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Step by Step Glaucoma Surgery

Kirti Singh
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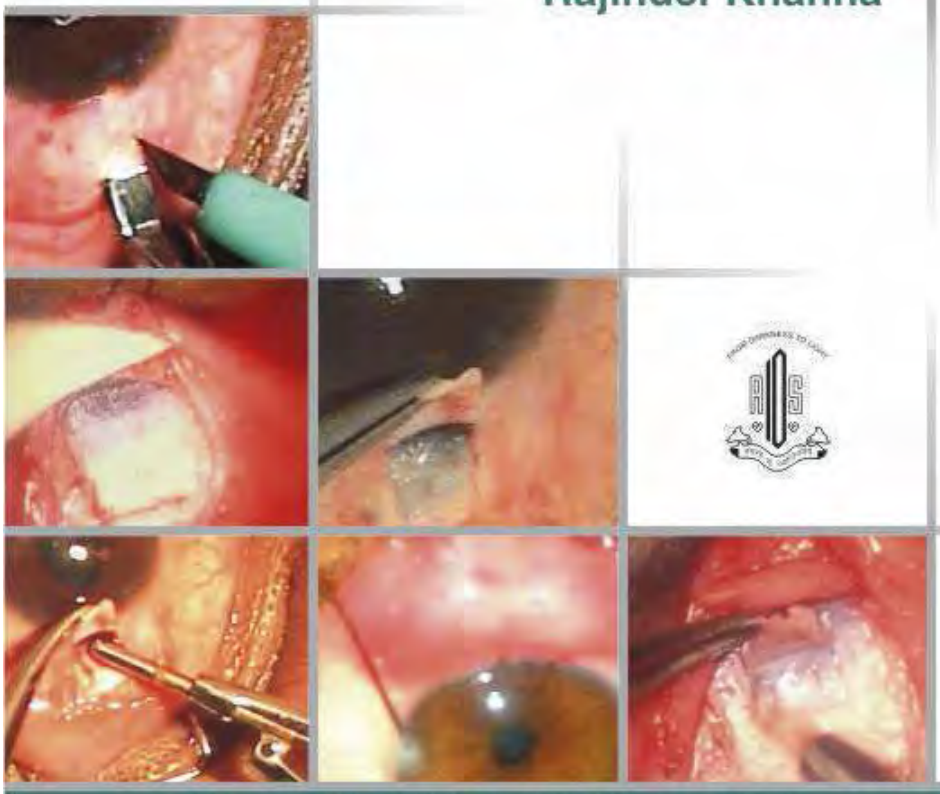

ALL INDIA OPHTHALMOLOGICAL SOCIETY

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Step by Step Glaucoma Surgery

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Foreword

Dear Colleagues,

The fast changing scenario of ocular therapy is keeping our fraternity on their toes in order to keep abreast. In addition today's patient is more informed and demanding. This coupled with the grueling routine grind of clinical load, leaves the surgeons with more need yet less time to update their skills. The CME booklets initiated by the All India Ophthalmic Society are a step taken to fulfill this need by providing well researched material detailing one clinical aspect of Ophthalmology. The reading material is concise and comprehensive. This issue is also following the tradition of previous CME series in dealing with germane issues, which in this issue is that of glaucoma surgery.

Swamped as we are with a multitude of glaucoma medications we tend to forget that we are surgeons. In order to impart the best to our patients, we need to upgrade our surgical skills in glaucoma. This booklet by dealing with three commonly performed glaucoma filtering surgeries seeks to answer basic queries, provide in depth knowledge of various steps of surgery and analyses the different ways of performing the same. We sincerely hope that this booklet befriends your bookshelf, and serves as a ready reckoner.

We take this opportunity to thank Dr. R. B. Jain, Dr. K. P. S. Malik, Prof. N. N. Sood, Prof. H.K. Tewari, Prof. Rajvardhan Azad , Dr. J. C. Das, Prof B. Ghosh, Prof Usha Yadav and Dr. B. N. Khanna for their support. We also thank the staff of Computype media for their painstaking help in printing. Above all thanks to our patients who have contributed to make this book a reality.

Rajender Khanna
Kirti Singh

Dedication

We dedicate this book to our mothers

Parkash Kaur

and

Padma Khanna

You shaped our bodies, moulded our minds and nourished our souls. The Spirit of Service which we serve willingly is but a pale reflection of the supreme spirit of Love and Service, which is personified in you dear Mother.

Section I

Current ideas about glaucoma treatment

Glaucoma is a progressive disease entity which comprises of specific visual field changes corresponding to a characteristic pattern of optic nerve head atrophy, which are intraocular pressure sensitive. This progressive disorder may be halted, if not reversed with appropriate medical and surgical therapy.

Globally it is the second most common cause of blindness after cataract. It accounts for 7-8 million bilaterally blind people.[1,2,3] It has been estimated that 60.5 million people world wide will be affected by glaucoma by 2010 and 79.6 million by 2020.[4] Asians are likely to represent 47% of their projected glaucoma morbidity. About 4.5 million people with open angle glaucoma (OAG) and 3.9 million people with angle closure glaucoma (ACG) may succumb to glaucoma induced bilateral blindness by 2010, this figure is likely to cross 5.9 and 5.3 million mark, respectively, by 2020.[4] Glaucoma is responsible for 8-12 % of blindness ,[5] and 11.4% of low vision morbidity in India . [6]

Evidence from several randomized controlled clinical trials has conclusively established the beneficial effect of lowering of intraocular pressure in halting the progression of the disease. [7-9] A frenzy of research over the last two decades has identified ***intraocular pressure as the only factor which we can currently modulate to halt the progression of this relentless disease.***

What are the modalities available for IOP control?

The modalities to regulate IOP are – medical, laser assisted therapy and/or filtering surgeries. Currently a vast choice of effective anti glaucoma drugs are available. The role of laser trabeculoplasty and glaucoma surgery as a primary option has declined by 50-60%, since these glaucoma drugs, particularly prostaglandins analogues came into the market.[10, 11] Yet, trabeculectomy or other glaucoma filtration surgeries hold an edge over the medical options in lowering the intraocular pressure more effectively and consistently.[12-14]

The current evidence from large multicentric trials like Collaborative Initial Glaucoma Treatment study (CIGTS) and Advanced Glaucoma Intervention study (AGIS) suggest that whereas mild disease could be stabilized with mid to high teens of intraocular pressure, a lower IOP in the low teens is required to stabilize moderate to advanced glaucoma.[12] The benefit of maintaining a more optimal control of IOP (around 6- 8 mm Hg lower), and a better diurnal control provided by surgery, more than compensates for the patient discomfort and risk of cataract progression, which it entails. [14, 15] ***Glaucoma filtering surgeries therefore, appear to be the primary option for advanced glaucoma*** where the aim is to achieve a consistently low intraocular pressure while medical management is used for the other subgroups. This current standard of care has been derived from global trials predominantly from developed countries.

These recommendations of global trials ***could be interpreted to justify primary surgery for any severity of glaucoma in the resource constrained developing world context.*** [16, 17]

Let us clarify and justify this viewpoint by highlighting some facts :

- Nearly 260 million Indian population (35%) falls below the international poverty line (lower than US 1$ per day). This limits their ability to bear the cost of prolonged, regular antiglaucoma medications. [18, 19]
- About 82% of blindness in our country stems from the 74.3% population – living in the rural areas – for whom medical facilities are neither easily available, nor affordable due to high prevalence of poverty. [20]
- Most ophthalmologists in India (70%) are located in the urban areas and cater to only 23% of it's population. [21, 22] This obviously leads to a mismatch in the patient – provider ratio in the rural areas; forcing these poorer sections of society to travel long distances for ophthalmic care. [18] This can be a major hurdle in adherence to therapy and monitoring glaucoma drug therapy. [23]

In such a setting, where as Rotchford so succinctly puts it, ***only "one shot" at the patient is allowed,*** surgical intervention as the primary treatment modality may be a more realistic option . [1, 18]

Another factor, in favor of primary surgical option in our country, is the high prevalence of angle closure glaucoma. (Table 1).[24-30] PACG comprising almost half,[30-33] of all Indian glaucoma is a ***more relentlessly progressive and unforgiving type of glaucoma*** compared to its gentler POAG cousin. [1, 34] To compound this further, angle closure glaucoma more commonly afflicts females and people from lower socioeconomic strata, the subgroups with extremely limited access to medical care. In addition the more silent, and aggressive chronic angle closure is the commonest subtype (87%) found amongst PACG cases.[27, 29, 31] This subtype is so silent and relentless that ***almost 42-***

Table1. **Prevalence of Glaucoma in India**

	Mean Age	*POAG*	*PACG*
Vijaya L, Chennai (Rural population)[25,26]	>40 yrs	1.62%	1.58%
Ramakrishnan R (Rural population – Aravind Comprehensive Eye Survey)[27]	>40 yrs	1.7%	0.5%
Jacob A, (Urban population – Vellore Eye Study)[28]	30-60 yrs	0.41%	4.3%
Dandona L (Urban population –Andhra Pradesh Eye Disease Survey)[29, 30]	>30 yrs	1.6%	0.7%
Dandona L (Urban population –Andhra Pradesh Eye Disease Survey)[29, 30]	>40 yrs	2.6%	1.1%

53% patients present with advanced glaucoma and blindness in one or both eyes at the point of first contact.[30, 32] In most of these patients, the trabecular meshwork synechial closure has crept past the stage where a simple iridectomy would suffice to halt the disease. This crippling glaucoma warrants a trabeculectomy. This is supported by a study, from North India, which showed that laser iridotomy with or without medications could only control IOP in 30 % of chronic ACG eyes.[31] A similar study from Singapore, a country where ACG is rampant, has conclusively established the inadequacy of a laser iridotomy alone to control IOP. [35] Nearly 62% of their patients who were on medical therapy after laser iridotomy, subsequently needed a filtering surgery after a mean time period of 7-18 months. In the Indian scenario expecting the patients to come for regular monitoring, after 6-12 months of having had a laser procedure performed, would be too optimistic.

Glaucoma acounts for 12% of blindnes, and 11.4% of low vision in Indian subcontinent.

So why prefer Surgery?

The aim in glaucoma management is to achieve the lowest possible IOP without affecting ***quality of life***. The following points suggest that medical therapy may improve the IOP, but not necessarily provide a good quality of life for glaucoma patients:

A. Drug problems

- Glaucoma medications are often cumbersome to put in the eye by the elderly cohort of glaucoma patients.
- Ocular discomfort ranging from stinging, redness, irritation and dry eyes are ubiquitous side effects of medications.
- Drug preservatives increase expression of HLA DR on conjunctival epithelial cells, thereby leading to subclinical inflammation.[36]

- The systemic side effects of the commonly used glaucoma drugs are very significant e.g. two drops of 0.5% Timolol are equivalent to a 10 mg oral dose. This can precipitate bronchial asthma in about 4-7 % of the at risk, elderly population. [37]
- Currently the most commonly used medication in our country are still Beta blockers. However over half of patients on β blockers would have changed their medication, would be using an additional drug or would undergo trabeculectomy after a 5 year period - this reflects the long term loss of effect of these drugs [38]

B. Compliance

Successful treatment needs good adherence to the drugs by the patient.

- Studies from developed world, have reported that if more than two anti glaucoma drugs are prescribed, almost 25-51% patients forget to instill their drugs for more than twice a week. [39, 40, 41] and may miss doses for periods ranging between 85-165 days in an year. [39]
- Apart from forgetfulness, need for a continued treatment for life in spite of lack of improvement in their vision does not motivate most patients. [1]
- In India compliance would be further dented by poverty, illiteracy and ignorance.

C. *Impact of intraocular pressure fluctuation*

Diurnal swings in intraocular pressure has been documented as the singular most significant risk factor for glaucoma progression by various authors, irrespective of the degree of increase in intraocular pressure, glaucoma severity, race or sex.[42] Trabeculectomy causes a less turbulent IOP wave form than the peaks and troughs seen with medical control. [15, 43]

Is Surgery the panacea?

The surgical option is however not without drawbacks, namely::

A. **Complications of surgery:** The inherent risk of complications, surgeon related factors; variation in patients' healing and inflammatory response; risk of sepsis take the sheen off surgery as the best option. Endophthalmitis, the most dreaded complication, has been reported in 0.2-1.5% cases.[44, 45,46] The use of antifibrotics like MMC or 5 FU further increases this risk to 1.3-3%.[45-48]

Hypotonic maculopathy, bleb leaks, choroidal detachments, and cataract progression are the other dangers of surgical options. [49-51] AGIS and CIGTS collaborative studies have conclusively shown a threefold increase in rate of cataract progression post trabeculectomy. [52-54]

B. Trabeculectomy is **not uniformly effective**: In a survey conducted by the National Health Service (NHS) in United Kingdom (UK), only 84% patients achieved target IOP post surgery and of these too, almost all (92%) required additional medications to achieve this target.[55]

C. The **limited life span of functioning trabeculectomy** bars it as being offered as an alternative for all. The waning effect with time, has been reiterated by numerous authors.[51, 56, 57, 58] Chen et al reported that the benefit of a functioning trabeculectomy declined from 100% at 1 year, to 82% at 5 years and 67% after 10 - 15 years. [56] Other long term follow up studies over 4-10 years reported similar waning of control and almost 71-80% of these initially successful trabeculectomies required additional pharmacological treatment.[51, 57, 58]

What does one conclude?

Although trabeculectomy appears as the better option for the masses in Indian scenario, it is not the final solution. No matter what treatment option one offers to the glaucoma patient, constant follow up and monitoring has to be emphasized. Remember, a lasting cure for glaucoma is yet to be discovered.

Key Messages

- ***In mild to moderate glaucoma, where compliance, affordability of drugs and follow up can be ensured, medical management is preferred as the primary treatment. In offering treatment to the have nots of the society , trabeculectomy even with its complications, risk of causing cataract , and waning effect will still offer a better chance of preventing irreversible blindness.***
- ***For advanced glaucoma the choice again has to be individualized. Trabeculectomy would lead to a more consistent and better IOP control. This may need to be combined with cataract extraction in some. A trial of medical treatment with more potent – though expensive – prostaglandin analogues may be done in appropriate situations (an adherent, affording patient).***

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Section II

Trabeculectomy – How to perform?

Any glaucoma filtering surgery aims at creating a bypass channel at the limbus, cirumventing the dysfunctional trabecular meshwork, and redirecting the aqueous into the subconjunctival space. Trabeculectomy is the commonest glaucoma surgery performed and the current chapter will discuss the steps of this surgery.

HOW TO PREPARE THE PATIENT ?

