‘EVALUATION OF DIFFERENCE IN THE ANTERIOR CHAMBER ANGLE FOLLOWING CATARACT SURGERY IN SENILE CATARACT’

By

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Dissertation submitted to the

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION ANDRESEARCH CENTRE, KOLAR

In partial fulfillment of the requirements for the degree of

MASTER OF SURGERY

IN

OPHTHALMOLOGY

Under the guidance of

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The Institutional Ethics Committee of Sri Devaraj Urs Medical College, Tamaka, Kolar has examined and unanimously approved the Synopsis entitled **"Evaluation of Difference in the Anterior Chamber Angle Following Cataract Surgery in Senile Cataract"** being investigated by Dr.KARISHMA AGGARWAL & Dr. Sandhya R in the Department of Ophthalmology at Sri Devaraj Urs Medical College, Tamaka, Kolar. **Permission is granted by the Ethics Committee to start the study.**

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LIST OF ABBREVATIONS

SL NO	ABBREVATIONS	FULL FORM
1	POAG	PRIMARY OPEN ANGLE GLAUCOMA
2	ACG	ANGLE CLOSURE GLAUCOMA
3	AC	ANTERIOR CHAMBER
4	IOP	INTRAOCULAR PRESSURE
5	N	NUMBER OF PATIENTS
6	mm	MILLIMETER
7	ACA	ANTERIOR CHMABER ANGLE
8	PCIOL	POSTERIOR CHAMBER INTRAOCULAR LENS
9	SL	SCHWALBE'S LINE
10	SS	SCLERAL SPUR
11	RPE	RETINAL PIGMENT EPITHELIUM
12	TM	TRABECULAR MESHWORK
13	CBB	CILIARY BODY BAND
14	CB	CILIARY BODY
15	PCI	PARTIAL COHERENCE INTERFEROMETRY
16	GAT	GOLDMANN APPLANATION TONOMETRY
17	CDR	CUP DISC RATIO
18	VA	VISUAL ACUITY
19	AL	AXIAL LENGTH

20	ACD	ANTERIOR CHAMBER DEPTH
21	LT	LENS THICKNESS
22	VCD	VITREOUS CHAMBER DEPTH
23	PSC	POSTERIOR SUBCAPSULAR CATARACT
24	LOCS	LENS OPACITIES CLASSIFICATION SYSTEM
25	SICS	SMALL INCISION CATARACT SURGERY
26	CCC	CONTINUOUS CURVILINEAR CAPSULORRHEXIS
27	RNFL	RETINAL NERVE FIBRE LAYER
28	PACG	PRIMARY ANGLE CLOSURE GLAUCOMA
29	PACS	PRIMARY ANGLE CLOSURE SUSPECT
30	APAC	ACUTE PRIMARY ANGLE CLOSURE
31	PAS	PERIPHERAL ANTERIOR SYNECHIAE
32	LPI	LASER PERIPHERAL IRIDOTOMY
33	CCT	CENTRAL CORNEAL THICKNESS
34	OCT	OPTICAL COHERENCE TOMOGRAPHY

ABSTRACT

TITLE: "EVALUATION OF DIFFERENCE IN THE ANTERIOR CHAMBER ANGLE FOLLOWING CATARACT SURGERY IN SENILE CATARACT"

Need for the study:

As per World Health Organization, cataract is the prime cause of blindness all over the world, held responsible for 47.8% of blindness and accounting for 17.7 million blind people. In India, 80% of the blindness is due to cataract.

Glaucoma is the second most common cause of blindness and a principal reason for permanent blindness globally. Asians embody 47% of cases of glaucoma and 87% of cases with Angle Closure Glaucoma (ACG). Worldwide, primary angle closure glaucoma (PACG) forms nearly half the glaucoma cases.

Many studies have indicated that cataract removal can cause anterior chamber deepening, iridocorneal angle widening, and intraocular pressure decrease in glaucomatous and non-glaucomatous eyes. Studies have also exposed that cataract removal can help in restoring vision and in relieving a narrow angle in eyes. Still, the anatomic predictors of angle widening subsequent to cataract surgery have not been completely understood.

