i notes

Ophthalmology PG Exam Notes

1st Edition

LENS

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MD (AIIMS)

I notes
(Ophthalmology PG Exam Notes)

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by inotesforPG.blogspot.com
1st edition, February 2014

This is a compilation effort from my preparation notes and other sources, thus any contributions or comments are welcomed in the effort to improve this book. Therefore, feel free to e-mail me at
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I notes

(Ophthalmology PG Exam Notes)

Thank you GOD

This manual is collection of the notes I made, found in books or internet while studying for the Final MD exams for ophthalmology.

I have segregated topics just like book chapters to find them back easily. Though these all might be far less then other preparation notes available, I am proud of what I have made and I feel nice to present them to my upcoming ophthalmology friends.

Good luck!

-Dhaval Patel MD
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February 2014

LENS

We can see further because we are standing

on the shoulders of those who came before us.

INDEX

IMP Basics

- Weight of natural lens: 230 mg

Lens Crystallins

- Crystallin structure 60% of the wet weight composed of proteins.
- The water-soluble crystallins constitute 90% of the total protein .
- Three groups of crystallins found in all vertebrate species can be divided into the A-crystallin family, The β/γ-crystallin superfamily
- first crystallin→ to be synthesized is α-crystallin,(found in all lens cells).
- The β- and γ-crystallins are first detected in the elongated cells that emerge from the posterior capsule to fill the center of the lens vesicle.
- same pattern of synthesis is maintained throughout life , so α-crystallins are found in both lens epithelial cells and fibers, whereas the β- and γ-crystallins are found only in the lens fibers .
- The α-crystallins are found in both dividing and nondividing lens cells, whereas the β- and γ-crystallins are found only in nondividing lens cells.
- Differentiation of a lens epithelial cell into a fiber, therefore, may be one of the factors that triggers a decrease in translation of the α-crystallin gene and stimulates the synthesis of the β- and γ-crystallins.
- ***Functions***
    - High concentration of crystallins and the gradient of refractive index are responsible for the refractive properties of the lens. →**Transparency**
    - A-crystallins also involved in the assembly & disassembly of the lens cytoskeleton. Similarities in structure between the small heat shock proteins (shsps) and αb-crystallin suggest that this crystallin family may provide the lens with stress-resistant properties.
    - A- and βb1- → needed for change in shape observed during the differentiation of an epithelial cell into a lens fiber.
    - α-Crystallins have chaperone-like functions to prevent the heat-denatured proteins from becoming insoluble and facilitate the renaturation of proteins that

have been denatured chemically. It acts as chaperones under conditions of oxidative stress

- B-Crystallins structural similarities with the osmotic stress proteins suggest that they also may act as stress proteins in the lens.
- The γ-crystallins (with the exception of γs-crystallin) are found in the regions of low water content and high protein concentration, such as the lens nucleus. Correlates with the hardness of the lens.
- Concentrations are higher in those lenses that do not change shape during accommodation, as in fish, than in those that do, as in the human.

- **Age-related changes in crystallins causes decrease in transparency**
  - Accumulation of high molecular weight (HMW) aggregates
  - Partial degradation of crystallin polypeptides.
  - Increased crystallin insolubility.
  - Photo-oxidation of tryptophan.
  - The production of photosensitizers

Steroid Induced Cataract

Mechanism: ***NCCLO***

1. inhibition of the **Na-K-ATPase pump** mechanism, which increases the permeability of the lens to cation
2. conformational changes in specific amino groups of the lens **crystallins**, which lead to the development of disulfide bonds and protein aggregation.
3. a decreased expression of **cadherin** (a family of cell-cell adhesion molecules that control the calcium-dependent cell adhesion of lens proteins that are necessary to prevent cataract formation)

4. binding of corticosteroids to lens proteins forming **lysine-ketosteroid** adducts that cause aggregation of lens crystallin proteins

5. corticosteroid-induced **oxidative stress** caused by accelerated gluconeogenesis, with reduced levels of glutathione sulphate attributed to the possible inhibition of glucose-6-phosphate dehydrogenase.

Preoperative Evaluation

Appreciation of the **severity** of the cataract, an assessment of the overall **visual prognosis after cataract** extraction, and a determination of preoperative **conditions that may complicate** surgery. The latter, in particular, includes the now well described intraoperative floppy iris syndrome (**IFIS**) associated with the use of alpha blocking agents, originally described by Chang and Campbell.

Given that "real-life" conditions present a far more complex series of visual clues to interpret than does Snellen testing, there has been an interest in and a need for the ***development of additional methods for testing visual function***. Such devices have been referred to as tests of "**functional vision**," which are designed to simulate the visual disability induced by ocular disease and its impact on the visual tasks presented under conditions of daily life. Two general categories of functional vision testing devices have been developed; one system tests for **glare disability**, or diminution of vision induced by ambient light, and the other evaluates **contrast sensitivity function (CSF)**, which tests visual recognition of varying target sizes against backgrounds of differing contrasts.

Glare *may be considered a subjective visual response to light*. In the absence of significant ocular disease, bright light may induce discomfort glare before retinal photic adaptation; visual function, however, is unimpaired by discomfort glare. Conversely, **disability glare** implies that there is a reduction in visual function caused by the ***scattering of incoming light by inhomogeneity of the ocular media***. As in other ocular diseases that induce partial opacification of the ocular media, cataracts disperse incoming light, creating forward light scatter and a “veiling luminance” that interferes with the perception of the visual object of regard. More commonly, this phenomenon is called glare disability.

Opacities of the anterior segment (cataract being the most typical) are associated with glare disorders, whereas posterior segment abnormalities are less likely to induce disabling glare. ***The closer the media opacity is to the retinal image plane, the less the geometric opportunity for light scattering and obscuring of the image***. Therefore, corneal edema is a more likely source of glare than is macular edema.

Cortical and posterior subcapsular cataracts generally cause **daytime glare** more readily than do **nuclear cataracts**, which are more prone to cause **nighttime glare**.

Automated instruments for measuring glare disability

Instrument	**Manufacturer**	**Test Format**	**Glare Light**
BAT	Mentor	Letter acuity	Background
Eye Con 5	Eye Con	Letters	Background
IRAS GT	Randwal Instrument Co	Sine wave acuity	4-point
MCT 8000	Vistech	Sine wave contrast	Points or background
Miller-Nadler	Titmus Optical	Landolt C contrast	Background
TVA	Innomed	Letter acuity	Point

The **brightness acuity tester (BAT)** is in common use because it is readily portable, compact, and relatively inexpensive and may be used in conjunction with the Snellen chart of the refracting lane. Another popular device is the **Miller-Nadler glare testing device**. This unit relies on a modified tabletop slide projector to provide diffuse background illumination against which the patient views one of a series of 20/400-sized Landolt rings that sit on a constant-contrast background circle.

Contrast sensitivity testing is somewhat analogous to audiometry, which measures hearing threshold sensitivity to audible tones of differing intensities and audio frequencies.

The typical human contrast sensitivity curve, reveals that the peak **contrast sensitivity of the visual system** occurs at **image sizes near six cycles per degree** as subtended on the retina. An object that subtends six cycles per degree on the retina corresponds in size to a 20/100 optotype. This indicates that the human visual system requires higher contrast for perception at higher spatial frequencies. Therefore, it is possible that the eye may perceive small target sizes at high contrast while not recognizing larger objects at reduced contrast levels. This concept offers an explanation for the visual complaints of patients who retain reasonably good Snellen acuity yet express difficulty in “real-life” visual function.

It has been reported that **early cataracts** reduce contrast sensitivity primarily at ***high*** and intermediate frequencie, whereas **optic neuropathies** are purported to reduce contrast sensitivity at ***low*** frequencies.

In addition, interest has centered on the effect of monocular cataract on binocular visual function. By means of CSF testing, it has been established that at high spatial frequencies, binocular contrast sensitivity decreases to a level below that of the cataractous eye alone. *This demonstrates binocular visual inhibition and indicates that a patient with one cataract may suffer significant visual disability, even when the noncataractous eye has normal monocular vision.* Furthermore, this information suggests that correcting only one eye in a patient with binocular cataracts may not fully improve functional vision; often the second eye will require surgery for the patient to gain the benefits of cataract rehabilitation. Moreover, a patient's perceived visual disability with cataract may correlate better with tests of binocular contrast sensitivity than with any of the monocular tests of visual function.

The determination of a CSF curve for the eye requires measurement of **two separate functions**: (1) the *perceived contrast threshold between the object and the background* and (2) the *target size of the object* subtended on the retina and measured in cycles per degree.

Currently, the familiar letter optotype contrast charts designed by **Terry, Pelli-Robson, and Regan** are used as clinical alternatives to sine wave gratings.

Letter optotype charts for contrast sensitivity testing

	Pelli-Robson	**Regan**	**Terry**
Contrast range	1–100%	4%, 11%, 25%, 50%, 96%	2.5–80%
Letter sizes	20/80	20/20–20/200	20/70
Testing distance	10 ft	10 ft	10 ft

In 2005, Chang and Campbell described what is now increasingly recognized and commonly known as **intraoperative floppy iris syndrome (IFIS).** This condition is associated with the systemic use of alpha 1A blocking agents such as **tamsulosin** (Flomax, Boehringer Ingelheim Pharmaceuticals, Inc.) for the non-surgical management of benign prostatic hyperplasia. It is important to recognize the potential for IFIS in the preoperative evaluation of the cataract patient. Its manifestations include iris floppiness or instability, poor pupillary dilation, progressive intraoperative miosis, and billowing of iris tissue in the presence of routine irrigating currents. Previous reports indicated increased complication rates in the presence of IFIS, including posterior rupture; however, identifying these patients preoperatively and applying preventative strategies can reduce or eliminate these complications. Standard methods for dealing with small pupils, such as pupil stretching maneuvers, do not help in the management or prevention of this condition.

Devices for determination of potential visual acuity

Guyton-Minkowski Potential Acuity Meter (Mentor)	Reduced Snellen chart
Lotmar Visometer (Haag-Streit)	Laser interferometer
Rodenstock (Rodenstock)	Laser interferometer
IRASInterferometer (Randwal)	Laser interferometer

Methods for determination of retinal function-integrity

Blue-field entoptoscopy (Mira)	Foveal capillary net
Visual evoked potential	Evoked cortical responses
Electroretinography	Electroretinography
B-scan ultrasonography	Imaging
Pinhole acuity	Potential acuity
Penlight entoptic phenomena	Purkinje images
Maddox rod	Gross macular function
Two-point discrimination	Gross retinal function
Color perception	Gross macular function

A **clinical rule of thumb** indicates that a predicted improvement of **four lines** of vision by the acuity tester suggests a good prognosis for cataract surgery.

In addition, simple and less expensive clinical tools may be useful in determining the visual prognosis after cataract removal in cases of suspected macular disease. One method is the y**ellow filter test suggested by Koch**. In this system, when a transparent yellow filter is placed over reading material, it is noted to worsen vision in the presence of a significant cataract but might be noted to improve vision if the macular degenerative process is more significant than the cataract.

Eye Evaluation

Extreme refractive error

Sclera ?Thin

Cornea ?Clarity

Iris ?Pupil size, stability

AC depth ?Iris prolapse, descemet's

Lens? Density? Stability? PXF?

Previous surgery ?PPV, bleb

Intraocular Lens Power Calculation

The three major components of IOL power calculation are (1) biometry, (2) formulas, and (3) clinical variables.

Biometry can be divided into its components needed to calculate IOL power: the axial length, the corneal power, and the IOL position.

Formulas can be divided into their generations, their usage and their personalization.

clinical variable: patient needs and desires, special circumstances, and problems and errors.

Considerations for obtaining accurate measurements (in order of importance)

A. Ultrasound Axial Length	**B. Corneal Power**
A-scan ultrasound instrument	Instrumentation
Real-time oscilloscope screen	Contact lens wear
Immersion technique	Astigmatism
Experienced technician	Previous refractive surgery
Appropriate ultrasound velocities	Corneal transplant eyes
B-scan backup	

A newer methodology for axial length was introduced in 1999 by **Carl Zeiss Meditec**. It uses laser coherent interferometry to measure AL. The instrument, called the **IOLMaster**® performs **four** functions:

(1) it measures the **AL**, (2) it measures the corneal power (**K** or r), (3) it measures the anterior chamber depth (**ACD**) (the latter two by optical means), and (4) it performs the formula IOL power **calculations** using four modern 3rd generation theoretic formulas.

Post Refractive Surgery

3 sets of error:

1. K misses flat central cornea
2. Incorrect index of refraction overestimates corneal power
3. IOL location miscalculated.

1. Approaches that rely entirely on historical data
   - Clinical history method
   - Feiz-Mannis Method
   - Corneal Bypass Method

2. Combination of prior data and current corneal measurements
   - Modified Computerized Videokeratography
   - Arramberi Double K Method
   - Latkany Formula
   - Masket Formula

3. Approaches that require no prior data
   - Trial hard contact lens method
   - Modified Maloney Method
   - Haigis-L Formula
   - Gaussian Optics Formula

- Clinical History Method:
  - Most accurate method Proposed by **Holladay**
  - requires pre-LASIK/PRK keratometry, pre-LASIK/PRK refraction and post-LASIK/PRK stable refraction.
  - **Corneal Power=** $K_{pre\text{-}LASIK\text{-}PRK}$ **+ Refractive Correction**

- Feiz Mannis Method
  - Calculate IOL power using pre-operative values
  - Correct IOL power for 70% of changes in refraction achieved by ablative refractive surgery.
  - **IOL Power**$_{post\text{-}LASIK\text{-}PRK}$**= IOL Power** $_{pre\text{-}LASIK\text{-}PRK}$ **+ (Refractive Correction/0.7)**

- **Corneal bypass method**
    - Its like using pre-excimer parameters and **aiming for pre-excimer refractive error**.

- **Arramberi double K method**
    - preoperative K→ used to predict ELP (Effective Lens Position)
    - postoperative K → used in the vergence formula to calculate the IOL power.
- **Latkany Method:**
    - PreLASIK data not available, but PreLASIK refraction (spectacles) available.
    - Measure the current flat K and calculate IOL power.
    - Adjust IOL power by: **-(0.47 [pre-LASIK SEq] + 0.85)**
- **Masket Metohod:** derived from plotting different data-set
    - IOL power adjustment= LSE x -0.326 + 0.101
- **Modified Masket Method:**
- **Speicher/ Seitz method**:
    - this takes into account 11.4% change in refractive index of the cornea after surgery. (n= 1.375-1 / 1.337-1 which is 1.11 that accounts for 11% change in K)
    - K= 1.114 x TK (postSx) – 0.114 x TK (preSx)

- **Haigis-L formula**
- **Wang-Koch-Malony Method:**
    - no data available
    - K= 1.114 x central power – 6.1
- **Contact Lens Method**
    - Power of CL
    - Base curve of CL

  - Refraction with CL
  - Refraction without CL
  - K= base curve + power + refraction with – refraction without

- Other practical methods:
  - **Holladay Equivalent K readings: EKR**
    - This is value given by PENTACAM and you can directly put it into your formula as K value. This is because pentacam does not assume about refractive index of cornea and it gives overall average K value.

