Congenital Nasolacrimal Duct Obstruction

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Congenital nasolacrimal duct obstruction is the most common cause of epiphora in children. In the majority of cases, it is due to an obstruction at the lower end of the NLD. The Ophthalmologist should have the throrough understanding of the developmental anatomy, abnormalities of the nasolacrimal system and other congenital disorders for appropriate diagnosis and management of the conditions.

Developmental Abnormalities

Punctal and canalicular abnormalities include punctal agenesis, stenosis or membranous occlusion of punctum.

Lacrimal sac fistula or diverticula of sac may occur.

Nasolacrimal duct obstruction is the most common congenital abnormality, seen in 50% of infants at birth. The level of obstruction may vary in congenital nasolacrimal duct obstruction.

1) The most common obstruction occurring at the lower end of the duct where it fails to perforate the mucosa of the inferior meatus (Fig 1).
2) Absence of duct due to failure to the osseous nasolacrimal canal to form, commonly seen with cleft palate anomalies.
3) Blockage of duct due to impaction of anterior end of inferior turbinate.

Anatomy of Excretory system

The drainage system comprises of puncta, upper and lower canalicului, common canaliculus, lacrimal sac and nasolacrimal duct (Fig 2).

The excretory system begins with puncta which is about 0.3mm in diameter. The lower punctum is located lateral in postion than the upper punctum. The punctum leads into canaliculus which comprises of 2mm vertical and 8mm horizontal limb. The two canaliculi may converge into common canaliculus in majority of cases. The two canaliculi or common canaliculus enter the lacrimal sac 3-5mm from its apex. A fold of mucosa i.e valve of Rosenmuller , at the junction of the canaliculi and sac prevents tear reflux from the sac back into the canaliculi.

The lacrimal sac lies within the lacrimal sac fossa, formed by the lacrimal bone and ascending frontal process of maxilla. The lacrimal fossa is enclosed by anterior and posterior crus of the medial canthal tendon. The lacrimal sac is about 15mm in height.

The lacrimal sac drains into nasolacrimal duct. The intraosseous part of nasolacrimal duct is approximately 12mm. The duct traverses downward, laterally and posteriorly. This is important to remember when surgeon is probing the lacrimal system , otherwise it may create a false passage. The distal portion extends into the middle meatus forming the meatal portion of the duct, which is about 5mm in length. The duct opens into the nose through the ostium under the inferior turbinate, which is covered by a mucosal fold called the valve of Hasner.

Important Landmarks:

1) Distance from punctum to the floor of the nose is approximately 20mm.
2) Distance of the ostium from the tip of the inferior turbinate is about 15mm and 25-30mm from the external nares.

Evaluation

Evaluation begins with a detailed history and needs to carry out a careful examination of the patient.

History

A thorough history from child's parents is essential as the child is unco-operative for proper evaluation. Patient usually present with complaint of persistent watering with or without mucopurulent discharge (Fig 3). The child may be asymptomatic for a month or so as the tear production begins a couple of weeks after life. Symptoms of photophobia, watering, corneal haze or nystagmus should be enquired to rule out congenital glaucoma.

Examination

Eyelid margin- Eyelid margins are inspected for punctal position, its apposition to globe and its patency. It is important to exclude any lid abnormalities and any cause for reflex secretion like epiblepharon, conjunctivitis, trichiasis, blepharitis or meibomitis.

Medial canthal area- An ophthalmologist should look for any swelling over the medial canthal area like mucocele or congenital dacryocele. Pressure over the medial canthus

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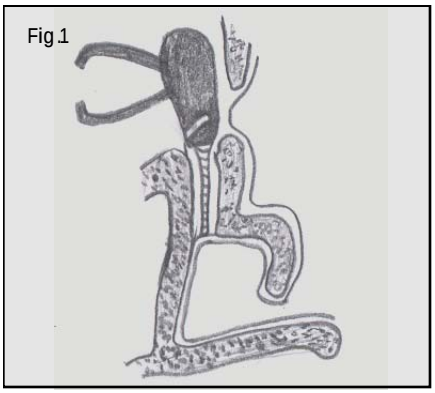


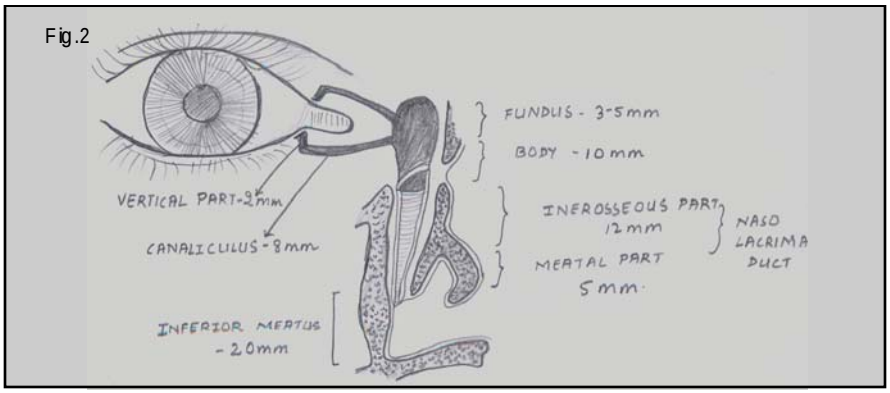


Fig.1: A diagram is showing nasolacrimal duct obstruction at or near the inferior meatus, due to non perforation of the nasal mucosa.
Fig.2: Diagram showing anatomy of lacrimal excretory system.

may cause regurgitation of discharge from the punctum if blockage is distal to the sac. One should differentiate the swellings above the medial canthal tendon which indicate conditions like anterior ethmoidal mucocele or encephalocele and needs to perform a CT scan to identify the condition.

Investigations

In cases of congenital lacrimal system obstruction, the diagnosis is usually clear cut on history and examination as child present with watering , discharge, matting of eyelashes and inferior palpebral congestion. In doubtful cases, the dye disappearence test can be conducted. A drop of 2% fluorescein is placed in the inferior fornix. Tear film is observed with cobalt blue light. Delay in clearence of the dye after 5minutes indicates outflow obstruction. This test is useful in children as diagnostic syringing cannot be performed in outpatient department.

Imaging has limited role in paediatric age though lacrimal scintigraphy or intraoperative dacryocystography can be performed in doubtful cases.

Management

Of the 50% of newborn infants who have obstruction at the inferior end of nasolacrimal duct, only 2-6% clinically presents with epiphora at 3-4 wks of age. Spontaneous resolution occurs in approximately 90% of all patients in first year of life. Conservative management is therefore recommended in all cases.

Conservative management

Parents are educated regarding maintenance of lid hygiene and lacrimal sac massage (Criggler massage).

Criggler massage - Surgeon should demonstrate the proper technique of massage to the mother. It should be emphasized to use the little finger for this maneuver. One should first palpate the medial canthal tendon and move the finger downwards, feeling the anterior lacrimal crest. Massage is done with firm strokes over the lacrimal sac at least twice a day. Approximately 90% of the infants respond to massage in first year of life and 60% respond in their second year of life.

Topical antibiotics are advised at least thrice a day to reduce mucoid discharge. Infants who do not respond to conservative management are taken up for probing.

Some cases of CNLDO may present with an acute episode of inflammation of lacrimal sac. It is often associated with cellulitis and needs to be managed vigorously with systemic intravenous antibiotics. One should not attempt to drain the pus in acute stage as it may lead to lacrimal - cutaneous fistula. Early syringing and probing is indicated once the acute stage subsides.

If lacrimal sac abscess is developed , surgical drainage is required.

Syringing and Probing

Timing of probing is controversial, most of the surgeons now prefer to wait till one year of age, while some surgeons advocate early probing.

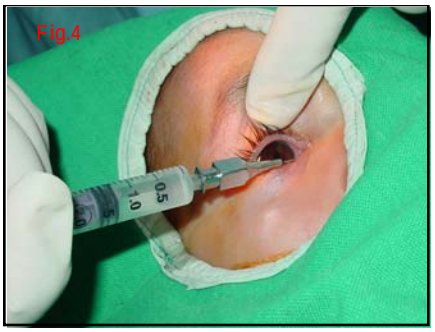
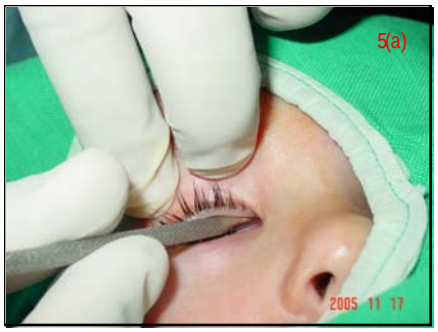


Fig.3: An infant who presented with persistent watering and discharge. **Fig.4:** Syringing is performed prior to probing of the nasolacrimal duct to evacuate the lacrimal sac.



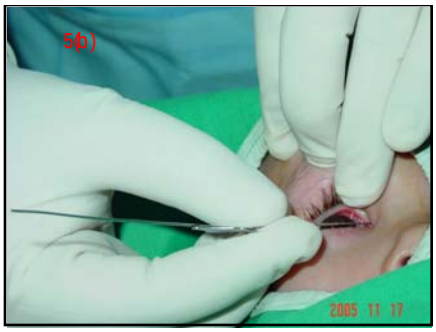
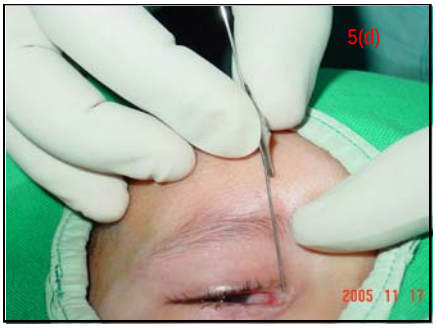
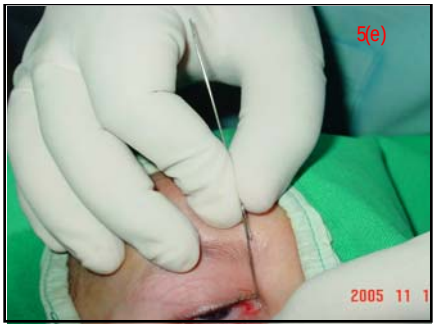


Fig.5(a): A Nettleship dilator is used to gently dilate the punctum **Fig.5(b):** Bowman Probe size 00 is introduced into upper punctum perpendicular to eyelid margin. **Fig.5(c):** While maintaining lateral traction of eyelid probe is advanced horizontally.





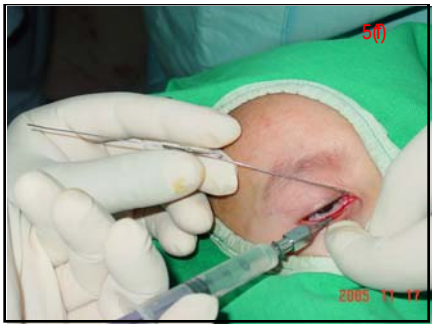


Fig.5(d): Probe lies over the supraorbital notch at superior orbital rim **Fig.5(e):** Probe is advanced into the nasolacrimal duct. **Fig5(f):** Syringing is done to check the patency.

Anesthesia- It is performed under general anesthesia with protected airway either using laryngeal mask or endotracheal intubation depending on the choice of the anesthesiologist.

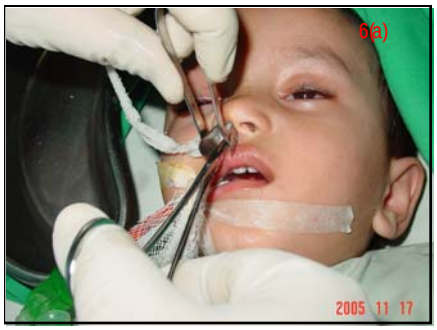
Technique- Before starting the procedure, the lacrimal sac needs to be evacuated either by performing massage over the sac area or syringing with saline(Fig.4).

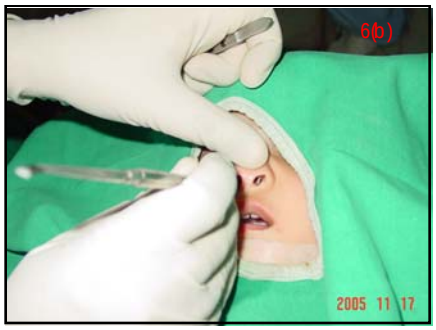
Upper punctum is preferred for probing to prevent any damage to the lower punctum during the manipulation. Punctum is dilated with Nettleship dilator (Fig.5a) and then Bowman probe (size0 or 00) is introduced into the punctum perpendicular to the eyelid margin (Fig.5b). It first traverses the vertical 2mm of the canaliculus and then the horizontal part while maintaining a lateral traction of eyelid. (Fig.5c). The lateral traction of skin stretches the canaliculus and avoids any chance of damage to the canalicular mucosa and decreases the probability of creation of a false passage. If one feels the resistance while passing the probe medially, it may be due to kink of the canaliculus. Surgeon should withdraw the probe slightly and then proceed medially maintaining the lateral traction. As the tip reaches the medial wall of lacrimal sac and lacrimal bone, surgeon will feel a hard stop.

The probe is then slightly withdrawn and rotated superiorly against the brow and should come to rest over the supraorbital notch at the superior orbital rim(Fig.5d). The probe is then passed downwards, posteriorly and slight laterally down the nasolacrimal duct (Fig.5e). The probe should slide down smoothly. In case of any feel of resistance, withdraw the probe slightly and proceed forward. If the surgeon feels the firm stop at a distance of about 12mm (distance fom punctum to nasolacrimal duct) and cannot manipulate further, it indicates a bony obstruction and absence of nasolacrimal duct. Dacryocystorhinostomy is indicated in such a situation. If probe pass down the nasolacrimal duct to about 20mm, it indicates that it has reached the inferior meatus. Some resistance is felt due to membranous obstruction. Firm pressure passes the probe into the nasal cavity with a slight " pop up" sensation. Successful probing is verified by syringing (Fig.5f). Some surgeons confirm the patency by passing a spatula under the inferior turbinate to have a metal on metal feel.

Availability of nasal endoscopes, may also assist in verifying the correct passage of probe. It aids rupturing of the membrane under direct visualization and thus avoids creation of false passage. Postion of inferior turbinate can be visualized and infracture of the turbinate can be done if inferior turbinate is impacted at the ostium.

Post-operatively, steroid - antibiotic drops four times a day for 2 weeks along with nasal decongestant drops are prescribed.





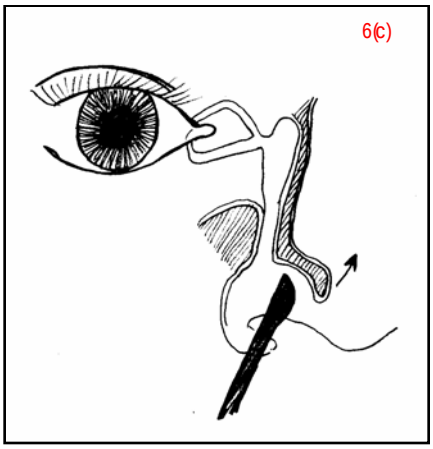


Fig.6(a): Nasal cavity is packed before proceeding for inferior turbinate infracture.

Fig.6(b)&(c): Inferior turbinate infracture with use of blunt spatula.

Failure

Probing may fail due to postoperative closure of small opening formed through the membrane or due to impaction of inferior turbinate.

Repeat probing is attempted at least 6 weeks after the initial one.

Inferior turbinate infracture

It is performed under general anesthesia. The nasal cavity is packed before proceeding for infracture (Fig 6a).

Lens spatula is passed under the inferior turbinate, the anterior end of turbinate is rotated medially and superiorly towards the septum. Then the spatula is passed backwards and then the middle and the posterior part of turbinate are fractured (Fig 6b& c). Patency is checked by syringing . Nasal cavity is packed for 24 hours as there may be a risk of slight bleed.

Postoperatively, steroid-antibiotic drops and nasal decongestants are prescribed.

Silicone intubation

Indication- Silicone intubation is indicated in cases of recurrent failed probing with or without inferior turbinate infracture or in cases of older children.

Various types of intubation sets like Crawford, Ritleng and others are available for the purpose.

It is performed under general anesthesia. Before intubation nasal packing is done to constrict the mucosa of the inferior turbinate. These silicone tubings have metal bodkins attached at each end. Punctum is dilated. If metal tube cannot be easily passed through the punctum, one or three snip procedure may be performed. The metal tubings are passed through each canaliculus into the nasolacrimal duct. They can be pulled into the nasal cavity with the help of an artery forceps. The silicone tubings are tied together in the nose near inferior meatus after removing the metal bodkins(Fig 7).

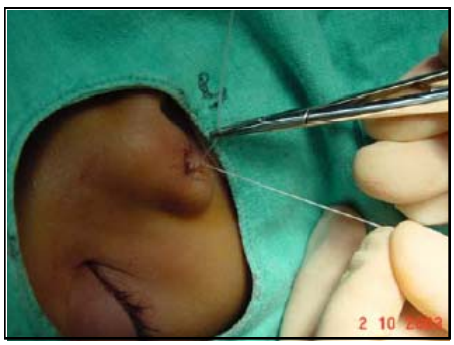


Fig.7: Silicone tubing are tied together in the nose.

The procedure can be combined with inferior turbinate infracture. Stents are left in position for at least six months.

Ballon Dacryoplasty

This is a new technique of management, where collapsed catheter is introduced into the nasolacrimal duct by a procedure similar to probing. The balloon is inflated with saline to 8 atm for 90 seconds, deflated, and then reinflated for 60 seconds with the catheter at the sac-Nasolacrimal duct junction and at the lower nasolacrimal duct. The balloon should not be inflated in the lacrimal sac as it may rupture the system. The procedure is not so popular due to dependence on the requirement of a catheter and its high cost.

Dacryocystorhinostomy (DCR)

DCR is indicated in cases of repeated failed probing with inferior turbinate infracture or silicone intubation or in cases where on the initial probing a bony obstruction is diagnosed. It is also indicated in traumatic cases leading to canalicular scarring or injury to intraosseous part of nasolacrimal duct and in craniofacial abnormalities, associated with nasolacrimal abnormalities.

Timing - Surgery is usually not performed before 3 years of age except in cases of persistent episodes of acyte dacryocystitis.

Anesthesia- The procedure is performed under general anesthesia. Mild hypotensive anesthesia may be preferred to minimize blood loss intraoperatively.

DCR in children may be difficult owing to smaller size of the structures. The technique requires some modifications due to some anatomical differences from the adult lacrimal system. The anterior lacrimal crest and the lacrimal fossa are pooly developed and it is sometimes difficult to locate the site for osteotomy. Medial canthal tendon insertion provides an important landmark to identify the superior part of anterior lacrimal crest.

Due to thin bones, osteotomy is easily performed. One should prefer to have a larger osteotomy as there may be postoperative bony regrowth which may be a cause of failure.

Failures have been observed in the paediatric age group due to less well defined anatomy, postoperative bony growth and greater scarring.

Mitomycin C have also been tried intraoperatively by applying a soaked piece of cotton to the osteotomy site to reduce fibrosis and scarring postoperatively.

Endonasal DCR

Endonasal DCR , though technically difficult in young children offers a number of advantages over the external approach. It avoids the need for a skin incision and consequent scarring, enables creation of a large ostium even when the lacrimal sac is small and scarred. It has additional advantage of limited intraoperative bleeding.

