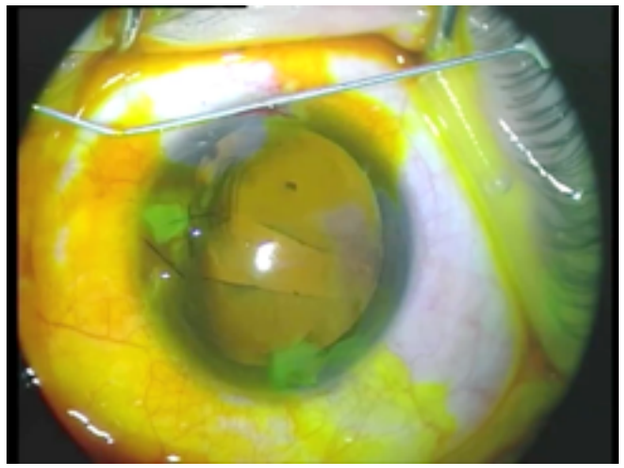
The wound has a slow leak despite suturing.



Final Steps

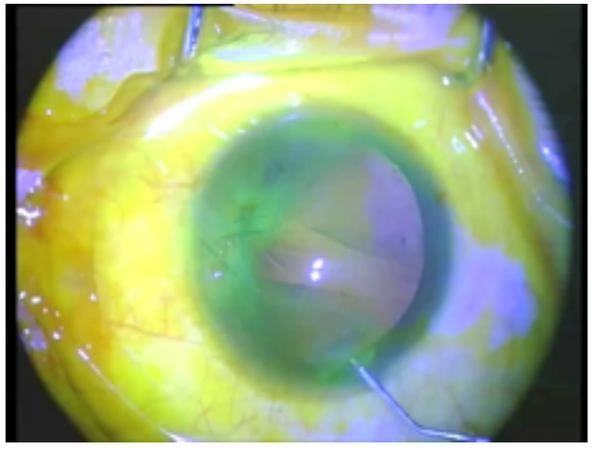
The suture tension is reviewed and any tight or loose sutures are replaced.
The viscoelastic injected at the beginning is removed from the anterior chamber.
The intraocular pressure is restored using saline through the paracentesis.
A few drops of sodium flourescein are placed on the cornea to check for wound leakage.
Finally antibiotics are administered intracamerally or subconjunctivally.

Movie 3.11 Use of fluorescein



Checking that the wound is watertight with fluoresecein.

Movie 3.12 Injection of intracameral antibiotics

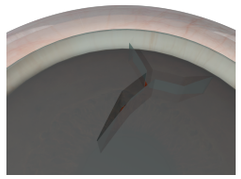


The final step in the procedure.

Knowledge Review

Review 3.1 Repair of Stellate Wound

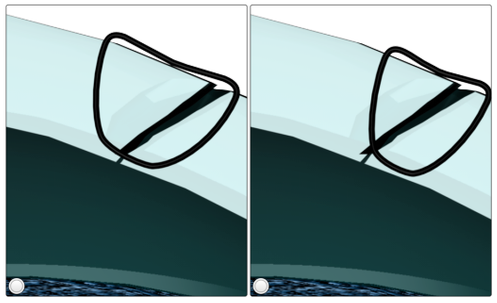
Which approach would NOT be appropriate in the repair of this stellate corneal laceration



- **A.** Akkins Suture
- **B.** Purse String Suture
- **C.** Continuous Suture
- **D.** All the above

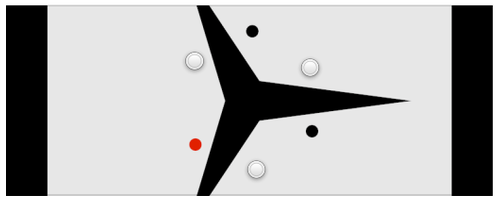
Review 3.2 Suturing a Shelved Laceration

Which of these suture placements is least likely to result in wound override?



Review 3.3 Stellate Lacerations

Imagine the star below is a stellate laceration and you are placing an Akkins star suture. The red dot represents the point at which the needle emerges from the cornea after the first half bite. The white circles represent points at which the needle enters the cornea.The black dots indicate points at which the needle exits the cornea. Indicate the order in which the needle should enter the cornea for the next 3 bites. The Akkins star suture can be conceptually confusing at first so review page 42 if you are unsure of the answer.



1 2 3

Review 3.4 Using Cyanoacrylate

Which statement concerning the use of cyanoacrylate is correct?

- **A.** Cyanoacrylate has bactericidal properties.
- **B.** The surface of the wound should be damp.
- **C.** Copious amounts of cyanoacrylate should be used to ensure closure.
- **D.** Cyanoacrylate should be applied before the wound is sutured.

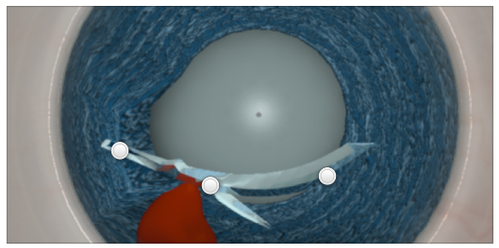
Review 3.5 Suture tension

Which of the following is NOT an indication for increasing tension in sutures

- **A.** Shelving section
- **B.** Non-shelving section
- **C.** Wound edema
- **D.** Combined primary repair and vitrectomy removal of intraocular foreign body.

Review 3.6 Wound features

Identify the following pathological features in this wound



Non-shelved section | Shelved section | Fork

Review 3.7 Viscoelastics

Which of the following statements regarding the use of viscoelastics in trauma is correct

- **A.** While making the paracentesis in a trauma case the limbus should be grasped 180^0 from the entry point
- **B.** Dispersive viscoelastics are preferred
- **C.** The iris may be gently disengaged from the wound using the viscoelastic cannula

Review 3.8 Suture Tension

The following statement is true regarding suture tension

- **A.** It is easy to judge the appropriate suture tension in a very soft eye.
- **B.** Central corneal flattening may be avoided by using shorter sutures towards the periphery of the cornea.
- **C.** The compression zone depends on both suture tension and length.

Review 3.9 Shelved wounds

Regarding shelved sections which of the following statements is correct

- **A.** Shelved wounds are particularly prone to leak.
- **B.** Shelved sections should be sutured tightly.
- **C.** When placing a suture in a shelved wound the suture bites should be symmetrical with reference to the superficial part of the wound.
- **D.** None of the above.

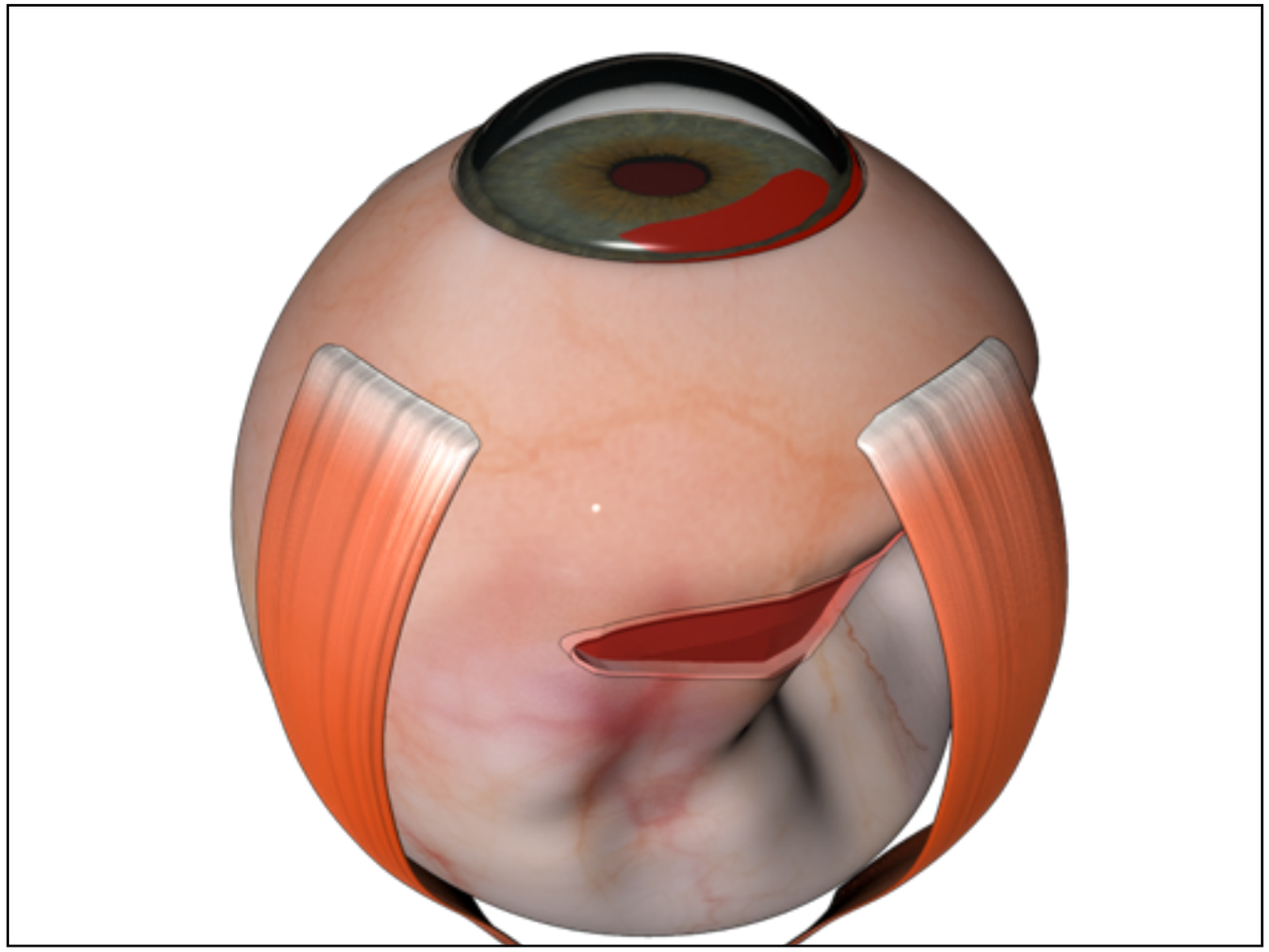
CHAPTER 4

SCLERAL WOUNDS

Repair of scleral wounds poses challenges different from those placed by corneal wounds.

Wound override and astigmatism are not major considerations.

Making the diagnosis, good horizontal wound alignment, adequate closure along the length of the wound and managing tissue incarceration can be more problematic.



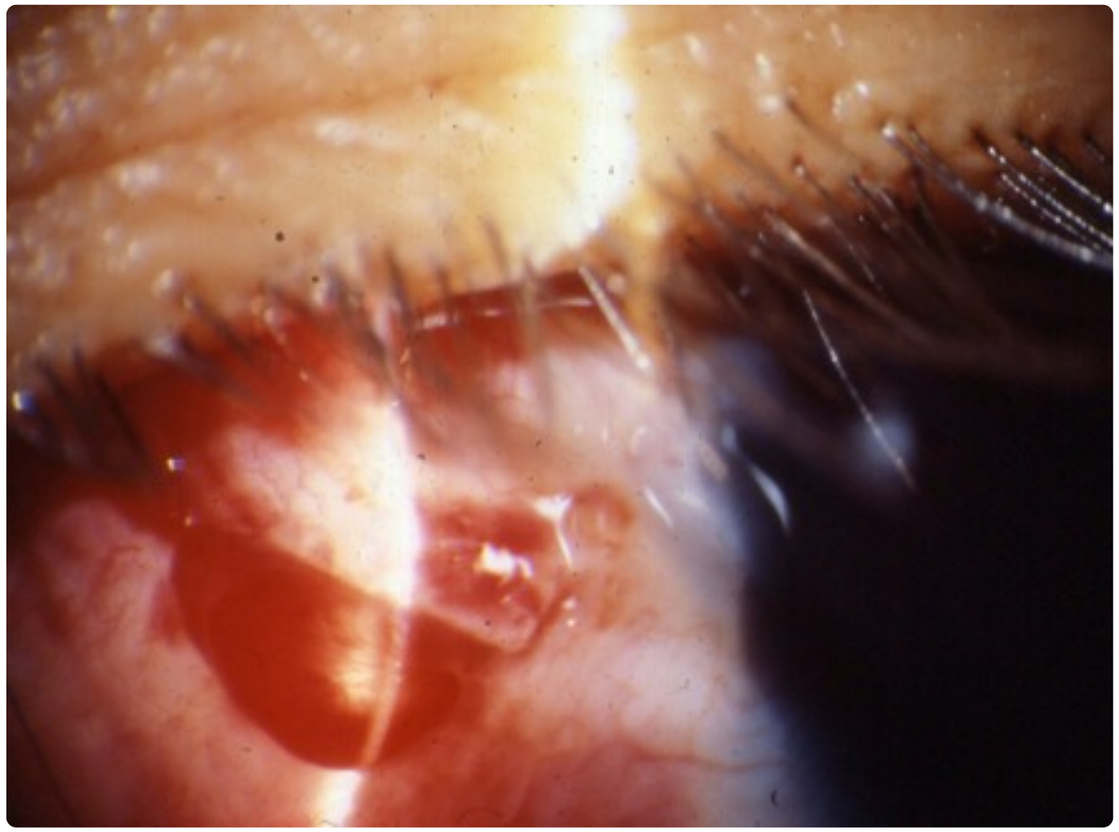
Diagnosing Scleral Wounds

Scleral lacerations (both penetrating and perforating) are relatively easy to diagnose.

The signs of globe rupture are more subtle and this diagnosis is frequently missed.

It is necessary to have a high index of suspicion and sometimes the diagnosis can only be established or excluded by performing exploratory surgery.

Gallery 4.1 Scleral Wounds



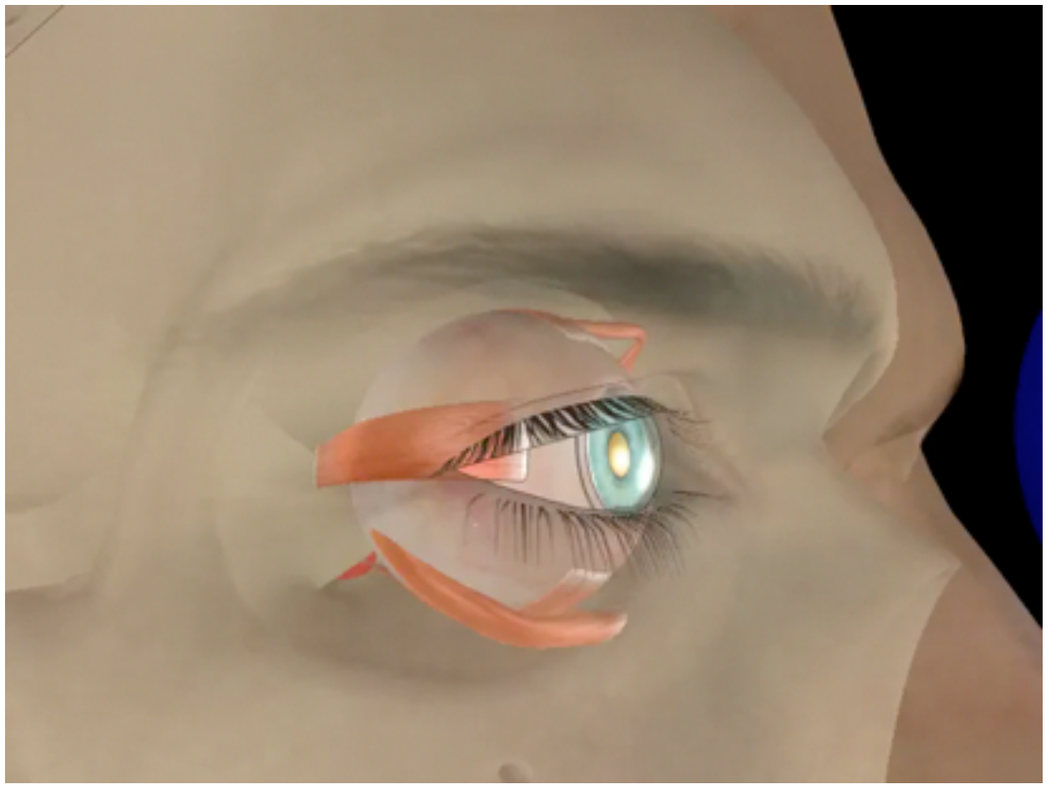
Visible Scleral laceration.

