REVIEW ARTICLE

Recent Advances in Ophthalmology

Yog Raj Sharma, Rajeev Sudan, Amit Gaur

Very significant and rapid technological advances have been made in the field of ophthalmology in the past few decades. Advances in refractive surgery, cataract surgery, diagnosis and medical management of glaucoma, and vitreo-retinal surgery have been revolutionary. Almost all of these have been introduced in India and are being rapidly accepted by ophthalmologists all over the country.

Refractive Surgery

One of the most revolutionary advances in ophthalmology in last decade has taken place in field of refractive surgery. This has been possible with the use of Excimer laser, which is a short wavelength UV laser (ArF-193nm) for corneal ablation with precise cut and minimal thermal damage to the adjacent tissue.

The two widely accepted refractive surgical procedure, Photo-Refractive Keratectomy (PRK) and Laser Assisted in Situ Keratomileusis (LASIK) are used mainly for correction of myopic refractive error. They are based upon the reshaping of the corneal curvature by ablation of portion of the corneal tissue.

PRK in human eyes was first performed in 1988. It involves removal of corneal epithelium followed by application of Excimer laser and has been proven to be safe and effective method of low to moderate power correction of myopia upto-6D (1). LASIK involves creation of a corneal flap with an automated microkeratome, followed by Excimer laser ablation of the stromal tissue. LASIK is being performed since early 1990s, and offers many advantages over PRK, less pain, less haze, less regression, faster recovery and effectiveness for high diopter correction-upto-30D (2).

Several techniques like holmium : YAG laser thermal keratoplasty (LKT), besides PRK and LASIK have been used to correct hyperopia and prebyopia. But results are not satisfying as in for myopia correction and search is still on for a reliable keratorefractive procedure for correction of hyperopia (3).

Various other procedures are being increasingly used for refractive correction.

Phakic Refractive Lenses

One such procedure is implantation of anterior or posterior chamber intraocular lenses in phakic patients. These are called Phakic Refractive Lenses (PRL) and include anterior chamber, angle supported or iris claw lenses (4). Posterior chamber phakic lenses are made up of silicone or a polymer collagen-HEMA–**Intraocular Contact Lens, ICL** (5). These PRL can be used to correct both myopia and hyperopia. The technique is safe, predictable, reversible and easy to perform for any skilled cataract surgeon.

From the Department of Dr. Rajindra Prasad Centre for Ophthalmic Sciences, AIIMS, New Delhi.
Correspondence to : Dr. Yog Raj Sharma, Additional Professor, Dr. Rajindra Prasad Centre for Ophthalmic Sciences, AIIMS, New Delhi.

Intrastromal Corneal Ring (ICR) and Intrastromal Corneal Ring Segment (ICRS)

Intrastormal corneal ring (ICR) were 1.3mm thick 360° intrastromal channel fashioned at two corneal depth, via a 2mm radial incision (6). Currently they have been modified to consist of two 150° PMMA arc segments called Intra Stromal Corneal Ring Segments **(ICRS or Intacs)** in order to facilitate surgical procedure and avoid potential incision related complication (7). Thickness range from 0.21-0.45mm and are inserted through a 1.8 mm radial incision in superior cornea near the limbus. Implantation of ICRS results in corneal flattening and with removal result in return of original corneal curvature. The procedure is safe, easily performed, reversible visual results are excellent, and the device provides stable and predictable correction post operatively in myopia upto 5D. Newer permutation may have other refractive application i.e. astigmatism concurrently with myopia and hyperopia.

Surgical Reversal of Presbyopia (SRP)

The current technique for surgical reversal of presbyopia (SRP) is scleral expansion. This technique involves expansion of the space between the ciliary muscle and the equator of the crystalline lens. Scleral Expansion Bands (SEB) have been used for this procedure since 1992 (8). Currently in this technique 4 PMMA bands, (SEB segment) are inserted into scleral belt loops formed 2.75 mm posterior to limbus in 4 quardrants. Results of this technique are quite encouraging (9). The global impact of this will be a driving force for the continual research and development of this procedure.

Phototherapeutic Keratectomy (PKT)

This is a technique in which the exact edging capability of Excimer laser is used in treating superficial corneal opacities, corneal scars, dystrophies and irregularities. PTK is still in its infancy and various disorders, where it is being applied are recurrent corneal erosions, corneal scars, corneal dystrophies, Band Keratopathy and polishing of denuded area after pterygium excision (10).

