Open Globe Injuries-Primary Repair of Corneoscleral Injuries

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Introduction

Open Globe Injury by definition is a full thickness defect in the cornea and or sclera. The care of such patients call for an approach which should be systematic and methodical, but at the same time gives enough opportunity or challenges (depending upon how you perceive it) for deviating from the well trodden path. Each case can be unique and calls for creativity and flexibility from the part of the surgeon. The need for a standardized terminology of the eye injury types has led to the now widely accepted classification designed by the Ocular Trauma Group based on the “Birmingham Eye Trauma Terminology”. The classification is dealt elsewhere in this journal but in a nutshell is given below in the following table [1,2]

Table 1: Classification of Open Globe Injuries

<table>
<thead>
<tr>
<th>Type</th>
<th>Grade (Visual acuity)</th>
<th>Pupil</th>
<th>Zone</th>
<th>History</th>
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<tr>
<td>A. Rupture</td>
<td>A. ≥ 20/40</td>
<td>A. Positive Relative APD in injured eye</td>
<td>I. Cornea and Limbus</td>
<td>First priority in any case of trauma ocular or non ocular is of course, the systemic status. So a general assessment of the injuries, recording of the vital signs etc are carried out first, usually in a triage area if available. Once the general condition is found to be stable, and other major organ injuries are taken care of, ophthalmic history and evaluation begins. History should be given the importance it deserves. A properly elicited history tell us a lot about the type of injury-open or closed globe, nature of the penetrating material, and the setting (work; home etc). A good history should lead the physician to make risk assessments for the possibility of globe perforation; occult rupture; posterior rupture; intraocular foreign bodies (IOFB), chemical exposure; endophthalmitis etc and fine tune the evaluation keeping in mind these clues. However one warning regarding history in Ocular Trauma- In our experience this is one condition (is it the only one?) where the patient might sometimes try to intentionally mislead the examiner away from the actual cause or nature of the injury. The devoted house wife who wouldn’t admit to the husband’s hand (literally or the hand might have held something) in the injury, the seemingly innocent child trying to escape the wrath of the grown ups or protect the involved friend or sibling- There are lots of examples. One case which we still vividly remember is the case of a 10 year boy with a clean cut laceration on the cornea due to a hit from a rubber ball. It was with great difficulty and round about questioning that we could extract from him that the rubber ball had rebounded from a heap of broken glass pieces and everything ended well with an active search for a foreign body revealing a small glass piece in the bottom of the anterior chamber.</td>
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| B Penetrating | B. 20/50 to 20/100 | B. Negative, Relative APD in injured eye | IL Limbus to 5 mm posterior into sclera | Ophthalmic Evaluation

A complete and thorough ocular examination, keeping in mind the clues obtained from the history is the next vital cog in the trauma management wheel. This should include flash light examination; slit lamp examination and fundus examination whenever possible. See Table No. 2 for some of the relevant findings to be looked for with the slit lamp. Poor presenting visual acuity and relative afferent pupillary defect are the most significant prognostic factors that can be detected on presentation. Signs such as diffuse chemosis; massive subconjunctival haemorrhage; asymmetric deepening of anterior chamber; Low intraocular pressure; “uveal show” under the conjuctiva; hemorrhagic choroid detachment etc especially in combination should make one think of and actively search for a scleral rupture which may be trying to escape detection owing to the intact conjunctiva or chemosis above it or due to its posterior location or location beneath the muscle insertion. If the initial examination still fails to exclude a rupture or a hidden full thickness scleral wound and even an iota of suspicion remains, then don’t hesitate to do an exploration in the OT after doing the necessary peritomy. In case of children this of course means general anesthesia.

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CT Scan is the imaging modality of choice in the acute setting of an Ophthalmic trauma were we are suspecting an Open globe injury. This can uncover or give corroborative evidence in cases of Occult globe rupture; detect IOFBs; give an idea of the orbital pathologies like retro bulbar hemorrhage; Orbital wall fractures. The B Scan Ultrasound is also very useful and is definitely a better test than CT to evaluate posterior segment structures, but it’s use in Open Globe injury on presentation is limited due to the necessity of contact of the probe with the cornea or lid. However following the primary repair it definitely has a role and can even identify some non metallic foreign bodies sometimes missed in the CT Scan like glass or wood. In fact not doing it in spite of having the facility may have serious medico legal implications. Magnetic Resonance imaging even though can be more sensitive and accurate than CT, is severely limited by the fact that it can’t be used when we are suspecting a metallic foreign body. But consider a situation where the patient is pregnant and the possibility of a magnetic foreign body is not very high. MRI may be the answer.