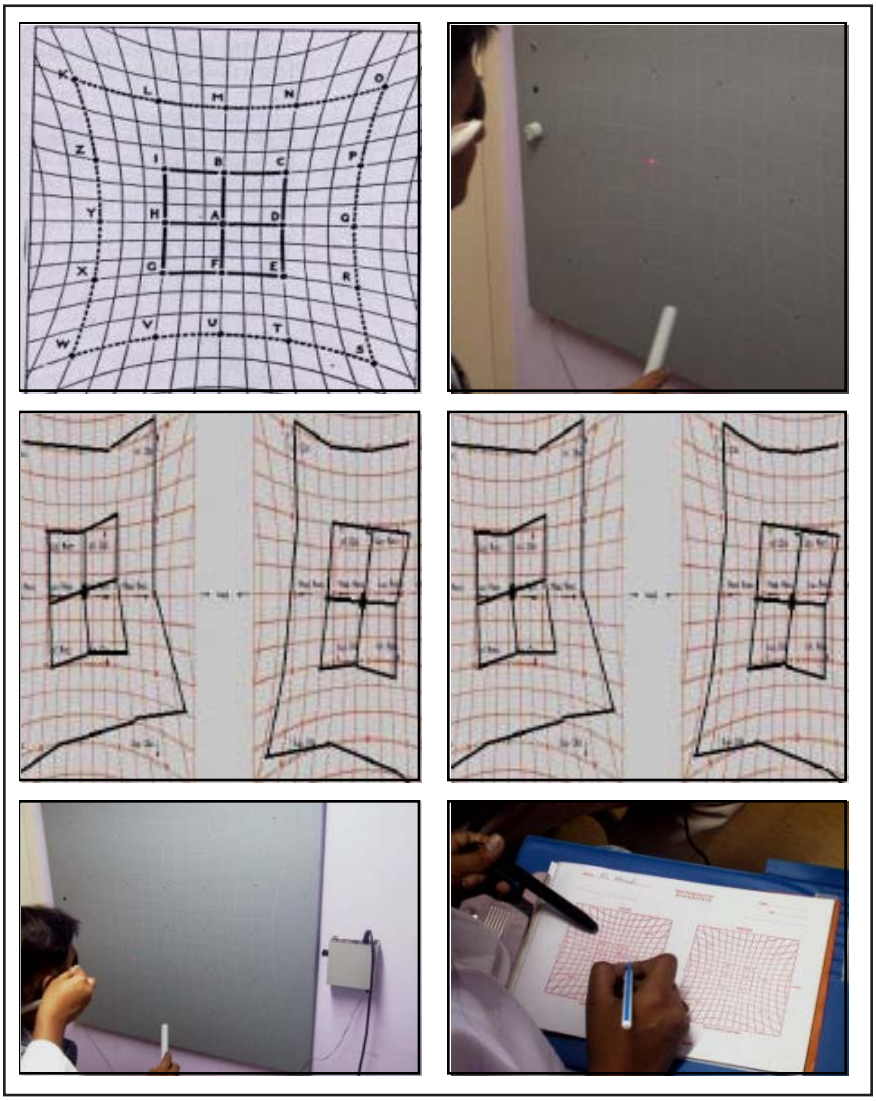
Summary

Congenital nasolacrimal duct obstruction resolves spontaneously in 90-95% cases in first year of life. Initial management includes massage of lacrimal sac and application of topical antibiotics. Syringing and Probing alone or in combination with inferior turbinate infracture is performed in cases who does not respond to conservative therapy after one year of age. Silastic intubation is performed for repeated failed probing and finally DCR is indicated in cases of failed probing after 3 years of age.

Hess Charting

Suma Ganesh MS, **Archana Gupta, Manish Sharma** MS, **Prem K.Singh**

The Hess screen test is an important diagnostic modality that helps in the diagnosis and prognostication of incomitant strabismus. It provides an accurate clinical method of determining the position of each visual axis in different directions of gaze. It provides a permanent and accurate record which may be compared with the results of subsequent examinations. When monitoring an incomitancy, it is unlikely that other motility tests assessment will be as repeatable or sensitive as the Hess test.



History and instrument characteristics

The original Hess Screen was a tangent screen of black cloth three feet wide by three and half feet long with a series of red lines which subtended an angle of 5°between them. At the zero point in the middle and at each points of intersection of the 15 degree and 30 degree lines there was a red dot. The red dots formed an inner square of eight dots and an outer square of sixteen dots. A pointer or indicator was a junction of three green cords knotted to form Y.

The electrically operated Hess Screen has largely replaced the original Hess screen in most clinics. This has a wooden screen with small red lights forming fixation points and a movable illuminated green indicator. A light source is present behind each red light aperture, the illumination of which is controlled from a control unit. Each of the red fixation spot lights can be switched on in turn by the insertion of a plug into the switch board, the apertures of which correspond to the circular apertures of the Hess Screen. The patient holds a green spotlight color, the color of which is identical with that of the green eyepiece of red green glasses

For interpreting the results of the Hess test, it is important to be aware of the muscle sequelae that follow paralytic strabismus and the laws that govern them.

Herings Law of equal innervation

Innervation to extraocular muscle is equal to both eyes . Thus when a nervous impulse is sent to an ocular muscle to contract an equal impulse is sent to its contralateral synergist to contract.

Sherringtons law

The contraction of a muscle is accompanied by simultaneous and proportional relaxation of its antagonist.

The three stages in the development of muscle sequelae.

1. Overaction of contralateral synergist according to Herings law.
2. Overaction of ipsilateral antagonist as its action is

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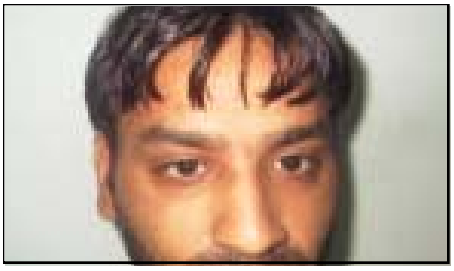

Figure 1

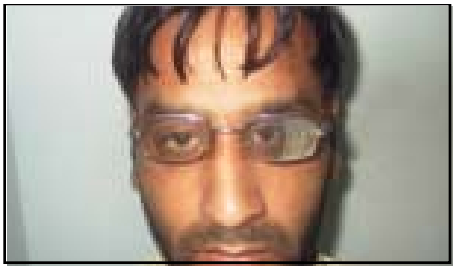

Figure 2

Features of Neurogenic Defects

- The smaller field has a proportional spacing between the outer and inner fields.
- Muscle sequelae is common.
- The Hess chart between the two eyes tend to become more similar in size with time.

unopposed by the paralysed muscle.

3. Secondary underaction of the contralateral antagonist. However, in long standing palsies, there is the spread of comitance and these stages cannot be easily discerned.

Procedure

There are certain prerequisites required before conducting a Hess charting.

- Full understanding of the procedure.
- Good vision in both eyes.
- Central fixation.
- Normal Retinal Correspondence

The patient is seated at 50cm facing the screen being plotted.

Head erect and eyes in primary position with the head centered on the fixation spot.

The patient wears red and green glasses.

Patient instructed to shine spotlight upon each red fixation light as it is illuminated.

With green glasses in front of left eye he fixes red dots with his right eye, Indicator shows deviation of left eye and then glasses are reversed.

Features of the Hess chart used for interpretation

1. The position of the fields.

The central dot in each field indicates the deviation in the primary position.

2. The size of the Hess chart.

- The eye with the smaller field is the affected eye
- Smaller field examined to ascertain in which of the cardinal positions there is maximum displacement.
- Larger field examined to ascertain in which of the cardinal positions there is maximum displacement.

Features of Mechanical Defects

- Compressed field either vertically or horizontally.
- The most obvious feature of a mechanical defect is normally the marked over-action of the contralateral synergist.
- There is not normally an obvious over-action of the direct antagonist, nor under-action of the contralateral antagonist

Uses of the Hess Chart

1. Diagnosis of a muscle palsy
2. Assessing progress
3. Planning treatment
4. Evaluating results of incomitant strabismus
5. Provides a permanent and accurate record which may be compared with the results of subsequent examinations

Case studies

Discussing the main uses with examples,

Case study # 1 (diagnosis of a muscle palsy)

A 37 year old male presented with a history of diplopia and face turn to the left side. Fig.1 & Fig.2. On examination, the positive findings were Left esotropia on cover test; on Prism bar Cover test with the right eye fixing, both the distance and near deviations were 20 D BI; with the left eye fixing, both the distance and near deviations were 30D BI. Extra ocular movements: there was limitation in abduction

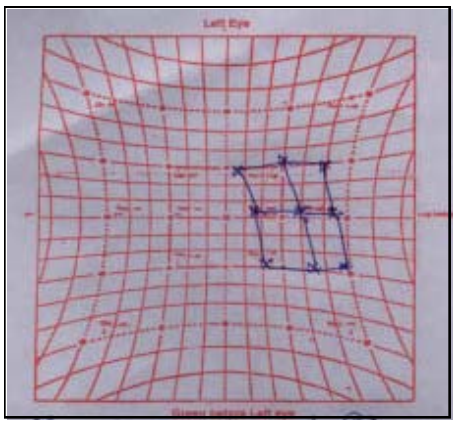

Figure 3(a)

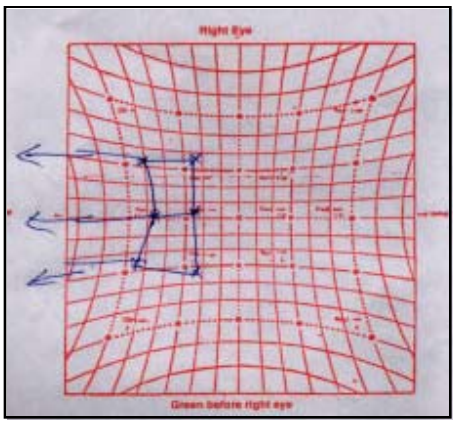

Figure 3(b)

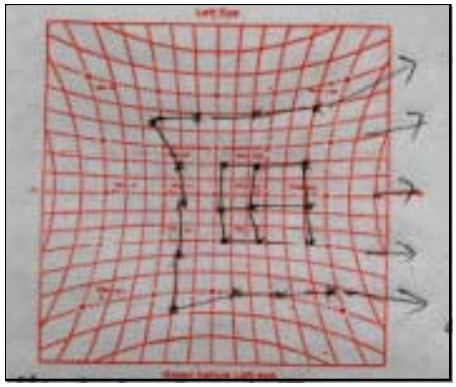

Figure 4(a)

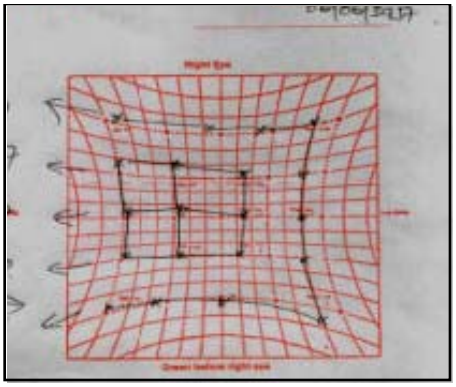

Figure 4(b)

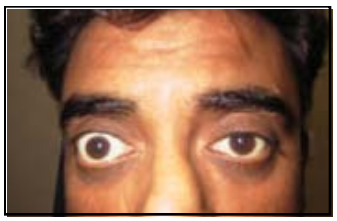

Figure 5(a)

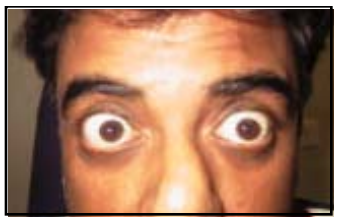

Figure 5(b)

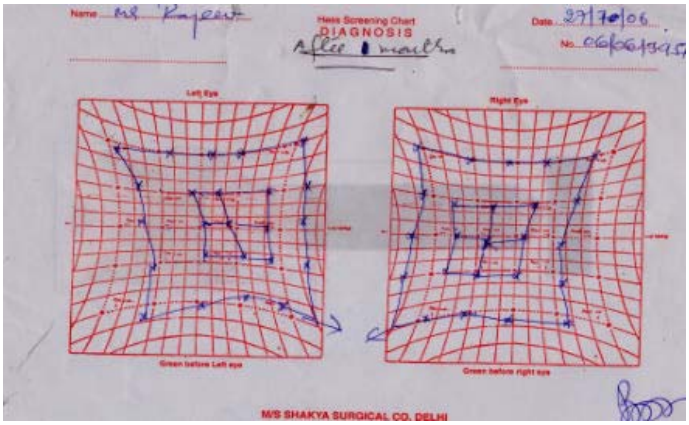

Figure 6

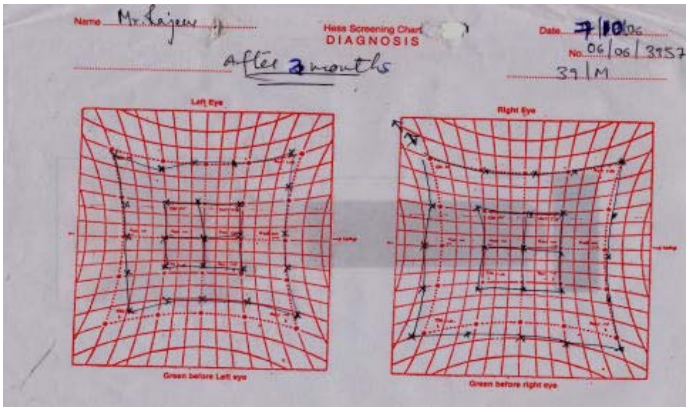

Figure 7

in the left eye. A diagnosis of Left Lateral Rectus palsy was made which was confirmed on Hess Charting (fig 3a and 3b). Treatment given: Fresnels prism in glasses.

Case Study # 2 (assessing progress):

A 39 year old male presented with a history of diplopia since 15 days. He also had a history of cramps in the lower leg. On examination, on cover test there was Left Esotropia. On Prism bar Cover test with the right eye fixing, both the distance and near deviations were 20 D BI; with the left eye fixing, both the distance and near deviations were 25D BI. Extra ocular movements: there was limitation in abduction and minimal limitation in elevation in the left eye.

As supported by the Hess charting (fig 4 a and b), a diagnosis of Left sixth nerve palsy was made at this stage. The patient presented 2 days later with total ophthalmoplegia. He also had weakness in the legs with no associated motor findings, dysphagia, bowel/ bladder involvement or fever. There was associated left side facial nerve palsy. Fig 5 a and b, Fig 6.

Investigations done by neurologist at this stage:

MRI brain normal; Repititative nerve stimulation negative;ACE antibodies negative,CSF normal, USG abdomen normal.

A clinical diagnosis of Miller Fisher Syndrome was made. On follow up at 3 months, symptomatically, the patient was comfortable, on examination there was esophoria and minimal underaction in abduction in left eye. The Hess charting as shown in fig 7 indicates the clinical recovery. Fig 7.

Case study # 3 (Planning treatment and evaluating results of Incomitant strabismus)

A 9 yr old male child presented with a history of face turn to left, drooping of the left eye. On examination, he had Ptosis left eye; on cover test, there was left Hypotropia. On Prism bar Cover test with the right eye fixing, both the distance and near deviations were 25 D Right hypertropia; with the left eye fixing, the distance deviation were 35D right hypertropia and there was25 D right hypertropia. On Head tilt to both sides there was 25 D Right hypertropia.

A diagnosis of Left eye congenital superior rectus paresis was made Surgery - Right Inferior oblique recession and Left Inferior Rectus recession was done.

After surgery, the face turn to left was reduced, cover test – minimal residual left Hypotropia; on Prism bar and cover test, the deviation had decreased to 5 D Right Hypertropia. The improvement was documented on Hess Charting.

Centurion Syndrome: An Underdiagnosed Entity

Ramesh Murthy MD FRCS

Centurion syndrome is an idiopathic and rare medial canthal anomaly; where the patient usually presents with unexplained epiphora.[1] The patients have an abnormal anterior insertion of the medial canthal tendon and a prominent nasal bridge. This term was coined by Sullivan et al.[1] The term "Centurion syndrome" was derived from the facial appearance of the Roman Centurions who have a similar nasal anatomy to these subset of patients.[1]

Anatomy

The anterior limb of the medial canthal tendon is the point of attachment of the medial eyelid. It forms the medial canthal angle and ensures lid-globe apposition. The anterior limb lies anterior to the lacrimal sac and averages 11.7 mm in length, 2 to 4 mm in width and 4.9 mm thickness in the anteroposterior plane.[2] It arises as a triangular band whose base extends from the anterior lacrimal crest towards the suture between the frontal process of the maxilla and the nasal bone. The site of attachment is usually posterior to the nasomaxillary suture. The lower border of the anterior limb is well defined, but the upper border is indistinct where it blends with the lacrimal sac fascia and periosteum. (Figure 1a)

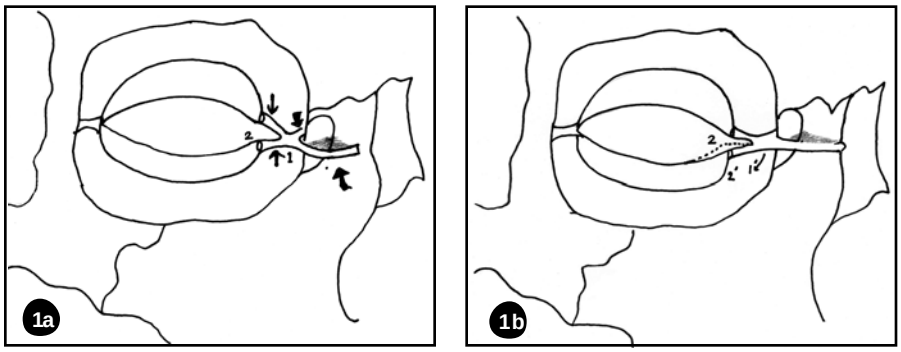

Fig.1a: Centurion syndrome: Diagram of the medial canthal tendon showing the horizontally orientated anterior and posterior limbs (curved arrows) and vertically orientated palpebral extensions (straight arrows). The shaded area represents the blending of the medial canthal tendon with the lacrimal fascia and periosteum. The angle between the anterior limb and the palpebral extension (1) and the position of the lower punctum (2) should be noted [adapted from Sullivan et al[1]].
Fig.1b: Centurion syndrome: Diagram of the medial canthal tendon in Centurion syndrome. The attachment of the anterior limb extends beyond the nasomaxillary suture. The medial canthus is pulled forward and the angle between the anterior limb and palpebral extension becomes more blunted (1'). The dotted line represents the normal lid position. The lower punctum gets displaced anteriorly (from 2 to 2') [adapted from Sullivan et al[1]].

Pathogenesis

This condition is characterised by the abnormal anterior insertion of the lacrimal puncta out of the tear lake, usually anterior to the nasomaxillary suture (Figure 1b). This results in delayed tear drainage at the inner canthus in an otherwise anatomically patent nasolacrimal system. During puberty, there is worsening due to growth of the mid face, especially the frontal process of the maxilla and the nasal bone, as the medial canthal tendon gets drawn outward. In addition patients have a prominent nasal bridge. Enophthalmos may be present; this retrodisplacement of the eyeball contributes to further loss of medial apposition of the punctum and the globe. However enophthalmos is considered to play a minor role in the pathogenesis of this syndrome.[1]

Clinical presentation

This commonly affects young males especially in the third decade of life.[3] The typical history is of epiphora, which has commenced in childhood for which the patient has been unable to find a cure. When the patient reaches puberty and has the growth spurt, the watering becomes more severe. This condition should be considered once other causes of epiphora like, hypersecretion of tears, eyelid abnormalities and drainage system abnormalities have been ruled out.

The patients have a prominent nasal bridge. The lid-globe apposition is lost medially and the lacrimal puncta lie outside the lacrimal lake (Figure 2a and 2b). Enophthalmos may be noted on exophthalmometry. The fluorescein dye disappearance test shows delay, however syringing is patent. [4] Dacryocystography may show hold-up of sac emptying or reflux of radio-opaque medium into the palpebral aperture.[1] Lacrimal scintillography shows a functional block at the inner canthus, with hold up of activity before entry into the sac. [1]

Management

Surgery is required for the management of this condition. The aim of surgery is to restore the eyeball-lid

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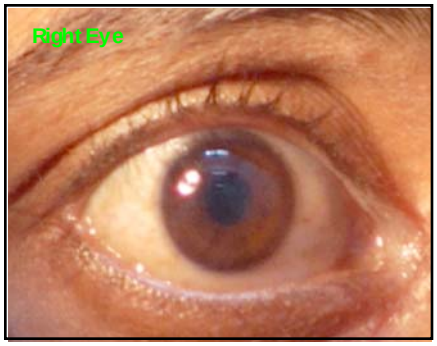
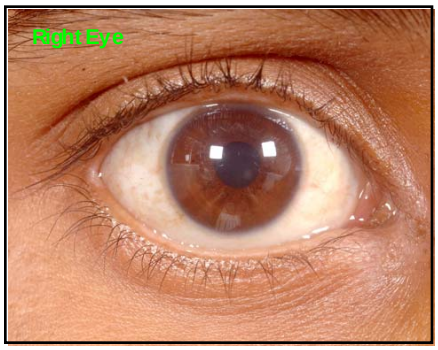


Fig.2: Centurion syndrome: Preoperative photograph showing the inferior punctum displaced out of the lacrimal lake and anterior displacement of the medial canthus.