Radio Frequency Keratoplasty (RFK)

RFK is performed by using a conductive high-frequency energy delivered to the cornea to promote intrastromal collagen fiber shrinkage deep within the cornea. This technology is under investigation and currently being evaluated for the treatment of hyperopia and compound hyperopic astigmatism. It has less regression as compared to other procedures used for treatment of hyperopia like holmium, YAG laser thermokeratoplasty, PRK and LASIK. The international prospective study on the Refratec RCS corneal shaper have revealed promising initial results (11).

Phacoemulsification

The technique of phacoemulsification is the most exciting recent innovation in cataract surgery in the 20th century. Though it was introduced by Kelman in 1967, its popularity has increased tremendously only in the last decade after the introduction of better and safer machines and techniques. Just as extracapsular cataract extraction (ECCE) had replaced intracapsular cataract extraction around 25 years ago, phacoemulsification is becoming the preferred method of cataract extraction all over the world. A recent survey showed that phacoemulsification is used in 86% and ECCE in 14% of adult cataract extraction in the United States (12).

Phacoemulsification is a sophisticated form of extracapsular cataract extraction. It permits removal of a cataract through a 3.0 mm incision thus eliminating many of the complication of wound healing related to large incision cataract surgery and shortens the recovery period. It does this by fragmenting the cataract, which allows aspiration. Phacoemulsification is becoming the preferred method of cataract extraction in developing countries too as it offers many benefits to both the surgeon and patient. Its prinicpal advantage is the small incision size, which allows the surgeon greater control over intraocular structures during surgery. There is less tissue injury, less post-operative pain and inflammation, and less surgically induced astigmatism. There are fewer restrictions on patient's physical activities in the early postoperative period compared with other cataract procedures.

Recent advances in Intraocular Lens Implants (IOLs)

The popularity of posterior chamber lens implantation during past two decades has been dramatic. PMMA lenses are still the most popular lenses. Important design change in the last decade has been the introduction of single piece, all PMMA lenses. This allows easier implantation and posterior capsular opacification. Another modification is the introduction of laser ridge which is supposed to retard posterior capsular opacification and facilitates Nd : YAG laser capsulotomy. With the rising popularity of phacoemulsification and small incision cataract surgery, PMMA lenses with 5 or 5.5 mm optic and 11.0 and 11.5 mm length are becoming the standard, which are less likely to decenter when capsulorrhexis is properly performed. To reduce the problem of retinopathy produced by ultraviolet radiation exposure, radiation blocking chromophores like Benzophenomes and Benzotriazole are incorporated into the optic of IOL.

With the rising popularity of phacoemulsification and small incision cataract surgery, there has been considerable interest in foldable lenses. These can be folded and implanted through a small incision, thus reducing surgically induced astigmatism and promoting and rapid wound healing and rehabiliation. Various soft polymers that have been widely investigated include silicone, polyhydroxyethyl methacrylate (poly HEMA) hydrogels, and the acrylate/methacrylate copolymers (foldable acrylic). Recently arcylic lenses are becoming most popular (13). These lenses unfold slowly and in a more controlled manner, they have excellent centration and incidence of posterior capsule opacification is extremely low with acrylic foldable lenses.

Over the past decade, a variety of multifocal intraocular lenses have been under investigation (14). Theses lenses incorporate refractive or diffractive optical principles to achieve simultaneous uncorrected distance and near visual acuity after cataract surgery. A few concerns still surround the use of these lenses, particularly the loss of contrast senstivity and inducement of glare and haloes from lights with night vision. It is expected that they will be improved and that a consensus will develop as to their future application.

Laser Cataract Surgery

One of the recent developments in Ophthalmology is the laser cataract surgical system. The technique is basically same as in normal phacoemulsification procedures, only difference being that instead of ultrasound power, laser energy is used to vaporize and aspirate the lens material out of the eye. The laser energy is generated through either of two solid state laser system available presently for cataract removal. The neodymium yttrium-aluminium garnet (Nd : YAG) laser and the erbium YAG (Er. YAG) laser (15). In this procedure (Dodick's approach) a Nd : YAG laser beam is fiber optically directed towards a titanium mirror target, the reflection produces waves of optical breakdown power, resulting in photoablation of the surface down to any depth desired (16). In Colvard's technique, Erbium laser beam is placed directly in contact with the nucleus of the cataract for nonpercussive cutting (17).