History

History of Phacoemulsification

- 1960: Charles D Kelman finished his residency at Wills Eye Hospital → GA was used for cataract surgery, no microscope was used.
- Kelman's previous discoveries:
  1. Cryoretinopexy
  2. Codiscovered cryoextraction of cataract

- Various drills, rotary devices and several types of microblenders → a dental ultrasonic unit
- the Christmas tree opening/ triangulrar capsulorhexis
- can opener technique
- Using an ENT microscope, the red reflex from the coaxial light gave him an incredible depth perception intraocularly. From then on, only ENT microscopes were used until Zeiss finally made one more suitable for ophthalmology.
- The original phaco handpiece was about the size of a large flashlight, and weighed almost a pound.
- Teflon → silicon sleeve

Evolutions of anesthetic techniques for cataract surgery

- General anesthesia 1846
- Topical cocaine 1881 **Koller**
- Injectable cocaine 1884 **Knapp**
- Orbicularis akinesia 1914 **Van lint, O'Briens Atkinson**
- Hyaluronidase 1948 **Atkinson**
- Retrobulbar (4% cocaine) 1884 **Knapp**
- Posterior peribulbar 1985 **Davis and Mandel**
- limbal 1990 **Furata** et al.
- Anterior peribulbar 1991 **Bloomberg**
- Pinpoint anesthesia 1992 **Fukasawa**
- Topical 1992 **Fichman**
- Topical plus intracameral 1995 **Gills**
- No anesthesia 1998 **Agarwal**
- Cryoanalgesia 1999 **Gutierrez-Carmona**

- Xylocaine jelly 1999 **Koch and Assia**
- Hypothesis, no anesthesia 2001 **Pandey and Agarwal**
- Viscoanesthesia 2001 **Werner, Pandey, Apple** et al

Evolution of techniques of cataract surgery

- Couching 800BC **Susutra**
- ECCE (Inferior incision) 1745 **J Daviel**
- ECCE (Superior incision) 1860 **Von Graefe**
- ICCE (tumbling) 1880 **H Smith**
- ECCE with PC-IOL 1949 **Sir H Ridley**
- ECCE with AC-IOL 1951 **B Strampelli**
- Phacoemulsification 1967 **CD Kelman**
- Foldable IOls 1984 **T Marrocco**
- CCC 1988 **HV Gimbel and T Neuhann**
- Hydrodissection 1992 **IH Fine**
- In-the-bag fixation 1992 **OJ Apple/EI Assia**
- Accommodating IOls 1997 **S Cummings/Kamman**
- Phakonit (Bimanual phaco) 1998 **A Agarwal**
- Air pump to present surgery 1999 **S Agarwal (gas forced infusion)**
- FAVIT technique 1999 **A Agarwal**
- MICS terminology 2000 **J Alio**
- Microphaco terminology using 0.8mm tip 2000 **R Olson**
- Eye enhanced cataract surgery 2000 **SK Pandey/l Werner/ OJ Apple**

- Sealed Capsule irrigation 2001 **AI Maloof**
- Factors for PCO Prevention 2002-2004 **DJ Apple /I Werner/ SK Pandey**
- Microincisional coaxial phaco (MICP) 2005 **Takayuki Akahoshi**
- Microphakonit cataract 2005 **A Agarwal**

Phaco Steps

Incisions

- scleral tunnel: **Girard and Hoffmann**
- 1989, **McFarland and Ernest**: corneal lip, corneal entrance and a posterior lip
- **Paul Koch**: incision funnel
- **Howard Fine** : single-step "stab" incision
- **Charles Williamson**: Two step grooved incision
- ***Healing of limbal and clear corneal incisions***: **7 days** for vascular origin (limbal) and **60 days** for avascular origin (corneal)

SCIERAL INCISION

- smile shape or concentric to the limbus
- frown shape or opposite of the limbal curvature: The frown configuration minimizes against-the rule astigmatism and is reportedly the most astigmatically neutral of these incision
- The scleral tunnel must extend into the clear cornea to avoid the prolapse of the iris, damage to the structures of the chamber angle, fluid loss and a flat anterior chamber and to create a valve effect which will seal the wound at the end of the surgery.

CLEAR CORNEAL INCISIONS

- a bloodless, self-sealing, sutureless and quick, relative astigmatic neutral
    - Single plane no groove

- Shallow groove< 400 microns
- Deep groove > 400 microns.

- Single-plane incision 2.5 by 1.5 mm, rectangular tunnel
- Two-plane incision 2.5 by 1.5 mm rectangular tunnel.
- Three-plane incision 2.5 by 1.5 mm rectangular tunnel

RELAXING INCISIONS

- LRI
- CRI
- AK

Capsulorhexis

- **“third hand” in phaco**
- Thomas F. Neuhann & Dr Howard Gimbel
- continuous tear capsulotomy → continuous curvilinear capsulorhexis (CCC)

NEEDLE TECHNIQUE

- first an initial puncture of the anterior capsule within the central area, to be removed
- end will automatically join the beginning of the curve *outside in*
- BSS or viscoelastics
- only the 23-gauge needle is recommended:
  - lumen of this type of needle is just sufficient to produce a pressure exchange between the anterior chamber and the BSS irrigating bottle
  - just enough rigidity to provide the necessary resistance for difficult manipulations.

FORCEPS TECHNIQUE

- Utrata forceps, mini forceps
- forceps technique is easier to leam
- viscoelastics is mandatory.

TWO-STEP NEEDLE TECHNIQUE

- older technique
- needle without bend → flap creation
- bent needle → flap rotation and completion

CAPSULOSTRIPSIS

- invented by **F Rentsch** and described by **JH Greite** at the 1995
- vitrector with infusion sleeve is used to create an irregular opening in the anterior capsule
- rounded, mousebite- like cuts of the vitrector tip, neve1theless produce a stable rim
- time-consuming

DIATHERMY CAPSULOTOMY

- Multiple irregularities and offers less stability and less elasticity.

two-incision push-pull capsulorhexis

- Nischal
- CCC in infantile and juvenile capsules
- Here, two stab incisions are made proximally and distally to the incision approximately 4.5-5.0 mm

POSTERIOR CAPSULORHEXIS

ANTERIOR AND POSTERIOR CAPSULORHEXIS

- **MJ Tassignon**: bag in the lens

CAPSULORHEXIS SIZE

- somewhat smaller than the optic diameter of the intraocular lens (IOL)

DISADVANTAGES OF THE CCC

- capsular shrinkage syndrome or capsular phimosis

Hydrodissection and Hydrodelineation

Hydrodissection

- described by Howard Fine
- cortical cleaving hydrodissection
- eliminates the need for cortical cleanup as a separate step in cataract surgery

Hydrodelineation

- term first used by Anis
- act of separating an outer epinuclear shell or multiple shells from the central compact mass of inner nuclear material, the endonucleus, by the forceful irrigation of fluid
- Circumferentially divides the nucleus.
- Provides a protective cushion.
- Reduces posterior capsule rupture during phacoemulsification

Nucleus Emulsification

Pre-requisites

- Optimal visibility
- Capsulorhexis
- Hydro procedure
- Sculpting
- Width: wide enough for free movement of ultra sound tip
- Length: must extend just below the capsulorhexis
- Depth: 80 to 90% of the nuclear thickness, two and half times the diameter of the phaco tip,

Divide and Conquer

- Howard V Gimbel
- Deep sculpting until a fracture is possible,
- Nucleofractis of the nuclear rim and posterior plate of the nucleus,
- Fracturing again and breaking away a wedge-shaped section of nuclear material for emulsification
- Rotation or repositioning of the nucleus for further fracturing and emulsification

Crater Divide and Conquer (CDC)

- In c/o hard cataract

- large crater sculpted, leaving a dense peripheral rim to fracture into multiple sections
- each wedge-shaped section is generally left in place for capsular bag distention.

Trench Divide and Conquer (TDC)

- in c/o grade 2-3
- central narrow trench

Trench Divide and Conquer with "Down Slope" Sculpting

- in c/o small pupil
- nudging the lens inferiorly with the second instrument
- upper central portion of the nucleus can be sculpted very deeply

Chip and Flip Technique

Phaco Chop

- K. Nagahara, 1993
- physics of splitting wood
- A chopping instrument (the hatchet) is used to split the nucleus (the log) resting against the phacoemulsification tip (the chopping block).
-

Stop and Chop

- Koch and Katzen
- groove → stop and rotate 90 degree → cracking and fragmentation
-

Aspiration and Irrigation

- Automated and Manual Systems
- Automated advantages:
    - Vitreous is pushed back thus ensuring safety of posterior capsule.
    - Less chance of endothelial damage due to well maintained AC.
    - Easier I/A because of open and accessible capsular fornices.
-

IOL Implantation

Postoperative Air

- Not ideal, so not in all cases
- ?? issue of sterility

Corneal Hydration of Incision

- popularized by Fine.
- Helps in preventing ingress of fluid from outside the eye to within
- decreased incidence of postoperative endophthalmitis in clear corneal wounds that were hydrated

Phacodynamics

Learn from written notes.

Instrumentation

The Phaco Machine

- computer to generate ultrasonic impulses, and a transducer, piezoelectric crystals, to tum these electronic signals into mechanical energy

POWER

- Power is created by the interaction of frequency and stroke length.
- Frequency is defined as the speed of the needle movement. Generally its 35,000 cycles per second (Hz) to 45,000 cycles per second
- Stroke length is defined as the length of the needle movement. Most machines operate in the 2 to 4 mil range. (thousandth of an inch)

ENERGY

- Forces which emulsify the nucleus, are thought to be a blend of the "jackhammer" effect and cavitation.
- The 'jackhammer" effect is merely the physical striking of the needle against the nucleus.
- Cavitation
    - Transient Cavitation: Phaco needle while moving creates intense zones of high and low pressure. This produces compression of the microbubbles until they implode. At the moment of implosion, the bubbles create a temperature of 13,000 degrees and a shock wave of 75,000 PSI.
    - Sustained Cavitation: beyond 25 milliseconds, transient cavitation with generation of microbubbles and shock waves ends. No shock wave is generated. Therefore, there is no emulsification energy produced

- Transient cavitation is significantly more powerful than sustained cavitation.
    - Continuous power: Only the initial energy is transient. The remainder is stabilized energy.
    - In a 50-millisecond pulse, only the initial25 milliseconds is transient.
    - In micropulse phaco, the entire pulse is transient energy

MODIFICATION OF PHACO POWER INTENSITY

1. Alteration of Stroke length: foot pedal adjustment

2. Alteration of Duration: burst, pulse, micropulse

3. Alteration of emission:

a. Power intensity is modified by altering bevel tip angle.

b. Power intensity and flow are modified by utilizing a 0° tip

c. flow can be modified by utilizing one of the microseal tips

- Micropulse → Abbott Medical Optics (AMO
  - A duty cycle is defined as the length of time of power on combined with power off.
  - Phaco OFF: 1. Nuclear material can be drawn towards tip 2. Cooling of phaco tip
  - Cold phaco: misnomer, its actually warm (<55 degree, temperature less than needed for wound burn)

PhakoNIT

- In phaKONIT, Its phaKO and not phaCO..remember
- (PHAKO) being done with a needle (N) opening via an incision (I) and with the phako tip (T).
- Amar Agarwal
- 15 August, 1998
- 1 mm cataract surgery
- **Principle:**
  - because of the infusion sleeves, minimum size 1.9 mm, titanium tip 0.9mm size
  - sleeve was removed and irrigating chopper used
- internationally, name of phacoNIT is now Bimanual Phaco. **Steve Arshinoff** gave term Biaxial Phaco.
- **Phakonit Thinoptx Rollabar IOL**
  - Ultrachoice 1.0 lenses

  - plus or minus 30 dioptres of correction on the thickness of 100 microns
  - evolutionary optic and unprecedented nano-scale manufacturing process
  - off-the-shelf hydrophilic material
  - more glare and halos
- **ThinLens**
- **Fresnel Lens**
- **MicrophacoNIT**: 700 micron

MICS

- Jorge Alio from Spain coined the term "microincision cataract surgery"
- **2 mm incision or less**
- MICS IOLs
  - Acrismart IOL
  - **Thioptics Rollable IOLs** (Wayne Callahan) → ultrathin lens using Fresnel principles

Manual SICS

- Advantages over conventional ECCE surgery
  - Minimal surgical time as no suturing performed.
  - Incision size less than half
  - Least chance of anterior chamber collapse.

- Least post-operative visit as no suture related problems are expected.
- Better wound stability
- Least induced astigmatism
- Early patient mobilization
- Early visual rehabilitation

- Advantages over phacoemulsification
  - It is cost effective as does not depend on sophisticated machine
  - No expensive infrastructure is required
  - Does not depend on expensive and failure prone equipments
  - Not dependent on highly trained maintenance personnel. Does not require an excellent capsulorhexis
  - Feasible for all types of nucleus
  - Requires least learning curve
  - No simultaneous foot coordination required
  - No expensive instruments are required
  - Least risk of complications
  - Quicker surgical time
  - Decreases learning curve of phaco
  - At the situation of "Phaco Failure", this procedure can be performed as an alternative procedure without additional surgical risk

- **Basic surgical steps**
  - Smooth and clean edged sclero-corneal pocket
  - Closed chamber side port entry.
  - Envelope type of anterior capsultomy / large capsulorhexis
  - Perfect hydrodissection to separate capsule from cortex.
  - Hydro delamination to separate the "hard core" nucleus from softer "epinucleus"

- Rotation of the nucleus to anterior chamber and nucleus delivery
- Cortical aspiration to minimize size of the nucleus

Ophthalmic Viscosurgical Devices

- advent of viscoelastic substances as a result of the research conducted by **Dr Endre A Balazs**, MD Budapest, Hungary).
- work on the structure and biological activity of hyaluronan
- Healon, Swedish Pharmacia: 1st viscoelastic, Noninflammatory fraction (NIF) of hyaluronic acid
- **Miller and Stegman** were the first to use Healon in human cataract surgery
- Change in generic name suggested by → **Steve Arshinoff** → OVDs

Desired properties of an ideal OVD

- Ease of infusion
- Retention under positive pressure in the eye
- Retention during phacoemulsification
- Easy removal/no removal required
- Does not interfere with instruments or IOL placement
- Protects the endothelium
- Nontoxic
- Does not obstruct aqueous outflow
- Clear

- **The rheologic characteristics:**
    1. ***viscoelasticity*** (Elasticity refers to the ability of a solution to return to its original shape after being stressed)
    2. ***viscosity,*** (reflects a solution's resistance to flow, which is in part a function of the molecular weight of the substance)
    3. ***pseudoplasticity = rheofluidity*** (refers to a solution's ability to transform when under pressure, from a gel-like substance to a more liquid substance)
    4. ***surface tension.***
    5. ***Coatability:*** It measures the adhesion capacity of OVDs. It is inversely propmtional to surface tension and the contact angle between the OVD and a solid material.
    6. ***Cohesiveness***: Cohesiveness is the degree to which material adheres to itself.
    7. ***Dispersiveness***: It is the tendency of a material to disperse when injected into the anterior chamber.

According to cohesiveness parameters, viscoelastics can be classified depending on their point-of-rupture (of the cohesion) and **cohesive/dispersive index (CDI)** into two main groups: cohesive and dispersive (i.e. not cohesive) substances. *The CDI is defined as the percentage of viscoelastic agent aspirated 100mm Hg*; it classifies OVDs in terms of viscosity, cohesion and dispersion.

INDICATIONS OF OVDs

- **In cataract surgery**: maintain the anterior chamber, mydriasis and media clarity, To prevent iris prolapse and trapping nuclear fragments, To protect the corneal endothelium To coat the interior of IOL injection cartridge
- **Filtering procedures:** intracameral and subconjunctival Healon,
- **Vitreoretinal surgery:** protect corneal epithelium

CHEMICAL PROPERTIES

three families of molecules

i. **Sodium hyaluronate (Na-HA) or Hyaluronic acid:**

  - linear polysaccharide molecule of sodium glycuronate and N-acetylglucosamine
  - first isolated from the vitreous humor and possesses a high uronic acid content
  -

ii. **Chondroitin sulfate (CS):**

  - biopolymer found in the extracellular matrix, mainly in solid tissue parts
  - in the vitreous: Type IX collagen and versican.
  - shark fin cartilage and bovine or porcine cartilages.

iii. **Hydroxypropyl methylcellulose (HPMC):**

  - Disaccharide
  - synthesized from methylcellulose, a component of plant fibers like cotton and wood pulp
  - significant inflammatory potential

COMBINATION

- **Viscoat**: single syringe combination of 3% sodium hyaluronate & 4% chondroitin sulfate
- **Eyefil**: single syringe combination 1.37% biofermentative hyaluronic acid and 0.57% HPMC.
- **Duovisc**: two syringes with two different products, Viscoat and Provisc
- **Ixium Twin**: One syringe with two phases, phase one contains 2% Na-Ha and phase 2 contains 1.4% Na-Ha
- **Twinvisc**: The first product to be injected is dispersive 1% Na-Ha and the second product is cohesive 2.2% Na-Ha
- **Visthesia**: combination of a cohesive OVD and an anesthetic product, 1% lidocaine and 1% or 1.5% sodium hyaluronate

- **Healaflow**: For glaucoma surgery, slowly resorbable cross-linked sodium hyaluronate injectable implant, indicated for penetrating and nonpenetrating glaucoma surgery, acts as a chinage implant and limits the postoperative fibrosis thus clearly improving the surgical success rate and in most cases eliminating the need of antifibrotic agents like mitomycin-C

ARSHINOFF'S SOFT-SHELL TECHNIQUE

Arshinoff, 1999

A low viscosity dispersive (or dispersive/cohesive) agent is first injected into the anterior chamber (Healon®, a dispersive/cohesive agent is mainly used). Then a highcohesive OVD (e.g. Heaton GV®) is injected into the posterior center of the dispersive agent, towards anterior capsule surface.

Once the cataract has been extracted, its better to proceed the other-way-round: the cohesive OVD is injected first, and then the low viscosity dispersive viscoelastic is injected in the center of the high viscosity OVD. The cohesive agent will stabilize the intraoculartissues during IOL insertion, and the dispersive agent will be easily aspirated at the end of surgery by placing in·igating/aspirating cannula on the I OL at the pupillaty plane. The cohesive OVD will be easily removed as a bolus after that.

ultimate soft-shell-technique: combining viscoelastics and/or balanced salt solution → good condition for controlled capsulorhexis without peripheral extension.

