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Vitrectomy in Open Globe Injuries

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1. Introduction

Correct management of traumatized eye is a complicated task needing a sound evaluation of the extent of trauma. An initial history, physical examination and judicious use of Para clinical techniques to determine the extent of injury and construct a prognostic view in mind, are a prerequisite to correct surgical approach to a traumatized globe. The vitreoretinal surgeon is usually not the first physician to see the patient and is consulted for management after a primary ophthalmologist has either repaired an open globe, or has diagnosed the open globe injury or presence of IOFB. For this reason, the primary steps of management of an open globe, although of outmost importance, are not addressed in this chapter.

For a vitreoretinal surgeon to approach an eye with repaired lacerations it is necessary to know the object that has caused the trauma, date of primary repair, procedures that have been done during primary repair, the extent of lacerations, presence or absence of vitreous and tissue incarceration into the wound, and the type of tissues incarcerated. Each of the above data has implications in the management. For example if an eye is traumatized by a piece of wood, then one must consider the probability of presence of wood particles within the eye and the high risk of development of endophthalmitis. In such a case, the surgeon may decide to do an earlier vitrectomy. The date of primary repair is used for timing of the surgery as will be discussed later. And the procedures for example, lensectomy that have been done during the primary repair, may help the surgeon plan about the steps of surgery like the site for placement of the inflow. Knowledge of the extent of laceration and the type and extent of tissue incarceration into the wound will help the surgeon construct a mental model of the condition to predict surgical steps needed and prognosticate the results preoperatively which may help in consultation with the patient and the family.

For a successful vitrectomy to be done, a watertight primary wound closure is necessary. The surgeon must also assess the clarity of cornea and lens (if present) to be sure there will be adequate view of the posterior segment structures for vitrectomy. If there is central corneal laceration, he or she must consult a cornea surgeon to be prepared for placement of a temporary keratoprosthesis and doing penetrating keratoplasty afterwards.

Another piece of data that is very important to have before surgery is the condition of the retina; is it attached or detached and incarcerated. This information will affect the surgical planning much.

Presence of IOFB, age of the patient, presence or absence of signs of intraocular infection, all will affect the timing and planning of a surgery.

2. Mechanism and complications of intraocular fibrovascular proliferation after open globe injuries

It has been shown that scleral lacerations with incarceration of vitreous in the wound have the potential complication of fibrovascular tissue growth into the eye, which will be enhanced by the presence of blood, lens material and inflammation[1]. This fibrovascular tissue can damage the eye by exerting traction on the retina or ciliary body causing tractional retinal detachment (RD) or ciliary body detachment. Growing over the ciliary body the membrane forms of a cyclitic membrane causing hypotony. (Figure 1) To prevent these grave complications, vitrectomy is indicated in every case of trauma that is judged high risk for growth of intraocular fibrovascular tissue[2].
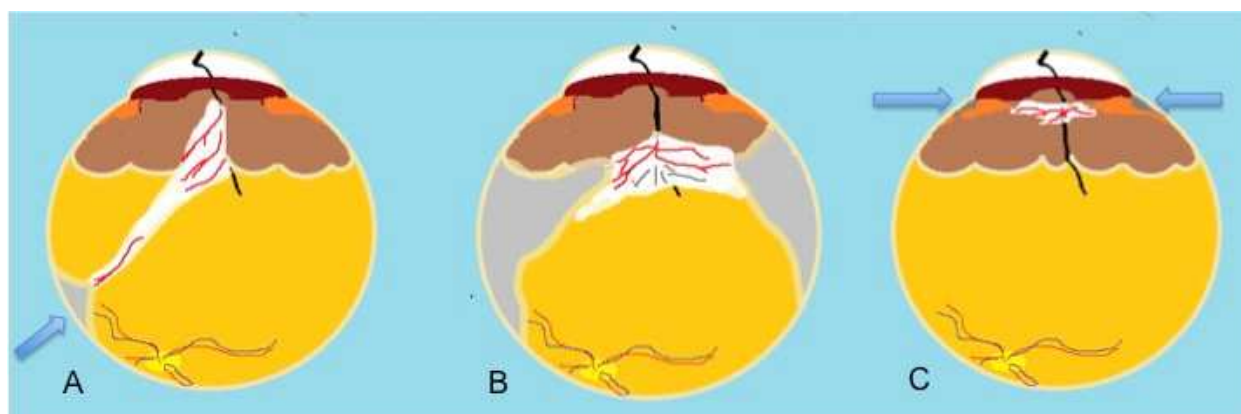

Fig. 1. Fibrovascular ingrowth into the eye can cause many complications: Tractional retinal detachment as a result of fibrovascular tissue growth over the path of a perforating eye injury (A) or in the vitreous base and cortex (B). Traumatic cyclitic membrane results from fibrovascular growth in the anterior cortex of the vitreous body in the region of the pars plicata(C).

3. Indications for vitrectomy in ocular trauma

The following are some of the more common criteria used for performing vitrectomy in an open globe injury:

a. Penetrating eye injuries involving the sclera with:
    i.   vitreous incarceration in the wound and moderate to dense vitreous hemorrhage,
    ii. vitreous incarceration in the wound and presence of lens material in the vitreous cavity
    iii. more than minimal retinal incarceration
b. Penetrating eye injuries not involving the sclera with
    i.   dense vitreous hemorrhage
    ii. suspected to involve the posterior segment
c. Perforating eye injuries
d. Presence of an (infected or toxic) IOFB

e. Presence of retinal detachment, extensive choroidal detachment or other posterior segment pathologies in need of repair.

Timing of surgery depends on the circumstances. Presence of IOFB or infection mandates early intervention.

a. *Penetrating eye injuries involving the sclera*:
As stated before, scleral lacerations can act as an entrance for migration of fibrovascular tissue into the eye. This can be enhanced if there is a frame for the pathologic tissue to grow on i.e. incarcerated vitreous, and the presence of material with exciting cytokines like blood and/ or lens material. Cleary and Ryan showed that the site of scleral laceration also matters: proliferation is more apt to occur if the wound is in the region of pars plana[3-5]. The primary goal of vitrectomy in penetrating injuries involving the sclera is to halt this process of fibrovascular tissue proliferation by removing incarcerated vitreous, and the blood and lens material present in the vitreous cavity. Secondary goals of surgery are: clearing the media, repair of any associated posterior segment trauma, and prevention of future epiretinal membrane formation or tractional retinal detachment by complete removal of the vitreous.