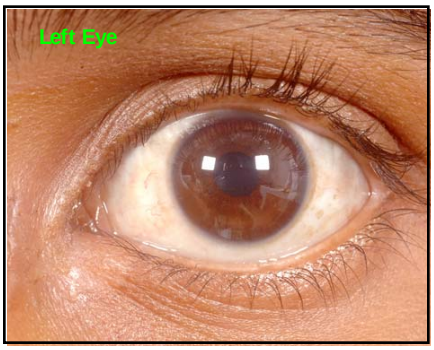


Fig. 3: Centurion syndrome: Postoperative photograph after release of the anterior limb of the medial canthal tendon. The punctum is now apposed to the globe.

apposition and place the puncta back in the lacrimal tear lake.

The techniques described for the management of this condition include:

1. Release of the anterior limb of the medial canthal tendon
2. Lower eyelid retractor plication
3. Medial conjunctivoplasty

Release of the anterior limb of the medial canthal tendon

This was first described by Sullivan et al.[1] High success rate in restoring the normal anatomy has been reported with this technique (Figure 3a and 3b). On the other hand Ma'luf et al reported that this surgery was not enough to restore the lid globe apposition.[5]

Technique

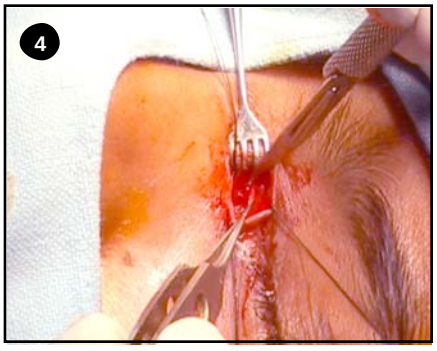
Under local anesthesia, a shortened skin incision as in DCR is made about 8-10 mm from the medial canthus (without extending it much inferiorly). A self retaining retractor or 4 traction sutures with 4-0 silk is placed to spread open the wound. Blunt dissection is performed. The anterior limb of the medial canthal tendon can be identified as a glistening white band. The anterior limb of the medial canthal tendon is released by a vertical incision over the insertion of the tendon (Figure 4). The tendon is dissected off the periosteum and from the anterior surface of the lacrimal sac, until the anterior limb of the medial canthal tendon is completely free. When this technique is insufficient, the released tendon stump is plicated posteriorly to the periosteum of the lacrimal fossa, just posterior to the anterior lacrimal crest with a 6-0 absorbable suture.

Lower eyelid retractor plication[3]

This procedure may be combined with release of the anterior limb of the medial canthal tendon if that is not enough to restore globe-lid apposition.

Technique

An incision is made along the inferior part of the medial tarsal plate, from below the punctum for about 12 to 15 mm laterally. The conjunctiva and orbital septum is incised. Two 6-0 vicryl sutures are passed through the anterior surface of the eyelid retractors and through the conjunctival cut edge and the inferior surface of the tarsal plate and tied so that the sutures are buried.



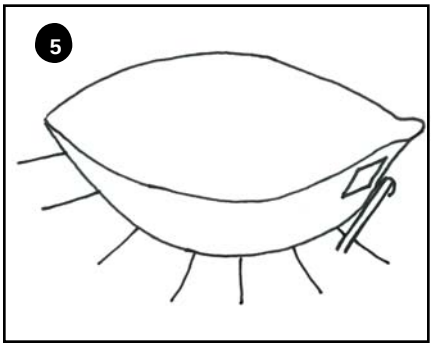


Fig.4: *Centurion syndrome:* The skin is incised as in a DCR incision. After exposing the anterior limb of the medial canthal tendon by blunt dissection, it is cut with an 11 no. BP knife and separated from its attachments to the sac surface and periosteum. **Fig.5:** *Centurion syndrome:* In medial conjunctivoplasty, a diamond of tarsoconjunctiva is excised below the punctum and the apices of this diamond are sutured.

Medial conjunctivoplasty

This procedure should be done if there is medial ectropion. The lower punctum is inverted by vertical shortening of the posterior lamella of the lid and tightening of the lower lid retractors.

Technique

After placing a probe in the inferior canaliculus, a diamond of tarso-conjunctiva is excised from below the punctum using a cautery or blade. The apex of the diamond should be about 1-2 mm below the lower punctum. A 6-0 absorbable suture is passed through the superior apex of the diamond and the other end through the inferior apex of the diamond taking the lower lid retractors along (Figure 5). This suture is tied so that the knot gets buried in the wound. If this is insufficient, an 'inverting suture' is passed. A double armed suture is passed similarly, but with the ends passed through the orbicularis and skin and tied over a bolster. This advances the anterior lamella of the skin and orbicularis and increases the inversion of the punctum.

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Vitrase

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Vitreous Hemorrhage is one of the leading cause of ocular morbidity .The common causes of vitreous hemorrhage include proliferaive diabetic retinopathy, posterior vitreous detachment, trauma, reinal tears and detachment, retinal vein occlusion,age related macular degeneration and retinal neovascularization due to any cause.[1]

The current management of vitreous hemorrhage include observation for few weeks followed by vitrectomy for non-clearing vitreous hemorrhage.[2-4] There is no approved drug therapy for vitreous hemorrhage. However, research into non-surgical approaches for the management of vitreous hemorrhage is underway.[5] Vitrase (Hyaluronidase ovine, ISTA Pharmaceuticals, Inc.) a specially purified enzyme, which has been under development for last few years has aroused interest in the treatment of vitreous hemorrhage.

What is Vitrase?

Vitrase is a lypholised preparation of highly purified ovine testicular hyaluronidase, a protein enzyme. The exact chemical structure of this enzyme is unknown. However, the amino acid sequence for the primary structure of the enzyme has been deduced from the sequence of purified peptides.

Vitrase (hyaluronidase for injection) dehydrated in the solid state under high vacuum with the inactive ingredients, is supplied as a sterile, nonpreserved, white, odorless, amorphous solid. The product is to be reconstituted with 0.9% Sodium Chloride Injection, USP, before use.

Each vial of 6200 USP units contains 5 mg lactose, 1.92 mg potassium phosphate dibasic, and 1.22 mg potassium phosphate monobasic.

The reconstituted solution is clear and colorless, with an approximate pH of 6.7 and osmolality of 290 to 310 mOsm.

Mechanism Of Action

Hyaluronidase is a spreading or diffusing substance, which modifies the permeability of connective tissue through the hydrolysis of hyaluronic acid, a polysaccharide found in the intercellular ground substance of connective tissue, and of certain specialized tissues, such as the umbilical cord and vitreous humor. Hyaluronic acid is also present in the capsules of type A and C hemolytic streptococci. Hyaluronidase hydrolyzes hyaluronic acid by splitting the glucosaminidic bond between C1 of the glucosamine moiety and C4 of glucuronic acid. This temporarily decreases the viscosity of the cellular cement and promotes diffusion of injected fluids or of localized transudates or exudates, thus facilitating their absorption.

Vitrase cleaves the glysosidic bonds of hyaluronan and leads to collapse and liquefecation of the vitreous,thereby facilitating diffusion of molecules and proinflammatory chemotactic factors.This in turn promotes the ingress of phagocytic cells and egress of red blood cells and proteins. At 3 days postinjection,vitrase shows marked disruption and liquefaction of the clot.

The half-life of vitrase in the eye is 60-112 hrs. The highest concentration is found in vitreous followed by the retina.The plasma half-life is 49hrs.

Clinical Trials on Vitrase

This investigational drug administered as an intravitreal injection, has undergone Phase I and Phase II trials in the United States and in Mexico. Data from prospective, randomized, double-masked studies evaluating three different doses in subjects with chronic, non-clearing haemorrhage persisting for a minimum of one month

have been presented by Quiroz, et al.[10] by Boyer et al.[11] by Harper and Thomas[12] and by Thomas.[13] More than half of the treated subjects experienced haemorrhage clearance sufficient to enable diagnosis and treatment for the underlying cause of the haemorrhage within the 8-week study period. Patients in the high dose group experienced the highest rate of clearance of severe haemorrhage. Sterile hypopyon was observed in some eyes within 1–2 days after injection and resolved within one week after onset. Patients in the high dose group experienced the highest incidence of sterile hypopyon. Retinal detachments were reported in three patients (one in each dose group). These latter sequellae and other serious adverse experiences (for example, hospitalization for diabetes-related complications) were not considered to be drug-related.

The phase 3 clinical trial program for Vitrase included 2 phase 3, double-masked, placebo-controlled clinical trials

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conducted at 131 sites in 12 countries. The primary objective of the study was to determine the safety and efficacy of a single intravitreous injection of vitrase for the treatment of severe vitreous hemorrhage.

The main eligibility criteria included presence of vitreous hemorrhage for at least 1 month, severe vitreous hemorrhage at entry that obscured visualization of the fundus and best-corrected visual acuity (BCVA) w orse that 20/200 in the study eye. The density of the vitreous hemorrhage assessed by a new standardized grading scale had to be grade 3 or 4 in 12 clock hours. The main exclusion criteria included presence or history of retinal tears or detachment, ocular trauma, prior vitrectomy, organized vitreous hemorrhage, or no light perception in either eye.

An independent Data Safety Monitoring Board reviewed the outcomes throughout the course of the study. The randomization groups included 3 different intravitreous doses of Vitrase: 7.5 IU, 55 IU, and 75 IU, as well as a saline intravitreous injection control group. The etiology of the baseline vitreous hemorrhage included proliferative diabetic retinopathy in more that 60% of the cases. The mean duration of the baseline vitreous hemorrhage was approximately 4 months. The baseline BCVA was off chart (light perception, HM, counting fingers) in over 90% of the cases.

In summary, the primary efficacy endpoint was not met at 3 months. However, the primary efficacy measure at months 1 and 2 was statistically significant in favor of Vitrase. In addition, all of the secondary endpoints (ie, improvement in BCVA and reduction of vitreous hemorrhage density) of the studies were met in a statistically significant manner in favor of Vitrase over saline injection control.

The most significant key adverse events included iritis in approximately 60% of Vitrase-treated eyes and approximately 30% of saline injection control eyes. Sterile hypopyon occurred in approximately 2%–5% of Vitrase-treated eyes and did not occur in saline injection control eyes. Most cases of retinal detachment were cases of tractional retinal detachment. Rhegmatogenous retinal detachment occurred in approximately 1%–2% of eyes and was not statistically significant when comparing vitrase to saline control eyes.

The results appear encouraging and indicate that this treatment may offer advantages of a non-surgical approach to the management of vitreous haemorrhage. Patients may benefit by having reduced risk of complications associated with surgery and the ophthalmologists may benefit by being able to perform the procedure in a clinic setting rather than the operating theatre. The potential for non-surgical treatment will significantly reduce the morbidity and ultimately translate into lower health care costs for the patient.

Current Indications and Usage

Vitrase is approved by FDA for use as a spreading agent . Vitrase (hyaluronidase for injection) is indicated as an adjuvant to increase the absorption and dispersion of other injected drugs; for hypodermoclysis; and as an adjunct in subcutaneous urography for improving resorption of radiopaque agents.

Contraindication

Hypersensitivity to hyaluronidase or any other ingredient in the formulation is a contraindication to the use of this product.

Warnings

Discontinue Vitrase (hyaluronidase for injection) if sensitization occurs.

Hyaluronidase should not be used to enhance the absorption and dispersion of dopamine and/or alpha agonist drugs.

Hyaluronidase should not be injected into or around an infected or acutely inflamed area because of the danger of spreading a localized infection.

Hyaluronidase should not be used to reduce the swelling of bites or stings.

Hyaluronidase should not be applied directly to the cornea.

Hyaluronidase should not be used for intravenous injections because the enzyme activity is rapidly inactivated.

Drug Interactions

When hyaluronidase is added to a local anesthetic agent, it hastens the onset of analgesia and tends to reduce the swelling caused by local infiltration, but the wider spread of the local anesthetic solution increases its absorption; this shortens its duration of action and tends to increase the incidence of systemic reaction.

Patients receiving large does of salicylates, cortisone, ACTH, estrogens, or antihistamines may require larger amounts of hyaluronidase for equivalent dispersing effect, since these drugs apparently render tissues partly resistant to the action of hyaluronidase

Adverse Reactions

The most frequently reported adverse experiences have been local injection site reactions. Hyaluronidase has been reported to enhance the adverse events associated with co-administered drug products. Edema has been reported most frequently in association with hypodermoclysis. Allergic reactions (urticaria, angioedema) have been reported in less than 0.1% of patients receiving hysluronidase. Anaphylactic-like

reactions following retrobulbar block or intravenous injections have occurred, rarely.

Overdosage

Symptoms of toxicity consist of local edema or urticaria, erythema, chills, nausea, vomiting, dizziness, tachycardia, and hypotension. The enzyme should be discontinued and supportive measures initiated immediately.

How Supplied

Vitrase® is supplied sterile as 6200 Units of lyophilized ovine hyaluronidase nonpreserved in a single-use 5 mL vial with a rubber stopper and aluminum seal; one 1 mL sterile polycarbonate syringe; and one 5µm sterile filter needle.

Not recommended for IV use. Protect from light.

Store unopened vial in refrigerator at 2-8oC (35-46oF). After reconstitution, store at controlled room temperature 20-25oC (68-77oF), and use within 6 hours.

Conclusion

Non-surgical pharmacologic treatment to facilitate clearance of vitreous haemorrhage may produce a useful adjunct to current techniques to treat vitreoretinal disorders and Pharmacologic vitreolysis can also be performed to replace vitrectomy.Although the day when vitreous surgery is replaced by non-invasive therapy remains far in the future, these developments hold great promise.

However it is important to keep in mind that other hyaluronidase compounds on the market have not been studied in the vitreous. Importantly, a preparation of ovine hyaluronidase containing thimerosal was found to be toxic to the retina when administered by intravitreous injection into rabbit eyes at doses up to 30 units.[14]

Vitrase offers a off-label pharmacotherapeutic option for the management of vitreous hemorrhage.

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Technique of intravitreal Avastin injection

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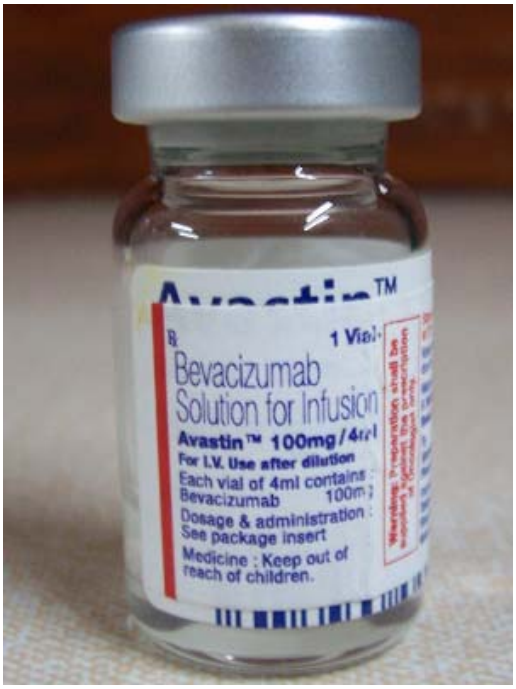
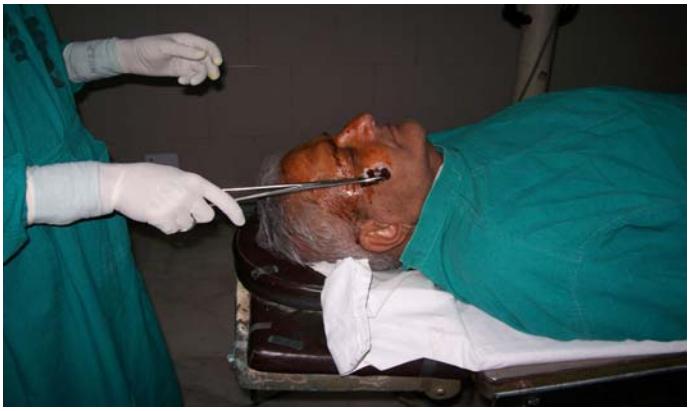
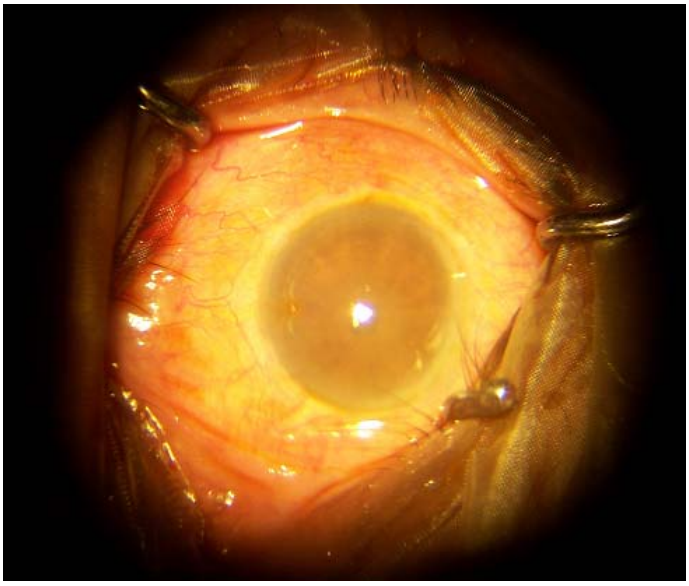


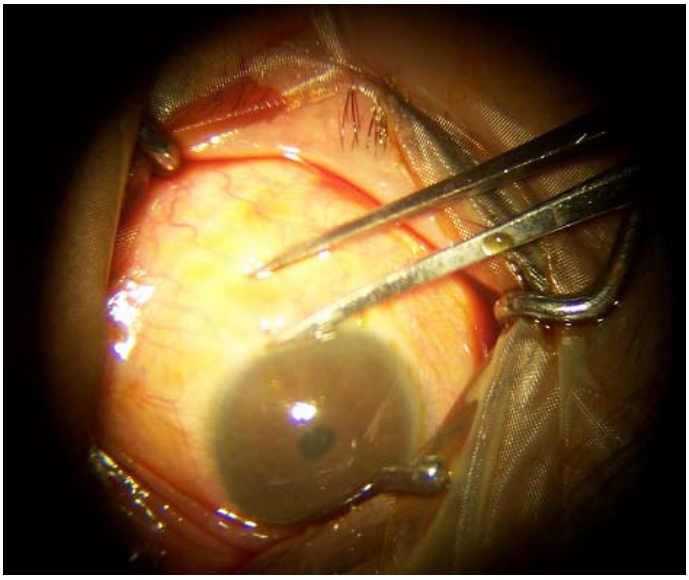
4 ml Avastin vial, tuberculin syringe with 30G needle for intravitreal injection



Cleaning with povidone-iodine and draping



5% povidone-iodine solution instilled in conjunctival sac



Site of intravitreal injection-3.5mm posterior to limbus in pseudophakic and 4mm posterior to limbus in phakic eyes in inferotemporal quadrant

