The Ocular Communique

The Journal of the Maharashtra Ophthalmological Society

Editor : Dr. B. K. Nayak

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Instructions to Authors

The Journal of Maharashtra Ophthalmological Society publishes three issues in a year. It accepts original articles, rare case reports and short reviews. All the articles are subject to editorial revision.

1. All the papers should be accompanied by a statement that, they have not been published in any other journal or presented in any conference and that, if accepted they will not be offered to any other publisher / conference without the consent of the Editorial Board. All the authors should sign in this statement.

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Editorial Office :
Dr. B. K. Nayak
P.D. Hinduja National Hospital, Veer Savarkar Marg, Mahim, Mumbai - 16.
Tel.: 24447127, 24447176
Fax: 91-22-24440425
Mbl.: 9987315599
E-mail:
drbknayak@gmail.com

Editorial

Dear Colleagues,

Greetings from the Editorial Board of JOMOS.

I have been the Editor of JOMOS for the past 6 years and it is a matter of honour for me to once again be given the responsibility of carrying out the role of Editor for yet another term. It is a honour bestowed on me by my colleagues and I thank the Managing Committee of Maharashtra Ophthalmological Society for their support and trust in my capabilities. I would like to thank all the members and office bearers of JOMOS from the core of my heart for all encouragement through the past so many years. However, it is my wish to train new aspirants for this role and I see a lot of talent in young doctors like Dr Parikshit Gogate who has volunteered for this purpose. I hope that my experience helps youngsters like him to take over and carry JOMOS to further heights in future.

Its my request to all the members to submit their articles for JOMOS. I am always available for any guidance, if needed.

Regards,
Dr. Barun K. Nayak
Editor-In-Chief
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Awareness Amongst Pediatricians Regarding Ocular Problems to help Combat Childhood Blindness.

Dr. P. M. Gogate, Dr. Nikhil Labhshetwar, Dr. Kuldeep Dole, Prof. Col. Madan Deshpande

Abstract:

Objective: The purpose of the study was to guage the awareness of causes of childhood blindness and visual impairment and interventions to deal with them amongst pediatricians, as they are important stakeholders in the management of childhood blindness and low vision.

Methods: A close-ended questionnaire was circulated amongst practicing pediatricians of an urban conglomerate in Western India. It had 15 questions on various causes of childhood blindness and visual impairment and interventions to deal with them. There was only one correct response amongst four choices. Each correctives response had a score of 1 (maximum possible score15) Participating pediatricians had a choice of anonymity.

Results: The average score was 7. 4 (minimum 3, maximum 11) on a possible range of 0-15 score, median score was 7.0 and the interquartile range was 6-9. One fourth of pediatricians scored less than 6 correct answers, while only 25% had score of 9 or above. Pediatricians scored higher on questions of ocular problems which had origin in systemic conditions (like retinopathy of prematurity, retinoblastoma), but scored lower on purely ocular problem.(cataract, low vision and refractive error)

Conclusion: Awareness of causes of visual handicap and blindness amongst children was low in many pediatricians, especially regarding management of cataract, refractive errors and amblyopia. Active steps like continual medical education programs and exposure visits should be taken to improve their awareness so as to combat childhood blindness and visual impairment.

Key words: Childhood blindness, pediatricians.

What is already known: Pediatricians are important stakeholders in combating childhood blindness and visual impairment.

What this study adds: Knowledge of childhood blindness and low vision interventions needs to be improved in pediatricians for early diagnosis and referral to pediatric ophthalmology clinics for adequate and timely interventions before dense amblyopia develops.

Introduction

There have been sustained efforts in the past few decades to eliminate avoidable (preventable and treatable) blindness. Blindness in India is defined as visual acuity less than 6 / 60 (less than counting fingers at 20 feet) in the better eye. Researches estimate that one-third to two third of blindness and visual handicap in children is avoidable- it can be easily prevented or treated[1]. While this avoidable component of childhood blindness has reduced in the past decade[2, 3], the reduction has not been as obvious as in the adult age group, especially in cataract, corneal opacity and trachoma. One of the reasons may be that adult visual handicap is dealt with only by ophthalmologists, while children's visual handicap needs diverse health care personnel (general practitioners, pediatricians, ophthalmologists, anesthetists, geneticist, etc.) for its amelioration.

Researches estimate there are nearly 1.5 million blind children in the world[4] of whom nearly 300000 are in India alone[5]. India has the largest population of blind children, more than any other country in world.

A particular disease's burden of blindness on the community is measured in blind person years[4]. Cataract, the commonest cause of avoidable blindness in adults contributes to the maximum burden. With 7 million cataract blind in India, each with an average life span of 5 years, contributed to 35 million blind person years of burden. Childhood blindness with 0.3 million in India, each with an average lifespan of 50 years, contributes to 15 million blind person years, more than any other disease, other than cataract. Thus interventions to reduce childhood blindness need to be promoted vigorously.

Unlike adult cataract, which can be easily treated by an ophthalmologist, childhood blindness management programs are multisectorial and barriers to access of care are far more. Pediatricians treating the affected children are a key component in this program. Parents in urban area first consult a pediatrician for all of their children's health problems while parents in rural areas first visit a general practitioner and later a pediatrician if necessary. The ophthalmologist comes later; even of there is an eye problem. The chief concern in childhood blindness is the late presentation and consequent amblyopia. There has been no successful strategy in place so far to get the affected children at the earliest under the care of a pediatric ophthalmologist, so as to have successful visual rehabilitation, before dense amblyopia develops.

The aim of the study was to guage knowledge and practices amongst pediatricians for children's eye problems as they are important stakeholders in the management of childhood blindness and low vision.

Methods:

A cross sectional survey of pediatrician practicing in an urban conglommerate of Western India was conducted. The focus was on visually disabling and

Dr. P. M. Gogate,
H. V. Desai Eye Hospital, Pune

potentially blinding conditions and interventions needed to treat them. Questions were pertaining to pediatric cataract and its interventions, glaucoma, low vision, refractive error, squint, retinopathy of prematurity and retinoblastoma. A closed ended questionnaire was circulated amongst practicing pediatricians in a large city. The fifteen questions had four options each, only one of which was correct (Annexure1). The pediatricians were briefed about the questionnaire and its aims, before it was administered to them, by an ophthalmologist. The pediatricians were given 15 min to half an hour to fill the questionnaire. They were requested not to consult any written material for the same. They had a choice of anonymity, but had to fill in their age and number of years of pediatric practice. The aim was not to compare one pediatrician with another or one institution with another, but to get a general trend in awareness about children's visual development and visual handicap. Questions were related to cataract, squint ,ROP, childhood blindness and miscellaneous

Permission was sought and obtained from the hospital's ethical committee. The study was in form of an awareness survey, which would not directly affect patients. Results of the study would be disseminated to the participating doctors and institutions and the medical fraternity through publication, with the hope to improve patient care. The subjects (pediatricians) were briefed and consent was asked for, before the questionnaire was given.

The data of the study was entered in excel and converted into SPSS software for analysis.

Results:

130 pediatricians in a large urban conglomerate in Western Maharashtra, India were contacted for the study. 23 refused to participate owing to lack of time. Of the 107 who participated, 59/107(55.14%) were males and 41/107(38.31%) were less than 30 yrs, 48/107(44.85%) 30-50 years and 18/107(16.82%) were more than 50 years of age. The number of years in pediatric practice ranged from 1-38 years.

On a possible range of 0-15 the mean score was 7.4 with minimum 3 and maximum 11. 25% percentile score was 6.0 (one fourth of pediatricians scored less than 6 correct answers) while the 75% percentile score was 9.0(only 25% had score of 9 or above, 11 being the maximum score). 50% percentile or median score was 7.0. The interquartile range (75% - 25% percentile) was 3 (between 6 and 9) signifying that nearly half the pediatricians gave approximately 50% correct responses.

82/107(76.6%) reported that blindness was avoidable in cataract, glaucoma and retinopathy of pre maturity. Almost 25% wrongly believed that blindness from glaucoma was not preventable.

Another 48/107(44.85%) believed correctly that glasses could be needed by a child from age of from six months, while another 27/107(25.2%) reported that children could need glasses from one year of age. Both groups in their own way are correct, but 29/107(27.1 %) were wrong in thinking that only a child more than two years would need glasses. 51/107(47.7%) reported correctly that a child wearing spectacles needed an eye checkup every 6 months Table 1 shows the correct response in the refractive error group.

29/107(27.10%) reported correctly that congenital cataract could be operated within two months of birth. Nearly one third, 34/107 (31.77 %) reported wrongly that we could wait till six months. Only 29/107(27%) reported correctly that children always needed to wear spectacles after cataract and intraocular lens implant (IOL) surgery. 31/107(28.57 %) reported correctly that IOL should be used in children only after two years of age. Table 2 shows the correct response with cataract group.

43/107(40.2%) reported the a child with squint should be treated by spectacles, exercises or surgery after 12 months of age, the sooner the better. 52/107(48.6 %) said a squint should be treated as soon as it was obvious though we can wait till the child is 8-9 months of age.

65/107(60.7%) reported correctly that pediatric glaucoma (buphthalmos) was primarily associated with increased intraocular pressure, 32/107(29.90 %) thought wrongly that increased size of the globe was responsible for the disease.

52/107(49.2%) reported correctly that a lid with ptosis can be treated by surgery. 35/107(32.7%) reported that conjunctivitis or red eye can be treated by antibiotic steroid combination, while /107 (%) believed correctly that only an antibiotic should be prescribed initially.

59/107(55.1%) reported correctly that blind children do have some residual vision. 41/107(38.31 %) had a misconception that blind children do not see at all.

65/107(60.7%) reported correctly that retinoblastoma, the commenest intraocular malignancy in childhood could be treated by surgery, chemotherapy and or radiotherapy. Table 3 displays the response of pediatrician regarding various treatment modalities for retinoblastoma.

72/107(67.3%) reported correctly that binocular single vision develops by six months of age.

80/107(74.8%) reported correctly the neonates born less than 32 weeks or with birth weight less than 1500 gm needed ROP screening. And 93/107(86.9%) believed, correctly, that the first ROP screening should

be performed in the neonatal ICU. Table 4 displays the awareness regarding questions on ROP, Table 5 shows the response of pediatricians to epidemiology of Childhood Blindness and other ocular problems while. Table 6 displays the summary results each questions group.

Discussion:

Awareness of pediatricians is high about conditions, which they deal with regularly like vitamin A deficiency, premature babies and their problems (>66% correct response).

Knowledge amongst some pediatricians has sketchy about purely ocular conditions which may not be seen by them on regular basis (cataract and its management, spectacle wear).

A child generally needs glasses from the age of two years when he begins to cruise around furniture and tries to pick up things. Some ophthalmologist would refract from 8-9 months while others would prefer to wait till at least a year,unless the refractive error was large. A refractive error of –1.0 D or more, +3.0 D or more or astigmatism of one or more diaoptors must be given spectacles to avoid amblyopia. (significant refractive error)

Though it is ideal to operate a congenital cataract as soon as possible, a wait of upto two months of age does not significantly alter the prognosis[6]. Early surgery may increase the anesthesia risk. A unilateral cataract has more chance of deprivational amblyopia and needs to be tackled sooner (by six weeks) than a bilateral one(upto 8 to 10 weeks)[6]. A child would always need spectacles after a cataract - IOL surgery as the child's refraction changes and there may be surgically induced astigmatism[7]. Also the child's ability to accommodate for near is lost and he / she would still need reading glasses even if he / she is emmetrope for distance. A bilateral congenital cataract is left aphakia after surgery and secondary IOLs are implanted after 2 years of age. In a unilateral cataract, IOL may be implanted after one year of age though most surgeons prefer to wait till age of 2 years. An annual check up of refraction is a must, though a six monthly check-up would be ideal. Uncorrected refractive errors account for the large percentage of blindness and low vision in children[8,9]. They can be easily and cheaply treated with a pair of spectacles provided these are given at the correct time, with the correct power and the child wears them.

Squint should be treated with spectacles, exercise or surgery after the child is one year of age, the sooner the better. For infants we prefer to observe till the first birthday as some ocular mobility problems resolve with age. Delaying the management of squint allows strabismic amblyopia to set in, with loss of binocular single vision and perhaps vision of one eye. This is wholly preventable. Improvement in binocular single vision is better if the surgery is before 2 yrs, of age[10, 11, 12]. Deferring the management to puberty to allow for 'natural rectification' is nothing short of negligence and can lead to uniocular blindness.

Pediatric glaucoma (buphthalmos) is associated with increased intraocular pressure. This is a progressive blinding condition, which can be arrested only by surgery.