i. Preoperative considerations:
One of the first considerations in these types of injuries is the indication for vitrectomy. If the media is clear enough for a complete fundoscopy, there is no or mild vitreous hemorrhage, and the site of laceration can be monitored, then the case can usually be safely followed without doing vitrectomy. In other cases without enough view of the posterior segment even if there is no significant vitreous hemorrhage in echography, the surgeon usually errs on the safe side i.e. performing a vitrectomy to be sure there is no additional posterior segment complications to repair.
Visual prognosis is another factor that must be considered when planning for surgery. Although vitrectomy has been performed on eyes with NLP vision[6], the results have not been rewarding. It is judicious to rely on the results of visual evoked potential in eyes with poor vision. If there are some recordable waves in the study, then the eye can be considered a candidate for surgery. Eyes without recordable waves had final visual acuity of hand motion in one study.[7]
Another preoperative consideration is timing of surgery. It has been shown that fibrovascular ingrowth does not grow clinically until the 3rd week after trauma , so surgery must be performed in this time period. There are some surgeons that advocate early vitrectomy i.e. within the first 72 hours after trauma[8]. The rationale behind this type of approach is prevention of fibrovascular tissue formation process from the outset and earlier repair of any associated posterior segment injuries. It is an idealistic type of approach, but may not reach its goal in every case due to the presence of intense corneal edema and congestion of ocular tissues in the first days after trauma, which will hinder surgery by inadequate visualization of the posterior segment and intraoperative bleeding. Also induction of posterior vitreous detachment (PVD), an important step of surgery is more difficult and sometimes impossible early after trauma. Besides, the surgeon may go into the eye without adequate knowledge of the extent of injury due to inadequate preoperative investigations. Many surgeons schedule the operation within the first 2 weeks after

trauma. This lag will allow the cornea to somewhat clear, the ocular congestion to subside and the vitreous to undergo changes that facilitate induction of intraoperative PVD. In this time period there is usually enough time for performing ancillary tests like echography, CT scans, and visual evoked potentials. Some studies have shown that visual prognosis does not differ with the time of surgery and depend more on the type and complications of the trauma itself.[9,10]

Another preoperative consideration to address is adequacy of visualization. With panoramic viewing systems, the probability to have visualization through corneas with central opacities have increased, but a cautious surgeon should always consider the need for use of intraoperative keratoprosthesis and subsequent penetrating keratoplasty in mind and arrange for it beforehand.

Preoperative consultation of the patient and family must include discussion about the prognosis that the surgeon has deduced from preoperative assessments, but also must uncover the degree of uncertainty he or she has about the condition.

ii.   Technique of surgery:

Three-port pars plana vitrectomy with the use of wide angle viewing systems is the standard procedure to use for trauma cases.

Transconjunctival sutureless techniques may be adequate in cases that do not need much manipulation near the functional sclerotomies and the surgeon have not planned for scleral buckling. In other cases, the stiffness of 20 gauge probes will be of help, but smaller gauge probes may also do well.

At the beginning of surgery, one of the very important factors to consider is the site of sclerotomies. Doing a sclerotomy adjacent to a repaired wound may cut the sutures of the wound and allow wound gape, or may cause extension of the sclerotomy into the wound. Either situation is difficult to repair. Site of wound is also important from another point of view: for planning the side of sitting of the surgeon. Side of the dominant hand of the surgeon, degree of frontal bossing of the patient and location of the wound all determine the ease of access to the wound and the surgeon must sit in a position to have the best access to the wound itself. There are some cases with the possibility of impact of the traumatizing object to the posterior wall of the globe. In these cases the surgeon must also have adequate access to the posterior impact site, and this is another factor to consider.

To have adequate view of the posterior segment, the surgeon may have to remove the edematous corneal epithelium and wash the anterior chamber. Placement of pars plana infusion cannula is one of the first steps to be taken, but its presence within the vitreous cavity may not be assured due to media opacities. In these cases, one may choose to place an anterior chamber inflow first (in cases with free communication between the anterior chamber and vitreous cavity) and turn the pars plana infusion on when it can be adequately visualized. When the lens is clear, one may use an angled needle for infusion and do a core vitrectomy until the infusion cannula tip can be seen in the vitreous cavity. Having adequate view of the procedure is an important issue that must be met in every case to prevent complications.

In cases with severe hypotony or choroidal detachment, use of a longer infusion cannula should be considered to ensure passing of the cannula through the pars plana epithelium at the beginning of surgery.
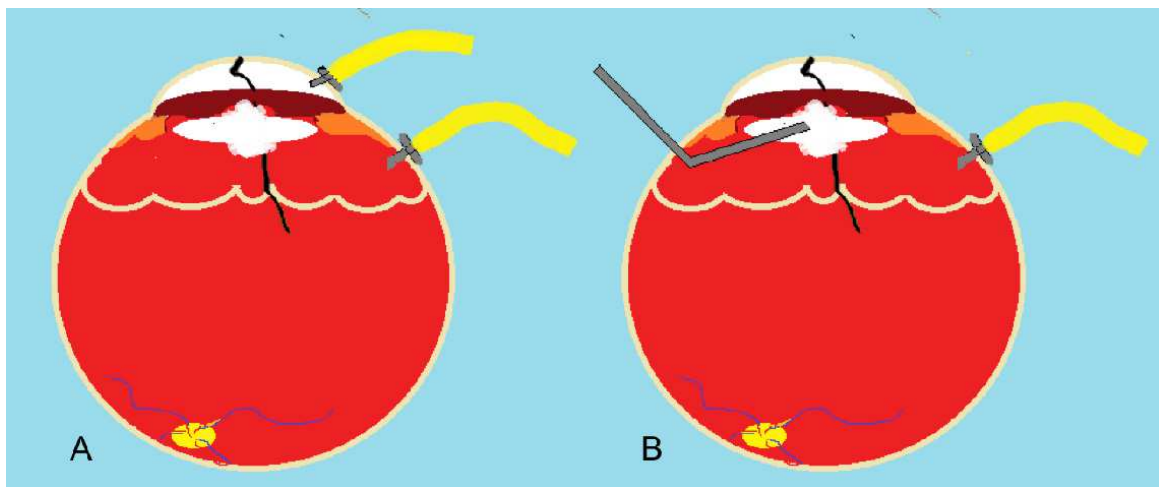
Fig. 2. When the regular posterior inflow tip cannot be visualized at the beginning of the procedure, anterior chamber inflow (A) or a bended blunt needle (B) can be used to make the media clear enough to see the main inflow.

A cataractous lens must be removed through lensectomy. Every effort must be done to save as much capsule as possible. Most surgeons do not place an IOL during the first vitrectomy session in order to place IOL in a more controlled manner: in an eye with stable posterior segment and with accurate calculation of the IOL power[11]. But some have advocated placement of IOL in the first surgery.[12,13]

Another cause for poor visualization during surgery is active bleeding which can be controlled by a. elevating the infusion bottle, b. use of intraocular diathermy, c. fluid/air exchange, d. endophotocoagulation, e. injection of silicone oil, PFCLs, or visco surgical devices, and f. use of thrombin in the infusion fluid[14,15].