- It is advisable to withdraw Pilocarpine, at least 2-3 weeks prior to surgery.[1] Pilocarpine increases permeability of the blood aqueous barrier, thereby increasing post operative inflammation which in turn may hasten bleb failure. It also causes irreversible miois, so if a combined cataract glaucoma surgery is planned, the pupil will not dilate on the table.
- Ideally, Prostaglandin group of drugs must also be stopped, as they can aggravate surgically induced inflammation. Pre-operatively, nonsteroidal drugs like Flurbiprofen or Diclofenac drops have been advocated by some to reduce the inflammation induced by iris manipulation, but we do not subscribe to this belief. One school of thought advocates discontinuing β blockers several days prior to surgery so that post operative aqueous flow is sufficient to form and maintain a functional bleb.[2] However, this may not be always feasible.
- The eye is prepared as for any intra-ocular surgery with Povidone Iodine lid scrubs, and topical broad spectrum antibiotics started 3 days prior to the trabeculectomy.
- We routinely prescribe Acetazolamide tablets three times a day/ or long acting Acetazolamide once a day, even in those patients whose pressures are controlled on topical drugs a day before the surgery is scheduled except in those for whom this drug is contraindicated e.g. sulpha allergy. This is done to ensure a soft eye on the day of surgery.

- Sedatives like Diazepam are given on the night before surgery, but avoid it's use on the day of the surgery unless the patient is very anxious.
- Intravenous Mannitol 20%, in the dose of 1-1.5gm/kg body weight, is given at least 30 minutes before the block. For an adult patient, this invariably translates into a full bottle of 350ml. The use of hyperosmotics controls the IOP and an eye with controlled IOP is less vulnerable to sudden decompression, snuff out, or expulsive haemorrhage. In angle closure patients, it allows the lens to fall back, and permits a deeper chamber for instrument manipulation. In patients with compromised renal function or with cardiac disease, Mannitol is avoided. ***Avoid giving the patient water after Mannitol and always ensure he/she passes urine before shifting to the theatre.***

What consent to take?

This is very important for a sight threatening condition like glaucoma. Patients must be clearly explained the risk and benefits of the surgery, in the language they understand. They must be told that a "***glaucoma surgery will only at best preserve their vision and at no time improve it***". The use of colloquial term "Motia" for both cataract and glaucoma is very confusing for the patient. This is also often responsible for the delay in seeking treatment for glaucoma-induced drop in vision, in the mistaken belief that it is cataract (Safed Motia).

The patient must be warned about the possibility of a drop of about 1 line of corrected visual acuity after trabeculectomy.[1,3] They should also be explained that glaucoma surgery will hasten the progression of cataract and rarely they may have loss of vision (snuff out phenomenon), in case of advanced visual field defects.

What type of anaesthesia to employ ?

Patients with advanced visual field compromise are given a lesser volume of the peribulbar injection. The intra-ocular pressure spike induced by the sheer volume of the local anaesthetic injection can wreak havoc on the compromised optic nerve head circulation. ***Avoid using epinephrine in the injection, since it can cause vasoconstriction*** of the small vessels supplying the already compromised optic nerve head.[4] Retrobulbar injections are unnecessary. ***Peribulbar or sometimes subtenon injections*** are sufficient to perform a trabeculectomy. General anaesthesia is only required for children or in cases with extensive scarring which would necessitate a prolonged dissection. The use of retrobulbar or peribulbar injection has been documented to increase the IOP by 20 mm Hg in 10% eyes, and by 10 mm Hg in 35% of glaucomatous eyes.[5] So it is best to lower the IOP before giving the block by hyperosmotics, as elaborated before.

The following technique is being used for peribulbar anaesthesia by the authors for over a decade.

- A vial of Hyaluronidase powder (1500 IU) is freshly reconstituted in 2 ml of 2% Lignocaine.
- One third of this solution is added into one full bottle of 2% lignocaine (containing 30 ml). This makes the hyaluronidase concentration as 15 IU/ml of fluid.
- 6 ml of Xylocaine is withdrawn from this bottle to which is added 4 ml of 0.5% Bupivacaine, to achieve a volume of 10 ml.
- 3-5 ml of this mixture is injected at the junction of the lateral one third and medial two third of the lower lid, parallel to the orbital floor using a 2.5 cm long 22/23 needle. Another 2-3 ml is injected at the junction of the medial one third and lateral two third of the superior lid. During the injections, the needle is directed parallel to the floor or roof of the orbit, taking care that only half the needle enters the orbital space. No resistance should be encountered and before injecting, a gentle sideways swaying movement is made to ensure that the needle is not in the ocular coats. If the eyeball moves along with the swaying needle it indicates that the needle has entered the ocular coats.

Avoid mechanical compresion by Super Pinky ball and use of epinephrine in the peribulbar injection, in cases of advanced glaucoma.

Recent papers have successfully positioned the use of subtenon, subconjunctival and ***topical anaesthesia*** in trabeculectomy and combined surgery. [6,7,8,9] Subconjunctival anaesthesia consisting of a 1- to 2 ml injection of the Xylocaine -Bupivacaine mixture without hyaluronidase in the superotemporal quadrant has been advocated be Azuaro Blanco et al. [7] Other authors avoid injectable anaesthesia in advanced glaucoma patients with constricted visual fields. They recommend subtenon or topical anaesthesia in the form of 2% lignocaine jelly, 0.5% Paracaine eye drops, or 2% Lignocaine drops as an equally effective and safer alternative.[8,9]

In ***advanced glaucoma cases, where only a small window of visual field is left, most surgeons avoid using the compressive ball like Super-Pinky*** or Honan so that sustained mechanical pressure does not jeopardize the vulnerable optic nerve head circulation. [2] Instead a **controlled gentle digital massage with the hand is advocated.**

HOW TO PERFORM THE SURGERY ?

(a) Selecting the filtration site

Our personal preference is superior, **slightly staggered to the nasal side**,

since it leaves more than adequate space on the temporal side for a repeat surgery. Superior limbus site is preferred as the bleb is snugly covered by the lid, which protects and hides it's unsightly appearance. The superior peripheral iridectomy (PI) is also covered by the upper lid and thus diplopia induced by an inadvertently large PI is also avoided. Inferior trabeculectomy should be avoided as the incidence of endophthalmitis increases with an inferiorly located bleb 7.8% per patient / year , which is 6 times the risk after superior trabeculectomy, especially if concomitant antimitotics are used. [10,11]

Buphthalmos or advanced glaucoma are conditions where the disease may not permit enough leeway to repeat the trabeculectomy, and the first trabeculectomy is the best take. A truly superior site, centered at 12'O clock position is preferred in these conditions, as it gives the best exposure.

If after conjunctival dissection an collector channel vein is spotted in the proposed area of scleral flap it is best to avoid the vessel. This may not however be feasible as these veins are often present in the proposed scleral flap site (Fig.1). The ooze from these veins, when cut; is very troublesome and may need a spot of bipolar cautery for control.

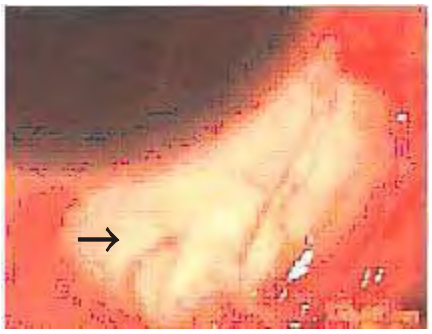


Fig.1: Collector channel

(b) Bridle suture

The conventional **superior rectus** suture placed 10-15 mm behind the limbus can give rise to a haematoma, which by releasing growth factors facilitates healing at the filtration site (Fig.2). Blood contains many growth factors, which promote healing and thereby contribute to bleb failure. [2] Furthermore, in a limbal based conjunctival flap, the superior rectus traction suture makes conjunctival suturing difficult. To avoid these complications, some surgeons are now switching over to a clear **corneal traction suture**. (Fig.3) However, we still prefer the superior rectus bridle suture as we find it technically easier.

The pulling force of a corneal traction suture in rotating the eyeball downward is superior to that of a superior rectus suture. The surgeon needs to minimize on the depth of penetration to avoid corneal perforation and avoid taking too superficial a bite, to prevent cheese wiring the corneal tissue. The ideal suture depth is till $3/4^{th}$ of the corneal thickness. It is placed 1 mm from limbus and the pass is at least 4-5 mm wide. The suture material is either 7-0 or 8-0 silk or nylon . On the other hand, the suture for superior rectus bridle can be a 4-0 silk or even simple autoclaved cotton thread.

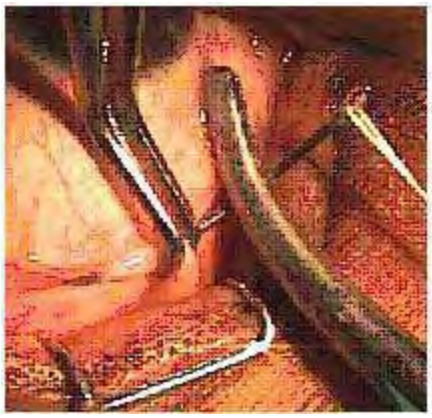


Fig.2: Superior rectus bridle suture

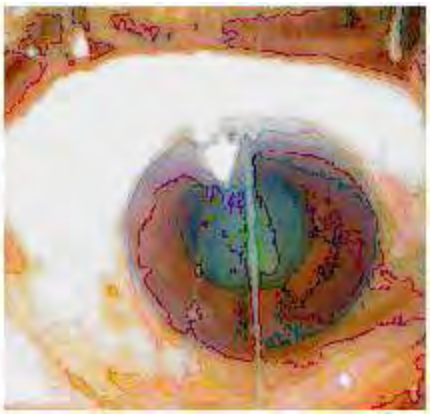


Fig.3: Clear corneal traction suture

(c) Conjunctival incision

Handle the conjunctiva very gently for it is this care, which will decide the fate of your trabeculectomy. Rough handling of conjunctiva not only entails the risk of buttonholing but also subsequent release of inflammatory mediators, which often herald early death of the filtering bleb. The conjunctival flap can either be limbal based or fornix based. (Fig.4&5).

Conjunctiva should be handled gently at all times, hold with a non traumatic toothed forceps whenever possible.

Two large recent studies using fornix or limbal based conjunctival flaps reported similar survival rates with either type. Interestingly the incidence of wound leak was more in fornix based flap in one study and with limbal based flap in the other. It appears that the operator is a more important factor than the position of flap, in this context.[12, 13] Mandic et al in 2004, conducted a prospective study wherein the first eye undergoing phacotrabeculectomy with mitomycin C received a fornix-based conjunctival flap, and the fellow eye when operated, received the limbal based flap. They found no difference

Fig.4: Limbal based flap

Fig. 5: Fornix based flap

in the safety or efficacy of the procedure between the two eyes, except that mild early bleb leak, was more common in the fornix flap group. [14] This study is in concurrence with most of earlier studies which compared extracapsular cataract surgery combined with trabeculectomy with phacotrabeculectomy and found that the use of limbal or fornix based flap resulted in equivalent lowering of IOP. [15, 16, 17, 18]

The minimal manipulation of conjunctiva with the fornix based approach minimizes the risk of a posteriorly placed restricting scar and should allow better posterior flow. [19] Dr Peng Khaw, the author of Moorfield safe technique of trabeculectomy has studied this in detail. He coined the term **"ring of steel "**, where a ring of fibrosis forms at the forniceal end of the bleb during healing process, which restricts posterior flow (Fig. 6&7). Since it coincides with the conjunctival incision in the limbus based flap, he has abandoned using the limbal based flap. He advocates a fornix based flap.

The following table encapsulates the different aspects of the two conjunctival flaps. (Table 1)

An adequate scleral exposure is important, and this should govern the length of conjunctival incision. A minimum of 8-9 mm incision length is required for a limbus based flap, however a 6-7 mm incision may be adequate if a fornix based flap is performed. Some surgeons advocate a relaxing incision at the edge of the first incision. This is called a **L shaped inci-**

Table 1. Comparison between limbal versus fornix based conjunctival flap

	Limbal based	*Fornix based*
Location	At the limbus	8 mm behind the limbus
Conjunctival incision length	Longer	Shorter
Scleral and conjunctival handling	More extensive, button-holing more common	Less
Haemorrhage	More	Less
Exposure of operating field	Not so well	Better
Scleral flap dissection	Difficult	Easier
Mitomycin application	More cumbersome	Easier
Releasable suture placement	Technically more difficult	Technically easier
Surgical time	Longer	Shorter
For combined surgery	Cumbersome	Easier
Wound leak	Risk minimal	Potential risk
Bleb morphology	Overhanging bleb	Posteriorly directed bleb
Bleb massage postoperatively	Do with confidence	Do with trepidation
Astigmatism induced	Less	More, especially with bleb forming corneal sutures, reverts after suture removal
In re-surgery	More difficult	Easier

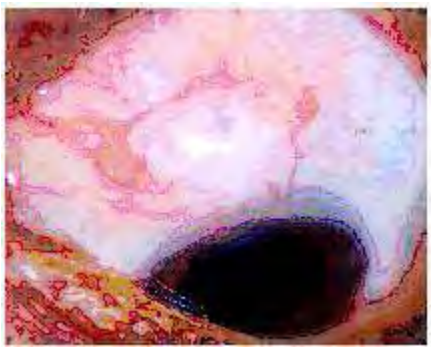


Fig.6: Limbal based flap giving rise to a scar at the incision site which restricts the bleb.

Fig. 7: "Ring of steel"

sion and it reduces the length of main conjunctival incision while providing similar exposure. Thus lesser clock hours of conjunctiva need to be dissected [20] (Fig.8).

The conjunctival flap is created using a non-traumatic forceps like Pierce Hoskin's forceps and Westcott's scissors, taking care not to buttonhole the conjunctiva. [21] The chance of buttonholing increases manifold in repeat surgeries, or post cataract surgery. Some surgeons use saline or Xylocaine subconjunctival injection in the conjunctival area to be dissected to create a cleavage plane, between the conjunctiva and episcleral tissue. In repeat surgeries, where the conjunctiva is scarred, a fornix based flap is preferred. The dissection is done beneath the flap with the Westcott scissors, just short of the superior rectus suture (Fig.9). This also allows placement of Mitomycin sponges till the posterior edge of the cleared subconjunctival space, away from the cut ends of the conjunctiva and finishing just short of the superior rectus insertion.

Both limbal and fornix based conjunctival flap give equivalent IOP control,the latter is preferred in repeat surgeries.

Fig.8: Relaxing cut at the edge of a fornix based conjunctival flap, L shaped incision.

Fig. 9: Posteriorly directed subconjunctival dissection ensures adequate space for the MMC sponges to be placed more posteriorly

(d) Tenonectomy

Some surgeons advocate tenonectomy as an aid in achieving lower IOP,[22, 23, 24] whereas others have concluded that it has no beneficial effect. [25, 26, 27] In fact, Scott et al went so far as to say that tenonectomy had an etiological role in the development of encysted blebs. A comprehensive study from Turkey sought to prove that leaving behind a thick Tenon capsule in young patients, in Mitomycin-C augmented trabeculectomy would prevent bleb leaks. However, they found that over a 2 year follow up avascular thin-walled bleb still formed in 84% eyes., shallow anterior chamber occurred in 31%, hypotony in 16 %, and endophthalmitis in 2%. Thus even a thick Tenon's capsule was no safeguard against MMC complications. [28] Miller et al, have advocated partial tenonectomy as being equivalent to total tenonectomy. [29]

The authors recommend, partial tenonectomy only in young patients and children where a thick Tenon capsule is present (Fig.10).