Diagnosing Globe Rupture

Globe ruptures occur due to massive deformation of the globe from a heavy blow. Anteroposterior compression and equatorial distention occur which splits the globe, usually circumferentially. While these may occur at the limbus they are quite commonly behind the muscle insertions (i.e. under the conjunctiva) which is why the wounds are not directly visible.

The history usually suggests a very heavy blow to the eye such as a kick or a golf ball into the orbit.

Movie 4.1 Mechanism of globe rupture



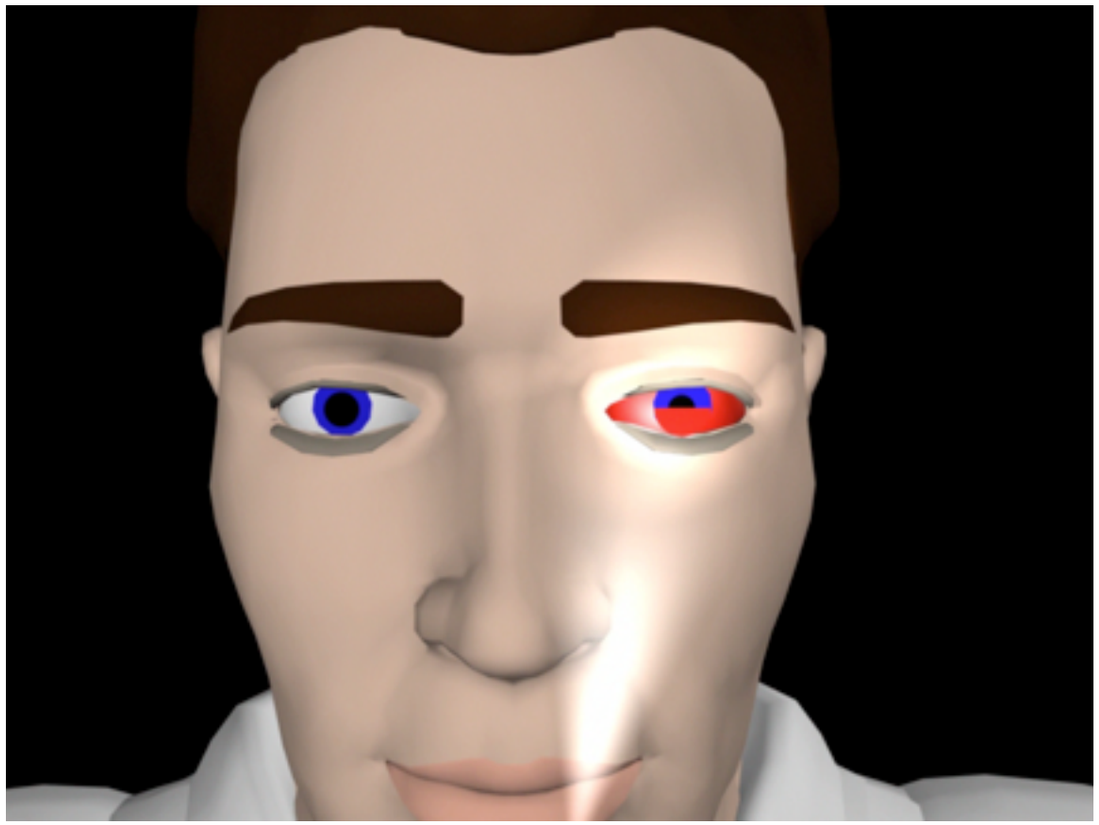
Note the typical location: a circumferential wound behind the rectus insertions which would not be externally visible.

Diagnosing Globe Rupture

The visual function is usually very poor.

As well as poor acuity a relative afferent pupillary defect is present. In the setting of trauma this can be elicited by observing the pupil reaction of the uninjured eye.

Movie 4.2 RAPD in globe rupture



The RAPD is detected by observing the uninjured eye.

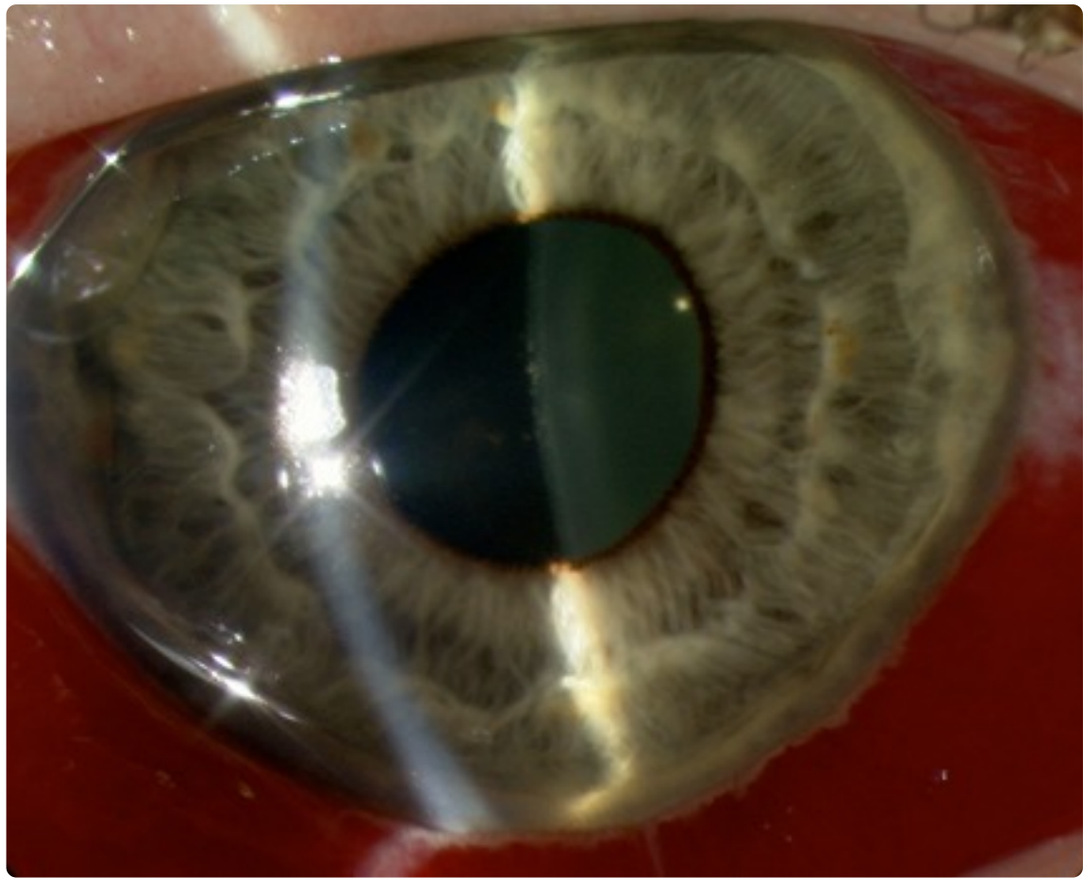
Diagnosing Globe Rupture

Anterior segment examination typically reveals:

- Hemorrhagic chemosis
- Hyphema
- A deep anterior chamber compared to the other eye.
- Reduced IOP

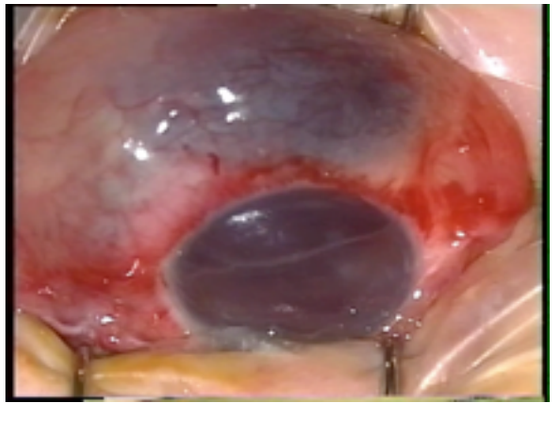
Note that after 24 hours the IOP may rise as fibrinous adhesions secure the wound so this sign is not reliable when presentation is delayed.

Gallery 4.2 Anterior segment signs of globe rupture



Deep anterior chamber.

Movie 4.3 Globe rupture, collapsed eye

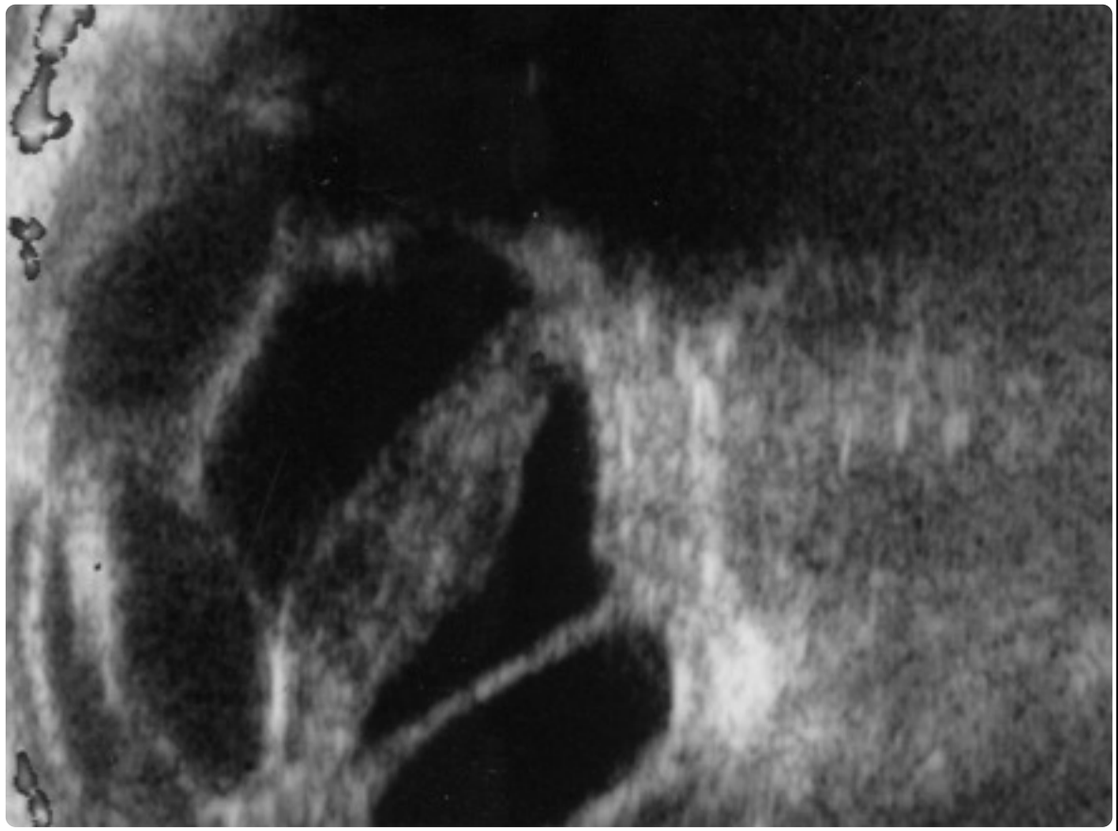


Very low IOP in a globe rupture

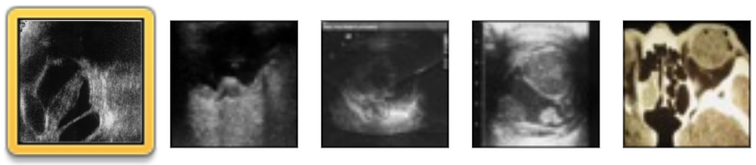
Diagnosing Globe Rupture

B scan ultrasound may be helpful in suspected scleral wounds.
The examination should be conducted very gently.
Posterior scleral wounds may be manifest as echolucent discontinuities in the sclera representing vitreous incarceration.
Direct imaging of globe ruptures in the more typical pre- and peri-equatorial location is difficult but their presence can often be inferred from the presence of massive suprachoroidal hemorrhage.

Gallery 4.3 B scan ultrasound of scleral wounds



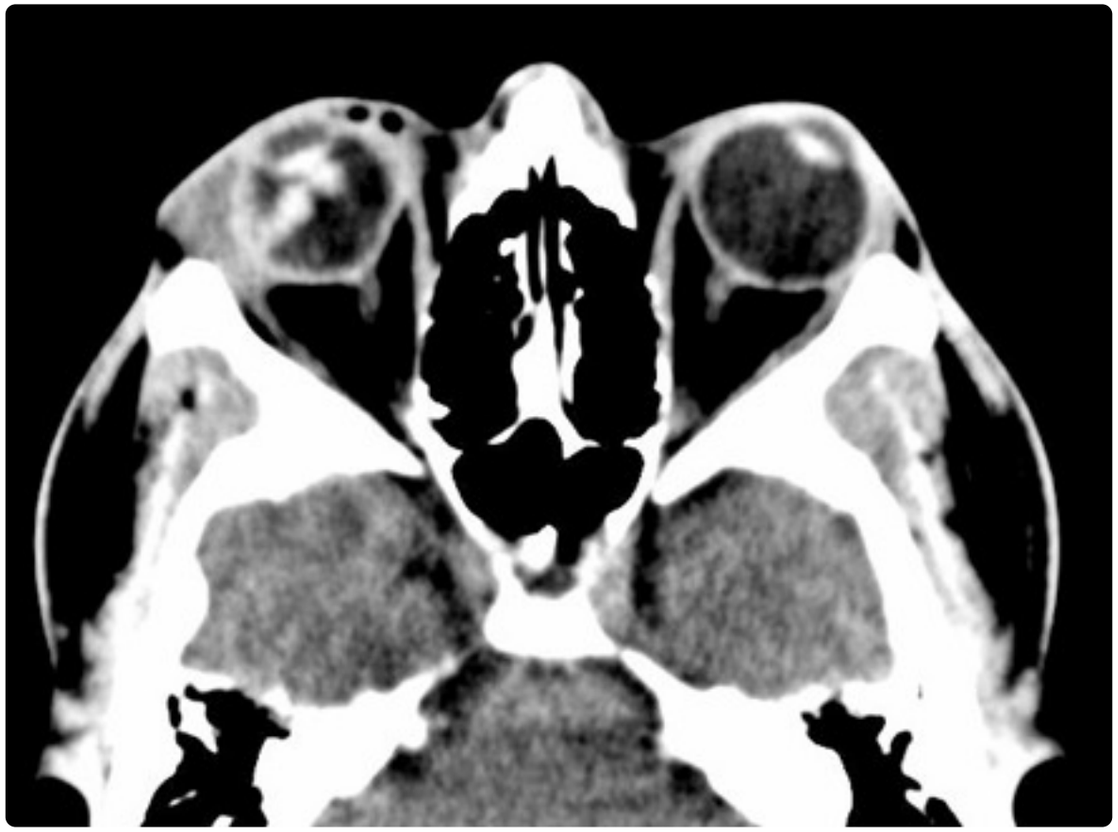
Transvitreal bands to a posterior incarceration.



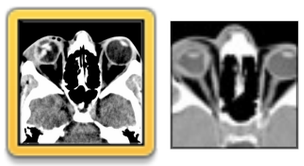
Diagnosing Globe Rupture

CT scanning is not part of the routine work up for suspected globe rupture but there are a number of radiological signs that support the diagnosis.