Tables 1 : Response of pediatric on Refractive Error-

Questions	Correct		Incorrect		Missing	
Min Age of presentation	19	(17.6%)	85	(79.4%)	3	(2.8%)
F/U frequency	51	(47.7)	55	(51.4%)	1	(0.9%)

Table 2 Response of pediatricians on cataract related questions

Questions	Correct		Incorrect		Missing	
Timing of surgery	25	(23.4%)	77	(72.0%)	5	(4.7%)
Need of glasses post cataract surgery	29	(27.1%)	34	(31.8%)	5	(4.7%)
Minimum Age of IOL Implantation	31	(29%)	45	(42.1%)	14	(14%)

Table 3: Response of pediatricians on treatment of various ocular problems

Questions	Correct		Incorrect		Missing	
Squint	43	(40.2%)	60	(56.1%)	4	(3.8%)
Ptosis	48	(44.9%)	58	(54.2%)	1	(0.9%)
Conjunctivitis (red Eye)	35	(32.8%)	69	(64.5%)	3	(2.8%)
Retinobiastoma	65	(60.7%)	41	(38.3%)	1	(0.9%)

Table - 4 Response of pediatricians on ROP Screening:

Questions	Correct		Incorrect		Missing	
	No		No	%	No	%
Criteria	78	(72.9%)	21	(19.6%)	8	(7.5%)
Place	94	(87.9%)	13	(12.1%)	0	0

Table 5:- Response of pediatricians Childhood Blindness and other ocular problems

Questions	Correct		Incorrect		Missing	
Definition	60	56.1	43	40.2	4	3.7
Avoidable in	82	76.6	25	23.4	0	0
Age Of BSV	72	70.6	30	28.0	5	4.7
Signs of Buphthalmos	65	59.6	42	43.1	0	0

Table 6: Summary results of all questions

Question Group	No. of Question	Correct	Incorrect	No. of respondents	Missing	% of Correct Answer
Avoidable blindness	4	212	208	4X107=428	8	49.53%
Cataract	3	85	212	3X107=321	9	26.47%
Squint	2	115	90	2X107=214	9	53.73%
ROP	2	176	46			
Miscellaneous	4	219	206	4x107=428	3	51.16%

Medicines are palliative till definitive surgical treatment like trabeculotomy and trabeculectomy is done. Congenital ptosis and most aquired ptosis are managed surgically. There is a role of medical management on myaesthenia gravis, which is rare in children

Conjunctivitis or red eye, if purely infective should be treated with antibiotics only. Steroids are to be added only for allergic conjunctivitis. Indiscriminate use of steroids may flare the infection and cause cataract and glaucoma in long term.

Most blind children have some residual vision. A recent study of schools for the blind in Maharashtra had shown that 58% children had some residual vision and 288 / 1778 (16.2%) improved with spectacles, low vision aids or surgery[3]. Many 'blind' children can be helped in their day-to-day tasks by low vision aids and non-optical aids and can contribute to the community.

A child's binocular vision develops by six months of age and is plastic till 6 years of age. If any media opacity like cataract, corneal opacity, squint or refractive error is present in the early years of life and not corrected before 6-8 years, the visual system cannot develop the binocular single vision so important for distance and depth judgment. So the earlier the visual deficit is detected and treated, the better it is for the affected child. Pediatricians are the key person for this. Most pediatricians were aware that the first screening for ROP had to be performed in the neonatal intensive care unit and regular follow up was necessary[13]. The child should be dilated with a diluted tropicamide and phenylephrine mix thre eye drop and examined with an indirect ophthalmoscope. Retinoblastoma can be treated with chemotherapy and radiotherapy and enucleation is needed only as a lost resort.

The relative lack of success of childhood blindness programs may be due to the emphasis on ophthalmologists and other eye care personnel in its management. Pediatricians, physician and other paramedics like anganwadi workers dealing with children need to be involved more in the early detection and management of children with visual disability to make this program successful and effective.

Residency training of pediatrics should involve exposure to pediatric eye clinics and childhood blindness and low vision should be highlighted in their syllabus. Ophthalmologists and other eye care workers engaged in the fight against avoidable blindness should involve pediatricians in this endeavor and increase their awareness and participation. Pediatricians can help with early diagnosis and referral. They can contribute immensely to conditions that need regular follow up and periodic examinations like post cataract surgery, ROP, glaucoma and refractive errors; and help prevent amblyopia and visual impairment.

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Annexure 1:Questionnaire used for the study.

Questionnaire:

1. Blindness in children is avoidable in the following conditions.

A. cataract
B. glaucoma
C. Retinopathy of prematurity
D. [14] all of the above.

2. A child could need glasses from the age of

A. six months
B. one year
C. Not below two years
D. four years (school entry)

3. Congenital cataract needs to be operated.

A. within one month of birth
B. immediately after birth
C. within three months of birth[15]
D. within 6 month of birth

4. A child may need to wear spectacles after cataract and IOL surgery.

A [16] always
B. sometimes
C. never

5. Intraocular lenses (IOLs) can be used in children

A. at any age
B. [17] after 2 years of age
C. after 4 years of age
D. after 6 years of age

6. Squint in child should be treated by spectacles / exercises or surgery.

A. as soon as it is obvious.
B [18] After 18 month of age – the sooner the better.
C. After 6 yrs. Of age.
D. When child becomes mature.

7. Pediatric glaucoma (buphthalmos) is primarily associated with

A. [19] increased intraocular pressure
B. decreased intraocular pressure
C. increased size of globe
D. blue sclera.

8. A lid with ptosis can be treated by

A. Medicines
B. [20] Surgery
C. Spectacles
D. Medicines + surgery

9. Conjunctivitis or red eye be treated by

A antibiotics only
B Steroids only
C. [21] antibiotic + steroid combination
D. Any of above

10. Blind children

A. cannot see at all
B. [22] can have some residual vision
C. can see fairly well.

11. Retinoblastoma, the commonest intraocular childhood malignancy can be treated By

A. surgery enucleation
B. chemotherapy
C. radiotherapy
D. [23] all the above

12. A child wearing spectacles need an eye checkup.

A. annually
B. once every 2 years
C. every 6 months
D. as ophthalmologist wishes.

13. Binocular single vision develops by

A. [24] Six months
B. Two years
C. Four years
D. Six years

14. Which neonates need screening for ROP?

E. all children born less than or equal 32 weeks after conception.
F. All neonates with birth weight less than 1500 grams
G. All neonates who are most sickly survivors
H. [25] All of the above

15. Where should the first ROP screening be performed?

A. [26] Neonatal ICU
B. Ophthalmologist clinic
C. Operation theatre
D. Pediatric ward

Laser Iridotomy - An Overview

Dr. Vishnukant Ghonsikar, Dr. Nayana Potdar , Dr. Chhaya Shinde , Dr. Roshni Shetty, Dr. Swapna Neklikar

Laser iridotomy is a surgical procedure that is performed on the eye to treat angle closure glaucoma, a condition of increased pressure in the front chamber (anterior chamber) that is caused by sudden (acute) or slowly progressive (chronic) blockage of the normal circulation of fluid within the eye. The block occurs at the angle of the anterior chamber that is formed by the junction of the cornea with the iris. All one needs to do to see this angle is to look at a person's eye from the side. Angle closure of the eye occurs when the trabecular meshwork, the drainage site for ocular fluid, is blocked by the iris. Laser iridotomy was first used to treat angle closures in 1956. During this procedure, a hole is made in the iris of the eye, changing its configuration. When this occurs, the iris moves away from the trabecular meshwork, and proper drainage of the intraocular fluid is enabled.

The angle of the eye refers to a channel in which the trabecular meshwork is located. To maintain the integrity of the eye, fluid must always be present in the anterior (front) and posterior (back) chambers of the eye. The fluid, known as aqueous fluid, is made in the ciliary processes, which are located behind the iris. Released continuously into the posterior chamber of the eye, aqueous fluid circulates throughout the eye. Eventually the fluid returns to the general circulation of the body, first passing through a space between the iris and the lens, then flowing into the anterior chamber of the eye and down the angle, where the trabecular meshwork is located. Finally, the fluid leaves the eye. An angle closure occurs when drainage of the aqueous fluid through the trabecular meshwork is blocked and the intraocular pressure builds up as a result.

For most types of angle closure, or narrow angle glaucoma, laser iridotomy is the procedure of choice. Changes in intraocular pressure (IOP) can alter the name of the condition when the IOP in the eye becomes elevated above 22 mm/Hg as a result of an angle closure. Then angle closure becomes angle closure glaucoma. Lowering of the IOP is important because extreme elevations in IOP can damage the retina and the optic nerve permanently. The lasers used to perform this surgery are either the Nd:Yag laser or, if a patient has a bleeding disorder, the argon laser. The majority of patients with glaucoma do not have angle closure glaucoma, but rather have an open angle glaucoma, a type of glaucoma in which the angle of the eye is open.

An angle closure occurs when ocular anomalies (abnormalities) temporarily or permanently block the trabecular meshwork, restricting drainage of the ocular fluid. The anatomical anomalies that make an individual susceptible to an angle closure are, for example, an iris that is bent forward in the anterior chamber (front) of the eye, a small anterior chamber of the eye, and a narrow entrance to the angle of the eye. Some conditions that cause an angle closure are a pupillary block, a plateau iris, phacolytic glaucoma, and malignant glaucoma. The end result of all of these situations is an elevation of the IOP due to a build-up of aqueous fluid in the back part of the eye. The IOP rises quickly when an acute angle attack occurs and within an hour the pressure can be dangerously elevated. The sclera or white of the affected eye becomes red or injected. The patient will usually experience decreased vision and ocular pain with an acute angle closure. In severe cases of acute angle glaucoma, the patient may experience nausea and vomiting. Individuals with neurovascular glaucoma caused by uncontrolled diabetes or hypertension may have similar symptoms, but treatment for this type of glaucoma is very different.

Within a normal eye, the iris is in partial contact with the lens of the eye behind it. Individuals with narrow angles are at greater risk of angle closure by pupillary block because their anterior chamber is shallow; thus, the iris is closer to the lens and more likely to adhere completely to the lens, creating a pupillary block. Patients who experience a pupillary block may have had occasionally temporary blocks prior to a complete angle closure. Pupillary block can be started by prolonged exposure to dim light. Therefore, it not uncommon for an acute angle closure to occur as an individual with a narrow angle emerges from a dark environment such as a theater into bright light. It can also be brought on by neurotransmitter release during emotional stress or by medications taken for other medical conditions. Pupil dilation may be a side effect of one or more of those medications. However, pupillary block is the most common cause of angle closure, and laser iridotomy effectively treats this condition.

The irises of individuals with plateau iris is bunched up in the anterior chamber, and it is malpositioned along the trabecular meshwork. Plateau iris develops into glaucoma when the iris bunches up further; this occurs on dilation of the iris, which temporarily closes off the angle of the eye. Laser iridotomy is often performed as a preventive measure in these patients, but is not a guarantee against future angle closure. This is because changes within the eye, such as narrowing of the angle and increase in lens size can lead to iris plateau syndrome, where the iris closes

Dr. Chhaya Shinde
Sion Hospital, Mumbai

the angle of the eye even if a laser iridotomy has already been performed. Peripheral laser iridoplasty and other surgical techniques can be performed if the angle still closes after iridotomy.

Other causes of narrow angle glaucoma are not as common. Phacolytic glaucoma results when a cataract becomes hypermature and the proteins of the lens with the cataract leak out to block the angle and the trabecular meshwork. Laser iridotomy is not effective for this type of angle closure. Malignant glaucoma exists secondary to prior ocular surgery, and is the result of the movement of anatomical structures within the eye such that the mesh-work is blocked. Patients who have no intraocular lens (aphakic) are at increased risk for angle closure, as well.

Laser iridotomy is also performed prophylactically (preventively) on asymptomatic individuals with narrow angles and those with pigment dispersion. Individuals with a narrow angle are at higher risk of an acute angle closure, especially upon dilation of the eye. Pigment dispersion is a condition in which the iris pigment is shed and is dispersed throughout the anterior part of the eye. If the dispersion occurs because of bowing of the iris (the case in 60% of patients with pigment dispersion) a laser iridotomy will decrease the bowing or concavity of the iris and subsequent pigment dispersion. This decreases the risk of these individuals to develop pigmentary glaucoma, a condition in which the dispersed pigment may clog the trabecular meshwork. Laser iridotomy is also done on the fellow eye of a patient who has had an angle closure of one eye, as the probability of an angle closure in the second eye is 50%.

There are other indications for laser iridotomy. It is performed on patients with nanophthalmos, or small eyes. Laser iridotomy may be also be indicated for patients with malignant glaucoma to help identify the etiology of elevated IOP. Because laser iridotomy changes the configuration of the iris, it is sometimes used to open the angle of the eye prior to performing a laser argon laser trabeculoplasty, if the angle is narrow. Laser trabeculoplasty is another laser procedure used to treat pigmentary and pseudoexfoliation glaucoma.

Laser iridotomy cannot be performed if the cornea is edematous or opacified, nor if the angle is completely closed. If an inflammation (such as uveitis or neovascular glaucoma) has caused the angle to close, laser iridotomy cannot be performed.

Purpose

The purpose of a laser iridotomy is to allow an equalization of pressure between the anterior (front) and posterior (back) chambers of the eye by making a hole in the superior peripheral iris. Once the laser iridotomy is completed, the intraocular fluid flows freely from the posterior to the anterior part of the eye, where it is drained via the trabecular meshwork. The result of this surgery is a decrease in IOP.

When laser iridotomy is performed on patients with chronic angle closure, or on patients with narrow angles with no history of angle closure, the chances of future pupillary blocks are decreased.

Demographics

Acute angle glaucoma occurs in one in 1,000 individuals. Angle-closure glaucoma generally expresses itself in populations born with a narrow angle. Individuals of Asian and Eskimo ancestry appear to be at greater risk of developing it. Family history, as well as age, are risk factors. Older women are more often affected than are others. Laser iridotomy is performed on the same groups of individuals as those likely to experience angle closures due to pupillary block or plateau iris. They are performed more often on females (whose eyes are smaller than those of males), and more often performed on the smaller eyes of farsighted people than on those of the nearsighted because angle closures occur more frequently in those who are farsighted. Most laser iridotomies are performed on those over age 40 with a family history of plateau iris or narrow angles. However, preventative plateau iris laser iridotomies are performed on patients in their 30s. Individuals who are aphakic (have no intraocular lens) are at greater risk of angle closure and undergo laser iridotomy more frequently than phakic patients. Phakic patients are those who either have an intact lens or who are psuedophakic (have had a lens implant after the removal of a cataract removal).