When state of the art imaging modalities like the above cannot be employed due to non availability or due to economic reasons then the Plain film Radiograph is still valuable.

| Table: 2 Relevant findings to be looked for during Evaluation with Slit Lamp<sup>3</sup> |
|---------------------------------|---------------------------------|---------------------------------|---------------------------------|
| **Structure/Layer** | **Findings** | **Structure/Layer** | **Findings** |
| Conjunctia (manipulate conjunctival wound edges gently to look for underlying pathology) | Chemosis; Hemorrhagic chemosis; Foreign bodies sequestered in redundant folds and fornices | Subconjunctival space | Foreign bodies; Expelled Lens/Intraocular Lens; Prolapsed Uvea/Retina/Vitreous |
| Cornea | Epithelial defects; Flaps and any foreign material under the flaps; Siedel’s test if necessary to confirm wound leak or full thickness nature of laceration; Foreign body –part of which is in the Anterior chamber-Remove only in OT |
| Sclera | Not so obvious full thickness wounds; Occult rupture; Posterior rupture |
| Anterior Chamber | Cells; flare; fibrin; hypopyon; hyphema; IOFB; Shallowing – uniform/Irregular |
| Iris and angle | Sphincter tears; Iridodialysis; Iris holes; Iridodonesis; foreign bodies |
| Lens | Subluxation; dislocation; Anterior capsule or Posterior capsule defects ;Cataract formation; Leakage of Lens material into AC;Intralenticular foreign body |
| Ophthalmoscopy (Defer dilated examination in cases with iris prolapse till primary repair is over.) | Hemorrhages in various locations/layers; choroidal ruptures; Retinal breaks; IOFB ; Macular edema etc |

**Imaging in Ocular Trauma**

CT Scan is the imaging modality of choice in the acute setting of an Ophthalmic trauma were we are suspecting an Open globe injury. This can uncover or give corroborative evidence in cases of Occult globe rupture; detect IOFBs; give an idea of the orbital pathologies like retro bulbar hemorrhage; Orbital wall fractures. The B Scan Ultrasound is also very useful and is definitely a better test than CT to evaluate posterior segment structures, but it’s use in Open Globe injury on presentation is limited due to the necessity of contact of the probe with the cornea or lid. However following the primary repair it definitely has a role and can even identify some non metallic foreign bodies sometimes missed in the CT Scan like glass or wood. In fact not doing it in spite of having the facility may have serious medico legal implications. Magnetic Resonance imaging even though can be more sensitive and accurate than CT, is severely limited by the fact that it can’t be used when we are suspecting a metallic foreign body. But consider a situation where the patient is pregnant and the possibility of a magnetic foreign body is not very high. MRI may be the answer.

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**Documentation**

Accurate and methodical documentation of all the relevant details in the history and evaluation is extremely important for clinical and medico legal reasons. What you wrote or did not write in the case record might turn out to be more important in the court than what you did or did not do.

**Initial Management and Planning the Surgery**

Surgical repair of a severely traumatized eye is a complex procedure involving expertise, skill as well as proper infrastructure. If for any reason an ophthalmic surgeon say in a general ophthalmology set up feels that he/she cannot address all treatable lesions that require emergency management, it is usually preferable to refer the patient prophylactic systemic and topical antibiotics with broad spectrum coverage has to be started.

**Timing of Intervention in Open globe injuries**

The risk of endophthalmitis does not significantly increase in the first 24 or 36 hours after the injury. So if appropriate equipment , staff or anesthetist is not available immediately, it is justifiable or even advantageous to wait for a few hours. However if the same is not an issue then it can be done immediately. In our Institute we make sure that the primary repair is done within 12 hours. Interventions like lens removal
if necessary, IOFB s without much risk of endophthalmitis; repair of retinal detachment etc can be done as a second planned procedure.