In eyes with dense traumatic vitreous hemorrhage, sometimes the RBCs are de-hemoglobinized conferring a whitish hue to the vitreous. There usually are remaining strands of red blood. This view can mimic the retinal surface and sometimes is very hard to differentiate from it. In this situation, the surgeon must work slowly and cautiously; remove the vitreous layer-by-layer and pay attention to the consistency of tissue that is removed. If there is certainty of complete retinal attachment through preoperative assessments, then the situation will be much simpler and the surgeon can work faster.

After removal of the core vitreous, the interior surface of scleral wound should be cleaned of incarcerated vitreous. The incarcerated vitreous must not be pulled out from the wound, but must be trimmed as near to the wound as possible (Figure 3). In limbo scleral lacerations with vitreous incarceration into the wound and a clear lens, one may clean the wound with scleral depression under direct view of the microscope. But this maneuver has the inherent risk of lens capsule touch and cataract formation. Some may do a clear lensectomy from the outset to ensure complete cleaning of the wound. If the lens is clear and hemorrhagic vitreous has been removed, the surgeon can allow less than complete removal of the vitreous from the wound as the risk of fibrovascular ingrowth in this situation will not be high and it seems that the risk-benefit ratio of removing a clear lens vs. complete cleaning of the wound slopes towards retaining the lens. Vitreous base must be
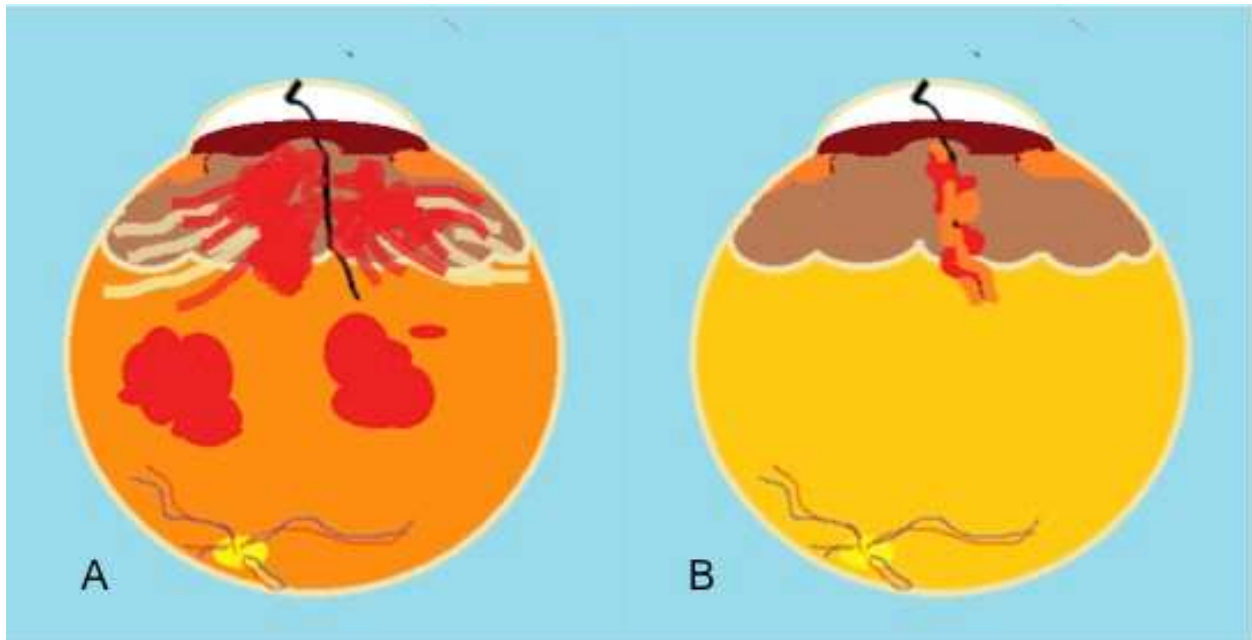
Fig. 3. Corneolimboscleral laceration with incarcerated hemorrhagic vitreous into the wound (A). Trimming of the vitreous incarcerated into the interior of the wound is an important step in this type of surgery removing the scaffold for fibrovascular ingrowth (B).

removed to the extent that is judged to be safe without forming retinal breaks. Induction of PVD is another important step of surgery. Induction of PVD along with trimming of incarcerated vitreous ensures that there remains no scaffold for proliferation of fibrovascular tissue. Induction of PVD is easier when the surgery is done with a time lag after trauma but may be still impossible in very young children. If there is retinal detachment (RD), both removal of core vitreous, and induction of PVD will be more difficult. Use of PFCLs helps in induction of PVD and stabilization of the retina and in reduction of complications like iatrogenic retinal break formation[16].

The surgeon must identify the type of retinal detachment and its cause. If the RD is tractional, then it is obvious that there is vitreous and retinal incarceration into the wound. If there is rhegmatogenous RD, then the task is to find the causative break.

In cases with retinal incarceration into the wound, if there is minimal incarceration without RD, the case can usually safely be managed with placement of a scleral buckle over the wound without the need to perform retinotomy. But in cases with significant incarceration and RD, retina must be cut near the wound to allow the rest of the retina to reattach. Care should be taken to save as much retina as possible. After adequate relaxation of the retina, perfluorocarbon liquids (PFCLs) can reattach the retina intraoperatively. Retinopexy with endolaser or cryotherapy must be done (Figure 4). Only if silicone oil is going to be used, can retinopexy of a superior retinotomy be deferred.

If there is rhegmatogenous RD, after removal of the vitreous, PFCLs are used and retinopexy applied to the edges of the break.

iii. Use of concomitant scleral buckling
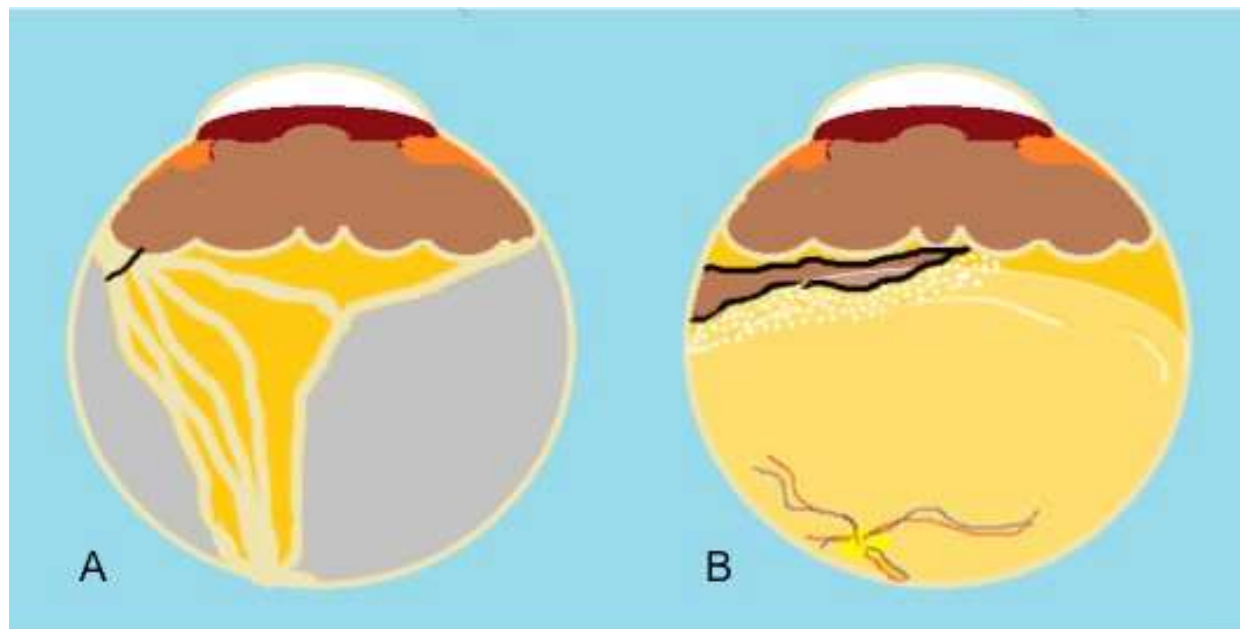   Scleral buckling may be placed for 2 indications:

