Endophthalmitis is one of the most vision threatening complication in Ophthalmology. Endophthalmitis refers to inflammatory response caused by infected intraocular tissues/fluids. The frequency of Endophthalmitis after cataract surgery and trauma varies from 0.07 - 0.13% and 2.4- 17% respectively in the various reported series. Majoriy of these infections are bacterial. Fungal endophthalmitis, despite being rare, is a distinct clinical entity due to delayed diagnosis and poor prognosis associated with it. It could be classified as exogenous or endogenous depending on the clinical setting.

Exogenous fungal endophthalmitis could be following trauma or surgery. Conjunctival sac flora appears to be the commonest source of infection in exogenous endophthalmitis. Normal conjunctival flora has 2.9% of fungal isolates comprising of Aspergillus Sp., Rhodotorula, Candida, Penicillium sp. The incidence of fungal isolates further increases in older age, Sjogrens syndrome, prolonged steroid use and in tropical countries. The occurrence of fungal endophthalmitis is rare and is reported to account for 3% of all endophthalmitis in the West. However fungal endophthalmitis is not so rare in India. Literature from South India report post surgical and post traumatic fungal endophthalmitis to be 18.6% and 17.7% of the culture positive cases respectively. The species isolated from India are also different than West where Candida is the commonest isolate. The isolates from India included Aspergillus species in 13.8%, Alternaria in 0.8%, Bipolaris in 0.8%and Helminthosporium in 0.5% in post surgical cases. Common isolates in post traumatic fungal endophthalmitis included Acremonium, Aspergillus, Bipolaris, Cladosporium, Fusarium, Dematiaceous fungus, Humicola species.

Clinical features: Exogenous fungal endophthalmitis is usually seen in healthy immuno-competent adults. Post traumatic fungal endophthalmitis is frequently reported after trauma with vegetative matter. Post surgical fungal endophthalmitis has been reported after cataract extraction, penetrating keratoplasty, glaucoma filtration and scleral buckling. It may sometimes appear as cluster infections caused by the use of contaminated intraocular irrigating solutions, intraocular lenses (IOLs), inadequate ventilation system and hospital construction activity.

Fungal endophthalmitis is known to occur as chronic endophthalmitis and Pflugfelder in his series found the mean latency of 7 weeks after surgery and 3 weeks after trauma. When it occurs as cluster infection it has acute and aggressive presentation. The symptoms are less. The visual deterioration and the pain is significantly lesser than bacterial endophthalmitis. It tends to be more localized, with inflammation confined to anterior chamber, pupillary space, or anterior vitreous. String of pearls appearance, pluff ball opacities in vitreous are commonly seen in these cases. Granulomatous reaction and fibrin could also be seen in these cases. Fungal endophthalmitis is known for variability of presentation. High index of suspicion is required for the diagnosis of the same.

The clinical picture of exogenous fungal endophthalmitis in India appears to be different from that in the West. We have reported the largest series of 27 cases of post surgical fungal endophthalmitis till date which describes the clinical presentation of such cases in India. We in India are seeing early presentation in majority of postoperative cases. Two thirds of the patients in India are seen to present within first three weeks after surgery. Most of the cases in our setup have diffuse intraocular inflammation involving the posterior vitreous cavity with poor media clarity that resembles bacterial endophthalmitis. We believe that it is important to have both bacterial and fungal cultures from the intraocular fluids to reach a definitive diagnosis. Looking for classical signs of fungal endophthalmitis could be misleading in substantial proportion of postoperative infections in the developing countries. Early and diffuse presentation is suggestive of a large amount of inoculum being introduced at the time of the surgery.

Microbiological Diagnosis: Vitreous aspirate or biopsy can be sent for an early diagnosis. Stained smear of intraocular
fluid specimens contribute to the diagnosis in less than 30% cases. Recovery of organisms from vitreous aspirate is as high as recovery from filtered vitrectomy specimen. All specimens must be inoculated in Sabaraud’s Dextrose Agar media (SDA) for atleast six weeks at 25°C and 37°C respectively. The mean time for inoculation of media with intraocular specimen to visible growth is 64 hours. Species identification of the organism and antifungal sensitivity tests often require an additional time period of several days to week.

Aspergillus flavus was found to be the most common isolate in about 2/3rd of the cases of postoperative fungal endophthalmitis from North India. The other fungi reported are Aspergillus fumigatus, Aspergillus niger, Acremonium, Fusarium and Candida. Aspergillus is reported to be the most common contaminant of the conjunctival sac in normal subjects and also the most common fungus cultured from the air in Manila. Frequent change of air filters and dehumidifiers is not a well-established practice in developing countries. Thus, Aspergillus contamination by air borne spores cannot be ruled out.

**Management**

**Prophylaxis**

All predisposing factors and immune status of the patient should be taken care of before planning any surgery for patient. Povidone -iodine solution is an excellent antiseptic and is recommended for both skin (10%) and conjunctival sac (5% solution) It is effective against fungi, bacteria, viruses, protozoa and spores.

**Treatment**

The treatment is difficult and prolonged due to a combination of growth characteristics of fungi, limited options of effective anti fungal drugs and poor tissue penetrance of these agents. No definite guidelines exist till date for the management of fungal endophthalmitis. The combination of vitrectomy and antifungal agents appears to be the best therapy for fungal endophthalmitis. One should try to remove as much of the infected tissue as possible. The removal of intraocular lens is indicated only in recurrent endophthalmitis, if exudates are localized around the IOL.

The current antifungal of choice is intravitreal Amphotericin B (5 μg). This is a broad spectrum fungicidal drug. This has to be given along with intravitreal dexamethasone (400μg) in view of the retinal toxicity of the drug.

Repeat injections are required if, after initial improvement, patient does not show continuous improvement or shows deterioration. The injection can be repeated after 2 days in vitrectomized eyes and 5-7 days in nonvitrectomized eyes. Systemic antifungals, itraconazole or fluconazole (100mg bd, or 200mg bd respectively), should be given in all patients with weekly monitoring of liver function tests for atleast 6 weeks. Oral triazoles achieve 50%-90%of serum levels in intraocular fluids. Topical antifungal agents, may be added in case of corneal involvement. Newer antifungal drugs have better ocular penetration and have superior efficacy. Caspofungin, first available echinocandin, has greatly expanded the antifungal armamentarium by providing effective efficacious activity and also having efficacy against refractory aspergillosis. It is available as intravenous dosage of 50 μg/ day. Voriconazole, the first available second generation triazole, has the benefit of oral as well as intravenous and intravitreal administration in the dosage of 200mg bd, 200mg bd, 100ug in 0.1ml respectively. Voriconazole has moderate serum binding of 58% and has 96% oral bioavailability and peak plasma concentrations are achieved 2-3 hours after oral administration. Intracocular penetration of orally administered voriconazole in the noninflammed human eye was found to be 1.13 + 0.57μg/ml and 0.81+ 0.31μg/ml in aqueous and vitreous respectively. These levels are several folds higher than MIC 90 values for the organisms most frequently encountered in fungal endophthalmititis. Susceptibility profiles of several antifungal agents to 541 fungal isolates from eye was studied at Bascom Palmer institute between (Marangon et al) 1980 and 2002 and Voriconazole was found to be the most effective against aspergillus, fusarium, and candida species. In vitro potency of voriconazole against yeast is 60 fold higher than fluconazole.

The side effects of Voriconazole include transient visual disturbance, hepatotoxicity and skin reactions. Intravitreal voriconazole upto 25ug/ml causes no ERG or histological changes in rabbit retina.
The role of corticosteroids is controversial. The size of fungal hyphae may preclude ingestion by the neutrophils, which therefore release lysosomal enzymes and oxygen metabolites into the surrounding tissues. Our aim of using oral corticosteroids in combination with pars plana vitrectomy and intravitreal fungicidal drugs is to control the surrounding tissue destruction due to direct damage by fungal toxins and by host defence mechanisms. The use of corticosteroids, as anti-inflammatory agents, in a case of fungal endophthalmitis has been studied and found to be useful in experimental studies and also human endophthalmitis cases. The deleterious effects of steroids are mainly reported with high intravitreal dosage and if they are not simultaneously combined with an efficacious antifungal agent.

Poorer initial visual acuity has been significantly linked to poorer outcome. Corneal involvement is another important independent predictor of poor final visual outcome. Majority of the cases with corneal involvement present early, which could be indicator of very high load of contaminating inoculum or fungal spores trapped in the sclero-corneal incision, or spores introduced intraocularly. Fusarium sp. is also associated with poorer outcome.

Different series report the successful outcome in exogenous fungal endophthalmitis to vary from 0%-44%. Pars plana vitrectomy eyes have better functional outcome than the non- pars plana vitrectomy eyes.

Endogenous fungal endophthalmitis is seen in debilitated and immunocompromised patients or in patients with intravenous drug abuse. It has been reported in patients of heart transplant, endocarditis, lung and liver transplant, leukemias and chronic pulmonary disease. Fungal infections account for more than 50% of cases of endogenous endophthalmitis. Usually Candida endophthalmitis accounts for 75%-80% of these cases and is reported in patients with prolonged catheterization, intravenous hyperalimentation etc. Candida has predilection for eye due to ability to form germ tubes in serum that embolize and lodge in choriocapillaris. Endogenous endophthalmitis is reported after infusion of intravenous fluids in healthy adults for minor ailments in India. Endogenous endophthalmitis typically develops 6 weeks after infusion. Aspergillus is the most common organism reported in such cases. It is speculated that the possible source of inoculum may have been the contaminated intravenous fluids. None of the patients had clinical evidence of fungal infection in any other organ. The presence of subclinical fungal infection however can not be ruled out.

Clinical features

Bilaterality is seen in only 25% cases. Endogenous candida endophthalmitis typically starts as a focal choroiditis after haematogenous spread. The infection then spreads into the retina and breaks into vitreous and or anterior segment. The presence of white vitreous opacities forms ‘string of pearls’ appearance. Characteristically a chorioretinal abscess and subretinal or subhyaloid hypopyon is seen. Endogenous fusarium endophthalmitis has been reported to present as frosted branch angiitis in intravenous drug abuser.

Treatment

PPV with systemic antifungals remain the treatment of choice in these cases. Recent studies have shown good results with the combination of oral voriconazole and caspofungin. In case of systemic problem decreasing the oral absorption, intravitreal antifungal drugs could be added. With timely intervention vision of 20/80 or better is seen in as high as 66% eyes.

A high index of suspicion is required for prompt diagnosis of cases of fungal endophthalmitis and to institute prompt management. Due to variability of presentation and relatively higher incidence of fungal endophthalmitis in our setup, microbiological investigations are essential in a case of endophthalmitis.

Preparation of antifungals for intravitreal injection

**Amphotericin B (5ug/0.1ml)**

- a) In a vial of 50 mg amphotericin B, add 10 ml of sterile water for injection USP (no preservatives)
- b) Take 0.1ml of ‘a’
- c) Add 9.9 ml of sterile water for injection (USP) to ‘b’.
- d) This gives 5 ug/0.1ml

**Voriconazole 0.050mg/0.1ml**

- a) Reconstitute a 200 mg vial voriconazole with 19 ml sterile water for injection
- b) Take 1ml of ‘a’, add 19 ml of sterile water for injection
- c) This gives 0.050mg/o.1ml

References


The definition of Glaucoma had undergone a change in the past few years. Earlier, high intraocular pressure was synonymous with glaucoma but now it is considered as just one of the risk factors. Ocular hypertensive patients have high IOP but no disc or field changes, and earlier it may have been rational to treat all patients with high IOP but in the current scenario it may not be so.

