Ophthalmic Viscosurgical Devices and Anterior Segment Surgery: Surgical Applications and Complications

Suresh K. Pandey M.D., **Jaya Thakur** M.D., **Liliana Werner** MD Ph.D., **David J. Apple** M.D.

Background

Viscoelastic substances are solutions with dual properties; they act as viscous liquids as well as elastic solids or gels. The ideal viscoelastic substance in ophthalmology should be viscous enough to prevent collapse of the anterior chamber at rest, yet liquid enough to be injected precisely through a small cannula. It should be elastic or shock absorbing and should enhance coating yet has minimal surface activity. It should be cohesive enough to be removed easily from the anterior chamber but not so cohesive that it is aspirated during irrigation and aspiration, which would provide no protection to endothelial cells during surgical manipulations. It should be eliminated from the eye in the postoperative period without any effect on intraocular pressure.

Viscosurgery was a term coined by Balazs to describe the use of these solutions that had viscous, elastic and pseudo plastic properties during and after surgical procedures. During viscosurgery, viscoelastic substances are used as a fluid or a soft surgical instrument.

Moran Eye Center, Department of Ophthalmology and Visual Sciences, Fifth Floor, University of Utah, 50 North Medical Drive Salt Lake City, Utah-84132, USA.

The viscoelastic sodium hyaluronate was first used in ophthalmic surgery in 1972, when it was introduced as a replacement for vitreous and aqueous humor. Since then ophthalmic surgical procedures had undergone considerable advancement. The use of viscoelastic materials has become commonplace in anterior and posterior segment surgeries. These agents facilitate delicate and often difficult intraocular manipulations during various ophthalmic surgical procedures.

OVD should be viscous enough to prevent collapse of the anterior chamber at rest, yet liquid enough to be injected precisely through a small cannula. It should be elastic or shock absorbing and should enhance coating yet has minimal surface activity

Surgical Application of the OVDs

In recent years the field of viscosurgery has broadened rapidly. It has been used both intraocularly as well as extraocularly, which includes cataract, cornea, glaucoma, viteroretinal, strabismus and oculoplastic surgeries.

Use of OVDs in Cataract Surgery

OVDs are helpful in each step of modern cataract surgery using phacoemulsification with IOL implantation. Some of these details are shown in the schematic photograph (Figures 1, 2).

Capsulorhexis

In order to perform an intact and successful capsulorhexis, the contents of the anterior chamber have an important role. Till date balanced salt solution (BSS®), air and OVDs have been used. Out of these three the best is viscoelastic as it is considered the easiest, safest, and the most reproducible method in both routine and difficult cases (Figures 2A, 2B). To perform a good capsulorhexis, the viscoelastic to be used should have the four basic features-

1- High molecular weight and high viscosity at zero shear rate, which maintains the anterior chamber.
2- Excellent visibility provided by high transparency.
3- Make surgical maneuvers easy, due to high elasticity and pseudoplasticity.
4- It should give a good capsular flap control, providing the soft and permanent spatula effect.

Cleavage of lens structure

It is best performed with the use of OVDs. The ideal viscoelastic material keeps the anterior chamber shape unchanged during BSS® injection and also avoids increase in pressure, which can be produced with excessive amount of BSS® known as capsular blockade.

Nuclear emulsification

During phacoemulsification, the viscoelastic is likely to remain in the anterior chamber instead of leaking out of the eye (Figure 2C). OVDs help in preserving the space and also because of their low cohesiveness, they remain in the anterior chamber despite high irrigation flow. Moreover OVDs adhere to the corneal endothelium, thus protecting the corneal endothelial cells. Healon® and Healon-GV® does not trap the air bubble and provide excellent endothelial protection (Figure 2D). This is because of-

1- Scavenger effect- This effect captures the free radicals released during phaco with consequent inactivation.
2- Binding sites- There are chemical receptors for viscoelastic materials on

the corneal endothelium. A molecular bond seems to occur between the viscoelastic solution and the corneal endothelium.

3- High Elasticity- This also smoothes the possible impacts of the lens material against the endothelium.

The phaco tip being in a closed system, its vibrations are transmitted to the internal structures of the eye but viscoelastic provides a smothering shield against them.

Irrigation and aspiration

The role of viscoelastic during this procedure is the protection of the endothelium. This is possible due to high adhesiveness. It remains where it is placed, without mixing with the cortex because of its low cohesiveness thus helping in easy removal of cortex.