It is expected that laser cataract surgery will soon develop into a procedure that will gain world wide acceptance as a safe effective method of removing cataracts. Advantages of this technique are, (a) requirement of the minimal incision (<2mm), (b) there is no unwanted transmission and scatter of laser energy to adjacent tissues, thus no damage to endothelium and very low rate of posterior capsular rupture, (c) no corneal burns as there is no heat production at the tip, (d) learning curve is fast and safe.

Restoration of Accomodation by refilling the lens

This technique is still experimental, the procedure consists of endocapsular removal of lens substance through a small capsular opening and refilling the empty capsular bag with and injectable material. Refilling the lens capsule while preserving the integrity of the lens capsule, zonules and ciliary muscles, offer the potential of restoring ocular accomodation after cataract surgery.

Parel and Heafliger termed this technique Phacoersatz and refilled the lens capsule of non human primate eye with precured silicone elastomer (18). But the substance tended to leak from the capsular bag. To avoid leakage of filling material, Nishi developed a soft, elastic, inflatable endocapsular balloon that is introduced into the capsular bag and then silicone compounds are injected into the balloon. Later same authors developed a new direct lens refilling procedure in which a capsular plug in used to obstruct the capsular opening created by mini circular capsulorrhexis (19).

Though the potential feasibility of refilling the lens has been demostrated in animal eyes, a number of issues remains to be resolved, like prevention of post capsular opacification, power of calculation for post surgical emmetropia, whether useful accomodation can be obtained in presbyopic eyes, before this tehnique gains acceptance.

Automated Perimetry

One of the most significant advances in glaucoma management has been the introduction of automated static perimetry, which has surpassed manual visual field examination in patients with glaucoma.

The two currently available automated static perimeter, the Octopus and Humphery Visual Field Analyzer are capable of measuring the differential light threshold for both screening and full threshold examinations. Their use has resulted in the ability to perform routine, high quality, reproducible visual field testing.

Standardization of various test conditions is a direct advantage of automated perimeters. Their use also eliminates perimetrist bias, which is a long-standing source of variability in manual perimetry. Never the less, the operator still plays an important role in instructing the patient, entering the selected test strategy, and monitoring the patient during the test.

The printout from an automated perimeter provides several categories of information regarding the patient, test conditions, patient reliability, and sensitivity of the test points examined. Computerized analysis of test results may consist of statistical data reduction, calculation of visual field indices, evaluation of serial examinations, or comparison of an individual examination with a stored database of perdicted normal values.

In the evaluation of glaucoma, commonly a full or central screening program is performed as the initial test, followed by a full thresholding program (such as Octopus 32 or Humphery 30-2).

High pass resolution perimetry (HRP) and short wavelength automated perimetry (blue on yellow) are two more recent, currently available perimetric methods that may prove valuable in the evaluation of glaucoma suspects or glaucoma patients. In HRP, the patient is presented with discrete ring shaped targets of different sizes composed of a bright core surrounded by dark annuli to determine spatial resolution thresholds (20). Testing time with HRP is shorter than with conventional perimetry and the results may directly reflect the number of functioning ganglion cells. Short wavelength perimetry can possibly identify galucoma suspects at greatest risk for glaucoma with blue on yellow perimetry. Despite further automation, the clinician's personal assessment of the visual field examination will remain an important part of the diagnosis and management of glaucoma.

Newer Drugs in Medical Management of Glaucomas

Various topical antiglaucoma agents belonging to different groups have become recently available for medical management.

Approval for clinical use of the topical carbonic anhydrase inhibitor, Dorzolamide (Trusopt) in 1995 is quite significant. At 2% concentration, administered three times daily its efficacy is intermediate between timolol and betaxolol by a small magnitude. Clinical trials have shown lack of statistically significant difference in three time daily monotherapy and adjunctive therapy by many ophthalmologist. Efficacy of Brinzolamide approved in 1998 is similar to dorzolamide. Latanoprost (Xalatan) is a prostaglandin analog, which lowers IOP by causing an increase in uveo-scleral outflow. Approved for clinical use in 1996, when used once daily in a concentration of 0.005%, it is an extremely potent ocular medication that consistently lowers IOP from 27%-34%. Brimonidine (Alphagan) in an adrenergic agonist having a much greater α_2- subtype selectivity than Apraclonidine (21). It also shows excellent promise as an adjunctive agent used twice daily. Levounolol (Betagan) is a non-selective topical β-blocker. Efficacy and side-effects are similar to timolol. Carterolol (Ocupress) and Metipranolol (Optipranolol) are potent non selective β-blockers with later having partial β-agonist activity (intrinsic sympathomimetic activity). Efficacy and safety are similar to those of timolol. Adrenergic antagonists (Prazosin, Thymoxamine and Dapiprazole) block smooth muscle α-adrenergic receptors.