Glaucoma presents to the practitioner at various stages of a continuum that is characterized by accelerated retinal ganglion cell death, subsequent axonal loss and optic nerve damage, and eventual visual field loss. These initial changes in the retina and optic nerve are often asymptomatic and undetectable with existing diagnostic tests (routine perimetry). Currently, there is no agreement on criteria for the diagnosis of early damage that precedes standard achromatic visual field loss. This suggests that awaiting overt signs of disease involves accepting some irreversible damage and probable progression. As optic nerve damage progresses, severe visual dysfunction and blindness may ensue in a small group of patients. Since some patients present in the early stages of the disease, the goal of treatment is to arrest, delay, or limit progression of predisposing ocular hypertension or early optic nerve damage to significant visual impairment.

The OHTS study was conducted to evaluate the effect of treatment for the ocular hypertensive and it was found that cumulative probability of development of POAG in 5 years was 9.5% of those not treated, compared to 4.4% of those who were treated. Hence treating all patients with OHT is unnecessary and costly. But at the same time treating none would mean depriving these patients, who have greater risk of developing glaucoma, to therapy, which could decrease the likelihood of progression.

But the question is - Who is at risk? What is the optimal strategy?

### The OHTS study also evaluated the various risk factors, which are associated with development of POAG. These are

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>For every</th>
<th>Estimated risk for glaucoma increased</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>10 year ↑</td>
<td>22%</td>
</tr>
<tr>
<td>IOP</td>
<td>1 mmHg ↑</td>
<td>10%</td>
</tr>
<tr>
<td>CCT</td>
<td>40 μm ↑</td>
<td>71%</td>
</tr>
<tr>
<td>Horizontal C:D ratio</td>
<td>0.1 ↑</td>
<td>27%</td>
</tr>
<tr>
<td>Vertical C:D ratio</td>
<td>0.1 ↑</td>
<td>32%</td>
</tr>
<tr>
<td>Standard pattern deviation</td>
<td>0.2 dB ↑</td>
<td>27%</td>
</tr>
</tbody>
</table>

*(Baseline risk factors for progression from OHT to glaucoma (OHTS). Adapted from Gordon et al. Arch Ophthalmol 2002:120, 714-720)*
this calculator has been influenced by those developed for use in cardiovascular medicine.

Risk assessment tool was designed to calculate the likelihood to conversion to glaucoma from ocular hypertension based on the 6 risk factors identified by OHTS (mentioned above). Analysis of the data identified that older age, higher IOP, thinner central corneas, larger vertical C: D ratio and higher PSD was associated with increased risk of progression to glaucoma.

Initially Cox proportional hazard regression model was use. To simplify, a scoring system was designed using the risk factors as points and then summed to identify corresponding percentage. (Fig 1)

For instance, a 60-year-old patient without diabetes mellitus and with a baseline IOP of 26 mm Hg, CCT of 570 μm, vertical cup-disc ratio of 0.4, and PSD of 1.9 receives a score of 35 points for predicting glaucoma: 4 points for age (step 1), 3 points for IOP (step 2), 13 points for CCT (step 3), 7 points for vertical cup-disc ratio (step 4), 8 points for PSD (step 5), and no points for absence of diabetes mellitus (step 6). This score corresponds to a predicted 5-year risk of glaucoma conversion between 11% and 15% (step 7).

In 2005, based on the research conducted at the Hamilton Glaucoma Center and endorsed by a panel of glaucoma experts, a clinician friendly Scoring Tool for Assessing Risk (S.T.A.R.) was developed and deployed. An electronic version is also available.

The performance of this tool was assessed at the Hamilton Glaucoma Center. 126 patients (252 eyes) with OHT who were never treated were reviewed for 86 months. These patients were derived from the ongoing longitudinal Diagnostic Innovations in Glaucoma Study (DIGS).

The patients underwent baseline and follow-up examinations and comprehensive ophthalmologic examination including medical history, best-corrected visual acuity, slit lamp biomicroscopy, Goldman applanation tonometry, gonioscopy, dilated fundus evaluation, stereoscopic optic disc photography and visual field examination.
In a follow-up period of 86 months in DIGS 31 patients (25%) patients who had a moderate to high risk of glaucoma, developed glaucoma. An average probability of glaucoma conversion in 5 years was reported as 12%.

To use this 3 simple steps are required

**Step 1:** the first tab A is pulled to approximate the patient’s age to the IOP

**Step 2:** without moving slide A, adjust slide B to set CCT at PSD

**Step 3:** now without moving B, read the 5 year risk of developing glaucoma by correlating the vertical C: D ratio with the percentage mentioned. This box has two rows depending upon the presence of diabetes mellitus.

The 6 risk factors to be used are assessed as
1. Age- at current visit
2. Baseline IOP- average of untreated IOP for both eyes determined in 2-4 visits in the past 6 months
3. CCT- average of 3 different measurements from both eyes in the same visit
4. PSD- average of both eyes as stated in the most recent visual field index report
5. Vertical C: D ratio- average for both eyes
6. Diabetes mellitus- yes or no

**Recommended action**

<table>
<thead>
<tr>
<th>Risk Level</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low risk</td>
<td>&lt;5% Observe and monitor</td>
</tr>
<tr>
<td>Moderate</td>
<td>5-10% Consider treatment</td>
</tr>
<tr>
<td>High</td>
<td>&gt;15% Treat</td>
</tr>
</tbody>
</table>

These recommendations should be considered along with the following aspects
1. General health status and life expectancy
2. Efficacy, safety, cost and convenience of the drugs to be used
3. Patient’s comfort level with degree of risk

In choosing patients for treatment, clinicians need to decide when the pros of the treatment outweigh the cons. And by directing the treatment primarily to patients with moderate to high risk of developing disease will increase the benefit: risk ratio of therapy.

It is to be kept in mind that the tool is not intended to substitute for clinical judgment and experience. Appropriate treatment is to be varied based on individual patient characteristics. This tool is applicable for untreated patients with ocular hypertension and should not be used to evaluate risk in treated patients or to reassess risk after the patients has started treatment.

By identifying patients with a higher chance of developing damage, the risk calculator can help physicians make decisions leading to more rational treatment of patients at highest risk, as well as discontinuing treatment and monitoring of patients at lowest risk. This could result in greater consistency in treatment, improving quality of care for patients with ocular hypertension and a decrease in patients who go on to develop glaucoma.

**References**

Risk Assessment in Patients with Ocular Hypertension

Tutul Chakravarti, MBBS, DO, DNB

Management of patients with ocular hypertension is complicated by the unpredictable course of the disease and by the evidence that only a subset at these patients with ocular hypertension will develop OAG during their lifetimes. According to the Ocular Hypertension Treatment Study (OHTS) findings, the cumulative probability of developing glaucoma after 5 years is 9.5% (untreated subjects developed glaucoma at twice the rate of treated subjects at 5 years, 9.5% vs. 4.4%) in eyes with untreated ocular hypertension. Frequently it is difficult for ophthalmologists to decide which patients to treat and how aggressively to treat a patient with ocular hypertension.

Even after the valuable contributions from the OHTS, particularly in identifying risk factors for progression to glaucoma, in individual patient over given time periods, or perhaps more importantly over a patient’s lifetime, are not yet available. Factors like, elevated IOP and increased cup-to-disk ratio, older age, and thinner cornea appear to be the most useful indicator of progression.

Increased cup-to-disk ratio possibly is indicating early structural damage in an individual with ocular hypertension. The thinner corneas are associated with increased risk, and the measurement of central corneal thickness is becoming a standard for patients at risk for ocular hypertension and glaucoma progression.

The glaucoma process

Glaucoma is a neuro degenerative disease of the optic nerve. The goal of treatment is to arrest, delay, or limit progression of predisposing ocular hypertension or early optic nerve damage to significant visual impairment in the early stage of the disease.

Glaucoma risk factor assessment

Lessons from Coronary Heart Disease

Chronic Heart Disease and Glaucoma are chronic and progressive diseases.

Both diseases are associated with modifiable risk factors. Epidemiological research in preventing cardiology for more than 50 years initially identified elevated cholesterol level as a primary risk factor for CHD. This experience of cardiovascular disease prevention may be useful to examine when playing development of risk factor assessment for prevention of visual field loss due to glaucoma. CHD model is used to find out the risk factor assessment in to the management of ocular hypertension.

Mean IOP: There is strong evidence that an elevated IOP level is associated with progression from ocular hypertension to primary open angle glaucoma. Some studies have not found higher IOP level to be associated with risk of disease progress OHTS, univariate and multivariate analysis found that every 1mm of Hg increase in mean IOP was associated with a 10% increase risk of progression from OHTS to Glaucoma.

Greater Cup to Disk ratio: There is consistent and strong evidence that increased cup to Disk ratio is an independent risk factor for the progression of ocular hypertension to glaucoma. Greater cup-to —disk ratio (>0.4/>0.5) also has been identified as a baseline risk factor for disease progression.

Central Corneal Thickness: Central corneal thickness has been a strong and independent risk factor for progression from ocular hypertension to POAG. That there is a potential correlation between corneal thickness and ocular hypertension has been established on the basis of a cross sectional, observational study. The patients with ocular hypertension and Visual field loss detected by SWAP had significantly lower corneal thickness measurements than the patients with ocular hypertension and normal visual field results. None of the patients with central corneal thickness > 600μm had abnormal SWAP findings.

Age: there is strong evidence that older age is an independent risk factor or the progression of ocular hypertension and glaucoma.

Black Race: Studies have reported a notably higher prevalence of glaucoma in individuals of black race when compared with other racial groups.

Family history of glaucoma increases the risk of an individual developing the disease, but the evidence for progression is weak.

Diabetic Mellitus: Analysis of the OHTS results suggested that diabetes protects against progression to glaucoma.
**Questions answered and unanswered**

- There are few marked differences between CHD and Glaucoma risk assessment and preventions.
- The OHTS findings are based on a relatively small select population of patients with ocular hypertension, making the study less generalized and not applicable to screening or population based intervention.
- Glaucoma prevention presently is limited to modifying a single risk factor (decreasing IOP level) whereas CHD has multiple modifiable risk factors.
- Though Ophthalmologists increasingly are able to measure IOP accurately and are beginning to understand the factors that affect IOP levels, many unknowns still exist.

For example the effect of fluctuation in diurnal IOP and nocturnal IOP on disease progression remains unclear and needs further evaluation. It is possible that period diurnal or nocturnal IOP fluctuations, which were not assessed in the OHTS may add to the risk of progression.

- Again IOP asymmetry was not assessed in the OHTS. Large differences in IOP levels between eyes was associated with progression from ocular hypertension to glaucoma. In another study such large difference between the two eyes were reported to be more common in patients with ocular hypertension (33%) and POAG (36%) than in normal subjects (10%).
- It is possible to argue that large cup-to-disk ratios in ocular hypertension patients may be an indication of early structural damage and not a risk factor. In fact, the finding of short-wavelength automated perimetry (SWAP) defects in 20% of patients on OHTS baseline indicate that limitations in detection may have allowed at least some of the OHTS patients with existing optic nerve damage to enter the trial.

- Patients having thicker corneas may represent structural difference in the optic nerve architecture which are protective against the development of glaucoma. An alternative possibility is that those with thicker corneas and measured IOP elevations that did not actually have ocular hypertension and another subgroup with thin corneas that may have had higher IOP levels than measured.

- Strong support for an association between family history and progression from ocular hypertension to OAG is lacking. Family history of glaucoma was not identified as a risk factor in the OHTS analysis.

- There was also an association between pseudoexfoliation and ocular hypertension, although this relationship was not significant.

**Conclusions**

This article summarizes and discusses different studies based on assessment of risk factors for the progression of ocular hypertension and glaucoma.