(e) Haemostasis

Blood releases many healing factors, which would unfortunately also cause conjunctival and scleral scarring thereby precipitating and aggravating bleb failure. Thus, meticulous subconjunctival and episcleral haemostasis is not only essential for adequate exposure and dissection, but also to ensure longevity of the bleb. A wet field cautery is ideal, but in settings where Tadworth ball cautery needs to be used, overenthusiastic applications of the latter is to be avoided since it causes scleral shrinkage, thus making it difficult to close the scleral flap without tension. ***Scleral** collector channel **veins are difficult to coagulate, the trick is to cauterise them lightly, and further check the ooze with gentle pressure by a swab stick or sponge** (Fig.11)*. If Mitomycin use is planned, this may be the opportune time to do it as the oozing will disappear or decrease after Mitomycin application. A mild ooze will be quenched by the aqueous outflow after performing sclerostomy. So there is no reason to be too aggressive in controlling minimal bleeding.

Fig.10: Partial tenonectomy being performed.

Fig. 11: Gentle wet field cautery being applied.

Fig.12: Rectangular scleral flap dissected. Note the flap is held with a McPherson or other atraumatic, non-toothed forceps.

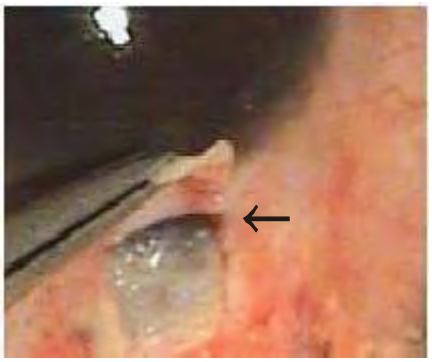


Fig.13: The dissection is carried on beyond the scleral spur, the blue grey tranlucent zone, till 1 mm into clear cornea.

(f) Scleral flap dissection

There are multiple ways to do it. A rectangular or a triangular flap is outlined in dimensions of 4-4.5 x 4.5 - 5 mm (rectangular) or 4.5-5 x 3.5 mm (triangular) (Fig.12).[21, 30] The base of the triangle rests at the limbus.

Lift the scleral flap with a non-toothed – Kelman McPherson or suture tying – forceps.

The instrument used could be either a Bard Parker handle, a 11 number blade, a disposable cutting knife or a diamond knife. The tip of the triangle or one corner of the rectangle is **lifted with a non toothed forceps** (the author's preference is a Kelman McPherson forceps). A lamellar cleavage plane is then dissected with a Crescent blade. The trick to get a clean cut, is to slide the blade tip by gentle tiny thrusts, at the leading edge corner of the scleral flap, before lifting it up with the forceps. It is best to aim at keeping the plane of dissection at 1/2 to 2/3rd depth of the sclera.

The dissection is carried on till one crosses the blue grey barrier where the white scleral fibres merge into the grey zone. The white, opaque sclera with crisscrossing fibres merges into a grey band of parallel fibres, which overlies the scleral spur. Anterior to this lies the transparent corneal tissue. The junction of the posterior border of the blue grey zone (trabecular band) and the sclera is the external landmark for the scleral spur. The dissection is further carried on into 1 mm of clear cornea (Fig. 13). ***The Schlemm's canal is usually situated just anterior to the circumferential fibres of the scleral spur, sometimes it is found behind it***. [21]

Another way is to make a straight scleral incision about 4-5 mm from the limbus and dissect a scleral pocket, similar to a manual small incision cataract surgery (Fig. 14). [20, 31] The two side incisions are then cut with a disposable blade, keeping the flat of the Crescent blade as a support on the base

Fig.14: Dissect a scleral pocket 4-5 mm posterior to the limbus.

Fig.15: First side cut made, keeping the crescent blade as a guard.

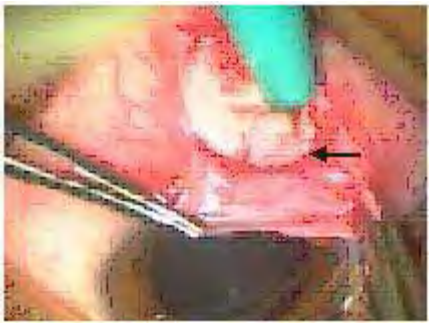


Fig.16: Second cut made – thereby creating a scleral flap. Note the ends stop short of the limbus by 1-2 mm (arrow).

Fig.17: Scleral pocket dissected in a fornix based flap.

(Fig. 15 &16). ***The side incisions in this case are not cut until the limbus (but only till 1-2 mm away) to encourage posterior flow of the aqueous***. (Moorfield's safe trabeculectomy technique). In this technique, it is essential to use a punch to perform the sclerostomy.[2] Fig. 14, 15, 16 depict the steps with a limbal based flap, whereas Fig.17,18, 19 depict the same steps with a fornix based flap.

The scleral flap should neither be too thick as it will offer high resistance to aqueous flow, nor too thin because then the chance of flap dehiscence would increase, or the aqueous seepage through the flap may be excessive. A thin scleral flap can cause over filtration, hypotony, or the flap can become staphylomatous. Ideally, the scleral flap should be half the scleral thickness.[21] In case the first nick is too deep and one realises it during the lamellar dissection, direction can be changed to make it less deep, for the rest of the dissection. It is better to have a flap of irregular thickness rather than have too thick or thin a flap.

Fig.18: First side cut of the scleral pocket. The incision is made over the crescent guard.

Fig.19: The second cut is made, the ends of the incision stop short of the limubs by 1 mm (arrow).

(g) Mitomycin application

Mitomycin is a bioreductive alkylating agent that undergoes metabolic reductive activation, and has various oxygen tension-dependent cytotoxic effects and arrests the cells in the S-phase by inhibiting cross-linking of DNA.[32, 33]

Mitomycin is the preferred antifibrotic in India, America and Japan whereas 5 Fluorouracil is a more popular antimetabolite in the United Kingdom. [34, 35]

MMC 0.2 mg/ml subconjunctivally for 3 minutes, followed by 30 second subsclerally is recommended.

Indications for use of MMC/5 Fluorouracil

- Young patients, less than 40 years.[36]
- Secondary glaucoma- uveitic, neovascular, aphakic, post keratoplasty.[36]
- Prior failed trabeculectomy.
- High preoperative intraocular pressure, more than 35-40 mm Hg at presentation. However, PACG (primary angle closure glaucoma) patients, prior to peripheral iridotomy are an exception to this rule. The pressures in these cases get partially controlled with iridotomy. If such high pressures persist after a patent iridotomy then only should MMC be considered for primary use.
- Buphthalmic eyes - initially MMC was reserved for repeat surgery [37] but recent trends show that more surgeons are now using it as a primary modality. [38]

Dose::

The ***concentration*** of MMC has long been as issue of debate.

Maquet JA et al has recently sought to solve the debate by comparing three different dosages of MMC namely: 0.1 mg/ml, 0.2 mg/ml, 0.4 mg/ml for 2 minutes in 60 trabeculectomies and 83 combined surgeries, and reported no significant differences in IOP control and postoperative complications with the three dosages. [39] Ozkiris et al also concur with the view that IOP control is similar whether 0.4 or 0.2 mg/ ml of MMC is used. [37] However, Meitz et al reported that using a higher concentration of 0.5mg/ml led to larger IOP drop and a better success rate.[40] Some studies have, however, cautioned against using the higher concentration (0.4 mg/ml), as it can increase the complications without providing any additional benefit in IOP control. [36] Thus the higher doses of MMC > 0.2 mg / ml maybe reserved for cases with more than two risk factors for bleb failure. [36, 41] This viewpoint is endorsed by the authors.

Duration of application:

The duration for which Mitomycin is applied varies from 2-5 minutes, however, a duration beyond 3 minutes, increases the risk of hypotony and visual acuity loss.[42, 43, 44]

The authors recommend 0.2 mg / ml, applied for 3 minutes as standard MMC protocol. In high risk cases like – repeat surgeries, uveitic and neovascular glaucoma 0.4mg/ml. is preferred and applied for no longer than 4 minutes. During their tissue repair experiments, Khaw et al have documented that the maximum uptake of the drug is within 3 minutes after which it plateaus out.[2]

In addition to the 3 minute subconjunctival application, we also apply it intrasclerally for 30 seconds

When to apply it?

Mitomycin could be applied before [45] or after complete scleral lamellar flap dissection.[42, 46]

The previous fear of Mitomycin C (MMC) percolating through the scleral bed, and causing toxicity to the ciliary body were ill founded, so intrascleral use has now become more common.[47, 48] However, few studies state that intrascleral Mitomycin did cause more ocular hypotony, choroidal detachment and a shallow anterior chamber.[46] Thus intrascleral application although is no longer taboo, it's use must be judicious. As stated before the authors recommend subconjunctival use for 3 minutes and intra-scleral (beneath the scleral flap) for a mere 30 seconds.

How to prepare it?

Mitomycin C comes in a vial as purple colour powder in 2 mg or 10 mg potency (Biochem laboratories). It is freshly reconstituted with distilled water or normal saline in concentration of 0.2 - 0.5 mg/ml. Add 10 ml of distilled water to the 2 mg bottle, shake it, after reconstitution the fluid assumes

a light purple colour. A colour, which is not purple, indicates ineffective drug and such bottles must be discarded The concentration of MMC in this fluid is 0.2 mg /ml. It can be used for multiple surgeries done during the same day but should be discarded at the end of the day.

Technique of application:

Merocel sponges are cut into multiple pieces. MMC is squirted onto cut pieces of the Merocel sponges (Fig.20). Excess Mitomycin is squeezed out with forceps, these soaked sponges are then pushed under the conjunctiva in all directions with the aim that contact with the cut edges of conjunctiva is avoided (to prevent retardation of healing), while a large subconjunctival area is covered (Fig.21). The larger area covered leads to a more diffuse bleb. Fig. 22 shows a 6 month post operative MMC bleb when MMC was used with a single sponge application and Fig. 23 shows the more diffuse bleb obtained when the multiple cut sponge technique of MMC application was used. After the requisite time limit, the sponges are removed, and freshly soaked sponges are then re-inserted for 30 seconds beneath the scleral flap. Subsequently these sponges are also removed and the area washed with running Ringer lactate. The cotton used to soak this fluid and the sponges are discarded, the instruments used in MMC application are not used again in the surgery, to avoid any MMC contamination of the surgical field. Even the surgeon must change gloves, since this antimitotic drug can be hazardous. ***The soaked sponges must be disposed of in an incinerator or safely in concordance with bio-waste rules and the instruments washed and autoclaved as maybe the routine.***

Using multiple small cut MMC soaked sponges increases the contact area of MMC and leads to a more diffuse, healthier bleb.

Fig.20: Cut Merocel sponges are soaked in Mitomycin C solution.

Fig.21: The soaked sponges are pushed under the conjunctiva. Prior space is created there with the help of a scissors.

Fig.22: Localised avascular bleb attained after the older technique of MMC application.

Fig.23: Diffuse bleb attained after authors started using cut sponges method of MMC application.

Success Rate:

Mitomycin trabeculectomy is uniformly successful, with most patients achieving a IOP in the low teens[47, 49] The success rate drops proportionately with increasing number of risk factors. [36] A very low success rate has been reported in glaucoma secondary to paediatric cataract surgery, namely 36.8% at the end of 3 years.[50] The success rate also declines over time from - 83.3% at 1 year, to 60% in the 6th year.[47]A recent Cochrane database review of eleven trials involving 698 participants, wherein MMC augmented trabeculectomy combined with cataract surgery and primary trabeculectomy were reviewed, concludes that Mitomycin C reduces the relative risk of failure of trabeculectomy, both in eyes at high risk of failure and in those undergoing primary surgery.[51]

What are the complications associated with Mitomycin use?

(i) Cataract

Almost 20- 66% patients develop some lens opacity over a 3 year period post trabeculectomy The addition of antimitotic drugs increases this risk.[52, 53]

Fig.24: Avascular bleb of MMC trabeculectomy.

(ii) Avascular blebs, bleb leak

A 2 year prospective study on Mitomycin bleb characteristics of 125 eyes, reviewed avascularity, transconjunctival oozing and leaks. The surgeries studied were trabeculectomy, deep sclerectomy, combined procedures and the MMC concentration used was 0.2 mg/ml for 2 minutes. This study revealed that bleb leaks occurred in 13.6 % cases, and that most eyes developed

bleb avascularity within the first year after surgery. Transconjunctival oozing eventually occurred in all eyes with avascular blebs and the incidence of leaks gradually increased with time. [45] ***Thus avascular blebs seen with MMC use, should be regarded with suspicion and monitored more vigilantly for signs of infection*** *(Fig.24).* Another study has however reported that these leaks are rarely significant enough to require surgical reconstruction.[47]

(iii) Bleb dysesthesia

It is a term applied to the group of conditions caused by the cystic, overhanging or elevated blebs. These blebs lead to tear film irregularities, blinking problems, dellen formation, dry eyes and foreign body sensation. [54]

(iv) Hypotony

Ocular hypotony, hypotonous maculopathy, choroidal detachment and a shallow anterior chamber are quite common after the use of Mitomycin, more so with the intrascleral application. [46] The 2-3 year post surgery incidence of hypotony, varies from 16- 42%, but fortunately hypotonous maculopathy is relatively infrequent.[55, 56]

(v) Risk of endophthalmitis

5 Fluorouracil protocol: Subconjunctival 5 mg is injected OD, starting from day 1 till day 10 post trabeculectomy.

The risk of endophthalmitis is indisputably higher with the use of antifibrotics. The incidence of blebitis varies from 0.8- 7.5%, and increases with time, the mean onset usually being 3 years post trabeculectomy [55, 57, 58] Aggressive medications controlled the infection in almost 68% cases, according to one study, but the visual prognosis was usually grim. [57] A review by Solomon et al found that incidence of endophthalmitis increased from 0.3% for plain trabeculectomy to 0.8 -1.3% for 5-FU and MMC trabeculectomy which implies a 3 - 4 times increase. [59, 60] The mean interval between the initial filtering surgery and endophthalmitis has been reported to range from 2-5 years. [59, 61] DeBry PW et al retrospectively reviewed 239 eyes and calculated the 5 year probability of developing a bleb leak, blebitis, or endophthalmitis to be 17.9%, 6.3%, and 7.5%, respectively.[58]

An analysis of risk factors, leading to the development of endophthalmitis, has pointed bleb leaks/ defects, bleb manipulations/ needling/ compression sutures, laser suture lysis, autologous blood injection, inferior bleb location, nasolacrimal duct obstruction and diabetes as the major risks. The organisms isolated have usually belonged to the *Streptococcus* and *Staphylococcu*s species [60, 62]

An interesting observation by Wells et al from Moorfield Hospital, London was that limbus based conjunctival flaps in paediatric glaucoma treated

by MMC augmented trabeculectomy had to a 3 times higher risk of developing cystic blebs (which are highly prone to infection). They postulated that bleb morphology, related to conjunctival flap technique contributes to the increased risk of endophthalmitis.[63] Thus this group routinely uses fornix based conjunctival flaps.