Capsular bag filling and IOL implantation

During IOL implantation, it is necessary to expand the capsular bag with a viscoelastic. It allows the surgeon to keep the bag well opened and formed thus allowing the easy IOL implantation. OVD is also helpful in correct positioning, centering and allowing for possible IOL rotation maneuvers (Figs. 1E, 1F). Beside posterior chamber IOL implantation, OVD has also been used for implantation of other IOL designs (e.g. anterior chamber, iris fixated, artisan lenses, etc.)(Fig. 2).

Cataract Surgery in Pediatric Cases

Pediatric cataract surgery like the adult surgery has undergone major changes in recent years with the evolution of techniques including small incision and the development of modern IOLs (Wilson ME, Pandey SK, Werner L, Apple DJ. Pediatric cataract surgery: Past, present and future, *Third Prize* for "Special Interest", Annual Video Festival, XXth Congress of the European Society of Cataract and Refractive Surgeons, Nice, France, September 2002). The main principle lies in the control of the very elastic nature of ocular tissues.

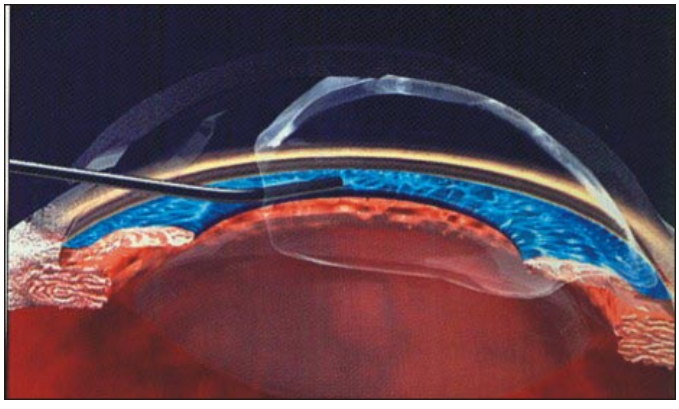

Fig.1A: Injection of the viscoadaptive OVD in the anterior chamber through a 25 G cannula.

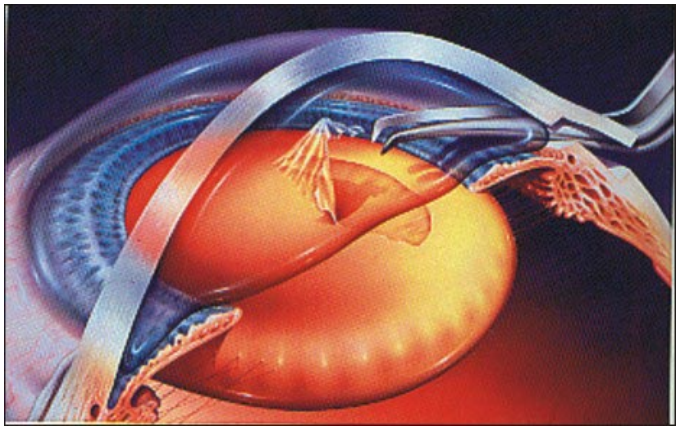

Fig.1B: Capsulorhexis is in progress.

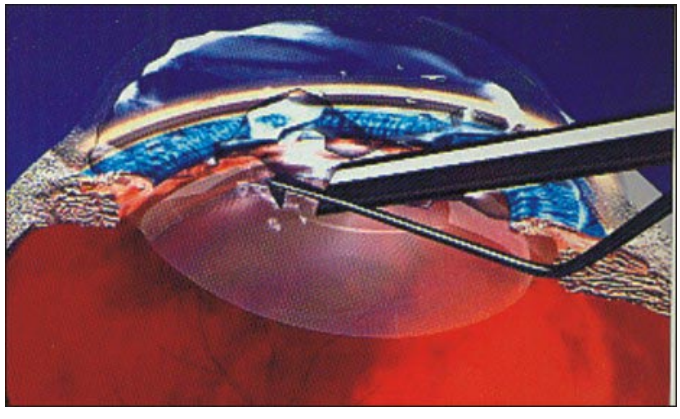

Fig.1C: Phacoemulsification in progress.

It is difficult to perform a good capsulorhexis in the presence of high capsular elasticity. Moreover there is low scleral rigidity, greater intravitreal pressure that makes the capsulorhexis even more difficult, as the pressure tends to curve the capsulorhexis. But with the use of viscoelastic, e.g. Healon-GV® the effective push is in the opposite direction and hence completion of capsulorhexis can be done.