Gallery 4.4 CT scans on globe rupture



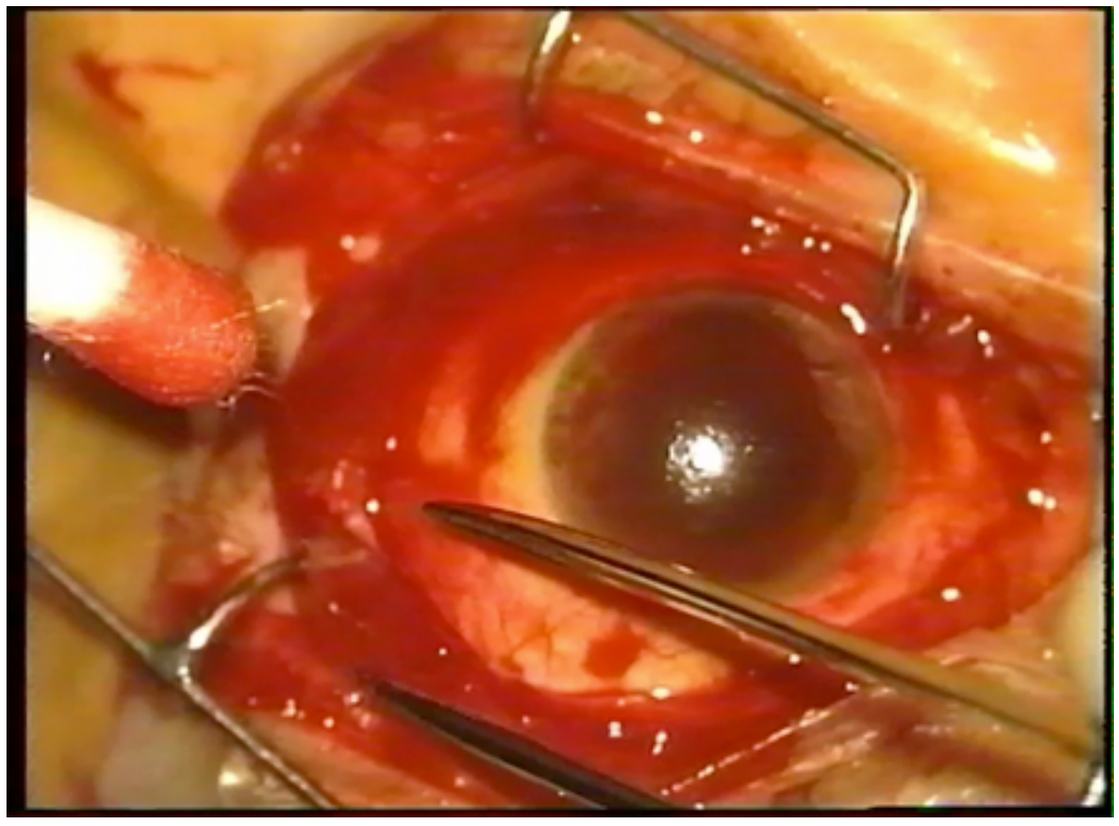
In this case CT shows the asymmetry of anterior chamber depth. The location of the extraocular hematoma gives a clue regarding the location of the rupture: in this case a large rupture was found under the lateral rectus muscle.



Diagnosing Globe Rupture - the role of exploratory surgery.

Sometimes the diagnosis of globe rupture can only be definitively established or excluded by exploratory surgery.

Movie 4.4 Exploration of suspected globe rupture

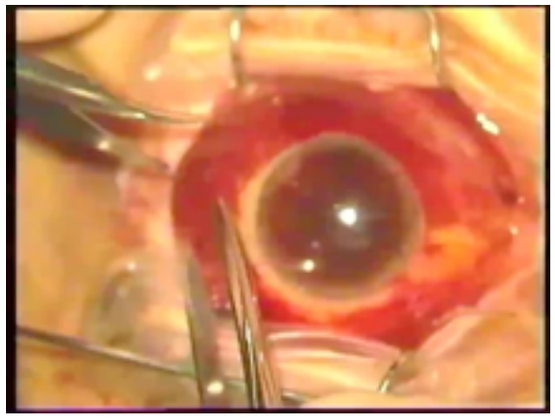


This patient had poor vision, an RAPD and a hyphema after being kicked in the eye. The diagnosis of globe rupture was only definitively established by exploration under anesthesia.

Exploration

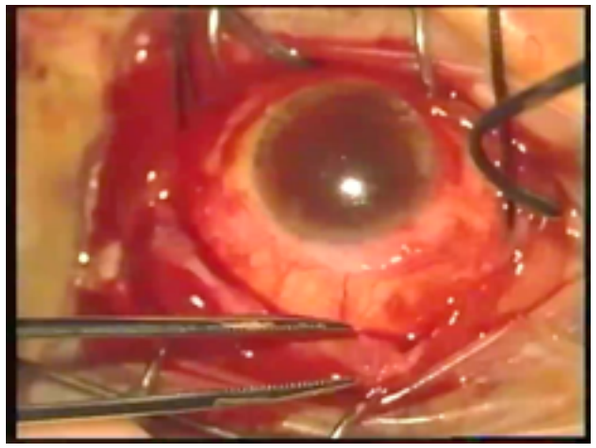
A 360º peritomy is performed.
If no anterior wound is visible the subtenons space is opened in each quadrant to allow exploration of the posterior sclera.
A small gush of altered blood or serosanguinous fluid is often seen on opening the subtenons space on the affected quadrant.
Once the wound has been identified bridle sutures are placed around the recti.

Movie 4.5 Peritomy



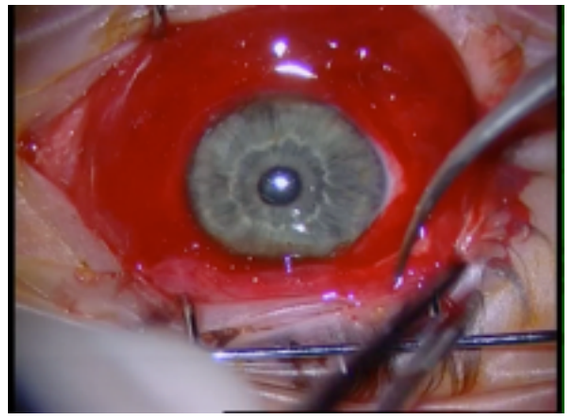
Great care is taken not to elevate the IOP during manipulation of the globe.

Movie 4.6 Slinging muscles



Here the wound is directly under the superior rectus and great care is taken passing the squint hook.

Movie 4.7 Opening tenons capsule



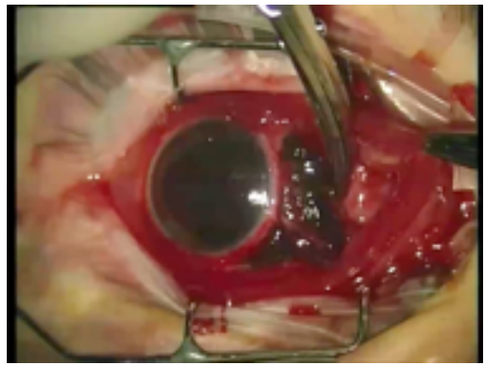
A small gush of fluid may indicate the location of the wound.

Defining the wound

For circumferential wounds all episcleral tissue and clotted blood is carefully cleaned away so that the wound edges can be seen clearly and its extent defined before suturing.

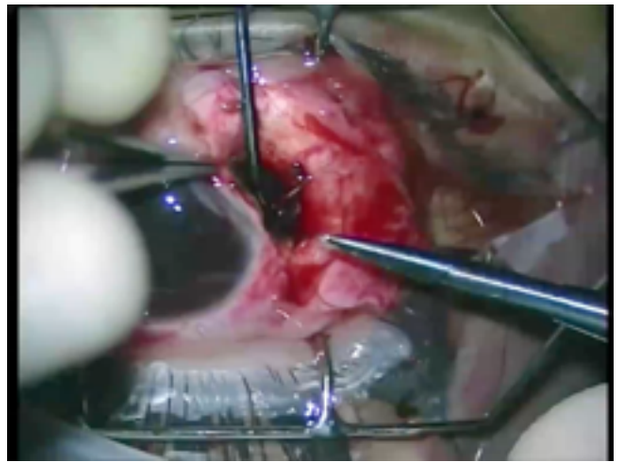
When a radial wound extends posteriorly it is cleaned and sutured progressively from front to back ('sew as you go'). It is important that, with the exception of very posterior wounds, the whole extent of the wound is identified and closed in this way.

Movie 4.8 Clean wound edges: correct technique



The clot and adherent episcleral tissue are removed.

Movie 4.9 Clean wound edges: incorrect technique



Here the wound has not been adequately cleaned of adherent clot. Consequently suture alignment is poor.

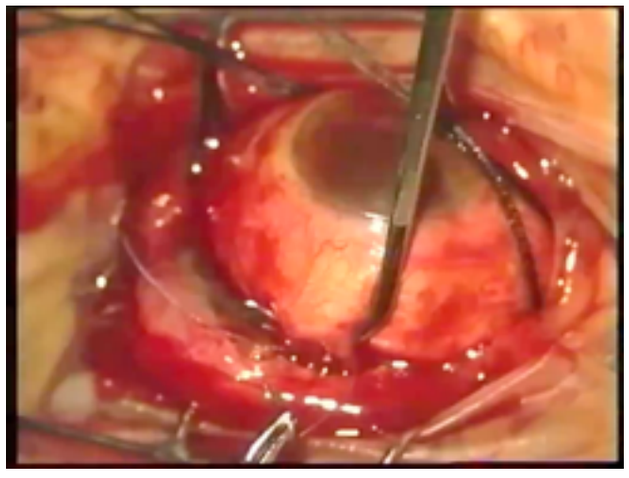
Detaching rectus muscles

When extensive wounds pass underneath rectus muscles temporarily detaching a rectus muscle may aid wound exposure.

It may also allow greater access to more posterior wounds by allowing rotation of the globe without elevation of pressure and the risk of expulsion of ocular contents.

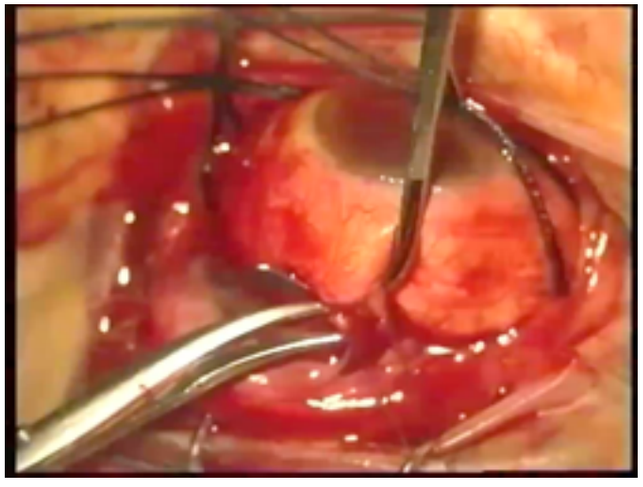
It is unnecessary to detach the muscle if adequate access can be achieved by an assistant with a retractor.

Movie 4.10 Pre placement of sutures



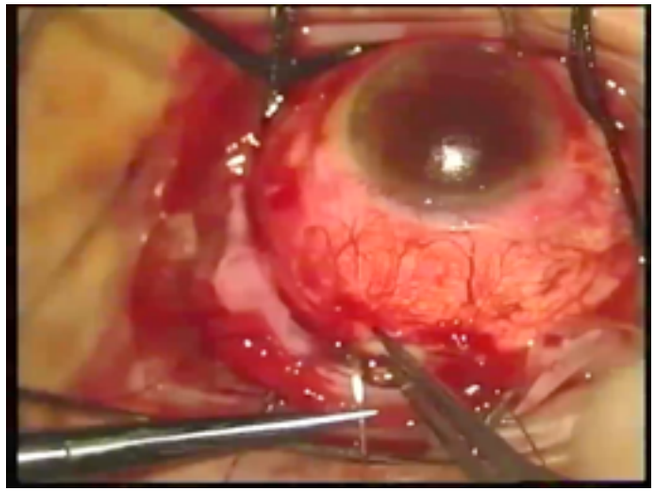
A double bite of 7/0 polyglactin is placed through either side of the muscle. The needle is left attached to the suture.

Movie 4.11 Dividing the muscle



The muscle is divided at its insertion taking care not to cut the preplaced sutures.

Movie 4.12 Reattaching the muscle



At the end of the case the muscle is reattached in its original .

Wound visualization

Closure of wounds behind the equator under the microscope risks expulsion of ocular contents because of the elevation in IOP induced by rotating the eye.
These more posterior wounds can be closed under direct vision. A loupe may be helpful.

Movie 4.13 Closure of scleral wound under direct vision

Note the good view that can be achieved in this way, especially if operating loupes and a head light are used. Wounds more posterior than the one shown here are best left unsutured to avoid extrusion of ocular contents from manipulation of the globe.

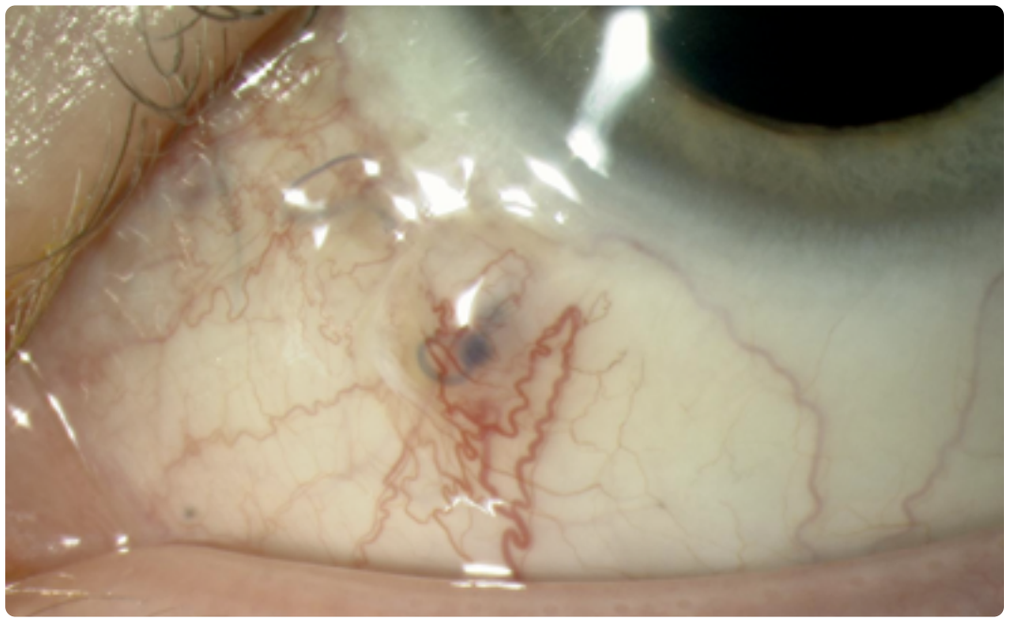
Choice of suture material

A non-absorbable suture such as 9/0 nylon is generally used for posterior scleral wounds.

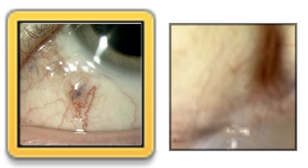
This is because the posterior sclera is relatively avascular and heals slowly. Absorbable sutures such as polyglactin hydrolyze in about 3 weeks which may not allow sufficient time to allow adequate wound healing, particularly if the eye undergoes subsequent vitreoretinal surgery.

An exception to this rule is a small wound in the very anterior sclera. Wounds here heal quite quickly. Furthermore protruding ends from subconjunctival nylon sutures in this position can be troublesome and difficult to remove in the office

Gallery 4.5 Sutures in the anterior sclera



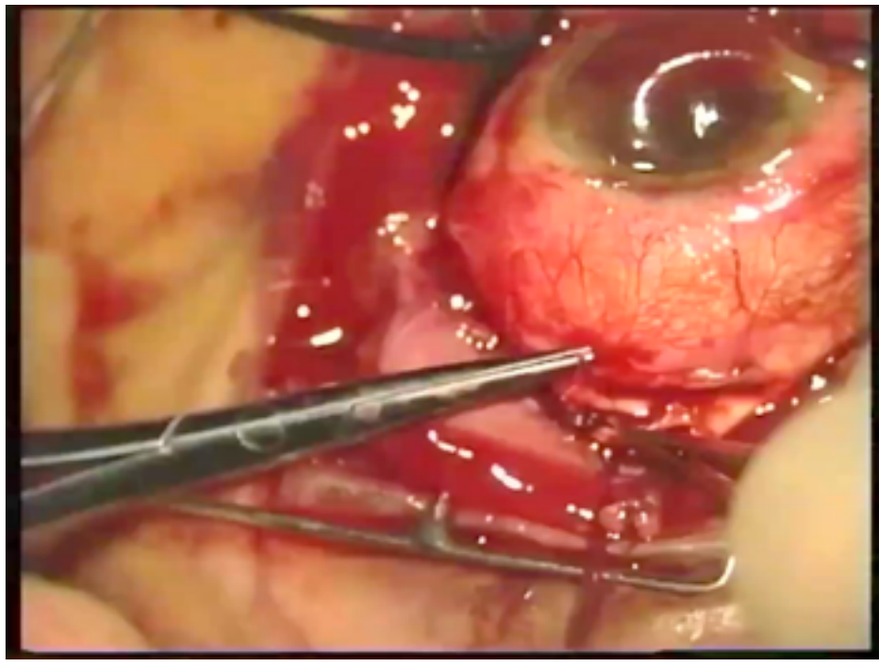
Polyglactin closure of anterior scleral wound.