(h) What are the alternatives to Mitomycin?

1. **5-Fluorouracil** - It is used as multiple post operative subconjunctival injections or as a single intra-operative application. [64] It is available in an ampoule - 500mg in 5 ml and 250 mg in 2.5 ml (Biochem Labs).

- 5 FU injections are given every day for 10 days, in the dose of 5 mg. To make this injection, withdraw 1 ml of 5 FU from the 500 mg / 5ml ampoule. This 1ml has 100 mg of the drug. To this 1ml add 9ml of distilled water and make it into a 10 ml solution. Of this 10ml, withdraw 0.5ml, which will contain 5 mg of the active drug. The dose recommended by the Fluorouracil study group is 2 to 5 mg per injection [65, 66]

  For the treatment to be effective the injections should be started from the first day after trabeculectomy[65]

- Intra-operative dose of 50 mg/ml can be applied over the site with soaked Merocel sponges for a period of 5 min, with equally efficacious results. (Fig. 20). A lower dose of 25mg/ml has also been found to be effective. [67] Intraoperative use of 5-FU, necessitates lesser postoperative 5-FU injections and has fewer side-effects like corneal epitheliopathy without compromising the success rates. [68, 69, 70, 71]

Like any trabeculectomy, 5-fluorouracil augmented surgery also, shows a decline in effect over time, the probability of successful control of a functioning filter at 1 year has been estimated to drop to 61% by 5 years, 44% by 10 years, and 41% by 14 years. [70, 72]

Comparisons between Mitomycin and 5 FU augmented trabeculectomy have reported equivalent results [73, 74, 75] whereas some studies have shown that MMC is more effective. [40, 56]

2. Amniotic membrane

Use of human amniotic membrane implanted under the scleral flap / conjunctival flap has been reported to be equally efficacious and much safer than the use of MMC.[76, 77, 78] While comparing amniotic membrane with MMC, blebs attained with MMC were found to be more thin walled, more leaky, and more frequently led to persistent hypotony and hypotonous maculopathy.[78] An experimental study proved the greater destruction of fibroblasts and macrophages by MMC, versus amniotic membrane.[79] In the author's experience, amniotic membrane is a much safer alternative to MMC.

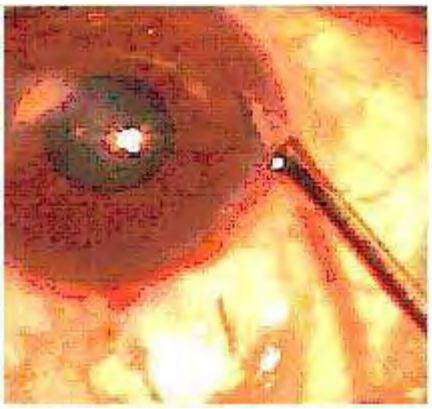


Fig.25: Creating a side port after dissecting the scleral flap. Note the tangential entry of the V lance.

3. Other modalities

Beta irradiation, TGF Beta, photodynamic therapy, are the other modalities which have been effectively used to prevent bleb fibrosis.[80, 81, 82]

(i) Side port creation/paracentesis

After application of MMC, the anterior chamber is entered via a side-port incision. This is made with V lance similar to the one made during phacoemulsification except that the direction is never towards the centre of the chamber, instead it is tangentially directed towards 6'O' clock, parallel to iris (Fig 25). If the pupil is dilated, as is the case sometimes with retrobulbar block, intracameral pilocarpine is injected from the sideport to miose the pupil. **One must ensure that the angle of the V lance is directed tangential and not perpendicular to the limbus.** Entry with the tip being perpendicular may inadvertently damage the lens by a precipitous entry, whereas in a tangential entry the knife faces away from the centre of the lens, over the blanket of the iris, thereby safeguarding the lens.

Create the anterior cut of the 2 by 3 mm sclerostomy with 3.2 mm keratome, entered at junction of blue grey zone where it merges into clear cornea.

This sideport serves many important functions:

- Is used to titrate aqueous flow through the scleral flap before tying the scleral sutures.
- In advanced glaucomatous damage cases, paracentesis is used to perform a controlled decompression as the smaller side port entry is self sealing compared to the larger sclerostomy incision. This controlled decompression is desirable to prevent "snuff out" phenomenon.
- It allows for the anterior chamber to be reformed with viscoelastic or Ringer lactate solution as the need may be, in case the anterior chamber (AC) becomes shallow during the surgery.
- Titration of the bleb at the end of surgery can be done and a patent sclerostomy, with adequate aqueous flow can be ensured.
- In case of persistent shallow chamber during the post -operative period, AC reformation is facilitated if the side port is already present.

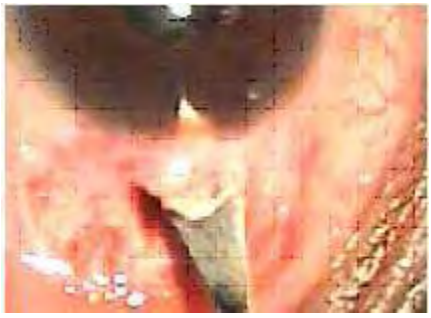


Fig.26: AC is entered with a 3.2 mm keratome in a controlled manner.

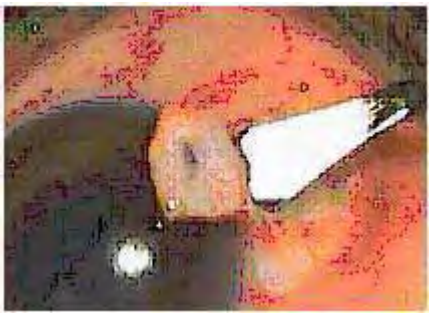


Fig.27: Entry bevelled at the base of the scleral flap, where the blue grey zone merges into clear cornea.

(j) Sclerostomy

After paracentesis, the inner sclerostomy block is marked out with the blade in the dimension 1.5 - 2 mm by 3.0 mm, at the base of the hinge of the superficial scleral flap. [83] Anterior to the sclerolimbal junction (where the white sclera merges into the blue translucent zone) is the clear cornea. A bevelled entry at an acute angle to the scleral bed, with the tip of the 3.2 mm keratome is made just where the translucent zone merges into the clear cornea (Fig.26, 27). ***It is preferable to err on the side of an anterior incision (nearer the cornea) than a too posterior one, since this would entail risk of ciliary body being damaged or exposed***. This happens, especially in the tightly stretched globe of the buphthalmic eyes where the limbal stretching is bizarre and landmarks are obscured. It is not unheard of to cut the block too posteriorly, mistake the stretched, thinned out ciliary body for iris and get vitreous after mistakenly sniping at the ciliary body to perform a peripheral iridectomy.

Fig.28: The keratome is withdrawn slowly. in this case of advanced visual field loss, viscoelastic has been injected in the AC before withdrawing the keratome. This is an additional safeguard to prevent "snuff out".

One should not insert the keratome fully if one wants the inner sclerostomy dimensions to be only 2 mm long, however a full entry is needed when aiming for a 3 mm wide inner sclerostomy. After entering with the keratome, the keratome is slowly withdrawn thereby ensuring a controlled decompression (Fig.28). At least 0.5 mm of the scleral bed is left, on either side of the sclerostomy, so that when the superficial scleral flap is sutured, the sclerostomy margins are not exposed.

The sclerostomy block is cut with a Vannas scissors or size 11 number blade. We have found it easier to enlarge the entry with the keratome and then **cut back on the sides with the Vannas** scissors.[83] The posterior edge (length of the rectangular block), nearer the apex of the flap is then cut with a horizontally angled Vannas scissors.

While using the Kelly Descemet's punch, a smaller sclerostomy of 1 -1.5 by 1.5-2 mm dimensions is made, which is more than adequate. [84, 85] The authors prefer the punch since it creates a compact neat hole without any jagged margins, and gives controlled cutting at all times thus avoiding shallowing of AC (Fig.29). The initial entry is made with the keratome, the punch is then introduced through this incision, with the cutting side turned posteriorly towards the fornix, and 5-6 bites are taken (Fig.30). The positioning is such that the tissue is excised from the posterior tip of the incision.[86] Each bite creates a 0.2 - 0.3 mm opening, our practice is to take at least 5-6 bites so as to create an adequately big sclerostomy, the size should be minimum 1.5-2 mm by 2 mm.[83]

The other punches which can be used are Luntz Dodick, Crozafon, De-Laage, Katena, Holth, Crestani.[84, 85, 87, 88]

An adequate peripheral irridectomy, the base being as large as the inner sclrostomy opening is mandatory.

(k) Peripheral iridectomy

Peripheral iridectomy is performed through the inner sclerostomy with a Vannas scissors and a single toothed fine forceps like Lim's or Pierce Hoskin's. The cut is performed keeping the scissors parallel to the limbus, so as to get a broad base. In order to avoid making too large an iridectomy with resultant glare and /or diplopia, the forceps is angled almost vertically down inside the sclerostomy. Keeping the

Fig.29: Kelly's Descemet punch being used to create the sclerostomy. The punch faces down onto the globe and is directed posteriorly, towards the fornix.

Fig.30: The cut scleral peice along with trabecular meshwork in the jaws of the punch.

Fig.31: Peripheral iridectomy being performed.

forceps tangential to the sclerostomy's forniceal end can result in making too large an iridectomy. Avoid forcefully pulling out the iris as this may cause an iridodialysis and/ or lens damage. The rationale for performing an iridectomy is preventing iris incarceration into the sclerostomy and relieving the element of pupil block glaucoma. ***The iridectomy base should be wider than the inner sclerostomy opening (Fig. 31).***

A few studies have suggested that trabeculectomy may work without a peripheral iridectomy [89] However in the **Indian scenario with angle closure glaucoma being so prevalent, it would be rather unjustified to perform a trabeculectomy or a phacotrabeculectomy without performing a peripheral iridectomy.**

(l) Scleral flap sutures

Scleral flap sutures regulate aqueous outflow. The resistance to bulk flow of aqueous is largely determined by the apposition of the flap to the underlying sclera adjacent to the sclerostomy, which in turn is determined by the suture position and tension. If the scleral flap is poorly constructed or too loose, trans sclerostomy flow will be too great, and may result in hypotony. If the scleral flap is too tight, the IOP will remain too high, placing the patient at risk of sudden loss of remaining visual field ("snuff out") or additional ganglion cell loss with resultant worsening of glaucomatous optic neuropathy. Manipulation of the suture tension and flap's fit could modulate aqueous flow beneath the flap, thereby the IOP.[90]

The first modality used to modulate aqueous flow post-operatively was the development of Simmon's plastic tamponade shell in 1970. This prevented hypotony by ensuring a tight flap fit in the early postoperative period.[91]

A subsequent development was laser suture lysis. In laser suturolysis the sutures holding the scleral flap, are cut during the first few days or weeks after surgery, thus allowing a better aqueous run off.[92] The technique was first described by Lieberman using a Goldmann goniolens. Subsequently many modifications have been made in the lenses, designed to facilitate comfort and proper focusing of the beam.[93-96] These lenses compress the conjunctiva to expose the underlying sutures.[95, 96] The disadvantages of this technique are- it requires access to argon laser, the cost and availability of which can be a major limiting factor in India. It also requires a Hoskin's or

equivalent lens, which enables compression of the filtration area during the procedure. Manipulating the operated area so soon after surgery carries the inherent risk of infection, flap dehiscence and wound leak, not to mention extreme patient discomfort and trepidation. Additionally, sutures maybe obscured by haemorrhage, overlying edema or a thick Tenon capsule all of which, preclude suture release (Fig.32). In addition laser suture lysis has its attendant share of complications such as conjunctival burns, conjunctival flap leak, hypotonous maculopathy, malignant glaucoma, iris incarceration and hyphema.[97-100]

These problems led to the innovation of releasable sutures, which were introduced by Schaffer et al [101] but popularized by Cohen and Osher.[102] The use of releasable sutures minimized the incidence of shallow anterior chamber and hypotony in the early postoperative period [97, 103, 104] Once the wound and anterior chamber stabilize, the sutures are released to enhance the outflow of aqueous humor. The resultant situation, resembling a full thickness surgery, ensures a good bleb function and provides lower long term IOP [104-106] In a nutshell it combines the benefits of partial thickness filtration surgery by allowing a formed anterior chamber in the immediate post operative period along with those of full thickness filtration surgery by allowing a freer flow of aqueous and consequently lower intraocular pressures (IOP) once the sutures are removed in the later post operative period.

Tightness of releasable sutures is modified on table by titrating the aqueous egress by injecting fluid from the paracentesis port.

In our country, where the prevalence of angle closure glaucoma is almost equal to that of open angle glaucoma, preexisting shallow AC is very common. This demands that the scleral sutures offer adequate resistance to aqueous outflow at least in the immediate postoperative period so as to prevent further shallowing. It is also a well-established fact that aqueous flow is essential to keep the bleb patent and functioning. So the glaucoma surgeon is constantly walking on a tightrope as to how tightly to tie the sutures. The sutures should be tight enough to prevent shallow AC and loose enough to keep the aqueous flowing. Releasable sutures comfortably overcome these problems.

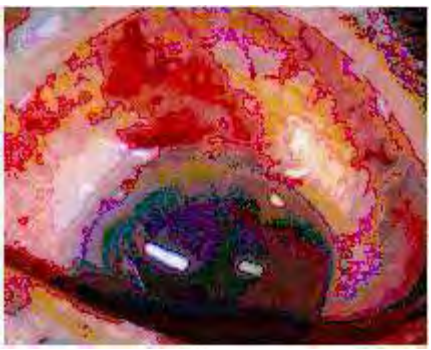


Fig.32: Subconjunctival haemorrhage obscures the scleral flap sutures.

How to tie these releasable sutures?

In a triangular flap, when the base of the triangle/ rectangle stops

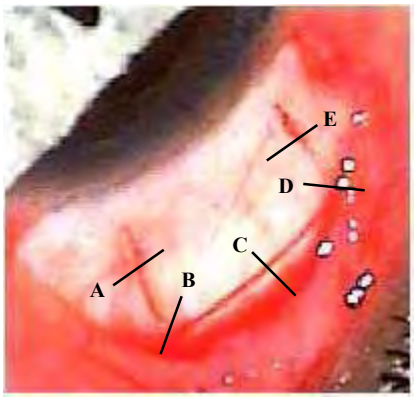


Fig.33: Rectangular flap which is not dissected till limbus would require 5 sutures, of which 2 are releasables. Sutures placed at A & E are fixed, B & C or D are made releasable.

short of the limbus by 1mm (safe surgery technique) then three sutures (in triangular flap) and five sutures (for rectangular flap) are adequate (Fig. 33).

If however the sides of the triangle/ rectangle reach upto the limbus, then 2 additional sutures, one on each of the limbal edges of the side arms of the triangular flap, maybe required. These additional two sutures are safeguards which prevent hypotony, once the releasable sutures are removed. These limbal sutures are not made releasable instead the more distal ones are made releasable.