Anesthesia
General Anesthesia is usually preferred, as you can avoid retro bulbar/peribulbar injections which can induce or aggravate prolapse of intraocular tissues with a lot of undesirable consequences. However systemic risks in some patients; and a lot of practical considerations combine together to result in local anesthesia via the peribulbar or retro bulbar route, still being widely used in many centers. (6).Topical Anesthesia supplemented by IV sedation can also be used in selected cases (7).

Primary Repair of Injuries

Involving Cornea

Self Sealed Corneal Wounds
The first question that we generally ask ourselves in these types of injuries is of course whether suturing can be avoided. We call them self sealed corneal wounds which on slit lamp examination appears exactly as described by the term with the full thickness wound appearing as an irregular line with good anterior chamber depth , no iris in between the wound lips. Well whatever be the line of management you choose always think about and rule out the presence of an intraocular foreign body. As far as primary repair is concerned Conservative management with only prophylactic antibiotics and no surgical repair is enough for very small self sealed corneal wounds of 2 mm or less , provided there is no other intraocular tissue at the wound, no other ocular structures are involved , no foreign material is present in the wound and Seidel’s test is negative. In such cases where it has been decided not to suture, it is always better to place a bandage contact Lens over the cornea and to leave it there for 2-3 wks. Topical Antibiotics and steroids can be continued. For Larger Self Sealed Lacerations- There are 2 options.
1. Routine surgical repair
2. Cyanoacrylate Tissue glue with Bandage contact Lens.
The surgeon can select one of these based on his experience, expertise and comfort zone .Suturing may result in more astigmatism and also brings into the picture a 2nd intervention even though minor in the form of a suture removal later.

Whenever you are selecting conservative management or gluing over surgical repair, Ask yourself this question?
1.Is there a risk of the wound reopening especially once the patient returns home and engages in his routine work? Eg: inadvertent rubbing, accidental bumping of the eye .
If the answer is “Yes” then you and the patient might be better off undertaking a proper surgical repair of the laceration

2. Children are not good candidates for this line(non surgical) of management.
Tip: An approximate idea of the strength of the seal can be obtained by applying some pressure on the sclera with one finger through the lids while observing under slit lamp and looking for any wound gape or shallowing of anterior chamber (a sort of simulation of the forces that can act on the wound once the patient is out of the hospital).Double check with a Siedel’s test.

Corneal Lacerations with Flaps
When the wound is not full thickness or only approaching full thickness in a very small area so that it is well sealed, the aim should be to see that whether the flap can be kept well apposed in its correct anatomical location without sutures, as suture in such case may only induce additional astigmatism and may not be of any benefit in the wound healing. So if it is not displaced a bandage soft contact Lens is all that is required.

However if the flap is displaced, it has to be repositioned and secured with sutures. In such cases make sure that sutures are partial thickness through the surrounding stroma .The tightness and number of sutures should be just enough to hold the flap in place.

Some cases which present late (after 24 hours), may have epithelial growth underneath the flap and this has to be debrided off before suturing. Any way in a displaced flap it is a good idea to irrigate the bed and undersurface of the flap to clean off any debris, foreign body particles etc.

Full thickness Non Self Sealing Corneal Wounds
These require surgical repair in the operating room with 10-0 or 11-0 nylon sutures .The principles of suturing are dealt with separately. A small piece of advice to the young surgeons- Having done a good job in suturing – Please do not forget the finishing touches-viz burying your knots. When you do that then you might suddenly realize that many of your suture ends are quite long and requires trimming. If you don’t do this then you will get a few patients who cannot even open their eyes in the convalescent period due to the intense suture irritation and watering .Before long you can even see large papillae in the upper tarsal conjunctiva.

Principles of Surgical repair of Corneal Lacerations
Our aim here should be the restoration of the optically clear, smooth surface and curvature of the cornea as even small irregularities in the curvature can lead to significant visual disability.