Suture Technique

Scleral wounds may be closed with continuous or interrupted sutures.
Using the 'pull don't push' principle the tissue is grasped and impaled on the needle.
The knot is tied under tension.
Shelving and astigmatism are not significant issues but correct horizontal wound alignment is crucial.

Movie 4.14 'Pull don't push'

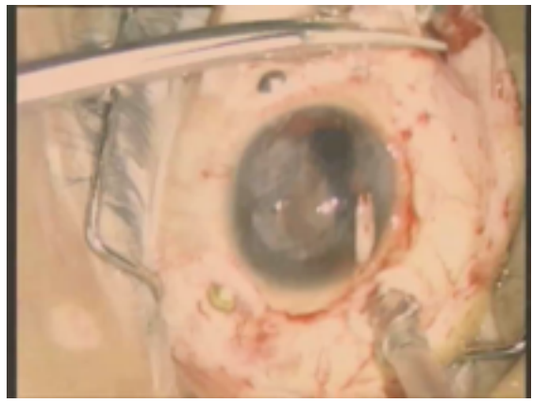


Pulling the scleral flaps sightly away from the globe before passing the suture bite.

Wound Alignment

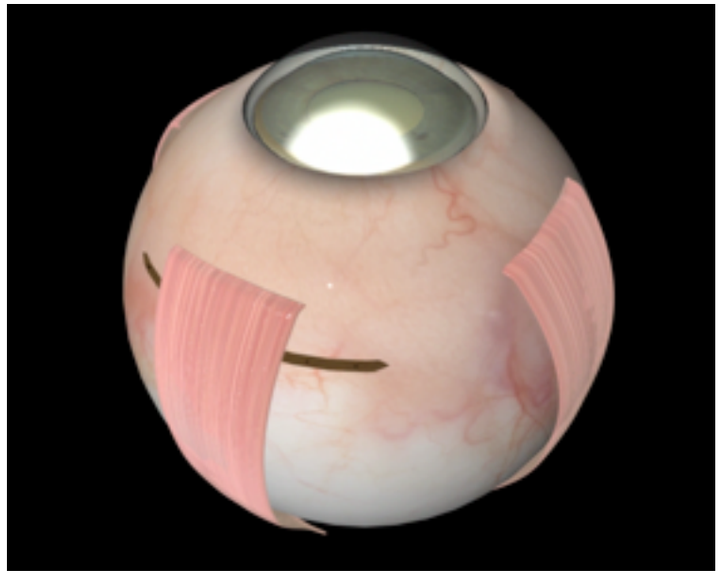
Circumferential wounds are generally closed using the '50% rule'.
Radial wounds are closed from front to back ('sew as you go'). This is done so that the wound has been partially closed when the eye is rotated to get access to the more posterior parts of the wound.

Movie 4.15 Sew as you go



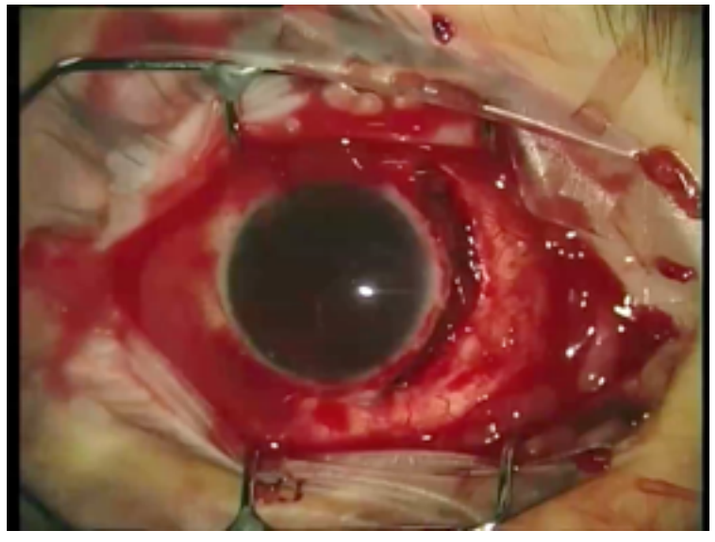
This was a radial laceration under the lateral rectus muscle. The patient also underwent vitrectomy for vitreous hemorrhage hence the infusion cannula.

Movie 4.16 The '50%' rule



Successively halving the wound giving good alignment and even spacing of sutures.

Movie 4.17 The 50% rule

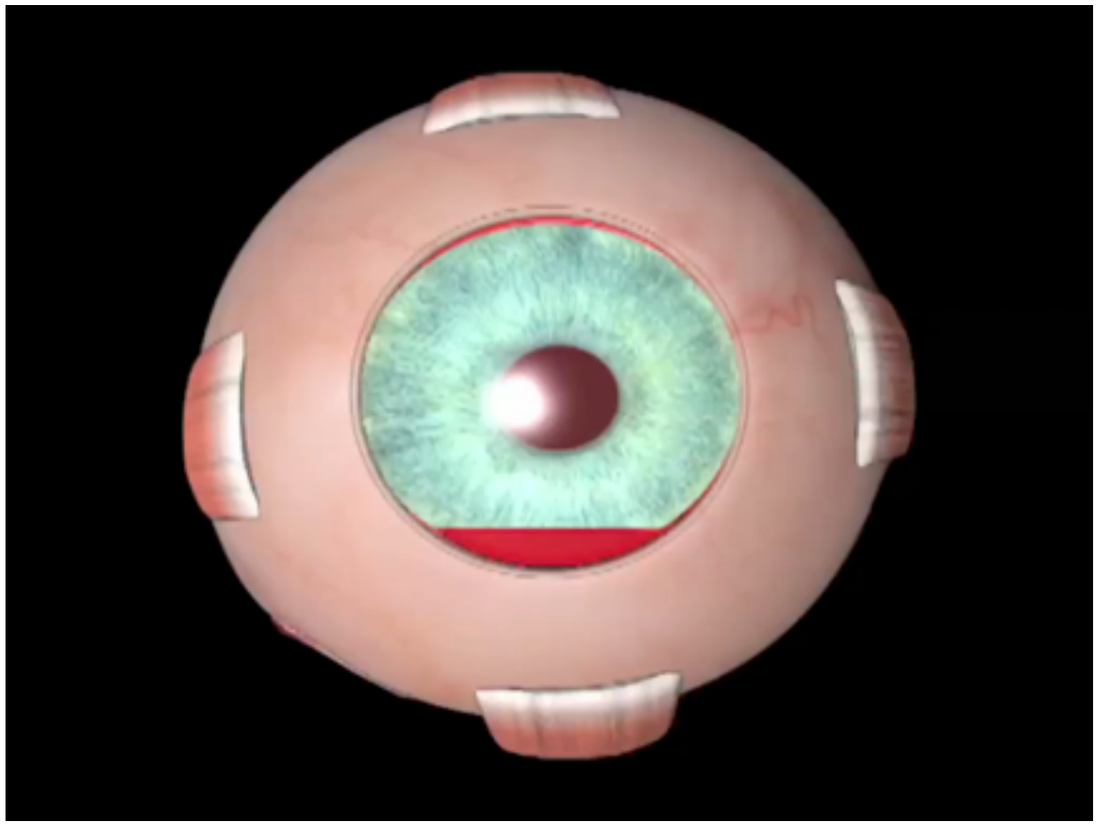


Practical application of the 50% rule.

Wound Alignment

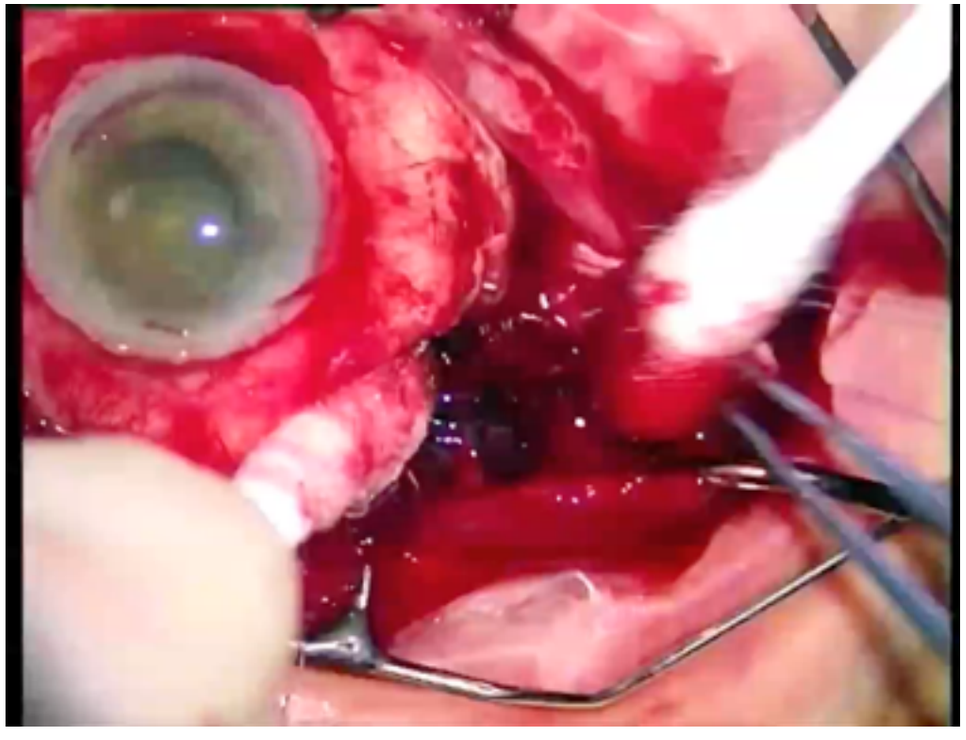
Long scleral lacerations behind the equator are sometimes associated with collapse of the posterior segment and very distracted scleral flaps. Under these circumstances it can be difficult to visualize the whole wound at once and judge the mid point. It is often easier to get the wound aligned by finding one end and start suturing from this point.

Movie 4.18 Long posterior scleral wound



Note the collapse of the posterior segment behind the rectus insertions.

Movie 4.19 Long posterior scleral wound: suturing from an identifiable end.

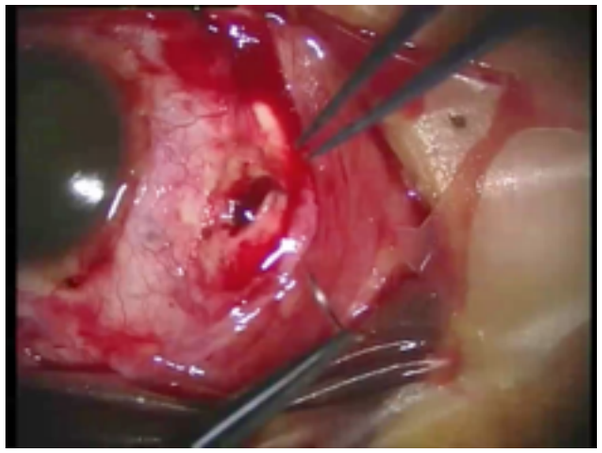


The wound is large and the flaps are widely separated. It is hard to visualize the whole wound simultaneously. It is easier to find one end of the wound and start suturing from there than to try to use the 50% rule.

Doglegs.

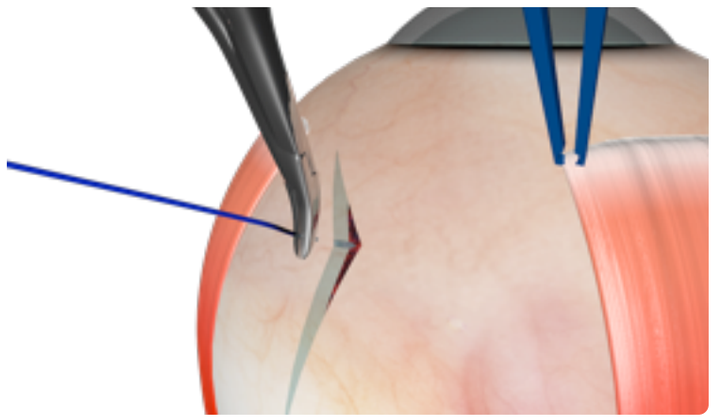
Scleral lacerations often have doglegs (zig-zags).
Closing these first aligns the rest of the wound.
The sutures should be passed from the side with the more acute angle which is effectively a flap ('ship to shore').

Movie 4.20 Ship to shore



The suture is passed from the more mobile flap to the less mobile one.

Figure 4.1 Ship to shore

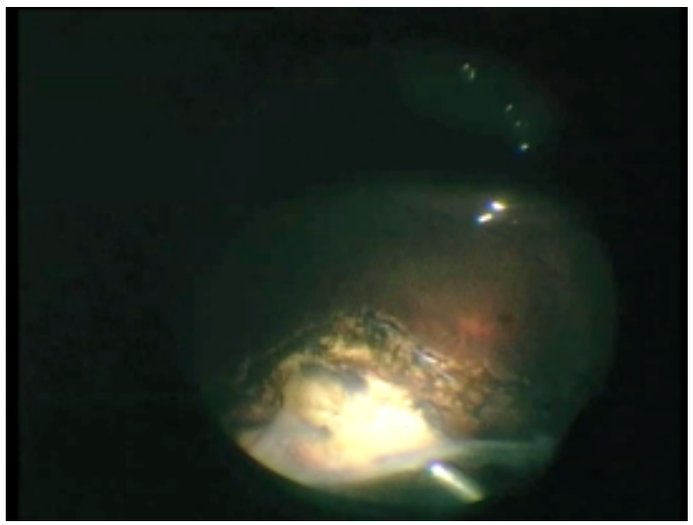


The suture is passed from the more mobile flap.

Managing the Knots.

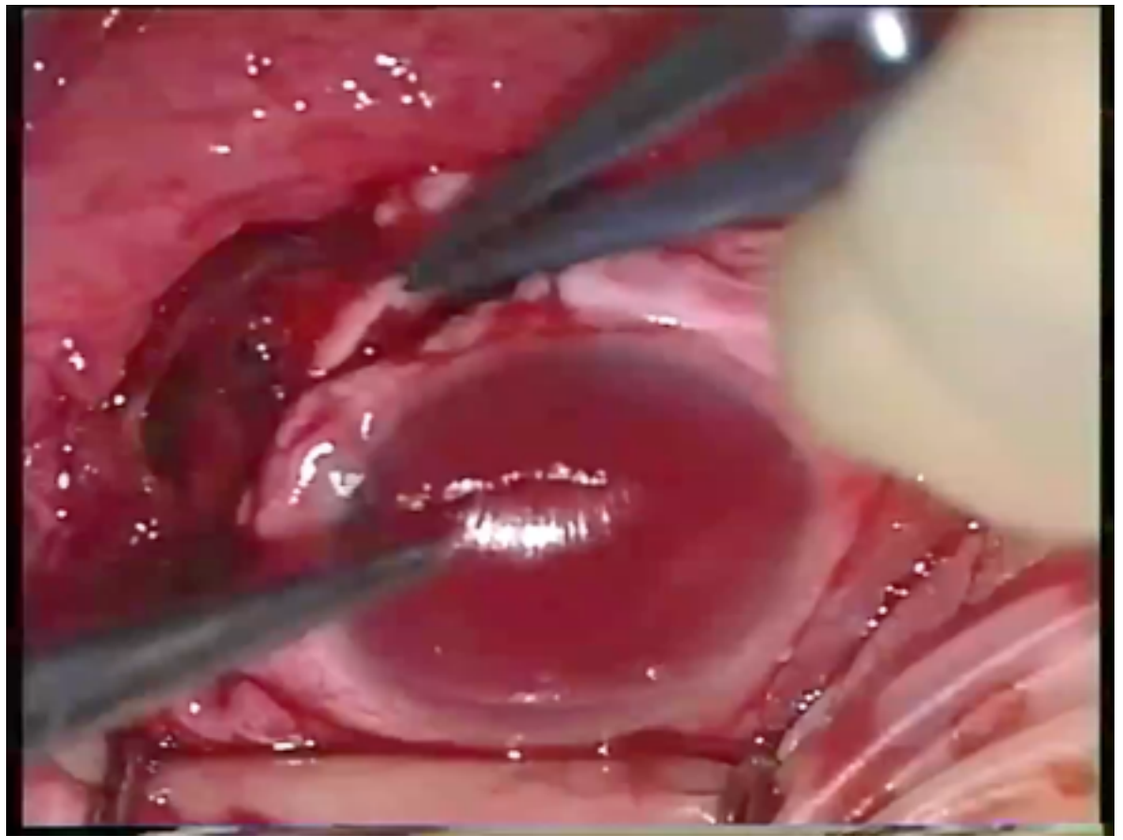
Rotation of scleral sutures to bury the knots is generally undesirable.
An exception occurs when suturing the very anterior sclera. If nylon has to be used here the suture should be started inside the wound so that the knot is buried.