- three main general categories:

1. dispersive
2. cohesive
3. viscoadaptatives

- **OVD characteristics**

Higher viscosity cohesive OVDs: Jelly like

- Create and preserve spaces; displace and stabilize tissues
- Low protection due to ease of aspiration
- Clear
- Easy to remove
- Healon9 (Abbott Medical Optics), Healon GV9 (Abbott MO), Provisc9 (Alcon), Amvisc9 (Bausch & lomb)

Lower viscosity dispersive OVDs: Honey like

- Selectively moves and isolates tissues
- Very protective of corneal endothelium
- Less clear visualization
- More difficult to remove
- Healon9 (Abbott Medical Optics), Healon GVS (Abbott MO), Provisc9 (Alcon), Amvisc9 (Bausch & lomb)

Viscoadaptative OVD:

- The rheological properties vary with the fluidics of phacoemulsification surgery.
- A viscoadaptative OVD changes its behavior at different flow rates.
- Healon5 (Na Ha 2.3%)(Abbott Medical Optics, Santa Clara, CA) was the **first and only** product marketed as viscoadaptative
- it as a pseudodispersive, super-viscous cohesive that behaves as a highly cohesive viscoelastic to pressurize and create space, but can also provide the protection of a dispersive OVD.
- At low flow rates, it is very viscous and cohesive. At high flow rates, it becomes pseudodispersive and effectively protects endothelial cells

Viscoelastic requirements during phacoemulsification

Surgical task	Viscoelastic function	Required properties	Agent category
Capsulorrhexis	Maintain deep anterior chamber	High viscosity at low shear rates; elasticity	Cohesive
Emulsify nucleus	Stay in eye to cushion and coat tissues, especially corneal endothelium	Low molecular weight; low surface tension; high viscosity at high shear rates	Dispersive
Remove cortex	Endothelial coating	Low surface tension	Dispersive
Open bag, insert IOL	Maintain deep anterior chamber and capsular bag	High viscosity at low shear rates; elasticity	Cohesive
Remove viscosurgical	Remove quickly and completely	High molecular weight; high surface tension	Cohesive

First noted with the use of Healon, the elevation is especially severe and prolonged if the material is not thoroughly removed at the conclusion of surgery, giving rise to what has been termed, **Healon-block glaucoma.**

IOLs

- Credit for the invention and first implantation of the IOL is given to **Sir Harold Ridley** of London. (two-step procedure: ECCE → IOL) 1949-1950, British fighter pilots' canopies's crush → made of polymethylmethacrylate (PMMA; Perspex). He worked with the Rayner, made Perspex CQ, a more purified "clinical-quality" PMMA. On May 25, 2001, at the age of 94 years he died in Salisbury, England, after a cerebral hemorrhage.
- **Warren Reese** was the first American surgeon to perform the first IOL surgery in the United States at the Wills Eye Hospital, Philadelphia, in 1952

Generations of Intraocular Lenses

1. 1949-1954, Original **Ridley posterior chamber PMMA IOL** manufactured by Rayner, Ltd., UK

2. 1952 -1962, **Early AC IOL**
3. 1953-1973, **Iris-supported**, including irido-capsular IOL implanted after ECCE
4. 1963-1992, Transition towards **modern AC IOLs**
5. 1977-1992, Transition to and maturation of **posterior chamber IOLs**
6. 1992-2000 **Modern IOLs**
   a) Monofocal IOLs designed specifically for in-the-bag implantation
      - Small, single piece modified C-loop designs
      - Foldable IOLs, designed for small incision surgery
   b) AC IOLs
      - Kelman (flexibility)
      - Choyce (footplates)
      - Clemente (fine-tuning, no-hole, three point fixation)
7. 2005--Present
   Modern flexible, ''specialized'' IOLs (often designated as ''**premium**'')
   Designed for special functions (refractive surgery, MICS, presbyopic correction, multifocal, accommodative IOL, telescopic IOL, light adjustable IOL, etc.)

Shape Factor

Materials for Intraocular Lenses

Factors affecting Surface properties on cell adhesion:

1. **free energy of the interface (FEI):** most hydrophilic materials, with a low FEI (< 5 ergs/crn2) and the most water-repellent materials, which have a high FEI (> 40 ergs/cm2) resulted in much lower cell adhesion than does PMMA. The intermediate FEI values (5 to 40 ergslcm2) of a PMMA make it favorable to cell adhesion and cell proliferation

2. **surface energy (SE):** hydrophilic → higher SE, hydrophobic → lower SE
3. **angle of contact (AC):** hydrophilic → lower AC, hydrophobic → higher AC

PMMA

- amorphous, transparent and colorless
- refractive index of 1.49 to 1.50
- transmits 92% of the incident light
- specific density of 1.19 gm/cm^3
- PMMA is fairly water-repellent

- has an angle of contact of 70°
- water absorption index of 0.25%.
- has to be sterilized at a low temperature,
- ethylene dioxide is therefore used to sterilize PMMA IOLs.
- manufacturing process: turning or molding
- ***SURFACE PROPERTIES***
  1. ***Treatment of the surface proper:*** alter some characteristics or the surface, such as roughness, hardness or slipperiness, without grafting molecules.

     Chemical techniques (chemical oxidation-ozone)
     Flaming
     Electromagnetic radiation

  2. ***Coating with a deposit:*** Another polymer (deposit) with the desired properties is deposited on the backing to form a layer, which may reach a thickness of about 10 microns. The method usually is that known as the "soaking method".

     Teflon-coated Lenses

  3. ***Grafting by the attachment of new molecules:***

     Heparin surface-modified lenses: better anti-adhesive effect, reduces complement activation by PMMA IOLs

surface passivated IOLs: to lower the energy and reduce the irregularity of the surface

IOLs treated with Cold Plasma CF4: fluoridated by cold plasma treatment,

Silicon

can be folded and inserted through small incisions

1. polydimethylsiloxane: low refractive index (1.412 at 25°C) → relatively thick lenses.
2. copolymer of diphenyl and dimethylsiloxane: refractive index of 1.464

manufacturing: injection molding → surface irregularities at the junction of the two sides of the lens → known as **molding flash** → glaucoma

Surface modification: oxygen plasma, which made their surfaces less water-repellant

Discoloration and capsular opacification of silicone IOL: granular brownish appearance,
It is recommended avoiding the use of this type of material if there is silicone in the posterior segment, or if there is a risk of a slipped retina, because the adsorption of silicone to the smface of these lenses is irreversible.

ACRYLIC IOL

1. stiff hydrophobic polymethylmethacrylate (PMMA)
2. soft hydrophilic hydrogels, such as PHEMA.

vitreous transition temperature (VTT): VTT of PMMA is 110˚C

SOFT ACRYLIC IOLs

1. An ester of acrylic acid and an ester of methyacrylate acid (AcrySof®/ Acrylens®)
2. two esters of methacrylate acid (Memorylens®

higher refractive indices

HYDROPHILIC: Memorylens, Hydroview, EasAcryl, Akreos

HYDROPHOBIC: AcrySof (refractive index of 1.55, appropriate for multiple implantations)

Sensar

AcryLens

HYDROGEL IOLs

38% water, biconvex lens and flanged flat loops. Their rear surface has a continuous convex area of curvature, giving it a "taco-like" appearance

hydrophilic, gives them the advantage of having a lower cell adhesion capacity than PMMA.

two drawbacks: decentration, increased PCO (rarely backward displacement while doing YAG Cap)

ACIOLs

- first AC IOL implantation was done in France in **1952 by Baron**

- II generation lenses were rigid anterior chamber lenses: Strampelli tripod ACIOL and Choyce Mark I AC IOL.
- IIIrd generation IOLs were the iris supported lenses
- **IV generation IOLs**: Lusko lens, Cilco Optiflex;
- modern AC IOLs:

Indications

- Rupture of the posterior capsule at the time of cataract surgery
- Subluxated lens/IOL
- Anterior/posterior dislocated lens/IOL
- Aphakia with no capsular support

Contraindications

The AC IOLS are best avoided in the following conditions:

- Uveitis patients
- Unhealthy corneal endothelium
- Pediatric eyes
- Eyes with shallow anterior chamber.

Complications

- Corneal edema
- Uveitis
- Glaucoma
- Hyphaema

- Pupillary distortion
- Cystoid macular edema
- Synechiea

Current status

- The flexible loops has decreased the need for exact determination of the IOL size
- tumbling technique used to polish the IOL provides a smooth optic haptic edges and a smooth surface this has decreased the incidence of iris chaffing and uveitis.
- The haptic loops are so designed that there are three to four point contacts with the angle which has greatly decreased the risk of developing post operative glaucoma and synechiea formation.
- The absence of holes in the IOL has resulted in easy explantation of IOL if and when required.
-

Premium IOLs

multifocal IOL

ReStor (Alcon)

Ceeon 811E (Pharmacia/Pfizer)

Technis Z9000

accommodative IOLs

AT-45 CrystaLens (Eyeonics, Aliso Viejo, California)

1 CU (Humanoptics, Mannheim, Germany)

Light adjustable lens (LAL)
(Calhoun Vision, Pasadena, California)

- The LAL is designed to allow for postoperative refinements of lens power in situ.
- The current design of the LAL is a foldable three-piece IOL
- cross-linked silicone polymer matrix and a homogeneously embedded photosensitive macromer.
- The application of near-ultraviolet light to a portion of the lens optic results in polymerization of the photosensitive macromers and precise changes in lens power through a mechanism of macromere migration into polymerized regions and subsequent changes in lens thickness.
- Once the desired power change is achieved, irradiation of the entire lens to polymerize all remaining macromer "locks-in" the adjustment so that no further power changes can occur.

Toric IOL Implants

- Astigmatism correction may be required in an estimated 15-29% of cataract cases.
- ***Mx***: toric IOLs, limbal relaxing incisions or astigmatic keratotomies, keratorefractive surgery or by the use of conductive keratoplasty (CK-A)
- ***Models:***
- Alcon Toric SN60T series 3-9 and the aspheric SN6AT series
    - recently approved by the FDA
    - built on the same platform as the standard AcrySof posterior chamber lens implant.
    - toric version has a 6.0-mm biconvex acrylic toric optic, available in the range of + 6.0 to +30.0 D.
    - SN60T/ SN60AT: 3 to 9 → T3 corrects 1.0D at corneal plane, 0.5D increase from 3 to 9
    - The axis of plus cylinder is marked on the lens optic.

- the STAAR Toric (silicone plate haptic)
    - FDA-approved, single-piece, plate-haptic, foldable silicone IOL designed to be placed in the capsular bag using an injector through a 3-mm incision. Once in the eye, it must be oriented with its long axis precisely in the steep meridian.
    - The 6-mm optic is biconvex with a spherocylindrical anterior surface and a spherical posterior surface.
    - The optic has a mark at either end to indicate the axis of plus cyli nder. The IOL is available in a length of 10.8 mm or 11.2 mm. A 1.15-mm fenestration located at the end of each haptic is designed to maximize capsular fIxation.
    - The IOLs are available in the range of +9.5 to +28.5 D spherical powers, with a choice of cylindrical powers of 2.00 D and 3.50 D. The toric surface corrects less astigmatism when measured at the corneal plane; STAAR states that the 2.00 D IOL corrects 1.50 D of corneal astigmatism and the 3.50 D IOL corrects 2.25 D.
- the Zeiss AT TORBI
- the Rayner T-Flex toric IOL
- Sulcoflex Toric (for sulcus placement) from Rayner

INDICATIONS:

corneal astigmatism is at least 1 dioptre

two major meridians of power are 90 degress apart (regular astigmatism)

ADVANTAGES OF TORIC IOLOVER LRI

- Predictability
- Stability
- Reduced likelihood of foreign body sensation
- Reduced risk of dry eye syndrome
- No corneal weakening-may be important in the event of severe blunt eye trauma
- Correction nearer to the nodal point of the eye
- Dangers of perforation for LRI.

DISADVANTAGES

- Added cost of IOL
- Not as straightf01ward to implant as standard IOL.

- the spherical equivalent of the toric lens is identical to that of a spherical IOL of the same dioptric power.
- the toric IOL flat axis (indicated by the three dots near each haptic insertion) is then aligned to coincide with the steep corneal axis.
- The IOL is then rotated so that last 15 degrees (clockwise) to be on axis.
- 10 degree misalignment → 33% astigmatic loss, 20 degree → 66%, 30 → 100%, >30 → adds

SPECIAL SITUATIONS

• Very high comeal astigmatism
• Combining LRI with Toric IOL.

Mx: combined "**bioptic**" approach, combination of LRI, LASIK, CK-A with toric IOL

Presbyopia Management

- **Principle**
    - Either producing simultaneous focus as in multifocal IOLs
    - alternating focus ie.focusing one distance at a time as in accommodating IOLs.

Accomodative Tx

1. Monovision

- when one eye is made emmetropic and the second eye purposely made myopic by 2.5 to 3.0 D for near vision has also been accepted to restore multifocality but has the inherent limitation of loss of stereopsis, which is not well accepted in most patients.
    - ***Problems:***

1. Loss of stereopsis
2. Reduction in distance acuity
3. Difficulty with night driving
4. Reduction of contrast sensitivity.
5. Nocturnal halos

6. Photic phenomenon

- Presbiopic lens exchange (**PRELEX**) aim to correct the loss of accommodation by removing the crystalline lens by phacoemulsifi cation and implantation of a multifocal intraocular lens (IOL) in the capsular bag
- C. Claou'e- 1997?? first described monovision
- Monovision in pseudophakic patients was first described in 1984?? by Boener and Trasher
- **Types**
    - When dominant eye is optimized for distance vision, it's called as **conventional** monovision
    - when nondominant eye optimized for distance, it's called **cross** monovision.
- **Factors affecting monovision**
    - Ocular dominance
    - Degree of anisometropia
    - Stereopsis
    - Patient's motivation
- The **mechanism** that enables monovision to succeed is ***interocular blur suppression*** (i.e. the ability to suppress the blur image from one eye and it is assumed that it is ***easier to suppress blur in nondominant eye***.

2. Multifocal IOL

- **Hoffer** in 1982 was the first to hit upon the idea of a multifocal IOL
- **Dr. John Pierce** in 1986 who was to implant the bull's eye style of the multifocal IOL.
- Three multifocal lenses are currently FDA approved for use after cataract extraction: the ReZoom lens (AMO), the AcrySof ReSTOR (Alcon, Fort Worth, TX), and the Tecnis (AMO) multifocal 101.

Type of Multifocals

1. **Refractive**

- *bull's eye lens,* Precision Cosmet
- central near add surrounded by distance optical power
- two foci – one for near and one for distance.
- sudden loss of vision in bright sunlight since constricted pupil blocks the distance segment of lens
- **pupil dependent**

2. **Diffractive**

- introduced by the 3M corp called as the **3M diffractive MIOL -PMMA**
- basic refractive power is provided by the anterior aspheric surface and the diffractive power comes from the multiple grooves on its posterior surface.
- 41% of light is focused for distance vision and another 41% is focused for near vision.
- **Pharmacia CEEON 808,811E -PMMA**
- **pupil INDEPENDENT**
- first FDA approved **foldable MIOL** which was the silicone **AMO Array** lens. It is divided into 5 concentric zones on its anterior surface with varying optical powers such that light distribution with a typical pupil size is approximately 50% for distance 37% for near and 15% for intermediate vision
- The ***Rezoom*** *lens* (non-aspheric) is a foldable acrylic MIOL from AMO. It has zones similar to Array, zone 1, **3** and 5 are distant dominant and zones 2 and 4 are near dominant
    - 60% of incoming light is for distance and 40% for near and intermediate distances

3. **Combination of diffractive & refractive**

- The **Tecnis** IOL (Abott Medical Optics, Inc., Santa Ana, DA)

  - *wavefrontdesigned, modified prolate, anterior-surface* optic that neutralizes the positive spherical aberration of the human cornea
  - biconvex
- AcrySof **ReSTOR** (aspheric)
  - apodized diffractive IOL
  - A central aprodized diffractive region is 3.6mm wide and the peripheral refractive region contributes to distance focal point for larger pupil diameter and is thus dedicated to distance vision.
  - The central apodized diffractive region consists of 12 concentric steps of gradually decreasing (1.3-0.2 microns) steps heights provide a good range of vision for different distances. This lens incorporates +4.0D of additional power in lenticular plane for near vision, resulting in +3.2D at the spectacle plane.

refractive portion of the optic functions like a standard IOL, with the optic periphery dedicated to distance vision and designed to optimize night visionwhen the pupil dilates under scotopic conditions.

The diffractive portion of the optic consists of 12 concentric rings on the anterior surface of the optic, and it is located within the central circle, which is 3.6 mm in diameter and is designed to provide distance and near vision in moderate to bright light.