The reasoning for making the distal sutures releasable is as follows. If the limbal sutures are made releasable, aqueous flow would be directed parallel to the limbus thereby creating an overhanging bleb once they are released, whereas if the distal sutures are made releasable the aqueous flow would be directed posteriorly toward the fornix and lead to a diffuse, posteriorly located bleb.

The suture tightness can be adjusted on the operation table by watching the egress of fluid from the scleral flap edges, by titrating from the sideport. If the flow is excessive the sutures are tightened and if poor the sutures are loosened.

How effective is the release?

The documented amount of immediate reduction in IOP is in the range of 7 -9 mm Hg; if the sutures were released during the first three postoperative weeks.[97, 106] The efficiency was decreased if they were released later. Within the first week a 5 mm Hg drop, was noted in 70% cases, compared to only 20% if the release was done after the third week.[97]

Many authors have speculated about the possibility of dangerous elevation in IOP with the tight closure of scleral flap with releasable sutures [103]. However, this fear has never been substantiated. The assurance that the suture can be released in the postoperative period allows the surgeon to secure the scleral flap tighter than usual thus minimizing hypotony and if high IOP is found in the postoperative period one or more suture may be released to allow improved filtration, which is not possible with permanent sutures.

Another consideration is the increased astigmatism induced by the re-

leasable sutures, since they impinge on the cornea. Hornova et al showed that though postoperative astigmatism increased by +2.8 D on the 1st day, it declined to +2 D by 1st month and after removal, a minimal residual astigmatism of +0.25D was created. [108]

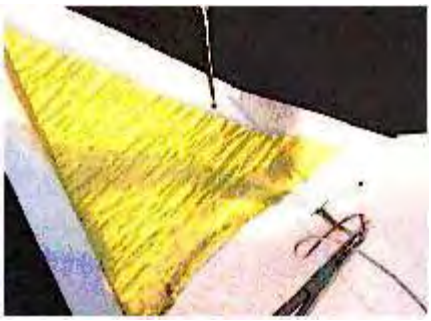
Popular techniques of releasable sutures:

Various releasable sutures techniques have been described. [102, 109, 110, 111]

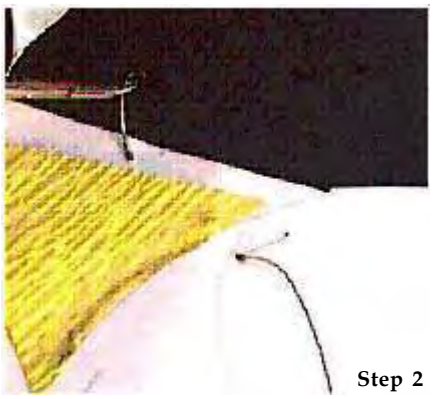
Wilson described a mattress type scleral suture, which was externalized with the knot on the cornea. Postoperatively, the suture could be cut or removed.[107]

1. *Richard Wilson's technique (Fig. 34)*
   - A preplaced corneal grove is created at the base of the scleral flap – 1-1.5 mm from the limbus (optional). (Step 1)
   - The first pass is taken from this groove/ clear cornea, traverses diagonally beneath the sclera flap, and out through the flap (Step 2).
   - Suture then loops over the scleral flap
   - Re-enters into the scleral bed 0.5 mm away from limbal edge of the scleral flap (Step 3).
   - Traverses beneath the scleral flap crossing over the suture in Step 2.

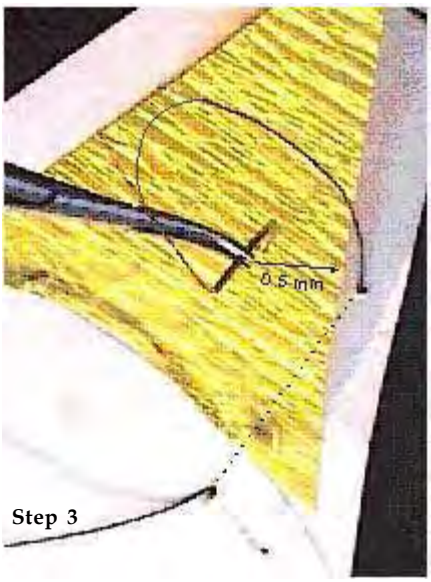
Fig 34: Wilson's technique of tying releasable suture (5 Steps)



Step 1



Step 2



Step 3

Step 4

Step 5

- Emerges 1-1.5 mm in the clear cornea adjacent to the step 1 suture (Step 4).
- The two ends are tied (Step 5). The tightness of the sutures is adjusted to approximate the edges of the scleral flap and aqueous flow is titrated by injecting fluid from the side port and watching its egress from the sides of the sutured scleral flap.
- The corneal end of the suture is then cut flush, to avoid leaving a protruding suture end.
- Two such sutures are placed on the two sides of triangular or apices of the rectangular scleral flap (Fig. 33).

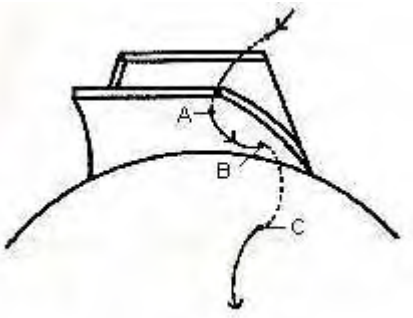


Fig 35: The needle is passed into sclera and through flap. After passing the needle through base of scleral flap, beneath the conjunctival insertion, it is taken through the peripheral cornea.

The knot can be cut later on the slit lamp, under topical anaesthesia and the suture pulled out.

2. Kolker's modification of Cohen and Osher technique of releasable sutures [102]*:* Fig 35-37.

- The needle of a 10-0 nylon suture is passed first into the intact sclera posterior to the scleral flap and then brought out anteriorly through the scleral flap, at A.
- This suture is then passed through the base of the scleral flap at B, beneath the conjunctival flap in-

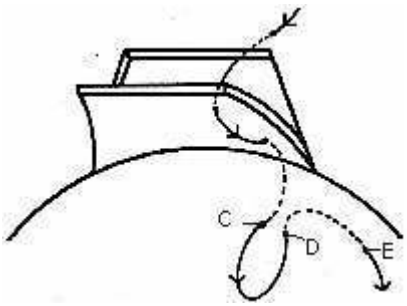


Fig 36: Superficial intracorneal pass C to D. The knot is cut flush at sutures exit from E.

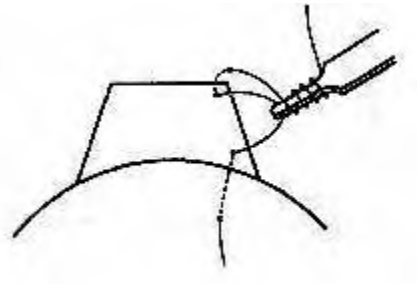


Fig 37: The suture is tied with a quadruple throw slipknot.

sertion, through partial thickness cornea 1 to 2 mm from the limbus, and then out on to the epithelial surface of the cornea, at C (Fig.35)

- A small superficial pass through the adjacent cornea is then made - Kolker's modification C to D. (Fig.36)
- Four throws of the distal end of the suture are then passed around the tying forceps before the suture end lying on the surface of the scleral flap is grasped to make a hemibow slipknot. (Fig.37)
- The tightness of the sutures is adjusted to approximate the edges of the scleral flap and restrict aqueous flow.

Shallow anterior chamber is at least 3 times less frequent when releasable sutures are used.[104]

The corneal end of the suture is then cut flush to avoid leaving a protruding suture end.

These sutures are released as and when required, under topical anaesthesia using the slit lamp. The exteriorized corneal loop is pulled out with a suture holding forceps. The sutures are released one at a time, within 10-14 days of conventional trabeculectomy. Suture removal usually produces an immediate increase in filtration with enlargement of the filtering bleb and a fall in IOP. Suture removal after 2-3 weeks has little effect on bleb appearance or IOP. [97, 103] However, in cases of trabeculectomy with antifibrotics, suture removal maybe delayed until 2-3 weeks after surgery, as post suture removal hypotony is more likely prior to 3 weeks.[105, 112, 113] In case the IOP remains controlled, the sutures need not be removed, until 5-6 weeks have elapsed, by this time healing has occurred, and removal of suture would not affect the IOP.

*What are the **Complications** of releasable sutures?*

Windshield wiper keratopathy occurs due to rubbing of the suture ends on the cornea with lid movements. This is seen as a distinctive wedge shaped keratopathy that resembles the pattern left on a car windshield by the wiper blade. [97,106] Although this keratopathy resolves with release or trimming of the suture, there is a potential for infection and techniques have been described to avoid this complication. The persistent track left after trimming of the suture, also poses a risk of **bleb infection**. Other complications reported are **epithelial abrasion** and **subconjunctival bleed** following the release of the sutures.[97] However, the only complications noted by the authors after a decade of routinely using releasable sutures are mild conjunctival irritation, **mucous deposit** near the knot, and occasional bleed during removal. Sometimes when the suture release is delayed for more than a month, then the knot gets so deeply buried beneath the corneal epithelium that it needs to be dissected. Such deeply buried knots may be left in place if they entail too much corneal dissection.

(m) Anterior chamber reformation

Viscoelastics may be used to reform the AC and check the blood ooze if any, after the scleral flap sutures have been tied (Fig. 38). The authors have been using Methylcellulose for the last 5 years to keep the AC formed and have witnessed no untoward incidence with it. Injection of methylcellulose is very beneficial in case of a post iridectomy bleed, as it limits the bleed and pushes the blood away from the sclerostomy cleft. Use of a viscoelastic has also been recommended by Wilson et al, who in a case control series found that viscoelastic use decreased the risk of complications.[114]

(n) Conjunctival flap closure

A. In a limbus based flap, incision is closed with continuous 8-0 nylon, or 8-0 vicryl, the edges of which are interlocked. The absorbable Vicryl does induce more inflammation but is the suture of choice in children where conjunctival suture removal would necessitate another general anaesthesia. Some surgeons prefer it for adults too since it ensures more patient comfort. Our personal choice is 8-0 nylon. Use of a round bodied needle is preferred, to avoid cutting through the conjunctiva. The superior rectus bridle suture is released at this stage, to allow for proper coaptation of the wound edges. Small closely spaced passes are taken in a running fashion. Interlocking of the

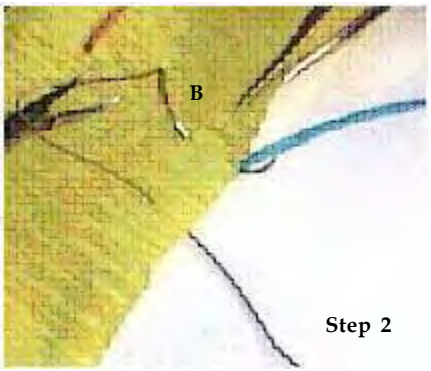
Fig 38: Viscoelastic being injected from the side port to reform the anterior chamber.

suture is not necessary. The ends however are interlocked, tied on itself and not cut too short. A little longer end causes less irritation, a short end may stand up and rub against the lid and cause more discomfort. Too long a suture also leads to a corneal abrasion and should be avoided.

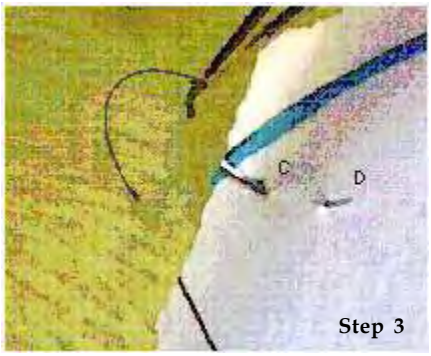
If antifibrotics are used or if the conjunctiva is very thin, tenon layer is sutured separately using interrupted 6 -0 vicryl sutures.

B. For fornix based flap- 10 zero nylon is the suture of choice. One or two sutures are placed at either end of the incision taking the bite from the anchored conjunctiva to the loose conjunctiva of the flap. These are called as

Step 1 – The needle of 10 zero monofilament nylon enters the sclera facing conjunctival end and exits on the conjunctival surface A.



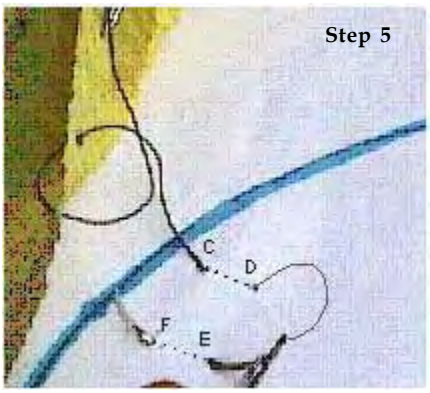
Step 2 – The needle re-enters 2-3 mm away from the surface of the conjunctiva, point B.



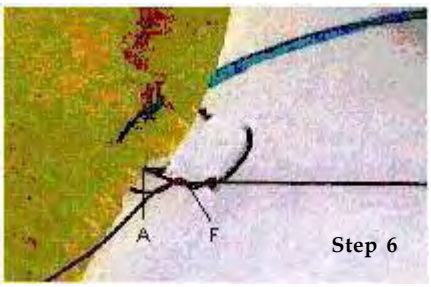
Step 3 – The needle impales and traverses through superficial corneal stroma entering 1-2 mm away from limbus and traversing for 1-2 mm from point C to D. The direction is perpendicular to the limbus.

Step 4 – The needle exits and forms a loop of 2-3 mm, parallel to the limbus and re-enters corneal stroma again perpendicular to limbus at point E.

Fig 39: Diagrammatic representation of corneal anchoring sutures.



Step 5 – The needle re-enters the corneal stroma at point E and traverses intracorneally till point F.



Step 6 – The sutures at point A and F are tied together with initial 3 throws, subsequent 2 and 1 throw, the knot is then cut flush.

the wing sutures. The conjunctiva is anchored to the limbus with 2-3 horizontal mattress sutures which involve intracorneal bites (Step 1-6 in Fig. 39). The knots are placed to lie between conjunctiva and cornea so as to not irritate the cornea (Fig.40,41). Another way is to create a shallow preplaced groove at the corneal limbus, and bury the knots into them. The incidence of wound leak and conjunctival retraction with this corneal anchoring technique is minimal. [2, 114] One study reported mild early wound leakage that resolved with conservative treatment in only 12% eyes.[114] If the conjunctival edge drapes snugly over the limbus after tying the two wing sutures and there is no wound leak noted on bleb titration then the corneal anchoring sutures need not be given.

(o) Bleb titration

At the end of the surgery, titration is done from the side port with a 24 or 26 gauge hydrodissection canula (the blunt tipped fine bored disposable needle which comes with Healon or Hyvisc, can also be used for this purpose). A 2 cc syringe filled with Balanced salt solution or Ringer lactate is attached to this needle and AC is reformed through the side port. The bleb will be formed on table, ***thereby ensuring patency of the sclerostomy and adequate tightness of the scleral sutures (Fig.42)***. In addition water tightness of the conjunctival closure is checked.

WHAT IS THE POSTOPERATIVE REGIMEN?