Movie 4.21 Inappropriately turned sutures



Posterior scleral sutures should be tied with unburied knots. Here posterior scleral sutures have been buried inappropriately and are visible intruding into the eye during vitrectomy.

Movie 4.22 Tying a buried knot in anterior sclera



The bite starts and finishes inside the wound to prevent suture ends protruding through conjunctiva.

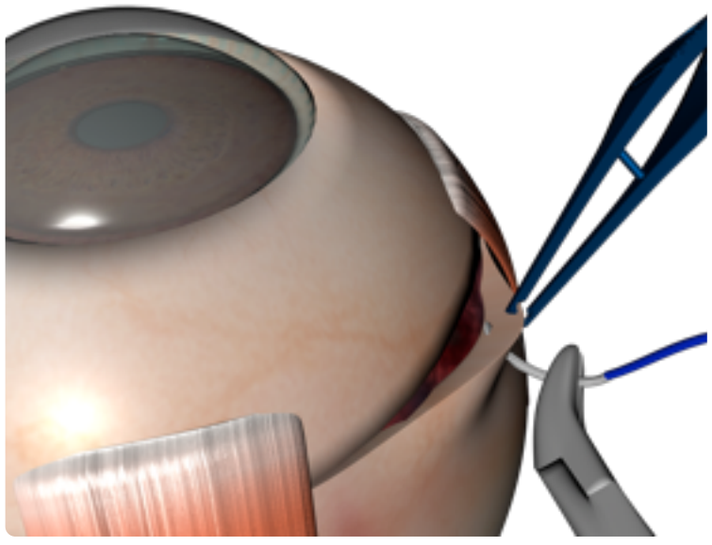
Prolapsed Choroid

This cannot be reposited with viscoelastic as in the anterior segment.

Pull the scleral flap slightly away from the globe towards the needle ('pull don't push') before making a bite.

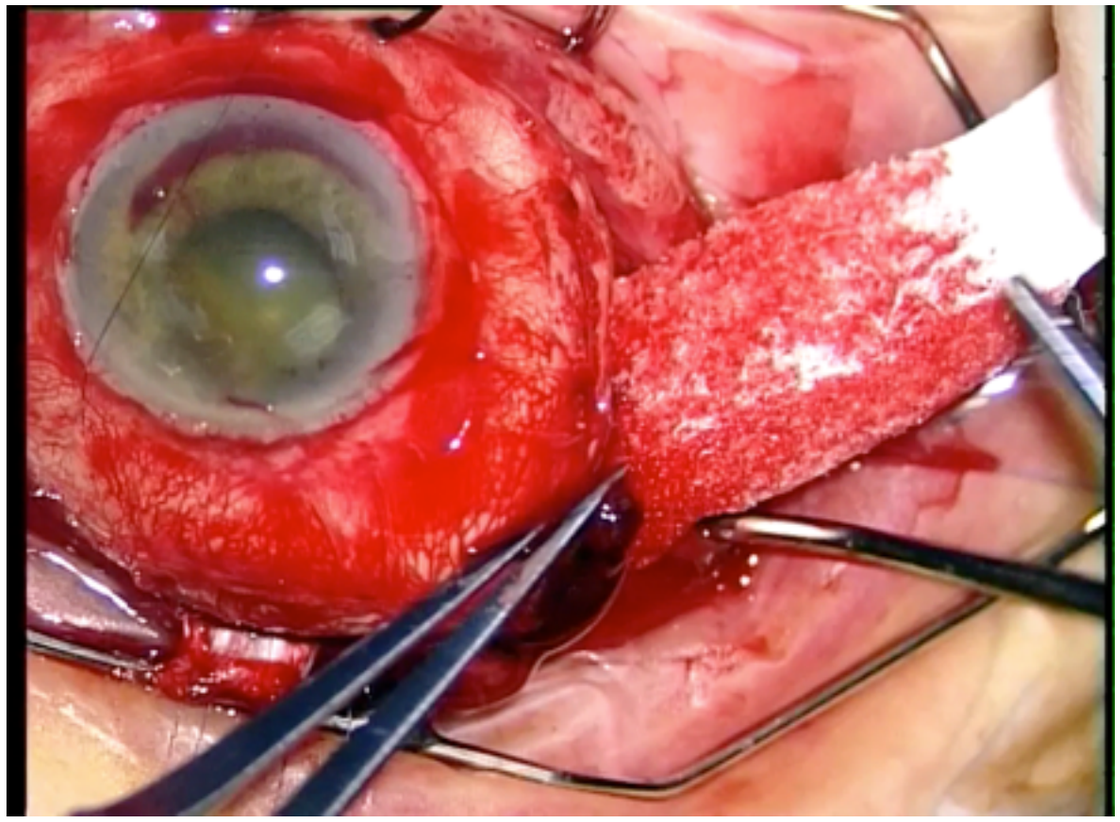
Avoid the temptation to excise choroid. As well as the collateral damage to retina the resulting bleeding can be difficult to control.

Figure 4.2 'Pull don't push'



Pulling a scleral flap up to pass a suture.

Movie 4.23 'Pull don't push'

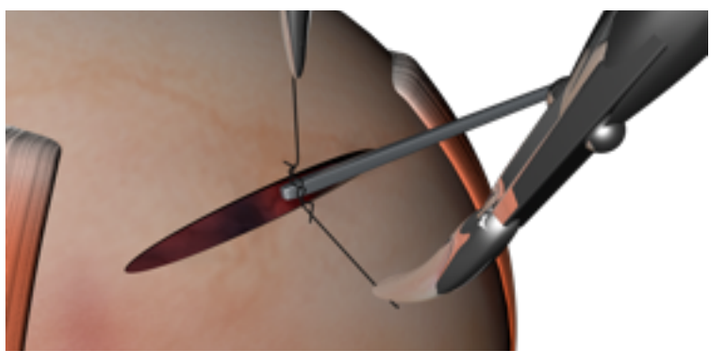


Gently pull the flap away from the globe before making a bite.

Prolapsed Choroid

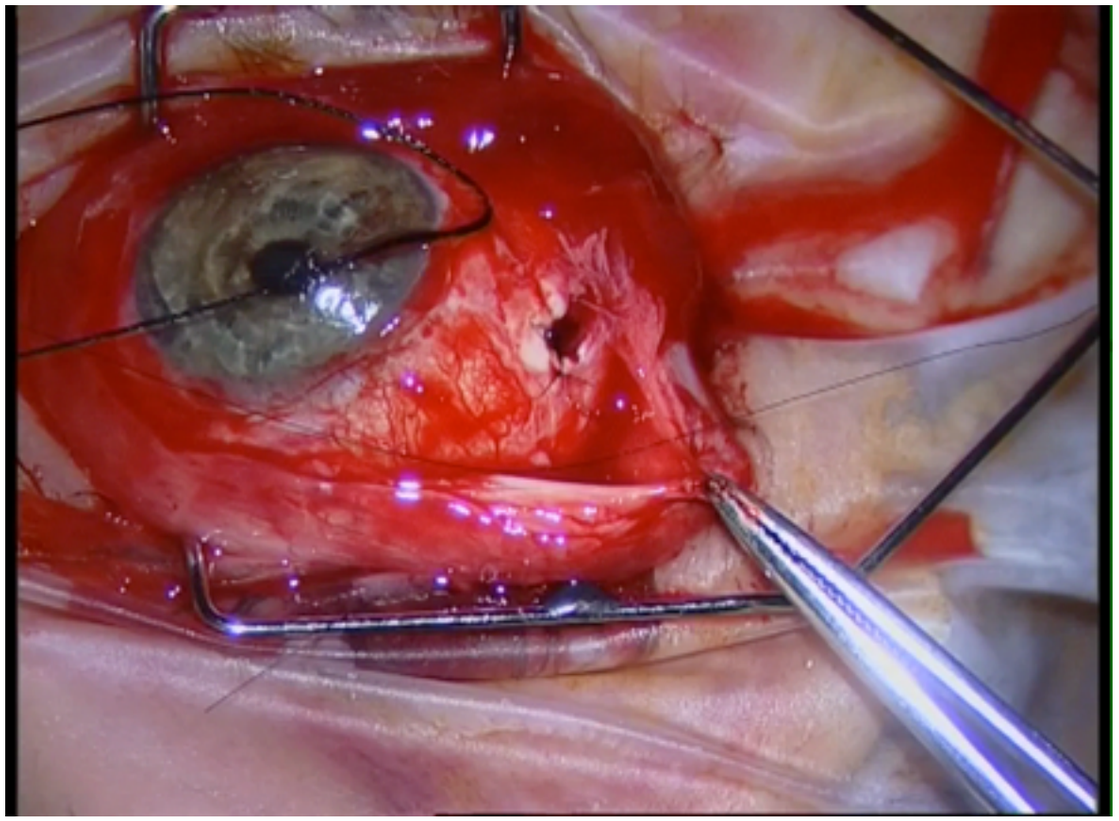
While tying sutures an assistant can gently reposit choroid while the suture is tied over it to prevent choroidal incarceration in the closing wound.

Figure 4.3 Tightening a suture over a reposited choroid



An assistant gently presses on the prolapsed the choroid with an iris repositor.

Movie 4.24 Tying sutures over a repositor.



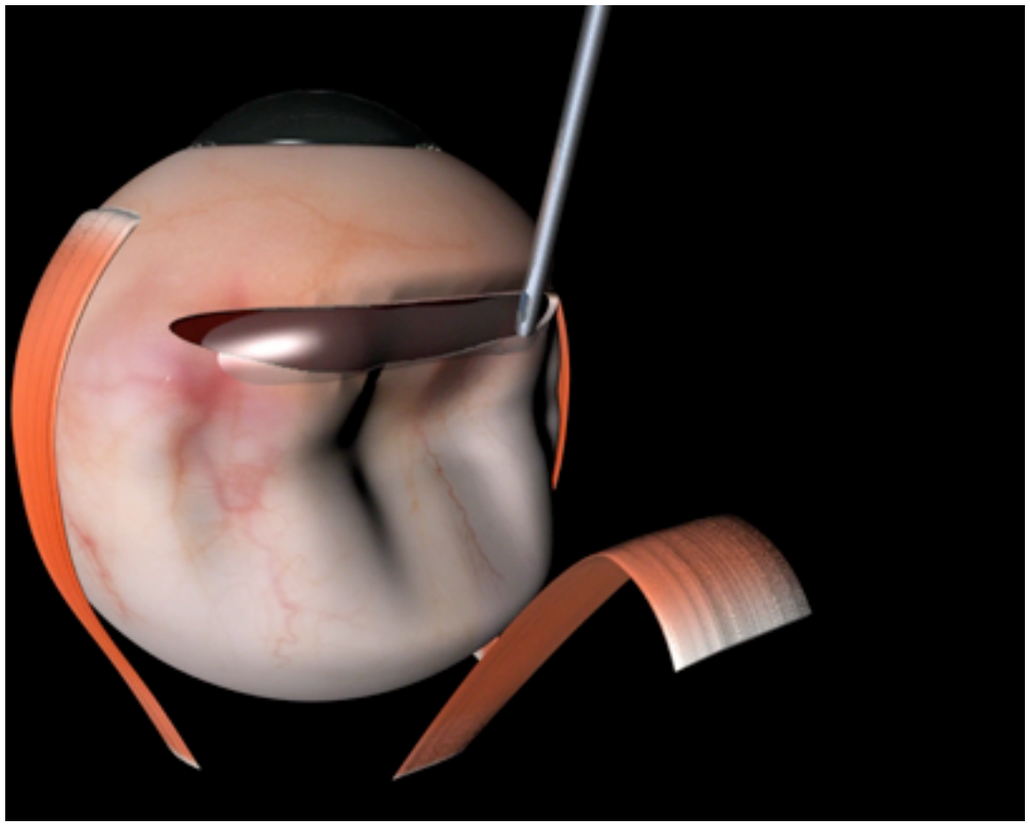
Extruded vitreous.

Vitreous trapped in the wound impedes wound closure.

Most can be removed with a vitrector. This is preferable to using a sponge and scissors which pulls more vitreous into the wound and can exacerbate incarceration.

Following this the ‘pull don’t push’ technique outlined above frees any remaining strands.

Movie 4.25 Vitrectomy for prolapsed vitreous

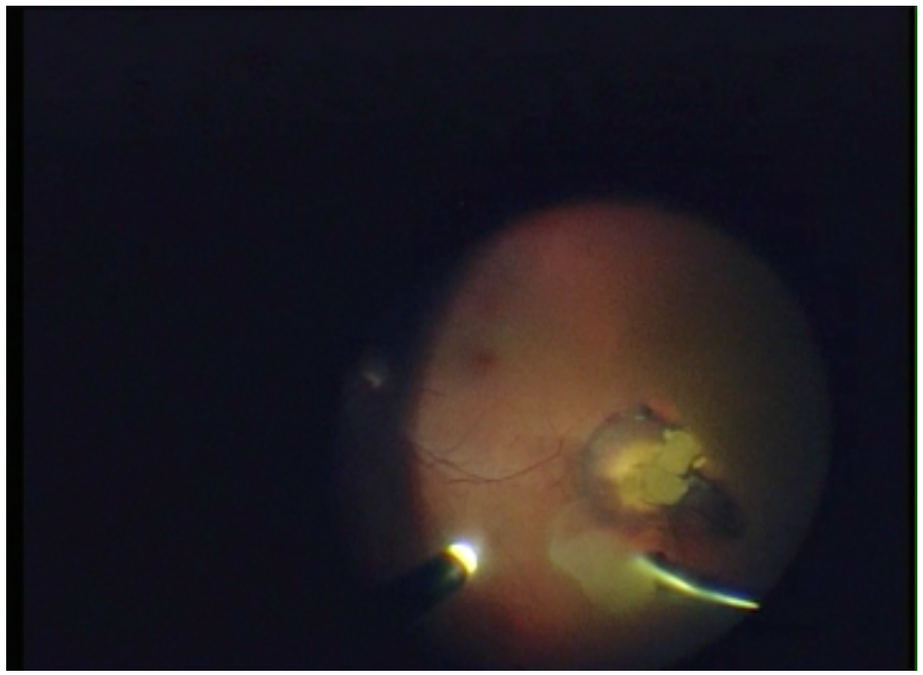


A vitrector is preferred to the traditional sponge and scissors.

When not to attempt closure

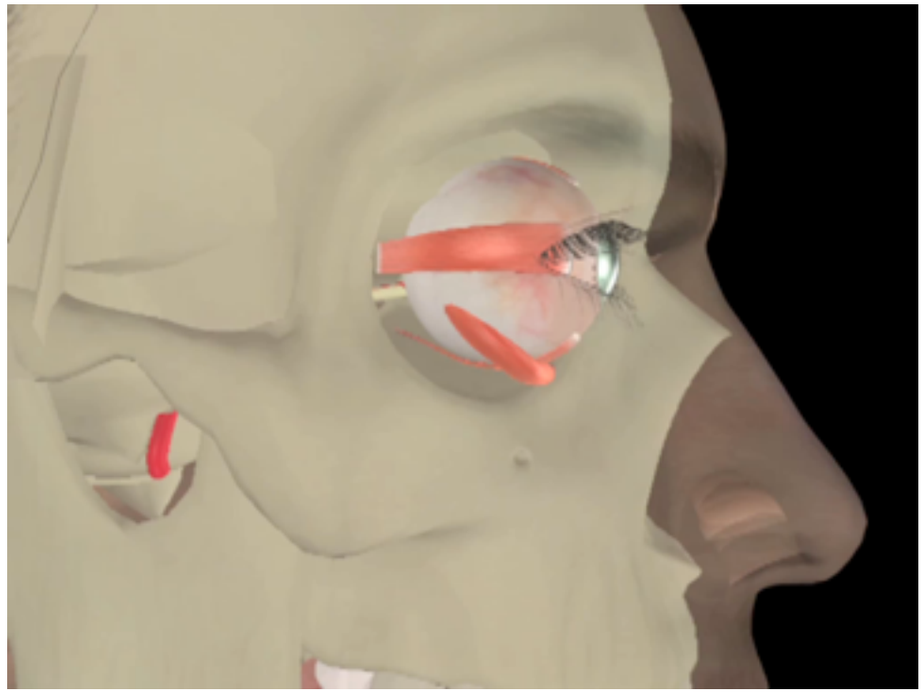
Very posterior wounds, such as the exit wound in a globe perforation, are best left unsutured. This is because of the risk of expulsion of globe contents from the manipulation involved in closure

Figure 4.4 Vitrectomy after perforating injury



Note that the posterior scleral wound, which was not sutured, is not leaking.