Description

After the cornea swelling has subsided and the IOP has been lowered, which is usually 48 hours after an acute angle closure, laser iridotomy can be performed. Pilocarpine is applied topically to the eye to constrict the pupil prior to surgery. When the pupil is constricted, the iris is thinner and it is easier for the surgeon to form a penetrating hole. If the eye is still edematous (swollen)—often the situation when the IOP is extremely high—glycerin is applied to the eye to enable the surgeon to visualize the iris. Apraclonidine, an IOP-lowering drop, is applied one hour before surgery. Immediately prior to surgery, an anesthetic is applied to the eye.

Next, an iridotomy contact lens, to which methylcellulose is added for patient comfort, is placed on the upper part of the front of the eye. This lens increases magnification and helps the surgeon to project the laser beam accurately. The patient is asked to look downwards as the surgeon applies laser pulses to the iris, until a hole is formed. Once the hole has

penetrated the iris, iris material bursts through the opening, followed by aqueous fluid. At this point, the surgeon can also see the anterior part of the lens capsule through the opening. The hole, or iridotomy, is formed on the upper section of the iris at an 11:00 or 1:00 position, so that the hole is covered by the eyelid. In an aphakic eye, the hole may be made on the inferior iris. After performing the laser iridotomy, the surgeon may place a gonioscopy lens on the eye if the angle has been opened. There is no pain associated with this surgery, although heat may be felt at the site of the lasering.

If a patient has a tendency to bleed, the argon laser will be used to pre-treat the patient prior to completing the procedure with an Nd:Yag laser, or the argon laser alone may be used. The argon laser is capable of photo-coagulation, and, thus, minimizes any bleeding that occurs as the iris is penetrated. Formation of a hole is more difficult with the argon laser because it operates with a decreased power density and the tissue response to the argon laser has greater variability. The argon laser can be used with more patients who have medium-brown irises, however, since the energy of this laser is readily absorbed by irises of this color.

Diagnosis/Preparation

To determine if laser iridotomy is indicated, the surgeon must first determine if and how the angle is occluded. The eye is anesthetized and the gonioscopic lens, which enables the surgeon to see the interior of the eye, is placed on the front of the eye. This is done at the slit lamp biomicroscope in a dark room. In cases of prophylactic surgery, an image of the eye is taken with a ultra-sound biomicroscope in both dim and bright light; this shows the doctor how the patient's iris moves with dilation and constriction, and how this movement can close an angle if the patient has ocular features that predispose the eye to an angle closure.

When an angle is completely occluded (blocked), the elevated IOP usually causes corneal edema (swelling). Because this swelling can obscure the surgeon's view of the iris, prior to performing a laser iridotomy, the IOP must be lowered. One technique to lower the IOP is corneal indentation, in which the gentle pressure is applied several times to the cornea with a lens or hook to open the angle. This pressure on the cornea causes a shift in the internal structures of the eye, enhances aqueous drainage, and lowers the IOP.

The doctor can attempt to lower the IOP medically, as well. One drug that lowers the pressure is acetazolamide, which is given either orally or by intravenous(IV) to decrease aqueous production in the eye. This may be administered up to four times a day, until the adhesion is broken. Another method of lowering the IOP, if acetazolamide is not effective, is with the use of hyperosmotic agents, which through osmosis causes drainage of the aqueous fluid from the eye into the rest of the body. Hyperosmotic agents are given orally; an example of such an agent is glycerine. Given by IV (intravenous administration), mannitol can be used. As the fluid drains from the eye, the vitreous—the jelly-like substance behind the lens in the posterior chamber—shrinks. As it shrinks, the lens in the eye pulls away from the vitreous, creating an opening to the anterior chamber such that aqueous fluid can flow to the anterior chamber. The success of this procedure is increased, due to gravity, if the patient is laying supine.

Once the IOP has begun to decrease, the pressure is further decreased using topical glaucoma medications, such as pilocarpine, or beta blockers. Any inflammation that occurs because of the iridotomy must be controlled with steroid eye drops.

If glaucomatous-like visual field is present prior to surgical intervention, the prognosis for the patient is not as good as if the visual field were completely intact. Thus, a visual field test may be done prior to surgery.

Aftercare

Immediately after the procedure, another drop of aproclonidine is applied to the eye. The IOP is checked every hour for a several hours postsurgery. If the IOP increases dramatically, then the increased IOP is treated until lowered. Because of inflammation is inherent in this procedure, corticosteroids are applied to the eye every five minutes for 30 minutes, then hourly for six hours. This therapy is then continued four times a day for a week. Thereafter, the patient is seen by the surgeon at one week post-surgery and again at two to six weeks post-surgery. If there are complications, the patient is seen more frequently.

After the pressure has been stabilized, a visual field test to determine the extent of damage to the optic nerve may be performed again.

Risks

The greatest risk of laser iridotomy is an increase in intraocular pressure. Usually, the IOP spike is transient and of concern to the surgeon only during the first 24 hours after surgery. However, if there is damage to the trabecular meshwork during laser surgery, the intraocular pressure may not be lowered enough and extended medical intervention or filtration surgery is required. Patients who undergo preventative laser iridotomy do not experience as great an elevation in IOP.

The second greatest risk of this procedure is anterior uvetis, or inflammation within the eye. Usually the inflammation subsides within several days, but can persist for up to 30 days. Thus, the follow-up care for laser iridotomy includes the application of topical corticosteroids. A posterior

synechia, in which the iris may again adhere to the lens, may occur if intraocular inflammation is not properly managed.

Other risks of this procedure include the following: swelling of, abrasions to, or opacification of the cornea; and damage to the corneal endothelium (the part of the cornea that pumps oxygen and nutrients into the iris); bleeding of the iris during surgery, which is controlled during surgery by using the iridotomy lens to increase pressure on the eye; and macular edema, which can be avoided by careful aim of the laser during surgery to avoid the macula. The macula is the part of the eye where the highest concentration of photoreceptors is found. Perforations of the retina are rare. Distortion of the pupil and rupture of the lens capsule are other possible complications. Opacification of the anterior part of the lens is common, but this does not increase the risk of cataract formation when compared with the general population.

When the iridotomy hole is large, or if the eyelid does not completely cover the opening, some patients report such side effects as glare and double vision. The argon laser produces larger holes. Patients may also complain of an intermittent horizontal line in their vision. This may occur when the eyelid is raised just enough such that a small section of the inferior part of the hole is exposed, and disappears when the eyelid is lowered. Blurred vision may occur as well, but usually disappears 30 minutes after surgery.

Normal results

In successful laser iridotomy, the IOP differential between the anterior and posterior chambers is relieved and IOP is decreased, and the pupil is able to constrict normally. These are the results of the flatter configuration of the iris after laser iridotomy. If an angle closure is treated promptly, the patient will have minimal or no loss of vision. This procedure is successful in up to 44% of patients treated.

Morbidity and mortality rates

For up to 64% of patients, one to three years after laser iridotomy, the IOP will rise above 21 mmHg, and long-term medical treatment is required. One-third of argon laser iridotomies will close within six to 12 weeks after surgery and will require a repeat laser iridotomy. Approximately 9% of Nd:Yag laser iridotomies must be redone for this reason. Closure of the iridotomy site is more likely if a uveitis presented after surgery. Up to 45% of patients will have anterior lens opacities after laser iridotomy, but these opacifications do not put the patient at an increased risk of cataracts.

Alternatives

An alternative to laser iridotomy is surgical iridectomy, a procedure in which part of the iris is removed surgically. This was the procedure of choice prior to the development of laser iridotomy. The risks for iridectomy are greater than for the laser iridotomy, because it involves an incision through the sclera, the white tunic covering of the eye that surrounds the cornea. The most common complication of an iridectomy is cataract formation, occurring in more than 50% of patients who have had a surgical iridectomy. Since an incision in the eye is required for surgical iridectomy, other procedures, such as filtration surgery—if needed in the future—will be more difficult to perform. Studies comparing the visual outcomes and IOP control of laser iridotomy with surgical iridectomy show equivalent results.

In the case of acute angle closures that occur because of reasons other than, or in addition to pupillary block, argon laser peripheral iridoplasty is performed. During this procedure, several long burns of low power are placed in the periphery of the iris. The iris contracts and pulls away from the angle, opening it up and relieving the IOP.

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Glaucoma, Drainage Devices

Dr. Nayana Potdar , Dr. Vishnukant Ghonsikar, Dr. Chhaya Shinde

Introduction

Glaucoma drainage devices (GDDs) create an alternate aqueous pathway from the anterior chamber (AC) by channeling aqueous out of the eye through a tube to a subconjunctival bleb. This tube is usually connected to an equatorial plate under the conjunctiva. GDDs are being used more frequently in the treatment of glaucoma that is not responding to medications and trabeculectomy operations. In certain conditions, such as neovascular glaucoma, iridocorneal endothelial (ICE) syndrome, penetrating keratoplasty (PKP) with glaucoma, and glaucoma following retinal detachment surgery, it has become the preferred operation. This article outlines the current concepts involving different GDDs, surgical techniques, and management of complications following GDD insertion.

History of the Procedure

The earliest attempt to drain fluid out of the anterior chamber into the subconjunctival space at the limbus dates back to 1906 when Rollet and Moreau implanted a silk thread connecting the anterior chamber to the subconjunctival space. Since that time, additional unsuccessful attempts were made, including insertion of a polythene tube by Epstein in 1959 and a silicone tube by MacDonald and Pearce in 1965. These operations failed because of excessive scar formation near the limbus, seton migration, and conjunctival erosion.

In 1969, Molteno introduced the concept that a large surface area was needed to disperse the aqueous beneath the conjunctiva. He inserted a short acrylic tube that was attached to a thin acrylic plate. The plate was sutured to the sclera close to the limbus. Most of the operations failed after the first 3-6 months because of plate exposure, tube erosion, and scar formation.

In 1973, Molteno improved his device with the idea of draining the fluid away from the limbus to increase the success rate. He introduced the Molteno implant with a long silicone tube attached to a large end plate placed 9-10 mm posterior to the limbus. All the currently available GDDs are based on this concept by Molteno. The Molteno implant and similar nonvalved implants offer no resistance to the outflow, resulting in hypotony, flat anterior chambers, and choroidal effusions.

Since then, 2 major concepts have been introduced to modify the implantation of the GDD.

The first approach was that of a valve to offer resistance to the outflow, thereby reducing the incidence of postoperative hypotony. In 1976, Krupin developed a pressure-sensitive, unidirectional valve that provides resistance to the flow of aqueous and prevents early postoperative hypotony. This "slit valve" is designed to open at a pressure of 11 mm Hg and to close at a pressure of 9 mm Hg.

In 1993, Ahmed introduced the Ahmed glaucoma valve (AGV), a pressure-sensitive, unidirectional valve that is designed to open when the intraocular pressure (IOP) is 8 mm Hg.

The second major change has been the realization that by increasing the surface area of the end plate, the surface area of drainage could be increased, resulting in lower IOPs.

In 1981, Molteno introduced the double plate implant with a surface area of 270 mm^2. In 1992, Baerveldt introduced a nonvalved silicone tube attached to a large barium-impregnated silicone plate with a surface area of 250 mm^2, 350 mm^2, or 500 mm^2.

Optonol Ltd developed the Ex-PRESS R50 glaucoma shunt to simplify the GDD implantation. This device is a single-piece, stainless steel, translimbal implant that is placed using an inserter. Although its implantation is efficient, the long-term efficacy and the risk of complications have yet to be determined.

Current glaucoma drainage devices

Current GDDs can be classified into those with no resistance, those with resistance, and those with variable resistance to aqueous outflow.

GDDs with no resistance

These GDDs consist of a silicone tube attached to an end plate that acts as a surface for bleb formation. Unless the operation is modified with a stent and ripcord technique, these implants are associated (in the early postoperative period) with a high incidence of overfiltration secondary to no aqueous outflow resistance. This can lead to hypotony, shallow-to-flat anterior chambers, and choroidal effusions.

- The single-plate Molteno implant is a silicone tube attached to a 135 mm^2 polypropylene end plate.
- The double-plate Molteno (DPM) is the same as the single-plate Molteno except that a second end plate is attached to the right or left of the original end plate, thus doubling its surface area. It requires a 2-quadrant dissection.
- The Baerveldt implant was developed to provide easy placement of a large end plate in a single quadrant. It is a silicone tube attached to a soft, pliable, barium-impregnated silicone end plate of various sizes (ie, 200 mm^2, 250 mm^2, 350 mm^2, 500 mm^2). The placement of the end plate wings underneath the rectus muscles can promote fibrous encapsulation, resulting in disturbing

Dr. Vishnukant Ghonsikar
Sion Hospital, Mumbai

diplopia. The design has been modified with fenestrations in the end plate that may allow fibrous tissue tacks to limit bleb elevation. Although not typical, diplopia continues to be a risk with this implant.