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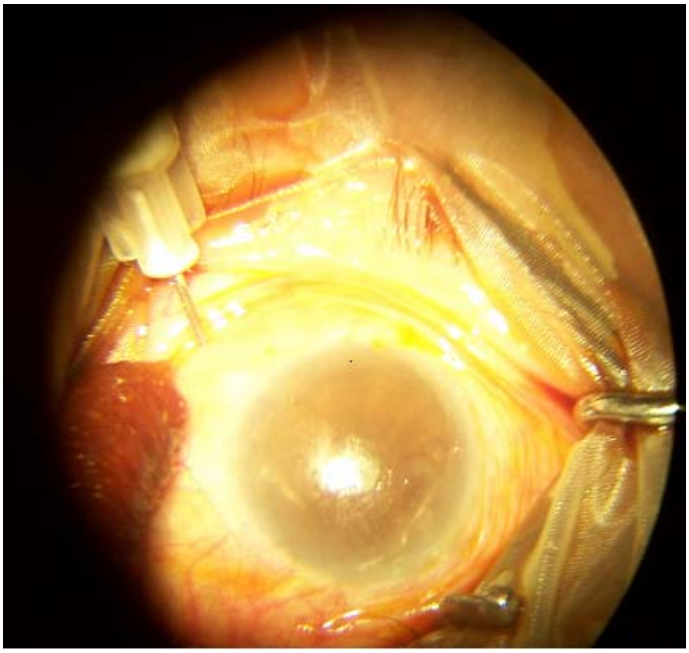
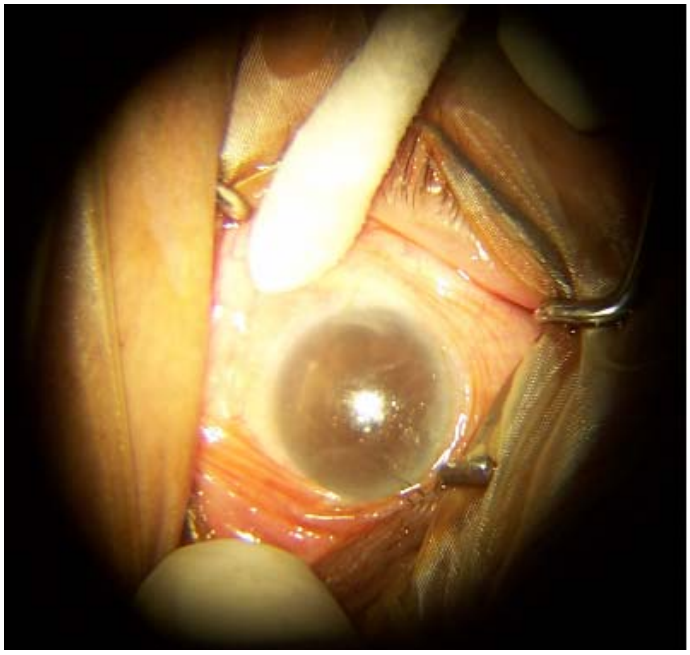
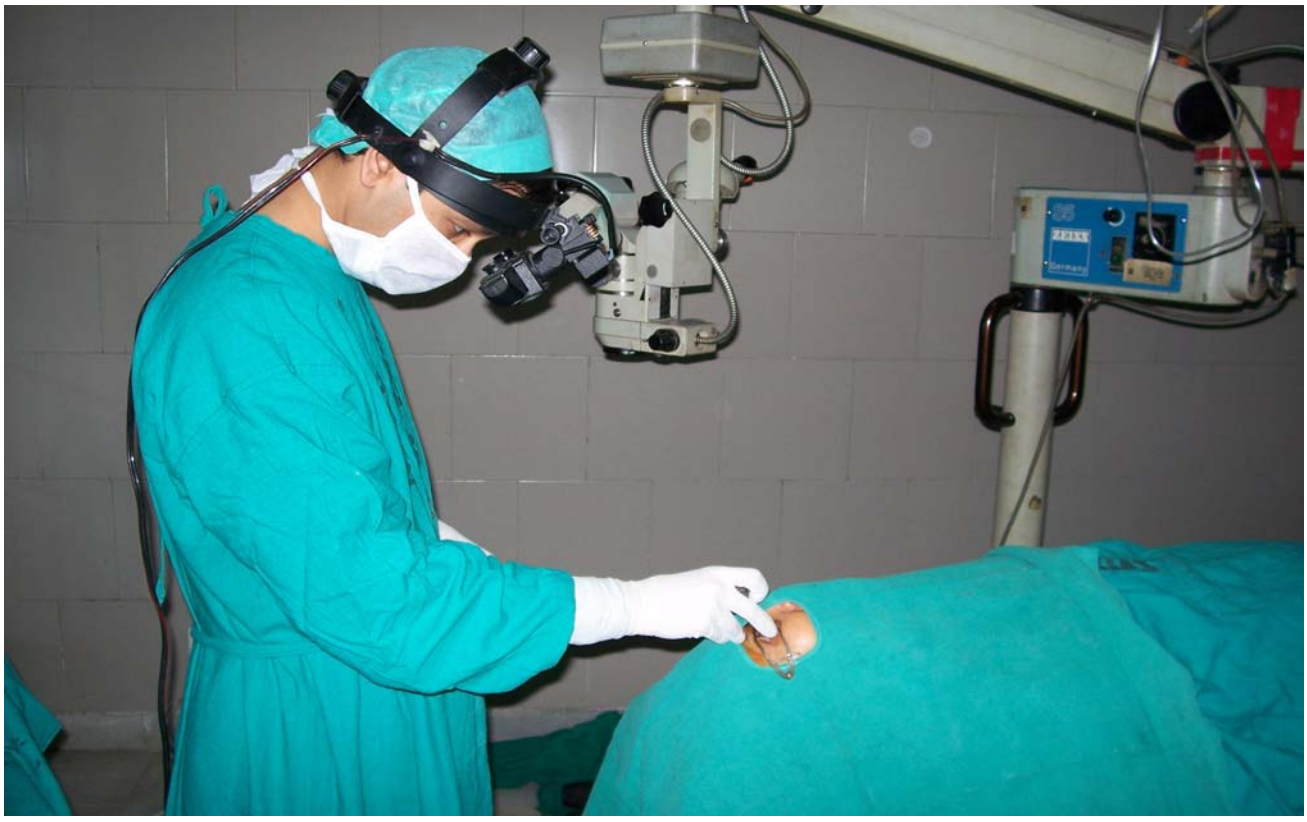
New Delhi



Valvular entry tract made with ½-5/8”30G needle directed towards centre of globe,with minimal movements while needle is in the eye. Globe is fixed with swabstick.Needle checked in pupillary area before injecting.



Tamponade applied with sterile cotton tipped applicator to needle track as it is withdrawn



Indirect ophthalmoscopy performed to check for retinal tears,RD and perfusion status of Central Retinal Artery

Management of Dropped Nucleus

S.N. Jha, Amit Khosla MD**, Neeraj Manchanda, Tinku Bali** MS, FRCS

Phacoemulsification is the accepted standard for cataract extraction. Posterior dislocation of lens fragments into the vitreous is one of the recognised complications of phacoemulsification that may compromise final visual outcome and has an incidence of between 0.3% and 1.1%.

This article will focus on the mechanism, risk factors and management options for displaced nuclear fragments.

Mechanism

Displaced nuclear fragments most often result from a large posterior capsular tear, although more rarely they occur following zonular dialysis. Several surgical steps may be contributory to a posterior capsular tear. Radial anterior capsular tear formation during capsulorhexis, which then proceeds to extend posteriorly, is a common precursor. Anterior capsular tear may also result from damage with the phaco tip, particularly when the capsulorrhexis is small or irregular. Direct perforation of the posterior capsule with the phaco probe may occur during deep sculpting or during nucleus removal, where there is inadequate protection of the capsule with the second instrument or following continued aspiration after fragment removal. Less commonly capsular rupture may occur on hydrodissection, particularly in the presence of a posterior polar cataract.

Risk factors

Surgical cases that offer the cataract surgeon a 'challenge' are more likely to result in loss of the capsulorhexis or later capsular tears. Late recognition of such tears is usually an identifiable factor in cases with a displaced nuclear fragment.

For the novice surgeon the risk of this complication is increased even in the seemingly straightforward case. As the surgeon gains a little more experience and is confident in routine cases, both trainee and trainer should be particularly vigilant in cases likely to provide challenge. Examples would include cases with corneal scarring, small pupil, dense nucleus or previous vitrectomy. Some cases will, of course, provide a challenge even to the experienced surgeon. Of particular note are posterior polar cataracts where, even in experienced hands, a posterior capsular rupture rate of between 11% and 36 % is reported.

Management

The management of the displaced nucleus can be divided into two parts:

1. Initial management by the cataract surgeon
2. Later management by the vitreoretinal surgeon.

Management by the cataract surgeon

The experienced cataract surgeon may be competent to continue with surgery in the presence of anterior capsular tears and even large posterior capsular tears. However, once it has been identified that a nuclear fragment has dropped into the vitreous cavity, it should be recognised that referral to a vitreo-retinal surgeon will be necessary. The key consideration at this point is that the situation is still entirely salvageable.

Appropriate management of the case by a vitreo-retinal surgeon is likely to result in a good visual outcome. However, inappropriate and/or inexperienced intervention may result in serious complication, which will compromise the outcome. The cataract surgeon should therefore resist the temptation to 'chase' nuclear fragments or perform procedures outside his/her expertise. An anterior vitrectomy, preferably with separate irrigation cannula or anterior chamber maintainer, should be performed to clear the wound. The section should be checked externally to ensure it is free from vitreous strands. A complete anterior vitrectomy can be performed, together with removal of the remaining soft lens matter, which can also be cleared with the suction cutter. It is essential to retain good capsular support, and if this procedure proves difficult it should be left for the vitreo-retinal surgeon who may be able to get clearance more easily from a posterior approach.

Where there is an intact capsulorrhexis a foldable lens can be placed in the ciliary sulcus and capture of the optic by the capsulorrhexis may be used to stabilise the lens. At the end of the procedure it should be ensured that the wound is secure.

A sub-conjunctival steroid injection can be given and the patient should be commenced on regular topical steroids, antibiotics and a mydriatic. Non-steroidal anti-inflammatory drops appear to be beneficial for the prophylaxis of cystoid macular oedema. The intraocular

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pressure should be closely monitored and managed medically as appropriate. Early referral to the vitreo-retinal surgeon should be made to allow flexibility with regard to subsequent management.

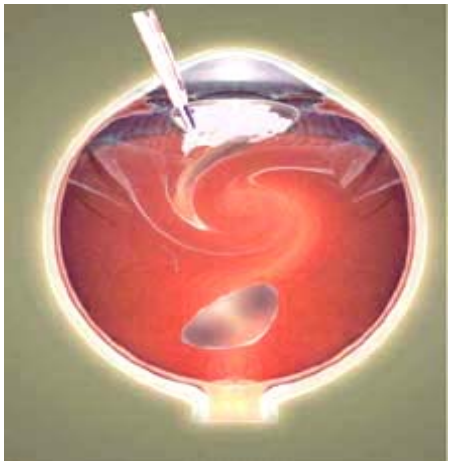

Fig.1: Posteriorly Dislocated Lens Nucleus

Management by the vitreo-retinal surgeon

The vitreo-retinal surgeon will assess the patient and make a judgement about the amount of lens matter present and the speed at which further intervention is required. If there are anterior retinal tears or early retinal detachment, early intervention is indicated. Similarly, if intraocular pressure cannot be controlled by medical means, or if there is a marked inflammatory response, early intervention will be beneficial.

Otherwise, a short delay may aid surgery due to resolution of corneal oedema and acute postoperative inflammation. Delay may also allow the retained lens material to soften, which may aid its removal.

Several studies have shown a higher incidence of long-term complications such as uveitis, glaucoma and corneal oedema with delayed surgery, particularly where surgery is delayed by more than four weeks. The aim should be to operate in the first 2 weeks. Small fragments may not cause significant inflammation and may eventually be reabsorbed if left. This has led to a belief that nuclear pieces of size less than 25% of the whole nucleus can be managed conservatively. However, even small fragments can be associated with inflammation, glaucoma and cystoid macular oedema and if a conservative course of action is taken, the patient should be closely observed. Our practice is to perform vitrectomy to remove any nuclear fragment. Vitrectomy, when it is performed, should be a standard three-port pars plana vitrectomy. A posterior vitreous detachment must be induced if it is not already present and vitreous should be removed from around the lens fragments to minimise retinal traction. If the lens matter is soft it can be removed with the vitreous cutter. Otherwise ultrasonic fragmentation, using a phacofragmatome can be used. To guard against retinal damage from traction produced by fragmatome aspiration of residual vitreous, a thorough vitrectomy must be performed before removal of lens matter. Nuclear fragments should be brought into the mid-vitreous cavity before ultrasound is applied. The vitreo-retinal surgeon must finally ensure that no nuclear fragments remain in the vitreous base and that there are no retinal tears.

If conditions are favourable after vitrectomy and fragment removal, an intraocular lens implant can be inserted (if not present already). A posterior chamber implant into the ciliary sulcus, where capsular support is sufficient, is a good option. Where there is doubtful capsular support, scleral-sutured lens may be indicated.

Conclusion

In summary, a dropped nucleus is a serious complication of cataract surgery. However, the most important predictor of good final visual acuity is a minimally complicated clinical course (eg. absence of suprachoroidal haemorrhage, retinal detachment or cystoid macular oedema). The cataract surgeon should therefore seek to minimise further complication, avoiding the temptation to attempt to remove dropped nuclear fragments and, following appropriate anterior vitrectomy, make early referral to the vitreoretinal surgeon.

Pachymetry: A Review

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Pachymetry (Greek words: *Pachos* = thick + *metry* = to measure) is term used for the measurement of corneal thickness. It is an important indicator of health status of the cornea especially of corneal endothelial pump function. It estimates the corneal barrier and endothelial pump function. It also measures corneal rigidity and consequently has an impact on the accuracy of intraocular pressure (IOP) measurement by applanation tonometry. Recent emergence of refractive surgeries has increased its value as a clinical variable.

The thickness of the cornea was first reported in ancient textbooks on physiological optics (Helmholtz, Gullstrand). Physiological interest was again revived in the 1950s by David Maurice, and over the next 50 years, this 'simple' biological parameter has been studied extensively.

Corneal Thickness in Normal Eyes

The normal corneal thickness varies from central to peripheral limbus. It ranges from 0.7 to 0.9 mm at the limbus and varies between 0.49 mm and 0.56 mm at the centre. The Central corneal thickness (CCT) reading of 0.7 mm or more is indicative of endothelial decompensation. The mean CCT as shown by various studies is 0.51-0.52 mm (standard deviation 0.02-0.04 mm). It has been found that cornea is significantly thicker in the age group of 40 – 80 years than in the individuals below 40 years as it seems to undergo age-related anatomic changes. Peripheral corneal thickness is asymmetric so that temporal cornea is thinnest followed by the inferior cornea.

Cornea in Newborn and Infants

The importance of corneal thickness in newborn is significant in cases such as buphthalmos. Therefore, it becomes important to know about corneal thickness in newborns and infants. Corneal configuration in newborns is similar to that of the adult cornea- ie peripheral cornea is thicker than central cornea. It has been found that cornea on day one is significantly thicker and decreases in thickness as the child grows older. It is said that, it may result from the fact that the eyes in utero remain closed for a long time. The decreasing thickness after the first day may suggest that a hydration control becomes operative. The average corneal thickness in infants is 585 ± 52 microns.

The peripheral corneal thickness/central corneal thickness ratio indicates ocular maturity—the greater the ratio the greater the development of the eye. *The superior peripheral cornea is thinnest in newborn compared to inferior, nasal and temporal.*

Factors affecting central corneal thickness

The CCT was found to be higher in younger patients, male patients and diabetic patients. Central corneal thickness does not correlate with refraction or systemic hypertension. The mean CCT of black children is thinner than that of white children. Several investigators have recently provided further evidence that African-American subjects tend to have thinner corneas than their white counterparts.

The PITX2/Pitx2 mutation seen in Axenfeld-Rieger malformations results in reduced corneal thickness .

Role in clinical practice

Corneal thickness evaluation has an important role in the following clinical situations:

1) *Glaucoma*: for applying correction factor in actual intraocular pressure (IOP) determination
2) *Congenital Glaucoma*: to assess the amount of corneal edema.
3) *Refractive surgeries:* a) preoperative screening and b) treatment plan of keratorefractive procedures like LASIK, astigmatic keratotomy, and previously even prior to radial keratotomy.
4) Post operative follow up of keratoplasty patients to determine endothelial cell function and its recovery and to become alert to early graft decompensation.
5) Contact lens: To assess corneal edema and in orthokeratology.
6) Assessing the thinness of the cornea as in corneal disorders like Terrien's and Pellucid marginal degenerations, keratoconus, keratoglobus, post LASIK ectasia.
7) *Other cases if corneal decompensation*: For monitoring and

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evaluating corneal edema and endothelial function as in herpetic endothelitis.

Role in Glaucoma

Goldmann tonometry is the gold standard in glaucoma measurement. Goldmann tonometer's chief advantage over its predecessors is that it is capable of adjusting IOP measurements for scleral rigidity. The impact of central corneal thickness (CCT) on applanation tonometry was first discussed by Goldmann. He assumed that the resistance of the cornea to indentation was compensated by the surface tension of the tear film. This assumption was only true for a central corneal thickness of 520 ìm, otherwise the accuracy of applanation tonometry can be considerably impaired. Applanation tonometry is based on Imbert Fick's law, which assumes that cornea is a perfect flexible, dry, sphere which is infinitely thin. Therefore increase in the tissue in thicker cornea makes it less compliant and subsequently leading to overestimation of IOP conversely thinner cornea lead to underestimation of IOP.

Ocular Hypertension Treatment Study (OHTS) group published a landmark report in 2002 that central corneal thickness (CCT) was an important independent risk factor for progression from ocular hypertension to early glaucoma.

Correction factor

To get a correct IOP reading various correction factors have been reported by various researchers. It is recommended that in chronic eye diseases like glaucoma and glaucoma suspects for every increase in central corneal thickness of 50 microns, the correction done is to decrease the recorded IOP by 2.5mm Hg. For acute onset diseases it was recommended to correct by 10 mm Hg for every 50 microns.

A general recommendation supported by the data so far is that one can take better care of patients simply by categorizing corneas as thin, average, or thick, just as it is important to recognize that optic discs come in small, medium, and large, allowing the clinician to interpret disc configurations accordingly.

Facts about CCT in Glaucoma

It has been confirmed that CCT bears an inverse relation with the risk of developing glaucomatous damage.

CCT may vary systematically in different forms of glaucoma. Bechmann in 2000 found following association of CCT with different forms of glaucoma.

- Increased CCT measurements are found in patients with ocular hypertension, which can lead to falsely elevated IOP readings,
- Decreased CCT is found in patients with low tension glaucoma, resulting in falsely reduced IOP measurements.

  To put the above two facts in another way, the true IOP in low tension glaucoma may not be as low as previously assumed, whereas the true IOP in ocular hypertension may be within the normal range, after taking central corneal thickness into account.
- Similarly, CCT was found to be lower in patients with Pseudoexfoliation syndrome (PXS) and in Primary open angle Glaucoma (POAG). In a study done by Brandt JD et al in 2004 on small number of PXS, corneas were found to be thinner regardless of presence of Glaucoma.
- There is no difference in corneal thickness in individuals with Pigmentary Glaucoma (PG) and Primary angle Closure Glaucoma (PACG).
- But this association of corneal thickness and PXS, POAG, PACG and Pigmentary glaucoma has not been proven in other studies.

Effect of CCT on Various Tonometers

Because of variable corneal thickness in different people across different ethnicities, Goldmann applanation tonometry has been found to be of lower reliability and has led to innovations in alternate methods for IOP assessment which are either independent of this variable or incorporate corneal thickness before displaying the IOP values.

It has been found that Ocular Blood Flow (OBF) - pneumotonometer and non-contact tonometer (NCT) showed a higher influence of CCT than Goldmann applanation tonometer (GAT) in glaucomatous eyes. This was attributed to the fact that NCT applanates a wider area as compared to GAT. While for GAT, a balance of applanating force on one side with IOP and corneal rigidity on the other side is considered as the end point of IOP measurement, for OBF-pneumotonometer the pressure of air flow has to exceed this balanced equilibrium, to escape. Therefore the corneal thickness has higher effect on OBF-pneumotonometer readings compared to those of GAT.