The surgeon should already have a plan in mind of the surgical steps going to be done and in what order. The plan is of course based on the initial evaluation findings. So during the initial slit lamp examination itself the surgeon should be on the look out for the normal anatomical land marks and
other features that will aid in apposing the edges of the wound correctly and restoring the displaced tissues to their correct anatomical location. The idea is that apposition of the edges of the laceration with properly placed sutures should first happen at these landmark marks. Once this is done correctly the chances of incorrect apposition of the remainder of the laceration are minimal and suturing can proceed smoothly.

Such landmark marks which can be found in a corneal laceration are illustrated in Figure 1 below.
1. Limbus
2. Stellate Edges
3. Pigmentation Lines in the Epithelium
4. Sharp angles of the laceration

It is very unusual to get a corneal Laceration without at least one of the above. Irrespective of whether he/she has made a plan taking in to consideration all these in the initial evaluation, a reassessment should be done on the table after cleaning off the debris if any from the wound edges and making the wound lips free of any extraneous tissue including iris (by repositioning/abscising as the case may be), vitreous etc. Based on this a final strategy on how to proceed with the wound repair should be made and executed.

Basic Suturing Techniques

Suturing techniques
Interrupted Sutures
The most preferred suturing method to appose the wound edges is interrupted suturing placed with 10-0 or 11-0 nylon with spatulated needle. Ideally a round suture loop should be placed in a single plane so that the 2 edges will be having a layer to layer apposition. Suture passes should be approximately 1.5 to 2 mm total in length\(^1\)(i.e. 0.75 to 1 mm on either side. In case of edematous or macerated wound edges slightly longer passes may be required to incorporate healthy tissue by the suture. Equal amount of tissue should be incorporated on each side of the wound. The depth of the sutures should be 85-90% of full thickness, which would mean that the needle passes over the Descemet’s membrane. Full thickness corneal lacerations generally have one of the following 2 anatomical configurations \(^1\).  
1. A more or less Vertical (perpendicular) laceration 
2. An oblique (shelved or beveled) laceration

The 2 types require 2 slightly different approaches to suturing so as to facilitate correct wound edge apposition without any overriding or distortion.

In vertical Lacerations the suture entry and exit sites should be equidistant from the wound margins so that the corneal suture is centered over the wound (See Fig 2). However we don’t have to worry whether it is centered with respect to the anterior aspect of the wound or posterior aspect of the wound as both would be in the same perpendicular line. If any of the limbs of the suture is longer than the other, the wound edge on that side will override the other edge when tightened.

In beveled or shelved lacerations a slightly different approach is required. Here if you are taking the bites equidistant from the anterior aspect of the wound margin, there will be wound overriding and tissue distortion. To prevent this care should be taken to ensure that the suture is centered on the posterior aspect of the wound margin. This means that the suture entry and exit sites will be displaced with respect to the anterior aspect of the laceration but will be equidistant with respect to the posterior aspect. (See Fig 3)
Figure 3: Suturing of a shelved laceration. The distance from the anterior margin of the wound to the suture entry site (A) is not equal to that from the same point to the suture exit site (B). But what matters here is the distance from the entry and exit sites to the posterior margin of the wound (C & D), which is equal (C = D). (Adapted from 101 Pearls in Refractive, Cataract, and Corneal Surgery second edition Edited by Samir A. Melki and Dimitri T. Azar)

Note that ideal depth through which the suture should pass is 90% which should take it just over the Descemet’s membrane.

An important factor to be taken into account during suturing of corneal lacerations is the issue of edematous wound edges frequently seen when the time gap between the injury and time of suturing is more than a few hours. This results in 2 problems

1. Because of the corneal edema being localized, you may end up with 2 opposing edges differing significantly in thickness. How to ensure layer to layer approximation (that is our aim) of the edges in such a situation?
2. Once the corneal edema decreases in the immediate postoperative period aided significantly by the topical anti-inflammatory drops that we invariably give, some of the sutures which we thought were of the correct tensile strength and producing good apposition are suddenly found wanting in doing the job they were entrusted with-viz holding the wound edges in close approximation.