Apodization is the radial variation in optical properties that comes from decreasing the height of each concentric ring from the center toward the periphery of the optic surface (from 1.3 to 0.2 μm). This balances the amount of light energy that is distributed between distance and near as a function of pupil size, which improves the efficiency and effectiveness of the quality of near vision achieved and reduces problems with glare and halos. Ring location, spacing and variation of height serve within the pupillary aperture to provide a satisfactory near image at approximately 25 to 33 cm.

Pre-operative Considerations

- *strong desire* to be spectacle independent
- *Functional & Occupational Requirements:*
  - painting, playing the piano, playing cards
  - *Occupational night drivers*
- *Pre-existing Ocular Pathologies*
- *Hypercritical & Demanding Patients:* should be strictly avoided
- *Strong urge for near reading without glasses*

Medical Exclusion

- ***Preoperative***

- *Patients with more than 1.0 D of corneal astigmatism*
- *Pre-existing ocular pathology*
- *Individuals with a monofocal lens in one eye*
- *History of previous Refractive Surgery*

- **Intra-operative**
    - Significant vitreous loss during surgery
    - Pupil trauma during surgery
    - Zonular damage
    - Capsulorhexis tear
    - Capsular rupture

-

- **Problems:**
    - loss of contrast sensitivity
    - small amount of glare and halos

3. CK

4. Corneal Inlays

Kamera inlays

Accommodative Treatment

1. Scleral Surgery

- anterior ciliary sclerotomy or ACS: Thornton first proposed weakening the sclera by creating 8 or more scleral incisions over the ciliary body
- scleral expansion bands.

2. Accomodative IOLs

Historical aspects

- **Dr J Stuart**: observed intraocular axial movement
- pharmacological induction of ciliary muscle contraction and relaxation by pilocarpine and cyclopentolate respectively and noted average optic movement of 0.7 mm

Classification

- Single optic design- Amount of accommodative effect is dependent on IOL power. E.g- Crystalens Eyeonics, Human optics AG Akkomodative ICU, Kellan Tetraflex KH-3500,Opal IOL, Acuity Ltd C-Well IOL, Morcher IOL, Tekia Tek Clear, Flex optic IOL
- Ring haptic design- E.g- Biocom fold 43A, 43E and 43S
- Dual optic- The concept was proposed by Hara et al in 1989. These IOLS have an anterior optic that is plus powered and posterior optic that is minus powered, which move anteriorly and posteriorly respectively, with axial movement. This leads to a greater change in refractive power for a similar amount of axial movement. Example- Sarfarazi EA-IOL, Synchrony IOL
- Lens bag filling design- Capsular bag is filled up with a material that can maintain its shape and optical power, and sustain a rapid, constant and predictable response to ciliary muscle action. Example - Medennium Smart IOL, Fluid vision
- Lenses with abilir - During accommodation, flexible anterior lens material is pressed through an aperture in a diaphragm, which decreases the radius of curvature of the anterior surface, while it increases the power of the lens. Example- Nu lens

Classification According to IOL Material

- Silicone- Crystalens, Sarfarazi Twin Optic EA IOL, Synchrony, Flex optic IOL,
- Acrylic- Human optics AG Akkomodative, OPAL, Meddenium Smart (proprietary thermodynamic hydrophobic acrylic)
- PMMA- Nu Lens, morcher
- HEMA- Kellan Tetraflex KH-3500, morcher

1. IOLswith flexible haptics that are designed to move forward with accommodative effort eg. **crystalens**

- **Crystalens**
  - The crystalens IOL (eyeonics) is the only accommodative IOL approved for clinical use by the FDA in 2003.
  - The IOL is designed to move forward with accommodative effort
  - change in lens contour with ciliary contraction.
  - modified **silicon plate** haptic lens. It has a hinge at the junction of its haptic and optic and T shaped **polyamide haptics** at the end of the plates. The lens is 11.5mm from loop tip to loop tip and the length as measured from the ends of the plate haptics is 10.5mm. The lens has a **biconvex optic that is 4.5mm** in diameter.
  - The amount of effective accommodation, however, varies frompatient to patient. Some patients require reading glasses to see small print or to read in low levels of illumination, but the majority of crystalens patients are able to perform most of their daily activities without glasses.
  - incidence of PCO is predicted to be higher **than current lenses**
- **1CU intraocular lens** (Human optics AG Erlanger, Germany)
  - one piece, three dimensional, foldable, acrylic IOL
  - optic is 5.5mm and the IOL has a diameter of 9.8mm
  - problems: 'infolding' of 1CU haptics, greater PCO
- **Dual optic accommodative lenses**
  - accommodation per mm of lens movement
  - **Synchrony** (Visiogen, Menlo Park, California, USA) is one such dual optic lens in clinical -trial, and the company has announced that the FDA US trials will start in early 2005
    - silicon lens with two optics joined by a spring mechanism
    - anterior high powered plus optic, 5.5mm in diameter and a complementary minus power optic work together to produce an accommodative effort of more than +2.75D.
    - plus powered anterior optic of power + 31 D and a minus powered posterior optic, the power of which varies as per the axial length. Posterior optic is fixed at posterior capsular bag and anterior optic moves forward to facilitate near vision

- The **Sarfarazi dual optic lens** (Bausch and Lomb, Rochester, New York, USA) has been implanted in monkeys with objective signs of up to 8 diopters of accommodation.
- **Advantages**

  1. Allows more accommodation than the single optic IOLs, with less lens movement
  2. Contrast or glare problems do not develop, unlike the multifocal IOLs.

- **Disadvatage:**

  1. Possibility of interlenticular opacification in between the two optics
  2. Not as predictable as the multifocals in terms of visual outcome.

2. IOLs with flexible optics that are designed to change in contour and increase in dioptric power with ciliary contraction eg. **Smart Lens (**Medenium, Irvine, California, USA **)**

   - placing a malleable material inside the capsule to produce a situation very close to our pre-presbyopic state.
   - This has been termed **ersatz phakia**
   - thermodynamic, hydrophobic acrylic IOL designed to completely fill the capsular bag.
   - Made up of Smart material(proprietary thermodynamic hydrophobic acrylic material).
   - Packaged as a solid material 30mm long and 2 mm wide.
   - At room temperature, it is convertible to a thin rod that can be inserted into the eye through a small incision. Under the influence of body temperature, it reconstitutes its original power
   - Dealing with after-cataract formation, refractive precision, and whether the anterior capsule must largely be intact to truly transmit an accommodative effort.

3. IOLs that use dual optic systems and are designed to function like a Galilean telescope, eg **Nu lens**.

   - It is based on the principle of compressible polymer between fixed plates so that on accommodative effort there is bulge in the polymer through an aperture in the anterior fixed plate

Merits

• Accommodative IOL implant may eliminate the need of any kind of refractive correction postoperatively.

• There is no incidence of glare, haloes, ghost images and loss of contrast sensitivity.

Demerits

• The present concept is based on a single plate IOL and there is a high incidence of contraction of capsular bag.

• Loss of pliability of material at the haptic- optic junction leads to poor movement of the optic in the long run and loss of function.

Phakic IOLs

History

- As first ACIOL was discovered, **Benedetto Strampelli** in 1953 reported use of minus power ACIOL for Phakic eye in treatment of high myopia → **Strampelli Lens**: radius of curvature of 13 mm but was thick and rigid
- **Dannheim lens**: still hard to match the lens length
- 1959, **Barraquer** lens: support was curved and the haptics were more elastic, providing a better fit into the AC.
- **Peter Choyce** in 1964 started to use implants with thinner haptics and reported a significant decrease in corneal
- Surgeons believed that ACIOL is not a good option.
- Baïkoff of France, who modified the four-point, angle fixation, multiflex AC
- Worst-Fechner biconcave myopia lens in 1986
- 1991, Ophtec changed the IOL design to a convex-concave

Types

- three main types of phakic IOLs
    - **AC angle-fixated IOLs**: Bailkoff NuVita (B&L), Phakic 6 (OII), ZSAL

- **PC IOL**: ICL (Staar), CIBA/Medennium PRL
- **Iris-supported IOLs**: Worst iris-claw lens = ARTISAN lens in USA (Ophtec)

Patient Selection

- Myopia: -3 to -20
- Hyperoia: +3 to +12
- Pupil Size: optical one of the implant limits the maximum scotopic pupil size allowed.
- ECD
- ACD > 2.8 mm

Contraindications

- Visually significant cataract
- Chronic uveitis
- Low endothelial cell count
- Abnormality of the iris
- Diabetic retinopathy
- Abnormality of the anterior angle
- Glaucoma
- Any form of progressive vision loss

Complications

- Glare/halo
- Macular edema
- Increased astigmatism
- Lens dislocation

- Loss of best spectacle-corrected visual acuity
- Cataract formation
- Under/over correction
- Secondary glaucoma
- Corneal edema
- Pupillary block glaucoma
- Hyphema
- Retinal detachment
- Intraocular infection
- Additional surgery to remove or replace the implant
- Iritis/uveitis

ICL (Implantable Collamer Lens)

- STAAR® Visian ICL
- It is made-up of 60% poly-HEMA, Water (36%), Benzophenone (3.8%) and Collagen (0.2%), it attracts the deposition of fibronectin on the lens surface, inhibits aqueous protein binding and makes the lens invisible to the immune system.
- Lasik for correcting high refractive errors has the drawbacks of lack of predictability, regression, corneal ectasia, and induction of high order aberrations.
- ICL was first developed in the late 1980's in Russia by Dr. S. **Fyodorov** and the first implant was placed in Europe in 1993
- Models
    - V1 model had the same dimension for the optic diameter and variable dimensions for the foot-plate
    - V2 model, the footplate dimensions remained constant and the optic diameter was variable. The optic diameter was inversely proportional to the diopter strength.
    - The optical diameter was optimized in the V3 model.

- By changing the concave base radius to 11.0 mm, increased anterior vaulting of the ICL was introduced in the V4 model in 1998.

- **Indications and pre-requisites**
  - When residual bed after LASIK is likely to be less than 250μ
  - When the initial corneal thickness is less than 480μ
  - Refractive error between the ages of 21-45
  - ACD greater than 2.8 mm
  - Stable refraction (<0.5D change in previous 12 months)
  - No ocular pathology (NSC, glaucoma, lid pathology, etc)
  - Mesopic pupil <6.0mm

- ICL: moderate to high myopia ranging –3.0 D to –20.0
- Toric ICL: -3 to -23 D of sphere and + 1.0 to + 6.0 D of cyl (The toricity is manufactured in the plus cylinder axis, within 22 degrees)

- **Measurement of white to white diameter**
  - Pentacam, OrbScan, UBM or using calipers
  - In myopic eyes, to determine the overall length (in mm) of the ICL, add 0.5 mm to the horizontal WW measurement.
  - If the ICL is too short for the sulcus, the lens vault may be insufficient to clear the crystalline lens, exposing it to the risk of an anterior capsular cataract.
  - If it is too long, the lens will vault excessively, crowding the angle and possibly causing closed angle glaucoma.

- **Vault**: Ideal ICL vault is approximately 500 μm, which is roughly one corneal thickness. There are concerns about high vault (1000 μm) leading to angle crowding and resulting in angle closure or synechiae formation. High vault may also increase iris chaffing and pigment dispersion, resulting in pigmentary glaucoma. Furthermore, low vault (125 μm) may also cause ICL contact with the crystalline lens and increase the risk of cataract formation over time.

- **Peripheral iridotomy**: A peripheral iridotomy is performed 1-2 weeks before the surgery to provide an outlet for the aqueous flow around the lens. Alternatively it may be performed intra-operatively after ICL implantation with a Vannas scissors or a vitrectomy cutter. It should be sufficiently wide (at least 500 μm), positioned superiorly (from 11 to 1 o'clock) and well away from the haptics placement.

- Vault Classification
  - Vault type 0 (T0): no space between the ICL and the lens
  - Vault type 1 (T1): small central space, with peripheral touch of the lens
  - Vault type 2 (T2): small space across the ICL

- Vault type 3 (T3): significant space across the entire ICL

Aspheric IOLs

New Intraocular Lens Technology

(just points for Short note, details in different sections)

Phakic IOLs

only one currently approved in the United States is an iris fixated lens (AMO **Verisyze**)
posterior chamber phakic lens should be approved shortly (Staar ICL, intraocular contact lens).

INTRAOCULAR SURGERY FOR PRESBYOPIA

Monovision

Multifocal IOLs

accommodative IOL

IOLS THAT FILTER VISIBLE BLUE LIGHT

Ultraviolet (UV) light is largely screened by the human lens and cornea; however, after cataract surgery, much more UV light can enter the eye. lipofuscin component A2E is a mediator of blue-light damage to the retinal pigment epithelium, and filtering blue light is protective of this damage when light is radiated on retinal pigment epithelium cell cultures.

in bright sunlight would have their blue pigments bleached to the point that their vision turned red (erythropsia).

Hoya Healthcare Corporation (Tokyo, Japan) came out with such a lens in 1991 and reported increased contrast sensitivity in photopic and mesopic condition.

The **Natural Lens** (Alcon, Inc, Fort Worth, Texas, USA) is an approved blue light filtering IOL.
Problems:

1. Colour Vision
2. Night vision: rods have different excitation spectrum, more in blue zone

LMI-SI (ORILENS)

- Dr Isaac Lipshitz
- For AMD/ PDR patients
- Telescopic IOLs → principle of using mirrors to magnify the central image while the peripheral field remains normal
- looks like a regular PMMA IIOL and is 5.00-6.00 mm in diameter (loop diameter is 13.50 mm)
- central thickness of 1.25 mm ..!!
- Preoperative assessment:
  - VA distance and near using ETDRS
  - VA with 2.5x external telescope
- To be placed in sulcus by extending incision upto 5-5.5 mm
- Can be placed over other IOL in sulcus

Akreos MIL lens

It's a 4 leg type, aspheric, hydrophilic lens with a 360 degree square edge. The material has been found in trials to adhere to the capsular bag and this in conjunction with the square edge should successfully retard PCO formation for a while.

Electronic IOLs

- ELENZA: Sapphire AutoFocal IOL
- IOL with Artificial Intelligence
- **Rudy Mazzocchi**

- The IOL builds upon an existing technology from PixelOptics (Roanoke, Va.), which created the world's first electronically focusing prescription eyewear
- relying on our individual pupillary response to automatically trigger accommodation between far and near.
- battery itself will have a 50-year cycle-life, it requires recharging every 3-4 days
- The fail-safe system is the IOL falling back to having only optimal distance vision … defaulting to a monofocal IOL

Complex Cases

Phacoemulsification in the Presence of a Small Pupil

Techniques for manipulation of the pupil

1. Pharmaceuticals:
    - phenylephrine 10% and cyclopentolate 2%
    - preoperative nonsteroidal anti-inflammatory agents (NSAIDs), such as flurbiprofen sodium 0.03%
    - intracameral preservative-free epinephrine 1:10,000
2. Viscoadaptive agents
    - Healon 5
    - inject viscoelastic in order to disrupt the iridocapsular adhesions.
3. Instrumentation
    - retract the proximal portion of the pupil through the incision with the **sleeve**
    - **Stretch pupilloplasty: second handpiece** in such a way as to stretch the pupil in advance of the phacoemulsification tip
    - **portion of the lens** may be manipulated through the pupil to maintain the pupil in a semi-dilated state

- **Beehler pupil dilator** (Moria #19009) is uniformly applicable in the presence of small pupils

4. Pupil dilating hooks and expansion rings

- **iris hooks** as described by McReynolds.
- **Mackool** has designed ***self-retaining titanium hooks***
- **De Juan** has designed ***disposable nylon hooks*** with an adjustable silicone retaining sleeve that can be used through smaller paracentesis
- ***Hydroview Iris Protector Ring*** (Grieshaber) forms a compressed oval in its dehydrated state, expands with hydration, and captures the pupillary margin by means of flanges
- **Morcher Pupil Expander Ring** Type 5S is a solid polymethylmethacrylate (PMMA) ring
- The **Perfect Pupil** (Becton-Dickinson) represents a new and effective option for both maintaining mydriasis and protecting the pupillary margin during surgery. This polyurethane device features a 7mm internal diameter
- **Malyugin ring** (Microsurgical Technology (MST). This ring is supplied with a disposible injector that compresses the ring to allow its insertion and then its controlled expansion within the eye.
    - Boris Malyugin
    - square shaped, transitory implant with four circular 'scrolls" that holds the iris at equidistant points
- **Agarwal Modification of the Malyugin Ring:** 6-0 polyglactic vicryl suture in the leading curl of the ring and tied a knot. The ring is then injected in the pupillary plane with the leading curl touching the iris margin at 6'o clock