Movie 4.26 Globe perforation



Exit wounds like this are best left unsutured.

Knowledge Review

Review 4.1 Diagnosis of occult globe rupture

Which of the following is NOT usually seen in globe rupture

- **A.** Hyphema
- **B.** RAPD
- **C.** Deep anterior chamber
- **D.** Hemorrhagic chemosis
- **E.** Suprachoroidal hemorrhage
- **F.** Elevated intraocular pressure

Review 4.2 Scleral Wound Closure

When repairing scleral wounds:

- **A.** Astigmatism is a major concern
- **B.** Very posterior injuries should always be repaired
- **C.** Polyglactin gives reliable and secure wound closure in all cases
- **D.** Scleral knots should always be buried
- **E.** Use of a sponge and scissors is an atraumatic way of removing vitreous from the wound
- **F.** When closing dog legs the suture should be passed from the more mobile flap.

CHAPTER 5

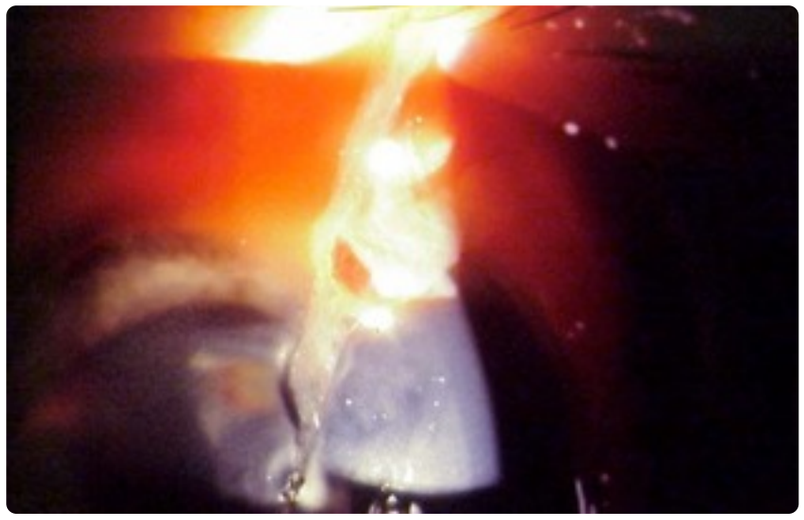
CORNEOSCLERAL WOUNDS

Any wound that extends to the limbus should be assumed to extend into the sclera until proven otherwise.

The first step in surgery is clearing the wound of very adherent episcleral tissue at the limbus to allow correct alignment of the wound correctly with a cardinal suture at the limbus.

Following the this the cornea and then sclera are repaired using the principles described in the previous 2 chapters.

Figure 5.1 Corneoscleral Wound

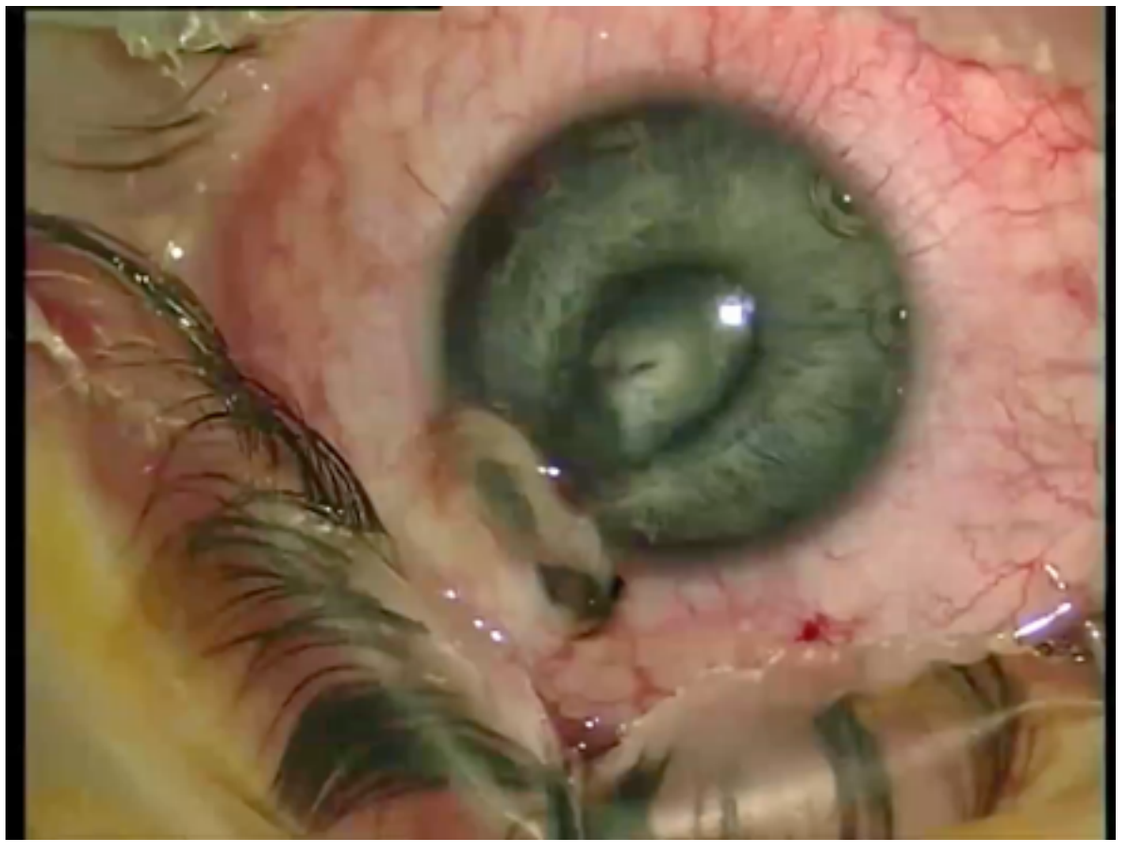


This wound extended several mm into the sclera. Failure to adequately explore and identify the posterior extent of corneoscleral wounds is a common error in ocular traumatology.

Clearing Episcleral Tissue

The temptation to suture conjunctiva and sclera as a single layer should be avoided.
First clear all episcleral tissue down to bare sclera. It is often easiest to start some way from the wound, identify the correct plane and work towards the wound.

Movie 5.1 Clearing the corneoscleral limbus of adherent tissue

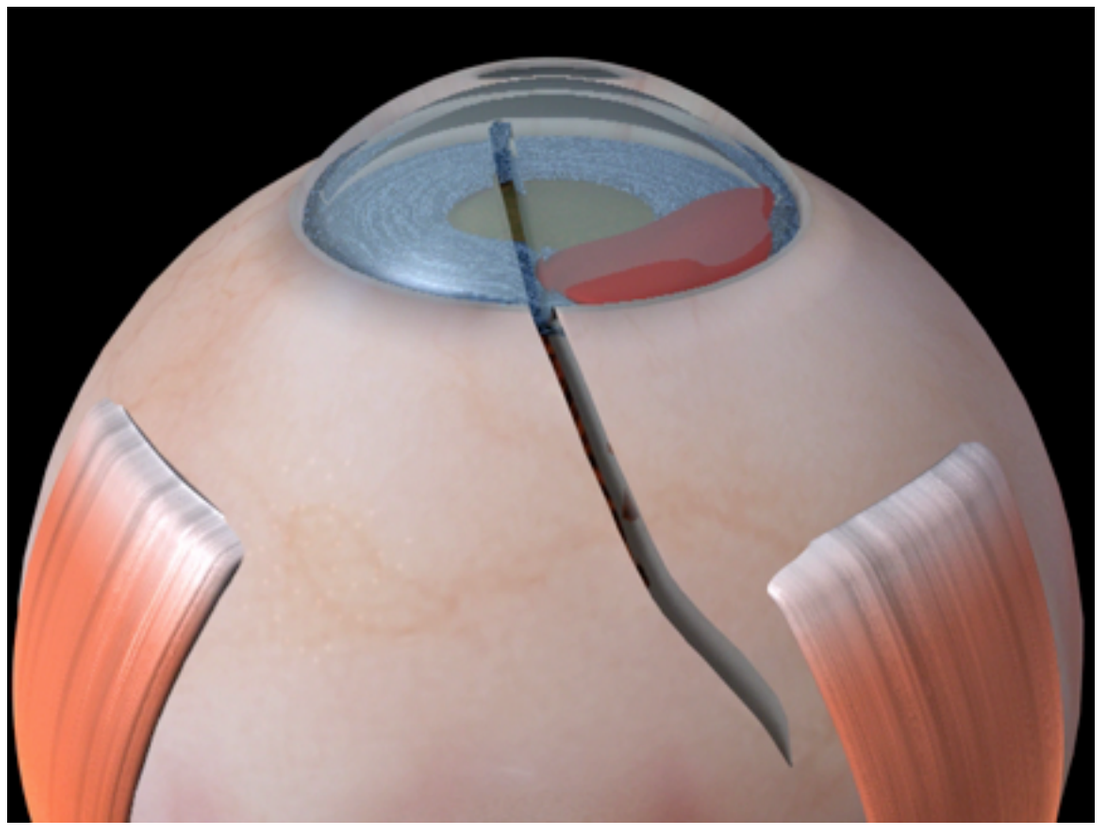


Note that the clearance starts a little away from the wound so that the dissection is in the correct surgical plane once the wound is reached.

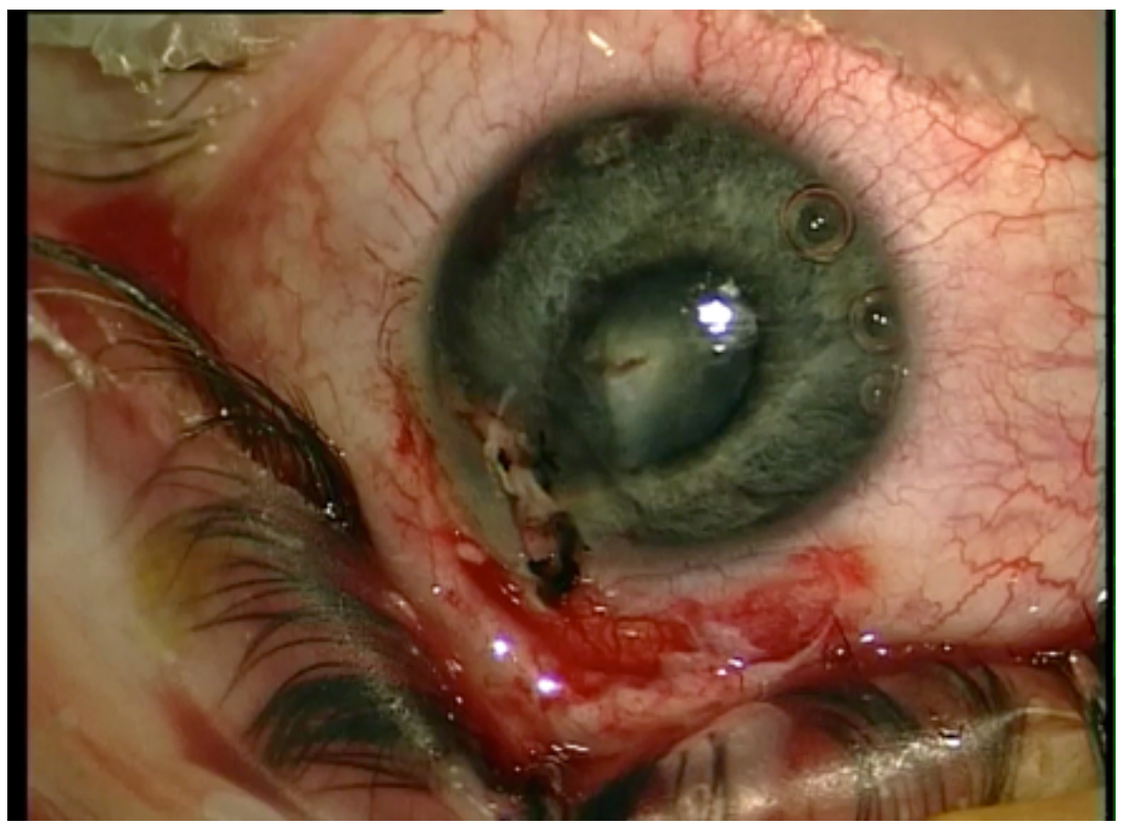
The Cardinal Suture

The first suture should be a 9/0 nylon suture at the limbus. This aligns the rest of the wound.

Movie 5.2 The cardinal suture



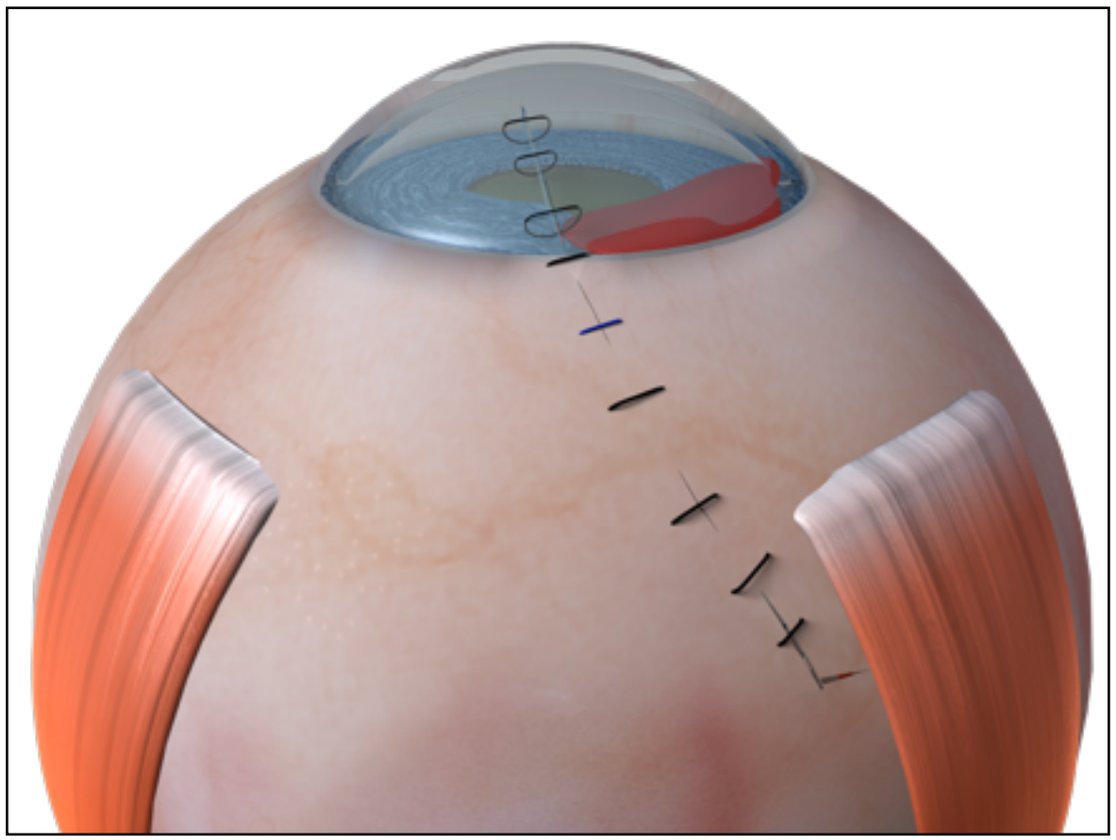
Movie 5.3 'Cardinal' suture at the corneoscleral limbus



This aligns the rest of the wound.