This article intends to address the needs of students and examinees (DO, MS & DNB). The author will be happy to interact with them if there is further question. All correspondence may likely be sent to drtutul@hotmail.com

**References**


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**THE GLAUCOMA PROCESS**

**NOT DEFINITELY DAMAGED**

**ASYMPTOMATIC GLAUCOMA DAMAGE**

**GLAUCOMATOUS DISEASE**

- Normal
- Acceleration of apoptosis
- Ganglion cell death / Axon loss
- Retinal nerve fibre layer change
- [undetectable]
- AS YMTOMATIC GLAUCOMA DAMAGE
- VF Changes are detectable
- Loss of perimetry sensitivity
- VF Changes are moderate
- VF Changes are severe
- Blindness
Lid injuries are on the rise primarily because of the increasing incidence of road traffic accidents, industrial mishaps and intentional assaults on the human body. Injury to the lids often occurs in association with injury to other parts of the body particularly the head and the face. Before proceeding to the management of localized injury the basic "ABC’s" (Airway, Breathing, Circulation) must be evaluated. It is also mandatory to rule out a cervical spine injury, intracranial injury or an occult chest and abdominal trauma. Therefore appropriate consultations should be performed.

**Ophthalmological Examination**

Before examining the adnexal injury, evaluation for any evidence of the eyeball or optic nerve injuries should be done. In a conscious patient, visual acuity, pupillary responses, slit lamp examination, IOP and dilated fundus examination should be performed. Even in an unconscious patient a complete ocular examination is possible.

**Adnexal examination**

1. **Duration:**
   The time lapsed since the patient suffered injury is important to decide the approach to wound repair.

2. **Mode of injury:**
   The mechanism of injury can indicate the depth of a wound and if a foreign body may be present.

3. **Site and extent of injury:**
   The extent and site of injury are important to delineate if the septum, canaliculus or the lid margin (fig.1) is involved. Lid position and levator function should be assessed (fig.2). Injury to Levator muscle or aponeurosis is diagnosed by asking the patient to look up as his frontalis muscle is blocked by pressing on the forehead. Inability to look up or absence or any wrinkling of the upper lid skin suggests injury to levator complex. Rounding or displacement of the canthal angles should be noted. A laceration medial to the punctum and lateral punctal displacement means there is a canalicular injury.

4. **Tissue Loss:**
   It is essential to note whether there has been an extensive tissue loss because it may necessitate the use of skin flaps from adjacent areas or free skin grafts.

5. **Infection:**
   The wound should be examined for signs of gross infection. If present, the wound repair may be postponed for a few days till the infection subsides.

6. **Margins:**
   The wound should be examined for presence of necrotic or devitalized tissue, which must be excised. The ragged edges of the laceration also have to be converted to smooth edges for better surgical apposition.

   The orbital evaluation is also necessary to rule out an orbital floor fracture, compression of optic nerve or presence of a foreign body. Therefore extraocular movements, diplopia in all fields of gaze are checked. Orbital rims are palpated. Significant tightness of the orbit should raise suspicion of compression of optic nerve. Orbital C T scan is the study of choice for an acute trauma setting. MRI is useful to identify optic nerve injury.

**Preparation of the Patient**

- Intravenous antibiotics should be administered
- Tetanus toxoid, 0.5 ml should be given if patient has not had a tetanus immunization within 5 years. If the patient was never immunised, 250 units of human tetanus immune globulin is given.
- Fasting for atleast 8 hours is necessary if general anaesthesia is required.
- Preparation of wound is done by cleaning the wound thoroughly with saline and betadine and is kept moistened with a wet gauze.

**Timing of the Surgery**

**Primary repair**

In patients presenting within 24 hours of the injury primary repair of the wound is undertaken immediately.
The primary repair affords the chance for best cosmetic and functional results.

**Delayed primary repair**

In cases where patient presents more than 24 hours after injury or in cases where there is marked lid edema or infection, a delayed primary repair is performed after 3 to 4 days. During this waiting period, tissues should be repositioned into as near their normal anatomic position as possible. Anti-inflammatory and antibiotics are administered to reduce tissue edema and to control infection.

**Secondary wound repair**

In cases where the patient presents a long time after injury or in cases of chemical & thermal burns, healing by second intention must be allowed to take place. In such cases, one must wait for a minimum of 5 to 6 months before planning a secondary wound repair.

**Anaesthesia**

Simple lid lacerations can be repaired under local anaesthesia if the patient is cooperative.

Extensive lid injuries, canalicular injuries, poorly cooperative patients and children should ideally be managed under general anaesthesia, as it allows a thorough examination and gives the surgeon flexibility of time. Even with the patient under general anaesthesia the injured area may be infiltrated with 2% xylocaine with adrenaline to ensure better haemostasis. One should avoid injecting too much lest the local anatomy gets distorted.

**Goals of Eyelid Repair**

1) To reestablish anatomical configuration.
2) To restore physiological function.
3) To provide better cosmetic appearance.

**Principles of Wound Repair**

- Thorough exploration should be performed to establish extent of injury.
- All foreign bodies should be removed.
- Debridement of only devitalized tissue is done.
- Wound margins are freshened if ragged or devitalized.
- Important landmarks are identified before closing the wound like hairline of the brow, acute angulations, apices of traumatic flaps.
- The orbital septum should not be incorporated in the repair of the lids as it can lead to marked lid retraction and lagophthalmos.
- If the septum is violated, exploration of the wound for deeper injuries or foreign bodies should be performed.

**Primary Wound Management**

**Repair of Non-Marginal Lid Defects**

**Simple Lacerations**

Smaller linear defects can be sutured without any undermining. But the round defect should be converted into an elliptical shape. There should be no tension or vertical pulling effect on the lid margins. Horizontal lacerations approximate spontaneously owing to the orbicularis action. The edges of vertical partial thickness lid lacerations usually retract and thus require the use of interrupted fine sutures to close the skin muscle layer. Non-absorbable skin sutures should be removed in about 5 days. The vertical linear wounds may be broken into multiple Z plasties in order to improve the scar.

**Complex lacerations**

Complex lacerations include deep nonmarginal lacerations, irregular shaped lacerations and lacerations with tissue loss. Deep lacerations require careful layer-by-layer inspection of the wound to assess the integrity of the orbital septum, levator aponeurosis, rectus muscles, and globe. The internal structure must be carefully reapproximated, followed by closure of the superficial portion of the wound. Lacerations of V type in which apex is devitalised can be transformed into a Y shaped configuration after the devitalised tissue is removed. Wide undermining often facilitates wound closure. If closure is not possible medially or laterally based advancement flaps can be used which have incisions parallel to the lid margin.

**Repair of Lid Margin Laceration**

(i) With minimal loss of tissue: (Fig.3a)

Lid margins need be freshened if edges appear to be devitalised to form straight, smooth surgical edges, sacrificing, as little tarsus as possible. The margin is then repaired using the three-suture technique. Use of magnification helps the repair a great deal, attempting primary closure without magnification may lead to wound dehiscence or notching.

Lid margin sutures are passed first. A 6-0 silk suture is passed just behind the grey line 3 mm from the edge of the tear, to a depth of 3mm. This is brought out of the wound and reinserted into the other side of the laceration 3 mm deep to the lid margin and emerging through just behind the grey line 3 mm from the edge of the wound. The same suture is then passed back behind the grey line on the same side, 1 mm from the edge of the tear, to a depth of 1 mm. The needle is brought out and reinserted into the opposite edge of the tear 1 mm deep to lid margins and emerging behind the grey line 1 mm from the margin of the wound. Two more vertical mattress sutures are passed exactly in the same way through the anterior lash line and...
in the plane of the Meibomian gland openings. These three sutures are triply tied and ends left long. (Fig.3b)

The three lid margin sutures are tied together under the knot of the anterior marginal suture so that ends will not rub against the cornea. There is no need to place sutures on the conjunctival surface since it will heal with the approximated tarsal edges. The eye is patched for 24 hrs. Skin sutures are removed in 5 to 7 days. Lid margin sutures are left in situ for 14 days.

(ii) With moderate loss of tissue (From one fourth to one half of eyelid).

In such cases, closure can be obtained by performing
1) a lateral canthotomy and cantholysis of either the upper or lower limb of the lateral canthal tendon, depending on the eyelid involved.
2) Tenzal flap, by creating a semicircular flap.
3) Transconjunctival flap, or free transconjunctival graft
4) Mustarde's marginal pedicle rotation flap

(iii) With severe loss of tissue (more than half of eyelid)

Tissue transfer techniques from the opposite eyelid or surrounding tissue will have to be performed. The commonly used tissue transfer techniques are
1) Cutler Beard procedure.
2) Hughe’s tarso conjunctival advancement flap.
3) Mustarde’s cheek rotation flap.
4) Free transconjunctival graft and mucocutaneous advancement.

(iv) Total loss of tissue

Total loss of tissue may involve a single eye lid or both lids may be lost. If only lower lid is lost the repair is slightly easier as compared to the upper lid loss, as corneal exposure is not a consideration. In upper lid loss and loss of both lids, protection of the cornea should be undertaken on an emergency basis. In this condition our primary aim is to protect the cornea.

Trauma to Levator Muscle or Aponeurosis

Patients with traumatic ptosis after blunt trauma should be observed for at least 6 months before definitive repair is attempted. It is possible to see a spontaneous improvement. If the septum of upperlid is disrupted (Fig.4) and the orbital fat is exposed, the wound should be explored for injury to levator aponeurosis or muscle.

A good regional anaesthesia is essential in finding the levator complex while exploring the wound. The Levator palpebrae superioris (LPS) fibers are identified by their vertical orientation, in comparison with the Orbicularis muscle fibres, which run circumferentially.

If the aponeurosis has been disinserted from the tarsus, the divided proximal end of the levator should be sought at the time of primary wound closure by asking the patient to look up. The cut edge is drawn forwards and reinserted by placing three 5-0 double arm vicryl sutures through the tarsus about 3 to 4mm above the lid margins. Both arms of the suture are then passed through the aponeurosis. If the patient is awake and if only a sensory frontal - N. block is used, the level of aponeurosis can be adjusted by having the patient look in the straight ahead gaze. After the aponeurosis is restored to the tarsus, the rest of the laceration is repaired as in any other case.

If the orbital septum has been opened due to the injury, it should not be sutured since this could result in lagophthalmos. If the laceration is at the level of the lid fold, the eyelid crease is recreated by placing 2-3 sutures. The sutures are passed through the skin muscle layer to include a superficial bite of the levator aponeurosis.

Injuries Involving Medial Canthus

Partial or full thickness lid lacerations of the medial canthal region are repaired as described below. Contraction of the resulting scar may result in ectropion and epiphora.

Avulsion of the lid at the medial canthus mostly involves the lower lid. (Fig.5&6) In such cases, one must attempt to reconstruct the medial canthal tendon (MCT). The distal cut end is identified and sutured to its proximal part.
with a 4-0 nonabsorbable suture (nylon/prolene). If the proximal part cannot be identified, as when it is avulsed from its insertion, the distal portion of the MCT is sutured to the periosteum in the region of the nasomaxillary suture. This ensures it is anchored adequately, so that the puncta are turned inwards and ectropion does not result.

In case the injury is more lateral, the divided tendon must be sutured to the medial end of the lower tarsal plate using a 4-0 non-absorbable suture.

**Injuries Involving Lateral Canthus**

Lacerations in the lateral canthal region are treated as those at the medial canthus but without involving the complication of search for and repair of the canaliculi. However, lack of proper technique in repairing these lacerations may lead to rounding of the lateral canthus.

If the lateral canthal tendon (LCT) is found to be severed, (Fig.7a) it is repaired by passing non absorbable 4-0 prolene as mattress sutures through both ends. When the lateral end cannot be found, the medial end of the severed tendon should be anchored to the peri-orbita on the inner aspect of the lateral orbital tubercle (whitnall’s tubercle), using a double arm 4-0 non-absorbable suture. (Fig.7b)

**Total Avulsion of Eyelid**

In this condition avulsed segments should be found and the avulsed tissue placed in a sterile container containing antibiotic solution and stored in a refrigerator until it can be surgically reimplanted.