Future directions for therapy of glaucoma

Various promising new drugs that substantially lower IOP after both topical and systemic application, include Ethacrynic Acid, Calcium Channel Blockers, Ocular glucocorticoid receptors and steriod antagonist, Ocular Renin Angiotensin System agents like topical ACE inhibitors, Cannabinoids, and Dopamine and related drugs. However they are still being investigated and need further research to develop less toxic, more efficacious, longer lasting and more easily administered forms if these drugs are to be useful for chronic treatment.

Optic Nerve Head and Retinal Nerve Fiber Layer Analyzer

The diagnosis of glaucoma is dependent on the clinical detecting the requisite structural [optic nerve head (ONH) and nerve fiber layer (NFL)] damage along with characteristic visual field loss.

Technology has been introduced over the past two decades to improve the examination of the ONH and more recently the nerve fiber layer. These include :

Optic Nerve Head Analyzers

In ONH Analyzers simultaneous stereoscopic optics or confocal optic images are analyzed by computer and transformed into surface topographic data (22). They are still of limited clinical application owing to variability and limited accuracy and reproducibility.

Confocal Laser Scanning Ophthalmoscope

This offers higher axial resolution and greater reproducibility than current ONH alalyaers. The topography of the ONH is mapped sequentially deeper to provide a series of scans and can also detect any significant change in surface contour of the optic disc on follow up examination (23). Confocal laser scanning ophthalmoscope can also be used for quantitative measurement of retinal nerve fiber layer (NFL).

Nerve Fiber Analyzer (Scanning Laser Polarimeter)

This instrument is also of value in detecting reduced thickness of the NFL (24).

Optical Coherence Tomography (OCT)

OCT is also used to evaluate the NFL thickness in glaucoma.

Variability of results using the three instrument for NFL analysis is quite small (25). However they still have limited application in clinical practice owing to the wide overlap between normal and abnormal values of NFL thickness. It may because a valuable method of examination if quantitative evaluation of retinal NFL becomes feasible.

Ultrasound Biomicroscopy (UBM)

Ultrasound imaging in ocular diagnosis is being done done since 1956 (26). UBM is a new method of ultrasonic imaging that uses high frequency ultrasound (50 to 100 MHz) to image the living eye at microsocpic resolution (27). It is based on the use of unique high frequency transducers incorporated into B mode scanning devices. UBM is based on the principle that by increasing the frequency, higher resolution can be obtained. While conventional ophthalmic ultrasound provides resolution of 600μm, UBM provides resolution of 50μm. But this increase in resolution is achieved at cost of loss of penetration. Maximal penetration that can be achieved with conventional ultrasound (10 MHz) is approximated 50mm, for the UBM (50MHZ), penetration is only 5mm. Therefore UBM is capable of imaging the anterior segment of the eye only, within that distance at which probe can be placed directly over the globe. Thus structure which can be evaluated include cornea, iris, angle structures, sclera, ciliary body, lens and peripheral retina anterior to the equator. Glaucoma, anterior segment tumors, intraocular lens complication and corneal diseases are amongst the increasing indications for UBM.

Optical Coherence Tomography (OCT)

Optical Coherence Tomography (OCT) is a new imaging modality that produces high resolution, cross sectional images of ocular structure in vitro and in vivo (28). OCT produces detailed two dimensional images of the retina and measures retinal thickness with a longitudinal image resolution of approximately 10μ. The principles of OCT are similar to B-mode ultrasound, however OCT utilizes the reflection of light waves from different structures in the eye rather than sound. Low coherent light, produced by a continous wave superluminescent diode source, is directed into the eye, it is reflected at the boundaries of tissues with different optical properties. Light source is coupled with a fibreoptic interferometer and low coherence interferometry is used to measure the time of flight delay of light reflected from structures within the retina. As OCT is an optical technique, it can be performed without physical contact with the eye and minimal patient discomfort. As the technique of OCT is performed in conjunction with slit lamp biomicroscopy, simultaneous viewing of the retina allows the OCT scan to be directed to the area of interest. OCT has proven useful in variety of retinal pathology, including macular holes, epiretinal membrances, macular edema, central serous retinopathy, and age related macular degeneration (29). Media opacities like vitreous hemorrhage or corneal edema limits the use of OCT for retinal imaging. High resolution imaging of anterior chamber structures and measurement of peripapillary nerve fiber layer thickness is also possible (30).