Corneal and Scleral Components

The remainder of the wound can be closed using the principles described in the previous 2 chapters. The cornea is closed first and then the sclera using the ‘sew as you go’ approach



Review 5.1 Corneoscleral Wounds

When closing corneoscleral wounds

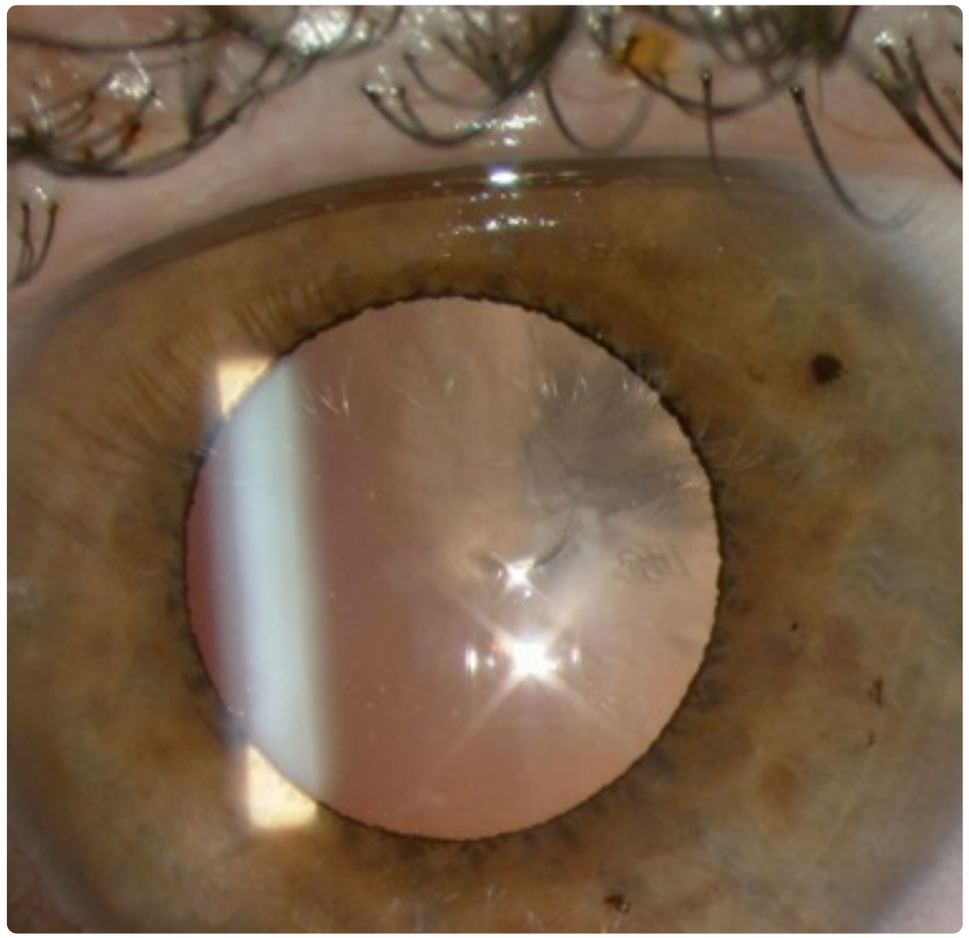
- **A.** The last suture should be at the limbus
- **B.** The scleral section should be sutured before the corneal section
- **C.** The limbal suture should be a non-absorbable suture such as 9/0 nylon.
- **D.** The sclera and conjunctiva should be closed together.

CHAPTER 6

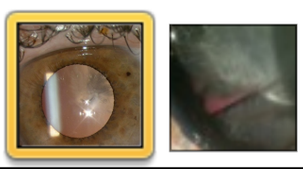
CATARACT

Penetrating injuries of the anterior segment often involve the lens capsule. This causes lens matter to hydrate and spill into the anterior segment.
If the cornea is sufficiently clear and the posterior capsule appears intact lens aspiration may be performed as part of the primary repair once the wound is watertight.
If the view of the lens is hazy lens aspiration should be deferred for a week to allow the cornea to clear.

Figure 6.1 Cataract after penetrating injury



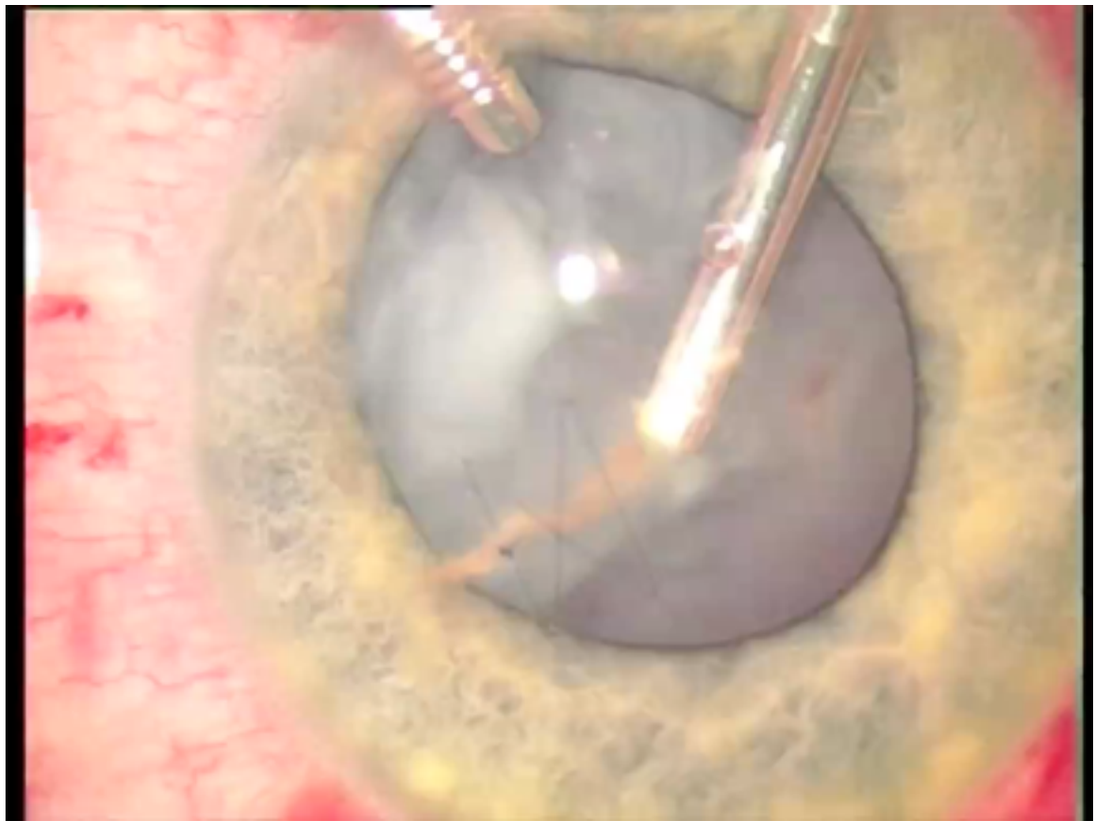
Self sealing laceration with an early cataract.



Lens Aspiration

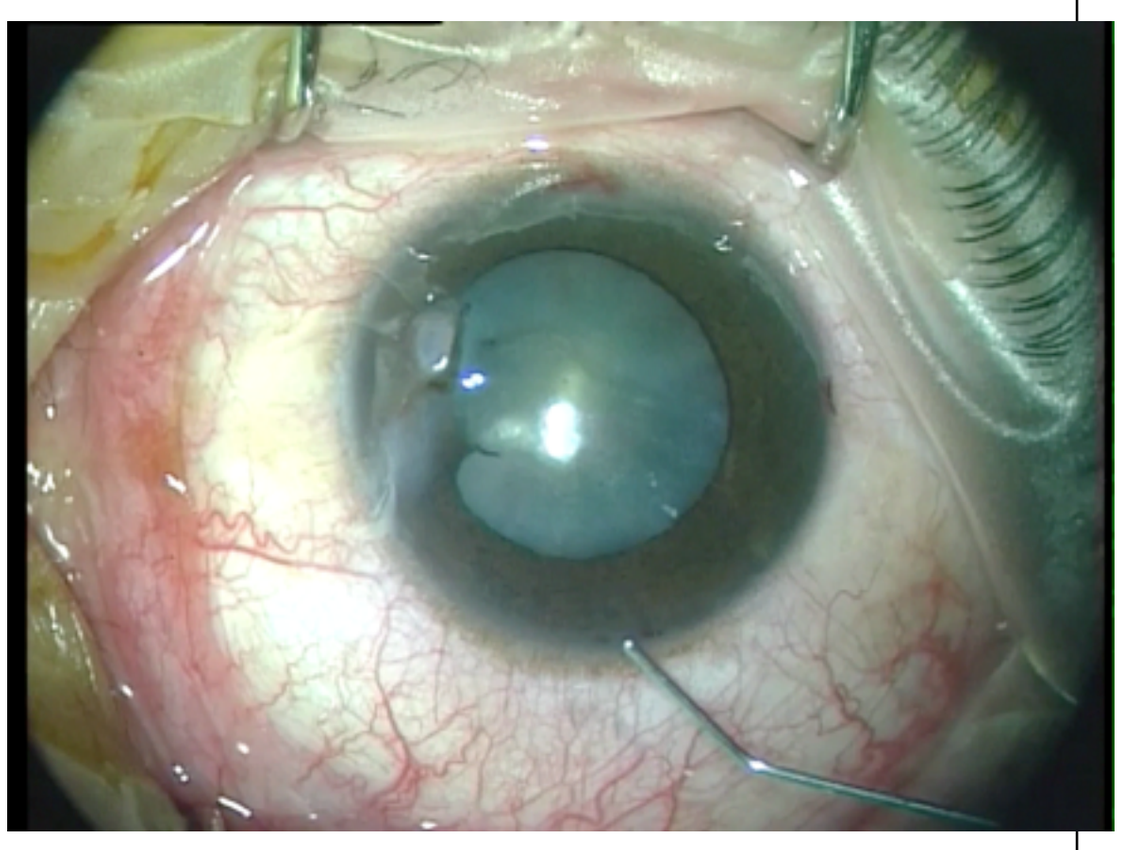
If lens removal is planned a capsule dye is injected into the anterior chamber at the start of the case.
In younger patients lens matter quickly becomes intumescent and is easily aspirated. This is less true of older patients who may have some degree of preexisting nucleosclerosis.

Figure 6.2 Lens aspiration



The lens matter is soft and easily aspirated.

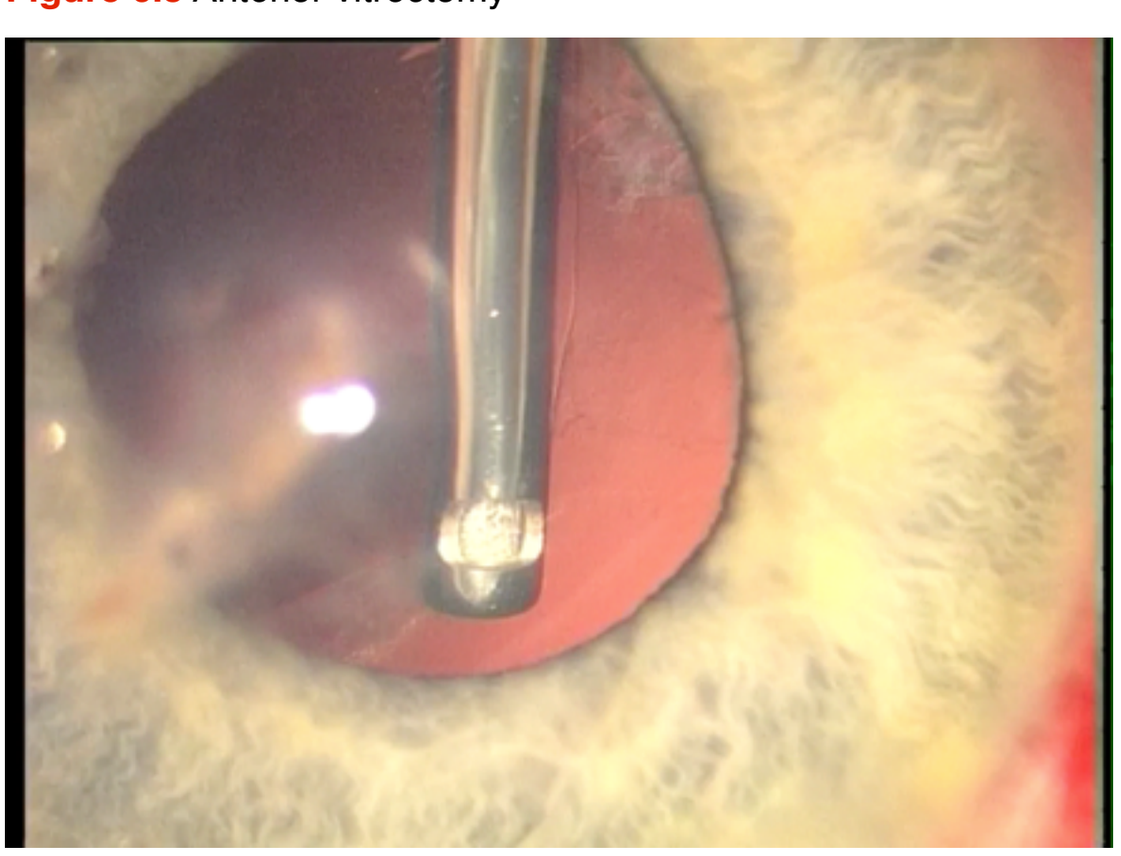
Movie 6.1 Introduction of capsule dye before suturing



Anterior Vitrectomy

While aspirating the lens one should be vigilant for the presence of vitreous, indicating a posterior capsule defect. The vitreous should be removed with a vitrector. Avoid cutting residual lens capsule if possible. Staining with triamcinolone can be very helpful in visualizing vitreous.

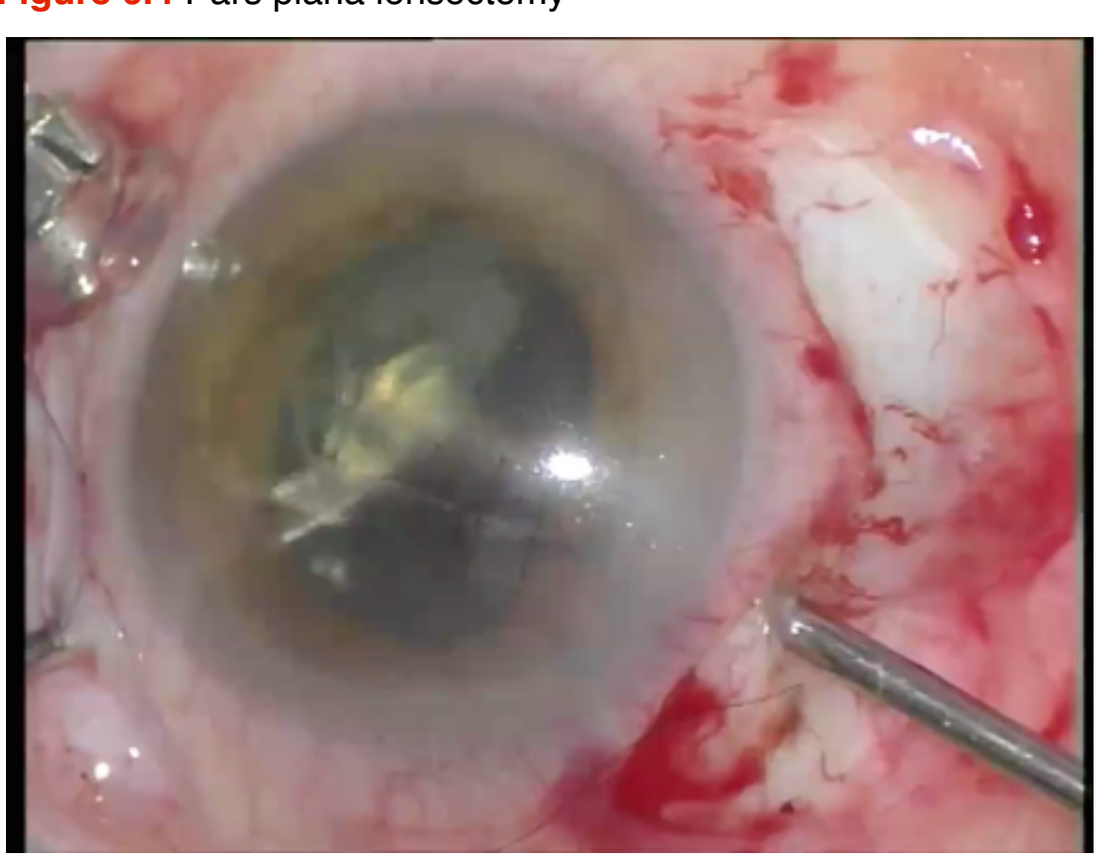
Figure 6.3 Anterior vitrectomy



Pars Plana Lensectomy

If there are large posterior capsule defects or lens matter in the vitreous deferred pars plana lensectomy is a safer option than an anterior approach. The patient should be referred to a retina specialist for this procedure.