A solution suggested by some authors for the first problem is to employ full thickness box suturing (See Figure 4) as when the full thickness of the corneal edges are incorporated in the suture loop, there is anyway going to be good approximation –almost layer to layer irrespective of whether there is thickness difference or not. To achieve the same approximation with a partial thickness suture in such a situation will require considerable skills from the surgeon. However there is the risk, even though minimal of the suture acting as a conduit, enabling microorganisms or epithelial cells to enter the eye. Personally we try to avoid full thickness sutures as far as possible. The 2nd issue has to be kept in mind when the sutures are tightened and that allowance has to be given.

Figure 4 (Top and bottom) The box suture is a compromise structure for an interrupted suture. The suture is placed full thickness. With tightening, the tissue is compressed but the wound alignment is not altered. The surface effects of the suture are relieved with suture removal, (Taken from Text book of Ocular Trauma Principles and Practice-Ferenc Kuhn; Dante J Pieramici)

Care must be taken to see that the sutures are always placed at right angles to the wound edge to avoid wound slippage (See fig 5).

Tightening of the suture will cause compression of the tissues, but if correctly done there will not be any eversion or inversion of the edges. The tissues on either side of the laceration will be well apposed without any displacement and the chances of slippage later are minimal. Of course the suture tightening will cause some surface distortion. But this will get corrected later once the wound has healed and the sutures are removed, provided no anatomic distortion occurs during the wound healing. Once the flattening effect of the sutures is relieved by their removal the corneal curvature will return back to normal. On the other hand if wound slippage or misalignment has occurred at the time of suturing or during the immediate postoperative period, both due to incorrect suture placement, well then the distortion that you
get will be permanent and no amount of suture removal or suture adjustment is going to correct that.

Figure 5A and B. Sutures should be placed at right angles to the wound at the point of the suture/wound inters section. Sutures at acute angles will cause wound slippage with tightening as illustrated (3) (Taken from Text book of Ocular Trauma Principles and Practice-Ferenc Kuhn; Dante j Pieramici)

Running sutures

Employing these may make the whole procedure faster. We use these for some lacerations with clean cut straight edges (e.g.: some knife wounds). They provide a continuous and uniform zone of compression (with some adjustment of tension before tying) and results in good wound apposition in ideal conditions. However the disadvantages are as follows

- Large zone of compression and thus excessive flattening of the cornea
- Misalignment of wound edges due to suture induced edge slippage
- Straightening of curvilinear incisions
- Rippling of corneal surface if sutures are not placed in the same depth or full thickness

So the continuous or running sutures can be employed in selected cases with good benefits.

Rowsey-Hay’s Technique of Corneal Suturing and its importance

Restoring the previous corneal curvature by your suturing—well that is attempting to recreate the exquisite work of the creator. You might be found severely wanting there. Our aim should be rather to provide the patient with a central cornea with uniform spherical contour rather than trying very hard at recreating the previous contour. This is facilitated by the Rowsey-Hay’s technique of corneal wound closure illustrated in Figure 6

Some sort of a qualitative keratometry can be utilized to ensure that the central corneal curvature is uniform. An easily available instrument in the OT for this will be a Fleringa ring. If that is not available a hinge spring of a safety pin may suffice. After the initial suturing, the surgeon can hold this ring over the cornea and utilizing the co axial illumination, its reflection from the epithelial surface is examined. The ideal reflection should be a round circle. If there is some astigmatism induced, the ring appears oval or distorted. In such case the surgeon can then tighten or loosen some sutures keeping in mind the Rowsey-Hay principle so as to get an ideal reflection. The problem of course is that we hadn’t applied any adjustable sutures here. So what to do now? No other way than to remove and reapply some sutures. The other way of course is to apply these sutures initially in a manner in which they can be adjusted later i.e. by employing some sort of slip knots (e.g.: sliding clove hitch or sliding half hitch).

Special Situations

Loose fragments

Full thickness corneal wounds with a lot of loose fragments often displaced in impossible angles, can be really tough to repair. However all these fragments have to be patiently and meticulously repositioned into their normal anatomic position. Having done this the next big problem is how to...
keep them there? As a first step try to place sutures through the edges of the fragments. If it works, good. If not then consider the following additional options
1. Oversewing
2. Using Bandage contact Lens as a splint
3. Glue

Stellate Wounds
Next to loss of tissue, this is the most difficult problem in corneal wound repair. They may require a combination of sutures and tissue adhesive, and sometimes, a patch graft for a proper closure. A purse string technique has been proposed by Eisner. (8) In some cases, the additional use of cyanoacrylic glue can be helpful.