Iris surgery

- proximal sphincterotomy:
-

Intraoperative Floppy Iris Syndrome

- **Chang and Campbell, 2005**
- poor dilation of the pupil, **intraoperative progressive miosis, billowing of the iris tissue, and iris prolapse** through the ocular incisions during cataract surgery
- alpha 1-a inhibitor, tamsulosin (Flomax), IFIS may be associated with other alphablockers (Doxazosin, Terazosin, Alfuzosin) psychotropic drugs, and over-the-counter agents such as saw palmetto. Tamsulosin is considerably more likely to induce IFIS than are other medications.
- IFIS does not occur until patients have been on tamsolusin therapy for approximately **4 to 6 months**.
- ***DM is not associated. (??)***
- **Grading**
    - mild (billowing only)
    - moderate (billowing and intraoperative miosis)
    - severe (billowing, miosis, and iris prolapse)
- **classification of pupillary behavior (S. Manvikar and D. Allen)**
    - Type 1 Pupil: good mydriasis preoperatively.
    - Type 2 Pupil: good mydriasis preoperatively but pupils constrict later during surgery.
    - Type 3 Pupil: a mid-dilated pupil initially that sometimes constricts later.
    - Type 4 Pupil: poor dilation at the beginning of surgery.
- **Pathogenesis:**
    - 1AR antagonists cause relaxation of the iris dilator muscle and cause disuse atrophy of this muscle in the long-term.
- **Preoperative evaluation**

- History (specifically ask for BPH/Tamsulosin)
- Dilatation

- **Signs**
  - classical triad of IFIS includes:
    1. Fluttering & billowing of iris stroma
    2. propensity if iris to prolapse through phaco and side port incisions
    3. progressive constriction of pupil
  - pupil dilates poorly in response to the routine preoperative mydriatics
  - starts to constrict soon after the first incision
  - iris tends to prolapse despite well-constructed incisions
  - iris stroma can be seen to be fluttering
- **Management**:
  - Preoperative topical atropine sulfate 1%: 2 days prior to surgery, continue their tamsulosin therapy, due to the risk of acute urinary retention with the use of atropine.
  - construct incisions that have long tunnels
  - direct stimulation of the iris dilator muscle by intracameral epinephrine (Joel Sugar)
  - High-viscosity OVDs → Healon5 and DisCoVisc
  - avoid irrigating large volumes of balanced salt solution infusate under the iris, as this will increase the likelihood that the tissue will billow and prolapse
  - mechanical iris retraction → standard iris retractors and the Malyugin Ring
  - Pupil expansion rings e.g. PerfectPupil
  - Manual stretching and ***sphincterotomies have not been found to be effective and may actually increase the floppiness*** of the iris
  - It is important to remember that ***stopping the tamsulosin does not help*** as the effect of the drug persists even after discontinuation. Acute urinary retention maybe precipitated if the drug is abruptly stopped.

- **Arshinoff's strategy to manage IFIS**: tight incision, long tunnel, outer soft shell with viscodispersive and inner with viscocohesive, water pocket is next made over the lenticular surface by injecting BSS.

Cataract Surgery in the Patient with Uveitis

- Anterior and intermediate uveitis
  1. the frequent relapses and chronic intraocular inflammation
  2. the chronic use of corticosteroid therapy
- 50% in juvenile rheumatoid arthritis and other forms of posterior uveitis, and up to 75% in chronic anterior uveitis
- **Complicated cases of uveitic cataract**: those are essentially on systemic or periocular medication to control the uveitis as well as to maintain a quiescent state
- **Uncomplicated cases of uveitic cataract**: excellent control of uveitis as well as near normal anterior segment with adequate pupillary dilatation and minimal distortion of pupillary sphincter.

SYMPTOMS

- DOV
- Glare

SLE

bulbar conjunctival hyperthymia, ciliary flush, comeal edema, an even anterior vitreous reaction.

laser flare cell meter, fluorophotometry, or an inflammation severity score (USS).

main indications for cataract surgery

(i) visually significant cataract if prospects for substantial improvement in visual acuity are good

PAM, LI

(ii) Glare

(iii) cataract that impairs fundus assessment in a patient with suspected fundus pathology.

Preoperative Consideration

- pupil dilatation
- status of the nonoperative eye
- uveitis controlled with topical steroids only
- vitreous inflammation to require vitrectomy
- uveitis inactive, chronic, or recurrent
- granulomatous
- glaucoma
- cystoid macular edema
- zonular dehiscence
- patient can tolerate aphakia or not
- risk of amblyopia

Preoperative management

- active inflammation control for at least 3 months
- The single most important sign of inflammation is the presence or absence of inflammatory cells in the anterior chamber or vitreous. Aqueous flare in anterior chronic uveitis simply denotes vascular incompetence of the iris and ciliary body, a consequence of vascular damage from recurrent uveitis.

- **Preoperative Regimen**

- Absolute control of uveitis for at least 3 months (use immune-suppressants if needed)
- High-dose oral corticosteroids 2-3 d preoperatively (prednisone 1 mg/kg per d)
- Intensive topical corticosteroids 1 wk preoperatively (eg, prednisolone acetate 1% every 1Y2 h while awake)
- Topical or oral nonsteroidal anti-inflammatory drugs starting 1 wk preoperatively
- Vigorous pharmacological synechiolysis
- Intravenous methylprednisolone 62.5-125 mg at the start of surgery

- ***Surgical Goals***
  - Preservation of capsular integrity
  - Meticulous cortical cleanup
  - In-the-bag IOL placement
  - Removal of all viscoelastics
  - Minimize trauma to iris

- **Management:**
  - Clear corneal or scleral tunnel incision
  - Viscoelastic substances
  - CCC
  - phacoemulsification procedure is accomplished by the most suitable technique for each case
  - **Type of IOL: Heparinized PMMA > PMMA > Acrylic > Silicone**

- **Post operative treatment**
  - topical steroids ,cycloplegics and Antiglaucoma
  - NSAIDs controversial

- Systemic steroids

- **Follow up**
    - Posterior Capsule Opacification: 25-30%
    - Membranes
    - Decreased Visual Acuity: Cystoid macular oedema, Epiretinal membrane, and Glaucomatous optic nerve damage.

IOL Implantation in Eyes without a Capsule

- posterior capsular rent with inadequate sulcus support
- large zonulodialysis or large subluxations of the lens or IOL
- primary aphakias

Sutured Scleral Fixated IOL

Ab INTERNO: needles are passed from the inside of the eye outwards

Ab EXTERNO: needle is passed from outside to inside the eye

COMPLICATIONS:

- Improper passage of the needle can result in retinal detachment
- degrade, erode and the knot may give way
- decentered IOL and consequent diplopia, edge glare effects, etc.
- Loose suturing can give rise to excessive intraocular mobility of the IOL which can results in pseudophakodonesis.
- lens rubbing on the iris which can result in pigment dispersion and uveitis-glaucoma hyphema syndrome

Sutureless PCIOL Fixation with Intrascleral Haptic Fixation

- combines the control of a closed-eye system with the postoperative axial stability of the posterior chamber IOL
- 3 piece/ multipiece PCIOL with heptice used for intrascleral fixation
-

Advantages:

- No contraindication
- Standardized technique
- Standard PCIOL with no extra storage, easy logistic, routine biometry
- Excellent centration
- Sutureless
- Scleral fixation
- Minimal uveal contact
- Independent from iris changes
- Also for special IOL like multifocal and toric
- In combination with refractive surgery (Bioptics).

Glued PCIOL implantation with Intralamellar Scleral Tuck

- Reliseal (Reliance Life Sciences, India).
- Tisseel (Baxter)

Reconstitution of Glue (Reliseal)

freeze dried human fibrinogen (20 mg/0.5 ml), freeze dried human thrombin (250 IU/0.5 ml), aprotinin solution (1500 kiu in 0.5 ml), one ampoule of sterile water, four 21G needles, two 20 G blunt application needles and an applicator with two mixing chambers and one plunger guide.

Advantages

No special IOLs
No tilt
Less pseudophacodonesis
Less UGH syndrome
No suture related complications
Rapidity and ease of surgery
Stability of the IOL Haptic

Advantage of SFIOLs:

sutured PCIOLs are appropriate for patients with glaucoma, diabetes, cornea guttata or low endothelial cell count, peripheral anterior synechiae, or known or suspected cystoid macular edema.

Complications of SFIOLs:

- IOL Tilt:
- Late IOL Dislocation:
- Suture knot erosion:
- Haemorrhage:
- Transient rise in IOP
- Retinal Detachment
- Cystoid Macular Edema
- Late Endophthalmitis

Iris Suture Fixation of Intraocular Lenses

The advantages of iris fixation compared to trans-scleral fixation are as follows:

1. ***Absence of conjunctival*** surgery.

2. The ability to perform the ***suturing through the small side-port*** incisions and, if the lens needs to be inserted, the insertion of a foldable IOL through small incisions.

3. ***Absence of any external sutures*** that can later erode to the surface and be the source for foreign body irritation and a track for organisms to enter the eye, causing endophthalmitis.

4. The apparent ***lower rate of late postoperative suture breakage*** and dislocation of the implant compared to trans-scleral suture fixation.

Concerns: potential for inflammation, However, the peripheral iris does not appear to have this potential for chronic inflammation, at least when the implant is secure and not moving against the uveal tissue.

- Peripheral Short Suture Bites
- Suture from the Concave Side of the Haptic
- Use a Three-Piece IOL
- Use a Dense Cohesive Viscoadaptive Device to Visualize the Haptic
- Tying the Suture

Phaco in Subluxated Cataracts

- partial displacement of the lens from its central position in the pupil
- **Classification**
  - Congenital
    - isolated ocular finding (Simple Ectopia Lentis)
    - systemic disorders like Marfans syndrome & its variants, Homocystinuria, Weil-Marchesani syndrome, Spherophakia, Atopic dermatitis, Hyperlysinemia, Ehlers Danlos syndrome, & Sulfite Oxidase deficiency
    - ocular disorders such as Ectopia Lentis et Pupillae, Congenital Glaucoma, Aniridia & Megalocornea
  - Acquired
    - Trauma, Pseudo-Exfoliation, High Myopia, Hypermature Cataract, Syphilis, Ectasias, Glaucomas, previous Scleral Buckling surgery, and Staphylomas
    - Iatrogenic subluxation following zonular dialysis, detected intraoperativly
- **Pathophysiology**:
  - Zonules are composed of Cystiene rich Glycoproteins, the chief component being Fibrillin. Poor secretion of Zonular Fibrils, Cystiene Deficiency or a Fibrillin gene defect are some of the theories to explain the Zonular weakness in Congenital diseases
  - excess Zonular stretching, Zonular damage and weakness occur in the Acquired Sub-luxations

- Investigations
  - Sodium nitroprusside test (in urine) for Homocystinuria **(Thromboembolic episodes during general anesthesia)**
  - FTA-ABS for syphilis
  - UBM
  - ECHO for Ao
  - musculoskeletal evaluation
- Management
- Clear Lens
  - Medical
    - Observation
    - complete refraction
    - Spectacle correction, aphakic glasses, contact lenses
    - Medical intervention can be in form of cycloplegics to enlarge the aphakic part or miotics to minimize diplopia and decrease the pupil aperture. ***Miotics pose the danger of pupillary block and should be used with caution***
    - Laser iridotomy / iridoplasty
  - Surgical
    - Lensectomy (Pars Plana route/ Limbal route)
    - LE
- Cataractous Sub-luxated lens
  - Surgical only
    - Less than 3 clock hours: Slow phacoemulsification
    - 3-5 clock hours: Phacoemulsification with Intraocular Lens Implant with CTR/ Iris or Capsular support hooks
    - 5-7 clock hours: Phacoemulsification can be attempted with the help of a combination of Capsular support system (iris hooks/ Capsular retractors) with fixation of Capsular bag by a Cionni CTR

- >7 clock hours: ICCE-AV/ PPL Vit

- Complications
  - Intra-operative: posterior capsular rupture, nucleus drop, CTR drop with the bag, and IOL drop.
  - Postoperative: Glaucoma, Iritis, Hyphaema, delayed IOL Sub-luxation or Decentration, Capsular Phimosis, Capsulorhexis contraction, Anterior Capsular Fibrosis, Vitreous Haemorrhage, Retinal Detachment, and Macular Oedema

Capsular Tension Rings

- Introduced by → **Hara, 1991 known as Equator ring (Closed ring)**
- **Toshiyuki Nagamoto**: Open ring but without holes,1990
- implanted in the first human eye during cataract surgery in **1993** by **Witschel and Legler**
- four main advantages:
  1. capsular zonular anatomical barrier is partially reformed, so that **vitreous herniation decreased**
  2. taut capsular equator **offers counter traction for all traction maneuvers**, making them easier to perform and decreasing the risk of extending the zonular dialysis
  3. The necessary **capsular support** for an in -the-bag centered implant
  4. bag **maintains its shape and do not collapse**, which can lead to proliferation and migration of epithelial cells.

- ***Indications***: trauma, pseudoexfoliation syndrome, previous ocular surgery (eg, vitrectomized eyes), mature/hypermature cataracts, and high myopia. Less common causes of zonular weakness include Marfan's syndrome, homocystinurea, Weill-Marchesani syndrome, microspherophakia, retinitis pigmentosa, lens coloboma, scleroderma, porphyria, hyperlysinemia, and intraocular neoplasms.

- **various designs**
  - **standard Morcher CTR** (intraoperative support also possible)
  - **Cionni Rings** for Sclera Fixation (only be placed after nuclear and cortical removal, so they cannot provide intraoperative support during phacoemulsification.)

- **Ike Ahmed** Capsular Tension Segments [CTSs]→ 120° of arc length and a 5-mm radius of curvature. Model MR-6D is 9.61 mm in length, and the MR-6E is 0.14 mm in length.
  Advantage:
  1. can be ***implanted without a dialing technique***, which minimizes trauma to an alreadycompromised zonular apparatus
  2. can be placed ***after the capsulorhexis and before cataract removal***
  3. can be used in cases of a ***discontinuous capsulorhexis, anterior capsular tears, or posterior capsular rents***
- ***Assia' s Capsule Anchor***: designed by **Ehud Assia** from Israel, PMMA intraocular implant, intact ACCC is a prerequisite, two lateral arms of the device are inserted behind the anterior lens capsule whereas the central rod is placed in front of the capsule

- **Henderson CTR** (eight equally spaced indentations of 0.15 mm and an uncompressed diameter of 12.29 mm that is compressible to 11 mm. The main advantage of the Henderson CTR is that it ***allows for easier removal of nuclear and cortical material*** while maintaining equal expansion of the capsular bag)
- **Burkhard Dick**: 8 hydrophobic and 8 hydrophilic ring segments. The CFCRs have a 9.2 mm minimum overall diameter. The CFCRs were inserted using various cartridge systems or a two-folded technique
- **Geuder injector**

- manufactured by **Morcher GmbH** (Stuttgart, Germany) and are distributed in the United States by **FCI Ophthalmics, Inc.** (Marshfield Hills, MA)

- **CONSTRUCTION**
  - CTR is a C-shaped, open ring made of polymethylmethacrylate
  - 12.3 mm (compresses to 10 mm, Morcher 14, used for axial length < 24 mm)
  - 13 mm (compresses to 11 mm, Morcher 14C, used for axial length of 24-28 mm)
  - 14.5 mm (compresses to 12 mm, Morcher 14A, used for axial length > 28 mm).