The purpose of this thesis is to assess if patients with senile cataract having narrow angle undergoing cataract surgery and intraocular lens (IOL) implantation are also incidentally getting treated for predisposition to angle closure. This study also correlates the biometric factors related to changes in the angle recess, like changes in Axial length (AL), Anterior

chamber depth (ACD), Lens thickness (LT), and ACA and scrutinizes for any noticeable associations between these parameters.

Objectives:

- To evaluate the difference in anterior chamber angle (ACA) following cataract surgery and in the bag posterior chamber intraocular lens (PCIOL) implantation in senile cataract.
- To correlate axial length (AL), anterior chamber depth (ACD), vitreous chamber depth (VCD) and lens thickness (LT) with angle of anterior chamber.

Methods: This was an observational study, where patients diagnosed with senile cataract and posted for small incisional cataract surgery with PCIOL implantation underwent thorough ocular examination. Anterior chamber angle was evaluated with gonioscopy and Van Herick'grading while AL, ACD, LT and VCD were measured through biometry before and after cataract surgery, and difference was estimated.

Results: Out of 48 participants, males consisted of (47.92%) (n= 23) and females consisted (52.08%) (n=25) of the study population. The 19 (100%) participants with Shaffer's grade 4, 17 participants with grade 3 (100%), 8 (72.73%) with grade 2 and 1 (100%) patient with grade 1 angle preoperatively on gonioscopy became grade 4 post cataract surgery and IOL implantation. A good association was found between cataract extraction and deepening of angle. The mean ACD difference was 0.53mm and mean VCD difference was 1.15mm for before and after cataract surgery values which was statistically significant ($p<0.001$).

Conclusion: This study proves that ACA and ACD change significantly following cataract surgery with PCIOL implantation in patients with senile cataract. All patients demonstrated

an increase in angle of anterior chamber as well as ACD and VCD post cataract surgery.

The study shows that the patients with narrow angle or susceptibility to angle closure in future, on undergoing cataract surgery, also benefit by preventing future development of PAC/PACG or by treatment of a preexisting case.

Keywords: Cataract surgery, senile cataract, anterior chamber angle, axial length, anterior chamber depth, lens thickness, Vitreous chamber depth, angle closure glaucoma

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INTRODUCTION

INTRODUCTION

As per the World Health Organization, cataract is the primary cause of blindness all over the world, accountable for 47.8% of blindness and accounting for 17.7 million blind people.[1]

In India, 80% of the blindness is due to cataract. Cataract surgery is the commonest performed ocular surgery.[2]

Glaucoma is the second most common cause of blindness and a foremost cause of irreversible blindness worldwide. Asians represent 47% of those suffering from glaucoma and 87% of those with Angle Closure Glaucoma (ACG).[3]

Angle closure is categorized by apposition of iris periphery against the trabecular meshwork, that leads to obstruction of aqueous outflow. The term glaucoma is used if there is evidence of glaucomatous optic nerve damage. Angle-closure glaucoma embodies as the 2nd most common form of glaucoma, but its outcome is graver due to a more chance of blindness than in patients with open angle glaucoma. A well timed and exact diagnosis is crucial in order to start the proper and definite treatment that can avoid progression to greater and irreparable impairment. The most imperative step for the diagnosis of possible or apparent angle-closure glaucoma is to assess the anterior chamber depth and the configuration of the anterior chamber angle.

Cataract and glaucoma are both more prevalent among the elderly population and commonly coexist.[4]

Therefore, huge numbers of glaucoma cases also have cataract, which can cause reduction in visual acuity, contrast sensitivity, and examination precision. For these reasons, many glaucoma patients undergo cataract surgery. Cataract surgery is considered to be a positive factor that aids in the inhibition of angle closure glaucoma, and various studies have stated that cataract surgery can reduce IOP in glaucoma patients. Lens removal by means of cataract

surgery can aid in preventing or treating angle closure glaucoma with severely narrowed angles. After cataract surgery, the anterior chamber angle configuration might widen, thus lowering IOP.[5]

The anatomy and functions of angle of anterior chamber is significant in aqueous humor outflow. Open angle status is a more favorable structure in aqueous humor drainage.