- The Schocket implant (anterior chamber tube shunt to encircling band [ACTSEB]) consists of a silastic tube used for nasolacrimal intubation. One end of the implant is inserted into the anterior chamber, while the other end is tucked underneath a No. 20 retinal-encircling band placed underneath the rectus muscles. Even though the procedure is lengthy and cumbersome, it is less expensive, and material can be assembled in most operating rooms
- The Ex-PRESS R50 implant is a 3-mm long tube with a 400 µm (27 gauge) external diameter and a 50 µm internal diameter. The penetrating tip is beveled with 3 side orifices and a spurlike projection to prevent extrusion. The flange is a small (<1 mm^2) disclike plate that prevents the device from being inserted too deeply. Both the flange and the spurlike projection are angled to conform to the sclera with the distance between them being equal to the scleral thickness at the site of proper implantation.

GDDs with set resistance

Even though manufacturers claim that these devices contain true valves, independent examinations of the flow characteristics for these devices suggest a wide divergence between observed function and the manufacturers' claims. The valves appear not to close after initial opening in perfusion tests at physiological flow rates. Of the 2 valved devices that are used commonly, the AGV has the lowest incidence of hypotony of all GDDs.

The AGV is a silicone tube connected to a silicone sheet valve held in a polypropylene body. The end plate measures 185 mm^2 (16 mm long X 13 mm wide X 1.9 mm thick). The valve consists of thin silicone elastomer membranes (8 mm long X 7 mm wide) that create a venturi-shaped chamber. The inlet cross-section of the chamber is wider than the outlet (Bernoulli principle), with a resultant pressure differential between the anterior chamber and the bleb. The valve is designed to open when the IOP is 8 mm Hg.

The Krupin slit valve consists of a silicone tube with a slit valve attached to a silicone oval end plate. The surface area of the end plate is 180 mm^2. The opening pressure of the slit valve is designed to be 11-14 mm Hg, and the closing pressure is designed to be 2 mm Hg. Unfortunately, these opening and closing pressures may vary significantly.

GDDs with variable resistance

These devices are modifications of the original Molteno implant and the Baerveldt implant. They attempt to incorporate a resistance mechanism dependent on tissue apposition to limit flow. Because the force of tissue apposition is variable, these devices do not function as true valves, and IOP levels remain unpredictable.

The Molteno dual ridge device (Molteno with a pressure ridge) attempts to limit the initial drainage area by dividing the top portion of the plate into 2 separate spaces with the help of a thin V-shaped ridge. Aqueous must overcome the overlying conjunctival resistance to flow across the ridge. The resistance offered by the overlying conjunctiva presumably prevents overfiltration and hypotony. In the authors' experience, these complications are not prevented by the pressure ridge mechanism, so the authors still recommend a stent with ripcord modification.

The Baerveldt bioseal is a flap that overhangs the silicone tube as it opens on the end plate. Apposition of the bioseal element to the sclera with absorbable sutures is supposed to provide early flow resistance, limiting initial aqueous escape from beneath the device. However, early clinical trials failed to prove this concept, and this modification was discontinued.

Indications

Glaucoma incisional surgery is usually performed to establish definitive IOP control when medical therapy and laser surgery fail or are unable to be performed. Historically, GDDs have been reserved for patients who failed or were likely to fail trabeculectomy surgery. Usually, these high-risk eyes do not do well; thus, the GDD is recommended as a last resort procedure. However, in spite of the high-risk profile of patients enrolled into previous GDD studies, moderately good success with various designs of GDDs has been observed.

Two articles by Gedde and associates provide the first multicenter, controlled clinical trial examining the efficacy and the outcomes of nonvalved GDDs versus trabeculectomy with mitomycin-C in similar patient populations with previous ocular surgery.

The first-year data provide evidence that, if confirmed with longer follow-up, will provide an evidence-based approach to the surgical management of complicated glaucoma.

The most provocative data presented in this study are the equivalent primary outcomes at 1 year in both the tube group and the trabeculectomy group. The mean IOP was not significantly different between the two groups. The trabeculectomy group had a larger percentage of complete successes (no adjunctive medical therapy), but the percentage of the overall

success rate (eyes with or without supplemental medical therapy) was higher in the tube group. Failure was defined as IOP persistently greater than 21 mm Hg or not reduced by 20% from baseline, IOP less than 5 mm Hg, reoperation for glaucoma, or loss of light-perception vision. There was a higher failure rate in the trabeculectomy group (13.5%) than the tube group (3.9%) at 1 year. Certainly, the low rate of tube complications is encouraging for those who advocate an earlier and wider use of GDD surgery in glaucoma. The indications for GDD implantation include the following:

- Neovascular glaucoma
- PKP with glaucoma
- Retinal detachment surgery with glaucoma
- ICE syndrome
- Traumatic glaucoma
- Uveitic glaucoma
- Open-angle glaucoma with failed trabeculectomy
- Epithelial downgrowth
- Refractory infantile glaucoma
- Contact lens wearers who need glaucoma filtration surgery

Contraindications

GDDs may have a complicated postoperative course. Thus, it is relatively contraindicated in patients unable to comply with self-care in the postoperative period. Borderline corneal endothelial function is a relative contraindication for anterior chamber placement of a tube.

Treatment

Surgical Therapy

The surgical technique for glaucoma drainage device (GDD) implantation is discussed in this section.

Preoperative Details

Retrobulbar anesthesia or modified topical anesthesia is administered. Systemic anesthesia may include Valium, 10 mg by mouth, 1 hour prior to surgery, followed by intravenous midazolam, 2 grams, and fentanyl, 100 mcg, at the time of surgery. Lidocaine gel insertion or frequent topical anesthetic may be placed into the inferior fornix. Following Betadine prep and limbal stay suture placement, a sub-Tenon injection of preservative-free 1% lidocaine mixed with 1 in 10,000 epinephrine is administered through limbal peritomy in the quadrant of the operation.

Intraoperative Details

Insertion of Ahmed glaucoma valve

The Ahmed glaucoma valve (AGV) is inserted using a fornix-based conjunctival flap method. A traction suture may be placed through a clear cornea or in the limbal sclera close to the 12-o'clock position so the eye can be easily rotated and stabilized inferiorly by securing the suture to the drape with a hemostat. With the eye properly placed, a limbal peritomy is made at the 12-o'clock position. The incision is extended to the superotemporal or superonasal quadrant to ultimately cover 3-4 clock hours. A 27-gauge cannula is used to inject preservative-free 1% lidocaine mixed with 1 in 10,000 epinephrine as far posteriorly as possible to create a sub-Tenon pocket. This technique provides the necessary anesthesia while preventing excessive bleeding. It also helps in dissecting the sub-Tenon tissue in a nontraumatic fashion before the Westcott scissors are inserted to lyse adhesions and to continue the dissection.

At this point in the procedure, bleeding can first be encountered. A dry Weck-cel sponge is inserted as far posteriorly as possible to provide hemostasis and to allow further dissection of the sub-Tenon pocket. Bleeding control is accomplished by light cautery. Warning patients that they may expect some degree of discomfort during the cautery phase is important.

After priming the AGV with balanced salt solution (BSS), using a 30-gauge cannula, the end plate is gently tucked into the sub-Tenon pocket with the tips of a nontoothed forceps held perpendicular to the plate or by holding the islet of the end plate. The valve is very delicate and should not be touched with the forceps. The plate is secured 7-8 mm from the limbus using 8-0 or 9-0 nonabsorbable suture.

At this time, the hemostat holding traction is released and the eye is returned to its natural position. The silicone tube is cut with the Westcott scissors 1-1.25 mm anterior to the limbus. Then, the anterior chamber is entered 0.5 mm posterior to the limbus by a 23-gauge needle directed parallel to and just anterior to the iris plane. The entry point should be posterior to the Schwalbe line and anterior to the iris plane. This will minimize the risk of corneal decompensation. Easy insertion of the tube is accomplished by grasping the anterior lip with 0.12 mm forceps as the needle is withdrawn and by grasping the silicone tube close to the tip with angled smooth tying forceps or specially designed tube forceps. Problems during the tube insertion can be avoided by holding the tube in the same direction as the needle tract. In some cases, injecting viscoelastic substance into the anterior chamber and into the needle tract can facilitate the insertion of the tube by pushing the iris away from the tube.

Before the human donor patch graft is placed, the silicone tube may be secured to the underlying sclera with 2 interrupted 10-0 nylon sutures. Some authors have used tissue glue to attach the patch graft and limbal closure.

A conjunctival closure is performed using an 8-0 Vicryl suture or a 9-0 nylon suture on a spatulated needle. The conjunctiva on each side of the peritomy is

secured to the underlying sclera to prevent leaks. The middle portion is secured to the cornea with a horizontal mattress suture.

Insertion of double-plated Molteno or Baerveldt implant

To insert a double-plate Molteno (DPM), a fornix-based conjunctival flap involving the superior half is created between the medial and lateral rectus muscles. The rectus muscles are identified. The DPM is irrigated with saline solution to verify patency.

A 4-0 nylon stent is inserted into the silicone tube. The end plates are secured to the sclera 7-8 mm from the limbus in the supratemporal and supranasal quadrants with a 9-0 suture. The authors do not attempt to insert the connecting silicone tube underneath the superior rectus. The anterior chamber is entered 0.25 mm posterior to the corneoscleral limbus with a 23-gauge needle; the needle tract is anterior and parallel to the iris plane. The silicone tube is trimmed, so the bevel faces the corneal endothelial surface, flush with the nylon stent, and then is inserted into the anterior chamber through the needle tract. A human donor scleral patch graft is placed on the tube with the anterior edge adjacent to the limbus, and it is sutured to the sclera with a 10-0 nylon suture.

A 10-0 nylon figure-of-eight suture is tied around the tube and anchored to the episclera between the end plate and the posterior edge of the scleral patch graft. This suture can be lasered in the postoperative period if the IOP is considered to be high. The long end of the 4-0 nylon stent is passed underneath either the lateral rectus muscle or the medial rectus muscle, depending upon the side, and is tucked into the subconjunctival space inferiorly. The conjunctiva is secured to the limbus with interrupted 10-0 nylon sutures.

The technique of ripcord suture with a 4-0 nylon stent can be used with all nonvalved implants, such as Baerveldt and Molteno. Some surgeons prefer to tie the tube tightly with a 7-0 Vicryl suture and to create a slit vent anterior to it with a sharp blade. This technique allows some fluid to escape from the vent, maintaining a low IOP and, at the same time, allowing time for the bleb to form around the end plate. The other modification of this technique is to combine the ripcord with an "orphan" trabeculectomy to control the IOP in the first 6 weeks.

Topical steroids and antibiotics, along with cycloplegic agents, are used for at least 6-8 weeks after the operation. Several studies have shown that no significant difference exists in complications or in the success of the operation with the use of mitomycin-C at the time of the operation.[15] In fact, it may lead to conjunctival melts and leaks.

The single-plate Molteno implant, Krupin valve, and Baerveldt implant are inserted in a similar fashion to the AGV; however, with the Baerveldt implant, the end plate is tucked underneath the adjacent rectal muscles.

Ex-PRESS shunt implantation

Ex-PRESS shunt insertion via the subconjunctival dissection is associated with a high failure rate secondary to subconjunctival fibrosis and complications, such as hypotony and conjunctival erosion with the risk of endophthalmitis. In select patients, using the Ex-PRESS shunt under the scleral flap appears to result in good IOP control while avoiding complications.

The technique involves limbal peritomy and a 3 X 3-mm partial thickness scleral flap. Sponge pieces soaked in the desired concentration of mitomycin-C should be placed under the scleral flap and the conjunctiva for the desired time, followed by copious irrigation similar to a trabeculectomy operation. Paracentesis is performed in the temporal quadrant followed by an injection of a high molecular weight viscoelastic substance into the anterior chamber. This injection is administered to prevent postoperative hypotony from overfiltration. A 27-gauge needle is used to create a needle tract into the anterior chamber, under the scleral flap, at the limbus. The Ex-PRESS shunt is then placed into the anterior chamber through the needle tract, with the rim being flush with the scleral bed. The scleral flap is secured to the surrounding sclera with 2 interrupted 10-0 nylon sutures (moderately tight). The conjunctiva is secured to the limbus with interrupted 10-0 Vicryl sutures.

This technique has the advantages of preventing complications related to overfiltration and conjunctival erosion and, at the same time, providing good postoperative IOP control.

Difficult conjunctiva

Difficult conjunctiva is one of the major problems facing the surgeon during glaucoma surgery. The conjunctiva may be scarred, tight, and/or button holed. Prevention is always best, so performing primary ocular surgery away from the 12-o'clock limbal position is important in patients with a history of glaucoma, as this can cause scarring at the location of future trabeculectomy or GDD surgeries.

In GDD cases with extensive conjunctival scar tissue extending several millimeters from the limbus, a dull blade (eg, 64 blade) can be used to dissect the conjunctiva and the Tenon capsule along with any superficial sclera beyond the scar tissue. Spreading and gently releasing the adhesions of the sclera to the scarred episclera with frequent snips of a Westcott scissors is a safer method of dissection in an eye that has undergone prior surgery. At this point, further dissection can commence as usual at the sub-Tenon plane.

If the conjunctiva is too tight, securing the conjunctiva to the limbus after inserting the end plate of the GDD may be difficult. Several techniques can be used to overcome this problem. If minimal shortening (1-2 mm) is present, the limbal peritomy can be extended by 2 mm into a quadrant with loose conjunctiva and then pulled back and secured. If more length is needed (3-5 mm), partial-thickness, relaxing incisions may be made close to the fornix. This is accomplished using a 64 blade on taut conjunctiva. Staying in the superficial conjunctiva and not extending into the Tenon tissue is important. Two or three of these incisions may safely be performed. In the worst cases, the conjunctiva may be anchored directly to the scleral patch covering the GDD end plate as close to the sclera as possible. The conjunctiva will grow over the scleral graft in 3-6 weeks.