Topical steroid antibiotic combinations are prescribed at 2-4 hourly intervals to suppress wound healing for first 2 weeks. They are then tapered gradually and are prescribed for a total of 6-8 weeks. Prednisolone or betamethasone combination with antibiotic is used. Topical cycloplegics namely homatropine drops or atropine ointment are routinely used by some

Fig.40: Wing sutures at the end of conjunctival incision.

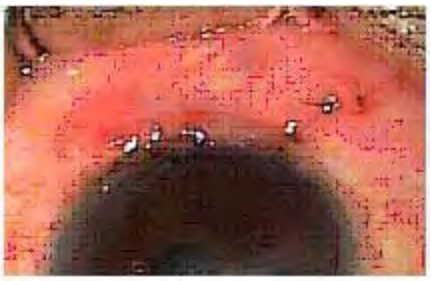


Fig.41: Corneal anchoring sutures in position. L shaped conjunctival incision sutured.

Fig 42: Bleb titration with 26 guage canula from side point. Note the bleb being formed.

surgeons to reduce ciliary spasm, prevent synechiae, or deepen the anterior chamber.

Marquardt D et al, has propounded an intensive post operative care regime, where wound healing control measures were used. These measures were, an increase in topical steroid administration if corkscrew vessels are present; repeated injections of 5-Fluorouracil (5-FU) at the beginning of bleb scarring; and/or needling plus 5-FU administration if an encapsulated bleb developed. In a retrospective study spanning 4-5 years, the patients subjected to these wound healing measures attained target IOP more frequently. [115] This study only highlights that vigilant post operative care is crucial for the continuing function of the filtering surgery.

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Section III

Combined Surgery

Cataract and glaucoma often coexist in the elderly patient and either one affects the treatment and prognosis of the other condition. Cataract can hinder the monitoring of glaucoma whereas cataract surgery influences both intraocular pressure and the functioning of a prior glaucoma filtering surgery. Glaucoma surgery, on the other hand, increases the risk of cataract progression. Combined surgery (phacoemulsification with penetrating or non penetrating filtering surgery) has the advantage of treating two distinct morbidities in a single operation. The enhancement in vision and the subsequent reduction in glaucoma medications significantly enhance the patients' quality of life.[1]

WHAT ARE THE SURGICAL OPTIONS IN SUCH PATIENTS?

Minimally invasive cataract surgery like phacoemulsification or manual small incision cataract surgery (SICS) reduce surgical trauma and hence improve results of combined surgery.

The following surgical options are available for the patient having coexistent cataract and glaucoma.

A. Where the ***glaucoma - is controlled on one topical antiglaucoma drug, cataract extraction alone is performed***. This may do away with the need for the single antiglaucoma medication in the immediate and intermediate follow up period. Over a long term follow up, the glaucoma medications may need to be reintroduced. A recent study monitored IOP changes over a 5 year period, after clear corneal phacoemulsification, in glaucoma patients and suspects. They reported small but significant sustained decrease in IOP in almost 85%, with the same number of glaucoma medications or less. [2]

B. In **advanced glaucoma** where, in a previously recorded 10-2 visual field testing (the current cataract status, may not allow a fresh 10-2 testing), the fields were so constricted that macular split is impending, then trabeculectomy alone is done first. This strategy is particularly important in eyes at high risk for filter failure, *e.g.* as eyes that have had prior intraocular surgery, neovascular glaucoma or young individuals. Cataractous lens is removed, by clear corneal temporal phacoemulsification at a later date, which should be at least 6 months after the trabeculectomy has been performed. The rationale for this is that the target **IOP required for advanced glaucoma cases is in**

the low teens and a combined procedure would rarely achieve that level of pressure control even when augmented with antimetabolites. [3,4,5]

C) ***Combined surgery*** is performed in the following case scenarios :

- Borderline controlled glaucoma despite maximum tolerable anti glaucoma therapy.
- Adequate IOP control but unacceptable drug side effects.
- Number of topical medications required to control IOP are more than two.
- Poor socioeconomic status - the patient is unable to afford the glaucoma medication.
- Poor access to medical care facilities- where frequent follow up is unlikely e.g. elderly people who reside in villages and are brought to the hospital by their care givers.
- Patients not compliant with medical therapy.[6]
- A one eyed patient with significant cataract and moderate glaucoma defect, wherein the other eye has lost vision due to glaucoma.
- Patient opting for surgery as an alternative to glaucoma drugs

The advantages of combined surgery are:

- Two morbidities are handled in one sitting.
- Economical.
- Post cataract surgery the glaucoma patient is subjected to IOP spikes, which damages the vulnerable optic nerve head further.[7,8] The IOP spike has been documented to reach almost twice the pre-operative IOP levels.[8] Combined surgery blunts this spike.
- The need for frequent and long term topical corticosteroids post cataract extraction, may exacerbate the glaucoma in steroid responders. Concomitant glaucoma surgery would downplay this effect.
- May be sight saving in the long run, since many patients delay the second surgery till a irreversible stage is reached.
- AGIS trial has proven that even after adjustment for age and diabetes, over a 7-11 years of follow up, trabeculectomy increases the risk of cataract formation by 78%.[9] Thus more than half of the patients on whom a trabeculectomy is performed, would become visually handicapped from a cataract within the next 5 years or so, and would anyway require a cataract surgery.

D) Occasionally, filtering surgery alone can postpone the need for cataract extraction, when vision is compromised because of the use of miotic therapy which is discontinued after trabeculectomy.

HOW EFFECTIVE IS COMBINED SURGERY?

A whole gamut of studies both prospective and retrospective, vouch for its effectiveness.[11, 12, 13] However, in terms of IOP control it is less effective than trabeculectomy performed alone.[3, 4, 5. 14]

WHAT ARE THE DIFFERENT TECHNIQUES OF COMBINED SURGERY?

A. ECCE trabeculectomy versus Phacotrabeculectomy

ECCE trabeculectomy is associated with excessive conjunctival and scleral manipulations, thereby leading to scarring of the incision area and hence reducing the efficiency as well as the longevity of the filtering bleb. [15, 16] The larger incision also causes more derangement of the blood aqueous barrier leading to increased inflammation, an increased incidence of wound leaks and subsequent shallow anterior chamber.[13, 15, 16, 1718, 21, 22]

Phacotrabeculectomy on the other hand minimizes the derangement in the balance of forces between the intravascular and interstitial compartment by maintaining controlled chamber dynamics. This decreases chances of anterior chamber reaction, hyphema and hypotonous maculopathy. [17] The smaller scleral and conjunctival incisions reduce stimuli to wound healing, inflammation and postoperative bleb scarring.[18, 19] This results in better IOP control, reduced complications and improved bleb longevity.[13, 15-18, 21, 22]

Combined surgery is less effective in reducing IOP as compared to a trabeculectomy performed alone.

B. Manual Small Incision Cataract Surgery and Trabeculectomy

Thomas et al, on comparing phaco-triple versus Blumenthal manual small-incision cataract surgery triple, found the two techniques to be equally efficacious.[24] In the authors' experience manual SICS triple gives equivalent IOP control, equivalent visual acuity gain and induced astigmatism when compared with Phaco triple using a non foldable IOL.

HOW DOES ONE PREPARE FOR SPECIAL ODDS IN COMBINED SURGERY?

Other than the routine preoperative evaluation for any intraocular surgery, certain special entities need to be assessed and planned for, since these may cause intra-operative difficulties and ultimately mar the success of the outcome.

A. Small non dilating pupil

This is a common confounder and is due to atrophy of iris stroma, chronic miotic use , posterior synechiae or prior angle closure attacks. The solution is to withdraw miotics at least 2-3 weeks before surgery, and confirm extent of pupil dilatation 2-3 days prior to surgery.

The following manoeuvres can then be employed:

- Mechanical stretching of the pupil with two Sinsky hooks introduced from two sideports, under viscoelastic blanket. The hooks can be made to pull their sided pupil margins towards their respective side ports. The stretching is repeated at 90^{O} to the first plane.
- Disposable Grieshaber iris hooks, introduced from 4 side ports, can be used.
- Pupil expanders.
- Multiple small sphincterotomies.
- A large superior PI is made, which is extended by a straight nick to the pupil margin. After completing the phacoemulsification, this nick is closed with 10 zero Prolene suture.

Since the introduction of the iris hooks, the pupil mutilating surgeries involving cutting of the pupil margin area are very rarely employed.

B. Increased post surgical inflammation

Anticipate increased inflammation after surgery. To minimize this the following regimen is implemented:

- Topical antibiotic steroid combination is started 2 days prior to surgery
- Prostaglandin analogues are withdrawn 2 -3 weeks before surgery, if feasible, as they increase the intensity of the post operative inflammation.
- Post operatively topical corticosteroids are used more frequently and for a longer duration than for routine trabeculectomy. Sometimes systemic corticosteroids are also required.

C. Pseudoexfoliation and uveitic glaucomas

- Anticipate weak zonules and keep capsule tension rings handy.
- Hydrodissection should be gentle.
- Phaco-chop and other techniques using minimal phaco energy should be employed.
- Specular microscopy is done to assess corneal endothelial status,

and in case of low counts, dispersive viscoelastics like Chondroitin sulphate, or viscoadaptive like Healon GV may be employed to ensure minimal endothelial disruption.[25]

D. Repeat gonioscopy a week or so before surgery, to confirm angle status

- Check for peripheral anterior synechiae
- Patency of laser PI, if present
- If synechiae are extensive or pseudoexfoliative material is seen— goniosynechiolysis and/or trabecular aspiration is attempted during surgery.[26] The authors use the irrigation and aspiration probes of the phacoemulsification machine and gently vacuum the angle area in the inferior 180 degrees in superior site phacoemulsification or nasal 180 degrees in temporal phacoemulsification.

E. IOP spikes can be very high post surgery and are devastating to the compromised optic nerve head circulation. [8] To reduce spiking, **meticulous removal of the viscoelastic is mandatory**. Intracameral pilocarpine must always be injected at the end of phacoemulsification. This not only blunts the IOP spike but ensures a cleaner, smaller, more peripheral iridectomy. [27]

2 site approach gives rise to better looking blebs, but the IOP control is almost similar to single site surgery.

F. In case of vitreous loss – a scleral fixated lens is the preferred option compared to an anterior chamber IOL. The best would be an IOL placed on the anterior capsulorrhexis, wherever feasible.

G. Conjunctiva of the glaucoma patients has usually been exposed for a long time to anti glaucoma drugs and is prone for a dry eye situation due to steroid use in the post operative period. [28] Thus steroids must be used sparingly and judiciously along with tear supplements.

SHOULD A SINGLE SCLERAL SITE OR A 2 SITE APPROACH BE PREFERRED ?

A recent study by Shingleton et al compared the results of 1-site versus 2-site phacotrabeculectomy for over 1 year and found them to be similar with respect to IOP control and visual gain.[29] Comparable results have also been reported by others.[30, 31] Over a longer follow up with MMC augmented phacotrabeculectomy, no difference was noted in the mean IOP irrespective of number of sites used, although clinically apparent filtering blebs were more common in the 2 site group.[32, 33, 34] Our experience concurs with Shingleton's findings.

Despite this, some researchers have however, advocated a 2-site approach in which the phacoemulsification component is performed through a temporal corneal approach followed by a trabeculectomy performed supe-

riorly. They contend that 2 site phacotrabeculectomy entails less conjunctival manipulation and leads to a slightly better control of IOP (around 1-3 mm Hg better).[12, 13, 21]

SHOULD ONE PREFER FORNIX OR LIMBAL BASED CONJUNCTIVAL FLAP ?

The studies analysing fornix-or limbus-based flap in phacotrabeculectomy have noted a shorter surgical time and relatively faster postoperative improvement in vision with the fornix-based flap.[35] However, early bleb leakage was more frequent with fornix flap technique.[36, 37] Another case control study compared phacotrabeculectomy augmented with mitomycin C, wherein the first eye received a fornix-based conjunctival flap, and the fellow eye of the same patient was assigned to the limbus-based group. No significant intergroup difference was found in either the IOP control or complications.[38]

WHAT ARE THE STEPS IN PATIENT PREPARATION?

In addition to routine preoperative preparation, the following treatment protocol should be implemented:

- Intravenous mannitol is given at last 30 minute before wheeling the patient in for surgery.
- Pupil dilatation is aided with flurbiprofen or diclofenac drops, applied every 15 minutes interval for at least 1 hour. They could also be initiated a day before surgery at 6 hourly intervals.
- Peribulbar anaesthesia is used without adrenaline.
- Unless dealing with advanced glaucoma, a good massage with the Super Pinky ball is performed.

WHAT IS THE TECHNIQUE ?

A. Same site phacotrabeculectomy through the scleral tunnel

Same as in trabeculectomy with the following exceptions:

- Fornix based conjunctival flap - technically easier, ensures better exposure and shortens surgical time in the authors' experience.
- Scleral tunnel phacoemulsification is performed.[39]
- The length of the scleral incision is predicted by the type of IOL (foldable or non foldable). The scleral pocket starts 2-3 mm behind the limbus.
- After IOL insertion, intracameral pilocarpine is injected to make the iris taut, and pupil miosed.
- The integrity of the watertight wound is deliberately breached by

removing a block of tissue from the posterior lip of the scleral tunnel, with a Kelly Descemet's punch. The punch is inserted and rotated to face the posterior lip of the incision.[40] Around 5-6 nibbles are taken so as to create a sufficiently large sclerostomy, approximately 1.5 by 1.5 mm. Under a 3 mm flap, sclerostomy as large as 2 mm can be made. *The tissue is excised from the posterior lip of the incision.*

- Peripheral iridectomy is performed through the sclerostomy, using a Lim's forceps. The forceps should be pushed down vertically rather than tangentially.
- **A 3-3.5 mm incision can be left unsutured but larger incisions should be sutured.** A single loose cross suture is sufficient. Although few studies have reported no untoward complications with sutureless 4- 7 mm scleral tunnel incisions ,[41, 42, 43] we recommend suturing of the larger scleral incisions and many studies support our viewpoint.[19,20, 31, 32, 44] If inadvertently the inner sclerostomy becomes larger, than also the scleral flap should be sutured, to prevent over filtration.[45]
- Releasable sutures are the preferred modality. [24, 45, 46]
- The aqueous flow is then titrated through the side port and the suture tightness and number is adjusted according to the aqueous egress.

The use of a punch to perform a sclerostomy through the scleral tunnel is technically easier than performing a Vannas sclerostomy.