Severe Hyperopia

- optical defect above +4D
- two categories:
  - those with small anterior segment and
  - those with a normal anterior segment

- Preoperative treatment
    - Stop miotic therapy 48 hours prior to surgery
    - Add oral acetazolamide
    - Add topical non-miotic hypotensive
    - Administer 20% mannitol,10 ml/kg body weight i.v. 2-4hours before surgery
    - Avoid excessive administration of phenylephrine to overcome miosis
-

Ectopia Lentis

Ghent Criteria

Revised Ghent Criteria

In the absence of family history:

1. Ao (Z ≥ 2) and EL = MFS
2. Ao (Z ≥ 2) and FBN1 = MFS
3. Ao (Z ≥ 2) and Syst (≥ 7pts) = MFS
4. EL and FBN1 with known Ao = MFS

In the presence of family history:

5. EL AND FH of MFS (as defined above) = MFS
6. Syst (≥ 7 pts) and FH of MFS (as defined above) = MFS
7. Ao (Z ≥ 2 above 20 yrs old, ≥ 3 below 20 yrs) + FH of MFS (as defined above) = MFS

Systemic score

- Wrist AND thumb sign – 3 (Wrist OR thumb sign – 1)
- Pectus carinatum deformity – 2 (pectus excavatum or chest asymmetry – 1)
- Hind foot deformity – 2 (plain pes planus – 1)
- Pneumothorax – 2
- Dural ectasia – 2
- Protrusio acetabuli – 2
- Reduced US/LS AND increased arm/height AND no severe scoliosis – 1 (The combined presence of reduced upper to lower segment ratio (for white adults <0.85; <0.78 in black adults; no data have been assessed in Asians) and increased armspan to height ratio (for adults >1.05) in the absence of significant scoliosis)
- Scoliosis or thoracolumbar kyphosis – 1
- Reduced elbow extension – 1
- Facial features (3/5) – 1 (dolichocephaly, enophtalmos, downslanting palpebral fissures, malar hyoplasia, retrognathia)
- Skin striae – 1
- Myopia >3 diopters – 1
- Mitral valve prolapse (all types) – **1**

Maximum total: 20 points; score ≥7 indicates systemic involvement

EL + FBN1 mutation without Ao and Syst (< 7) → **ELS** (ctopia lentis syndrome)

Syst (≥ 5), absent EL and Ao → **MASS** (myopia, mitral valve prolapse, aortic root dilation, skeletal findings, striae syndrome)

MVP and Syst (< 5) without Ao and EL → **MVPS**

Microspherophakia

Weill-Marchesani syndrome (WMS):

- short stature
- brachydactyly
- joint stiffness
- characteristic ocular findings → microspherophakia, ectopic lentis, cataract formation, severe myopia, and acute or chronic glaucoma.
- AD → fibrillin-1 gene, chromosome 15q21, ectopic lentis
- AR → ADAMTS10 mutation, chromosome 19p13, microsherophakia

Intralenticular foreign bodies

- IOFBs account for approximately 40% of all penetrating ocular traumas
- 7-10% of all intraocular foreign bodies
- Metallic
- Nonmetallic: cilia, glass, stone, vegetable matter and coal
- Cx: altered capsular integrity which results in the formation of visually significant cataract. There is usually a minimal accompanying globe disruption but complications like uveitis, glaucoma, abscess formation, endophthalmitis and intralenticular metallosis
- Mx:
    - ICCE
    - ECCE with PCIOL combined with extraction of lenticular magnetic foreign body

Management of Preexisting Astigmatism

- aim of modern cataract surgery is to have UCVA as good as BCVA.
- Incidence
  - 36 to 45% of patients have astigmatism of > 1D (78% have < 1.5D, 20% have 1.5 - 3.0D and 2% have >3.0 D.)
- The chief methods of correcting preexisting astigmatism during cataract surgery are:
  - Limbal relaxing incisions (LRIs)
  - Astigmatic keratectomy
  - Opposite clear corneal incisions(OCCIs)
  - Toric intraocular lens (Toric IOLs)

- **Limbal relaxing incision**
  - Can treat upto 4D of astigmatism
  - Various Nomograms
    - Gills Nomogram
    - NAPA Nomogram (Nichamin Age and Pachymetry Adjusted Intralimbal Arcuate Astigmatic Nomogram)
    - Donnenfeld Nomogram
  - Limitations
    - Regression
    - Mechanical instability
    - Ocular surface discomfort
    - Infection
    - Perforation
    - Decreased corneal sensation
    - Induced irregular astigmatism

    - Misalignment/axis shift
    - Operating upon the wrong (opposite) axis

- **On Axis Cataract Incision and Opposite Clear Corneal Incisions**
  - Phaco-incision is considered to be astigmatically neutral
  - 3.2 mm incision induces 0.25 to 0.50 D of astigmatism.
  - biggest advantage of this technique is the stability of the cornea which is achieved in 2 weeks time
  - minimum fluctuations in vision and minimal regression.
  - The amount of correction depends upon:
    1. Types of incisions: Hinged > Triplanar > Biplanar > Uniplanar
    2. Site and location of the incision: (Superior > superotemporal/superonasal >Temporal)
    3. Size of the incision: The lesser the width of the incision, the more will be the correction.
    4. Amount of astigmatism: The more is the preexisting astigmatism, the greater is the correction achieved.
  - not need to change IOL power due to the coupling effect
  - **Coupling Effect**: ***Cravy*** has described ***gauss's law*** of elastic domes – "for every change in curvature in one meridian there is an equal and opposite change 90 degrees away". This phenomenon of corneal behavior is known as the coupling effect.
  - **Limitations**: limited amount of correction induced

- **Toric IOL**
  - do not require the additional surgical skills needed to create clear corneal incisions
  - implanted using standard cataract surgical techniques
  - **Limitations:** proper alignment of a toric IOL during surgery is critical.

Bioptics

Complications

Viva question: Complications

Retrobulbar hemorrhage

Signs: tense globe, taut lids, resists retropulsion, SCH

Goal: decrease IOP to prevent CRAO

Management: lateral canthotomy

Prevention: blunt needle, topical

Perforation of globe

Signs: acute hypotony or acute hypotension

Goal: early recognition

Prevention: recognize high risk eyes

Corneal abrasion

Due to speculum,

Prevention: attention to prep, drape, speculum

Bridal suture complication

Signs: vitreous under conjunctiva, VH, RD, or hypotony

Incision site

Position: too posterior or too anterior

Width: too tight or too loose

Length: too short or too long

Depth: more imp for scleral incision

Clear corneal incisions:

? less forgiving ? high Endophthalmitis rate

Cons: burns, need proper length

Pro: easier to create, no hyphema, conserve conjunctiva

Anterior capsulotomy:

Argentina flag sign:

Small opening

Hydrodissection

Capsule rupture possible

Correct pressure imbalance, depress wound lip

Watch for posterior polar cataract

Singh sign for posterior polar cataract:

Descemet's detachment

Signs: visible flap – do not confuse with capsule

Prevention: careful insertion of tools

Iris prolapse

Problem: increased pressure

Prevention: speculum, SR suture, flow, wound, vitreous, visco

PC rupture

Aggressive hydro

Phaco tip induced

Nucleus removal – extension of capsular tear, can-opener or rent in CCC

Cortex removal

Polishing posterior capsule

Management:

Recognise the signs- deepening of AC, loss of followability

Stop phaco: cant cut vitreous, infusion will enlarge the hole and vitreous prolapse, prevent deep sixing

Assess the size of hole: is it enlarging?

Plug the hole with viscoelastics.

- Is anything left?
    - Nothing:
    - Vitreous:
        - Manage first and throughout cleanup
        - Where is it? Anterior or posterior
        - Does it need Vitrectomy? Dry, bimanual vs coaxial, low flow
        - When to stop? Round pupil, no vitreous in the wound
    - Nucleus:
        - Enlarge incision
        - Viscoelastic: float up remnant, protect endothelium
        - Insert sheet glides
        - Remove remnant without external pressure

- Cortex:
  - Consider posterior rhexis
  - Low flow low vacuum low infusion
  - Strip towards the hole
  - Manual IA if very large
  - Don't be aggressive, remove from visual axis only

IOL options

PCIOL in the bag- small hole well defined border, no dialing

PCIOL in the sulcus-

ACIOL:

SFIOL

Aphakic

Domino effect:

Posterior Capsular Opacification

- physiological postoperative consequence of an uneventful uncomplicated extracapsular cataract surgery
- referred to as 'secondary cataract' or 'after cataract', develops over the clear posterior capsule a few months to a few years

Aetiopathogenesis

In the normal crystalline lens, the LECs are confined to the anterior surface at the equatorial region and the equatorial lens bow. This single row of cuboidal cells can be divided into two different biological zones

- The **anterior-central zone** (corresponding to the zone of the anterior lens capsule) consists of a monolayer of flat cuboidal, epithelial cells with minimal mitotic activity. In response to a variety of stimuli, the anterior epithelial cells **("A" cells)** proliferate and undergo fibrous metaplasia. This has been termed "pseudofibrous metaplasia" by Font and Brownstein.

- **E cells** migrate posteriorly along the posterior capsule and often forms large balloon like bladder cells, known as **Wedl cells**. These are clinically termed as **Elschnig pearls**. Each pearl represents the failed attempt of epithelial cell to differentiate into a new lens fiber.

- E cells are also responsible for a dumb bell dough-nut-shaped opacification, known as **Soemmering's ring.** The Soemmering's ring, a dumb-bell or donut shaped lesion that often forms following any type of rupture of the anterior capsule, was first described in connection with ocular trauma. The pathogenetic basis of a Soemmering's ring is rupture of the anterior lens capsule with extrusion of nuclear and some central lens material.
- Can be in form of **PCO/ ACO/ ILO**

Incidence & Assessment

- as high as 50% to as low as <5%
- presence or absence of PCO within the central visual axis
- comparing the neodymium:YAG (Nd:YAG) capsulotomy rates
- PCO-induced loss of contrast sensitivity
- **POCOman software:**
- **EAS-1000 system** (Scheimpflug videophotography)

Risk Factors

- Nonmodifiable

    - Age: younger individuals at a higher risk
    - At the 1-year follow-up, diabetic patients had significantly severe PCO
    - Myopia
    - hydrophobic acrylic IOLs ??
    - myotonic dystrophy
    - retinitis pigmentosa
    - traumatic cataracts
  - Modifiable Surgical Techniques
    - **Continuous Curvilinear Capsulorhexis:** fusion between the edge of the continuous curvilinear capsulorhexis to the posterior capsule, forming a Soemmering's ring. This ring provides a closed environment, which restricts the migration of the LECs toward the central posterior capsule
    - **In-the-Bag Fixation:** primarily to enhance the IOL optic barrier effect, reducing the incidence of central PCO
    - **Anterior Capsule Overlap of IOL Optic:** IOL optic keeps the anterior lens epithelium away from the posterior capsule. This would decrease the incidence of migration of the anterior LECs behind the IOL optic.
    - **Cortical Cleaving Hydrodissection:**
    - **Hydrodissection Combined With Rotation:**
    - **Cortical Clean Up:**
    - **Bag-in-the-Lens Implantation:**
    - **Polishing (Scraping) the Anterior Capsule**

IOL Factors

  - IOL Design
    - **Plate-haptic versus Loop-haptic IOLs:** high rate of ACO/ PCO in plate → lens tilt, Z syndrome and decentration
    - **Single-piece versus Multipiece IOL Design:** No statistical difference
    - Round optic edge versus sharp optic edge IOL optic design: sharp optic edges of the IOL appeared to induce contact inhibition of migrating LECs

    - **Haptic Designs & Angulation:**
    - Accommodating IOL: increase PCO
  - IOL material
    - **Biocompatibility:** PMMA IOL, silicone IOL and AcrySof IOL, it was found that all three IOLs were sufficiently biocompatible for uvea. For capsular compatibility, AcrySof was better.
    - **Bioadhesive IOL Materials:** Bioactive materials are those that allow a single LEC to bond both to the IOL and the posterior capsule i.e. acrysof lens prevent PCO more than PMMA and silicone IOLs, which are biocompatible but also bioinert. Hydrophobic acrylic material binds more firmly to fibronectin, a plasma protein that is also secreted by LECs, compared with PMMA, silicone and hydrophilic acrylic materials.

Treatment

- **nonsurgical Nd:YAG laser capsulotomy**
  - The need for performing capsulotomy depends on the patient's functional impairment of vision, discomfort, demand and the presence of associated risk factors such as high myopia, history of retinal detachment, high risk of cystoids macular edema and only functioning eye.
  - A size that is larger than the pupil diameter under scotopic conditions may prevent disturbances of vision such as monocular diplopia

Prevention of posterior capsule opacification (PCO)

SIX Important factors given by David J Apple

Surgery-related factors that help in the prevention of PCO

1. **Hydrodissection-enhanced cortical clean-up**

- Dr I Howard Fine: cortical cleaving hydrodissection
- tenting up of the anterior capsule during subcapsular (or cortical cleaving) hydrodissection

2. **In-the-bag IOL fixation**

3. **Performance of a capsulorrhexis slightly smaller than the diameter of the IOL optic.**

The same studies helped in the definition of three **IOL-related factors** for PCO prevention.

4. **Use of a biocompatible IOL to reduce stimulation of cellular proliferation**

5. **Enhancement of the contact between the IOL optic and the posterior capsule**

6. **An IOL with a square truncated optic edge.**

Pharmacological Prevention of Posterior Capsule Opacification

- antimetabolites (such as methotraxate, mitomycin, daunomycin, 5-FU, colchicine, and daunorubicin)
- anti-inflammatory substances
- hypo-osmolar drugs
- immunological agents
- **Sealed capsule irrigation of maintaining postoperative capsular bag transparency:** In dealing with capsular contracture or after-cataract formation, the **Perfect-Capsule**, developed by **Anthony Maloof**, may be a significant breakthrough. By sealing the capsule, irrigated sterile water will produce hypotonic lysis of the lens epithelial cells and may be able to provide an acellular capsule such that capsular contracture and aftercataract formation can be avoided in the future.
-

PCR ±VL

- PCR or PCT
- Any breach in the continuity of the posterior capsular is defined as posterior capsular tear (PCT)
- It may be associated with vitreous loss, cystoids macular edema, uveitis, glaucoma, retinal detachment, vitreous touch syndrome, vitreous wick syndrome, and expulsive haemorrhage.
- **0.7% to 16% of phaco, 2 to 10% of ECCE**
- potential seriousness is usually detetmined not by their occurrence per se, but by the way in which they are managed.
- Risk Factors:
  1. intrasurgical PCT (planned in PCCC, else accidental)
     - poor visibility:
     - during capsulorhexis: small rhexis, discontinuous margin
     - during hydrodissection: capsular block or due to failure to ballotte the nucleus backwards
     - during phaco: learning phase, poor visualization
  2. pre-existing PCT
  3. spontaneous PCT: hypermaturity, posterior lenticonus intra ocular tumors and posterior polar cataract

- Four cardinal signs:
  1. sudden deepening of anterior chamber
  2. momentary papillary dilatation
  3. nuclear does not followed towards the Phacoemulsification tip
  4. nucleus falls away from the phaco tip.

- first tell-tale sign of PCT occurring during hydrodissection is "**Pupil snap sign**"
- Three possible situations
  - Posterior capsule tear with hyaloid face intact and nuclear material present
  - Posterior capsule tear with hyaloid face ruptured without luxation of nuclear material into vitreous
  - Posterior capsule tear with hyaloid face ruptured and luxation of nuclear material into vitreous.

- **Management**
  - If PCT is identified during early stages of ECCE: plugged with viscoelastic substance followed by dry aspiration of the remaining cortex
  - PCT with intact hyloid face with nuclear material present: In cases of small nuclear material viscoelastic is injected to plug the PCT and nuclear material is moved into the anterior chamber with spatula and emulsified with short bursts.
  - Post capsular tear with ruptured hyloid face without luxation of nuclear material into vitreous: dry AV and aspiration
  - In case of large residual nuclear material: convert to routine ECCE
  - Post capsular tear with ruptured hyloid face with luxation of nuclear material into vitreous: 0-18%
  - Intraocular lens implantation in PCT
    - If PCT <6mm / margins are clearly visible with no vitreous prolapse – PCIOL implantation in the capsular bag may be performed.
    - If PCT >6mm / margins are not clearly visible– ACIOL
    - If Anterior Rim available: PCIOL in the sulcus

Posterior Dislocation of Lens Material

TASS

- acute, non-infectious inflammation of the anterior segment of the eye following cataract and anterior segment surgery
- It was initially referred to as ***Sterile Postoperative Endophthalmitis***, accurately termed **TASS by *Monson*** *et al.* in 1992
- **TECDS**: toxic endothelial cell destruction syndrome, When the damage is restricted to corneal endothelial cells
- **Incidence:** not known
- **Causes**
    - ***Bacterial endotoxin residues:*** heat-stable endotoxins of GN bacteria
    - ***Viscoelastic residues:***
    - *Solutions and intraocular fluids:*
    - ***Preservatives***: benzalkonium chloride, edetic acid, 0.1% sodium bisulfite, methylparaben of lidocaine, 0.01% thimerosal
    - *Medications:*
    - *Intraocular lenses:* Ethylene oxide residue, IOL polishing compound aluminum oxide
- **Clinical Features**
    - within 12-24 hours of the surgery
    - corneal edema which is characteristically "limbus to limbus"
    - nonreactive dilated pupil
    - moderate to severe anterior chamber reaction with cells, flare, hypopyon and especially fibrin
    - increased intraocular pressure
    - Pain is mild to moderate