New Development in Retinal Laser Therapy

(i) Dye Enhancement

Several methods have been investigated to increase the specificity and effectiveness of laser procedures. Dye enhancement requires administration of an exogenous agent that concentrates in the target tissue. Localization of the Laser effect to the target tissue is based on the similar wavelenght of absorption for the exogenous agent and the emmission from the laser.

Currently Indocyanine Green (ICG) dye is used for dye enhancement. ICG dye has a predilection to concentrate in choroidal neovascular membranes. As the peak wave length of ICG absorption (805nm) is similar to that of diode laser emission (810nm), administration of ICG dye immediately prior to diode laser photocoagulation, permits selective ablation of ICG filled choroidal neovascular membrane (CNVM) with lower energy requirement, thus limiting laser-induced damage to the adjacent normal retina (31). ICG enhanced diode treatment have shown encouraging results in treatment of subfoveal occult choroidal neovascularization.

(ii) Photodynamic Threapy

Photodynamic therapy (PDT) depends on activation of an exogenous agent by low intensity light to produce a photochemical reaction with subsequent tissue damage. PDT produces selective tissue damage, as the exogenous photo sensitizing agent preferentially concentrates and is retained longer in hyperproliferating and neoplastic tissues than in normal surrounding tissue (32). PDT is currently being investigated to treat a variety of systemic and cutaneous maligancies. PDT is well suited for ophthalmic application due to the optical properties of the eye and accessibility of the eye to light irradiation by the transpupillary route. Hematoporphyrin derivative (HPD), which is activated by light of 624mm has been used in humans to treat retinoblastoma and melanomas of the choroid, ciliary body and iris (33). In animals PDT has successfully produced closure of choroidal neovascularization.

Macular Hole Surgery

Though macular hole were first recognised over 100 years ago, there has been renewed interest in the pathophysiology and natural history of macular holes in the past two decades. Full thickness macular holes were once considered untreatable but with better understanding of the pathophysiology, pars-plana vitrectomy was suggested and evaluated as a possible treatment by Kelly and Wendel in 1991 (34). Since than it has been adopted by vitreo retinal surgeons all over the world and recently improved results with higher sucess rate have been reported in various studies.

Diagnostic Indocyanine Green Videoangiography

Fluorescein angiography (FA) revolutionized the diagnosis of retinal disorders. Indocyanine Green (ICG) dye has several advantageous properties over sodium fluorescein as a dye for ophthalmic angiography. ICG absorbs and fluoresces in the near infrared range, and it is highly protein bound. These properties allows enhanced imaging of the choroid and its associated abnormalities. In 1992, Guyer and coworkers introduced use of digital imaging system which improved the resolution of ICG, making it clinically practical (35). It is useful adjunctive diagnostic technique to FA for studying choroidal disorder especially in the diagnosis of occult and recurrent CNV, intraocular tumours and choroiditis. Preliminary studies suggest that ICG guided laser photocoagulation may be beneficial in the treatment of CNV (36).

Drug Delivery to the Posterior Segment

Drug delivery to the posterior segment is a major challenge in ophthalmology. Direct injection into various cavity is required for rapid delivery. Since multiple intravitreal injection are traumatic to patient, means are being developed to sustain drug concentration in the vitreous cavity while minimizing toxicity and enhancing efficacy. Liposomes have been investigated with respect to sustaining drug concentrations in the vitreous cavity. These are phospholipid vesicles which prolong half life of various drugs. Liposome encapsulated gentamicin, fluorooratate, cidofavir and amphotericin B have been investigated in animal studies.

Various other means for sustain drug delivery in the vitreal cavity include microspheres (co-polymer of glycolic acid and lactic acid), biodegradable polymeric devices called scleral plug and surgically implantable non biodegradable device for ganciclovir for treatment of CMV retinitis (37).