Button holes are an unfortunate consequence that can occur during any glaucoma surgery. Even careful handling and diligent dissection cannot prevent button holes from occurring in delicate conjunctiva. Small holes can be closed with 10-0 sutures on a BV needle. If the conjunctiva is extremely delicate allowing holes at suture sites, a double folding technique may be used. The conjunctiva posterior to the leak is anchored to the limbus and adjacent cornea with a mattress suture. This double fold covers the suture leak and heals nicely. A large hole can be anchored to the scleral patch itself and the conjunctiva will grow over the exposed graft in 3-6 weeks.

Postoperative Details

Hypotensive phase

This phase lasts from day 1 to 3-4 weeks following the operation. During this phase, the bleb appears to be diffuse and thick-walled with minimally engorged blood vessels. The IOP is low (ie, from 2-3 mm Hg to 10-12 mm Hg).

Hypertensive phase

This phase begins 3-6 weeks after the operation and lasts for 4-6 months. The bleb becomes visibly inflamed and dome shaped and, in some cases, is associated with increased IOP to greater than 30 mm Hg. The incidence of the hypertensive phase appears to be increased with the AGV as compared to the Baerveldt implant or the DPM. This increased incidence could be explained because of the larger surface area of the Baerveldt implant and the DPM or because of different biomaterials being used in the different implants.

Stable phase

Following the hypertensive phase, this phase is characterized by stabilization of the IOP in the mid-to-high teens. At this time, the blebs are supposed to maintain IOP for the rest of the patient's lifetime; however, in reality, more than 50% of blebs fail by the end of 5 years. The bleb appears as a thick-walled, dome-shaped, elevated area overlying the end plate with no associated inflammation.

Complications

Gedde and associates provide the first multicenter, controlled clinical trial examining the efficacy and the outcomes of nonvalved GDDs versus trabeculectomy with mitomycin-C in similar patient populations with previous ocular surgery. They reported a surprising equivalence of intraoperative complications in the two groups. A higher incidence of postoperative complications was encountered in the trabeculectomy group; however, serious complications causing reduced vision and / or the need for reoperation were comparable between the two groups. Gedde and associates also found that the presence of intraoperative or postoperative complications did not increase the risk of treatment failure. This is in contrast to what was found previously by the Advanced Glaucoma Intervention Study (AGIS) study The rate of postoperative complications in the tube group was less than has been previously reported.

The most common complications in GDD surgeries are discussed below.

Hypotony

Low IOP (<5 mm Hg) with a shallow anterior chamber in the immediate postoperative phase may be related to overfiltration, wound leak, and / or choroidal effusions. The incidence of hypotony, mainly from overfiltration, is 20-30% higher with nonvalved implants in the absence of the ripcord technique or stent insertion. The incidence of hypotony is much less with the AGV (9%) than with any other GDD. However, the DPM may also achieve similar results, providing the operation is performed with a stent and a 10-0 nylon stay suture around the tube.

Hypotony from overfiltration generally does not require any treatment unless a flat anterior chamber develops with lens-cornea touch. In this case, the anterior chamber has to be reformed with a viscoelastic agent. In persistent cases, the GDD may have to be revised. Persistent wound leak, especially at the limbus, caused by conjunctival retraction should be treated by securing the conjunctiva to the limbus with interrupted sutures. Choroidal effusions may be treated with topical and / or oral prednisone. However, if the choroidal effusions are kissing and / or involving the macula, they must be drained surgically.

Tube obstruction

Tube obstruction presents with elevated IOP and deep anterior chamber. The obstruction may be caused by blood, fibrin, vitreous, or iris plug, or it could be related to a tight external ligature around the tube. In the case of blood or fibrin clot, intracameral injection of

5-10 mg of tissue plasminogen activator (TPA) in 0.1 mL of BSS can be injected. Watch for recurrent hemorrhage after TPA injection.

Vitreous incarceration can be severed with Nd:YAG laser. Iris incarceration into the tube can be reversed by peripheral argon laser iridoplasty (applied to the base of the plug). A tight external ligature can be cut with argon laser.

Tube retraction

Tube retraction from the anterior chamber should be confirmed by gonioscopy and can be corrected by attaching an extender sleeve tube with a larger diameter over the preexisting tube to lengthen it. If the anterior portion of the tube is found to be too short at the time of surgery, the end plate should be moved more anteriorly to the limbus to allow enough of the tube in the anterior chamber.

Hypertensive phase and its management

The incidence of the hypertensive phase is higher with the AGV as compared to the DPM or the Baerveldt implants. This may be related to the larger surface area of the DPM (270 mm^2) and the Baerveldt implant (350 mm^2 or 500 mm^2) as compared to the AGV (185 mm^2).2 The higher incidence of the hypertensive phase with the AGV may also be related to the biomaterial and the shape and consistency of the end plate.

Even though the DPM and the AGV are made of the same biomaterial (polypropylene), the shape and consistency of the end plates are very different. For example, the AGV end plate is extremely rigid; therefore, it may exhibit more micromotion in the postoperative period, resulting in more inflammation and increased IOP. On the other hand, the ridged, disc-shaped end plates of the DPM are more flexible and may be more stable on the scleral surface. Also, the ridge may prevent the fibrous capsule from growing directly on the implant. The smooth surface of the AGV end plate seems to attract white cells and collagen to grow on its surface, which can lead to a failed bleb.

In patients with the DPM or the Baerveldt with the stent who are not responding to topical medications, the 10-0 nylon ripcord suture can be lasered and / or the 4-0 nylon stent pulled by making a small incision of the overlying conjunctiva in the inferior fornix. This usually results in a dramatic decrease in IOP, especially in the first 2-4 weeks after the operation.

Diplopia

Diplopia, as a complication, was first noted in detail with the early models of the Baerveldt implant. The occurrence of diplopia and strabismus was significantly higher (18%) with the Baerveldt implant than with the AGV or the Molteno implant (3% and 2%, respectively). This difference is attributed to the unique design of the Baerveldt implant, because of the placement of the reservoir plate beneath the 2 adjacent rectus muscles. The resulting bleb incorporates the overlying rectus muscles and muscle sheath, leading to extraocular muscle imbalance and diplopia. Modifications of the Baerveldt end plate with fenestrations have minimized these results. Persistent diplopia might require the removal of the implant.

Other implants may also cause diplopia if the height of the reservoir pushes down the eye. This height could be reduced by a 30-gauge needling procedure followed by digital massage.

Corneal decompensation

The incidence of corneal decompensation appears to be similar following all GDDs (10-20%), but the etiology remains unknown. Corneal decompensation could be related to tube-corneal touch and chronic low-grade inflammation from the presence of the silicone tube in the anterior chamber leading to endothelial damage. If tube-corneal touch is noticed, the tube should be repositioned.

Graft failure

GDD surgery appears to be associated with a high incidence of graft failure (10-51%; average, 36.2%) in patients with corneal graft associated with glaucoma. The cause for this failure is multifactorial. The presence of underlying chronic inflammation, extensive peripheral synechiae, and multiple previous surgeries may compromise the graft. The timing of GDD surgery is another factor. A trend toward a higher incidence of graft failure exists when seton surgery is performed after PKP. This may simply reflect the poor graft prognosis associated with any intraocular surgery. The introduction of a GDD into the anterior chamber may also be associated with increased inflammation and may compromise the graft. In these cases, topical steroids should be used for prolonged periods to prevent graft rejection.

Tube and end plate exposure

In cases with end plate exposure, a conjunctival autograft can be performed to close the defect, usually with temporary Vicryl ligation of the tube. A pericardial patch graft sutured to the Tenon capsule can be used in some cases. If the tube is exposed, a scleral or pericardial patch graft may be used to cover the tube, followed by a conjunctival autograft. In some cases, the area of the conjunctival melt is too large or the autograft fails. The GDD may have to be removed at this time.

Suprachoroidal hemorrhage

Sudden excruciating pain with increased IOP in the operated eye either during the operation or in the postoperative period might indicate a suprachoroidal hemorrhage. Clinical signs include a shallow anterior

chamber, increased IOP, and choroidal elevations that appear darker than choroidal effusions. B-mode ultrasonography is helpful in making this diagnosis. The incidence of suprachoroidal hemorrhage among the different GDDs is similar.

Management of suprachoroidal hemorrhage includes supportive therapy, followed by topical and oral steroids, glaucoma medications, cycloplegic agents, and pain medications. Indications for drainage include intractable pain, involvement of the macula by the hemorrhage, kissing choroids, and cornea-lens touch.

Late failure

For most GDDs, the Kaplan-Meier estimated probability of success is 70-80% at 12 months following surgery and is 40-50% at 36-48 months following surgery. Multiple reasons for late failure exist, including chronic low-grade inflammation leading to fibrosis of the bleb, fibrosis of the valve or the outlet of the nonvalved implants, extrusion of the end plate or the tube from conjunctival melt, or infection. The fibrosis of the bleb could be triggered by another operation, such as cataract surgery. It also may be related to the biomaterial of the end plate, micromotion of the end plate with ocular movements, and blinking.

Endophthalmitis

Endophthalmitis following a GDD operation is very rare. Estimates of less than 2% have been reported.Early bleb-associated endophthalmitis is typically caused by host flora, whereas late bleb-associated infection may be caused by transconjunctival migration of bacteria, especially through thin-walled blebs or areas of aqueous leakage.It has also been reported that the incidence of endophthalmitis is higher in children and following needling of the bleb.

Loss of vision

Loss of vision by 2 or more lines can occur in 20-40% of patients following GDD surgery. This may be related to the various complications listed above, such as suprachoroidal hemorrhage, corneal edema, and endophthalmitis. It may also be secondary to the formation of cataracts, the progression of glaucoma, band keratopathy, and cystoid macular edema.

Advantages of the valved implants

The advantages of the valved implants, especially of the AGV, appear to be easy insertion following 1-quadrant dissection and low incidence of hypotony in the immediate postoperative phase. However, it is associated with a high incidence of the hypertensive phase (as much as 80%) that occurs 1-3 months after the operation. On the other hand, GDDs with larger surface areas, such as the double-plate Molteno (DPM) implant and the Baerveldt implant, appear to exhibit a lower incidence of the hypertensive phase and may achieve slightly lower IOP.

Recommendations

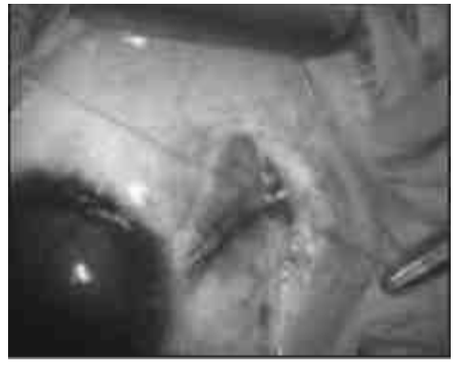
The AGV is easy to insert, has 1-quadrant dissection, requires less operative time as compared to other GDD operations, and has a low incidence of hypotony in the postoperative period. The AGV has a higher incidence of the hypertensive phase postoperatively that might require additional glaucoma medications or needling of the bleb. This implant is ideal for patients with diseases presenting with high IOP and minimal damage to the optic nerve, such as neovascular glaucoma, PKP with glaucoma, glaucoma following retinal detachment surgery, and uveitic glaucoma.

The Baerveldt implant and the DPM implant require more extensive dissection, additional operative time, and the use of a stent to avoid postoperative hypotony and a shallow anterior chamber. The larger surface area of the end plate results in larger blebs and lower IOPs.

AHMAD VALVE

PLACEMENT OF IMPLANT

MECHANISM OF ACTION



PLACEMENT OF IMPLANT

Clinic On Fire..Prevention And Treatment

Dr. Quresh B. Maskati

I did have a major fire in my cabin at the Maskati Eye Clinic. This started out as a small spark from my window AC around 4.45pm on Friday, 28th August. I was doing a keratometry on a patient at the time. I reassured the patient and switched off the AC and continued the keratometry. I was then explaining to the patient about A- scan which I was going to do next. Around 7-8 minutes must have passed. It was only then that I noticed a small flame coming out from the wire connecting the AC to the wall socket. I asked the patient to leave the room and tried to douse the fire using some sand obtained from nearby. (No fire extinguisher {FE}in my clinic). My staff then called the Fire Brigade, while I sent someone to the bank next door, for a fire extinguisher. All this while, the fire was restricted to the AC area. The bank was half closed. The security guard refused to hand over a FE. I lost precious 10 minutes, when I went down myself to plead with the guard. By the time I came back up (my clinic is on the first floor), it was too late. My cabin, which is all wood, with concealed wiring was billowing flames and smoke. It was impossible to enter. I evacuated all patients, my father and the other staff from the premises and awaited the fire brigade, which arrived 11 minutes after the phone call. They extinguished the blaze in 15 minutes. There was no injury to anyone, patients or staff. However, my entire cabin with all instruments such as slit lamp, Visual field analyzer, computers, printers, keratometer, contrast sensitivity test , ophthalmoscopes, trial sets, furniture, walls, ceiling and floor etc were gutted; the large reception and waiting area were badly damaged too, including 4 split unit AC's, reception area computers, printer, fax machine, telephones etc.