- B scan shows clear vitreous

- **significant overlap between the clinical presentation of TASS and that of infectious Endophthalmitis**
  - *Onset:* Usually, TASS occurs within 12 to 24, endophthalmitis is within 4-7 days of surgery
  - *Pain:* Only mild to moderate pain occurs in TASS
  - *Corneal Edema:* limbus to limbus in TASS
  - *Inflammation:* marked breakdown of the blood-aqueous barrier, flare and significant fibrin formation in TASS
  - *Pupil:* Iris atrophy may occur significantly in TASS, poorly reactive pupil
  - *IOP:* as high as 40 mm Hg to 70 mm Hg in TASS
  - *Cultures:*
  - *B Scan: TASS* does not involve vitreous inflammation generally
- **Treatment**
  - Hourly topical prednisolone acetate must be started immediately. Cycloplegics should be frequently instilled. Oral steroids (1mg/kg body weight) should be prescribed. Antibiotics must be continued till the diagnosis is clear.
- If the reaction is mild, there is rapid improvement in signs and symptoms of inflammation. Hypopyon resolves very fast. Within 24-48 hours there is improvement in visual acuity. From hand movement to counting fingers within a day is seen. Patient's vision improves remarkably thereafter. The inflammation usually clears within one to three weeks. Moderate cases take between three to six weeks to resolve. In severe cases, TASS can cause permanent damage.
- Most cases of TASS appear to result from inadequate instrument cleaning and sterilization. ASCRS 2006
  - Specified concentration of the recommended cleaning agent
  - Final rinsing sterile, distilled, or deionized water
  - Single-use brushes should be used and disposed
  - Sterilize per instrument manufacturer recommendations'
  - Avoid flash sterilization

IOL Glistening

- fluid filled micro vacuoles that form with in the IOL optic when IOL is in an aqueous environment
- PMMA, Silicone hydrophilic, hydrophobic acrylic
- 2 theories for the formation of glistening
    - **Microvoid theory**
        - Microvoids can be found within network of polymers depending on their architectural structure. water is absorbed which remains invisible, because it is in form of water vapor → detaches from the surrounding polymer and accumulates in a void (phase separation) to visible water drops. sparkling appearance of fluid-filled vacuoles (thus, the term Glistening).
    - **Theory of Impurities**
        - slow moving hydrophilic impurities from aqueous to IOL. segregate in to polymers voids, which create osmotic pressure difference – leads to influx of water in to voids.
- Grading of Glistening
    - **Miyata Grading system**: high magnification with full dilated pupils, amount of glistening -0-50-100-200- corresponding grade 0-1-2-3.
    - Semi quantitative Slit lamp grading (10*2 mm)
        - Trace fewer than 10
        - 1+ 10 to 20
        - 2+ 20 to 30
        - 3+ 30 to 40
        - 4+ > than 40
    - Scheimpflug Photography (pentacam) Grading
- Factors influencing on glistening

  - Effect of temperature: Glass Transition time (Tg)
  - Manufacturing technique: Cast molded technology made lenses have higher tendency to have glistening due to incomplete polymerized chain reaction in mold
    - cast molding: Alcon, Matrix, Hydromax
    - lath cutting: Sensor, Hoya, Bausch Lomb, Aurolab, OII
  - Packaging material
  - Break down of B-A-B
  - Dioptoric power IOLs
- Progression of glistening
- Effect on visual function
  - Grade 1 & 2: no statistically significant effect on Visual acuity, Contrast sensitivity, Glare & wave front analysis
  - Grade 3+ or 4: borderline correlation with high spatial (12cycle/degree) contrast sensitivity observed.
- In hydrophobic IOLs, glistening are more in high Tg Value IOLs, cast molded IOL, Acrypack packing material, more with 10% saline as compare to 0.9% saline, surgery with high BAB disturbances.

Refractive Surprise

Causes (Jones 2007)

- Prior refractive surgery
- Incorrect biometry
- Very long eyes (posterior staphyloma)
- Very short eye or high hyperopia
- Anatomically different eye with differect ELP

- Incorrectly labeled IOL (very uncommon)

Solution

Intraocular: IOL Exchange, Piggyback IOL

Extraocular: LASIK, Surface Ablation, CK, LRI

1. **IOL Exchange**
    - If error in lens calculation is known, IOL XC is viable option
    - Challenging with higher complication rate
2. **Laser refractive surgery**
    - Special set-up required or have to co-manage with other surgeon
    - Added cost
    - Many surprises are hyperopic and hyperopic LASIK-PRK is not as predictable
    - Wait 3-4 months after cataract surgery to perform LASIK
3. **Piggyback IOL**
    - Best for cases with spherical error
    - Collamer or silicone 3-piece IOL with smooth anterior surface
    - Never piggyback an acrylic lens over another acrylic lens
    - can correct error in relatively short period after surgery
    - works well for relatively large errors
    - no need to worry about corneal problems like dry eye etc.
    - for myopic error: multiply 1.1
    - for hyperopic error: multiply 1.4

Pediatric Cataract

Infant Eye is Different:

- Vertical palpebral fissure: ½ the size of adult
- Diameter of eyeball: 66% of adult (grows rapidly in first 2 yrs)
- Hyperopia is common
- AL changes from 17 to 24 mm
- Corneal diameter: 6.6-7.4 to 7.4-8.4 mm
- Average K: 52 D at birth (adult: 42-44 D)
- Infant sclera is ½ as thick as adult
- Excellent VA on VER by 6 months

- **preoperative evaluation**
    - visual acuity
    - strabismus, fixation and nystagmus
    - assess the cataract, measurement of intraocular pressure (IOP), corneal diameter, posterior segment evaluation, keratometry, biometry and gonioscopy.

- **Investigations**
    - *Unilateral cataract, posterior lenticonus, familial cataract need no investigation except for detailed examination.*
    - TORCH serology, VDRL titer, urine for reducing substance to rule out galactosemia.
    - Systemic workup and investigations are carried out when any metabolic disease
    - Blood assay for sugar, calcium and phosphorus and urine aminoacid for Lowe's syndrome.

- **decision to operate**
    - unilateral cataract: immediately.
    - total cataract or more than 2.5 mm posterior sub capsular, posterior polar, posterior lenticular, zonular or any cataract which occludes the visual axis in normal light or dim light on distance direct ophthalmoscopy.

Etiology and Morphology

Congenital cataracts*: present at birth but may go unnoticed until an effect on the child's visual function is noticed or a white pupil reflex develops.*

Infantile cataracts*: develop in the first 2 years of life*

juvenile cataracts*: onset within the first decade of life.*

presenile cataract: *onset prior to 45 years of age.*

Age-related or so-called "senile" cataracts*: at/ after age 45 years*

Etiological Classification

- Isolated Findings
- Hereditary: AD (75%), AR, XR, Sporadic

- Part of Syndrome or Systemic Disease

  Hereditary

  - With renal disease:
    - Lowe's oculocerbrorenal syndrome
    - Alport syndrome (autosomal dominant)
  - With central nervous system disease
    - Marinesco Sjögren's syndrome (autonomic recessive)
    - Sjögren's syndrome (autosomal recessive)
    - Smith-Lemli-Opitz syndrome
    - Laurence-Moon-Bardet-Biedel syndrome
  - With skeletal disease
    - Conradi's syndrome (presence of cataract indicates worse prognosis)
    - Marfan's syndrome
    - Stippled epiphysis
  - With abnormalities of head and face
    - Hallermann-Streiff syndrome
    - Francois dyscephalic syndrome
    - Pierre Robin syndrome
    - Oxycephaly
    - Crouzon's disease
    - Acrocephalosyndactyly (Apert's syndrome)
  - With polydactyly
    - Rubinstein-Taybi syndrome
  - With skin disease
    - Bloch-Sulzberger syndrome
    - Congenital ectodermal dysplasia of the anhidrotic type
    - Rothmund Thomson syndrome
    - Schafer's syndrome
    - Siemen's syndrome
    - Incontinential pigmenti
    - Atopic dermatitis
    - Cockayne's syndrome
    - Marshall syndrome
  - With chromosomal disorders
    - Trisomy 13 (usually die within 1 year)
    - Trisomy 18: Edward's syndrome
    - Trisomy 21: Down's syndrome (often cataract formation delayed until approximately age 10)
    - Turner's syndrome
    - Patau's syndrome
  - With metabolic disease
    - Galactosemia (autosomal recessive): vomiting and diarrhea and may develop “oil droplet” cataracts. It is thought that 10% to 30% of

newborns with classic galactosemia develop cataracts in the first few days or weeks of life. Once a newborn is put on a galactose-restricted diet, cataracts usually clear.
    - Galactokinase deficiency
    - Congenital hemolytic jaundice
    - Fabry's disease
    - Refsum's disease
    - Mannosidosis
  - With miscellaneous hereditary syndromes
    - Norrie's disease
    - Hereditary spherocytosis
    - Myotonic dystrophy

Nonhereditary

  - Prenatal causes
  - Postnatal causes
  - Associated with another ocular abnormality

Morphological Classification (Survey article)

term "zonular cataract" is used to describe lens opacities, which are localized to one part of the lens; the term may encompass nuclear, sutural and lamellar opacities. Its no more used now and particular term like sutural or lamellar is used.

- Diffuse/total
- Anterior polar
- Lamellar
- Nuclear
- Posterior polar
- Posterior lentiglobus
- Posterior (and anterior) subcapsular
- Persistent hyperplastic primary vitreous
- Traumatic

Anterior Polar Cataract (APC): symmetrical and discrete lesions

Posterior Polar Cataract (PPC): stationary and progressive

Nuclear: opacification of embryonal and/or fetal nuclei.

Coppock cataract: opacities within a 6-mm nucleus

Coppock-like cataract: fetal nucleus, approximately 2.5 mm in diameter, early insult

Lamellar: the concentric deposition of newly differentiated secondary fiber cells around the embryonal nucleus during normal lens

Pulverulent: characterized by powdery (pulverized) opacities that may be present throughout the lens

Aceuliform: rare form of congenital cataract is associated with needle-like projections extending from the nucleus into the anterior and posterior cortex. Also called “speisskatarakt” and “needleshaped cataract”

Cerulean: discrete pinhead-shaped blue-and-white opacitiesare distributed throughout the lens

Total: Complete opacification of the fetal nucleus at birth and the cortex after birth is referred to as *total cataract*

Cortical: late insult as there is opacification in the newly formed secondary fibers.

Polymorphic:

Sutural: isolated sutural opacities may be seen in female carriers of X-linked cataract, particularly *Nance-Horan Syndrome*

Genetics

- most inherited nonsyndromic cataracts show an **autosomal dominant**
- Nearly **one-third** of congenital cataract patients have a ***positive family history***.
- Mutations in 11 genes, **including 6 genes for crystallins** (αA, αB, ßA3/A1, ßB2, γC, γD), 2 for gap junctional proteins (GJA-3 and GJA-8), 1 for beaded filament chain protein (BFSP-2), 1 for major intrinsic protein (MIP), and 1 for heat shock factor (HSF-4), have been identified for its different phenotypes

Epidemiology

- **Prevalence of childhood cataract**: **1 to 6 per 10,000** children

- The prevalence of **BL from cataracts in children** in developing countries is probably **1 to 4/10,000**, compared with approximately 0.1 to 0.4/10,000 children in the industrialized world.

Preoperative Workup

Evaluation

- Presentation
  - white pupillary reflex
  - strabismus
  - Nystagmus or poor visual fixation
  - School/ preschool vision screening
- Visual Acuity
  - assessed by history, observation of the ocular fixation and following reflex, behavioral testing, and electrophysiologic examination.

Indications for Treatment

- central cataracts >3 mm in diameter (visually significant)
- dense nuclear cataracts
- cataracts obstructing the examiner's view of the fundus or preventing refraction of the patient
- if the contralateral cataract has been removed
- cataracts associated with strabismus and/or nystagmus.
- The threshold for surgical removal of a partial cataract: 20/50 or worse.
- unilateral cataract: immediately.

IOL Power calculations

- axial length (AL): A-Scan ultrasound can be done using either contact or immersion methods
- cornea power (K): handheld keratometry,

Cataract Surgery

History

1950s: complications of Sx → thick secondary membranes, glaucoma, and corneal decompensation. So other methods were invented as follow:

- Optical Iridectomy
- Discission/Needling: **Aurelius Cornelius** (Roman physician)
- Through-and-Through Discission: **Ziegler** → Ziegler knife
- Linear Extraction: needling procedure f/by irrigation; **Gibson**
- Aspiration of Cataracts: 1960, **Scheie**
- Irrigation-Aspiration Technique: double-barreled cannula
- Intracapsular Extraction
- Automated vitrector
- Phacoemulsification: 1970
- IOL Implantation

First implant in a child for aphakic correction	*1958*	**Epstein/Choyce**
Manual aspiration of congenital/juvenile cataract	*1960*	**Scheie**
Iridocapsular implant	*1969*	**Binkhorst**
Advancement in vitreous cutting instrument	*1972*	**Machemer**
Binkhorst intraocular lenses (IOLs)	*1977-1982*	**Hiles**
Posterior chamber IOLs	*1982*	**Hiles**
Iris-claw lenses	*1983*	**Singh**
Pathophysiology of amblyopia	*1977-1985*	**Weisel/Raviola**
Posterior chamber IOLs	*1983-1993*	**Sinskey/Hiles**
Posterior capsulotomy/anterior vitrectomy	*1983*	**Parks**
Epikeratophakia	*1986*	**Morgan**
Epilenticular IOL/pars plana endocapsular lensectomy	*1988*	**Tablante**

Retropseudophakic Vitrectomy via limbus	*1991*	**Mackool/Chhatiawala**
Pars plana posterior capsulectomy and vitrectomy	*1993*	**Buckley et al.**
Primary posterior capsulorhexis/optic capture	*1994*	**Gimbel/DeBroff**
IOL biomaterials/Designs/sizing in children	*1994*	**Wilson et al.**
Primary posterior capsulotomy & anterior vitrectomy	*1994-2000*	**BenEzra/Cohen Vasavada/Desai/Trivedi**
Anterior capsulotomy for pediatric cataract surgery (vitrectorhexis)	*1994*	**Wilson et al.**
Heparin in BSS to decrease postoperative inflammation	*1995*	**Brady et al.**
Dye-enhanced pediatric cataract surgery	*2000-2002*	**Pandey et al.**

BSS, balanced salt solution.

Incision Construction

Location: Superior/Temporal/Meridian of Steepest Curvature

Scleral/Corneal:

Shape of the Incision: Straight/Frown/Circumlimbal

Anterior Capsule Management

Anterior capsulotomy & IOL	*1949*	**Sir Harold Ridley**
Can-opener capsulotomy	*Unknown*	**Little and Pearce**
Envelope (horizontal)	*1979*	**Galand/Baikoff**
CCC for adults	*1992*	**Gimbel & Neuhann**
Vitrectorhexis	*1994*	**Wilson et al.**
Push-pull CCC in rabbit model	*1994*	**Auffarth et al.**
Radiofrequency diathermy	*1994*	**Kloti**
Fugo plasma blade	*1999*	**R. Fugo**
Dye-enhanced CCC/cataract surgery	*2000*	**Pandey/Werner/Apple/Wilson**

Multiquadrant Hydrodissection

- **Faust** coined the term hydrodissection in 1984
- 1992, **Fine** published his classic description of the "cortical-cleaving hydrodissection" technique

Signs of Successful Hydrodissection

1. Forward bulge of the nucleus
2. Visible presence of a fluid wave: This is considered a definitive sign of successful hydrodissection, but it may not always be visible in pediatric eyes. Strong corticocapsular adhesions in pediatric eyes may prevent the appearance of a visible fluid wave.
3. Prominence of the capsulorhexis edge
4. Release of trapped fluid from the rhexis margin following decompression of the nucleus

Lens Substance Aspiration

- not only to aspirate the lens substance, but to aspirate it thoroughly.
  - Single-Port Versus Bimanual Approach
  - Manual Versus Automated Approach

Posterior Capsulotomy and Anterior Vitrectomy

- Proponents & Opponents
  - <5 years: PCC+AV
  - 5-8 years: PCC
  - >8 years: intact PC
- Primary capsulotomy versus secondary capsulotomy
- Surgical capsulotomy versus YAG laser capsulotomy
- Type of surgical opening: Capsulorhexis or capsulotomy?
- Limbal versus pars plana approach
- Before versus after IOL implantation
- Architecture of the posterior capsule opening: size, centricity, and shape
- Does no-suture vitrectomy technology have a role?
- Are special aids or techniques for visualization needed?

- How is the end point of the vitrectomy defined? How much vitreous should be removed?

Lensectomy and Anterior Vitrectomy

Lens Implantation in Children

Posterior Chamber Lens Implants

Associated Anatomical Anomalies

Type I Diabetes Mellitus

- **1%**
- Acute cataracts have been described in young people as a presenting feature of their diabetes. band of anterior or posterior subcapsular vacuoles or dense white cortical "***snowflake" opacities***.
- **osmotic hypothesis**→ The polyol pathway involves intracellular excess glucose being reduced to sorbitol by aldose reductase. Sorbitol is then reduced by sorbitol dehydrogenase to fructose, which can penetrate the cell membrane. The increase in intracellular sorbitol causes an osmotic gradient leading to swelling of lens fibers and subsequent alterations of membrane permeability. There is a resultant loss of potassium ions and amino acids, with a rise in sodium ions and a cessation of lens protein production. Continued lens hydration and electrolyte disturbances result in lenticular opacification.