**Management of Canalicular Laceration**

All canicular lacerations should be primarily repaired as early as possible as an early repair is easy and more successful than late repair.

Avulsion of lid at the medial canthus or lacerations in this region will result in complete severance of the canaliculi. It is important never to sacrifice the upper canaliculus and it must be repaired in the same fashion as a lacerated lower canaliculus.

The first step is to identify the two cut ends of the canaliculi. (Fig.8a) The lateral cut end identified by passing a lacrimal probe through the punctum. To identify the medial cut end, the wound is examined under magnification, preferably an operating microscope. The tiny opening of the cut canaliculus is rather paler than the surrounding tissues. However, if the cut end is not obvious, it is identified by pooling sterile saline in the wound and then watching for bubbles while injecting air from the upper canaliculus. The use of a pigtail probe to identify the medial end of the lacerated canaliculus should be avoided because of the risk of creating false passages and trauma to the intact canaliculus.

Once the 2 cut ends are identified, the general concept of canalicular repair is to pass an internal stent to bridge the laceration and to reestablish the continuity of the disrupted canalicular epithelium. (Fig.8b) There are multiple options for stent selection. Monocanalicular stents (Viers rod, sialistic tube) or bicanalicular stents (Pigtail, nasolacrimal probe). Our preferred technique is to use a monocanalicular stent as there is no risk of damaging the opposite intact canaliculus. A 22 gauge cannula (venflon) sleeve after removing the sharp tip of the stellate is introduced up to the medial sac wall. Then pericanalicular bites are taken, posteriorly and anteriorly for recanalisation of the canaliculus with 8-0 non-absorbable sutures (nylon/prolene).

The lid margin wound is closed by the technique of marginal repair, as described and MCT if severed should be repaired before tying the canalicular sutures so that there is no traction on the canalicular edges. The sleeve is left in place for at least 3 months.

Monocanalicular stent is fixed by double arm sutures passed through the tube and the eyelid skin over a peg. These sutures are then carried subcutaneously upwards and medially and tied again over a peg. These sutures provide an upward and inward traction to the tube preventing its extrusion. (Fig.8c) To aid in its retention, the silicone tubes may be passed into the nose by using Quickert-Dryden probing system wherein the silicone tube is fixed to a malleable
probe which is passed into the inferior meatus through nasolacrimal duct and recovered from there. The other end of the tube is also passed into the nose from the opposite punctum. This ensures retention of the probe for the required period of time.

Secondary Repair of Lid Injuries

Disfiguring, puckering, distortion and eversion of the lid are due to poor surgery, late surgery, or lack of any surgery. All will need secondary repair.

Timing of the repair of secondary contracture is extremely important and as a general rule, scars should be left for five to six months before any secondary surgery is carried out. The objective of surgical reconstruction is to release contractures by removing all scar tissue and replacement of the defect with skin.

The secondary repair of lid injuries will be dealt with under the following sequence:
1. Marginal misalignment
2. Cicatrical ectropion
3. Canthal displacements
4. Traumatic ptosis
5. Traumatic symblepheron
6. Traumatic ankyloblepharon
7. Traumatic epicanthal fold
8. Traumatic coloboma of the lid

Minor to moderate scar

When the scar tissue remain limited to the lid margin without extending any distance in to the lid, excision of the scar tissue and resuturing of the marign gives sufficiently good results. (Fig.9a&9b)

Severe scarring

When the scar extends in to the pretarsal or preseptal zones of the lid, excision of all scar tissue must be combined with a Z plasty of the skin muscle flap.

Deep or ragged scars left by lid trauma, contract as they mature over the months following primary repair and may distort the tissue. Although the scar formation following maticulus primary repair is less but in neglected wound even if it is small, the chances of scar formation is very high. Simple linear scar may be excised and then corrected most simply by Z plasty or series of small Z plasties to lengthen and break up the line of the scar.

The commonly used procedures are Z plasty and V - Y plasty.

Z-plasty: is a transposition of triangular shaped skin flaps. It serves to lengthen or changes the tension on an antecedent scar or wound defect. If the scar tissue is very long, multiple Z plasties can be prepared to achieve maximum lengthening effect.

Marginal Misalignment

Non repair of lid laceration or faulty repair of the full thickness lid laceration involving the lid margin, results in excessive scar formation which contracts in a vertical direction resulting in a notching of the lid margin. Such type of deformity in the lid may lead to corneal exposure.

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V-Y Plasty

A V-shaped incision is given on the line of scar with the apex of the V centered in it. The surrounding tissue external to the V is undermined. This results in release of the V in one direction thus lengthening the base of the V. The areas is then closed by suturing the former base of the V in a linear fashion with interrupted 6-0 silk. The arms are thus converted in to Y6.

Anterior lamellar scarring often results in significant skin shortage. In upper lid the skin crease and in lower lid lower subciliary crease are usually the most appropriate sites for the first incision which may reduce the appearance of the scar size. Hence all lid surgery should be done in the above lines to avoid postoperative scar and to give better cosmetic results.

During revision of the scar the levator muscle and the canaliculi should be isolated and protected during the division of the adjacent scars. Some time superior rectus muscle also need protection. To avoid the injury to the canaliculi (if scar near the lacrimal canaliculi), lacrimal probe should be pass through the punctum to the sac-wall.

The scar tissue should be completely excised, including deep tethering of the scar to underlying muscle, periosteum or the globe itself. Once all the distorting forces on the lid are divided, the size of the area of the skin loss can be measured and then grafted. Ideally the skin from hairless and color match area is used for grafting. The lid crease may be reformed where necessary by using skin muscle suture.

Canthal Malposition

Canthal malposition may involve the medial canthus or the lateral canthus. Medial canthus may show either a vertical displacement or a shift laterally. Traumatic telecanthus may occur from injuries by cutting instruments or direct blunt injury to the nose and canthal region. This requires shortening of the medial palpable ligament by tucking or transnasal wiring. Vertical displacement (Fig.10) of the canthus may occur in isolation or in association with other injuries. It may be corrected by a Zplasty, in cases where the lacrimal canaliculi are already compromised due to trauma. Transnasal wiring may be necessary to reform the canthal angle in cases where the problem is more severe. (Fig.11a&11b)

Rounding of the lateral canthus follows a long standing division of the canthal tendon. This may be repaired by recreation of the original injury and suturing the divided tendon, the exposed cut edges of the tarsal plate with 5-0 prolene/nylon or the inside of the orbital margin or to the periosteum. (Fig.12a&12b)

If the rounding is marked, the junction of the two lids is divided completely and resutured in an acutely angled fashion.

Traumatic Ptosis

Traumatic ptosis occurs due to palpebral, orbital or intracranial injury.

A traumatic ptosis should be observed for at least six months or until no further spontaneous return of function is occurring. An exception to this general rule is in the young children where the possibility of occlusion amblyopia is being considered.

If traumatic ptosis is due to dis-insertion or laceration of the levator palpebrae muscle, (Fig.13a) it is important to identify the levator muscle, so that its tendon can be returned to the upper margin of the tarsus during the surgery.

In other cases a Fasanella Servat procedure, (Fig.13b) levator shortening procedure, or frontalis sling procedure will be required. Choice of procedure may be made on the basis of...
evaluation as for any other case of acquired ptosis.

Cicatricial Ectropion

Cicatricial ectropion produces the greatest deformities of the lids and can endanger the cornea due to lagophthalmos. The most pronounced degrees of ectropion, commonly occur after extensive burns of the face due to contracture of the anterior lamella of the lid. Treatment of non-operative nature may be effective in minor and temporary cases.

The permanent or surgical management depends on tissue loss.

In absence of tissue loss, single or multiple Z-Plasties may be carried out to achieve the correction. Some times a V-Y plasty may be carried out. (Fig.14a, 14b&14c)

However if the ectropion is related with tissue loss, then extensive excision of scar tissue with replacement of tissue or anterior lamella is required. The replacement of tissue may comprise:

1) Split skin grafting (Fig.15a & 15b)
2) Full thickness skin grafting
3) Flap cover

The basic guidelines for skin grafting for ectropion are:
• Upper eye lid should be repaired first. Preferably one eye lid at one time.
• Partial thickness graft is preferred for upper lid and full thickness skin graft for the lower lid.
• Hairless and color matched skin is taken for grafting.
• The graft should be at least a 30% over correction of the defect created by the lysis of the scar to allow for postoperative graft contraction.

At times lid shortening is also necessary, to correct horizontal lid laxity caused by the scarring that stretches the lids.

Coloboma of Lid

Incidence of traumatic coloboma of the lids are on the rise primarily because of increasing incidence of road traffic accidents, industrial mishaps and intentional assaults on human body. Extensive laceration with loss of tissue generally lead to traumatic colobomas. It may be either a partial or a full thickness defect of the lid margin.

Management is determined by the size of the defect and the state of the corneal epithelium. Initially it is possible to manage most of the defect with conservative measures i.e. topical lubricants and bandage contact lenses. In general, colobomas of the lower lid are better tolerated than those of the upper lid. Trichiasis is frequently associated and is often the precipitating factor in the decision to operate. Small defects (<30%) can be repaired by direct layer closure. Moderate defects (30-50%) of the upper and lower lid should be converted to a pentagonal lid defect by freshening the margins and closed with or without a lateral cantholysis and a semi circular flap as described by Tenzel. Large defects (.50%) are better repaired.

Fig.14a: Cicatricial ectropion of medial lower lid. Fig.14b: Relaxing Z&V incision given at medial canthal scar tissue. Fig.14c: Suturing of V&Z, correcting the ectropion.
Traumatic Epicanthal Fold

Traumatic epicanthal fold may result from facial injuries, where one or both canthi are displaced medially. On examination there is a vertical fold in the medial canthal or lateral canthal area. (Fig.16a) It may develop in any vertical or near vertical scar which exist in the skin around either the medial or the lateral canthus.

The traumatic epicanthal fold is generally corrected by V-Y technique as described by Callahan and Callahan in 1979 or a Z-plasty may be used. (Fig.16b) It is important to carefully dissect the orbicularis from the transposition flap in order to flatten the medial canthal area. Meticulous suturing of the skin edges is needed to reduce post-operative scarring. (Fig.16c) It may be ameliorated with topical steroids.

Traumatic Ankyloblepharon

Traumatic ankyloblepharon is the union of the lids at the lateral canthus resulting from contracture of traumatic scars. It is essentially different from lateral displacement of the canthus in that medial canthal tendon itself is undisturbed and the actual canthus is not in an abnormal position. Treatment is by simple division of the web right up to canthus, trimming away excess skin where necessary, and attaching skin to mucosa along the lid margin using interrupted silk sutures. When the punctum and canaliculi are involved, then any repair of this area should involve careful identification of these structures. The use of punctoplasty with canalicular intubation of the canicular system to re-establish patency of the drainage system may be required.

Traumatic Symblepharon

Traumatic Symblepharon occurs when there is adhesion between the bulbar and palpebral conjunctiva of the eyelid due to trauma. This condition may arise after penetrating injury of the eyelid, lacerated injury or burns, which lead to a bridge of mucosa running from the lid to the globe with normal fornix lying peripheral to it (deep). It is often associated with diplopia due to globe restriction due to symblepharon and may range in severity from mild to total. (Fig.17a)

Treatment consists of operative separation of the lids. Incision is given to the conjunctiva parallel to the border of symblepharon from its end to the tarsal border. After dissecting the conjunctival flap, it is secured to the internal aspect of the lid. The bare sclera is then covered with conjunctival flap or mucosal graft and symblepharon ring is kept in situ for 8-12 weeks. Once the graft is vascularised after 1-2 week a topical steroid is applied. (Fig.17b)

Conclusion

Adequate primary repair of the lid injury gives the most satisfactory results and meticulous repair is mandatory for lid injuries. However in certain conditions,
secondary repair also gives reasonably better correction as far as functional and cosmetic results are concerned.