Fig. 4. Retinal incarceration into an anterior wound accompanied by retinal detachment usually needs retinotomy to release the incarcerated retina. Retinotomy must be done as peripherally as possible (A) retinopexy is done after reattachment of the retina under perfluorocarbon liquids (B).

1. Prophylaxis
2. Treatment

Prophylactic buckles are placed when:

a. Media opacities do not allow adequate visualization of the retinal periphery. If the trauma has caused excessive traction on the vitreous base, tractional breaks may have formed in the retinal periphery, and may not have produced RD due to the absence of liquefied vitreous (Figure 5). When the surgeon is not sure of absence of peripheral retinal breaks in a case of severe trauma, she or he may choose to place an encircling narrow buckle to support the peripheral retina instead of doing complicated steps to help visualization of the peripheral retina like penetrating keratoplasty. This complicated surgery, usually does not have good results[17,18].

b. There is no retinal detachment, but there is retinal incarceration into the wound, or there are visible breaks or retinotomies that cannot be adequately supported by endotamponade agents. In this situation one may place a segmental buckle to support the site of pathology, or do encircling buckling.

When buckles are placed in a condition that retinal detachment has occurred, usually support of the offending break or retinotomy is enough, but some prefer encircling buckling.

In traumatized eyes with traumatic cataract, the myopic shift induced by placement of encircling buckle is not a significant issue, as it will be compensated for in the power of IOL that will be placed. Another issue with encircling buckling that has raised some objection to its use is the possibility of induction of choroidal ischemia by encircling buckles[19,20].
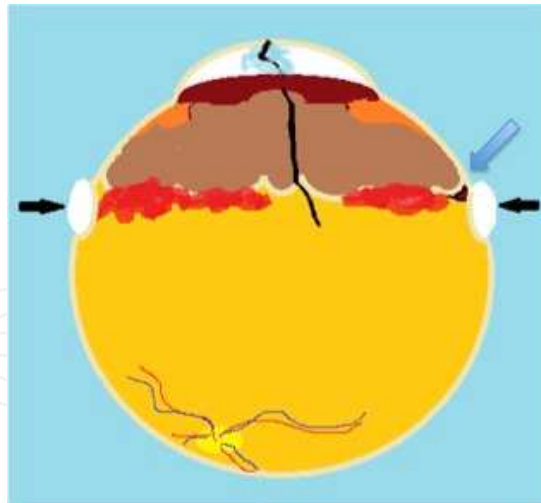
Fig. 5. Placement of a prophylactic band(black arrows) in cases without enough visibility of retinal periphery may obviate the need for complicated surgery to clear the media. Blue arrow points to a small dialysis that cannot be visualized due to the hemorrhagic remnants of the vitreous base and corneal opacity.

iv. Use of endotamponade:

Long acting gases usually suffice for endotamponade in cases with attached retina to support the laceration site while retinopexy takes effect. For cases with detached retina and retinal breaks, or retinotomies, one may choose the agent for endotamponade as a regular case of RD, but I myself prefer silicone oil in these eyes because I believe that reproliferation is more common in these cases and may cause redetachment.[21] I do not want the macula to detach again after primary reattachment.

Inferior retinal breaks and retinotomies must be supported either by an external buckle, or by heavy silicone oil.

v. Management of media opacities:

As stated before, a successful operation needs adequate view of the field. This may not encompass all parts of the retina. If the degree of media clarity is enough to see the inside of the wound, and to induce PVD and be sure that there are no other impact sites and breaks, then performing complicated surgery to restore media clarity is not needed. As stated before, one may choose to place an encircling buckle if he or she is not sure of the absence of peripheral breaks.

When corneal condition does not allow adequate visualization, then one may choose temporary keratoprosthesis placement followed by penetrating keratoplasty, or do the vitrectomy by endoscope (endoscopic vitrectomy). Endoscopes for vitrectomy are not widely available and have a long learning curve so most surgeons prefer the first choice. Anyway, the surgeon and the operating room staff must be prepared for these complicated surgeries beforehand, again accentuating the importance of preoperative evaluation of the eye by the surgeon him/herself.

Another obstacle to visualization of the posterior segment is the condition of the iris which may be adherent to the corneal wound, or be drawn into a limbo scleral laceration. It is preferable to pull the iris out of corneal wound if possible, but this

maneuver may cause wound leak and the need for resuturing. If an adequate pupil is not present, then pupilloplasty must be performed.

vi. Management of accompanying anterior and posterior segment injuries:
In a severely lacerated globe, usually the lens capsule is also damaged and lens material is present in the anterior chamber and vitreous cavity. In these cases, the decision to do lensectomy is straightforward. One important issue is preservation of as much lens capsule as possible for future IOL implantation. If enough capsule for placement of IOL is not present, then the future options for placement of IOL will be: iris supported IOLs, ACIOLs, and scleral fixation IOLs. These eyes usually do not have adequate iris support for placement of an iris supported or ACIOL and scleral fixation of IOL which is a complicated surgery will be the only remaining option.[22,23] Iris diaphragm lenses have been placed in these eyes[24], but recently, glaucoma and corneal decompensation have been reported to occur in long term.

In cases with traumatic cataract with intact lens capsule, preservation of the capsule is simpler.

Lensectomy of a clear lens may be needed in special circumstances like when hemorrhagic vitreous is incarcerated into limboscleral wound and the taut vitreous strands cannot be removed without touching the lens. Another case is for complete cleaning of a limboscleral wound.

Any other posterior segment injuries including retinal breaks, choroidal detachments, and retinal detachments must be addressed during vitrectomy for open globe injuries.