In pediatric cases, the capsulorhexis must be started in the central portion and not towards the equator, in order to prevent radial extension. The high density viscoelastic agents stabilize the posterior chamber and push back the vitreous face during the posterior capsulorhexis. During IOL implantation, the capsular bag is kept open and the anterior chamber is well formed thus ensuring easy and safe implantation of the IOL in the bag. These agents also help to dilate the pupil thus maintaining a good intraoperative mydriasis.

OVDs like Healon-GV® can easily be removed at the end of the surgery including the position which is behind the IOL due to its high cohesiveness thus preventing capsular blockade.

Use of the OVDs in Glaucoma Surgery

Viscocanalostomy

Viscocanalostomy is a new surgical procedure for glaucoma therapy. Viscoelastics play an important role in this procedure. Figure 3 illustrates the surgical

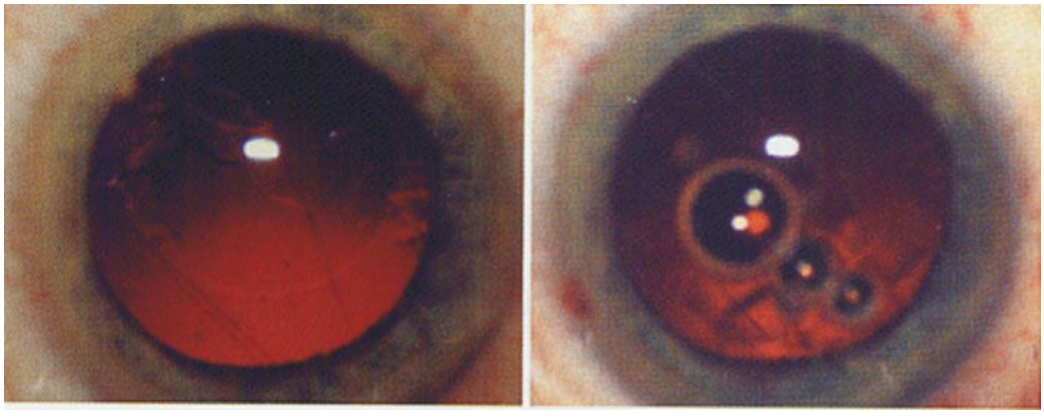

Fig.1 D: Viscoadaptive OVD is transparent and easy to see during removal (left). Note the presence of the air bubbles within the anterior chamber after use of dispersive viscoelastic solution (right).

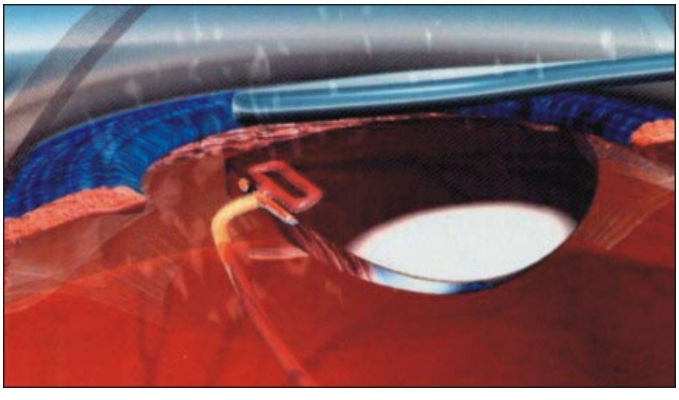

Fig.1 E: Implantation of a posterior chamber intraocular lens in the capsular bag.

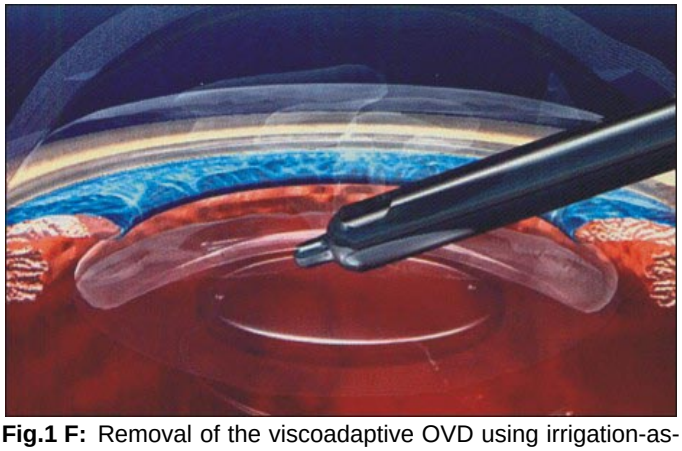

Fig.1 F: Removal of the viscoadaptive OVD using irrigation-aspiration tip.