Injuries to LASIK Flaps
The corneal flaps created during LASIK are vulnerable to traumatic dehiscence and dislocation, even years after the procedure. A partially displaced flap can be managed with a bandage contact Lens while a completely displaced flap should be repositioned and secured with sutures. It is always better to get the help of a refractive surgeon in these cases.

Loss of Tissue
This situation is extremely rare and in most cases the missing piece of the puzzle (tissue) will be there—mostly turned down as a flap into the anterior chamber or just displaced from its normal site. So before allowing the alarm bells to ring, do a careful examination of the full thickness of each of the wound edges, if necessary with the help of a blunt instrument like an iris repositor to detect and reposition such corneal fragments or displaced flaps. Once that is done all that is remaining will be to apply a few well placed sutures.

However wounds with loss of tissue can occur in a few cases of trauma with high speed missiles as in gunshot wounds or explosions. If the defect is small, the area can be closed with tight sutures even though it can result in significant amounts of tissue distortion and wound tension and may later cause significant irregular astigmatism. However when such tissue loss exceeds 5 mm in diameter a corneal patch graft is usually required. Full-thickness patch graft is technically easier to perform but requires a donor cornea. A lamellar patch graft is effective and may be performed with a corneal auto graft or donor sclera. These grafts are often located outside of the visual axis; therefore, graft clarity may not be essential for good postoperative vision.

Some general considerations while repairing corneal wounds
1. Handling of tissue should be kept to minimum. Repeated attempts at grasping the wound edges can lead to maceration especially as the tissue might be edematous and fragile. The surgeon will be making his job more and more difficult by doing this. The spatulated needle point of the 10-0 should be prevented from touching any other tissue other than the wound edge as it can easily get blunt and would make suturing more difficult, thereby forcing the surgeon to do just what he should not be doing i.e. grasping and regrasping the tissue. Many a time maintaining the anterior chamber with a tight air bubble lets you do the suturing without needing to grasp the wound edges with forceps or by just fixing the globe gently by grasping at the perilimbal episcleral tissue. An exquisitely sharp spatulated tip for the suture needle is absolutely necessary for this.
2. Options to be considered when wound leak persists in spite of suturing
   i. Bandage Contact Lenses
   ii. Tissue adhesives
   iii. Patch graft
3. Avoid putting sutures in the visual axis as far as possible. If unavoidable make sure that the suture limbs are kept very short.

Scleral and Corneoscleral Injuries
The main goals in the management here include
1. Restoration of integrity of the globe
2. Avoidance of Further injury to Ocular tissues
3. Prevention of Corneal scarring and astigmatism

Very small scleral defects as in a puncture wound by a sharp thin wire or the common broom stick, without uveal prolapse can be managed conservatively with appropriate antibiotic therapy. However most of the larger scleral wounds require surgical repair.

Unlike the purely corneal injuries, scleral wounds especially ruptures can sometimes be missed since they can be hidden by the intact conjunctiva and/or large subconjunctival hematoma. So there has to be a high index of suspicion in cases with suspicious signs and typical history (see evaluation). Any lingering doubts are to be settled by a globe exploration under the appropriate anesthesia. If necessary a 360 degree peritomy is made as in RD surgery so as to retract the conjunctiva and provide good exposure of the sclera. Special attention is to be given to the areas of muscle insertions and the areas in between them as this is one of the most common sites for a rupture.

General Principles of Closure of Scleral Wounds
Full thickness scleral wounds are generally apposed with interrupted sutures with “8-0” or “9-0” Silk or Nylon. A needle with a spatulated end is to be used.