Retinal breaks must be freed of any adherent vitreous and treated with retinopexy and supported by endotamponade. Management of retinal detachment was discussed above.

In case of choroidal detachment, if it is not extensive, then one may leave it untouched. But choroidal detachment that is kissing or so extensive that does not allow the surgery to be performed must be drained. The technique does not differ much from the standard procedure for drainage of postoperative choroidals.

b. *Perforating eye injuries*:

i. Timing of surgery:
All the considerations about timing of surgery in penetrating eye injuries, also apply in perforating eye injuries. Another important issue in perforating eye injuries is sealing of the exit wound, which cannot usually be accomplished during the primary surgery. It takes around a week for a fibrous plaque of adequate strength to form there. So vitrectomy must be scheduled after this time. This lag will also make induction of PVD easier. Sometimes there is a need for earlier surgery, like the presence of endophthalmitis. In this situation, the surgeon must be prepared to have a difficult surgery with intraoperative hypotony, and a protruding globe with extensive conjunctival chemosis.

ii. Technique of surgery:
Perforating eye injuries are open globe injuries that have an entrance and an exit wound. In this type of trauma, vitreous is usually incarcerated in the exit wound and forms a tract between the entrance and exit wounds. Fibrovascular tissue

usually grows on this tract, contracts and causes tractional retinal detachment. Removal of this vitreous scaffold is the basis of doing vitrectomy in perforating eye injuries.

The entrance wound, if scleral, must be treated as in penetrating injuries; cleaned of any incarcerated tissues. Then a deep vitrectomy must follow and PVD must be induced. Induction of PVD is of much more importance than in cases of penetrating eye injuries because remaining vitreous cortex, which is incarcerated at the exit site, will itself act as a scaffold for fibrous proliferation, epiretinal membrane formation and tractional distortion or detachment of the retina. So the surgeon must exert all efforts to induce PVD in these eyes. Induction of PVD may not be easily accomplished by suction over the optic nerve head. Sometimes trimming the vitreous cortex and exerting traction outside the arcades is needed. In other situations, a retinal pick must be used for perforating the vitreous cortex and elevating it. When PVD is induced, the vitreous remains incarcerated at the site of the exit wound. Treatment of the exit wound must include trimming all the vitreous strands incarcerated into it (Figure 6). The vitreous must not be pulled out from within the wound. Usually there is no need for retinopexy around the exit wound, but if there is any doubt about the existence of retinal breaks, then retinopexy is mandatory.
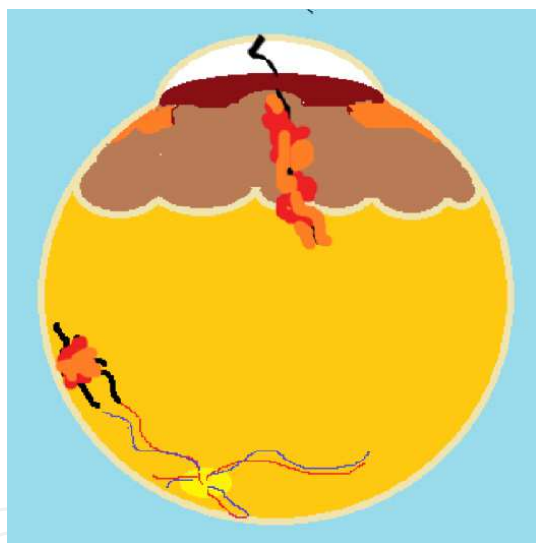

Fig. 6. In perforating eye injuries, trimming the vitreous incarcerated at both the entrance and exit wounds is of outmost importance.

If there is TRD due to retinal incarceration into the exit wound, then one must do circumferential retinotomy around the wound to release the retina and allow reattachment. Use of perfuorocarbon liquids (PFCLs) will attach the relaxed retina and retinopexy can be accomplished by application of endolaser. In such cases my own preference is the use of silicone oil for tamponade; because the risk of proliferation and retinal redetachment is high in these cases.

iii. Use of concomitant scleral buckling:
Scleral buckling for the entrance wound follows the rules for penetrating eye injuries. If the exit wound is at the posterior pole, it is usually supported by internal

tamponade agents. Peripheral exit wounds are approached like the entrance wounds in penetrating eye injuries.

iv. Use of endo tamponade:
Choice of the agent used for endotamponade depends not only on the position and condition of entrance and exit wounds, but also on the presence of large retinotomies and use of scleral buckles. For small exit wounds at posterior pole with attached retina, and without entrance wounds involving the retina, long acting gases usually suffice. If retinotomy of entrance or exit wounds is done, one may prefer silicone oil for superior or posterior pole lesions, or heavy silicone oil for inferior lesions.

v. Complications:
One of the common complications during dissection of the vitreous around the wound is retinal break formation. Break formation may also occur at the time of induction of PVD. Inability to induce PVD is considered a major complication in posterior segment traumas as the remaining vitreous cortex acts as a scaffold for proliferation of fibrous tissue resulting in formation of epiretinal membranes or membranes causing instability of the wound or retinotomy. Suprachoroidal hemorrhage which can occur during any type of vitrectomy, may be more common during vitrectomy on traumatized eyes[25]. Avoidance of intraoperative hypotony is very important to prevent this dreaded complication.

c. *Intraocular foreign bodies (IOFBs)*:
Like other traumatic injuries to the eye, occurrence of IOFBs is effectively prevented by adherence to safety measures, because most of them are work related. Some activities like hammering and chiseling have a high probability of producing high-speed projectiles that can enter the eye. War injuries also have a high probability of IOFBs.[26-28] Sometimes foreign bodies are entered into the eye by a larger object impacting the eye such as cilia that enter the eye through penetrating traumas by objects like stone or wood.

i. Preoperative evaluation:
Preoperative evaluation of IOFBs encompasses identifying the following:

a. Material of the IOFB and its magnetic properties
This information is of great help to decide on whether to remove the IOFB or not and to make decision about the technique of removal. It may also mandate a very early surgery due to the toxic nature of the IOFB. This information may be gathered by accurate questioning or even examining the source of the projectile. Ancillary tests like CT scan and echography may also be of some help.

b. Size of the IOFB, which is of critical importance for decision about the technique of removal and determination of prognosis. This can be estimated by fundoscopy or from CT scan images or by echography.

c. Location of the IOFB and its relation to ocular tissues is also much important for planning the technique and the steps of surgery. This information is best got through examination, ultrasonography and CT scans.

d. Risk of infection or presence of any signs of infection; if present mandates surgery as soon as possible even when a non-toxic, non-organic IOFB is

present. Presence of IOFBs has been shown to increase the rate of endophthalmitis.[29]

e. Extent of accompanying ocular damage, which varies widely from minimal to near loss of normal globe architecture. This issue is important in planning the steps of surgery, and prognosticating the case.

ii. Indications for removal:

All IOFBs in the acute phase are candidate for prompt removal because of the potential risk of infection[30]. Beyond that time, an IOFB must be removed if it is toxic or organic, or if it has sharp edges. Iron and copper especially if pure, are the most toxic substances for the eye and must be removed promptly[31,32]. They can cause acute siderosis or chalcosis that can mimic endophthalmitis. Even in the absence of chalcosis, copper has been shown to be toxic to the retinal tissue and induce electrophysiological changes that may be partly reversible upon removal[32]. Plastic, glass and cilia are non-toxic to the ocular tissues and if there is no risk of infection, or they do not have sharp edges, they may be left in the eye.