steps of viscocanalosotomy. Viscocanalostomy literally means "opening of the canal by means of viscoelastic substance". This procedure is a non-penetrating and independent from external filtration. The advantages are decreased risk of infection, and decreased incidence of cataract, hypotony and flat anterior chamber as the anterior chamber is not opened, and moreover, with the absence of external filtration the bleb formation is prevented and also the related discomfort with it. It minimizes the risk of late infections and is independent from conjuntival and episcleral scarring.

Viscocanalostomy allows the aqueous to leave the eye, through Schlemn's canal and episcleral veins thus restoring the natural outflow pathway. This procedure creates a bypass by which aqueous humor reaches Schlemn's canal, skipping the trabecular meshwork. A chamber is produced inside the sclera, which is in direct communication with the Schlemn's canal. There is also a communication through the Descemet's membrane with the anterior chamber.

The OVDs should have high pseudoplasticity to allow injection into Schlemn's canal through a small needle and should have high viscosity at shear rate of zero to maintain the spaces as long as possible. Healon-GV® and Healon-5® are viscoelastics of choice for this procedure.

OVDs for Intraocular Delivery of Dyes or Anesthetic Agents

Researchers and vision scientists have been using OVDs as a vehicle to deliver capsular dyes for use during cataract surgery. Mixing these substances with the viscoelastic agent was attempted to prolong their effect and to limit the adverse effect on ocular tissues. Ciba Vision Corp. (Duluth, GA, USA), has recently proposed mixing an OVD with lidocaine.

This was termed "viscoa-

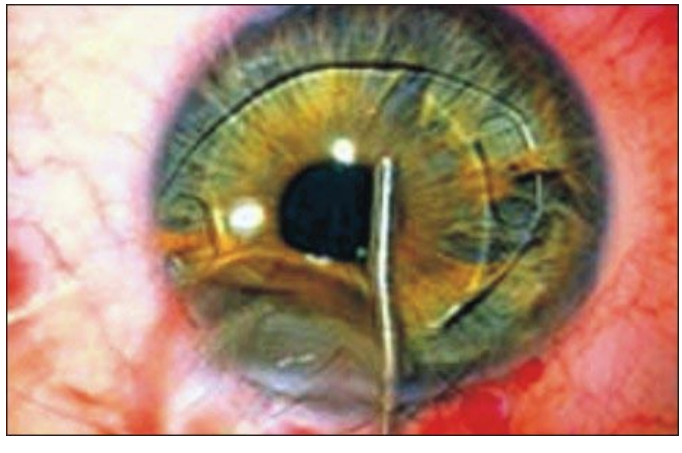

Fig. 2: Beside posterior chamber IOL fixation in the capsular bag, OVDs can also be used for implantation of the various phakic and aphakic IOL designs in the anterior chamber, ciliary sulcus etc. Use of the OVD facilitated the implantation of the Artisan® IOL as shown in this photograph. (Courtesy: Camil Budo, M.D.).

Fig.3. Surgical steps of viscocanalosotomy. (Courtesy: Dr. Med. Tobias Neuhann, M.D., Munich, Germany).

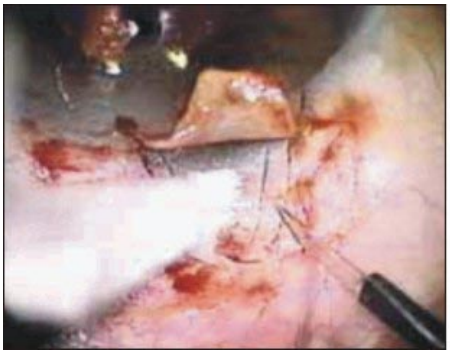

Fig.3.A: Deep block construction incision.