- Conjunctival closure needs to be very meticulous. In fornix based conjunctival flap the sides are anchored to the cornea with two wing sutures, and the centre is anchored to clear cornea, anterior to the limbus with a horizontal mattress suture (Fig. 1). These sutures are released after 2 weeks once a bleb is formed and limbal reattachment of the conjunctiva has occurred.
- The advantages of the scleral tunnel approach is that the edges of the tunnel are not grasped during dissection, thus the incidence of flap perforation or tear is less, compared with standard flap making.[39] The fur-

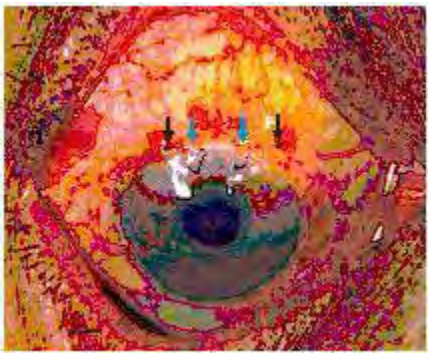


Fig. 1: Conjunctiva anchored to the limbus with (black arrows) two wing sutures at the ends and centrally to the cornea with (blue arrows) two horzontal mattress sutures.

ther dissection of scleral pocket into clear cornea allows production of anterior scleral ostium, which promotes successful filtration.

B. Same site phacotrabeculectomy through the scleral flap

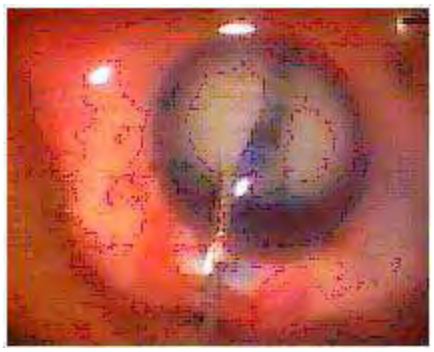
- A triangular / trapezoidal scleral flap is dissected at the superior pole.
- Dimensions of the flap are : 3 x 3 or 4x 3 mm - if foldable IOL is to be used; 3 x 6 mm – if 5.5 mm PMMA IOL is to be used; 3 x 7 mm – if a 6-6.5 mm PMMA IOL is to be used.
- The scleral flap is dissected till 1-1.5 mm into the clear cornea.
- Phacoemulsification is performed through the base of the flap.
- After IOL insertion, a sclerostomy is performed preferably with a punch / 11 No Bard Parker blade/Vannas scissors.
- Peripheral iridectomy is done.
- Closure of the scleral flap, by two regular sutures at the upper corners and two releasable sutures at the edges of the flap is performed. In case of a triangular flap the apical suture is fixed and the side arm sutures are releasables.
- Conjunctival closure is done as mentioned above.

C. Phacotrabeculectomy through two different sites

- The trabeculectomy flap is prepared at the superior site. The flap is dissected and left.
- If mitomycin is planned, it is applied at this stage. Thorough rinsing of the area of MMC application is done.
- The surgeon then shifts to the temporal side of the patient and performs a clear corneal phacoemulsification, inserts the IOL, injects intracameral pilocarpine and hydrates the wound. A little amount of viscoelastic is injected into the AV to make the eye turgid, so as to enable an easier and cleaner sclerostomy.
- The surgeon again shifts to the superior trabeculectomy site and inserts the keratome at the base of the scleral flap, performs an inner sclerostomy, peripheral iridectomy and secures the scleral and conjunctival flap with sutures.[47]
- Bleb titration is done on table as detailed earlier.

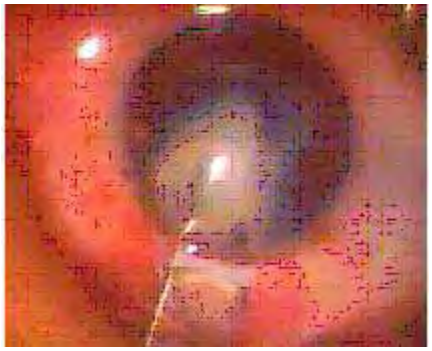
D. Phacofracture or Blumenthal triple through single site (Fig.2)

- A 5.5 mm scleral tunnel is made superiorly.
- Manual small incision cataract surgery is performed and a 5.5 mm



Step 1: Nucleus bissection performed in the anterior chamber, under viscoelastic cover.

Step 2: Nucleus half being removed by Irrigating vectis.



Step 3: Second half of the nucleus being removed

Step 4: Trabectomy by using a punch through the scleral tunnel, after IOL insertion.

Fig 2: Phacofracture triple – technique.

PMMA IOP is inserted (Fig. 2– Step 1, 2, 3). The technique used may be Phacofracture, Blumenthal or sandwich technique.

- Inner lip sclerostomy is performed using the Kelly's punch (Fig. 2– Step 4).
- The remaining steps are same as for phacotrabeculectomy through same site.

E. Mitomycin use

The use of mitomycin combined with phacotrabeculectomy achieves the best IOP lowering of all types of combined cataract and glaucoma surgery currently possible, but can be associated with potentially sight-threatening

complications. [21, 44, 48] However, many researchers advocate its use since it causes better IOP control, larger blebs and requirement for less anti glaucoma medications. [21, 24, 25, 45, 49, 50]

F. Combined surgery in deep sclerectomy

Non penetrating deep sclerectomy can be combined with phacoemulsification. The early results of phacotrabeculectomy vesus phaco -deep sclerectomy are comparable as both give about 30% drop of IOP, but delayed bleb leaks are more often seen in the phacotrabeculectomy group. [51] Deep sclerectomy combined surgery has been documented to result in quieter eyes with less incidence of inflammation, and hyphema.[52] However, long term control of IOP is better in trabeculectomy eyes.

WHAT ARE THE COMPLICATIONS OF COMBINED SURGERY?

Anterior chamber inflammatory reaction is usually more after phaco trabeculectomy than after plain trabeculectomy.[3, 53] Probably the breakdown of blood aqueous barrier lasts longer after phacotrabeculectomy. It is hypothesised that the release of lenticular crystalline material and epithelial cells into aqueous humor, the effect of ultrasound and/or the high volume of fluid passing through the eye at the time of surgery upregulates the productions of fibrogenic cytokines in the aqueous humor. This lesser inflammation, accounts for the better IOP control seen after trabeculectomy alone as compared to phacotrabeculectomy.[54]

Fibrinous exudation is the commonest complication observed followed by hyphema, and choroidal detachment (Fig. 3). [13, 32, 55, 56, 57] The incidence of fibrinous reaction after ECCE trabeculectomy has been documented to be as high as 27-54%. [17, 18, 55, 58] Late complications reported are posterior synechiae and posterior capsule opcification.[54, 59, 60]

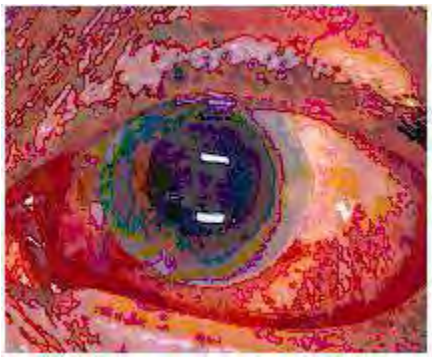


Fig. 3: Anterior chamber inflammation – post operative day 1.

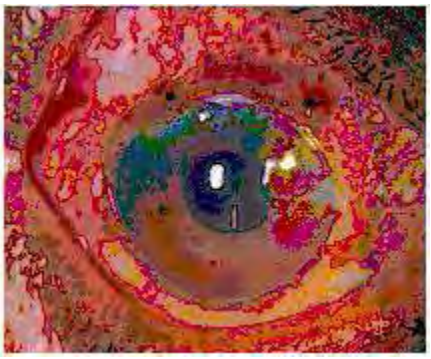


Fig. 4: Shallow bleb prior to suture removal, post operative day 14.

WHAT IS IMPACT OF COMBINED SURGERY ON BLEB MORPHOLOGY?

In the authors' experience, blebs in combined surgeries are usually flatter and not so pronounced as in trabeculectomy alone (Fig. 4). Other researchers have concurred with this and concluded that bleb height is lesser with the single site phaco-trabeculectomy and almost 2/3rd cases do not show a good bleb [15, 18, 24, 61] Limbal based flaps form higher blebs than fornix based flaps, 15% vs 9% in. one study.[15] So the surgeon should not be worried at the absence of a good bleb, the filter still functions nevertheless.

HOW DOES CATARACT SURGERY AFFECT FUNCTIONING TRABECULECTOMY BLEBS?

A knowledge of this is relevant since this is a very common scenario faced by the ophthalmologist. Most studies have shown that cataract surgery in patients with prior trabeculectomy *increases the intraocular pressure,* increases the need for antiglaucoma drugs, and decreases bleb size especially if extracapsular cataract extraction is done [62, 63, 64] The probable reasons for bleb failure include - inflammation of the conjunctiva adjacent to the filtering bleb after a corneoscleral incision and probable transient decrease in aqueous humor production in the first few days after cataract extraction.[64, 65] Post-operative intraocular inflammation and shallowing of anterior chamber results in peripheral anterior synechiae, and synechiae formation around the sclerostomy site. Thus the chances of long term failure of the bleb are increased.[66, 67]

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Section IV

Non-penetrating Glaucoma Surgery

Nonpenetrating glaucoma surgeries, namely deep sclerectomy (DS) and viscocanalostomy work by enhancing the natural aqueous outflow channels, while reducing outflow resistance to which trabecular meshwork attributes 75% and outer wall of Schlemm's canal (SC) 25%. A deep scleral flap and external wall of SC is removed leaving behind corneal stroma, anterior trabeculum and Descemet's membrane, thus creating a scleral lake. The aqueous humor leaves the anterior chamber through the intact trabeculodescemet's membrane and reaches the scleral lake, from where it egresses into different pathways. To further enhance the filtration, even the inner wall of the Schlemm's canal and juxtacanalicular meshwork are peeled gradually using a specially designed Mermoud forceps, or capsulorrhexis forceps. [1, 2]

DS is a good surgery for mild to moderate glaucoma, wherein the target IOP is in the mid teens.

WHO FATHERED IT?

Louis de Wecker was the first one to describe it 1869-71 but it was Krasnov who performed the procedure almost a century later in 1962. [3] In the ***sinusotomy*** which he performed, a lamellar band of sclera was removed, Schlemm's canal was opened from 10-2'O clock. At a later date he performed a surgical peripheral iridectomy. This is the equivalent to DS followed by goniopuncture of today. Thus, Krasnov deserves the title of being the father of deep sclerectomy.

HOW DOES IT WORK?

Aqueous humour flows through the thin trabeculodescemet's membrane, which offers little resistance to aqueous outflow and allows a gradual fall in IOP thereby reducing the incidence of shallow anterior chamber (AC). The resistance offered by trabeculo-descemet's membrane is low enough to ensure a significantly low IOP and simultaneously high enough to maintain anterior chamber depth. The main site of aqueous outflow resistance is the juxtacanalicular meshwork, therefore removing this tissue after de-roofing

Schlemm's canal (SC) along with floor (inner wall) of SC hits the nail on the head, by removing the villain of the story.

How does the aqueous drain ?

Through four proposed mechanisms: .

a. *Subconjunctival filtering bleb:* A low, diffuse subconjunctival bleb forms.

b. *Intrascleral bleb:* The empty scleral space left beneath the superficial scleral flap is transformed ***into an intra scleral bleb over time***. To maintain the patency of this intrascleral bleb various implants namely collagen , hyaluronic, HEMA etc. have been used. These prevent this space from collapsing upon itself. The aqueous humor from this space is probably absorbed by new aqueous drainage vessels.[4]

c. *Subchoroidal passage*: The thinned scleral bed (10% of original thickness) allows aqueous to permeate through it into the suprachoroidal space.

d. *Episcleral drainage via Schlemm's canal:* On either side of deep sclerectomy the two surgically created ostia of Schlemm's canal drain the aqueous into the episcleral veins.

WHERE ALL IT WORKS ?

- Open angle glaucoma and its variants [5, 6]
- For mild to moderate glaucoma
- Target pressure required is in the mid teens

It seems to work well in most races[7], but there have been some reports where it seems to be less effective in blacks.[8]

The long term control of IOP in DS, is less efficient than that with conventional trabeculectomy. [9, 10] The short term efficacy is however, quite similar to trabeculectomy.[11, 12]

The success of the surgery maybe predicted from the IOP on the first postoperative day. Andre' Mermouds' group observed that first day IOP of < 5 mm Hg, is associated with a prolonged success and less requirement for subsequent goniopunctures.[12]

WHERE ALL IT DOES NOT WORK ?

- Narrow angle glaucoma : In narrow angle glaucoma, the pathology and resistance to outflow lies prior to the juxtacanalicular meshwork, thus DS is unable to rectify it.
- Post-traumatic Angle Recession Glaucoma
- Post-laser Trabeculoplasty treatment
- Neovascular glaucoma

WHAT ALL IMPROVES THE EFFICACY OF THE SURGERY ?

The main nemesis of any glaucoma filtration surgery, especially in the Indian, Oriental and Afro-African races is subconjunctival and subscleral fibrosis, which ultimately leads to it's failure. The two methods used to prevent fibrosis at the level of subscleral and subconjunctival space are the use of implants or the time tested antimitotics. [13]

1. Implants

That the use of implants is essential for the continuing function of the DS filter has been conclusively proven by Shaarawy T et al. They randomized one eye of each patient to receive a Collagen implant whereas the other eye underwent a DS without implant. At a 5 year follow up the filter was functioning in 69% of the implant eyes compared to only 38% of the plain DS eyes. Implants not only enhance the success rates, provide significantly lower IOP levels, but also lower the need for postoperative medications and goniopunctures.[14] Implants can be both absorbable and nonabsorbable.

a. Absorbable

- Collagen implant (Aquaflow^{T}, Starr Surgical AG), 2.5 by 1 mm, is a purified biologically inert, porcine scleral collagen.[15] The water content of the hydrated device is 99%, and it swells to two to three times its dry size, after placement in the subscleral space. Complete resorption of the implant occurs by 6-9 months[16, 17]

Implants or MMC dramatically improve the success and longevity of deep sclerectomy.

- Healon GV [18, 19]
- Reticulated cross-linked sodium hyaluronate implant **SK Gel** (Corneal Laboratories Paris, France) swells up in contact with water. This biosynthetically produced implant is triangular in shape and comes in two sizes - 3.5 and 4.5 mm. [20, 21]
- Autologous sclera.[22]
- Amniotic membrane - It creates an anatomic barrier by keeping the potentially adhesive surfaces apart, and also prevents fibrosis of the decompression space. It has anti-fibrotic properties owing to down regulation of TGF- Beta (responsible for fibroblastic activation in wound healing), and the avascular stroma of amniotic membrane inhibits ingrowth of new vessels**.** It has been used as an alternative to the prohibitively expensive implants**.** [23, 24]

b. *Non absorbable*

- T-Flux(IOL Tech). This T shaped hydrophilic acrylic device is 0.2 mm thick. Its two arms are placed in the cut ends of the Schlemm's canal. It is anchored to the sclera using a 10 zero monofilament nylon suture through a hole in its limb .[18, 25]
- T- bar – Stainless steel.
- Mermoud **X** (CARE group).
- PMMA – less expensive. [16]

2. Antimitotics

Mitomycin-C, 5-fluorouracil, daunorubicin also minimize fibrosis, thereby prolonging the survival of deep sclerectomy, consistently produce lower IOP and reduce the requirement of goniopunctures.[20, 24, 26, 27, 28] The dose used is 0.2-0.4% placed under the superficial scleral flap and in the sub-conjunctival space for 2- 4 minutes. Caution needs to be used with mitomycin, as its application on the area of scleral flap, is associated with a high incidence of bleb avascularity, transconjunctival ooze, avascular blebs and delayed bleb leaks. [29]

HOW TO PERFORM A DEEP SCLERECTOMY ?