IOFBs with sharp edges that can injure the retina and have the risk of future RD must also be removed irrespective of their nature.

If there are other ocular injuries in need of a vitrectomy surgery, then removal of IOFB should be part of the procedure.

iii. Timing of surgery:

Some surgeons remove the IOFB during primary repair. This strategy is helpful in preventing the inherent risk of endophthalmitis which is more common when an IOFB is present[33]. Inadequate visualization, inability to induce PVD and risk of hemorrhage are more common with early surgery. Performing surgery on an elective basis, allows the surgery to be done in a more controlled manner with expert personnel being at hand, but the risk of development of infection is more than the previous strategy. Inadequate visualization, inability to induce PVD and hemorrhage may be less of a problem in delayed surgery. Some studies have shown that delayed removal of IOFBs is not associated with poorer visual or anatomical outcomes[27,28]. As it has been shown that prophylactic injection of intravitreal antibiotics reduces the risk of endophthalmitis, if a delayed surgery is planned, intravitreal injection of antibiotics is indicated during primary repair[34]. In one study, this strategy has been followed even in eyes with signs of endophthalmitis i.e. injection of intravitreal antibiotics and doing the vitrectomy in a more controlled condition, and the authors concluded that the results are good enough to consider this strategy as a viable alternative to early vitrectomy[35].

iv. Choosing the technique for removal and appropriate instruments.

This step depends on the material of the IOFB, its magnetic properties, size, location, and presence or absence of traumatic cataract. For magnetic IOFBs, external or internal magnets can be used for removal[36]. External magnets are used only if the IOFB is visible, floating in the vitreous cavity and without a visible capsule. In this case, a sclerotomy about 1.5 times the size of the IOFB is made in pars plana adjacent to the IOFB, and the magnet is placed over pars plana epithelium and turned on while some side-to-side movement is applied to help IOFB pierce the pars plana epithelium.

Most magnetic IOFBs cannot be removed in the above manner, and along with non-magnetic IOFBs must be removed by forceps or baskets.

Baskets are used for small and medium sized IOFBs. Foreign body forceps is used for most non-magnetic and also magnetic IOFBs. But magnetic IOFBs are better elevated from the retinal surface by a rare earth intraocular magnet, and then grasped with the forceps, as the magnet cannot hold the IOFB during passage through obstacles like sclerotomy.

Other techniques for removal of IOFBs like use of snare or catheter have been reported[37,38].

v. Steps in vitrectomy:

If the lens is cataractous and there is the decision to remove it, then lensectomy, via either pars plana or limbal approaches must be done at the beginning of surgery. One must attempt to save enough capsule for placement of IOL; but IOL placement must be deferred until the end of surgery, as one safe place to remove the IOFB is through the anterior segment. Placement of the IOL is usually done at the end of surgery.[39]

A complete pars plana vitrectomy is needed and as much peripheral vitreous as possible must be removed.[26] PVD must be induced, usually with the aid of intravitreal triamcinolone acetonide injection. IOFB removal must be done after induction of PVD because tractions on vitreous strands during removal of IOFB may easily incite break formation, especially retinal dialysis (Figure 7).
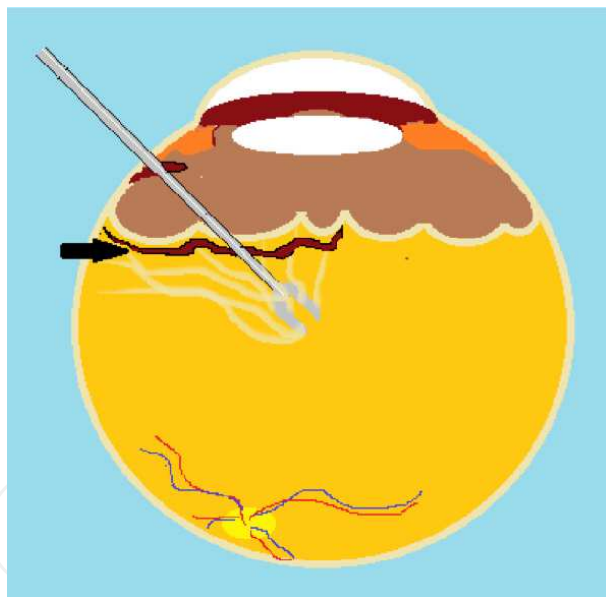

Fig. 7. If vitreous is not adequately removed before IOFB removal, insertion of the forceps or removal of the IOFB through the sclerotomy will cause traction on vitreous base, which may result in the formation of retinal dialysis (black arrow).

If there is accompanying RD, use of PFCLs after induction of PVD will cause retinal reattachment and will facilitate IOFB removal. The surgeon must find the causative break(s) and be sure of their proper management.

vi. Choosing the site for extraction of foreign body: pars plana vs. limbal incision

The surgeon must decide which route for IOFB removal will cause least damage to the ocular tissues. If the lens was cataractous and lensectomy has been done, IOFB

can be removed through a posterior and anterior capsulotomy and through a clear corneal or limbal wound. This way is my preferred method for removal IOFBs if the lens is not present (Figure 8 B).

For removal of large IOFBs through pars plana, the sclerotomy must be enlarged to a large size and a large sclerotomy has a high risk for posterior segment complications like vitreous incarceration and retinal break formation, so one may choose clear lens extraction to remove a large IOFB through a limbal incision.

For small IOFBs, in an eye with clear lens, the pars plana sclerotomy can be enlarged to accommodate the forceps grasping the IOFB (Figure 8 A).

In every case of IOFB removal, the surgeon must examine retinal periphery at the end of operation meticulously.