References

2. Committee on Trauma of the American College of Surgeons: Advanced trauma life support course, Chicago, 1984, American College of Surgeons.
Correcting -30 D with ICL, AK and E-lasik
Sanjay Chaudhary MS, Ajay Aurora MS, Neeraj Sanduja MS

How many of us have even encountered myopia of -30D, a far cry from even the thought of managing such a situation. With the combination of new technologies, we have made a -30D patient emmetropic while still retaining his active accommodation.

Mohit Bakshi had a myopia of over -30 D
Mohit Bakshi, a 20-year-old boy, with a pathological Myopia visited our clinic on 20.4.2006 for a refractive procedure to correct his eyesight. His refraction in the right eye was -29.0-2.25x20° with a vision of 6/18 and in the left eye -24.0-2.25x160° with a vision of 6/12. After a combined procedure of ICL (Phakic IOL), Astigmatic Keratotomy and E-lasik, he is emmetropic in both the eyes with an active accommodation.

Introduction
There are two ways to correct a person who presents with myopia of over -20. One is Phakic IOL (ICL or Verisyse), which comes with a maximum power of -23 and can correct myopia of -19.5. If the eye has a cylinder power too, incorporating the cylinder into the lens reduces the effective power of the lens the cylindrical correction can be reduced or corrected by Astigmatic Keratotomy thus giving the maximum advantage to the spherical power of a Phakic IOL. If this combination does not suffice and there is still a residual myopia, it needs to be corrected by a corneal-based refractive procedure such as E-lasik. E-lasik is the procedure of choice, as lasik requires building up the IOP to 65 mmHg, which puts the retina, the corneal astigmatic incisions and the Phakic IOL to risk. AK also helps in reducing the depth of tissue ablation in E-lasik. The depth of tissue ablated for 2 D of cylinder is similar to that for 2D of spherical correction.

The second option is a refractive lens exchange, where the crystalline lens is replaced with an IOL of predetermined power. There is a loss of accommodation, so it is best avoided in young people where accommodation is active.

Bioptic
The term essentially means using two refractive procedures to correct a refractive error. This term is used to describe a correction of residual refractive error post cataract with lasik since cataract is now also a refractive procedure. Importance of bioptic is more relevant in multifocal IOLs where a pre-existing cylinder or a residual spherical power would jeopardize the outcome.

The term is also extended to include any mixing of two refractive procedures. In correction of very high myopia with refractive error of over -20, a use of a Phakic IOL like the ICL along with E-lasik can achieve the target.

Implantable Contact Lens (ICL-V4)
This is a type of Phakic IOL developed by Staar Surgical, Switzerland and is a posterior chamber lens.

It has a plate haptic design and is made of Collamer. The thinnest part of the optic may sometimes be just 50 microns. It can be injected through a 3.2 mm incision and
is positioned between the iris and the crystalline lens. The haptic rests on the suspensory ligaments or the ciliary sulcus. The central part of the lens has an anterior vault and helps to maintain a sufficient distance between the ICL and the crystalline lens in the V4 design. Even when the natural lens accommodates and the anterior capsule moves forward, it does not come in contact with the ICL. This has brought down the incidence of cataract to less than 1%.

**Discussion**

**Lasik in myopia of -8 to -14D**

Lasik is the procedure of choice in myopia of -8.0D or less because it just involves remodeling the cornea without entering the globe. It is a walk in, walk out procedure with a very high degree of accuracy and patient satisfaction. Beyond the power of -8, the additional amount of corneal flattening increases the spherical aberration many folds and causes a marked reduction in contrast sensitivity. Higher depth of ablation also has an inherent risk of ectasia. Still its advantages outweigh the disadvantages and in our clinical practice, we use lasik for correction up to -14 D or an ablation depth of 130 microns, thickness of cornea permitting. Beyond the level of -14D, we prefer to look for alternative procedures.

**Case report**

Mohit Bakshi, a 20-year-old boy has pathological Myopia

**Anterior segment evaluation:**

Normal

**Post segment evaluation:**

Lattice with holes. LIO was done by a Retina Specialist

A decision to use a Phakic IOL like ICL was made on the following parameters:

<table>
<thead>
<tr>
<th></th>
<th>Right eye</th>
<th>Left eye</th>
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</thead>
<tbody>
<tr>
<td>Refraction</td>
<td>-29.0-2.25x20°</td>
<td>-24.0-2.25x160°</td>
</tr>
<tr>
<td>Vision (BCVA)</td>
<td>6/18</td>
<td>6/12</td>
</tr>
<tr>
<td>White to white</td>
<td>11.5mm</td>
<td>11.5 mm</td>
</tr>
<tr>
<td>ACD</td>
<td>2.76mm</td>
<td>2.76mm</td>
</tr>
<tr>
<td>K</td>
<td>43.5/45.25</td>
<td>43.25/45.00</td>
</tr>
<tr>
<td>Corneal thickness</td>
<td>551</td>
<td>550</td>
</tr>
<tr>
<td>Endothelial cell density</td>
<td>2892</td>
<td>2822</td>
</tr>
</tbody>
</table>

**The lens parameters calculated were as follows:**

ICM120V4 -23.0  ICM120V4 -23.0

Where 120 mm is the size of the lens, V4 the lens model and -23 the power of the lens. The lens does not come beyond the power of -23

**First surgery ICL**

Bilateral simultaneous implants under topical anaesthesia with astigmatic Keratotomy by Dr. Sanjay Chaudhary on 10.5.06.

**Result as on 10.06.06**

| Acceptance Right Eye | -6.5-1.25x15° | Left Eye | -5.5-1.0x155° |
| Vision Right Eye     | 6/12         | Left Eye | 6/9           |

**Second surgery Lasik (E-lasik)**

Bilateral E-lasik under L.A. on 12.8.2006 by Dr. Sanjay Chaudhary

**Result**

<table>
<thead>
<tr>
<th>Right eye</th>
<th>Left eye</th>
</tr>
</thead>
<tbody>
<tr>
<td>emmetropic</td>
<td>emmetropic</td>
</tr>
<tr>
<td>6/12 unaided</td>
<td>6/9 unaided</td>
</tr>
</tbody>
</table>
if the corneal thickness permits for correcting myopia of over -14D with an active accommodation, the procedure of choice becomes a Phakic IOL. With an option of both the spherical and the toric lenses, the myopia along with the myopic astigmatism can be fully corrected. The IOL power calculation formulae’s are fairly accurate, no spherical aberration is induced, and there is usually a gain in 1-2 lines on the snellens chart attributed to reduction in the minification of the retinal image. This gain is more than that seen with lasik when handling a similar power and is attributed to the preservation of contrast sensitivity and a Galileo’s telescopic effect of a two lens system when dealing with a Phakic lens.

ICL or Verisyse Phakic IOL

We are using both the phakic IOLs. 

**ICL** is posterior chamber IOL and can be used only if the anterior chamber depth is more than 2.75mm. Anterior chamber depth is measured from the endothelium to the anterior corneal surface. It is well away from the endothelium and therefore endothelial cell loss is of no concern and endothelial cell density calculation is optional for the procedure. However, the lens is close to the crystalline lens and there is a risk of cataract formation. With the present V4 design which has a sufficient anterior vaulting, the risk of the ICL touching the lens is minimal and the incidence of cataract now less than 1%.

**Verisyse iris claw** Phakic IOL is clipped to the iris and is an anterior chamber IOL. Its proximity to the endothelium may be a cause of concern to a refractive surgeon. It can be used only if the anterior chamber depth is more than 3 mm. In our series of 40 patients, we reported an endothelial cell loss of 5.5% with a near stability at 6 months. The loss was more in our first few cases and is less than 4% in our later series. International literature also supports similar observations. The IOL is well away from the crystalline lens and therefore the eye is at a negligible risk of developing cataract.

*Our choice:* When it comes to taking a risk with the endothelium or the crystalline lens, we prefer the crystalline lens, as cataract is a safely treatable entity

**Refractive lens exchange (RLE) in Myopia of over -14D and age over 40 years**

When lasik is not to be done even if the corneal thickness permits for correcting myopia of over -14D with an inactive accommodation, the procedure of choice becomes Refractive lens exchange. Here, the crystalline lens is removed with the Phaco technique and a foldable/non-foldable IOL implanted in the capsular bag. Around the age of 40, the lens is still soft and many times it can just be aspirated out without using any Phaco power.

The degenerative effect of high myopia also results in an early cataract formation, thereby justifying the removal of this lens around the age of 40. The visual acuity improves by 1-2 lines and is similar to the effect achieved by a Phakic IOL.

Multifocal lenses are not available to correct very high myopia, but in the lesser ranges of myopia, they are useful
**Conclusion:**
The following is a ready reckoner we use in our clinical practice.

-1 to -14 (normal thickness cornea)  C-LASIK
-1 to -8 (thin cornea)  E-LASIK
-14 to -25  (Age 20-40 Yrs)  PHAKIC IOL (ICL or Verisyse)
-14 to -25  (Age Above 40 Yrs)  REFRACTIVE LENS EXCHANGE (RLE)
+1 to +5  C-LASIK
+5 to +10  RLE

in giving correction for both distance and near.

Customised Lasik (C-lasik) is still the hallmark of refractive surgery. Corneal thickness permitting, it is still the best procedure for correction low degrees of myopia and hyperopia. It is the best tool for correcting myopia till -8, and is an acceptable tool for correcting myopia till -14. Beyond this, it should be used with great caution because of its inherent properties of inducing spherical aberration due to flattening of the cornea, making the corneal surface oblate. We have used this procedure in the past years to correct myopia over -14, with fairly acceptable results (anything is better for a person with such high myopia). With better options now available to correct this range of myopia like the ICL, it is better to now restrict the lasik to -14. Several international workers have brought this level down to -8, and are using ICL beyond this level. Thin cornea's are now being accepted as inherently weak cornea's with risk of ectasia, and many workers are now advocating ICL in such situations even if the person has a low myopia and could have undergone an E-lasik.

**References**

8. The Implantable contact Lens in the treatment of myopia (ITM) Study group. U.S. FDA clinical trial of the implantable contact lens for moderate to high myopia.
Intraocular lenses have been used since 1999 for correcting larger errors in myopic (near-sighted), hyperopic (far-sighted), and astigmatic eyes. This type of IOL is also called PIOL (phakic intraocular lens), and the crystalline lens is not removed.

Once implanted, IOL lenses have three major benefits. First, they are an alternative to LASIK, a form of eye surgery that does not work for people with serious vision problems. Effective IOL implants also entirely eliminate the need for glasses or contact lenses post-surgery. IOL implants prevent cataracts from forming later in life.

Most PIOLs have not yet been approved by FDA, but many are under investigation, and some of the risks that FDA have been found so far during a three year study of the Artisan lens, produced by Ophtec USA Inc, are:

- a yearly loss of 1.8% of the endothelial cells,
- 0.6% risk of retinal detachment,
- 0.6% risk of cataract (other studies has showed a risk of 0.5 - 1.0%), and
- 0.4% risk of corneal swelling.

Other risks include:

- 0.03 - 0.05% eye infection risk, which in worst case can lead to blindness. This risk exists in all eye surgery procedures, and is not unique for IOLs.
- glaucoma,
- astigmatism,
- remaining near or far sightedness,
- rotation of the lens inside the eye within one or two days after surgery.

One of the causes of the risks above is that the lens can rotate inside the eye, because the PIOL is too short, or because the sulcus has a slightly oval shape (the height is slightly smaller than the width).