1. Ensure proper exposure and visibility of the wound edges. A common mistake by many of the beginners is involvement of the tenon’s or even the conjunctiva in the suture supposed to approximate the scleral wound edges. Worse there might be only tenons and no sclera. Best way to ensure this doesn’t happen is to clear the tenons and conjunctiva completely off the wound edges before passing the suture.
2. Involvement of any prolapsed or prolapsing tissue (uvea, retina or vitreous) in the suture is also to be diligently avoided. So it follows that any such tissue must be gently reposited back or absced away as the case may be before passing the suture. Vitreous of course should be amputated at the scleral surface. When doing this any unnecessary traction on the vitreous should be avoided. The wound edges may be raised gently with forceps while passing suture bites so as to keep any uveal tissue from being impaled by the suture needle. Using viscoelastics to reposition uveal tissue in a scleral laceration may not be a good idea as the viscoelastics may enter the sub retinal space from where it is only poorly absorbed resulting in excessive inflammation and increased risk of Retinal detachment.

3. Scleral wounds are generally closed from anterior to posterior direction. Just as in the cornea here also suturing should begin from a recognizable landmark. If the Limbus is involved then without doubt that is where the first suture should go. Otherwise we start from a recognizable landmark like the apex of the laceration.

4. Large wounds extending posteriorly, it is better to employ a “Close as You Go” strategy as illustrated in Figure 7. Also if you leave the last tied suture ends long, these ends can be used to exert some traction on the globe so as to rotate it anteriorly so as to expose more of the posterior portion of the wound.

5. But even with this method there is a limit to the posterior limit up to which you can go in a wound extending posterior to the equator. In such cases some portions of the posterior most portions of the wound might have to be left unsutured. It is better to do so than to cause additional damage and further tissue prolapse with extreme manipulations.

6. Following the same principles an isolated posterior scleral wound near the optic nerve may be best left alone unsutured, trusting the surrounding orbital tissue to give good tamponade as the wound heals.

7. In cases where the scleral wound extends through or under an extra ocular muscle, an assistant can retract the muscle gently using a muscle hook to aid in exposure. If more exposure is needed especially if the laceration is under the insertion of the muscle, the same may need to be temporarily disinserted so as to allow the suturing. Following the closure of the scleral defect the muscle may be reinserted.

**Corneoscleral Wounds**

We just need to combine the principles of corneal and scleral wound repair here. Commonsense dictates that the major landmark here is the Limbus and so that is the area to be apposed first. Next continue with repair of the corneal aspect followed by the scleral aspect adhering to the principles already discussed. See Figure 8 for illustration.

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**Figure 7:** The “Close as You Go” technique for Exploration and Primary Closure of a Scleral Wound. Here the visible anterior portion of the wound is exposed and sutured first and having reached the visible end a little more of the wound is exposed by opening the conjunctiva and Tenons there and sutures are applied to this exposed area. Having finished this more of the wound is progressively exposed and sutured. This ensures that the still to be sutured, open part of the laceration is supported by the periorbita and this will prevent the intraocular contents from prolapsing out. 

(Taken from Text book of Ocular Trauma Principles and Practice-Ferenc Kuhn; Dante J Pieramici)

**Figure 8:** Left side fig shows the anatomic Land marks identified in the corneoscleral wound. These are Limbus (1) and the angles of the wound (2, 3). So first suture at (1), then corneal part and then scleral part. (Taken from Text book of Ocular Trauma Principles and Practice-Ferenc Kuhn; Dante J Pieramici)

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**Special Situations**

**Scleral Defects Not repairable by suturing alone**

This can occur in severe trauma to the globe or even not so severe trauma involving areas already thinned out or weakened by previous infections ; inflammations or degenerations (eg staphyloma in high myopia). In such cases repair using a scleral patch graft is indicated. Depending upon the size of the defect and need for structural support, a variety of materials can be used for grafting as follows
Other alternatives when autologous tissue is needed and sufficient sclera is not available are Fascia Lata, Periosteum from anterior tibial crest or split –thickness dermal graft. However this would mean multiple incision sites and general anesthesia and the patient should be able to tolerate this.