The site of IOFB impact may be left without retinopexy provided that PVD has been induced and the vitreous has been completely cut from around the impact site[40].
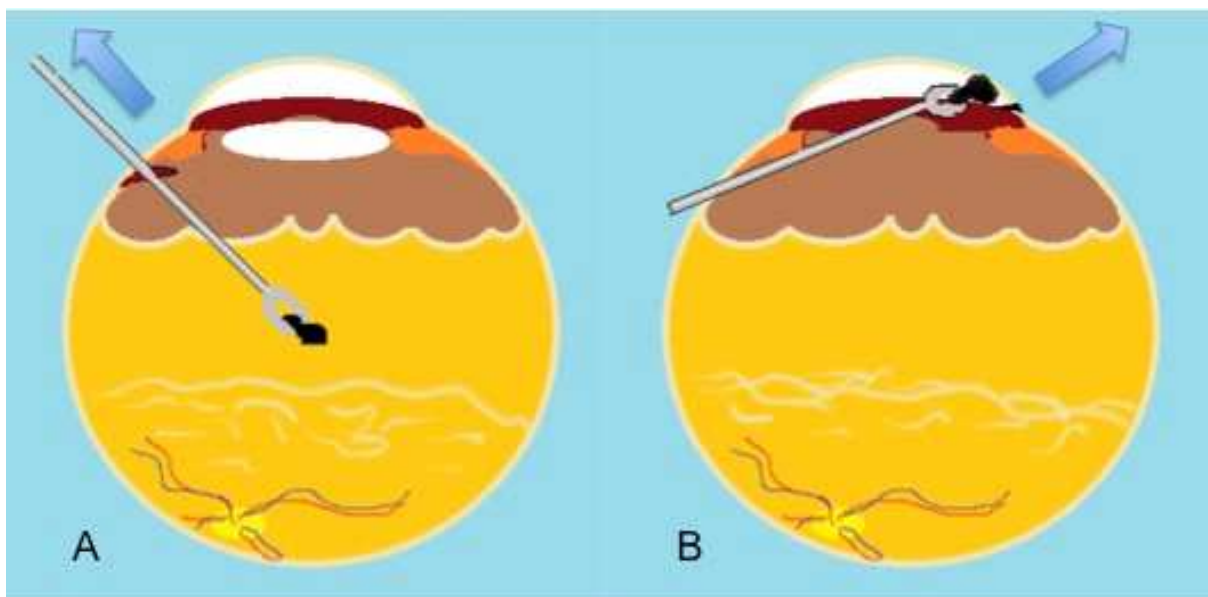

Fig. 8. The sclerotomy is enlarged in phakic eyes before introducing the forceps or basket for removal of the IOFB. Although removal of small IOFBs through enlarged sclerotomy is relatively safe, for larger IOFBs or whenever the eye is aphakic, extraction through a limbal incision seems to be safer. Note that for protection of a normal fovea, the vitreous cavity is filled up to two thirds of its volume by visco-elastic material before removal of the IOFB.

vii. Protecting the normal macula:
      In most cases undergoing surgery for IOFBs, the macula is not affected. Maintaining a healthy macula during surgery is the key to good visual prognosis. As there is the risk of drop of the IOFB over the normal macula during various steps of surgery: releasing the IOFB, it's grasping by forceps and extraction through sclerotomy or anterior segment structures, surgeons have proposed various methods to protect the normal macula. Use of PFCLs and visco-surgical devices are some to mention[41,42] (Figure 8).

viii. Complications:
      In addition to the typical complications of a vitrectomy procedure, intraoperative hemorrhage and retinal break formation are significant complications that can

occur in this type of surgery. If an IOFB is impacted into the choroid, its manipulations have the inherent risk of choroidal hemorrhage. One must be prepared to confront this condition with prompt elevation of IOP and use of PFCLs to prevent sub macular migration of the hemorrhage.

Retinal breaks may form when the IOFB is being released from its attachments to the retina or when attempting to grasp it with a forceps. Traction on vitreous strands is another cause for formation of peripheral retinal breaks. Meticulous surgery and complete removal of the vitreous are key factors to prevent retinal break formation. Postoperative retinal detachment have been reported to occur in eyes undergoing IOFB removal in 6.25% to 32.5% of cases [43-45].

Another reported complication of IOFB removal is late onset RRD[46].

Traumatic cataract is another complication of vitrectomy for removal of IOFBs. If a long or twisted IOFB is to be removed from pars plana, with a clear lens in place, the surgeon must be cautious to avoid contact of the instruments or IOFB with the lens.

ix. Prognosis:

Visual prognosis for eyes with small to medium sized IOFBs is generally good except for cases with direct impact of the IOFB to the fovea, or those developing endophthalmitis. The prognosis for eyes with large IOFBs is more unpredictable because there is not only higher risk of posterior pole impact, but also more surgical complications.[47-49] Presence of preoperative RD also worsens the prognosis.[48,49]

About one third to half of eyes containing IOFBs attain final VA of 6/12 or more[43,45,50].

d. *Endophthalmitis and vitreous abscess*:

Posttraumatic endophthalmitis and vitreous abscess formation is another indication for doing vitrectomy in open globe injuries.

i. Prophylaxis of posttraumatic endophthalmitis:

Cases with open globe injuries are usually hospitalized and receive 3 days of prophylactic systemic antibiotics.[29] Intravitreal injection of Cefazoline and Gentamicin during primary repair have been shown to be only effective for prophylaxis against development of endophthalmitis if the eye harbors an IOFB[34]. In cases that primary repair may be delayed and there is a large wound, intravitreal injection of antibiotics have also been proposed[51].

ii. Timing of surgery:

If there is suspicion of posttraumatic endophthalmitis in an eye with repaired open globe injury, management depends on severity and course of endophthalmitis and the need for vitreous surgery for indications cited above.

In an eye without any other indications for vitrectomy, for example in an eye with corneal laceration, and traumatic cataract without any other posterior segment injuries, endophthalmitis with a subacute course may well be controlled with intravitreal antibiotics. Prompt vitrectomy has been advocated for other scenarios of endophthalmitis in eyes with open globe injuries[52]. Early vitrectomy has the advantage of being able to do the procedures intended for an open globe injury when the media have not become much hazy and halting the fibrovascular ingrowth which is accentuated by the presence of infection.[21]

If there is an acute or hyper acute endophthalmitis in an eye that has sustained open globe injury, then doing the vitrectomy may not be so simple especially when there exists an RD. Doing vitrectomy and complicated vitreoretinal procedures without adequate visualization is very difficult if not impossible. In this difficult situation, the surgeon may opt to quiet the infection by doing a vitrectomy (not a complete vitrectomy but as much as possible and safe) and washing the vitreous cavity with infusion fluid containing diluted antibiotics, filling the eye with silicone oil, and doing a second operation at a later date. Silicone oil is the preferred tamponade agent if there is RD plus endophthalmitis.[53]

iii. Goals of surgery
Vitrectomy for endophthalmitis in cases with repaired open globe injuries is done with 2 main goals:
a.   Control of the infection,
b.   Achieving the goals of vitrectomy in open globe injuries at the same time minimizing the probability of iatrogenic trauma and complications of surgery.