Vitrectomy for removal of sub macular hemorrhage

Recent advances in vitreoretinal surgical tecniques have sparked a growing interest in the removal of sub macular hemorrhage. These include manual clot extraction with subretinal extrusion cannula or forceps, tissue plasminogen activator (t PA) injection followed by aspiration or clot extraction, tPA plus perfluorocarbon liquids, and intravitreal tPA injection (38).

Macular Translocation

Different surgical techniques involve macular translocation with punctate or no retinotomies/with incomplete circumferential retinotomy/with 360 degree retinotomy. Because long term follow up is not available, and is still unclear whether short term benefit from macular translocation will persist with longer follow up. A multicenter, randomized pilot clinical trial is under way to compare the results of macular translocation with both photodynamic therapy or observation in eyes with subfoveal CMV secondary to AMD (39).

Retinal/RPF Translocation

Eye disease with primary photoreceptor degeneration (retinitis pigmentosa) and those where RPE degeneration is believed to be primary (AMD) are amenable to transplantation. Human RPE transplants were first reported in 1991 and transplants of survival of retinal cells and RPE in human donors in 1995 (40, 41). Though transplantation and long term survival of retinal cells and RPE in humans is possible, little data exist to support the notion that such transplants results in recovery of formed vision. Much work is needed before these transplantation becomes a clinically useful therapy.

References

1. Dutt S, Steinert RF, Raizman MB, Puliafito CA. One year results of Excimer laser photorefractive keratectomy for low to moderate myopia. *Arch Ophthalmol* 1994 ; 112 : 1427-36.
2. Pallikaris IG, Siganos DS. Excimer laser in situ keratomileusis and photorefractive keratectomy for correction of high myopia. *J Refract Corneal Surgery* 1994 ; 10 : 498-510.
3. Waring GO Evaluating new refractive surgical procedure, free market madness versus regulatory rigor mortis. *J Refract Surg* 1995 ; 11 : 335-38.
4. Duplessie MD, Rocha G, Sanchez-Thorin JC. Advances in refractive and corneal surgery. *Int Ophthalmol Clin* 1996 ; 36 : 4.
5. Hatsis A. Phakic posterior IOLs for the correction of high hyperopia and myopia. ASCRC Annual meeting, Boston 1997.
6. Nose W, Neves RA, Burris TE *et. al.* Intrastromal corneal ring-12 month sighted myopis eyes. *J Refract Surg* 1996 ; 12 (1) : 2028.
7. Waring GO III, Abbott RL, Asbell PA *et. al.* One year outcomes of intrastromal corneal ring segments for the correction of 1.0 to 3.5 dioptres of myopia. American Academy of Ophthalmology Meeting, New Orleans 1998.
8. Schachar RA : Treatment of presbyopia and other eye disorder 1994.

9. Cross WD, Zdenek GW. Surgical Reversal of Presbyopia. Refractive Surgery. Jaypee Brothers, New Delhi 2000, 592-608.

10. Hersh PS, Wagoner MD. Excimer Laser Surgery for corneal disorders. Thieme : New York. 1998.

11. Mache EE : Hyperopic Radiofrequency keratoplasty (RFK) American society of cataract and refractive surgery: Seattle 1999.

12. Learning DV. Practice styles and preferences of ASCRS members. 1994 surgery. *J Cataract Refract Surg* 1995 ; 2 : 378-85.

13. Learnign DV. Practice styles and preferences of ASCRS member 1996 survey. *J Cataract Refract Surg* 1997 ; 23 : 527-35.

14. Weghaupt H, Pieh S, Skorpik C. Visual properties of the foldable array multifocal intraocular lens. *J Cataract Refract Surg* 1996 ; 22 : 1313-17.

15. Aasuri MK, Basti S. Laser cataract surgery. *Curr Opin Ophthalmol* 1999 ; 10 : 53-58.

16. Dodick JM. New laser phaco-Eye Care Tehnology 1994.

17. Colvard DM, Erbium, YAG laser removal of cataracts. Presented at the American Society of Cataract and Refractive Surgery (ASCRS) Annual meeting, 1993.

18. Haefliger E, Parel JM, Fantes F *et. al.* Accomodation of an endocapsular silicone lens (phacoersatz) in non human primate. *Ophthalmology* 1987 ; 94 : 471-77.

19. Okihiro N, Kayo N. Phacoemulsification, Laser Cataract Surgery and foldable IOLS. New Delhi *Jaypee Brothers,* 2000 : 597-605.