Special types of Phakic IOLs (PIOLs) are available in patients requiring IOL implantation without removal of crystalline human lens, particularly useful in refractive surgery for high myopia. For this, the eye surgeon has to determine the size of the PIOL. If the lens is of incorrect length, then it can rotate inside the eye, causing astigmatism, and/or damage to the natural lens. It can also block the natural flow of fluid inside the eye, causing glaucoma. The size is usually estimated, by measuring white-to-white, and estimating the ciliary sulcus diameter. However, the surgeon can perform 3D ultrasound biomicroscopy with for example Artemis for a completely accurate measurement. 3D ultrasound is to traditional 2D ultrasound as computer assisted tomography is to x-ray. Therefore, 3D ultrasound examination is strongly recommended, since the white-to-white guesstimate does not have a strong correlation with sulcus-to-sulcus - neither for myopic, nor for hyperopic. About 1% of sulcus-to-sulcus estimates based on white-to-white are so wrong that serious complications can arise. This type of phakic lens has to be ordered from the manufacturer, requiring a number of weeks before the surgery. However, on the other hand, the routine posterior chamber IOLs (PC-IOLs) used for routine cataract surgical cases are available with the surgical suite or doctor’s office, and the cataract surgery can usually be performed without delay once the patient is cleared for surgery.

Phakic IOLS (PIOLs) can be either spheric or toric - the latter is used for astigmatic eyes. The difference is that toric PIOLs has to be inserted in a specific angle, or the astigmatism will not be fully corrected, or it can even get worse.

According to placement site in the eyes phakic IOLs can be divided to:

- Angle supported PIOLs: those IOLs are placed in the anterior chamber. They are notorious for their negative impact on the corneal endothelial lining, which is vital for maintaining a healthy dry cornea.
- Iris supported PIOLs: this type is gaining more and more popularity. The IOL is attached by claws to the mid peripheral iris by a technique called enclavation. It is believed to have a lesser effect on corneal endothelium.
- Sulcus supported PIOLs: these IOLS are placed in the posterior chamber in front of the natural crystalline lens. They have special vaulting so as not to be in contact with the normal lens. The main complications with this type is their tendency to cause cataracts and/or pigment dispersion.

There are many different manufacturers of intraocular lenses.

**Acrylic**

- Hoya manufacturers high quality hydrophobic acrylic IOLS, distributed by Spectrum
- ERILENS produces hydrophilic acrylic lenses

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Garg Eye Institute & Research Centre, 235, Model Town, Dabra Chowk, Hisar
Medennium produces the Matrix Acrylic™ IOL, distributed by Medennium.

Ophtec produces the Artisan® lens, distributed by Spectrum

OII Intraocular Lenses produces hydrophilic acrylic IOLs.

**Silicone:**

- AMO (Advanced Medical Optics) produces the Verisyse™ lens.
- Tekia Inc. produces the Kelman Duet lens.
- The Vision Membrane phakic IOL is produced by Vision Membrane Technologies Inc., Apollo Optical Systems LLC, and Millennium Biomedical Inc.
- The PRL™ Phakic Refractive Lens is produced by Medennium, distributed by IOLTech.

**Other:**

- Staar produces the Visian ICL™ lens, in a material called Collamer®.

**Myopia**

Compared to the corneal procedures, the intraocular procedures suffer from one glaring handicap, ie, patients with the lens implants have to be under careful supervision of the ophthalmic surgeon throughout their lives to prevent or to treat any adverse development. The role of microtrauma or macrotrauma as a result of blinking, squeezing, and minor rubbing during the waking hours and involuntary hard rubbing during some phases of sleep, in producing tissue changes, cannot be overemphasized.

The future of phakic IOLs shall be determined by the newer techniques of corneal refractive surgery, especially the wave-guided ablations. Phakic IOLs cannot take care of preexisting astigmatism. Surgery might introduce astigmatism of its own. Also, with the passage of months and years, patients with phakic IOLs tend to miss detailed follow-up examinations. Situations do exist where phakic IOLs and corneal procedures can be combined to provide the best refractive results. Whether a phakic myopia IOL in a young patient will be a problem in future decades is still unknown.

Myopia is a common refractive error, which exists from a young age. A unilateral myopia, with or without amblyopia, might remain undiscovered for a long time. The treatment of unilateral myopia is not easy. Since the vision is very good in the other emmetropic eye, the child is not impressed by the glass or the contact lens for the affected eye because the child prefers to use the nonaffected eye. Most parents give up all efforts out of sheer frustration, and the magnitude of wasted sight is immense.

Slight or moderate myopia is hardly a problem as far as the vision is concerned. These patients do extremely well with glasses or contact lenses. However, high myopes do experience serious handicaps, both cosmetic and visual, for which surgery becomes a matter of importance.

Myopia is not merely a refractive problem. The importance of regular retinal examination should not be overlooked. Fundus examination may show various degrees of lattice degeneration, with or without one or more holes. The macular area may show disturbed macular reflex, chorioretinal atrophy, or posterior staphyloma.

**Patient examination**

- All patients should undergo a complete ophthalmic examination.
- Manifest and cycloplegic refraction
- Uncorrected visual acuity
- Spectacle and/or contact lens corrected visual acuity
- Slit lamp examination of the anterior segment and ocular adnexa
- IOP
- Pupil size measurement under scotopic conditions
- Corneal endothelial cell count with specular endothelial microscopy
- Biometry to calculate axial length of the eyeball and the anterior chamber
- White-to-white corneal diameter measurement, if contemplating angle-supported or posterior chamber implants
- Videokeratography and keratometry
- Fundus examination by indirect ophthalmoscopy
- Field charting

**Surgical Indications**

Indications include unilateral or bilateral, moderate or severe myopia; cosmetic needs; and professional requirements. The final decision to do lens implantation comes after a discussion with the patient, stressing the need for a life-long follow-up.

**Questions to be Answered**

- What is the minimum age at which the lens is to be implanted?
- What is the minimum or the maximum refractive error to be treated?
- What should be the lowest limit for anterior chamber depth?
- What is the lowest corneal diameter at which lens implantation will be refused?
- How accurate is the white-to-white diameter on the basis of which the length of an implant lens is to be derived?
What is the smallest size of the lens available?

How can the risk of complications be minimized? What are those complications? What are the chances of occurrence?

**Surgical contraindications**

- Myopia other than axial
- Evidence of nuclear sclerosis or developing cataract
- History of uveitis
- Presence of anterior or posterior synechiae
- Corneal dystrophy
- Glaucoma or IOP higher than 20 mm Hg
- Personal or family history of retinal detachment
- Diabetes mellitus
- Anterior chamber depth less than 2.75 mm

**Hyperopia**

Today, the quality of corneal refractive procedures is improving. However, lens-related procedures are getting more popular. They include phakic intraocular lenses and a procedure like clear lens extraction with high-plus power lens implantation. Clear lens extraction causes a loss of accommodation but is preferred if the patient is older than 45 years or has any degree of cataract.

Numerous innovative corneal procedures have been tried. All have been discontinued because of the difficult nature of these procedures, the serious flaws, and the complications. 2 new and promising modalities have appeared: the excimer laser for use as PRK or LASIK and newly designed phakic IOLs. While some experience with these modalities exists in adult patients, little or no experience exists in the group of young patients who need the treatment.

The optic-mechanical solution to the problem of hyperopia is only one side of the story. The prevention and management of amblyopia is equally important, and efforts in these areas are being made but the outcomes are with variable results so far.

**Complications**

**Precrystalline lens phakic implant**

**Early complications**

Early problems can develop within 24 hours of the operation. Pupillary block glaucoma may develop because of the blockage of previous laser iridotomies or viscoelastic material residue in the posterior chamber. Red eye, corneal oedema, shallow anterior chamber, dilated pupil, and a marked rise in IOP can occur.

If the condition does not respond to systemic therapy with acetazolamide, hyperosmotic agents, local miotics, and beta-blockers, opening the eye under general anesthesia to explant the lens is recommended. In 2-3 weeks, the eye might regain the earlier corrected vision.

Specular endothelial microscopy may reveal a substantial loss of endothelial cells. The closure of the peripheral iridotomies and pupil block glaucoma can occur after 1 or more weeks. Such cases may be treated by a repeat laser iridotomy, surgical peripheral iridectomy, or a lens explantation.

**Late complications**

An anterior subcapsular cataract may form due to contact with the natural lens. A small IOL has greater chances of having direct contact with the crystalline lens. Uveitis also can occur in an acute or a chronic form. Pigment dispersion may be seen on the artificial lens or the natural lens. Late glaucoma may occur because of crowding of the angle and pigment deposits in the angle. In some cases, the pupil may become partially dilated and not respond to the usual miotics. The implanted lens may dislocate due to the dissolution of the zonular fibers.

**Iris claw lens**

Early dislocation is due to inadequate fixation. Early or late anterior uveitis can occur. If a patient compulsively rubs the eyes and produces recurrent endothelial touch, late corneal decompensation can occur. Postoperative endophthalmitis has not been reported; however, since it is an intraocular procedure, the possibility cannot be excluded.

**Endophthalmitis**

Infectious endophthalmitis is one of the most serious complications of ophthalmic surgery. Successful management of infectious endophthalmitis depends on timely diagnosis and institution of appropriate therapy.

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**Where is my copy of DOS Times?**

**Dear DOS members, anyone who could not receive DOS Times from the month of March, 2007 onwards.**

**Please Contact:**

President DOS: Dr. MAHIPAL SINGH SACHDEV or

Secretary DOS: Dr. HARBANSH LAL
Room No. 2225, 2nd Floor, New Building, Sir Ganga Ram Hospital, Rajender Nagar, New Delhi - 110 060 Ph.: 65705229, 42252225 Email: dosonlin@vsnl.net
Impression cytology (IC), a non or minimally invasive biopsy technique samples the superficial layers of the conjunctival and corneal epithelium. Initially Thatcher et al designed this technique using a plastic impression disc in order to study the cytologic response of the conjunctiva in various disorders of the ocular surface, and concluded that it was easier and rapid than any other technique like scraping technique, cotton swab technique, or the pipette technique to collect tears. However, it was David Maurice's group who designed the technique that is currently used. IC has become a useful research tool in both basic and clinical aspects for sampling ocular surface epithelium.

IC technique has been used in the aetiological diagnosis of various ocular surface disorders, such as dry eye syndrome, cicatrizing conjunctivitis, chemical injuries, vitamin A deficiency, and diagnosis of limbal deficiency, for documenting changes in the conjunctival and corneal surface over a period of time and for staging conjunctival squamous metaplasia. The technique was further used for monitoring adverse effects of various topical eye drops and as an investigational tool for analysing ocular surface disease with immunostaining and DNA analysis. The utility of IC for the detection of micro-organism invasion of the ocular surface was also seen.

Technique of Specimen Collection

Imprints from the surface of the bulbar and palpebral conjunctiva are obtained using absorbent filter papers of different kinds. Egbert et al. first reported good results using filters composed of mixed esters of cellulose with submicroscopic pores (MF-Millipore, type VS). The widely accepted paper filters are those with pore size ranging from 0.025\(\mu\)m and 0.45\(\mu\)m, though 0.22\(\mu\)m pore size renders the best results. Larger pore size filter papers result in better collection of cells, yet the resolution of details under the microscope are better with smaller pore size filter strips.

The filters are usually cut in different shapes and sizes and applied to the conjunctiva with forceps. They are pressed onto the ocular surface for 3 - 5 seconds with the aid of a solid rod and peeled off from the ocular surface. Initially no anaesthetic drops were used and patients complained of a pricking sensation, now-a-days a drop of topical anaesthesia is used and the procedure becomes absolutely painless for patients. While the specimen is collected, the lids should be held apart so that the paper does not get wet with tear fluid because this may lead to poor yield of cells. The back of the paper is marked before applying on to the surface for easy identification of the surface to be stained later. The filter paper is then transferred into a 24 well plate containing fixative solution.