iv.   Surgical steps:
Like vitrectomy for postoperative endophthalmitis, it is desirable to get an undiluted sample of the vitreous for laboratory evaluations. But due to the disorganization of ocular structure and probability of presence of RD, one must be very cautious not to make iatrogenic trauma when dry vitrectomy with its attendant hypotony is performed. The infusion is turned on after the sample is taken. It is advisable to use diluted antibiotics in the infusion fluid. As stated above, the surgeon must decide on how complete to do the procedure. In some cases with very poor visualization, the surgeon may decide to do only a core vitrectomy and perform the rest of operation in another session. In this situation, usually the second procedure must not be delayed too much; otherwise fibrovascular ingrowth will take its effect and produce its own complications. In other circumstances, there may be a good condition for performing a complete procedure. Another option in cases with poor visualization is the use of endoscopic surgery[54].
If the surgeon is not sure of the presence or absence of retinal breaks, then use of silicone oil for tamponade, may improve the prognosis.[53,55]

v.   Prognosis:
Depends on the virulence of the organism and associated posterior segment injuries. Retained IOFBs and poor initial vision have been found to predict a worse visual outcome[56].

e. *Suprachoroidal hemorrhage*:
Drainage of suprachoroidal hemorrhage in traumatized eyes is similar to other conditions except for the possibility of presence of associated posterior segment injuries needing repair. So one must schedule the operation 5-7 days after the trauma to give enough time to hemorrhage for liquefaction. For access to the globe equator to do drainage sclerotomies, rectus muscles must be caught by bridle sutures. Then a drainage sclerotomy without touching the choroid is placed 9mm from the limbus in the quadrant with the most amount of suprachoroidal hemorrhage. These cases usually have hyphema and cataract in association with suprachoroidal hemorrhage and at the beginning of the operation the anterior segment should be cleaned of

hemorrhage, lens material, and vitreous. For this step usually an anterior chamber inflow can be placed. After cleaning the anterior segment and performing lensectomy of a cataractous lens, a long posterior chamber inflow usually 6 mm long is placed through pars plana. Prior to this step, one may infuse air through the anterior chamber inflow and open lips of the drainage sclerotomy with a forceps to help reduce the suprachoroidal hemorrhage. This maneuver may somewhat lessen the degree of protrusion of the pars plana epithelium and enhance placement of an inflow. The pars plana infusion should be turned on only after its tip has been seen to be in the vitreous cavity. Then with the combined infusion of air and perfluorocarbon liquids, the most complete drainage of the suprachoroidal hemorrhage can be accomplished. The surgeon must always be prepared to face other posterior segment injuries in these complicated cases and must repair them too. One important matter in this situation is that fishing of clot or hemorrhage through the sclerotomy is forbidden and may damage the choroid and the retina. Subtotal drainage of suprachoroidals is preferable to making additional retinal and choroidal injuries.

f. *Dense vitreous hemorrhage without other identifiable posterior segment injuries*:
In a case of open globe injury with dense vitreous hemorrhage and no other identifiable injuries in echography, it is desirable to clear media within a reasonable time usually the first two weeks after trauma to be sure of the absence of injuries that may have been missed in echography like damage to retinal vessels or ciliary body without significant vitreous incarceration.

g. *Removal of Traumatic cyclitic membranes*:
Traumatic cyclitic membranes i.e. fibrovascular membranes covering the ciliary body are one of the late complications of open globe injuries involving the anterior sclera. This complication usually occurs in eyes with scleral lacerations and vitreous incarceration along with vitreous hemorrhage or liberated lens material in the vitreous cavity that have not undergone due pars plana vitrectomy. Another condition that theoretically may predispose to their development is inadequate vitrectomy and cleaning of the wound and vitreous base area. When they develop, they lead to ocular hypotony and can cause phthisis. These eyes essentially do not have worse ocular traumas than others but are lost as a result of delay in surgery. Ocular hypotony after trauma may have other etiologies such as: post traumatic uveitis and cyclodialysis cleft and RD. The first one is temporary and does not persist for more than a few weeks. Cyclodialysis clefts are visible in gonioscopy, which may be very difficult to do in these eyes and ultrasound biomicroscopy is a viable alternative option for their diagnosis.[57] RD can be diagnosed with ultrasonography.
Sometimes the cyclitic membrane grows in the pupillary area to produce a fibrovascular membrane visible through the pupil causing extensive posterior synechia formation.
Removal of these membranes is a demanding procedure. Zarbin et al[58] discussed the technique of dissection for cyclitic membranes secondary to PVR. But traumatic cyclitic membranes are different from anterior PVR. Traumatic membranes usually grow on the anterior hyaloid face over the pars plicata and do not make anteroposterior contraction of the vitreous base. To see the region of pars plicata, the surgeon must use scleral depression and direct viewing through the operating microscope. Another option is the use of endoscopic vitrectomy.

One technique described for their removal includes removal of the center of the membrane and core vitrectomy, placement of radial cuts over the membrane and removal of the remnants with vitrectomy probe. It has been reported that if one quarter of the ciliary body circumference is salvaged, then the IOP returns back to normal. Cases with cyclitic membrane and RD after open globe injury have a poor prognosis.[22]

4. Is there an inoperable eye after trauma?

There are reports of vitrectomy on eyes with NLP. But generally the prognosis is poor[6,59]. Presenting vision has been shown to be the most important prognostic factor in traumatized eyes [60]. So the surgeon must consult the patient about prognosis of an eye with poor vision and both decide about the management.

So if the eye can be closed during primary surgery, vitrectomy can be done. But the surgeon must weigh the risks and benefits of surgery and consult the patient and family about doing the operation.

5. Prognosis of open globe injuries with posterior segment involvement

Generally studies have reported up to 50% final vision of 20/50 or better after vitrectomy for open globe injuries[61].

Several factors have been reported to contend a poor visual prognosis in these injuries including: poor initial VA[60,62,63], initial relative afferent pupillary defect[60], site[63,64] and large size of laceration[60,62,65], presence of intraocular foreign bodies, perforating eye injuries, associated posterior segment injuries[63,64], delay in primary repair[66], and endophthalmitis[62].

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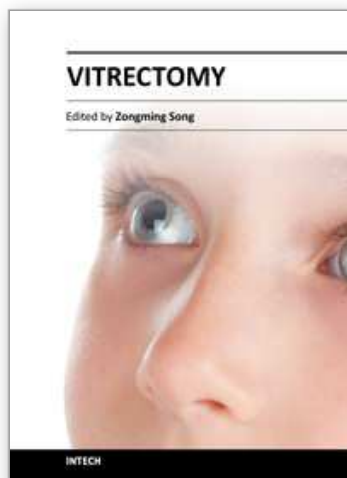
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Edited by Dr. Zongming Song

This book is a comprehensive and systematic introduction to the basic theory, surgical techniques and the latest advances in vitrectomy. It focuses on vitreoretinal surgical indications and contraindications, surgical and operating techniques, surgery-related complications and their prevention, post-operation evaluation and prognosis. The book is divided into 6 chapters and has abundant content as well as a strong scientific and practical value. This book will be a valuable reference to ophthalmologists on all levels, especially vitreoretinal surgeons and researchers.

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