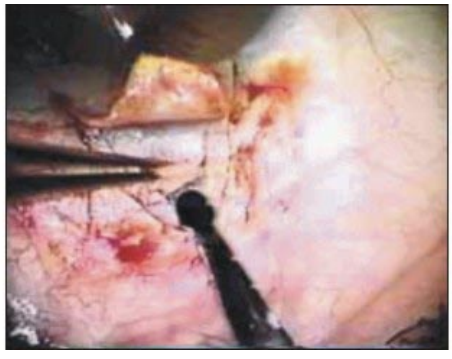

Fig.3.B: Cutting the deep block in a single plane with a spoon blade.

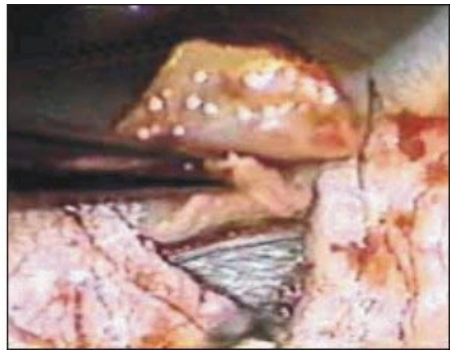

Fig.3.C: Proximal to Schlemm's canal there is a subtle change in the scleral fibers, from a crossing pattern to a tangential pattern, with an increased opacity.

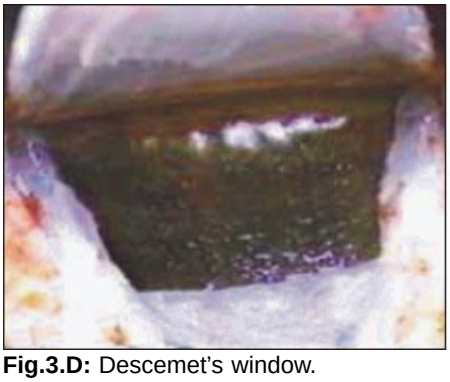

Fig.3.D: Descemet's window.

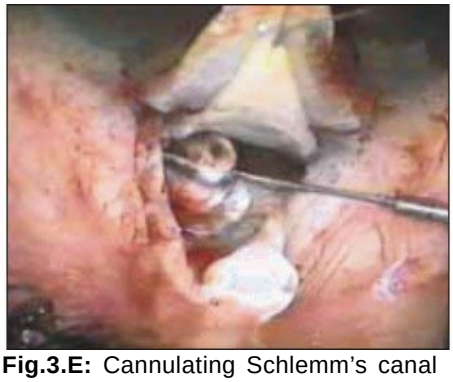

Fig.3.E: Cannulating Schlemm's canal with three puffs of viscoelastic directed at the osteum.

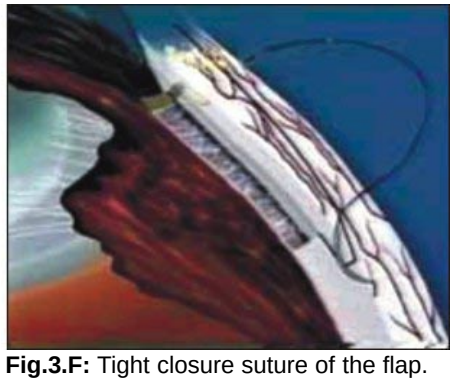

Fig.3.F: Tight closure suture of the flap.

nesthesia" and was intended to prolong the anesthetic effect of intracameral lidocaine, as a complement to topical anesthesia. Also, the steps of intracameral injection of OVDs and of intracameral injection of lidocaine, as a complement to topical anesthesia, would be combined in only one step.

Removal of the OVDs

Several techniques have been reported in the literature for removal of the OVDs. These include: Rock and roll technique, two-compartment technique and bimanual irrigation / aspiration technique.

We would like to emphasize that a careful and thorough removal of the OVDs from the capsular bag and the anterior chamber of the eye is must after the end of the surgery. This is important to avoid complications such as rise in intraocular pressure, crystallization of the IOL surface. Studies have shown that complete removal of viscoelastic material from the capsular bag can be more difficult when some hydrophobic acrylic lenses are used because of the IOL's tacky surfaces (Apple DJ, Auffarth GU, Pandey SK. Miyake posterior view video analysis of dispersive and cohesive viscoelastics, video presented at the Symposium on Cataract, IOL, and Refractive Surgery, Seattle, WA, April 1999).