Other materials have also been used for collection of specimens, such as nitrocellulose, Biopore membranes or polyether sulfone filters. Biopore membranes (Millicell-CM 0.4 mm, Millipore) have been preferentially used for immunohistochemistry, either unmounted or mounted and have also been used for ELISA and for the study of neoplasms of the ocular surface.

Specimen Staining Technique

The commonly used stains for routine histological staining of impression cytology specimens are the Papanicolaou or haematoxylin and periodic acid Schiff (PAS) stains. Other stains used include the Alcian blue, Wright's stain and Giemsa stain. The staining procedure is given in figure 1. Care should be taken, that throughout the staining the cell side of the filter paper must be completely soaked with staining solution. Continuous magnetic stirring of the filter paper suspended in the large jar along with the solution should be there so that constant monitoring would not be required.

Processing Method

The various processing methods used to study the cell profile include light microscopy, electron microscopy, immunocytochemistry, polymerase chain reaction, flow cytometry, immunoblot analysis, and other techniques like immunoenzymofluorometry. Amongst all the above techniques, light microscopy is the most widely used in studying the cellular changes at the level of conjunctiva. It is important that at least 1-3 layers of the epithelial cell surface are obtained in the IC specimens.

The features evaluated from an IC specimen include:

1. The quality of epithelial cells – degree of squamous metaplasia, the nuclear-cytoplasmic ratio, the epithelial cell area to be determined.
2. Goblet cells – density, shape and PAS intensity.
3. The presence of non epithelial cells like inflammatory cells, micro-organisms.

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March, 2007
Several grading systems have been published by various authors, Nelson’s grading system in 1983 modified in 1988, the Tseng’s classification 1985 and the Adam’s grading system in 1988. Nelson’s classification system was used to evaluate the morphology of conjunctival ocular surface and the degree of squamous metaplasia by using the specific criteria based on the appearance of the epithelial cells (morphological changes in the nucleus, nuclear:cytoplasmic [N/C] ratio, and metachromatic changes in the cytoplasm) and the density of the goblet cells and subsequently assigning a grade (0-3) to the ocular surface, grade 0 and 1 were considered normal, whereas 2 and 3 were abnormal (Figure 2a, b & 3). Adam’s classification defined a simple scoring system based on goblet and non-goblet epithelial cell morphology, also considering the presence and absence of inflammatory cells. Tseng’s classification was a modification of the conventional IC technique where the squamous metaplasia changes were progressively defined from normal (stage 0) to advanced keratinization (stage 5), Figure 4.

**Description of the Normal Ocular Surface**

IC has been used to describe the ocular surface in normal conditions. The IC technique was used to describe the normal pattern of conjunctival and corneal epithelium and their topographic variations. An increase in N/C ratio in and around the limbal area was seen. A variation in the number of goblet cells according to gender was demonstrated, with women having less goblet cell. No correlation between the numbers of goblet cells with age was found, whereas a negative correlation existed between N/C ratio and age. An interesting study demonstrated that repetition of sampling in the same area (at days 0-4, 8 and 12) produced a localized decrease in goblet cell density and an increase in N/C ratio, with a recovery after 4 days. Other interesting findings of normal IC specimens were, harbor of latent Epstein–Barr virus, presence of conjunctival dendriform cells from normal or inflammatory specimens, pattern of cytokeratin expression, the expression of the receptor tyrosine kinases and epidermal growth factor receptor and transcripts of conjunctival mucin genes present in normal healthy donors in conjunctival IC samples.

**Applications of Impression Cytology**

**Dry Eye Syndrome**

IC technique has been helpful in the diagnosis of various types of dry eye states as they are usually accompanied by progressive squamous metaplasia of the ocular surface and goblet cell decrease as the disease gets more severe. During squamous metaplasia of the conjunctival epithelium a continuous change occur, with decrease and loss of goblet cells with progressive morphological changes of non-goblet epithelial cells such as increased stratification and keratinization.

Conjunctival epithelial cells from dry eyes have been shown to over express inflammatory markers such as HLA-DR, ICAM-1, the low affinity receptor for IgE CD23, CD40-CD40L, or Fas and APO2·7 levels by immunocytochemistry and flow cytometry. IC samples from Sjögren’s patients express higher levels of ICAM-1 and many proinflammatory cytokines in the conjunctival epithelium, analysed by immunofluorescence, Real Time-Polymerase Chain Reaction (RT-PCR) and ELISA. A decrease in the
Detection of microorganisms

There are several reports on the successful isolation of organisms from the ocular surface, which include acanthamoeba organisms, detection of retrovirus and herpes simplex virus.

Monitoring effects of topical medication

IC has also been used to demonstrate the adverse effects of long-term use of topical medications on the conjunctiva. Antiglaucoma medications have been shown to induce conjunctival metaplasia associated with the number of medications used. Abnormal expression of inflammatory markers in conjunctival cells in the absence of clinical inflammation in patients receiving preserved antiglaucoma drops chronically has been demonstrated. IC samples taken from the conjunctival surface after filtering surgery showed long-term damage of the conjunctival epithelium overlying filtering blebs, especially in those patients treated with mitomycin C. A study showed persistent HLA-DR overexpression on conjunctival cells measured in IC by flow cytometry still 6 months after glaucoma surgery, indicating the increased ability of epithelial cells to induce inflammation and possibly subsequent fibrosis.

Number of transcripts for several mucin genes (MUC1, MUC2, MUC4 and MUC5AC) in conjunctival epithelium from dry eye patients has also been demonstrated.

Ocular surface neoplasia (OSSN)

The use of IC has also been evaluated for the specific study of OSSN and positive results have been seen to range between 77 and 80% of cases with the use of cellulose acetate or Biopore membranes.

Vitamin A deficiency

The use of conjunctival IC as an indicator of vitamin A deficiency (squamous metaplasia and goblet cell loss) is very widespread, serving as an easy method to perform screening and aiding in the recommendations of giving vitamin A supplements. Although it may not be a reliable indicator of a person’s vitamin A status, yet it can accurately characterize the risk of the deficiency.

Diagnosis of limbal deficiency

IC on the cornea has been used to demonstrate the corneal phenotype and regression of goblet cells. It has also been demonstrated that it can be used to diagnose and monitor corneal disease with limbal dysfunction, by showing goblet cells in the cornea as sign of conjunctivalization and in predicting the outcome of penetrating keratoplasty in such individuals.

<table>
<thead>
<tr>
<th>GRADE</th>
<th>PROPERTIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>EPIHELIAL CELLS</td>
<td>NUCLEUS</td>
</tr>
<tr>
<td>0</td>
<td>Small, round, eosinophilic cytoplasm</td>
</tr>
<tr>
<td>1</td>
<td>Slightly larger, more polygonal, eosinophilic staining cytoplasm</td>
</tr>
<tr>
<td>2</td>
<td>Larger and polygonal occasionally multinucleated, variably staining cytoplasm</td>
</tr>
<tr>
<td>3</td>
<td>Larger and polygonal with basophilic staining cytoplasm</td>
</tr>
</tbody>
</table>

Figure 4
Other applications

IC technique has also demonstrated changes in the ocular surface in cases of chronic conjunctivitis, pterygium. In cases of systemic illness like diabetes, peripheral neuropathy, Sick Building Syndrome, chronic renal failure, anorexia nervosa and radiation therapy, the utility of IC has been reported in literature.

Conclusion

IC is a useful technique to evaluate squamous metaplasia and goblet cell changes in any ocular surface disease. It has not yet become a routine diagnostic tool in most clinics because of it’s relatively time consuming procedure. There are numerous clinical and research applications of impression cytology. The ability to obtain multiple samples of the ocular surface at one sitting with minimal discomfort to the patient makes it an ideal method of investigating ocular surface disorders when the diagnosis is not clinically obvious. Ophthalmic centres should develop and introduce this technique into routine clinical practice because of its uniqueness.

Suggested Reading

Optical Coherence Tomography (OCT) is nothing but an optical biopsy. It provides an in vivo picture of the retina including its subdivisions, which closely resembles a histopathological section. OCT works on the principle of time delay of light reflected from tissue determined with interferometry.

Thus, it is a non-invasive, non-contact, non-contrast, near cellular, micron resolution cross-sectional scan of the retina. The different layers of the retina are analysed based on their relative reflectivities.

The normal retina can be divided into 3 parts based on the reflectivity of the layers on OCT:
- The high reflective areas the RPE and choriocapillaris and the Nerve fibre layer (NFL) are represented in RED.
- The areas of moderate reflectivity include the plexiform layers and nuclear layers (GCL, OPL, and IPL) represented in GREEN.
- The area of low reflectivity formed by photoreceptors is shown in BLACK.

**OCT IN ARMD**

Age-related macular degeneration is a disease of diverse presentation. Tissue changes associated with ARMD are either of non-neovascular or neovascular type.

Pathology of ARMD includes deposition of abnormal material in the Bruch’s membrane, geographic atrophy, subretinal neovascularization and detachment of the retinal pigment epithelium (RPE). Diagnosis of ARMD can be made using direct analysis from indirect ophthalmoscope, fundus photograph and scanning laser ophthalmoscope. The fundus picture can be further enhanced using fluorescein angiography and ICG angiography. It is primarily a cross sectional imaging modality which offers a non invasive real time imaging with high resolution of the cell and tissue microstructure to depths of a few millimeters in retina. Although clinical OCT has been there for about 10 yrs, it was not until the stratus OCT III (Carl Zeiss, Germany) became available about 5 yrs ago that the technology was embraced by Ophthalmologists, the world over & with newer algorithms available, OCT has become a valuable tool for quantitative assessment of the macula.

OCT has a diagnostic role in each phase of the disease. In addition to being a diagnostic modality in ARMD, it plays an important role in the evaluation of results of various treatment modalities. OCT has become the gold standard for evaluation of the response of wet ARMD following photodynamic therapy (PDT) or anti-VEGF injection.

**Role of OCT in ARMD**

1. Disease characterization and classification
2. Early lesions, missed on FA can be picked up on OCT
3. Associated retinal pathologies can be picked up like cystoid macular edema, RPE rip etc.
4. It helps in monitoring the response to treatment

**OCT interpretation in a case of ARMD**

Interpretation of an OCT image in patients with ARMD should include the following points to be borne in mind:

1. Identification of the highly reflective RPE on the image and comment on its contour.
2. Identification of the intermediate reflectivity layers and look at their relative positioning with reference to the underlying highly reflective RPE.
3. Identification of the foveal region on the OCT image.
4. Identification of the areas of backscattering from the RPE and its quantification.
OCT findings in non neovascular ARMD

a) Soft Drusen
1. Soft drusen present as small modulations with shallow borders in the contour of the highly reflective RPE, appearing red on OCT, in vertical image causing both irregularities and undulations.
2. As the disease progresses the drusen increase in size, height, and become confluent and indistinct.
3. Drusen typically have moderate reflectivity, appearing green on OCT and produce a corrugated elevation of RPE.
4. Drusen do not produce any shadowing towards the choroids which differentiates them from PED.

b) Geographic atrophy
1. Geographic atrophy on OCT presents as decrease in thickness of neurosensory retina.
2. Disappearance of hyporeflective band of rods and cones.
3. Increased hyperreflectivity of RPE choriocapillaris complex extending towards the choroid due to increased penetration of the light (both incident and reflected) through the atrophic retina.
4. Alteration in the contour of the fovea.
5. There is a clear delineation between the atrophic and normal retina.

OCT changes in Neovascular AMD

a). Serous, Hemorrhagic and Fibrovascular detachment of the retina:

Serous pigment epithelial detachment present as elevation of the neurosensory retina with optically clear space (black on OCT) underneath them with underlying choroid showing shadowing of reflection. The elevation of the neurosensory retina alone does not show elevation of the central red line, which is elevated with pigment epithelium detachment. The angle of the edge of detachment is typically acute, probably because of the tight adherence of RPE cells to Bruch’s membrane at the edge of the detachment.