Figure 6.4 Pars plana lensectomy

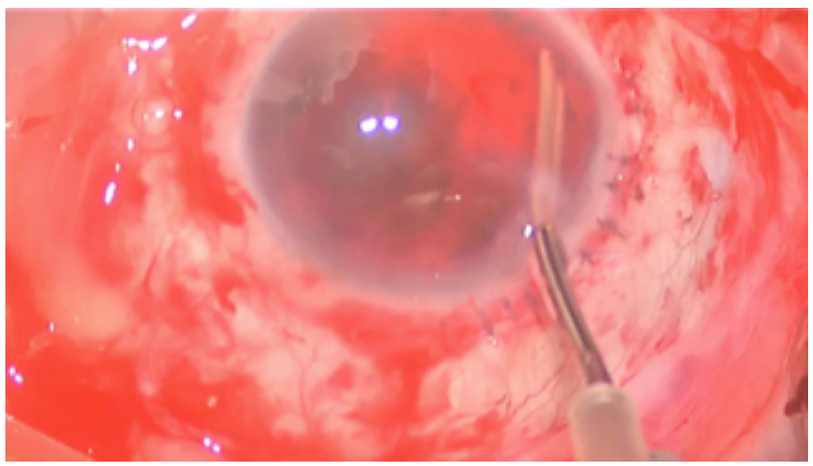


CHAPTER 7

HYPHEMA

No attempt should be made to aspirate solid blood clots from the anterior chamber during primary repair because of the risk of secondary bleeding.
If intervention is required (for example to prevent corneal blood staining) it is easier and safer to do this after the clot has liquefied.

Movie 7.1 Inappropriate removal of solid clotted blood



This practice is strongly discouraged because of the risk of secondary hemorrhage.

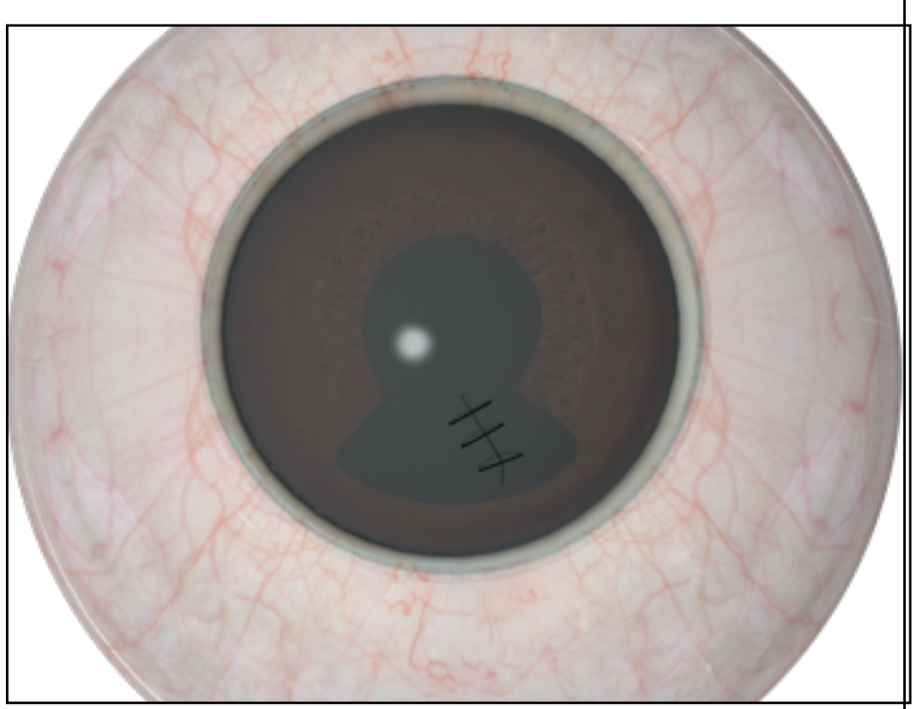
Movie 7.2 Delayed Anterior Chamber washout

It is much easier to remove the blood once it has liquefied.

CHAPTER 8

IRIS DEFECTS

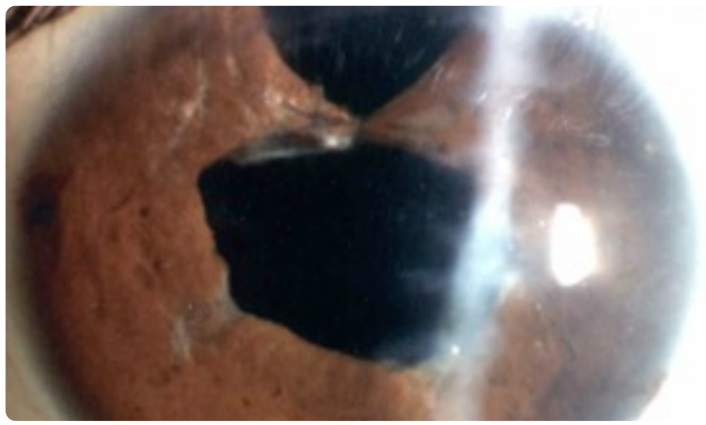
Defects in the iris may be repaired after the traumatic cataract has been dealt with. Restoration of the iris diaphragm is an important surgical goal. Iris defects can cause many problems including disabling glare. Restoring the iris in the primary surgery reduces the likelihood of postoperative synechiae. Once these are established iris repair becomes much more difficult. A full review of iris repair is beyond the scope of this book but a simple McCannell suture can give excellent results.



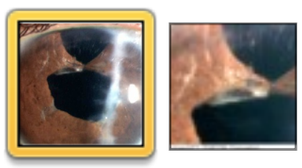
McCannel Suture

Iris defects can be repaired using a modified version of the transcorneal suture devised by McCannel for the management of dislocated intraocular lenses.
The Siepser technique allows the knot to be tied internally.

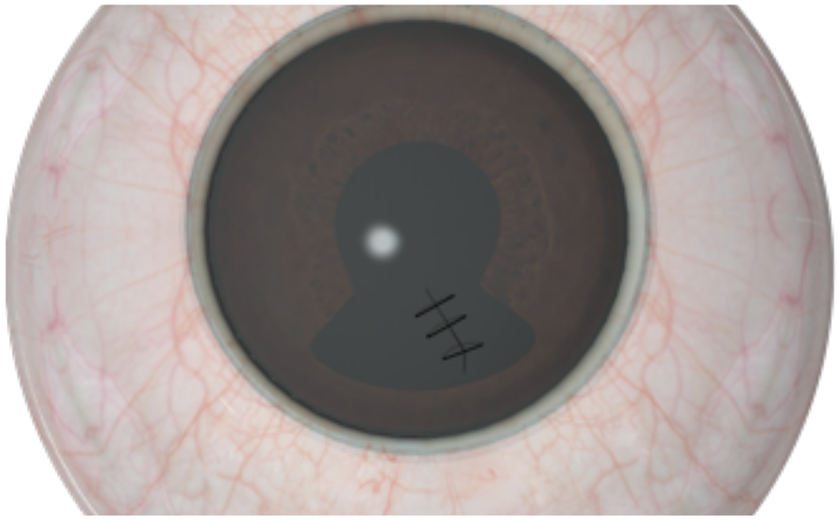
Gallery 8.1 McCannel Suture



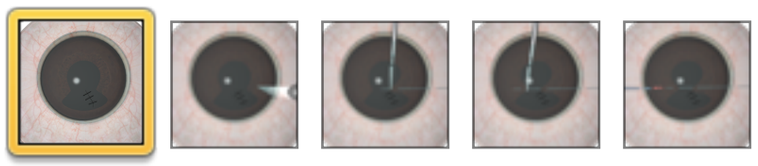
McCannel suture in place.



Gallery 8.2 Passing the McCannel Suture



A 9/0 prolene suture on a straight round bodies needle is used. The knot is tied by externalizing a loop and using a sliding knot such as the Siepser sliding knot.



Movie 8.1 McCannell suture and Siepser knot

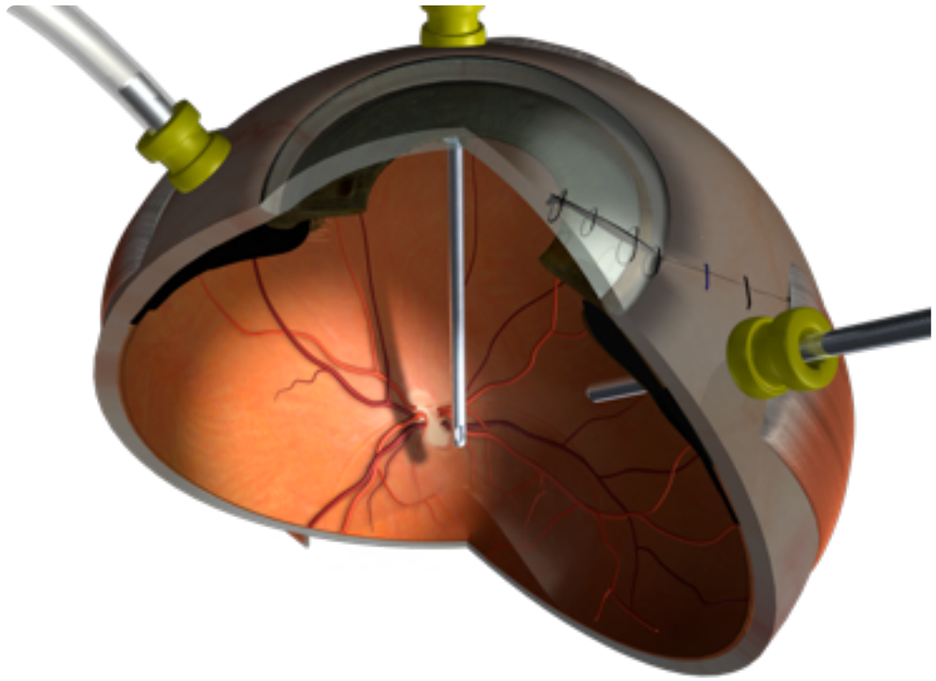
Loops of the distal suture are externalised through the proximal incision and the proximal suture is threaded through the loop.

CHAPTER 9

VITRECTOMY

Many eyes that have undergone severe trauma will require vitreoretinal intervention. This has greatly improved the visual prognosis of severely injured eyes.
It is generally performed as a secondary procedure.
The exception is vitrectomy for retained intraocular foreign body, where removal of the IOFB is combined with the primary wound repair when possible.

Figure 9.1 Vitrectomy after primary repair



All the ocular wounds should be watertight before vitreoretinal surgery is undertaken.

CHAPTER 10

REMOVAL OF THE EYE

Primary enucleation (or evisceration) of severely injured eyes has been advocated for eyes in which the visual prognosis seems hopeless.
This practice has been challenged on a number of grounds:

Judging the visual potential of severely injured eyes can be very difficult. In particular modern vitreoretinal techniques can restore vision to eyes previously considered irretrievably blind.

Sympathetic ophthalmia is treatable.

The evidence base that enucleation or evisceration are effective in the prevention of Sympathetic Ophthalmia is quite weak.

Primary removal of the eye is often extremely distressing for the patient.

The only indication for primary removal of the eye is massive tissue loss making repair impossible.

CHAPTER 11

CONCLUSION - THEORY TO PRACTICE

One's first repair of a penetrating injury case is an important milestone in the development of the trainee ophthalmologist. It is impossible to know when the opportunity to do this will arise so the reader is strongly advised to prepare by practising in the wet lab.

Animal eyes are easy to obtain. Devices such as the modified Marty Head are available to mount the eyes. If you are unable to get hold of one you can simply attach a portion of a cardboard egg box to a cork dissection board and pack it with tissue paper and mount the eye in this. Then simply lacerate the eye in increasingly complex ways and try to repair it.

Reuse disposable microsurgical instruments and left over suture ends and substitute KY jelly for the viscoelastic to reduce the cost. Cheap commercial cyanoacryate ('superglue') can be used instead of medical cyanoacrylate to practise corneal glueing.

Even experienced surgeons can benefit from wet lab practise to try out new suturing techniques in a high fidelity stress free environment.

Akkins suture

A star shaped suture for closing the points at which wound flaps meet in a stellate laceration.

Related Glossary Terms

Stellate

Index Find Term

Bootlace suture

A double running continuous suture which starts and ends with a single buried knot.

Related Glossary Terms

Drag related terms here

Index Find Term

Cohesive

A viscoelastic substance that tends to fill and maintain space during opthalmic surgery, very useful in trauma.

Related Glossary Terms

Viscoelastic

Index Find Term

Compression zone

The compression zone of a suture is the area of the wound that is closed by the suture.

This is a function of the length and tension in the suture.

Related Glossary Terms

Drag related terms here

Index Find Term

Dangel knot

A type of slip knot with a final opposing suture.

Related Glossary Terms

Slip Knot, Surgeon's knot

Index Find Term

Dispersive

A viscoelastic agent that tends to coat and protect ocular structures during ophthalmic surgery.

Related Glossary Terms

Viscoelastic

Index Find Term

Intraocular foreign body

see IOFB

Related Glossary Terms

IOFB

Index Find Term

IOFB

Intraocular Foreign Body

Related Glossary Terms

Intraocular foreign body, Laceration

Index Find Term

IOP

Intraocular pressure

Related Glossary Terms

Drag related terms here

Index Find Term

Jaffe speculum

A speculum which consists of 2 separate lid retractors which can be clipped to the surgical drape. See also http://www.ncbi.nlm.nih.gov/pubmed/3827701.

Related Glossary Terms

Drag related terms here

Index Find Term

Laceration

Any wound from a cut by a sharp object. Includes penetration, perforation, intraocular foreign body

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Related Glossary Terms

IOFB, Perforation

Index Find Term

Locking knot

A widely used technique in ophthalmic surgery in which the suture ends are pulled to one side of the wound after the first sequence of throws to maintain tension in the wound while the second throw is being made. It does not have the structure of a surgeon's knot and so may slip unless at least 2 subsequent throws are made e.g., for nylon, 3-1-1.

Related Glossary Terms

Drag related terms here

Index Find Term

Penetrating eye injury

An umbrella term for all full thickness ocular wounds

Related Glossary Terms

Drag related terms here

Index Find Term

Perforation

A wound with separate entry and exit wounds caused by an object traversing the globe.

Related Glossary Terms

Laceration

Index Find Term

Polyglactin

A widely used suture absorbable suture in ophthalmology. Often referred to using the trademark applied by the company which manufactures it e.g. Vicryl, Surgically, Novosyn, Biovek, Visorb, Polysorb or Dexon.

Related Glossary Terms

Drag related terms here

Index Find Term

RAPD

Pupil reaction on the presence of damage to the retina or pre chiasmal optic nerve

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Related Glossary Terms

Drag related terms here

Index Find Term

Reef Knot

A 1-1 knot which does not slip as it is composed of 2 interlocking symmetrical loops. The symmetry is a consequence of the strict alternation in the direction of throws (forward then backward) and direction of pull of the suture ends.

Related Glossary Terms

Drag related terms here

Index Find Term

Rupture

A blunt injury resulting in rupture of the eye wall through the dramatic resulting deformation and distention, particularly around the equator of the globe

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Related Glossary Terms

Drag related terms here

Index Find Term

Slip Knot

Otherwise known as a granny knot. A 1-1 knot in which the strict symmetry of the reef knot is absent so it slips under tension.

The term has also been used for many different types of knot but the above definition is used strictly in this book.

Related Glossary Terms

Dangel knot

Index Find Term

Spatulated needle

An ophthalmic surgical needle profile designed by Charles Schepens with a flat upper and lower surface and cutting sides. Used for suturing in sclera and cornea.

Related Glossary Terms

Drag related terms here

Index Find Term

Square knot

An alternative term for a reef knot

Related Glossary Terms

Surgeon's knot

Index Find Term

Stellate

‘Star shaped’. A branching laceration.

Related Glossary Terms

Akkins suture

Index Find Term

Surgeon's knot

A variant of the reef knot with a 2-1 configuration. Because of its symmetry it does not slip when tightened.

Related Glossary Terms

Dangel knot, Square knot

Index Find Term

Viscoelastic

A material that exhibits both viscous and elastic characteristics when undergoing deformation. Widely used in ophthalmic surgery. Classified in ophthalmic surgery as dispersive or cohesive.

Related Glossary Terms

Cohesive, Dispersive

Index Find Term