Dynamic contour tonometry is a newer promising modality, affected to a lesser degree by CCT but has been found to over estimate IOP. Therefore it is wise to measure IOP by this instrument in individuals in which corneal thickness is deviating from the normal value. It has an electronic strain gauge embedded in a contoured plastic tip which creates a tight-fitting shell on the corneal surface without applanation of corneal tissue when the tip comes in contact with the cornea. It is assumed that the tonometer compensates for all forces exerted on the cornea, allowing

the strain gauge to measure IOP largely independent of corneal biomechanical properties.

Clinical Implications in glaucoma

It is useful in determining risk of developing glaucoma and interpreting unexpected intraocular pressure (IOP) measurement results. Increased corneal thickness can produce false high IOP readings, and decreased corneal thickness can produce false low IOP readings even on Goldman Applanation Tonometry (GAT).

Corneal pachymetry appears to be an essential tool in predicting the progression from ocular hypertension to POAG. Lower CCT is considered as a risk factor for the development of glaucomatous damage in OHT patients OHT patients with SWAP abnormalities had significantly lower CCT measurements than those without it. Similarly patients with frequency doubling technology perimetry defects had thinner corneas than those with normal results.

There is a positive correlation between increasing measured IOP and CCT among children with normal corneas and anterior segments.

It has been reported that refractive surgical procedures such as Excimer photorefractive keratectomy (PRK) and laser in situ keratomileusis (LASIK) tend to lower IOP readings performed with applanation tonometry, and thinning of the central cornea is believed to be the underlying cause because of laser ablation induced reduced corneal thickness. The problem will arise after 10 or 15 years when these subset of patients become older and are at risk for glaucoma development, and when these individuals neglect to inform their ophthalmologist that they had LASIK years ago.

Evidence Based Guideline for Corneal Pachymetry in Glaucoma

Corneal Pachymetry may be appropriate for patients who have risk factors for developing Primary Open Angle Glaucoma. Patients who have one or more of the following characteristics would be considered at risk for developing glaucoma and therefore corneal pachymetry is recommended:

- Elevated intraocular pressure repeatedly measured > 24 mm Hg
- African descent
- Advancing age (>65 years old)
- Family history of glaucoma
- Diabetes mellitus (though it is controversial)

Pachymetry in refractive surgery

Central corneal thickness measurement has got important role in following situations:

- It is important in the *preoperative assessment* of candidates for corneal refractive surgical procedures such as laser in situ keratomileusis (LASIK). It is recommended that before undertaking patients for LASIK a residual stromal thickness of 250-300 μm must be ensured.
- It has got an important role in *determining the type of corneal refractive* procedure to be undertaken. Patient with adequate thickness to their corneas may be candidates for LASIK while those with thinner corneas may be safer considering PRK / LASEK as their treatment option
- It is important *to evaluate the outcome* of laser refractive surgical procedures, especially in candidates for enhancement surgery. Underestimation of corneal pachymetry may lead to exclusion of some of these patients and, in general, to a conservative treatment plan. It is vital to know that whether there is enough tissue in the cornea to allow removal of a certain amount during the re-sculpting by the laser while leaving an adequate amount untreated to reduce chances of post LASIK ectasia.
- Conversely, overestimation may increase the risk of corneal ectasia.
- Corneal thickness also undergoes age related changes. Therefore surgeon should consider this fact when planning penetrating keratoplasty and refractive surgery.

Corneal thickness calculator: online corneal thickness calculator is available. This calculator determines if patients have enough corneal thickness to safely proceed with refractive surgery. If pachymetry measurements are not entered then the calculations will be based on the average corneal thickness (540 microns). It can be downloaded from the following website: http://www.pcli.com/od/pachyCalc.html. The chart below is available to feed the patient's information. After this it can calculate the required thickness of the cornea depending on the ablation zone and also calculates surplus corneal thickness.

Patient Name: Date: Bottom of Form

Enter Patient InformationODOS

Pachymetry in contact lens use

Analysis of corneal thickness in contact lens wearers is essential for monitoring any changes in the cornea.

Moreover assessment of corneal thickness before contact lens prescription is another important thing to analyze. A study showed that corneal edema in contact lens wearers resolved in 2-15 days after the use of soft contact lenses was stopped. Therefore, it is recommended that the time period for the pachymetric readings to

stabilize is around 15 days. So, one must discontinue contact lens atleast 15 days before surgery to get the accurate pachymetric readings.

It has another important role in contact lens practice while employing overnight orthokeratology.

Techniques of Pachymetric Measurements

There are two types of pachymetric techniques

A. *Spot measurements:* These technologies include traditional optical pachymetry, specular and confocal microscopy, ultrasound pachymetry, and optical low-coherence reflectometry.

B. *Wide area mapping:* These provide the capability to map a wide area of the cornea. Pachymetric mapping technologies include slit scanning optical pachymetry and very high–frequency ultrasound imaging.

Pachymetric mapping provides several advantages over spot measurements. Mapping can reveal abnormal patterns such as keratoconus and pellucid marginal degeneration. It also allows preoperative planning for surgeries that primarily do not concern just the center of the cornea, such as astigmatic keratotomy, intracorneal ring segment (ICRS) implantation, phototherapeutic keratectomy, and deep anterior lamellar keratoplasty (DALK).

Despite these advantages, conventional ultrasound spot pachymetry is still the standard because of its reliability, ease of use, and relatively low cost.

Methods of Measurements (Fig. 1)

1. Ultrasonic techniques
   a. Conventional ultrasonic pachymetry
   b. Ultrasound Biomicroscopy (UBM)
2. Optical Techniques
   a. Manual Optical Pachymetry
   b. Specular Microscopy
   c. Scanning Slit Technology
   d. Optical Coherence Tomography (OCT)
   e. Optical Low Coherence Interferometry
   f. Confocal Microscopy
   g. Laser Doppler interferometry
3. Alternative Measurements
   a. Pentacam
   b. Pachycam
   c. Ocular response analyzer (ORA)

Ultrasonic Pachymetry

This is the most commonly used method these days and is regarded as the gold standard. In 1980, Henderson and Kremer introduced the ultrasonic pachymeter.

Principle

The ultrasonic pachymetry measurements depend on the reflection of ultrasonic waves from the anterior and posterior corneal surfaces. It is the measurement of the time difference (transit time) between echoes of ultrasonic signal pulses from the transducer of the probe and the reflected signal from the front and back surface of the cornea to the transducer.

Corneal thickness is calculated by following simple formula:

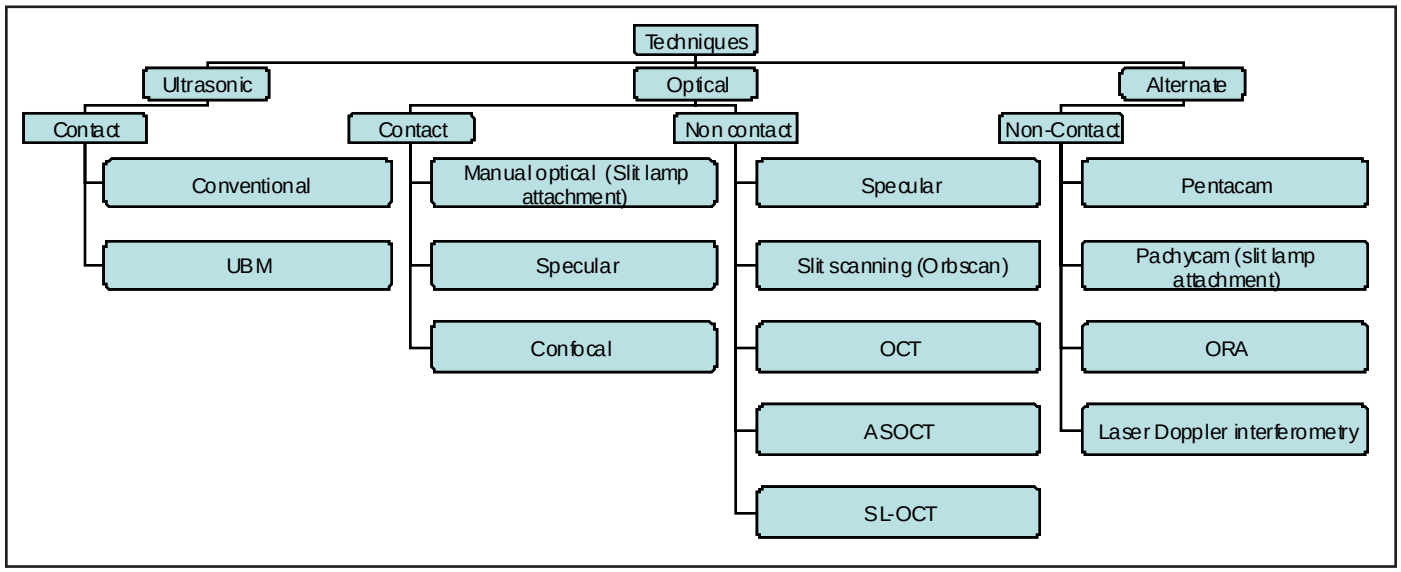


Fig.1: Methods of Pachymetry

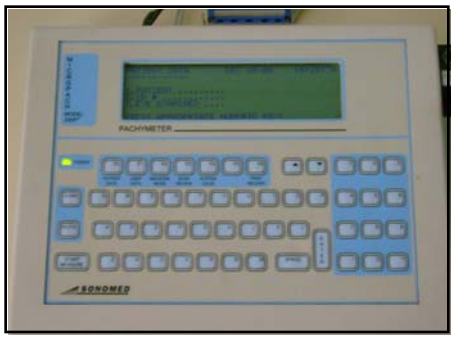


Fig.2: Ultrasonic Pachymeter

Fig.3: Probe of Ultrasonic Pachymeter

Corneal thickness = (Transit time × Propagation velocity) / 2

The sound velocity through normal cornea is taken as 1640 m / sec. Kremer et al selected this sound velocity because it gave him the average reading of 0.512 ± 0.035 mm which was same as given by optical pachymetry.

There are 3 major components of Ultrasonic pachymeter (Fig 2):

a. Probe handle

It consists of a piezoelectric crystal which vibrates at frequency of 10 - 20 MHz. This is a hand held probe which is very small, light and easier to use clinically. Some probes also have a digital read outs where the readings can be read directly.

b. Transducer

It sends ultrasound rays through the probe to the cornea and receives echoes from the cornea.

4. Probe tip (Fig 3)

The diameter of the tip should not be more than 2 mm, so that ultrasound beam spreads over a lesser area and the place where the tip of the probe is kept can be seen. The probe tip should be smooth enough to avoid damage to the corneal epithelium. A wide probe tip and a wide transducer beam reduce the accuracy of the corneal thickness reading.

When performing the measurement the probe tip has to be placed perpendicular to the centre of cornea. As corneal thickness increases peripherally, lateral displacement of the probe may cause elevated readings as well as shift of the probe out of the correct perpendicular position.

Advantages

- Fast
- Simpler : therefore easier for paramedical staff to use
- Requires minimal observer judgment and is therefore consistent and repeatable between observers thereby eliminating interobserver variation
- Portable
- Dry (no coupling medium required)
- Can be used intraoperatively

Disadvantages

- Contact method
- Accuracy is dependent on the perpendicularity of the probe's application to the cornea
- Reproducibility relies on precise probe placement on the center of the cornea.
- Difficult to control the patients gaze during repeated measurements, so that the placement of the probe is difficult to reproduce.
- There is variable sound speed in wet and dry tissues.
- Furthermore, the exact points of sound reflection in ultrasonic pachymetry are ill defined and the applanation force may disturb the anterior reflecting surface by pushing away the precorneal tear film and by thinning of the epithelium.
- Low resolution
- Not accurate in edematous corneas

Thus, to summarize, examiner's experience can influence the reliability of measurements.

Ultrasound Biomicroscopy (UBM)

Ultrasound biomicroscopy (Paradigm Med Ind, Inc. Salt Lake City, UT) is a high resolution ultrasound machine which images anterior segment of eye. It has got a 12.5 - 50 MHz probe so that the depth of penetration is lesser (4 mm) than conventional ultrasound. It gives real-time images of anterior segment (**Fig 4**).

Corneal thickness can be measured by the caliper incorporated in the machine or through the UBM software after acquisition of images (**Fig 5**).

Advantages

- Anterior segment examination (high resolution) can be carried out along with measurement of corneal thickness.
- Especially useful in cases where cornea is opaque.
- Various layers of cornea can be identified.

Disadvantages

- The main drawback of UBM imaging is the inconvenient requirement of immersing the eye in a

Fig.4: UBM

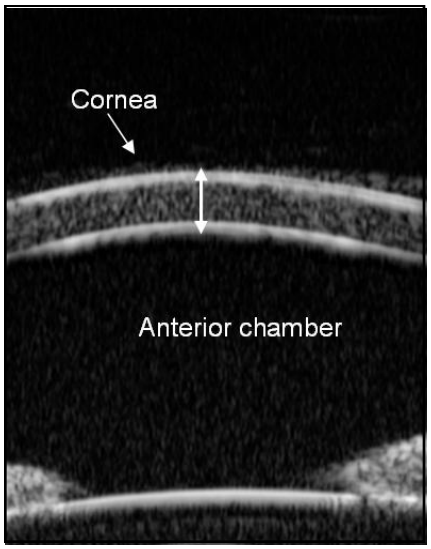


Fig.5: CCT on UBM

Fig.6: Non-contact Specular Microscope

coupling fluid.

- Contact method.
- Requirement for the patient to lie supine during the examination
- The device cannot be used intraoperatively.
- Difficult to standardize

Manual optical pachymetry

The central corneal thickness is measured with the Haag-Streit slit lamp using the pachymeter attachment (Haag Streit AG, Koeniz, Switzerland). This is the prototype of optical pachymeter. A slit beam is projected perpendicularly to the cornea through the narrow diaphragm of the instrument. To ensure the perpendicularity of the incident beam on the corneal surface, it comes with or without a Mishima-Hedbys fixation attachment. The instrument contains two plano glass plates that splits the image of the corneal parallelepiped. A uniocular right-sided split-image eyepiece replaces the regular eyepiece of the slit-lamp.

There are two methods to measure corneal thickness

"Just touch" method: The observer moves the scale of the instrument until the focused upper half of the corneal image is positioned so that its posterior surface (endothelial border) just touches the anterior surface (epithelial border) of the lower image. This method is easier and more practical.

"*Overlap method*": The bright line of endothelial border overlaps with the bright line of epithelial border.

The corneal thickness is then directly read from the scale on the instrument. The range of measurement is from 0 to 1.2 mm, with a least gradation of 0.02 mm.

Disadvantages

Lack of accuracy in measurements; the usual range of error with an optical pachymeter is ± 2%. It has been suggested that the accuracy of optical pachymeter readings using the Haag-Streit attachment can be increased by correcting for the corneal curvature.

Lack of repeatability. This is because of following factors:

- Fixed position of the fixation target
- Slit beam does not intersect cornea at the same angle on repeat measurements
- End point is not consistent and is subjected to observers' bias.
- Width of slit lamp beam has no consistency and it lacks compensation too.

Requires slit lamp and therefore has poor portability and cannot be used in operating room (OR).

Specular pachymetry

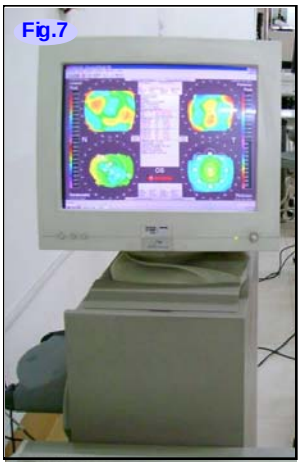
This is the oldest method to measure corneal thickness.

Principle- This measures the distance between the anterior and the posterior surfaces of cornea and depends on the focusing of light rays through front back cornea unlike sound waves in ultrasound pachymeter.

There are 2 types of specular microscope

1. Contact
2. Non-contact (**Fig 6**)

The newer non-contact machines are better as they do not touch the cornea. Being quick and easy they are also equipped with auto-focus and image analysis program.



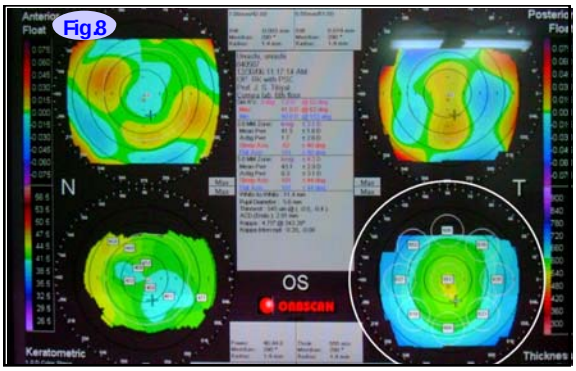


Fig.7: Slit Scanning Technology (Orbscan)
Fig.8: Pachymetry on Orbscan

by calculating the difference between elevation of anterior and posterior corneal surface.

Advantages

- It gives wide field pachymetry (**Fig 8**) that is measurement across the entire cornea.
- It also identifies the thinnest point (Fig 8) in the cornea, both by value and location. *In a normal eye, the thinnest point is very close to the geometric center of the cornea. If the thinnest point measured is off-center, it may be an indication of a corneal health problem like keratoconus.*

But readings with non-contact method are found to be significantly thinner than contact method. Modern instruments are also fitted with digital read out that record the thickness.

Advantages

- Operator independent
- Non invasive
- Simultaneous measurement of cell count

Disadvantages

- The exact point where the reading is taken is not known.
- Contact method has its own disadvantages of risk of infection and epithelial damage.
- Time consuming.
- Less reproducible than ultrasonic and ultrasound biomicroscopic pachymetric measurements.
- Impractical for use in operation room
- Clinical use is limited to corneas free of edema, scarring, deposits or opacities that may distort light transmission.

Slit-scanning pachymetry

The Orbscan II (Bausch & Lomb, Rochester, NY, USA) is an elevation based system which uses scanning slit technology (**Fig 7**). It is capable of assessment of multiple functions in the cornea, including thickness profile, anterior and posterior topography, elevation, and anterior chamber depth. It gives pictorial representation of corneal topography in the form of 4 coin map.

Principle

It measures anterior and posterior corneal elevations by comparing it to a best fit sphere. Pachymetry is done

- Corneal alignment is not required.
- Can be used to calculate ablation depth and optical zones in corneal refractive surgeries.

Disadvantages

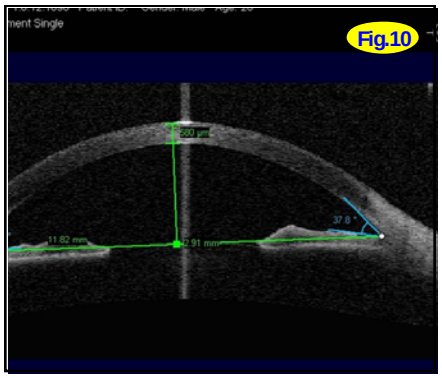
It overestimates corneal thickness by 5%.

The main drawback of Orbscan is the tendency to underestimate corneal thickness in Keratoconic, post-PRK, and post-LASIK eyes because of the following reasons:

- Scattering from corneal haze and stromal interface, interfere with the identification of the corneal surface reflections due to the limited resolution of slit scanning.
- Moreover, the measurements are adjusted for normal prolate shape of cornea. Change of shape may interfere with the reconstruction algorithms.
- This has got important implication in refractive surgery. The amount of residual bed to be left should be more if pachymetry has been done with Orbscan than with conventional ultrasound. Central corneal thickness measurements are on an average, 28 micron higher with the Orbscan than with the ultrasound pachymeter in normal eyes and 13 micron lower in post-LASIK eyes. An acoustic correction factor of 0.92 has been provided by the manufactures to convert Orbscan readings in ultrasonic readings.
- This is not fast enough for pachymetric mapping because of motion artifacts in the measurements.
- The Orbscan system showes decreased accuracy in measuring corneal thickness when clinically significant haze is present.