Lessons to be learnt:

1. Make sure you have working fire extinguishers at your clinic and know how to use them
2. Make sure you have a valid fire insurance policy (I do), in which you have listed all the possible equipment in your clinic as accurately as possible. Every year when you renew, make sure you put a realistic value to the equipment. Though that increases the premium, the increase is a very small amount. I had not done that. Ideal is to put in a clause, known as a re-instatement clause, that will make the insurance company pay market value for a new instrument or equipment in case of fire. For this clause to be effective, you must find out every year, the market values of all your instruments and equipment. For example, you may have purchased your Computerised perimeter for Rs.3 lacs 8 years ago. Today, the market value for a new perimeter is Rs.9 lacs. You put down cost of perimeter as Rs.9 lacs in your policy, with a re-instatement clause. In event of fire destroying your equipment, you will be paid Rs.9 lacs, not the Rs.3 lacs you had paid 8 years ago and not the Rs.30, 000/- that your old instrument would have fetched had you sold it in the market today. This unique re-instatement clause exists in India today – very few agents tell you about this and still fewer doctors take the trouble to find out market value of new equipment and put it down in their list at the time of premium renewal
3. Make sure you have your important documents, such as your insurance papers or their photocopies stored at another place as well, such as your residence, or on a CD somewhere else. I had my fire policy original stored at home - all credit for that goes to Dr. B.T.Maskati, my father. He fished it out immediately when we reached home.
4. When a fire does occur, if cause is electrical, put off the main switch of the entire clinic. This will reduce the chances of it spreading tremendously. I was told this by the fire brigade after the event. I had put off the main switch almost 15 minutes after the fire started, just before we evacuated the clinic -this was too late.
5. Always have some openable windows in your premises. My clinic had all windows boarded up. The only ventilation was from AC's. The fire brigade told me, if there were windows which could be opened, the heat and smoke would have gone out, lessening the damage.
6. Make sure you have circuit breakers (CB) in your wiring and that they are in working order. See that the switch for the CB is clearly labelled and there is a sign in big letters saying do not put off, so your staff does not put it off by mistake on closing the clinic every night! I did have circuit breakers - but was informed that the CB switch was in the off position, so it did not work when it was most needed, thanks to over efficient staff!
7. Avoid assembled Air Conditioners. Most modern Air Conditioners come with built in CBs which trip automatically in case of fire, restricting the damage to the AC itself.

I have lost a clinic in a fire, but have felt tremendous warmth at the outpourings from the ophthalmic fraternity from my city and from around the world as they learnt the news. I am certain I have gained more than I have lost. I hope you can take some lessons from my tragedy so that it does not happen to anyone else.

Dr. Quresh B. Maskati
Maskati Eye Clinic, Mumbai

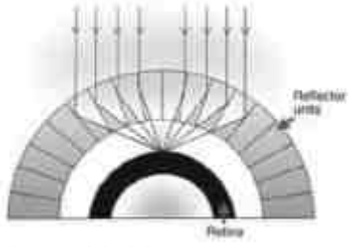
Bio-inspired Designs & Eye

Dr. P. M. Gogate

The richness I achieve comes from nature, the source of my inspiration – Claude Monet

Beauty they say lies in the eye of the beholder. Like the famous French impressionist painter, Claude Monet who remarked, 'The richness I achieve comes from Nature, the source of my inspiration'; numerous scientists have looked at Mother Nature and taken an inspiration to design new products. While the use of bio-inspiration has been recent in eye care, there are numerous instances of biological eyes being the source of inspiration for many products.

Lobsters may be a very expensive and exotic menu in many five star restaurants, but the reflecting superposition eyes of lobsters were an inspiration for some astronomers. Lobster eyes are structurally very different from that of other animals. The cornea actually contains an array of mirror-like reflectors, each arranged at a specific angle that ultimately focus incoming light rays onto the retina. The optics is reflection rather than the more conventional refraction. This enables these eyes to collect photons from an extremely wide range of angles. So the lobster has a view of virtually the whole hemisphere above it. X-ray astronomers recognized the value of an image capture device design of the lobster's eye that offered such a large field of view. It inspired them to design and develop a device that operated in wholly analogous manner to the lobster system that would capture X-ray astronomical information from up to 1000 square degrees of space at once, rather than from only a few square degrees as with previous conventional imaging devices.



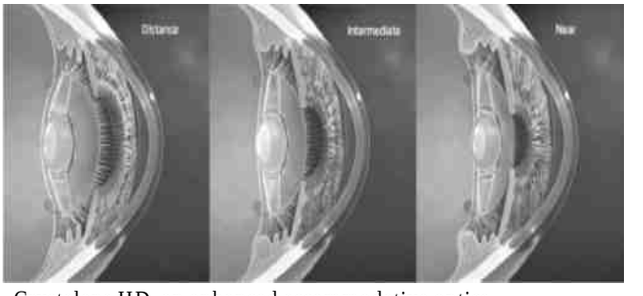
Cornea of the lobster, containing array of mirror like reflectors arranged at specific angle focusing incoming light rays on retina

The majority of insect compound eyes are adorned with a regular sub-wavelength nanostructure in the form of a two-dimensional array of surface protuberances. This has the effect of improving the transparency of its surface by significantly reducing the intensity of light that it reflects, thereby optimising the eye's overall optical collection efficiency. Engineers of the protective coverings on solar cells and architects designing buildings incorporating large glazed openings for maximum lighting function using this biological principle.

I love to think of nature as an unlimited broadcasting station, through which God speaks to us every hour, if we only will tune in - George Washington Carver

George Washington Carver used to think of nature as an unlimited broadcasting station, through which God speaks to us every hour, if we only will tune in. Animal eyes have been a source of inspiration not just for physicists but also for medical scientists. Nocturnal helmet geckos have been found to have excellent night vision due to a series of distinct concentric zones of different refractive powers. Studies on the gecko eyes are used to develop more effective cameras, multifocal contact lenses and multifocal intra-ocular lenses.

Artificial limbs and joints are inspired by the natural biological structures they are intended to replace. The Crystalens (Baush+Lomb) is an accommodating IOL designed to mimic the natural accommodative ability of the crystalline lens. It moves within the eye to allow our patients to see at near, intermediate and distance with equal clarity. The everyday function of Crystalens is as close as we can get to the natural lens.



Crystalens HD, an enhanced accommodative optics IOL designed like a natural lens.

Contact lenses are one of the most bio inspired form of visual correction. They form a more optimal and physiological image compared to spectacles. Many contact lenses are aspheric like the human cornea and have ultra-violet absorbing capacity like the cornea and the crystalline lens. They reduce the burden of ultra-violet absorption on the ocular tissue. At time a contact lens wearer is so

Dr. P. M. Gogate,
Dr. Gogare Eye Clinic, Pune

emmetropic that the wearer may forget that he / she is wearing a lens and the negative psychosocial impact of spectacles is done away with. The wearer can have almost emmetropic vision for sports activities. Hydrogel contact lenses have been designed to release hyaluron at a controlled rate for therapeutic delivery of hyaluron to the eye, to improve the wettability of contact lenses and treat the symptoms of dry eye.

Hyaluronan is a naturally occurring glycosaminoglycan that is found throughout the human body- in the connective tissue of the skin, inside the umbilical cord, in synovial fluid of joints and in the eye. In the eye, hyaluron is present in the vitreous, lacrimal gland, cornea, conjunctiva and tear fluid. It has anti-inflammatory properties and it plays a role in wound healing. It has a protective effect against oxidative damage to cells because of its ability to inhibit free radicals.

Healon (Abbot Medical Optics), containing 1% sodium hyaluronate was designed as a vitreous replacement. It is used extensively in cataract surgery to protect the endothelium during phaco-emulsification. The random coil structure of hyaluron results in unique water-retention properties and viscoelasticity. Hyaluron can be found in rewetting drops. Several studies have been conducted using hyaluron in artificial tears to determine its effect on dry eye signs and symptoms. Patients with mild to severe dry eye, as well as patients with such corneal disorders as epithelial corneal dystrophy, contact lens-induced irritation, ocular pemphigoid, filamentary keratitis and neurotrophic keratitis benefit from such artificial tears.

Did You Know? The watermelon seed inspired prism ballasted design, which is successfully used in many toric soft contact lenses.

When the watermelon seed is held and squeezed between the index finger and thumb, it always slips out of the fingers with thick bottom first. This analogy applies to a prism ballasted toric soft contact lens

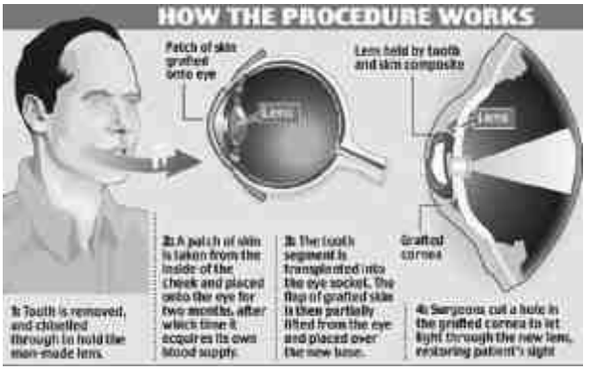
Watermelon seed is an inspiration for the prism ballast design of toric contact lenses. The shape of the watermelon seed is unique as the top of the seed is thin and bottom is thick. When the watermelon seed is held and squeezed between the index finger and thumb, it always slips out of the fingers with thick bottom first. The prism ballasted toric contact lenses are similar to the watermelon seed as the top of the lens is thin and bottom is thick. When this lens is worn in the eye, the lens is held between the upper eyelid and the surface of cornea like the watermelon seed is held between index finger and thumb. When blinking action occurs, the thinner portion goes under the upper eyelid and the thicker portion is pushed towards the lower lid. This way the he lens stays in a particular position and the axis orientation is correctly maintained.

Biopore implants for reconstruction of socket after enucleation were designed keeping the normal human tissue in mind. Extra-ocular muscles can be easily sutured to it, adding to the normal motility of the implant. Earlier donor sclera wrapped around a methacrylate implant would be used. The Biopore mimics the scleral tissue. The lightweight property of Biopore implants, the biocompatibility of the porous polyethylene and the ability to place the implant deep in the socket contribute to the overall popularity of this implant. Biopore implants can be easily cut / moulded / reshaped during surgery and sutures or other rigid implants can be passed through it. This makes it an exciting material with ever-increasing range of application in maxillofacial, orbital, and neurosurgical surgeries.

A balanced salt solution (BSS) is a solution made to a physiological pH and salt concentration. Solutions most commonly include sodium, potassium, calcium, magnesium, and chloride. Balanced salt solutions are used for washing tissues and cells and are usually combined with other agents to treat the tissues and cells. They provide the cells with water and inorganic ions, while maintaining a physiological pH and osmotic pressure. In medicine, balanced salt solutions can be used as an irrigation solution such as during intraocular surgery and to replace intraocular fluids. The BSS plus is reconstituted just before surgery and contains the appropriate bicarbonate, pH, and ionic composition necessary for the maintenance of normal_retinal electrical activity. BSS plus human in vivo studies have demonstrated it to be safe and effective when used during surgical procedures such as pars plana vitrectomy,

phacoemulsification, cataract extraction / lens aspiration, anterior segment reconstruction. It almost mimics the composition of the aqueous and this allows for a healthy endothelial cell layer immediately after surgery.

While the diamond is the hardest substance on this planet in the non-living world, the enamel of the tooth is the hardest substance in the living world. This property was used by making the tooth the carrier of the artificial cornea and lens in the osteo-odonto keratoprosthesis (OOKP). In OOKP the lenticule, which replaces the cornea, is embedded into the human tooth and sutured to the front part of the eye to focus light on the retina. OOKP (also known as "Tooth in eye" surgery) is a medical procedure to restore vision in the most severe cases of corneal and ocular surface patients. It includes removal of a tooth from the patient or a donor. After this, a lamina of tissue cut from the tooth is drilled and the hole is fitted with optical lens. The lamina is grown in the patients' cheek for a period of months and then is implanted upon the eye. An operation to graft the OOKP is undertaken in severe pemphigoid, chemical burns, Stevens-Johnson syndrome, trachoma, Lyell syndrome and multiple corneal graft failure. There is a significant risk of anatomical failure of lamina in the long term, with the main risks being laminar resorption, particularly in allograft, and glaucoma, but it is more successful than Osteo-Keratoprosthesis (OKP).



As medical technology progresses, scientists have realized that anything that is similar, if not identical, to a human structure / composition is also likely to function better and give optimum results to the patients. This century may see a wave of bio inspired products to help us see, look and feel better. Because finally it is better to let nature have her way, she understands her business better than we do.

Vital Dyes in Ophthalmology

Dr. Rashmi Shukla , Dr. B. K. Nayak, Dr. Preetam Samant

Introduction

Dyes are chemicals that bind to a substance to induce colour. A vital dye is a chemical compound that colours living tissues or cells. Intravital staining is staining done in a living organism and supravital staining is staining of living tissues freshly removed from the body.[1] In the medical field dyes are used widely for staining , colouring , as test reagents and therapeutically. In this article we will briefly discuss the classification , biochemistry , pharmacology , clinical application and toxicity of the various dyes available or have been studied for ophthalmic use.

Classification

Dyes may be classified based on pH , solubility , source , staining property. According to their biochemistry dyes are classified as azo dyes , thiazine dyes, cyanine dyes, xanthene dyes, arylmethane dyes and natural stains.