Hemorrhagic PED presents with back scattering from the RPE which attenuates towards the entire retina. There is moderate reflectivity, appearing green beneath the detachment and not a optically clear space. Penetration through the hemorrhage is usually less than 100 microns. The RPE detachment produces a very steep angle with the choriocapillaris and the OCT beam penetration below the detachment is minimal because it is blocked by blood. A shadow area is formed which obscures the underlying choriocapillaris and all other posterior layers.

Fibrovascular PED presents with separation of the neurosensory retina from the RPE and is associated with moderated back scattering below the RPE. The reflected band may be fragmented and thickened ‘lumps and bumps’ and represents subretinal neovascularisation.

b) Neovascular ARMD

Exudative or neovascular ARMD can be picked up on the OCT using a number of direct and indirect evidences. However, OCT does not yet have the resolution to identify the exact location of CNV. We really can’t determine if the
CNV is under the retina, under the retinal pigment epithelium within Bruch membrane, or in the choroid, but OCT does show us a highly reflective thickened Bruch/RPE complex that is characteristic of CNV in AMD.

1. The indirect evidence that point towards the presence of a neovascular ARMD are leaking vessels which produce an elevation or retinal thickening due to fluid (subretinal or intra retinal), decrease in the foveal depression and detachment of the RPE, thickening and fragmentation of the RPE, beginning at the inferior border.

2. Direct signs that point towards the presence of CNV are the visualization of vascular topography, extent of the vascularisation and spatial orientation of the RPE with regards to neurosensory retina and also the disease activity.

**Classic choroidal neovascular membrane presents with**

1. Increased thickness of the sensory retina which presents as highly reflective, nodular or fusiform, continuous band with thickened edges which is located either in front of, or in contact with or slightly separated from a slightly disrupted retinal pigment epithelium.
2. Flattening of the foveal depression and
3. RPE detachment.

**Occult choroidal neovascular membrane produces**

1. Hyper-reflective band in the RPE which is irregular and fusiform shape
2. Associated subretinal fluid / retinal edema.
3. Shadowing towards the choroid.

Optical coherence tomography can be used to distinguish a Type II choroidal neovascular membrane with most of the neovascular complex anterior to the RPE, from a Type I choroidal neovascular membrane where having neovascular complex below the RPE band. In a Type II choroidal neovascular membrane, the OCT images demonstrate an area of increased reflection suggestive of choroidal neovascular membrane penetrating through the RPE/choriocapillaris band and lying in the subretinal space. On the contrary, a Type I choroidal neovascular membrane is located predominantly in the sub-RPE space and is a representation of a fibrovascular retinal pigment epithelial detachment. These lesions have a thickened, cystic retina associated with subretinal fluid, a pigment epithelial detachment, and a Bruch/RPE complex devoid of the thickening seen with CNV in AMD.
Monitoring of the treatment using OCT

OCT also helps monitoring the ARMD treatment. Following may be outcomes of the treatment for ARMD.

1. Persistence of active CNVM
2. Healing process
3. Fibrosis
4. Cystic change in retina and subretinal fibrosis (corresponding to RPE- Bruch complex)

OCT has been used for monitoring the response of RPE and retina after PDT. Inter-observer agreement for the presence of leakage was moderate for FA and good for OCT. In real-world OCT helps us to decide when to re-treat.

Pharmacologic therapies in current development have incorporated OCT imaging as an adjunct to FA in the hope of better understanding the effect of these drugs on macular anatomy.

OCT & Retreatment for CNV

Our experience using OCT in the management of AMD patients receiving anti-VEGF agents for the treatment of CNV has resulted in a new study named the PrONTO Study:

This open-label nonrandomized clinical study is currently under way and the decision when to stop and start therapy is determined by OCT imaging.

Chorio-Retinal Anastomosis (CRA) in Age-Related Macular Degeneration

Focal elevation of the retinal pigment epithelium is observed in eyes with stage 1 (pre-clinical) CRA. Small hyperreflections at the level of the elevated retinal pigment epithelium are observed in stage 2 CRA. In stage 3 CRA, a hyperreflective “bump” at the level of the elevated retinal pigment epithelium and associated thickened retina is observed. In stage 4 CRA fluid accumulates in sub-retinal pigment epithelium region, and complete macular disorganization occurs in stage 5 CRA.

Advantages of using OCT in ARMD

1. Non-invasive
2. Accurate identification and differentiation of the various forms ranging from drusens to fibrovascular PED and neovascularisation.
3. Early identification of neovascular membrane in choroidal neovascularisation

Disadvantages of OCT in ARMD

1. Costly
2. Severe hemorrhagic or exudative RPE detachments reduce light penetration to the choroid and may cause CNV lesions to go undetected.
3. Artifactual errors.

Newer advances in OCT

Scanning Laser Ophthalmoscopy (SLO) OCT provides fundus images along with high resolution OCT pictures, and helps to interpret the lesion more accurately.

In vivo imaging of blood flow in human retinal vessels using color Doppler OCT. Color Doppler optical coherence tomography (CDOCT) is a novel technique using coherent heterodyne detection for simultaneous cross-sectional imaging of tissue microstructure and blood flow. This technique is capable of high spatial (20 μm) and velocity (<500 m/sec) resolution imaging in highly scattering media. Quantification of retinal blood flow may lead to a better understanding of the progression and treatment of ARMD.

Three-Dimensional ULTRA High-Resolution Fourier-Domain Optical Coherence Tomography Imaging: 3D Fourier-Domain OCT is a non-invasive, modality that measures and localizes CNVM in patients with obscured media due to vitreous hemorrhage. High contrast B-scan and 3-D images of ARMD by high-speed FD-OCT provide a complete picture of the chorioretinal pathology. This high resolution and high contrast technique gives us an understanding of not only the epi, sub and intraretinal structures but also and understanding of the structures lying beneath the RPE which has help us enhance our current understanding of the complex disease like ARMD. It is not commercially available due to its high cost and
Spectral OCT is another addition, which provides better image quality, segmentation of the macula & fundus reconstruction. [a virtual image of the fundus is generated]. S-OCT also provides a clear resolution of ERM’s over the retina. How far its scores over the conventional stratus OCT (version 3 or 4) remains to be seen as it is pretty expensive, and the stratus images suffice quite well in neovascular AMD lesions.

**Suggested Reading**

Allvar Gullstrand
Lt Col Rakesh Maggon, Col JKS Parihar, Lt Col V Mathur

(1862-1930), Swedish ophthalmologist, recipient of the 1911 Nobel Prize for Physiology or Medicine for his research on the eye as a light-refracting apparatus.

Gullstrand studied in Uppsala, Vienna, and Stockholm, earning a doctorate in 1890. He became professor of diseases of the eye at Uppsala in 1894 and in 1913 was appointed professor of physiological and physical optics there.

Gullstrand contributed to knowledge of the structure and function of the cornea and to research on astigmatism. He improved corrective lenses for use after surgery for cataracts and devised the Gullstrand slit lamp, a valuable diagnostic tool that facilitates detailed study of the eye. Gullstrand’s investigations led to a new concept of the theory of optical images. He expanded the classic theory of the German physicist Hermann von Helmholtz to include the redisposition of internal parts of the lens structure in accommodation, a mechanism by which the eye can focus for near or far vision within certain limits. Gullstrand showed that although accommodation depends about two-thirds on the increase in convexity of the lens surface, the remaining one-third does not.

Allvar Gullstrand, eldest son of Dr. Pehr Alfred Gullstrand, Principal Municipal Medical Officer, and his wife Sofia Mathilda née Korsell, was born on June 5, 1862, at Landskrona. He was educated at schools in Landskrona and Jönköping, where he passed his matriculation in 1880; he then went to Uppsala University, which he left in 1885, and spent a year at Vienna, afterwards continuing his medical studies at Stockholm where he graduated in medicine in 1888, presented his doctorate thesis in 1890, and was appointed Lecturer in Ophthalmology in 1891. After holding various appointments as Doctor and Lecturer and serving on the Swedish Medical Board, he was appointed the first Professor of Ophthalmology at Uppsala University in 1894.

He occupied this post until 1913. As from 1914 onwards he held a Personal Professorship in Physical and Physiological Optics at Uppsala University. He was appointed Emeritus Professor in 1927.

He was entirely self-taught in the fields covering his most important work (geometric and physiological optics). The basis of the science he developed was laid in 1890 in his thesis Bidrag till astigmatismens teori (Contribution to the theory of astigmatism). The complete proof of this theory is found in the following three works: Allgemeine Theorie der monochromatischen Aberrationen und ihre nächsten Ergebnisse für die Ophthalmologie (General theory of monochromatic aberrations and their immediate significance for ophthalmology), 1900, which received awards from the Swedish Royal Academy of Sciences and the Swedish Medical Association; Die reelle optische Abbildung (The true optical image), 1906; and Die optische Abbildung in heterogenen Medien und die Dioptrik der Kristallinse des Menschen (The optical image in heterogeneous media and the dioptics of the human crystalline lens), 1908, which was awarded the Centenary Gold Medal of the Swedish Medical Association. The results are combined in the works Tatsachen und Fiktionen in der Lehre von der optischen Abbildung (Facts and fictions in the theory of the optical image), 1907; Handbuch der physiologischen Optik (Handbook of physiological optics), by H. von Helmholtz, 3rd edition, Vol. I, 1909, and Einführung in die Methoden der Dioptrik der Augen des Menschen (Introduction to the methods of the dioptics of the human eyes), 1911.

Of his other works, the following received awards: Objektive Differential-diagnostik und photographische Abbildung von Augenmuskellähmungen (The objective differential diagnosis and photographic illustration of disabilities of the eye muscles), 1892; Photographisch-ophthalmometrische und klinische Untersuchungen über die Hornhautrefraktion (Photographic-ophthalmometric and clinical investigations of corneal refractions), 1896; Die Farbe der Macula centralis retinae (The pigments of the central macula of the retina), 1905; the first Pharmacy Diazepam Prozac Propecia Zoloft two received awards from the Swedish Medical Association and the latter received the Björkén Prize of the Uppsala Faculty of Medicine.

As the holder of the Research Professorship in Physical and Physiological Optics, Gullstrand devoted himself mainly to calculations and methods for achieving a more suitable form of refracting surfaces in optical instruments, and to investigation of optical system laws of higher order. A result of the former is a record which is kept in the

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Uppsala University library and which relates to calculations for optical systems, inter alia optical systems with appropriate non-spherical surfaces, and the publication Über asphärische Flächen in optischen Instrumenten (On aspheric surfaces in optical instruments), 1919. As a result of the latter we may mention the publications Das allgemeine optische Abbildungssystem (The general optical image system), 1915 and Optische Systemgesetze zweiter und dritter Ordnung (Laws of the optical system of the second and third order), 1924. He gave the last summary of his optical experiments in Einiges über optische Bilder (Some aspects of optical images), 1926.

His methods of focal illumination, particularly by means of the slit lamp (1911), have acquired the greatest importance to the practical ophthalmologist. His reflex-free ophthalmoscope (1911) is also a valuable instrument to the ophthalmological diagnostician.

His great administrative ability found expression particularly in the Faculty of Medicine and the Council of Uppsala University and the Swedish Academy of Sciences.

Gullstrand was an honorary Doctor of Philosophy of the Universities of Uppsala, Jena and Dublin, and a member of a number of Swedish and foreign scientific societies. In 1911 he received the Nobel Prize for his work on the dioptrics of the eye. He was member of the Nobel Physics Committee of the Swedish Academy of Sciences (1911-1929), and its Chairman (1922-1929). In 1927 he was awarded the Graefe Medal of the Deutsche Ophthalmologische Gesellschaft.

In 1885 he married Signe Christina Breitholtz. They had one daughter, who died at an early age. Gullstrand died in Stockholm on July 28, 1930.

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