Anterior Segment Optical Coherence Tomography (ASOCT)

ASOCT (Visante-Carl Zeiss Meditec AG) is a high-resolution, non- contact optical coherence tomography customized for the anterior segment. It provides high-



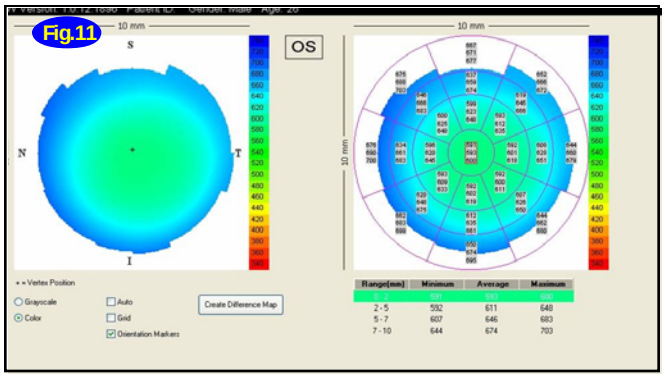


Fig.9: Anterior Segment OCT, **Fig.10:** Anterior Segment & Pachymetry on Anterior Segment OCT, **Fig.11:** Pachymetry map on ASOCT

resolution corneal images (**Fig 9**). It gives color coded map of the corneal thickness (**Fig 10,11**).

Advantages

- Noncontact
- Rapid acquisition during the pachymetry scan ensures an accurate and repeatable pachymetry map.
- High Resolution
- It measures and documents both corneal flap thickness and residual stromal thickness immediately following LASIK surgery.
- Measures through corneal opacity

Optical Low Coherence Reflectometry (The Haag-Streit OLCR)

The instrument is attached to a slit lamp (**Fig 12**) and is a single mode fiber optic based Michelson's interferometer with a high repetitionrate. This system can measure corneal thickness to a precision of one micron.

Principle

It is based on Michelson interferometer. It uses diode laser beam. Due to the refractive index differences occurring at the air-to-cornea and cornea-to-anterior chamber interfaces, the measurement beam is reflected from the anterior and posterior corneal surfaces. These reflections reach back into the detector. When the light emitting diode (LED) beam strikes the corneal front and back surfaces perpendicularly the interference signals are generated.

It comes in two forms:

1. Slit lamp mounted
2. Excimer laser mounted

Advantages

- Precise 1 micron measurement
- Automatic alignment
- Non-contact
- Real-time data acquisition and display
- Convenient and easy
- Variability of measurements is significantly lower than the measurements taken with the contact ultrasound pachymetry.
- Intraoperative measurements possible

Disadvantages

- Measures only central corneal thickness

Confocal Microscopy

This function is called confocal microscopy (**Fig 13**) through focusing (CMTF) on the Tandem Scanning Confocal Microscope . Briefly, rapid movement of the objective lens itself or the focus of the objective lens in the Z-axis is automated and registered by a computer. The amount of light backscattered by the central section of each image is also recorded, allowing the generation of an intensity profile curve (**Fig 14**).

Advantages

1. Offers moderate to good repeatability, particularly for measurements of thin layers such as epithelial or Bowman's layer thickness.
2. As well as corneal thickness, measurements of epithelial thickness, Bowman's layer thickness, and following laser in situ keratomileusis (LASIK) surgery, flap thickness can also be obtained.
3. The z-scan curve can be used to assess the level and location of corneal haze associated with the various corneal dystrophies.

Disadvantages

1. Poor agreement between CMTF and ultrasound pachymetry, the latter apparently overestimating corneal thickness.

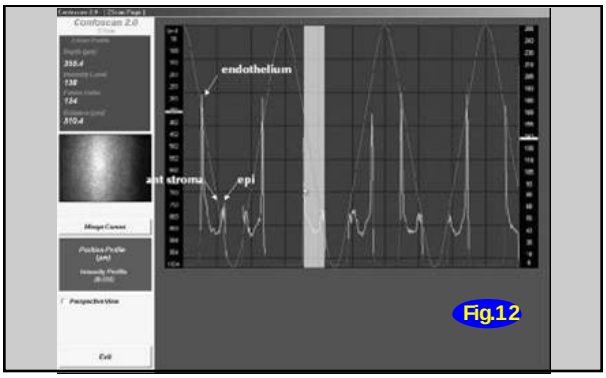


Fig.12: Optical Low Coherence Reflectometry Pachymetry, **Fig.13:** Confocal Microscope, **Fig.14:** Confocal Microscope – Z curve

Fig.15: Pentacam

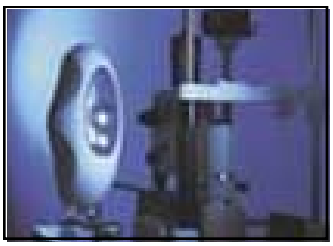


Fig.16: Pachycam

2. The precision of measurements with this technique will vary with contact lens hydration, post-lens tear film thickness and observation angle.
3. Slower data acquisition
4. Poor penetration of corneal opacity
5. Cumbersome

However, the recent advances in the confocal microscopy instrumentation with the introduction of newer version of confocal microscope into clinical practice (Confoscan 4.0 with z-ring adapter: z-CS4) the inherent problems of ocular and instrument misalignment during data acquisition has been sorted out as reported by Brugin E et al in a recent report. According to their study the central corneal thickness as reported with the z-CS4 *is lesser* (US: 512.6 ± 65.8 µm; z-CS4: 487.8 ± 60.1 µm; $p < 0.0001$) as compared to the conventional ultrasonic pachymetry but the instrument has got good accuracy and interobserver repeatability.

Pentacam (Fig 15)

It analyses the complete anterior segment, corneal topography, quantification of lens density, anterior chamber, angle measurements, and utility to monitor new therapeutic modalities like collagen crosslinking treatment for Keratoconus.

Principle

The Pentacam (Oculus Inc., Germany) is also based on the true elevation measurement and images the anterior segment (cornea + lens) of the eye by a rotating Scheimpflug camera measurement which supplies pictures in three dimensions. The center of the cornea is measured very precisely because of this rotational imaging process. The corneal thickness is displayed as a color image, showing the entire area from limbus to limbus.

Advantages

- Noninvasive, non contact
- Even minute eye movements are captured and corrected simultaneously.
- It gives precise representation and repeatability.
- The high quality of the Scheimpflug image allows pre- and post operative monitoring as in the case of an intraocular contact lens.

Disadvantages

It underestimates the corneal thickness in comparison to ultrasonic pachymetry.

Pachycam (Fig 16)

The Oculus Pachycam is compact and portable non-contact pachymeter with built-in keratometer. It can be mounted on slit lamp. It automatically corrects the IOP (intraocular pressure) in accordance with various correction tables to obtain the "real" IOP. Image acquisition is done with the help of a 3D alignment screen.

Principle

It is also based on Scheimpflug principle of the horizontal 4 mm cut image which is evaluated and represented. It also gives central k-values as well as the local k-readings on the 4 mm cut.

Advantages

1. Noncontact

2. Immediate indication of central and thinnest pachymetry readings
3. Compact, portable, lightweight

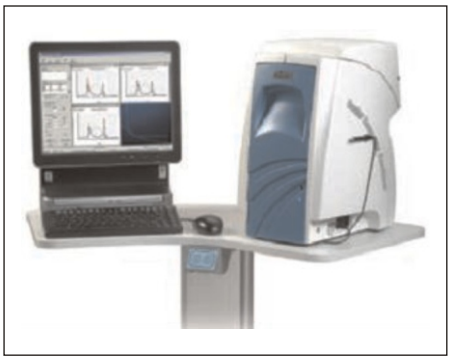


Fig.17: Ocular Response Analyzer

Ocular response analyzer (Fig 17)

Ocular response analyzer (Reichert Ophthalmic Ins. NY) is a newer modality for measuring biomechanical properties of cornea. It measures Corneal Hysteresis (CH) that is a result of viscous damping in the corneal tissue.

It utilizes a rapid air impulse, and measures delays in the inward and outward applanation events of cornea, resulting in two different pressure values. The difference between these two pressure values is a measure of corneal hysteresis.

Central Corneal Thickness is measured by built-in 20 MHz ultrasound pachymeter.

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Specular Microscopy

Saurabh Arora MBBS, **Parul Sony,** MD

Specular microscopes have been use to visualize the corneal endothelium. Vogt coined the word 'Spiegelmikroskopie', which translated to English as 'specular microscopy'. In 1968, David Maurice developed the first high powered specular microscope to photograph endothelial cells ex vivo at 500x. Later regular specular microscope was developed by Laing in 1975.

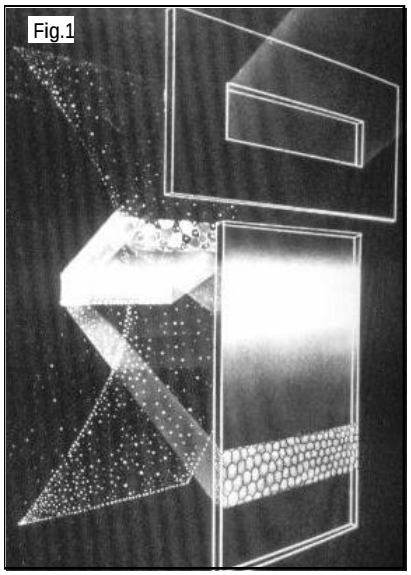
The corneal specular microscope is a reflected-light microscope that projects light onto the cornea and images the light reflected from an optical interface of the corneal tissue, most typically the interface between the corneal endothelium and the aqueous humor

Optical Principles

Light striking a surface can be reflected, transmitted, or absorbed. Generally, some combination of the three effects occur. In clinical specular microscopy is the light that is reflected specularly (i.e. "mirror-like") where the angle of reflection is equal to the angle of incidence. As light strikes the posterior corneal surface, almost all of it is transmitted into the aqueous humor. Because there is a change in index of refraction at the endothelium-aqueous humor interface, about 0.022 per cent of the total incident light is reflected; this reflected light is captured by the clinical specular microscope and forms the endothelial image. As the illumination beam passes through the cornea, it encounters a series of interfaces between optically distinct regions where some light is reflected back toward the photomicroscope and some is transmitted deeper into the cornea. The greater the difference in index of refraction between the two regions, the greater the amount (intensity) of the reflected light. (Figure 1 &2)

If a sufficiently narrow slit of incident light is used, one can generally distinguish a bright zone formed by light reflected from the lens-coupling fluid or the coupling fluid-epithelial interfaces or both (Zone 1), part of the stromal region, darker in clear corneas and brighter in edematous corneas (Zone 2), the endothelial region (Zone 3), and part of the aqueous humor, dark zone (Zone 4). The demarcation line between Zone 3 and Zone 4 that separates the illuminated cornea from the non illuminated structures located more posteriorly., is called the dark boundary, the demarcation line between Zone 2 and Zone 3 is called the bright boundary. If the angle of incidence of the illuminating source is increased, a wider slit can be used and a larger field of endothelial cells can be seen with a decrease in contrast of the endothelial image and a loss of cellular definition.

Projected light can be in the form of a stationary slit, a moving slit, or a moving spot and the optical design can either be non-confocal or confocal. Although primarily used to evaluate the corneal endothelium, the corneal epithelium, stroma as well as the crystalline lens can also be visualized and evaluated



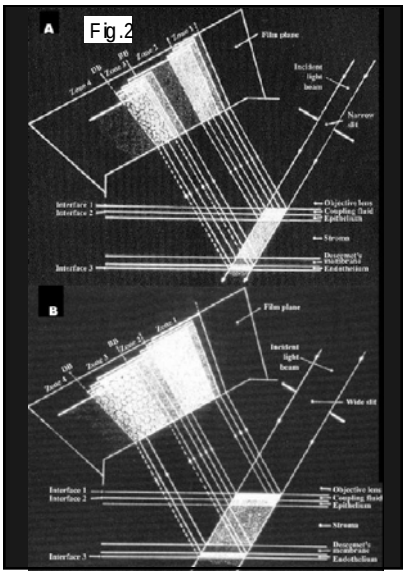


Fig.1: Pathway of light from its source in the clinical specular microscope, back to the film plane of the same instrument. **Fig.2:** Representation of an optical section when a narrow slit (A) or a wide slit (B) of light passes through various corneal layers and is focused on the posterior corneal surface.

Improvements in Instrumentation and Methods

Considerable improvement in image quality and ease of use of the original clinical instrument was accomplished with the design of an improved objective lens by Laing.Sherrard and associates developed a fluorite cone

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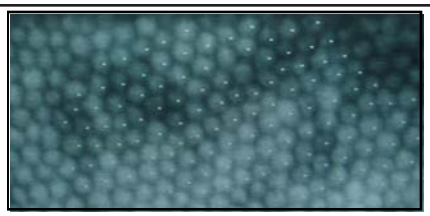
New Delhi-17



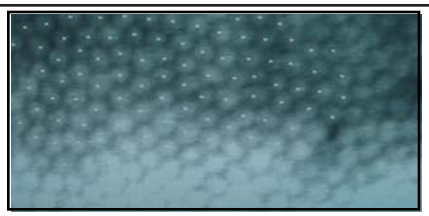


Fig.3(a)&(b): Young normal corneal endothelium with quasi-regular array of hexagonal cells

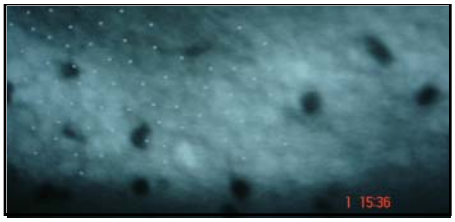
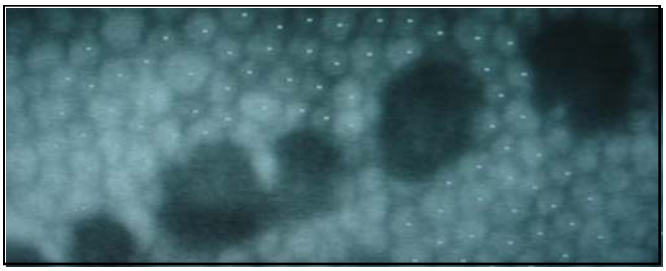


Fig.3(c): Intracellular dark areas denoting endothelial cilia.



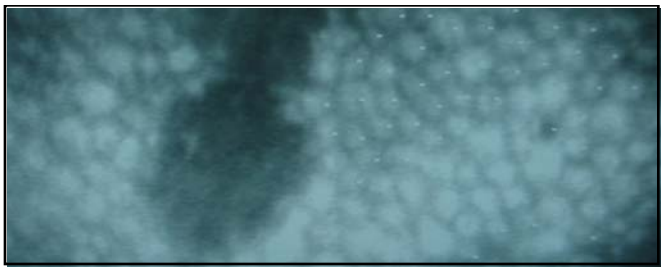


Fig.3(d)&(e): Corneal guttate;

Fig.3(f): Corneal folds;

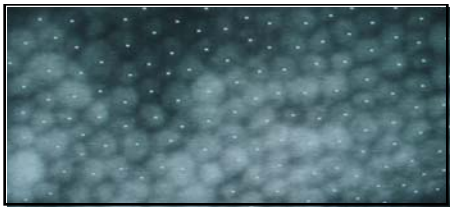


Fig.3(g): Polymegathism;

Fig.3(h): Bright intracellular areas denoting endothelial cells under stress.

for the objective lens that reduced the interfering objective lens-epithelial reflection and enabled a wider slit to be used, Koester designed an optical system that moved a narrow slit of light repeatedly up an down on the endothelium in such a way that a wide image was produced without suffering degradation from stromal scattering.

Clinical specular microscopy can be accomplished either at higher magnification and resolution using contact objective lenses that touch the cornea and inhibit eye movement or at lower magnification and resolution using non-contact objective lenses that do not touch the cornea.

Epithelial Specular Microscopy

Specular microscopic photographs of the corneal epithelium were originally obtained by Laing and associates using a special plastic conical element that fit over the normal dipping cone objective lens. Using this conical element, saline, hydroxymethyl cellulose, or other fluids could be held between the glass surface of the contact lens and the epithelium so as to obtain epithelial images. This refractive index matching that occurred because of the fluid interface was also accomplished using the fluorite tip on the objective lens that was designed by Sherrard. When a soft contact lens having nearly the same index of refraction as the cornea (1.370) is placed on the corneal epithelium, the reflection from the epithelium can be reduced, permitting observation of the epithelial cells

Qualitative Morphometric Analysis of Specular Images

Both qualitative and quantitative assessments of the corneal endothelium can be made. Qualitative cellular analysis identifies abnormal endothelial structures and grades the endothelium either according to the number or size of the abnormal structures present or on the basis of an overall visual assessment of endothelial appearance. This type of analysis provides a rapid clinical evaluation of the endothelium to assess the risks of intraocular surgery, to establish a diagnosis, or to decide upon treatment. Complete qualitative analysis requires that several parameters be evaluated including cell conformation, cell boundaries and their intersections, configuration of the dark boundary, and the presence of acellular structures.

Cell Conformation

With age, the average cell area increases, the cellular pattern becomes distinctly pleomorphic, and the cell size distribution becomes skewed toward larger cell areas. In young people with normal eyes the cell side lengths are all roughly equal, usual quasi-hexagonal configuration. Dark structures that disrupt the endothelial pattern

- Guttate: a smooth excrescence of Descemet's membrane (i.e., cornea guttatae)
- Intracellular Bodies: base of an endothelial cilia, intracellular vacuole or bleb.
- Intercellular dark structures represent invading inflammatory cells.

Intracellular bright structures, some of which may be only the cell nucleus, are variable in size and typically are contained completely within a single endothelial cell appears to be associated with stressed cells.

Quantitative Morphometric Analysis of Specular Images

Various morphological parameters that can be quantified. These include cell size (cell area or cell density), polymegathism (variation of cell size such as coefficient of variation of mean cell area CV), pleomorphism (variation of cell shape such as percent of hexagonal cells or coefficient of variation of cell shape), cell perimeter, average cell side length, cell shape, and so forth.

Two equivalent parameters have been used to quantify endothelial cell size:

Mean cell area = 10E6/cell density (cells/m^2)

Cell density (cells/mm^2 = 10E6/mean cell area).

The corneal endothelium is a hexagonal cell monolayer that does not divide significantly. An infant's endothelial cell count begins at 3500 – 4000 cells/mm2. As individuals age, the cell count declines; adults typically only have 1500 – 2000 cells/mm2 of endothelium. Although the endothelial cell density is a very important parameter for assessing the health of cornea, cell density only cannot determine the stability of cornea. If there are two corneas with same cell density, one having Coeffecient of Variation (CV) of 20 and the other 79; the one with low CV and higher percentage of hexagonality will be the more stable cornea to withstand the trauma of the surgical procedure. When the endothelium is insulted, not only cell density decreases, but also changes its size and shape.

Two different methods, fixed frame analysis and variable frame analysis, can be used to measure either of these two parameters of cell size.

Fixed Frame Analysis of Cell Size

Counts the number of cells within a frame or window of constant area. All cells lying completely within the frame are counted as whole cells. Each cell that is only partially within the frame is counted as one half cell regardless of the fractional area of that cell located within the frame. The total number of cells (the cell count) is then taken as the sum of the number of whole and half cells within the frame. The size is obtained by dividing the cell count by the area of the frame and expressed as cell density in cells per mm^2.

Variable Frame Analysis of Cell Size

A computer based analysis system such as the Bambi system (Bio-Optics, Inc. Arlington, MA). This method eliminates the problem of counting fractional cells along the boundary, thus providing a more accurate determination of mean cell size than fixed frame analysis assuming that cellular pleomorphism is not too great. In variable frame analysis, one first measures the variable area occupied by an integral number of cells by tracing around a contiguous group of cells with a mouse. The user then marks each cell by clicking it with the mouse. The computer then calculates the cell density by dividing the number of marked cells by the area of the frame. An equivalent value, the mean cell area, can also be obtained by dividing the frame area by the number of cells.

Individual Cell Analysis

Single cells can be traced with the stylus of the planimeter or digitizer, and this then permits individual cell analysis. Such an analysis provides much more information about the endothelial cell pattern. It can be performed either manually, semi-automatically, or fully automatically. The cell density or mean cell area can be obtained by averaging the data on a group of cells. In addition, a frequency distribution (or histogram) of cell size can be obtained.