Complications of OVDs:

OVDs have many positive attributes but their drawbacks and complications must be given careful considerations. Some of the important complications are as follows-

1. Increase in intraocular pressure

Increase in intraocular pressure is the most important postoperative complication of OVDs. It was first noted with Healonâ . The increase in pressure can be severe and prolonged, if the material is not thoroughly removed at the end of the surgery. The rise in pressure occurs in the first 6 to 24 hours and resolves spontaneously within 72 hours postoperatively. The rise in pressure is due to the mechanical resistance of the trabecular meshwork to the large molecules of the viscoelastic material, which decreases the outflow facility. Hence to decrease the incidence of this complication,

Increase in intraocular pressure is the most important postoperative complication of OVDs.

many have advocated removing and aspirating the viscoelastic material from the eyes at the end of the surgery.

2. Capsular block syndrome or capsular bag distension syndrome

Capsular block syndrome (CBS), is a newly described complication of cataract-IOL surgery. It is characterized by accumulation of a liquefied substance within a closed chamber inside the capsular bag, formed because the lens nucleus or the posterior chamber IOL optic occluded the anterior capsular opening created by the capsulorhexis. Depending on the time of onset, CBS is classified as intraoperative (CBS seen at the time of lens luxation following hydrodissection), early postoperative (originally described CBS), and late postoperative (CBS with liquefied after-cataract or lacteocrumenasia).

Recently use of high-density viscoelastic agents, such as Healon-GV®, has been found to be associated with complication of late CBS. Main ingredient of the transparent liquid in capsular bags is sodium hyaluronate and that the distention is caused by aqueous humor being drawn into the capsular bag by an osmotic gradient across the capsule when the capsulorhexis diameter is smaller than that of the PC IOL and by viscoelastic material retained and trapped in the bag intraoperatively.

Suggested Reading:

1. Arshinoff SA, Opalinski YAV, Ma J. The pharmacology of lens surgery: ophthalmic viscoelastic agents. In: Yanoff M, Ducker JS, eds, *Ophthalmology*. St Louis, Mosby-Yearbook, 1998; 4:20.1-21.6
2. Pandey SK, Thakur J, Werner L, Sharma V, Izak AM, Apple DJ. Ophthalmic viscosurgical devices: An update. In: Garg A, Pandey SK, Sharma V, Apple DJ, eds., *Advances in Ophthalmology*. Jaypee Brothers, New Delhi, India 2003, (in press).
3. Liesegang TJ. Viscoelastics. *Surv Ophthalmol* 1990; 34:268-293
4. Pandey SK, Werner L, Apple DJ, et al. Dye-enhanced pediatric cataract surgery. *J Pediatr Ophthalmol Strabismus* 2003 (in press).
5. Ram J, Pandey SK. Anesthesia for cataract surgery. In: Dutta LC. *Modern Ophthalmology*. Jaypee Brothers, New Delhi, India, 2000, PP 325-330. 437-440, 378-384.
6. Saini JS, Pandey SK. Advances in techniques of penetrating keratoplasty. In: Nema HV, Nema N, eds., *Recent Advances in Ophthalmology*, Volume IV, Jaypee Brothers, New Delhi, India, 1998, pp 37-51
7. Pandey SK, Thakur J, Werner L, Izak AM, Apple DJ. Classification, clinical applications and complications of ophthalmic viscosurgical devices: An update. In: Garg A, Pandey SK, eds., *Textbook of Ocular Therapeutics*. Jaypee Brothers, New Delhi, India 2002, PP: 392-407
8. Pandey SK, Wilson ME, Apple DJ, Werner L, Ram J. Childhood cataract surgical technique, complications and management. In: Garg A, Pandey SK, eds. *Textbook of Ocular Therapeutics*. Jaypee Brothers, New Delhi, India 2002, PP 457-486.

REQUIRED

Full time Ophthalmologist for a upcoming Eye Hospital in East Delhi

Contact : **Dr. Sanjay Bajaj**
A-1/1, Nathu Colony Chowk,
Shahdara, Delhi – 110093
Ph : 9810623636, 9810015012

Perimetry & Imaging In Glaucoma

Perimetry: Basics, single field and followup. Interpretation, analysis and application in day to day clinical situations .

Newer imaging techniques : basics and interpretation : Utility in diagnosis and followup

Groups of Ten Each
On Sunday :
December 14, 2003
February 8, 2004

Contact:
Dr. Devindra Sood
Glaucoma Imaging Centre
P-13, South Extension Part II
New Delhi 110049
Tel: (011) 26257803 : 26252000