Persistent Fetal Vasculature

- **Goldberg** replaced term PHPV to PFV in his **1997** Jackson Memorial Lecture

- some, or all, components of the fetal intraocular vasculature remain after birth.
- several clinical variants
  - Persistent pupillary membrane.
  - Iridohyaloid blood vessels.
  - Persistence of the posterior fibrovascular sheath of the lens.
  - Mittendorf dot.
  - Persistent hyaloid artery
  - Bergmeister papilla.
  - Congenital tent-shaped retinal detachment.
  - Macular abnormalities.
  - Optic nerve abnormalities.
  - Microphthalmos.
- **5-10% bilateral**
- **Mx**:
  - Posterior Approach
  - Anterior Approach
- **Complications**: glaucoma, secondary membrane formation, vitreous hemorrhage, retinal detachment, and strabismus.

Retinopathy of Prematurity

1. **Transient**: Focal opacities (either punctate or vacuolated) insignificant and often resolve spontaneously.
2. **Progressive and visually significant**: Progressive lens opacification generally leads to total cataract and completely obstructs the visual axis.
3. **Associated with retinal detachment**.

- **Etiopathogenesis**
  - Tunica vasculosa lentis

- Anterior segment ischemia
- Thermal injury
- Uveal effusion
- Vitreoretinal pathology
- Rent in lens capsule

Eyes Treated for Retinoblastoma

- in cataract caused by irradiation there is a tendency toward a ***proliferation of the epithelium under the anterior capsule into a metaplastic fibrous layer***. This strengthens the anterior capsule and makes this type of cataract particularly suitable for intracapsular extraction. **Extracapsular extraction in such cases is contraindicated** because the lens epithelium remaining after the nucleus is extracted may continue to proliferate and form dense fibrous tissue, which tends to produce iridocyclitis and secondary glaucoma.

Preexisting Posterior Capsule Defects -PPCD

- 10%
- Singh signs
  - A deep anterior chamber
  - White to chalky-white spots are produced, which are seen in front of and around the posterior capsular defect.
  - The capsule behind the opaque lens may show a partial or a complete white ring-shaped opacity. This opacity is contained within the posterior cortex, while the posterior capsule shows a hole with chalky-white spots on and around the defect.
  - Rarely, an opening in the posterior capsule shows pigment along the margins. Fine dustlike pigment along with fine dense white opacities may be seen in the Berger space. The presence of pigment suggests widespread movement of the fluid beyond the posterior capsular defect.
- Membranous cataract
- Mostly empty capsular bag.
- Opaque posteriorly displaced fetal nucleus.

- Milk bag cataract.
- Partial or complete opacification of the lens.
- Posterior lenticonus.
- Thick fibrovascular membrane in the pupil in place of a cataract.
- Large ciliary processes attached to the back of a normal-sized lens
- Pearly white thick membrane presentation of the posterior capsule.
- Posterior subcapsular cataract with attached hyaloid vessel.
- Dumbell cataract.
- Onion ring cataract.
- Posterior capsular plaque.

Anterior Lenticonus in Alport Syndrome

- ***less common than posterior lenticonus*** and most often found in association with **Alport syndrome** (AS)
- However, isolated cases have been reported, as well as a rare association with **Lowe syndrome** and **Waardenburg syndrome**
- The **anomalous basement membranes** of the ocular, auditory, and renal systems cause the characteristic triad of abnormalities in patients with AS (i.e., ***ocular signs***, ***sensorineural deafness***, ***and hereditary nephritis***).
- genetic defect within one of **the α chains of Type IV collagen**,
- **Mx:**
  - Conservative Management
  - Surgical Approach

Aniridia and Cataracts

- **1 in 64,000** to 1 in 96,000 live births
- **panocular syndrome** in which the most dramatic manifestation is partial or nearly complete absence of the iris

- **bilateral in 98%**
- ***Genetics***
    1. AD - 85%
    2. Congenital sporadic aniridia: WAGR 13%, 11p13
    3. AR - 2%, a/w cerebellar ataxia and mental retardation (Gillespie's syndrome).
- Cataracts develop in **50 to 85%**

Lowe Syndrome

- X-linked recessive, **Xq25** (**Lyon's hypothesis**, which implies that, very early in embryogenesis, one of the two X chromosomes in females is deactivated.)
- **oculocerebrorenal syndrome**
- mental retardation, Fanconi syndrome of the proximal renal tubules, and congenital cataract. Other findings include glaucoma, corneal opacity (keloid), enophthalmos, hypotonia, metabolic acidosis, proteinuria, and amino aciduria.
- degeneration of the primary posterior lens fibers account for their loss and for the flattened, discoid, or ring-shaped cataract. The other findings, such as anterior polar cataract, subcapsular fibrous plaque, capsular excrescences, bladder cells, and posterior lenticonus

Dislocated Crystalline Lenses

- Marfan syndrome, homocysteinuria, and Weill Marchesani syndrome

Eyes with Uveitis

- juvenile idiopathic arthritis (JIA), inflammatory bowel disease, ankylosing spondylitis, Reiter's disease, and sarcoidosis.

Intraoperative Complications

- Incision-Related Complications:

- Formation of the Capsulorhexis → "**runaway rhexis**" , Inappropriate size and shape, radial tear during surgery
- Positive Vitreous Pressure
- Intraoperative Miosis → iris hooks, using the Beehler dilator, performing multiple sphincterotomies with microscissors, using iris retractors, and using the Graether pupil expander, Perfect Pupil Injectable

  (some infants usually have nearly cryptless irises with a poorly formed pupillary ruff and no collarette.)

- Complications of the Posterior Capsule: tear

  pars plana posterior capsulotomy and anterior vitrectomy → laceration of the equator of the capsular bag, bleeding into the vitreous cavity

- Zonular Dialysis:
- Intraocular Lens Complications → malplacement or malpositioning, Displacement of the IOL through a primary posterior capsulotomy
- Miscellaneous: rupture of the posterior capsule may occur during the surgical step of hydrodissection

Postoperative Complications

Early-Onset Postoperative Complications

- **Postoperative anterior uveitis** (fibrinous or exudative)
  - 5 units of intravenous heparin in 500 mL of irrigating solution.
  - heparin-surface-modified (HSM) IOLs
  - intraocular streptokinase (500-1,000 IU)
- **Corneal Edema**
- **Endophthalmitis:** 7 in 10,000
- **Noninfectious Inflammation:** excessive photophobia, tearing, and even the inability to open the eyes postoperatively. It may persist for days or even weeks and may preclude early contact lens fitting in aphakic patients.

Late-Onset Postoperative Complications

- **Capsular Bag Opacification**: universal, beginning at 18 months after surgery and reaching nearly 100% over time
  - PCC
  - PCC + AV
  - square-edge IOL profile
  - posterior capsulorhexis with optic capture without anterior vitrectomy.
  - Predisposing Factors for Recurrent Opacification
    - Capsulotomy Size: <3 mm, increased risk
    - Age at Surgery: 4.7 times higher in children <1 year of age
    - Sulcus Versus Bag Fixation: no significant difference??
    - Type of Cataract: traumatic > congenital
    - Associated Ocular and Systemic Conditions: PFV (persistent fetal vasculature) or microcornea; ocular conditions such as rubella syndrome, toxocariasis, toxoplasmosis, and pars planitis; and systemic diseases such as juvenile rheumatoid arthritis are associated with a higher incidence
- **Secondary Membrane Formation**: closure across a previously open space such as the pupillary membrane after anterior capsulotomy or a posterior membrane after posterior capsulotomy.
- **Pupillary Capture**: 8.5 to 41%, when IOL is in the sulcus or small optic IOL implanted
- **Deposits on the IOL Surface**: pigments, inflammatory cells, fibrin, blood breakdown products
- **IOL Decentration:**
- **Delayed Postoperative Opacification of Foldable IOLs**
- **Postoperative Glaucoma:**
  - 6.1% (Chrousos study)
  - 3 to 32%
  - More in aphakia than in pseudophakia

- Mechanism:

  1. ***open-angle mechanism (Walton's)*** →circumferential repositioning of the iris insertion anteriorly at the level of the posterior or mid-trabecular meshwork with resultant loss to view of the ciliary body band and scleral spur occurred.

  2. ***pupillary block and chronic angle closure*** from peripheral anterior synechiae as the typical mechanism following cataract removal by the "aspiration" mechanism. (theory not accepted now)

- **Risk Factors**

  - microcornea, poorly dilating pupils, surgery at <1 year of age, the presence of other ocular disease (e.g., congenital rubella syndrome), nuclear cataract, persistent fetal vasculature (PFV), and performance of a posterior capsulorhexis.

- **Treatment**

  - A surgical or laser peripheral iridectomy is standard treatment once pupillary block is recognized.

  - seton implantation, trabeculectomy, and cyclodestructive procedures.

- **Retinal Detachment:**

  - **1 to 1.5%.**

  - higher incidence of RD in males, myopes, those in the second and fourth decades of life, and those with a longer interval after cataract surgery

  - **Post YAG Cap: 2.5% in 1 year, 3.6% in 2 years.**

- **Cystoid Macular Edema**

  - Typically CME is noted 4 to 16 weeks after cataract surgery

  - Relatively less than adults due to better vascular stability

  - Angiographical CME: as high as **70%**

  - clinical CME: **0.2 and 0.4%**

  - CME in c/o vitreous loss during cataract surgery: **10 to 20%**

  - main etiologic factors: direct vitreous traction on the macula, ocular inflammation, increasing age, and other contributory factors such as hypotony

- **Hemorrhagic Retinopathy:** flame-shaped retinal hemorrhages during the first 24 hr following surgery, are nonprogressive, and resolve within a few weeks.
- **Strabismus**:
  - 33.3% of patients preoperatively
  - 78.1% of patients postoperatively (aphakia)
  - 9% of children with unilateral pseudophakia

Management of Residual Refractive Error

After Surgery in Infancy

- small soft eyes will not yield a reliable refraction
- marked temporary astigmatism (often 3 to 5 D [diopters]) will be seen initially
- axial growth in a normal eye is 4.5 mm = 10D over the first 2 years
- **maximum single IOL**: ***30 D → up to 40 D*** *can now be ordered*

After Surgery in Toddlers

- 2 to age 6 years: 0.4 mm per year
- Unlike infants, these children are prescribed their full cycloplegic refraction for distance and a +3.00-D bifocal for near viewing.

After Surgery in School-Aged

- plano refractive aim when surgery was done at age 10 years

Aphakia

Contraindications to Intraocular Lens Implantation

1. Institutional factor: Nonavailability of an IOL
2. Surgical factor: Surgeon prefers not to implant a lens in the patient.
3. Patient factors: Minimum age at surgery for an IOL implantation varies from surgeon to surgeon and varies between unilateral and bilateral cataracts.
4. Ocular factors: Vary from surgeon to surgeon: ***associated uveitis, severe microphthalmia such that IOL size is not feasible to implant, persistent fetal vasculature, inadequate anterior and/or posterior capsular support***, etc.
5. Parental factor: Permission/consent denied

Different Modalities to Correct Aphakia

Aphakic glasses

- three primary types of high-power plus-lenses
  1. Lenticular lenses
  2. Aspheric lenticular lenses
  3. Multidrop lenses
- Selecting a Frame: smallest frame, strong color, proper bridge, Cable temples (earpieces) that wrap around the back of the ear, Spring hinges

Contact lenses

1. PMMA
2. Soft material
3. Silicone

- Complications
  - Lens Loss

- Noncompliance
- Infection
- Corneal vascularization
- Power changes
- Parental stress

Epikeratophakia

The only theoretical indication for this procedure is probably a patient with unilateral aphakia who cannot have an IOL implant (because of serious intraocular inflammation, uveitis) and is intolerant of contact lenses.

Intraocular lens

Assessment of Visual Functions

- Resolution acuity: ability to resolve the spatial separation of contrasting visual stimuli

  Recognition acuity: knowledge of the stimulus shape and/or ability to match the shape

Symbol and Letter Recognition

- **LEA symbols** (3 meters)
- **New York Lighthouse Acuity Test** (3 meters)
- **Glasgow acuity cards** (3 meters) →progression of letter size in equal steps, equivalent letter spacing on each line, and an equal number of letters per line.

- Crowding reduces recognition acuity significantly, when stimuli are at high contrast but at low contrast the effect of crowding is negligible.

Preferential Looking Technique

- **Keeler and Teller** cards

- **forced-choice PL**:
- **Cardiff Acuity test**: Instead of a grating pattern, the stimuli consist of simple, recognizable shapes. The stimuli are known as "***vanishing optotypes***" because the shapes disappear at the observer's resolution limit.

Visual Electrophysiology

- ERG to assess retinal function
- VEP to assess function of the retino-cortical visual pathway

Optokinetic Nystagmus

- slow pursuit phase, during which a moving target is smoothly tracked, followed by a fast saccadic phase, allowing refixation when the eye meets its limit of movement in the direction of pursuit.
- Catford drum

VEP acuity up to four times higher than PL acuity in early infancy16 and PL acuity two to three times higher than OKN acuity during the first 3 years

Contrast Sensitivity

- Enhancement Game
- Hiding Heidi (HH) test
- LEA low-contrast symbols

Amblyopia Management

- postoperative compliant occlusion therapy
- Pharmacological penalization

Phakic Intraocular Lenses in Children

- three basic types of lenses
    1. posterior chamber ciliary body sulcus-supported
    2. anterior chamber angle supported
    3. anterior chamber iris fixated: whether the iris will tolerate fixation of the lens haptics

- posterior chamber is a triangular space of about **65 μL**
- zero depth at the pupillary margin
- **angle-supported lens**: said to be supported by the **scleral spur** (which is situated at a depth), actually rest and press against the corneoscleral trabeculae, Schlemm canal, ciliary body in the angle recess, and, sometimes, blood vessels and nerves nearby.

Patient suitability

- **Corneal diameter <11 mm** is not suitable for angle-supported
- **2.7-mm ACD** is the lowest acceptable limit
- Preferably **two YAG-PI**

Complications

Early: Pupil block glaucoma, Inflammatory reactions, Size mismatch, Hyphema, An injury to the crystalline lens

Late: Acute or subacute inflammation, Cataract formation, Erosion of iris and ciliary body, Ovalization of the pupil, Endothelial loss

Pediatric Refractive Surgery

Hutchinson's review

1. Does the pediatric cornea respond differently to the excimer laser than the adult cornea?
2. What is the ideal laser refractive procedure for children?
3. Are refractive outcomes predictable and stable in children?

1. complications such as haze, regression, diffuse lamellar keratitis, and even corneal flap problems have not occurred in children to a greater extent than in adults.
2. The ideal procedure for children would be one that is painless, requires little cooperation, has a precise refractive predictability that is stable over time, has a low risk for loss of best corrected visual acuity, and is adjustable (or can be advanced). ***NO IDEAL PROCEDURE EXISTS***.
3. refractive outcomes are less predictable and are likely to be less stable than in adults.

Traumatic Cataracts in Children

- Trauma has been reported to be responsible for up to **29%** of all childhood cataracts
- **Blunt trauma**: coup, countercoup, and equatorial expansion
  - classically form stellate- or rosette-shaped posterior axial opacities
- **Penetrating trauma**:
  - disruption of the lens capsule forms cortical changes that may remain focal if small or may progress rapidly to total cortical opacification

- **Examination**
  - ***Before Dilation***: BCVA, Fixation preference, Pupillary reflex, IOP, Iris, Zonule
  - ***After Dilation***: Slit-lamp examination, posterior segment examination, Gonioscopy

  - AL, Keratometry

- **Timing of Surgery:**
  - IOL implantation at the time of primary repair.
  - not necessarily required at the time of initial repair even when anterior capsular rupture is present.
- **IOL Implantation**
- **Postoperative Complications**: PCO and/or secondary membrane formation, pupillary capture, IOL precipitates, and decentration/dislocation of the implant.

Approach

- ***The Incision***: MVR for Bimanual, "near clear" incision for IOL, The **superior approach allows the wound to be protected by the brow and Bell's phenomenon in the trauma-prone childhood years.** Both scleral tunnels and corneal tunnels can be easily made from a superior approach since children rarely have deep-set orbits or overhanging brows.

- ***Anterior Capsulotomy***:
  1. CCC
  2. Vitrectorhexis
  3. high-frequency endodiathermy (Kloti radiofrequency endodiathermy)
  4. Fugo plasma blade
- ***Phacoaspiration:***
- ***Primary IOL Implantation:***
- ***Secondary IOL Implantation:***
- ***IOL Power Selection:***
- ***Management of the Posterior Capsule***
- ***Postoperative Management***

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