Clinical indications

- Aging
- Fuch's Dystrophy
- Lattice corneal dystrophy
- Iridocorneal endothelial syndrome
- Posterior polymorphous dystrophy
- Intraocular inflammation
- Cataract extraction
- Secondary & Primary Intraocular lens implantation
- Penetrating keratoplasty (donor count)
- Intraocular irrigating solutions
- Vitreocorneal contact
- Epithelialization of the anterior chamber
- Diabetes

Suggested readings

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IOL Power Calculation-How to Avoid Common Errors

Piyush Kapur DNB, MNAMS, **Harbansh Lal** MS, **Anita Sethi** MD, DNB, FRCS

Highly accurate IOL power calculations result from optimizing a collection of interconnected nuances. The keratometry technique, method of axial length measurement, IOL power calculation formula, optimized lens constant, and configuration of the capsulorhexis-all individually influence the final refractive outcome. For this reason, focusing on a single item such as the axial length measurement or the IOL power calculation formula is usually insufficient to ensure consistent accuracy over a wide anatomical range. The surgeon must consider the process as a whole while simultaneously optimizing each component.

Keratometry

Ophthalmologists and their technicians often accept without question corneal power measurements by keratometry or simulated keratometry, but not all measurements have the same level of accuracy or reproducibility. It should be remembered that keratometry errors have a 1:1 correlation with postoperative refractive errors at the spectacle plane. For example, if the keratometry reading is off by 0.50 D, the result will be a 0.50-D postoperative refractive error at the spectacle plane, even if all other aspects of the IOL power calculation and surgery are perfect. Add in other small errors such as variable corneal compression induced by applanation A-scan biometry or the use of an older 2-variable formula in axial hyperopia, and a 1.00-D deviation from the target refraction is not difficult to imagine.

To maximize keratometry accuracy, first, make the decision to use a single instrument for all pre- and postoperative measurements in order to limit the number of variables. For manual measurements, switching to a Javal-Schiotz-style keratometer will to help improve accuracy. Autokeratometry is quick and easy, but it typically requires multiple measurements to confirm accuracy. The simulated keratometry feature of many topographers is an excellent way to objectively determine the axis of astigmatism, but it can sometimes be less accurate than careful manual keratometry for measuring the central corneal power.

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Second, regularly check your keratometer against a set of standard calibration spheres and consider keeping a logbook of these evaluations. Third, if the results for any patient vary, ask a second staff member to confirm the measurements to ensure accuracy. Finally, if the keratometry mires are unreliable or distorted, obtaining a topographic axial map may help uncover something unsuspected such as a forme fruste of keratoconus.

Axial Length Measurements

One of the most common reasons for an incorrect IOL power is an error in the axial length measurement. The familiar and trusted 10-MHz applanation A-scan biometry is probably no longer accurate enough to consistently satisfy contemporary patients' expectations. The reason is that measurements by the applanation technique produce a falsely short axial length and sometimes widely different results due to varying degrees of corneal compression and axial alignment.

Immersion A-scan biometry is unquestionably a more reliable method. This technique causes no corneal compression, and, when used in conjunction with a Prager shell, measurements can be of very high quality and quite reproducible. Even in the hands of the most skilled biometrist, however, immersion A-scan biometry is still limited by the fact that it is based on the resolution of a 10-MHz sound wave (Figure 1).

At present, optical coherence biometry using the IOL Master is unquestionably the most accurate way to measure axial length prior to cataract surgery. Optical coherence biometry's use of a short-wavelength light source (instead of a longer-wavelength sound beam)

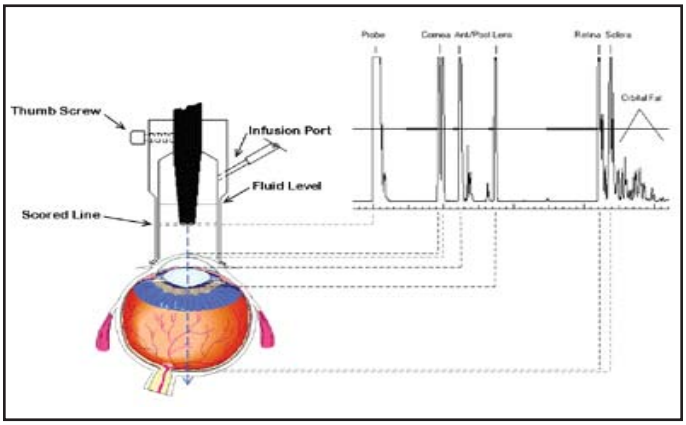


Fig.1: Immersion Biometry

Fig.2(a): IOL Master

increases axial length measurement accuracy by fivefold when compared with ultrasound (Figure 2a).

For challenging axial length measurements (eg, in eyes containing silicone oil, extremely short nanophthalmic eyes, or extremely long myopic eyes with posterior staphylomata), the accuracy of optical coherence biometry is unparalleled. The one disadvantage of the technique is that it is an optical method. Axial opacities such as a corneal scar, dense posterior subcapsular plaque, or vitreous hemorrhage may decrease the signal-to-noise ratio to the point that reliable measurements are not possible. In general, optical coherence biometry is unable to measure between 5% and 15% of patients, and immersion ultrasound is required.

Name:
Date of Birth:
Exam Date:

ID:
Eye Surgeon:
Formula: **SRK/T**

Preoperative Data:
AL: **24.73 mm**
K1: **43.66 D @ 5°**
K2: **44.70 D @ 95°**
opt. ACD: **3.08 mm**
Refraction:
Visual Acuity:
Eye Status: **phakic**
Target. Ref.: **plano**

OD
right

118.0		118.4		118.6		118.9	
A Const:	118	A Const:	118.4	A Const:	118.6	A Const:	118.9
IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)
17.0	-0.88	17.5	-0.95	18.0	-1.16	18.0	-0.95
16.5	-0.53	17.0	-0.61	17.5	-0.82	17.5	-0.62
16.0	-0.19	16.5	-0.28	17.0	-0.48	17.0	-0.29
15.5	**0.15**	**16.0**	**0.06**	**16.5**	**-0.15**	**16.5**	**0.04**
15.0	0.48	15.5	0.38	16.0	0.18	16.0	0.36
14.5	0.81	15.0	0.71	15.5	0.50	15.5	0.68
14.0	1.14	14.5	1.03	15.0	0.82	15.0	0.99

Preoperative Data:
AL: **23.28 mm**
K1: **45.61 D @ 143°**
K2: **46.11 D @ 53°**
opt. ACD: **3.32 mm**
Refraction:
Visual Acuity:
Eye Status: **phakic**
Target. Ref.: **plano**

OS
left

118.0		118.4		118.6		118.9	
A Const:	118	A Const:	118.4	A Const:	118.6	A Const:	118.9
IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)	IOL (D)	REF (D)
20.0	-1.16	20.5	-1.17	20.5	-1.00	21.0	-1.08
19.5	-0.81	20.0	-0.83	20.0	-0.66	20.5	-0.75
19.0	-0.46	19.5	-0.49	19.5	-0.33	20.0	-0.42
18.5	**-0.12**	**19.0**	**-0.15**	**19.0**	**0.00**	**19.5**	**-0.09**
18.0	0.22	18.5	0.18	18.5	0.33	19.0	0.23
17.5	0.55	18.0	0.51	18.0	0.65	18.5	0.55
17.0	0.88	17.5	0.83	17.5	0.97	18.0	0.86

Fig.2(b): IOL Master

IOL Power Calculation Formulas

Limitations

The main limitation of all IOL power calculation formulas pertains to their ability to accurately predict preoperatively where the IOL will be located postoperatively in relation to the cornea. As described by Jack Holladay, MD, of Bellaire, Texas, this distance from the secondary principal plane of the cornea to the thin lens equivalent of the IOL is known as the effective lens position.

Commonly used 2-variable formulas such as SRK/T predict the IOL's postoperative position based on the eye's axial length and keratometry readings. To produce this prediction, these formulas must make a number of broad assumptions. In general, most 2-variable formulas assume that short eyes produce a shallower effective lens position and longer eyes will result in a deeper effective lens position. They also assume that flat K readings will result in a more shallow effective lens position and steeper Ks will result in a deeper effective lens position. The anterior and posterior segments of the human eye are often not proportional, however. This is the main reason why the accuracy of 2-variable formulas decreases at the extremes of axial length and corneal power, especially in the setting of axial hyperopia.

As long as an eye has parameters close to those of a schematic eye, 2-variable formulas work very well. For example, every modern 2-variable formula will predict essentially the same IOL power for an eye with an axial length of 23.49 mm and K readings of 43.50 D. Repeat the exercise with an axial length of 21.00 mm, however, and their IOL power recommendations quickly diverge. Formulas that base their calculations on more information than axial length and keratometry have an obvious advantage over those that do not.

Best Bets

Currently, the Holladay 2 formula is the best "off-the-shelf" tool for improving the accuracy of IOL power calculations for all axial lengths. The Holladay 2 formula employs several additional variables to adjust the recommended IOL power; these include the horizontal corneal diameter, lens thickness, measured anterior chamber depth, and the patient's age and preoperative refraction. Holladay-2 took almost 30,000 cases in the study to make it the biggest most accurate one.

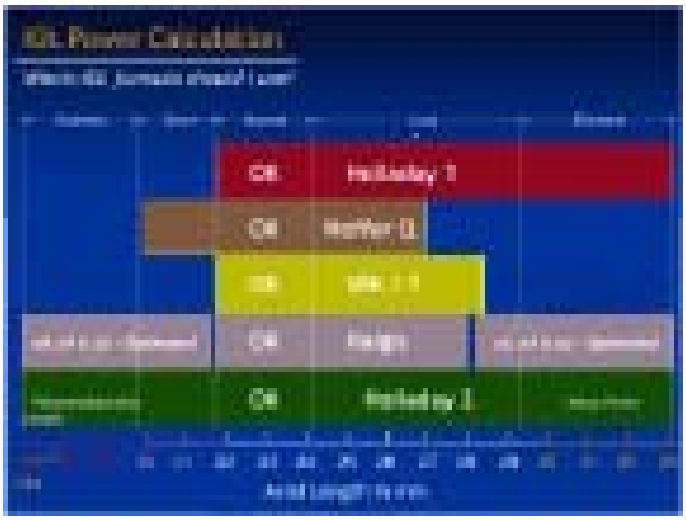


Fig.3: Choice of formula depending on the axial length.

The Haigis formula also represents a significant improvement over popular 2-variable formulas. It uses three IOL and surgeon-specific variables (a0, a1, and a2) in order to set both the position and the shape of an IOL power prediction curve. At present, Haigis constants for many popular IOLs are being developed from data submitted by physicians worldwide (visit http://www.augenklinik.uni-wuerzburg.de/eulib/index.htm). The Haigis formula is included as part of the IOL Master's standard software package. The same is represented by a graph shown in (Figure 3)

IOL Constant Optimization

Surgeons must personalize the lens constant (Holladay 1 Surgeon Factor; SRK/T A-constant; Holladay 2 or Hoffer Q anterior chamber depth; Haigis a0, a1, and a2) for a given formula in order to make adjustments for a variety of practice-specific variables, including different styles of IOLs, keratometers, and variations in A-scan biometry calibration. Most IOL power calculation programs provide either internal software or specific recommendations for how to go about lens constant optimization. After maintaining a record of year own biometries and carefully calibrating with the refractory outcomes one should develop his as her own personal A-constant to minimize the surgeon's factor.

Surgical Technique

The configuration of the capsulorhexis can affect refractive outcomes if a surgeon is implanting a single-piece acrylic or a three-piece assembled IOL. If the capsulorhexis' diameter is larger than the lens optic, the forces of capsular bag contraction may anteriorly displace the IOL, a situation resulting in an increased effective lens power and more myopia than anticipated.

A simple "rhexis rule" is that the capsulorhexis should be round, centered, and slightly smaller than the optic. In order for the IOL power calculation formula to be most consistent and accurate, the capsular bag should completely contain the IOL. Attention to this detail can help maximize refractive accuracy.

Conclusion

Overall suggestions for improving IOL power calculations include (1) minimizing the number of variables, (2) verifying measurements when necessary, (3) relying upon either immersion ultrasound or optical coherence biometry, (4) carefully tracking your refractive outcomes, (5) optimizing the lens constants for each IOL used, and (6) creating a round, centered capsulorhexis that is slightly smaller than the IOL's optic. By following these simple rules, you will be well on your way to maximizing the accuracy of your refractive outcomes after cataract surgery.

Vision and Art

Umang Mathur

Vision has two components- Colour and Luminance

Colour is first determined by the three cones in the retina and subsequently, recoded into colour-opponent signals in the brain. The response of each cone type (red, blue or green) depends on the light's wavelength and its intensity. Inputs from the different classes of cones act in opponency to each other at subsequent stages of processing in the brain.

Renoir

Luminance- 'Perceived Lightness'

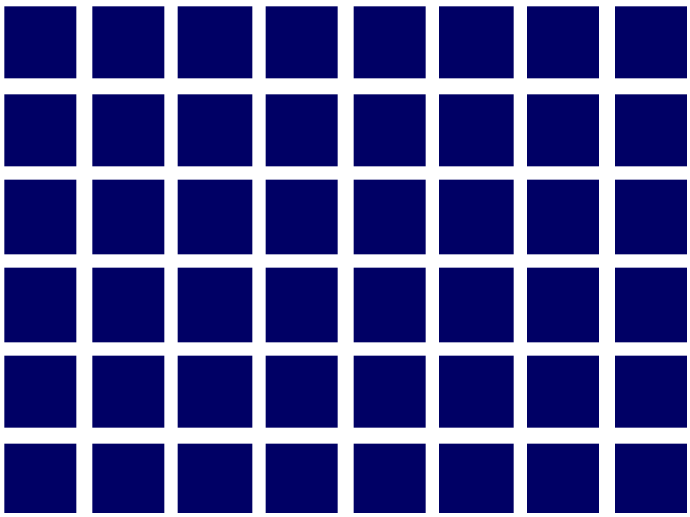
It is not the colour, but the luminance that allows 3-D shape and spatial organization to a visual scene. Colour and Luminance are analysed separately in the brain. Luminance system is evolutionarily older and present in all mammals. Parts of the brain that analyze the most basic feature of a scene are colourblind!

In Pablo Picasso's 'Tragedy', blue colour gives the emotion of melancholy to the picture, but the perception of depth, 3-D, movement (or lack of it) and spatial organization are carried out by Luminance differences (even with out colour)

Pablo Picasso's 'Tragedy'

Centre- Surround

Retinal Ganglion cell is stimulated by light falling on the small part of the retina and suppressed by light falling on the surrounding region.



The illusionary points at the centre of the intersections appear as dark spots, as they are more suppressed by four bits of white lines in their surrounds as compared to the white of the lines that are suppressed by only two

Neurons respond to sharp changes, rather than gradual shifts in luminance. Only few cells at the edges need to signal, helps in conserving energy.

Dr. Shroff's Charity Eye Hospital
Daryaganj, New Delhi

Rembrandt's Meditating Philospher
Gradual background changes and local abrupt changes in luminance, simulates a much larger range of luminances than the pigments supply

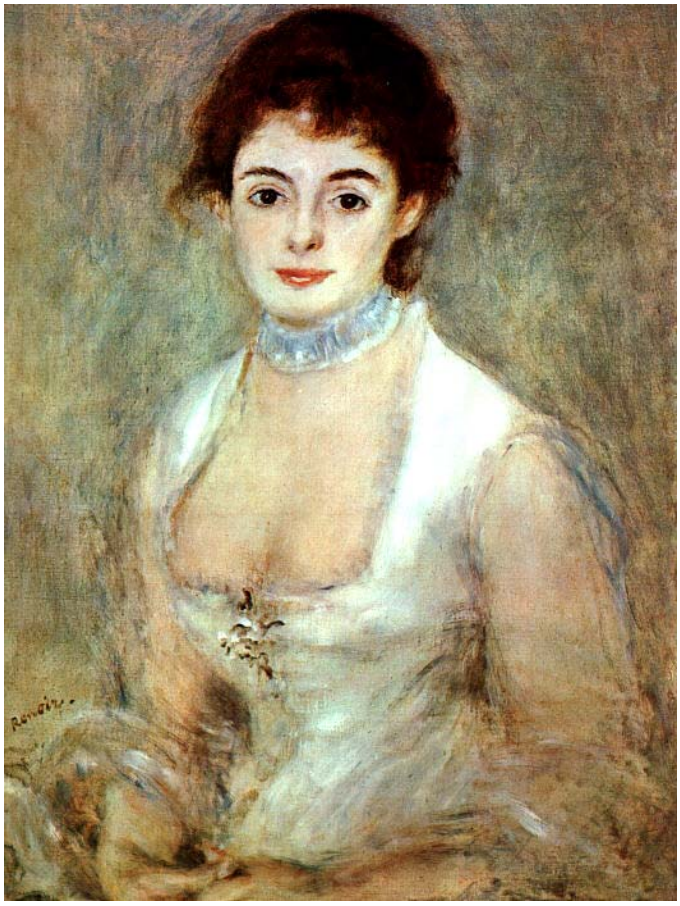
Visual acuity falls dramatically with eccentricity. Fovea is responsible for recognizing detail. Peripheral Retinal vision organizes spatial scene.

Monet's Rue Montorgueil in Paris

Poussin's Rape of the Sabine Women

Lack of detail in Monet's Rue Montorgueil in Paris gives the picture a sense of movement as apposed to Poussin's painting that has too much detail. We see movement with our peripheral vision that should be fuzzy and not detailed.

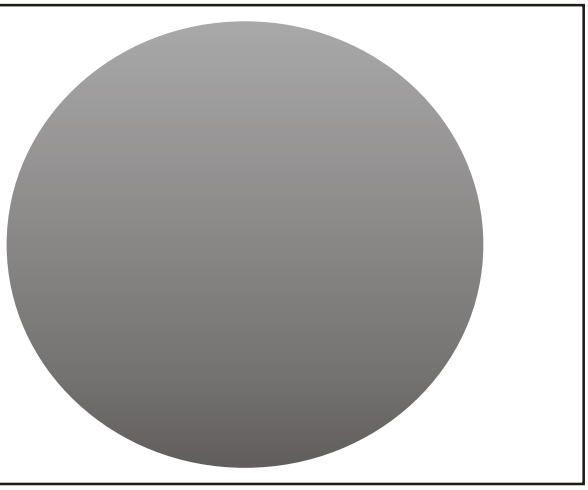
Subjects tend to look towards high contrast and fine detail (and items of significance). This fact is used by artists to get the viewer's attention.



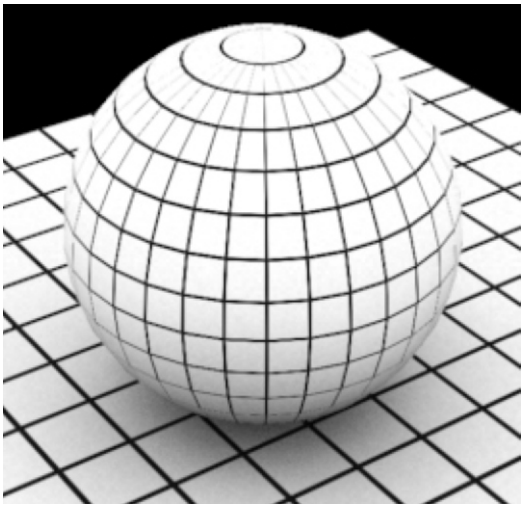
Renoir, Portrait of Madame Henroit
High resolution and high contrast of the subject's eyes and facial features, draw the viewer's gaze

Artists look at a 3-D scene with their 2-D retinas and then generate a 2-D painting that appears 3-D to viewers with their 2-D retinas!