20. Sample PA, *et. al.* Short wavelength colour visual fields in glaucoma suspects at risk. *Am J Ophthalmol* 1993 ; 115 : 225.

21. Greenfield DS, Liebmann JM, Brimonidine RR. A new alpha 2 adreno receptor against for glaucoma treatment. *J Glaucoma* 1997 ; 6 : 250.

22. Varma R. Image analyzers: introduction. In: Varma R, Spaeth GL (eds). The optic nerve is glaucoma philadelphin. *JB Lippincott Co* 1993 ; 209.

23. Rohrschneider K, Burk RO, Kruse FE, Volcker HE. Reproducibility of the optic nerve heal topography with a new laser tomographic scanning device. *Ophthalmology* 1894 ; 101 : 104.

24. Weinres RN, Shekiba S, Zangwill L. Scanning laser polarimetry to measure the nerve fiber layer of normal and glaucomatous eyes. *Am J Ophthalmol* 1995 ; 119 : 627.

25. Williams JM, Zangwill L, Weinreb RN. Measurement of the nerve fiber layer using the optical coherence tomograph. Heidlberg retina tomograph, and nerve fiber analyzer. *Invest Ophthalmol Vis Sci* 1997 ; 38 : 5837.

26. Mundt GH, Hughes WF. Ultrasonics in ocular diagnosis. *Am J Ophthalmol* 1956 ; 42 : 488.

27. Pavlin CS *et. al.* Clinical use of ultrasound biomicrocopy. *Ophthalmology* 1991 ; 98 : 287.

28. Huang D, Swanson EA, Lin CP *et. al.* Optical coherence tomography. *Science* 1991 ; 254 : 1178-81.

29. Puliafito CA, Hee MR, Schuman JS, Fujimoto JG. Macular diseases. In optical coherence tomography of Ocular Diseases. *New Jersey* SLACK incorporated 1996 ; pp 37-289.

30. Schuman JS, Hee MR, Arya AV *et. al.* Optical Coherence Tomography A new tool for glaucoma diagnosis. *Curr Opin Ophthalmol* 1995 ; 6 : 89-95.

31. Guyer DR, Yanuzzi LA, Slakter JS, *et. al.* Digital indocyanine green Videoangiography of occult choroidal neovascularization. *Ophthalmology* 1994 ; 101 : 1127-37.

32. Henderson BW, Dougherty TJ. How does photodynamic therapy work photochem photobiol 1992 ; 55 : 145-57.

33. Murphee AL, Cote M, Gomer CP. The evolution of photodynamic therapy in the treatment of intraocular tumers. Photochem Photobiol 1987 ; 46 : 919-23.

34. Kelly NE, Wendel RT. Viterous surgery for idiopathic macular holes. Results of a pilot study. *Arch Ophthalmol* 1991 ; 109 (5) : 654-59.

35. Guyer DR, Yannuzzi LA, Slakter JS *et. al.* The status of indocyanine green videoangiography. *Curr Opin Ophthalmol* 1993 ; 4 : 3-6.

36. Schwartz S, Guyer DR, Yannuzzi LA *et. al.* ICG videoangiography-guided laser photocoagulation of primary occult choroidal neovascularization in age related macular degeneration. *Invest Ophthalmol Vis Sci* 1995 ; 36 : 186.

37. Vincent HL, Lee Drug Delivery to the posterior segment. In: Ryan SJ (ed). Surgical Retina Mosby 2001 ; 2270.

38. Kemei M, Tano Y, Maeno T, *et. al.* Surgical removal of submacular hemorrhages in tissue plasminogen activator and perfluorocarbon liquid. *Am J Ophthalmol* 1996 ; 121 : 267-75.

39. Fujii GY *et. al.* Limited macular translocation. In: Ryan SJ (ed). Surgical Retina Mosby 2001 ; 2580.

40. Peyman GA, Blinker KJ, Paris CL *et. al.* A technique for retinal pigment epithelium transplantation for age-related macular degeneration secondary to extensive subfoveal scarring. *Ophthalmic Surg* 1991 ; 72 : 102-8.

41. Del Cerro M, Das T, Reddy VL *et. al.* A human fetal neural retinal cell transplantation in retinitis pigmentosa. *Vis Res* 1995 ; 35 (Suppl) : 140.