- A limbal-based / fornix based conjunctival flap is created. (Fig 1)
- Haemostasis is ensured with minimal wet field bipolar cautery, taking care to avoid any of the aqueous draining channels. The key ***is to use cautery to a minimum*** to avoid damage to the collector channels, aqueous veins which are going to be the main drainage pipes for aqueous in this surgery.
- Excess Tenon tissue is excised .
- A 5x5 mm rectangular/ parabolic, one-third scleral thickness flap is made and dissected ***1 –1.5 mm anteriorly into clear cornea*** with a disposable crescent knife (Fig. 2 & 3).

Fig.1: Limbus based conjunctival flap

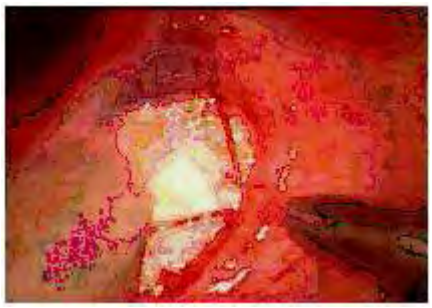

Fig.2: Superficial scleral flap being dissected.

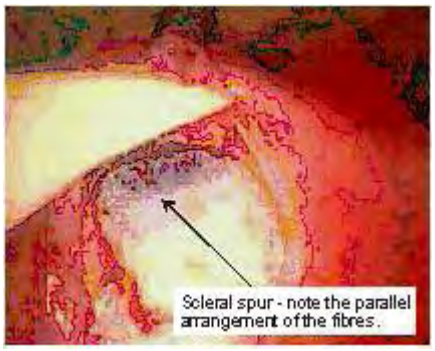

Fig.3: End point of superficial scleral flap

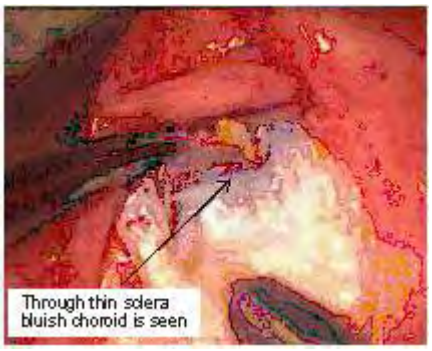

Fig.4: Deep scleral flap being dissected

- Mitomycin, if needed, is applied in the dose of 0.2 -0.4 mg/ml for 2-3 minutes. The same precautions and technique is used as elaborated in Section II. [28]
- A second 5x5 mm deep scleral flap approximately 90% of scleral thickness is then dissected leaving a thin layer of deep sclera over the choroid. This smaller deeper flap stops short of the larger superficial flap by leaving a small margin on each side. ***An important tip is that if one is in the right plane, at 90% depth, one will see the bluish brown choroid shining through the thin layer of sclera***. At this point it is advisable to increase the magnification of the microscope to 16-20 X (Fig. 4).

– At 90% depth, blue brown choroid is visible during dissection.
– Microperforations during surgery are usually inconsequential.

- Near the limbus, the random arrangement of the ***scleral fibres gives way to a parallel, circumferential arrangement, namely the scleral spur. Usually*** **Schlemm's canal** ***lies just anterior to this***. Thus the circular ligament serves as a landmark for the identification of Schlemm's canal (Fig. 3).
- The Schlemm's canal is then deroofed. ***Some surgeons prefer to do a paracentesis before this step to reduce the bulge of the Schlemm's canal (SC).*** After deroofing , the sclerocorneal dissection is carried forward for 1-1.5 mm to remove the sclerocorneal tissue in front of the anterior trabeculum, and inner wall of the SC. Radial incisions with the help of a blunt diamond knife are made from the edges of the deep flap and the floor of SC . The juxta canalicular trabecular meshwork is gently peeled with the help of a special forceps, or a capsulorrhexis forceps. The area must be meticulously dried before peeling the inner wall of SC. Avoid perforating the trabeculo-descemet's membrane at this stage, by keeping the magnification at a maximum and dissection slow and gentle.

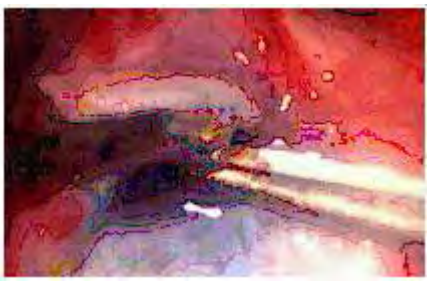

Fig.5: Cutting deep scleral flap. Note the aqueous percolation.

Fig.6: Amniotic membrane being placed from a spatula onto the scleral bed

- The end point of dissection is when the aqueous starts percolating through the remaining thin trabeculo-descemet's membrane. The deep scleral flap is then excised at the base taking the corneoscleral tissue overlying anterior trabeculum using a Vannas scissors or diamond knife. (Fig 5)
- A simple yet novel modification by Abdelrahman AM is to insert the trabeculotome through a vertical cut at one end of the deeper scleral flap, just anterior to the scleral spur (anterior to the circumferential band of scleral fibres and just at the posterior end of the translucent blue grey zone). This is made after complete superficial flap dissection and once the deep flap has been marked out. The trabeculotome is then introduced into the SC and traverses it horizontally. At the other edge of the 3 x 3 mm deeper scleral flap, a direct vertical incision is made over the trabeculotome, and the instrument tip is allowed to exit. The handle of the trabeculotome is then rested on the surface. With the trabeculotome in place, the deeper flap is dissected and the SC is opened along its posterior wall thereby exposing the steel arm of the trabeculotome. [30] With this technique SC is easily identified and completely de-roofed.
- An implant or 10 x 6 mm amniotic membrane with the epithelial side up, is then placed over the deep scleral bed. The amniotic membrane does not need to be sutured (Fig 6). Alternatively an implant- collagen, T flux etc. can be placed on the scleral bed and anchored with one or two 10 zero nylon sutures,

Fig.7: Suturing the superficial scleral flap - with 2 loose sutures (10/0 nylon).

- The superficial scleral flap is secured to the scleral bed with two ***loose*** interrupted 10-0 nylon sutures and the knots are buried (Fig 7).

- Conjunctiva and tenon capsule are closed in two or single layers.
- The trick is to perform the deep dissection under high magnification, in as dry a field as possible.
- At the start of the deeper flap dissection, Mermoud recommends that the posterior limit of the deep flap is cut upto 100% depth, this induced microperforation gives a clue as to the depth of the sclera. Hold the edge of sclera at one corner a with a non toothed forceps, then with a crescent blade the dissection plane is made, a hair breadth above the full thickness cut.

THE POSTOPERATIVE COURSE

Topical antibiotic corticosteroid drops are prescribed for 6-8 weeks, cycloplegics are usually not required. Visual acuity returns to baseline within 7-10 days and there is virtually no anterior chamber inflammation. Usually a very shallow diffuse bleb forms within the first week.

Fibrosis at the level of trabeculo-Descemet's membrane, inspite of implant usage is seen in more than half (51-63%) the patients. [19, 31, 32] In this scenario a technique known as Goniopuncture needs to be performed. This is usually required 3-21 months after surgery [31, 33] It is performed once insufficient aqueous percolation has been documented by rising IOP. It is done with a Neodymium: YAG laser, using a gonioscopic mirror lens - (CGI from LASAG or Rousell & Frankhauser from Haag Streit). The aiming beam is focused on the thinned out, less pigmented trabeculo-Descemet's membrane with a power of 2-4 mJ. Around 5-15 shots may be required at the level of Schwalbe's line, and also above and below it. Some air bubbles may be generated during the procedure and a dramatic fall in IOP is usual, within hours of a successful goniopuncture.[33] Spontaneous iris prolapse with subsequent IOP rise is a common complication which may need treatment with pilocarpine, laser goniosynechiolysis, and rarely surgical revision.[19, 34,]

Effect of DS wanes with time, and gonipunctures with Nd:YAG need to be performed in 50 - 60% cases.

This converts the procedure into a minipenetrating one, but since this is usually done more than 10-12 months after the primary surgery, the risks of hypotony and shallow AC are very minimal.

With time filtration of DS wanes inspite of goniopunctures. Supplemental medications and / or repeat surgery is required in more than 50% after 4-5 years.[6,19] In a 6 year retrospective follow up, the success rate, defined as an IOP lower than 21 mm Hg, was 66.46% at 60 months off all glaucoma medications and 80.32% with additional medical or surgical treatment. [32]

WHAT ARE THE MODIFICATIONS OF DEEP SCLERECTOMY ?

1. Combined with cataract surgery

Combined phacoemulsification with DS, with or without implant / antimitotics achieves target IOP in almost 85% cases. [3, 35] The most frequently observed complications are conjunctival wound leakage, severe inflammatory reaction and hyphema.[35, 36, 37.] Phacotrabeculectomy controls the intraocular pressure more effectively compared to DS phacoemulsification, [38] but carries a greater risk of hypotony and visual deterioration.[39]

The technique:

- Perform a temporal clear corneal phacoemulsification .
- Anterior chamber is filled with viscoelastics to create a firm eye, and the corneal wound is sutured even if it is self sealing.
- The surgeon then shifts to the superior site for DS.
- To observe for percolation of aqueous after de-roofing of SC, the AC is partly emptied of viscoelastic and refilled with BSS/Ringer to evaluate the adequacy of trabecular meshwork removal.
- After conjunctival flap suturing, the viscoelastic is completely aspirated from the eye

or Alternatively

- First the superficial scleral flap is dissected, deeper flap outlined
- Mitomycin is applied and washed
- Then clear corneal temporal phacoemulsification is performed
- The rest of the steps are as outlined above

2. Laser assisted Deep sclerectomy

Carbon dioxide and Erbium: YAG lasers have been used to ablate the roof and floor of the Schlemm's canal. [40, 41]

3. Viscocanalostomy

First proposed by Robert Stegman in 1991, in South Africa where a glaucoma surgery was required for people living in poor hygienic conditions with poor drug compliance and limited accessibility to medical care. The surgical steps are same as for deep sclerectomy till Schlemm's canal is deroofed. Then by a paracentesis the IOP is lowered, the two cut ends of Schlemm's canal are cannulated with a special 165 μm canula and high molecular weight sodium hyaluronate is slowly injected into the canal. Upto 1-2 clock hours of the canal is atraumatically dilated. The slow injection is repeated six to seven times on each side.[7] The rest of the procedure is same as described for deep sclerectomy except that the outer scleral flap is tightly

secured with 6-7 10/0 nylon sutures to ensure that a intrascleral chamber is created. Healon GV is left beneath the superficial scleral flap.

WHAT ARE THE COMPLICATIONS NOTED IN DS?

I. Intra-operative

(a) *Perforation of the trabeculodescemet's membrane (TDM)***:** It is the commonest complication in the learning phase and has been reported to be as high as 30% in the learning period. That this surgery has a steep learning curve is evident by the fact that in experienced hands this rate comes down to 3%. Perforation with no iris prolapse occurs due to a large Descemet's tear or anterior trabeculum hole. To avoid subsequent iris prolapse or peripheral anterior synechia, small amount of low molecular weight viscoelastic should be injected into the anterior chamber. A perforation of the TDM transforms a non-penetrating surgery into a penetrating one.

(b) *Microperforation of TDM :* This is the commonest complication after the learning curve is over. Seen in almost 7.0 % cases, it is almost always located in the thinnest portion, namely the anterior trabeculum and Descemet's membrane. [9, 18] Small perforations with deep anterior chamber are generally ignored and the surgery can be continued.

The hallmark of DS is minimal complications like less inflammation, less shallow AC and less cataract.

(c) Hemorrhages*:* Intra-operatively bleeding may occur either at the conjunctivoscleral level or in the uveal tissue and can also be seen secondary to blood reflux from the Schlemm's canal. During the conjunctival and then the scleral dissection, major bleeding should be treated with light wet field cautery. Intraocular bleeding from any uveal or retinal vessels; secondary to IOP drop is rare, since the IOP fall is more controlled in this surgery.

II. Early Postoperative

a) *Wound leak*: It is seen due to insufficient wound closure. [10, 18, 32]

b) *Hyphema* : Relatively rare complication of non-penetrating surgery. The blood in the anterior chamber can be due to rupture of small iris vessels or from a leak of red blood cells through the TDM.[18, 32]

c) *Inflammation* : Degree of anterior chamber inflammation is very nominal since the anterior chamber is not opened. Penetration of anterior chamber leads to the breakdown of blood-aqueous humour barrier, which leads to release of inflammatory mediators.

d) *Hypotony* : Mean IOP can drop upto 5.0 mm of Hg on the first postoperative day. It is short lived, self resolving and does not require any treatment. In fact, early hypotony without any perforation is an excellent indica-

tor of good surgical dissection and prognosticates a successful surgery.

e) *Shallow or flat anterior chamber* : After an uncomplicated deep sclerectomy a totally flat chamber is almost never seen. A shallow chamber necessitates ruling out conjunctival wound leak, pupillary block and malignant glaucoma. Shallow chamber with hypotony can be due to perforation of TDM or choroidal detachment .

f) *Decreased visual acuity* : Visual deterioration after deep sclerectomy is very mild since no postoperative cycloplegics, are prescribed and anterior chamber inflammation is nominal. Visual acuity may decrease by one or two Snellen lines for the first postoperative week only. The drop is probably due the readaptation of retinal and choroidal blood flow to a new level of intraocular pressure.

g) *Cataract formation*: Due to maintenance of anterior chamber depth, relatively slower fall of IOP and low degree of inflammation there have been no reports of surgically induced cataract so far . However, few studies have documented progression of preexisting senile cataract. [31, 32]

III. Late postoperative complications

Late postoperative complications of deep sclerectomy are not much different from those seen in trabeculectomy because the late complications are mostly related to the excessive scarring of the operated tissues.

a) *Fibrosis of subconjunctival bleb* : Fibrosis and flattening of the sub conjunctival bleb is common after deep sclerectomy but as such it does not have much influence on IOP because the presence of intra scleral bleb reduces the need for a subconjunctival bleb. If the IOP is adequate, then a flat bleb does not require any treatment. Needling with 5 FU or revision of surgery is required only if IOP control fails.

b) *Increased intraocular pressure :* Late increased IOP may be caused by TDM, subscleral or subconjunctival fibrosis. Ultrasound biomicroscopy of the surgical site would help in visualizing the site of obstruction. Goniopunture, medical therapy or revision of filtering surgery would be the subsequent modalities to control the IOP.

c) *Late rupture of trabeculodescemet's membrane* : Usually does not occur spontaneously because the membrane's outflow resistance builds up slowly for several weeks after surgery. Subsequent to ocular trauma rupture of the membrane has been reported, however it usually resolves without treatment.

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