Perspective- Global changes in size and relative positions of objects i.e, Farther the object, smaller the image; Receding lines are drawn as converging

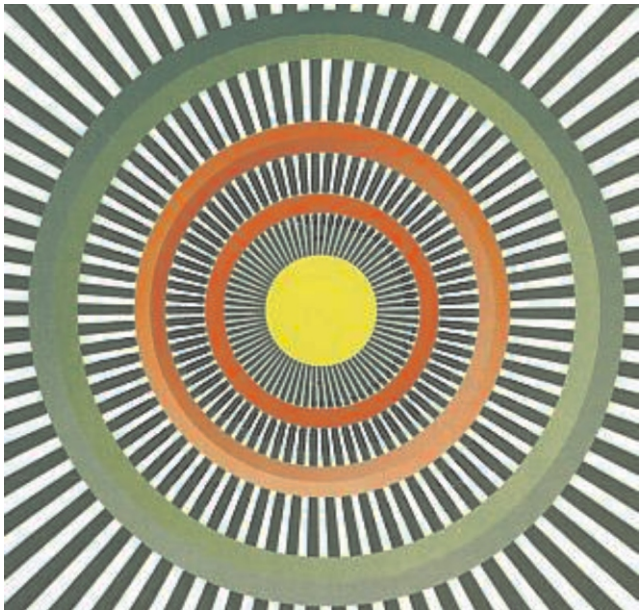


Shading-When a 3-D object is illuminated, different parts of the surface reflect different amounts of light, depending on the angle of light hitting them

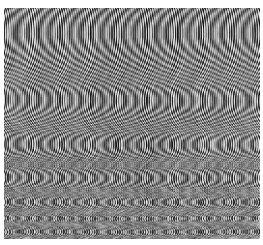


Occlusion- Objects in front block view of objects behind

Absence of Stereopsis-Blurriness does not allow activation of stereopsis (cannot see the differences!)- allows other cues to make a more powerful impression



Juxta position of luminance-contrast borders with areas of equiluminance cause an illusion of motion



Illusionary stereo depth from repetitive patterns

Sympathetic Ophthalmia (SO) following Perforated Corneal Ulcer: a rare case

Shilpa Taneja DNB, **Tinku Bali** MS, FRCS (Glas.)

Bartisch in 16th Century wrote in his textbook of ophthalmology that 'after injury in one eye, the other good eye is in great danger'. This thought led us to the discovery of a well recognized through rare entity in ophthalmology known as sympathetic ophthalmia (SO). Against the pre-existing belief that an eye with suppuration will never incite SO in other eye, there have been few clinical case reports describing the development of SO in patients with suppurative eye disease.[1]

Purpose

To report a rare clinical case of SO following perforated fungal (?) corneal ulcer.

Method

A 45 year old male farmer presented to us with diminution of vision in his left eye for past 10 days which was gradual, painless, progressive and was associated with photophobia, difficulty in near work and floaters.

There was history of trauma to his right eye with vegetable matter (wheat grain) 5 months ago following which he was diagnosed elsewhere to have right eye corneal ulcer. Inspite of vigorous treatment for 15 days, he developed a corneal perforation.

Other than this conspicuous history of vegetable matter trauma there was no other history of flashes of light, any kind of surgery in the eye, vertigo, loss of hair, skin whitening, back pain, cough, fever, joint pain, any nodules beneath skin or headache.

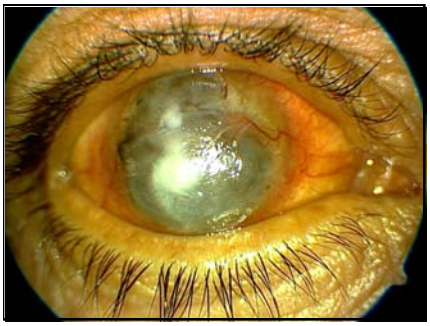


Fig.1: Right Eye

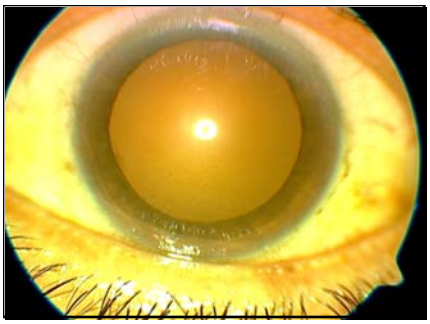


Fig.2(a): Left Eye (pharmacologically dilated pupil)

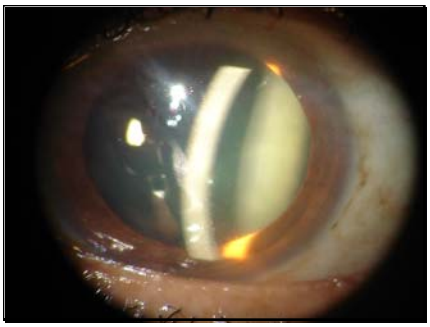


Fig.2(b): Left Eye showing KP's, 2+ cells and 2+ flare

Fig.3: Left Eye hyperemic disc with 0.3 cup, retinal edema, exudative RD

On examination the patient had normal systemic parameters and his best corrected visual acuity was just light perception with inaccurate projection of rays in right eye and 6/36 in the left eye.

In the Right eye (Fig.1) the anterior segment showed ciliary congestion along with an anterior staphyloma with vascularized, parchment looking anterior surface. Fundus details could not be visualized for obvious reasons.

The Anterior segment examination of the left eye (Fig.2a) too showed ciliary congestion with fresh keratic precipitates, more conspicuous on inferior one third of the cornea with 2+ cells and 2+ flare (Fig.2b). Pupil was 5mm, round, sluggishly reacting to direct light and the consensual light reflex was absent. Vitreous too had 2+ cells. On fundus examination (Fig.3) the disc was hyperemic with 0.3 cup and healthy neuroretinal rim. The AV ratio was normal with mild tortuosity of vessels. There was a generalized retinal edema with prominent ILM folds at the macula and areas of exudative retinal detachment with a small pocket of shifting fluid present inferotemporally. There was subretinal yellow mottling especially in midperiphery representing *Dalen – fuch's nodules* (Fig.4) and guiding us towards the suspicion of sympathetic ophthalmia.

The patient was further investigated and had normal complete blood counts, blood sugar and blood pressure.

FFA showed multiple diffuse punctate hyper-fluorescent spots at the level of RPE in early phase which persisted with increase in hyper fluoresence in later phases. (Fig.5a,b,c) area of exudative retinal detachment was seen

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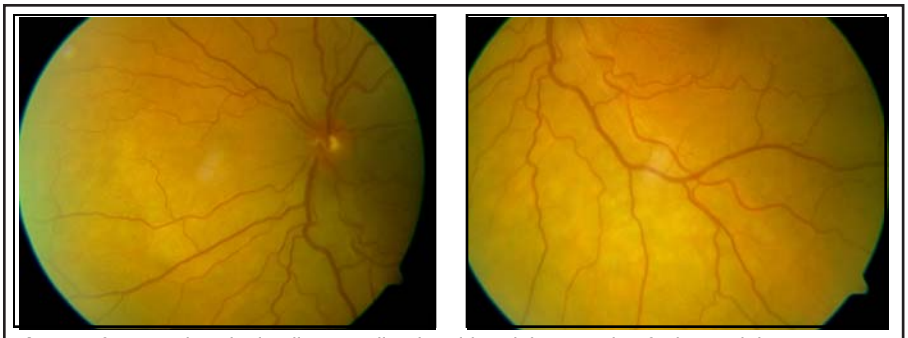

Fig.4: Left Eye sub retinal yellow mottling in mid-periphery: Dalen-fuch's nodules

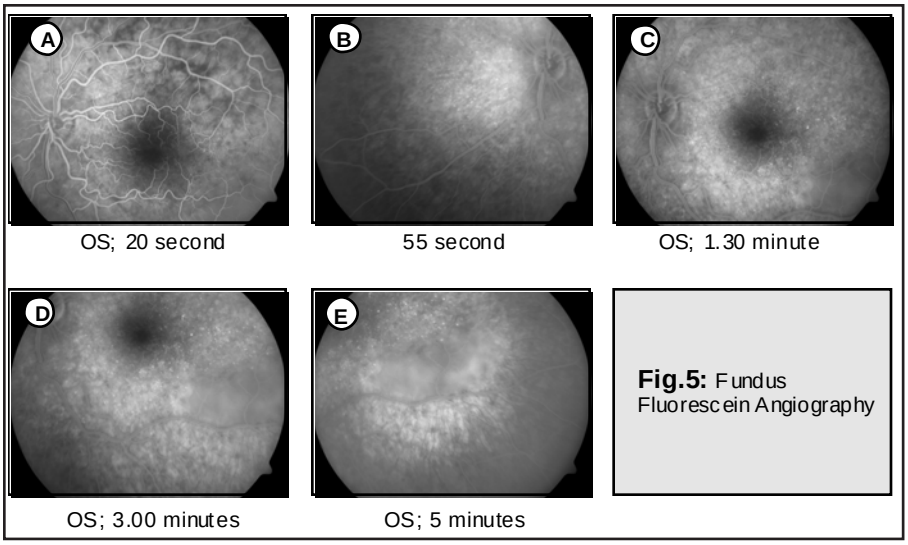

Fig.5: Fundus Fluorescein Angiography

as pooling of dye inferotemporally (Fig.5d,e).

USG B scan showed mild choroidal thickening (Fig.6) with exudative retinal detachment inferotemporally (Fig.7).

Audiometry, which was normal, too was done to rule out other possibilities.

On the basis of these findings our diagnosis was sympathetic ophthalmia in the left eye following perforated corneal ulcer in the right eye.

The patient was started on systemic oral corticosteroids at a dose of 80 mg/kg for 1 month. He gradually showed a response to corticosteroids. Anterior Chamber reaction subsided though fundus picture did not change until 2 weeks of treatment (Fig.8).

The patient improved from 6/36 left eye to 6/6 in 1 month. The characteristic sub-retinal yellow mottling also disappeared as seen in the fundus pictures (Fig.9). Steroids were gradually tapered. The patient did well 2 months post treatment even when steroids were discontinued with quiet eye and maintaining vision of 6/6 (unaided).

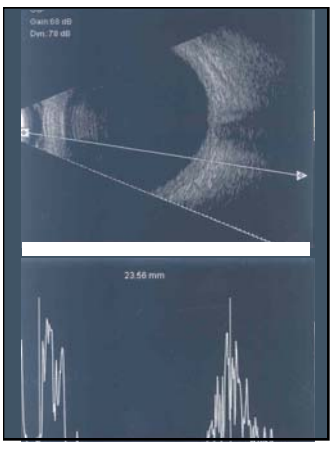

Fig.6: Choroidal thickening

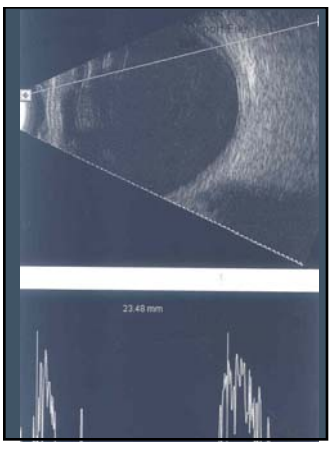

Fig.7: Exudative Retinal detachment

Discussion

Sympathetic Ophthalmia (SO) also known as *sympathetic ophthalmitis* or *sympathetic uveitis* is a bilateral diffuse granulomatous inflammation of the uveal tract occurring days to years after penetrating eye injury which might be accidental or even surgical.

History

In 1840 when *William MacKenzie* described this entity clinically and coined the term 'Sympathetic Ophthalmia', the histopathologic characteristics of the disease were unknown. *Ernest Fuchs*, in 1905 gave the classical microscopic findings and established the pathological definition of SO[2]. Since then the disease has become well recognized.

Key Feature

About 1000 A.D. Hippocrates stated that "the right eye, when diseased, often gives suffering to the left". This is the key feature of SO i.e. both the eyes are affected. The traumatized eye is known as 'Exciting Eye' and the fellow eye rightly has been called as 'Sympathizing Eye'.

Epidemiology

SO is a relatively rare disease as the onset of disease is very variable ranging from days to months to years. Secondly it can hardly be confirmed histopathologically i.e. only in those cases where enucleation has been possible. Thirdly it may sometimes also be established histologically in cases where there is no clinical finding or suspicion.

- Incidence in Non-surgical penetrating wounds = 0.19%.[3]

Fig.8: 1 week post-treatment

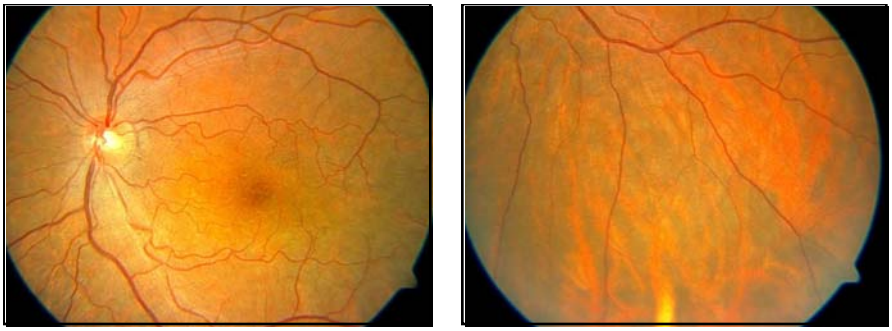

Fig.9: 2 months post-treatment

- Incidence after Intra Ocular surgeries (like cataract extraction, iridectomy, paracentesis, cyclodiaysis, vitrectomy, keratectomy, retinal detachment repair laser cyclocoagulation) = 0.007%.[3]
- Incidence after PPV alone = 0.01% [4]

Sex Ratio

- Higher incidence has been found in males which is a reflection of increased incidence of trauma in males.
- In surgical trauma cases equal incidence in males and females has been found.

Age

- Bimodal variation has been seen
- First peak-in first to second decade when accidental trauma is more
- Second peak – in sixth to seventh decade when more surgical intervention is done

Clinical Features

Ocular manifestations can vary from mild anterior or posterior uveitis to severe panuveitis with an insidious or fairly rapid course.

Symptoms

Patients usually complain of further decrease in vision and increasing photophobia in the exciting eye. One may notice mild pain, photophobia, blurring of vision or increased lacrimation in the sympathizing eye.

Signs

Exciting eye characteristically exhibits persistent granulomatous inflammatory reaction. Development of keratic precipitates on corneal endothelium in exciting eye is taken to be *the most ominous sign*.

Disease process in sympathizing eye might begin in anterior segment or from posterior segment in few cases.

Ciliary flush, cells, flare, K.P.'s are seen in anterior segment involvement first.

Posterior segment findings include

(a) Papillitis which provides a useful means to follow the progress of the disease.

(b) Generalized Retinal edema

(c) Small, focal, elevated, yellow – white exudates beneath RPE are common in mid periphery (*Dalen – Fuch's spots*)

(d) Choroiditis

(e) Exudative Retinal Detachment in severe cases

Time of onset

Peak incidence is 4-8 weeks after trauma to the exciting eye. It is rare before 2 weeks, although the shortest reported time for the development of SO is 5 days after injury.[5]

In general 90% occur with in 1 year of injury and the longest reported cases is 66 years later.[6]

Course of Disease and Complications

It is characterized by *exacerbations and remissions* leading to chorio-retinal scarring and moth – eaten appearance of retina, macular scars leading to visual loss. Cataract, secondary glaucoma, exudative retinal detachment and optic atrophy may follow.

Diagnosis

SO is not easily diagnosed. Suspicion is usually clinical, fluorescein angiography may show multiple, persisting, fluorescent dots at the level of RPE in venous phase. Coalescent dye pools forming due to leakage of dye from these foci may be seen in areas of exudative retinal detachment. Only 20% of clinically suspected cases are confirmed histopathologically.[2]

Etiopathogenesis

Incarceration of iris tissue, ciliary body or choroids has been found a common factor and appears to be essential for the development of SO. Presumably a penetrating wound with uveal prolapse permits tolerated ocular antigens to reach the dendritic cells (the antigen presenting cells).

Immunological basis of SO: Presence of blood tissue barriers at the levels of the retinal vascular endothelium and retinal pigment epithelium (RPE) with lack of intraocular lymphatic drainage makes eye an immune privileged site and penetrating injury allows previously sequestered ocular autoantigens to access conjunctival lymphatic drainage. Autosensitivity against these antigenic protein from uvea or retina eg: retina 'S' antigen tyrosinase related protein leads of development of SO. *Genetic predisposition* has been found.

HLA – A ll, B 40, DR4/DRw53, DR4/DQw3 has been found to be associated. But serological tests and HLA typing are *not* helpful.

Histopathology

Histopathological picture of SO is similar in both exciting and sympathizing eyes.

Typical picture is a uniform infiltration of uveal tract with lymphocytes and epitheloid cells. The inflammation is diffuse, granulomatous, non-necrotising, sparing chorio capillaries and not involving the retina.

- Infiltration of iris leads to thickened iris and formation of posterior synechiae as cells spread to anterior lens capsule.
- Infiltration of pars plana occurs early and cells may spill over into vitreous cavity leading to vitreous haze.
- Infiltration of choroid leads to its thickening. Pigment usually is seen within the giant cells and epitheloid cells in choroid.
- Nodular cellular clusters of epitheloid cells containing pigment are seen lying between the RPE and Bruch's membrane, known as Dalen-Fuch's nodules which clinically appear as Drusen like, yellow white dots described before as Dalen-Fuch's spots.
- Scleral involvement is seen with infiltrates around the emissary veins.

Atypical picture may be seen like

Retinal detachments (50%), optic nerve involvement plasma cell infiltration (60%) and eosinophilia (34%).

Treatment

As well known "prevention is the best cure", careful microsurgical wound care and proper early closure of all penetrating wounds can prevent SO. In eyes where no vision gain is possible, enucleation with in 2 weeks after injury has been seen to prevent development of SO. Delayed enucleation i.e. >2 weeks is not preventive. Enucleation of exciting eye once SO has set in is controversial as in few cases exiting eye may eventually provide the better visual acuity and enucleation would thus deprive the patient of this benefit.

Use of steroids following penetrating trauma before development of sympathetic ophthalmia has been seen to be of no use. Though not so effective, steroids are the mainstay of therapy after SO has set in. Anti-inflammatory action of the steroids is used to suppress the inflammation completely as soon as possible. So large doses are given initially (100-200 mg daily). Dose is reduced and then tapered and continued for 6 months after apparent resolution of inflammation. Subtenon's depot steroids may be added for posterior uveitis and topical steroids can be used for marked anterior uveitis. In addition mydiatics and cycloplegics are used.

For cases where corticosteroids do not control the inflammation or produce unacceptable systemic or ophthalmic side effects, reduced dosages of steroids may be used in conjunction with other immunosuppressive agents like Azathoprine, methotrexate, chlorambucil or cyclosporine.

Andrasch and associates supplemented prednisolone (10-15 mg/day) with Azathioprine (2-2.5 mg/kg/day) or chlorambucil (6-8 mg/day, orally) with initial response seen with in 4 weeks. Once remission is observed, decrease steroid dose by 2.5mg/week till 2.5 mg/day dose is reached. Then reduce dosages of chemotherapentic agents. In case of untoward side effects of chemotherapentic agents, switch over to another agent.

Special care is to be taken with respect to RFT, LFT, Bone marrow functions, which should be continuously assessed.

Positive reports have been seen with use of cyclosporine (5mg/kg/dose) too.

Outcome and prognosis

Early diagnosis and management improves visual outcome. *Chan* et al reported 20/40 vision in 50% patients and *Makely and Azar* showed vision of 20/60 in 64%. But relapses and excacerbations are seen in 60%.

Summary

It was believed formerly that a purulent eye infection with penetrating ocular injuries would destroy the uveal tissue and antigens to such an extent that such eyes do not incite SO. However few previous clinical case reports have established the existence of endophthalmitis in eyes with SO. This case too is contrary to previous studies

emphasizing that a purulent infection with in an eye could prevent development of SO. This case where SO developed following ulceration in other eye stressed and supported the view that purulent infection may not offer protection against development of SO. Current views suggest that uveitogenic antigen (choroidal melanin, tyrosine peptide) may not be altered by the purulent infection and bacterial products may even function as an adjuvant in enchancing the uveitogenic potential of the antigens.[7]

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