Details of the techniques of harvesting the graft materials and the actual grafting are beyond the scope of this article and the reader is advised to refer standard text books for the same. Some general principles to be noted during preparation of the recipient bed are

i. Any frankly necrotic or infected appearing tissue has to be removed and the devitalized or irregular margins trimmed using scissors or a sharp blade to form a smooth circular recipient bed. Be careful not to cause any further injury to the underlying uveal tissue.

ii. Another approach is to do a partial thickness trephination and use a sharp scissors or blade to remove the rest of the tissue in the bed. A suction trephine will be better suited for trephining in these hypotonous globes.

### Controversies

1. **Reconstruction Vs Enucleating in No PL Eyes**

The current thinking is that even if the globe appears very badly damaged and vision is NO PL, every effort should be made to preserve the globe in the emergency management setting. In such cases secondary enucleating can be considered if later the eye despite all the reconstructive attempts remain NO PL and the risk of sympathetic ophthalmitis is perceived to be higher than usual. The decision can then be taken after discussion with other colleagues and also the patients and relatives. The psychological trauma inflicted on the patient by an enucleation in the acute period can be tremendous and is best avoided.

2. **Timing of Primary repair- Immediate Vs Delayed**

This has already been discussed. The gist of the matter is that several studies have proved that the risk of endophthalmitis in open globe injuries does not significantly increase in the first 24 or even 36 hours (4, 5). So if a few hours delay can improve the quality of the surgery and patient care, then it is better that way. However where the risk of infection is high as in large uveal prolapse; certain types of intraocular foreign bodies such a delay may not be prudent.

3. **Primary Wound Closure Vs Comprehensive Reconstruction**

In the former the primary management is limited to a proper wound toilette; management of the prolapsed intraocular tissue (repositioning or abscessing); Removal of any obvious anterior chamber and wound lip foreign bodies and apposition of the wound by suitable sutures. The advantages are that things are kept very simple requiring only average skill and expertise. A thorough evaluation can be carried out in the post operative period including B scan; CT scan and even electrophysiology and further management involving complicated procedures like Vitreo-Retinal procedures can be planned and executed in consultation with other colleagues or even other centers.

On the other hand a truly comprehensive management involves tackling the other co existing pathologies like cataract, Posterior segment IOFB, Posteriorly dislocated Lens or IOL, Retinal detachment Vitreous hemorrhage etc and depends on the availability of ophthalmologists who are fully trained to work in the anterior as well as the posterior segment of the eye or a comprehensive team of Anterior and Posterior Segment surgeons along with the proper infrastructure and technical support.

So even though the first is definitely more practical and also the only option in many centers, the latter approach has some advantages some of which are as follows

1) Comprehensive management is less expensive.

2) Comprehensive management offers potential prevention of endophthalmitis by removing the inoculated media (eg an Intravitreal non metallic foreign body)

3) Comprehensive management offers the potential reduction of post-injury inflammation and the prevention of scar tissue formation, such as proliferative vitreoretinopathy (PVR), again by removing stimulating factors (cytokines) present in the vitreous cavity.

4) Comprehensive management offers earlier visual rehabilitation.
Research is still going on in this field and may ultimately settle this question in favour of one of the approaches.

4. **Role of Prophylactic Cryotherapy in Corneoscleral Injuries**

Prophylactic cryo in a setting like this was done by a few surgeons in the hope that it might prevent a retinal detachment. However, this might be counterproductive as it may trigger increased intraocular inflammation and fibrosis thereby increasing the chance of a detachment. If retinal view is there a barrage laser should be considered.

5. **Role of Prophylactic Scleral Buckle**

Despite numerous studies, there are no substantial data to indicate whether a scleral buckle might decrease the subsequent risk of retinal detachment or even reduce the need for secondary surgical intervention. However, if the scleral and retinal laceration extends posterior to the ora serrata, if the peripheral retina cannot be visualized, and in case of retinal incarceration, a prophylactic scleral buckle should be considered.

**Conclusion**

The principles of wound repair hitherto dealt with should be treated not as strict rules, but as guidelines. Trauma surgery is an area which needs a lot of innovations and thinking on the feet and modifying our techniques as per the situation. No set of rules or guidelines, however comprehensive cannot cover the entire panorama of wounds that is going to be thrown up at a trauma surgeon. But to the inquisitive and adventurous surgical minds these journeys along untrodden paths can be exhilarating.

**References**


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