Azo dyes : synthetic organic dyes with aromatic ring and nitrogen in the azo form (-N=N-). These are bright dyes giving high intensity colours , cheap and easily available. Trypan blue (TB)Fig 1 ($C_{34}H_{24}N_6Na_4O_{14}S_4$) commercially available in 0.15% for vitreoretinal (VR) surgery and 0.06% for cataract surgery is an anionic hydrophilic azo dye with molecular weight 960 daltons. It stains degenerated cells with disrupted cell membranes. It usually does not colour tissues with intact cell membranes due to selective cell membrane transport.[2] Janus green (JG) ($C_{30}H_{31}N_6C_l$) is a basic azo dye which stains depending on the content of tissue oxygen. It is used prior to keratoplasty for supravital staining of the corneal endothelium to test its viability.[3] There is no intraoperative use.

Arylmethane dyes : these are dyes having one carbon linked to two benzene groups bound to one N or O and one amino group.[4] There are four subgroups (aminotriarylmethanes , diarylmethanes , hydroxytriarylmethanes , hydroxyaminotriarylmethanes)[1] depending on the substitution of rings in the amino group. Brilliant blue (BriB) ($C_{47}H_{48}N_{3S}2_{O7}N_a$) with molecular weight of 854 daltons is a blue anionic aminotriarylmethane dye which has been approved for intraocular use in Europe.[5] It is used in vitreoretinal surgery and for anterior capsular staining in cataract surgery. Gentian violet (GV) is a purple cationic aminotriarylmethane dye , has molecular weight of 407 daltons.[1,6] It is used as a histopathological stain and as a corneal and conjunctival marker. It has been tried for anterior capsule staining. Bromophenol blue (BroB) has molecular weight of 670 daltons . It is a dark blue hydroxytriarylmethane dye useful in cataract and vitreoretinal surgery , not yet available commercially. Patent blue (PB) with molecular weight of 582 daltons is a blue coloured anionic triarylmethane dye. It is approved in Europe as an anterior capsule stain in cataract surgery and has been used offlabel in vitreoretinal surgery.[7]

Cyanine dyes : these high coloured dyes have a –CH= group which links two heterocyclic rings containing nitrogen. The two main dyes in this group are Indocyanine green (ICG) and Infracyanine green (IfCG). ICG with molecular weight of 775 daltons is amphiphilic and binds to both cellular and acellular elements in the living tissue.[8,9,10] Its absorption and fluorescence maximums are within the infrared range. It is used for ICG angiography , for which it is commercially available , as it allows good visualization of the choroid. The dye contains sodium iodine so should be diluted in distilled water prior to saline dilution to prevent precipitation. Such a iodine containing hypotonic solution is damaging to the retina. Despite widespread popularity , its use in ocular surgery is offlabel due to retinal toxicity from iodine.[11,12] IfCG is similar to ICG but without the sodium iodine so it can be diluted in 5% glucose to make a safer iodine free isoosmotic solution. Both ICG and IfCG are used in vitreoretinal surgery to stain epiretinal membrane (ERM) and internal limiting membrane (ILM).

Thiazine dyes : contain one ring of four carbon , one nitrogen and one sulphur. Methylene blue (MB) a heterocyclic thiazine dye with molecular weight of 319 daltons has been recently used in ophthalmology for guiding layered excision of some cutaneous carcinomas , removal of orbital dermoid cysts , and for identification of adipose pockets during blepharoplasties.[13] Toluidine blue (ToB) with molecular weight 305 daltons is a metachromatic thiazine dye used to stain conjunctival tumours. It is not used intraocularly due to toxicity.[14]

Xanthene dyes : are yellow organic heterocyclic dyes with the property of fluorescence. Sodium fluorescein (SF) ($C_{20}H_{10}Na2_{O5}$) in water has a very high fluorescence. This property has been used as an extensive diagnostic tool in the form of fundus fluorescein angiography. The dye has been shown to stain the vitreous gel in ocular surgery.[15-17]

Natural stains : Alizarin red (AR) with molecular weight 240 daltons has been experimentally shown to stain denuded Descemet's membrane and delineate viable and non viable cell borders in cornea[18] but not used clinically.

Steroids : Triamcinolone acetonide (TA) molecular weight 434 daltons and Fluorometholone acetate (FMA) molecular weight 418 daltons [19] are synthetic steroids used in ocular surgery as dyes to stain the vitreous mainly due to crystal deposition.[5,20,21]

Anterior segment uses of vital dyes

SF, lissamine green, rose bengal are used for corneal and conjunctival staining and dry eye tests. SF is also used in Jones test and Dye disappearance test to evaluate watering eye , applanation tonometry , Seidel's test for wound leaks and patency of the filtering bleb , anterior segment angiography , contact lens fitting.

Use of dyes in anterior segment surgery

Corneal surgery: Dyes are used during corneal preservation to check the endothelial viability of the stored donor corneas and for intraoperative staining of cornea for better visualization of endothelial cells , corneal incisions , corneal stroma or Descemet's membrane. The viability of the preserved corneal endothelium can be assessed by measuring the endothelial cell density by specular microscopy , optical microscopy or vital dye staining.[22] Dyes

Dr Rashmi Shukla
P.D. Hinduja National Hospital, V. S. Marg, Mahim, Mumbai - 16.

stain the dead and damaged cells with disrupted cell membranes. The advantage is the simple and fast detection of non viable cells. However vital dyes may underestimate the total number of non viable cells as some impaired cells with intact membranes remain unstained.[23] The dyes that have been used to stain endothelial cells to test their viability are TB[24] , JG[25,26] , ICG[27,28] , fluorescein diacetate.[29] The natural stain AR is an intercellular dye that stains denuded Descemet's membrane and delineate viable and non viable cell borders thus can be used as an adjunct to TB in the dual staining technique.[18] This technique is still under experimental laboratory studies.[30]

With newer techniques of keratoplasty , DLEK and DSEK , dyes help in identification of the corneal layers by staining specific structures such as collagen fibrils , endothelial cells and Descemet's membrane in both the donor and host corneas. TB 0.02% is used to stain the Descemet's membrane of the donor as well as the host cornea in PKP for better alignment and visualization of the edges of the donor and recipient tissue for proper suturing.[31] TB 0.02% is also used for complete stromal dissection and avoid Descemet's membrane perforation in lamellar keratoplasty.[32] ICG is useful in DLEK [33] as it stains the stroma of the transplanted donor corneal disc allowing visualization of the tissue interface. GV stains the peripheral stromal surface of the graft containing the Descemet's membrane and the endothelium to allow proper visualization and proper unfolding of the donor disc in DLEK and DSEK.[34]

Vital dyes for clear corneal incision: Due to the frequent difficulty in finding clear corneal incisions during intraocular surgery, the use of TB-coated blades has been proposed. [35] A 3.0-mm phaco incision blade tip was coated with TB in order to improve visualization.

Vital dyes in conjunctival surgery: Benign inflammatory and neoplastic conjunctival lesions may be semi-transparent and difficult to differentiate from normal tissue. Vital dyes stain these lesions and facilitate their complete removal and reconstruction of the remaining conjunctiva.[14] ToB stains only the malignant conjuntival tissue (squamous cell carcinoma) and not the benign lesions and helps enbloc removal of the tumour.[14] ICG and TB injected in the conjunctival cyst stain its capsule and facilitate complete removal thus preventing recurrence.[36,37] To prevent collapsing of the cyst capsule , a mixture of sodium hyaluronate (2.3%) and TB(0.06%) is injected to keep the capsule distended and prevent collapse of the cyst before removal.[37,38]

Use of vital dyes in cataract surgery: Staining of the anterior capsule was initially reported in 1993 to address the problem of poor red reflex in patients with hypermature , dense , complicared cataracts and those with corneal opacity causing difficulty in capsulorrhexis.[39] Since then, the use of vital dyes as an adjuvant in cataract surgery has been widely reported.[40-42] TB staining of the capsule edge in CCC was initially introduced in 1999.[43,44] (Fig 2). TB stains the basement membrane of the lens capsule and gives differentiation from the lens cortex.[45,46] TB facilitates better identification of the capsule in advanced cataract , other conditions with poor red reflex[47-51] , anterior and posterior capsule in paediatric cataracts[31,52-55] and learning surgeons.[56,57] The staining or exposure time ranged from 5 seconds -2 minutes in most studies.[55,58] Most clinical studies prefer 0.1% TB to stain the anterior capsule, even though , effective staining has been achieved with concentrations as low as 0.06%. [59] Clinically, TB to facilitate CCC is used in concentrations from 0.0125% to 0.4%.[60,61] ICG staining for capsule visualization in conditions with poor or no red reflex has been reported since the end of the 1990s.[62-66] The concentrations used ranged from 0.125% - 0.5% and according to an in vivo study in rabbit eyes , the lowest effective concentration of ICG to provide a comparable contrast with TB was 0.25%.[59,67] Comparative studies about staining effectiveness of TB versus ICG for CCC has been controversial. Xiao et al in their in vivo analysis found that TB under an air bubble was a slightly superior colouring agent, although the success rate for achieving CCC with ICG or TB was not significantly different.[68] Pandey et al, in a study with post-mortem human eyes, concluded that intracameral subcapsular injection of ICG was superior to TB in enabling anterior capsule visualization.[69] One advantage of TB over ICG is lower cost. SF in a 2% concentration was the first dye used to stain the anterior capsule, in 1993.[39,70] The migration of SF into the vitreous cavity and staining of the lens cortex and nucleus and corneal endothelium result in inadequate contrast between the lens capsule and cortex , limiting SFs' usefulness in staining the capsule. The use of GV to stain anterior capsule in humans was first presented in 1998 (XVIth Congress of the European Society of Cataract and Refractive Surgeons, Nice, France, September 1998). Since then, only a few papers have addressed the use of this dye in cataract surgery. A recent study of BriB in enucleated pig's eyes raises the possibility of this new dye for cataract surgery.[71] Further studies should elucidate the role and safety of BriB.

Techniques of dye injection for staining the anterior capsule are air bubble injection , intracameral subcapsular injection , injection under viscoelastic , intracameral one step injection. Melles and co-authors filled the anterior chamber with air and injected the dye under the air bubble for 30 seconds. This is the air bubble injection technique.[43,44] Benefits of this technique are , better staining of the peripheral anterior capsule rim, as well as lack of dye contact with corneal endothelium. In the intracameral subcapsular injection, aqueous is replaced with viscoelastic, and the dye is carefully injected beneath the anterior capsule with a small-gauge needle. The dye remains trapped in the subcapsular space, and in contact with the posterior surface of the anterior capsule, especially in the center and midperiphery. Although , both capsule and cortex are stained by the dye, they can be clearly distinguished by the feathery appearance of the cortex and the smooth staining of the capsule. The anterior capsule may tear if excessive dye is injected.[39,53,54] Injection of vital dyes under viscoelastics is an alternative for capsule staining to minimize endothelial damage. This technique involves placement of a drop of the dye onto the anterior capsule under a viscoelastic . The anterior chamber is thoroughly irrigated, and fresh

viscoelastic is injected again. Disadvantages of this method are poor control of the dye diffusion, peripheral dissection of the dye through the zonules into the vitreous, increased cost, and loss of red reflex.[58,64,72,73] Wong et al prospectively compared staining under an air bubble and under viscoelastic.[58] Using an air bubble had the advantage of creating a "dry lake" over the lens capsule and being less expensive; however, it is more difficult to maintain anterior chamber depth, and the dye is more likely to leak out. With injection under viscoelastic, it is easier to maintain the anterior chamber, and the contact of dye with corneal endothelium is minimized. Wong et al found both techniques were equally effective and safe to corneal endothelium , concluding that the choice of procedure should rest on the surgeon's preference. In the intracameral one-step injection method , the dye is instilled via a paracentesis port at the beginning of cataract surgery.[74] Aqueous is allowed to exit the anterior chamber, which shallows, and the resulting pupil block confines the colouring agent to the anterior chamber. A viscoelastic is used to flush dye-stained aqueous from the anterior chamber, circumventing the need for anterior chamber washout This method requires no additional instruments or materials and is faster.

TB and TA can be injected in the anterior chamber to stain the vitreous to facilitate anterior vitrectomy in the event of vitreous loss during cataract surgery.[75-78]

Use of dyes in glaucoma surgery : Dyes can be used to evaluate patency and leakage of the trabeculectomy bleb. Antimetabolite agents coloured with a dye allow better control of their application to the ocular tissue. TB (0.06%) can be used to check patency of bleb[122] and 0.1% may be added to the transparent MMC and 5-FU to delineate the antimetabolite treatment area and control excess at the wound margins.[79,80] ICG (0.25%) can also be used to check bleb patency and aid in bleb repair and 0.5% can be mixed with MMC.[81]

Use of dyes during orbit surgery

TB and MB allow intraoperative identification of tissue layers during enucleation , removal of dermoid cysts and tumours and visualization of the adipose tissue in the intraorbital fat compartment. TB stains the tenons and conjunctiva and helps in enucleation and implant placement.[37,82,83] MB stains certain orbital tumours [84] and dermoid cysts facilitating their complete removal. It helps to identify the fat compartment during blepharoplasty.[13]

The Use of Vital Dyes in Strabismus Surgery

Saxena et al described the use of vital dyes for staining the superior oblique tendon in 15 cases using either TB, GV, or ICG.[85]

Posterior segment uses of vital dyes.

Diagnostic uses in the form of fundus fluorescein angiography and indocyanine green angiography.

Use of vital dyes during vitreoretinal surgery : The use of vital dyes to stain pre-retinal tissues during vitreoretinal surgery, "chromovitrectomy", allows visualization of the thin, transparent tissues in the vitreoretinal interface ; the ILM, epiretinal membrane (ERM), or the vitreous posterior surface.[86] Abrams et al reported the first use of vital dye during vitreoretinal surgery and found fluorescein a great aid in vitreous identification.[87] Since 2000 chromovitrectomy has achieved widespread use.[88] Initially, intravitreal injection of ICG facilitated the visualization of the ILM.[5,89-92] (Fig 3) Later, TB was proposed to be helpful in identifying ERM and TA was found to stain the vitreous.[93] Recently, other dyes, including IfCG, PB, BroB, and BriB , have been proposed as alternatives for chromovitrectomy.[5,90,91] Dyes when used , improve visualization of the preretinal tissues , make the surgery safer , faster with decreased light toxicity to the retina. Retinal damage by unnecessary picking to search for the edge of the tissue is also minimized. ICG and IfCG have high affinity for the acellular ILM. ICG adheres well to the extracellular matrix components of the ILM, such as collagen type 4, laminin, and fibronectin.[9,10,94] Wollensak et al showed, in a porcine model, that ICG with light exposure produces a significant increase in biomechanical stiffness, thereby facilitating ILM peeling.[95] Following the Kadonosono et al publication of ICG use in macular hole surgery, many authors have reported easier and less traumatic ICG-guided peeling with good clinical results.[94,96-10

Incubation time or the time that the dye remains in the vitreous cavity before aspiration, may vary from immediate removal to 5 minutes. ICG has been also used to facilitate ILM peeling in other diseases such as diabetic macular edeme (DME) and ERM. Kamura et al evaluated the use of ICG-assisted ILM peeling in diabetic macular edema. No signs of retinal toxicity were seen, and visual outcome was similar to vitrectomy without ICG.[101] Radetzky et al evaluated ILM peeling with ICG for persistent macular edema from causes such as central retinal vein occlusion, DME, Irvine-Gass syndrome, and vitreomacular traction syndrome. Significant improvement in visual acuity was observed only in patients with DME.[102] During ERM removal ICG can be used in the negative staining technique or the double staining technique. In the negative staining technique, the ILM is stained positively by the dye whereas the ERM does not take the stain (negative). This is because the ICG dye is hydrophilic and taken up by the acellular collagen of the ILM but not by the cellular ERM.[103,104] In the Double staining technique, TB solution is used to stain the ERM. After peeling of the ERM, ILM is stained by ICG and peeled off. These two dyes are complementary, each having a different affinity for ERM and ILM, respectively. In terms of concentration and osmolarity, RPE toxicity is more common when the ICG solution has an osmolarity below 270 mOsm and concentration above 0.5% .[96,105-109] Recent studies have used ICG in a concentration of 0.05% and osmolarity around 290 mOsm with few or no signs of RPE toxicity.[64,110-112] Infracyanine Green–assisted ILM peeling: IfCG stains the ILM in a way similar to ICG. The difference is the solvent that is 5% glucose solution and thus isoosmotic. As the hypo-osmolarity of ICG is suspected to be responsible for RPE damage, infracyanine green may offer a safer alternative .[113]

Soon after its introduction in cataract surgery, TB was proposed as a stain for chromovitrectomy.[114] However, TB

does not enhance ILM-visualization as well as ICG ; and TB is recommended mainly for ERM-staining.[5,91] TB exhibits a strong affinity for ERM due to the presence of dead glial cells within these membranes.[5,91,115-117] Trypan-Blue assisted ERM Peeling (Fig 4) : 0.06% concentration does not provide satisfactory staining in all cases and a higher concentration 0.2%, gives a more useful bluish discolouration that facilitates surgery.[118] The stain not only makes the ERM more easily identified, but enables a complete removal of the membrane. The area of ERM is usually larger than that estimated ophthalmoscopically. With the stain, a larger area of the membrane can be identified and removed.[119] This is especially true for the mature ERM that stain better than fresh, immature membranes.[119] Heavy TB staining: main drawback of using TB in vitreoretinal surgery is the requirement of an air fluid exchange (AFX) . Heavy TB prepared by mixing 10% glucose with membrane blue isovolumetrically can be delivered efficiently to the retinal surface without an AFX. BriB (Fig 5) and BroB are emerging as good alternatives for ICG and IfCG in chromovitrectomy due to the remarkable affinity of BriB for ILM and BroB for ERM and ILM as well minimal toxicity to the retinal pigment epithelium (RPE).[120-125] TA for ILM peeling was first used by Kimura et al , with the observation that , the white specks and crystals deposit over the ILM, thereby facilitating its identification and removal.[126] They obtained good clinical results and observed no adverse effects after three months. Since then other studies have confirmed that TA-assisted ILM removal provides good results.[76,127,128] PB is shown to have moderate affinity to ERM and vitreous, but poor affinity to the ILM in animal studies and preliminary clinical data.[5,91] Recent clinical data reveals , PB is as appropriate a vital dye for colouring ERM as TB.[129,130]

Use of vital dyes for subretinal break identification :

Exact localization of retinal breaks is a critical step in the surgical treatment of rhegmatogenous RD. In the early 20th century, numerous experiments were done to stain retinal breaks during retinal surgery.[5,131] In 1939, Sorsby used intravenous Kiton-Fast-V-Green in patients with

RD to detect retinal tears. He observed a greenish retina with an unstained retinal break.[132] The first subretinal application of dyes to stain retinal breaks was in 1947 by Black. He used methylene blue through a transcleral needle.[133] Jackson applied subretinal 0.15% TB with a 41-gauge cannula to identify retinal breaks during RD surgery . Retinal breaks were identified in four of the five patients, and no retinal toxicity was seen in this study. However, the small number of patients does not allow assessment of the risks and potential toxicity.[134,135]

Use of vital dyes to stain vitreous : During vitreoretinal surgery for macular hole , macular edema , diabetic retinopathy , complete vitrectomy may enhance surgical outcome .[136] TA deposition onto the vitreous surface was initially reported by Peyman et al.[137] The crystalline steroid adheres to the acellular tissue, thereby giving a clear contrast between the empty vitreous cavity and the areas where vitreous fibers are still present.[16,76,138-141] (Fig 6)

Dye injection techniques : In the "dry method" or "air-filled technique" , fluid in the vitreous cavity is removed by a fluid—gas exchange before dye injection. Although this technique has the advantage of concentrating the dye in the posterior pole and avoiding contact at the posterior capsule of the lens, it may expose the retinal surface to a higher concentration of dye , because in an air-filled eye , the full concentration of dye reaches the retinal surface.[89,90] The other technique called the "wet method" or "fluid-filled technique" involves injection of dye under fluid left behind in the vitreous cavity. Here , the concentration of the dye in contact with the retinal surface is lower because it is diluted by the fluid in the vitreous cavity. The disadvantage is the possible dispersion of the dye leading to unwanted staining of the retina elsewhere. Czajka et al compared the two methods in a porcine model and concluded that the air-filled technique induced a higher incidence of RPE atrophy and outer retinal degeneration.[142] The incubation time of the dye on the retinal surface is usually kept short and the dye is washed out a few seconds after its injection as early dye washout minimizes exposure on retinal tissue .[143] To avoid unnecessary and non-selective staining of the entire retina , a new dye applicator called VINCE (Vitreoretinal Internal limiting membrane Color Enhancer; Dutch Ophthalmic, Zuidland, The Netherlands) has been produced , consisting of a modified backflush needle with an adjustable silicone tube, surrounded by a metal cannula. This device may allow a better visualization of fine, delicate, semitransparent pre-retinal tissues, while avoiding the uncontrolled staining of the RPE.[144] Measures to avoid dye injection directly through the macular hole are , slow injection of the dye , use of VINCE [144] or placing substances over the macular hole such as perfluorocarbons liquids (PFCL).[145-147]

Toxicity of vital dyes

TB : at higher concentration > 0.1% causes corneal endothelial damage, inflammation, lens epithelium toxicity causing posterior capsular opacification. It may leak into the vitreous through zonulolysis and cause retinal damage.[148,149] A relative contraindication for TB is the use of hydrophilic expandable acrylic intraocular lens (IOL), which has high water content (73.5%) . The IOL expansion depends on hydration by fluids in the capsular bag. Because the TB that remains in the aqueous humor may be absorbed into the lens, patients may experience more glare than with other IOLs.[150] TB may induce retinal damage in the form of RPE damage.[151] ICG : side effects are similar to TB. Causes RPE , outer nuclear layer and photoreceptor damage.[151] The iodine and sodium cause additional retinal toxicity. Hypotonic solution also causes RPE damage. SF: can cause hypersensitivity, anaphylaxis, diffusion into the vitreous due to low molecular weight. TA : may cause steroid induced cataract and glaucoma , retinal toxicity is not seen . MB : causes endothelial decompensation , iris pigment dispersion.[152] Newer stains , BriB and BroB are safer as compared to the commonly used TB and ICG.

Mechanisms of dye induced retinal toxicity :

Postulated mechanisms of intravitreal dye-related toxicity include surgical damage to superficial retinal cells, damage due to type of injection ; subretinal or intravitreal ,

direct dose dependent damage , damge due to the secondary ions such as sodium and iodine in ICG , osmolarity effect of ICG solution , and light toxicity.[5,91,153] The subretinal injection of dyes may be associated with a greater risk of toxicity than intravitreal injection.[154-156] This is because the presence of Muller glial cells and their basement membrane (ILM) between the vitreous dyes and the neural cells has a blocking effect.[5] Also ,as photoreceptors have higher metabolic rates and contribute to the maintenance of visual pigment recycling, they could be more sensitive to external stimuli that cause apoptosis.[157] Dyes exacerbate phototoxicity secondary to surgical illumination. Light damage to the retina occurs through thermal, mechanical, or photochemical effects and depends on the wavelength, intensity, and duration of the injuring light.

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Fig 1 : Trypan Blue dye

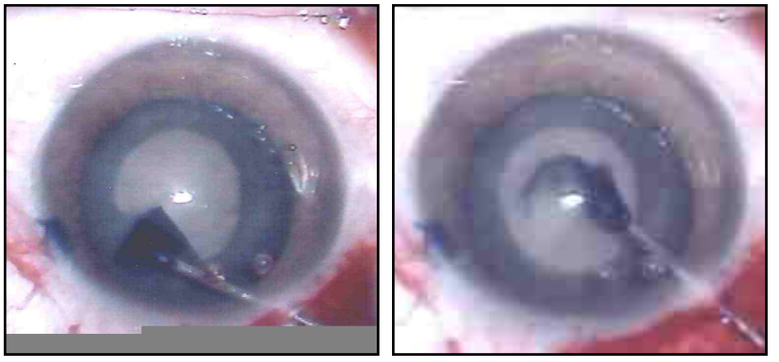

Fig 2 : Trypan Blue assisted anterior capsulorrhexis

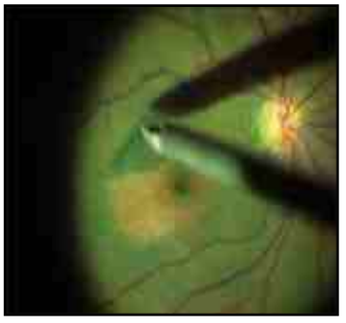

Fig 3 : ICG assisted removal of ILM in macular hole surgery

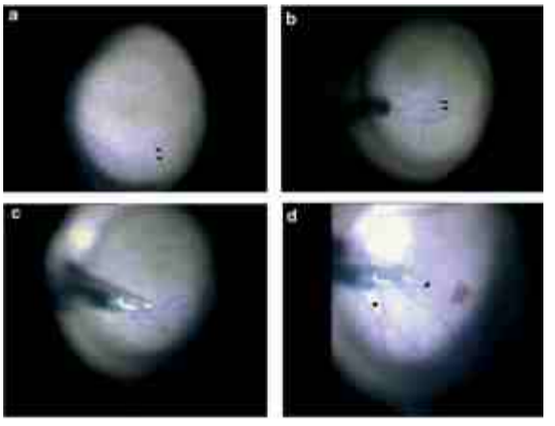

Fig 4 : Trypan Blue assisted ERM removal

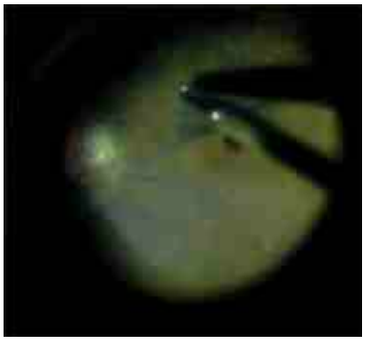

Fig 5 : Brilliant Blue assisted staining of ILM in macular hole surgery

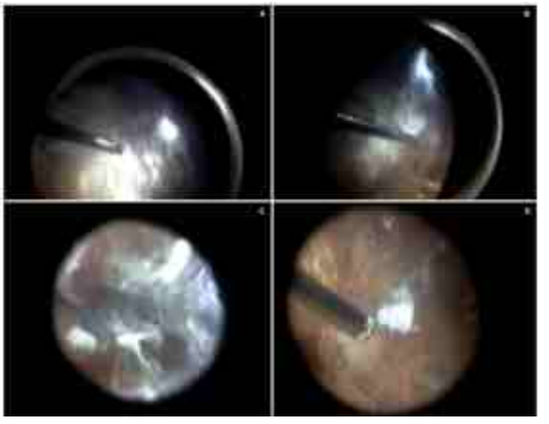

Fig 6 : Triamcinolone acetonide guided vitrectomy