In this study, we will evaluate if anterior chamber angle widens after cataract surgery and thus, in turn benefits in preventing angle closure glaucoma attacks likely in future.

We will also look for correlation between various parameters – axial length, anterior chamber depth, lens thickness and vitreous chamber depth, before and after cataract surgery.

OBJECTIVES

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- To evaluate the difference in anterior chamber angle (ACA) following cataract surgery and in the bag posterior chamber intraocular lens (PCIOL) implantation in senile cataract.

- To correlate axial length (AL), anterior chamber depth (ACD), vitreous chamber depth (VCD) and lens thickness (LT) with angle of anterior chamber.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Anatomy of Angle of Anterior Chamber [6]

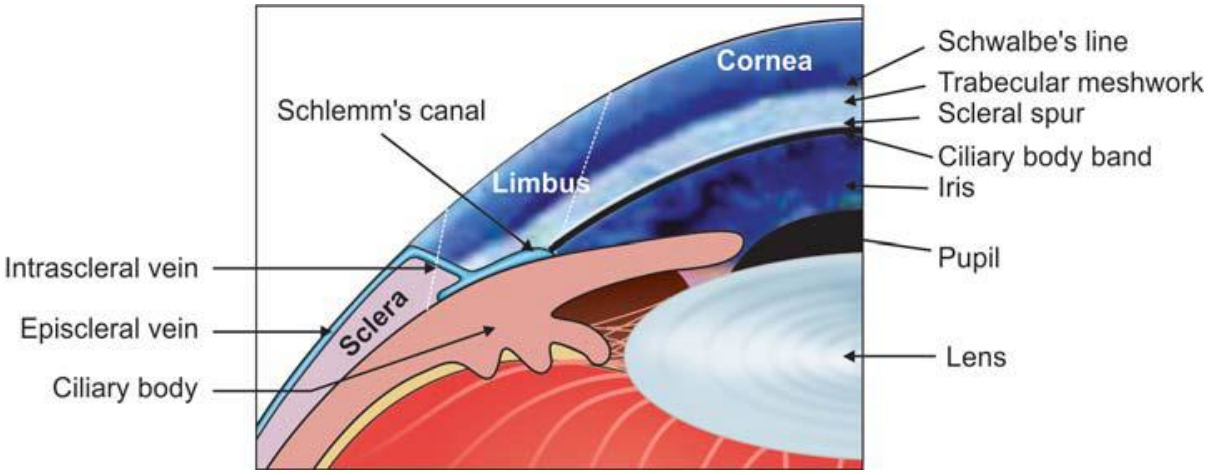


FIGURE 1- ANATOMY OF ANGLE OF ANTERIOR CHAMBER (ACA)

- In normal angles, the following structures should be seen on gonioscopy:
    - Schwalbe´s line
    - Trabecular meshwork
    - Scleral spur
    - Ciliary body band
    - Few other findings may be seen in normal or abnormal angles.

1. **Schwalbe's line** – It is the anterior most structure apparent on gonioscopy. It is a collagen condensation of Descemet´s membrane, that is present between the endothelium of cornea and the trabecular meshwork. It is characteristically seen as a slim, translucent line that projects into the anterior chamber and may have considerable pigmentation over it.

2. **Trabecular meshwork** - It lies posterior to Schwalbe's line and extends to the scleral spur. It has a dull grey appearance and is a little translucent, but has some pigmentation over the lower half. Schlemm's canal can be apparent through it occasionally, when blood refluxes at the time of gonioscopy.

3. **Scleral spur**- It follows posterior to trabecular meshwork. It is a transitory extension of sclera constituting the inferior wall of a scleral pocket in which Schlemm's canal lies. The longitudinal ciliary muscle inserts here. It looks white and has an opaque nature and seems like a thin white line under the trabecular meshwork.

4. **Ciliary body band**- This is apparent on gonioscopy below the scleral spur like a grey to dull brown band. Its apparent thickness depends on the iris insertion.[8]

5.

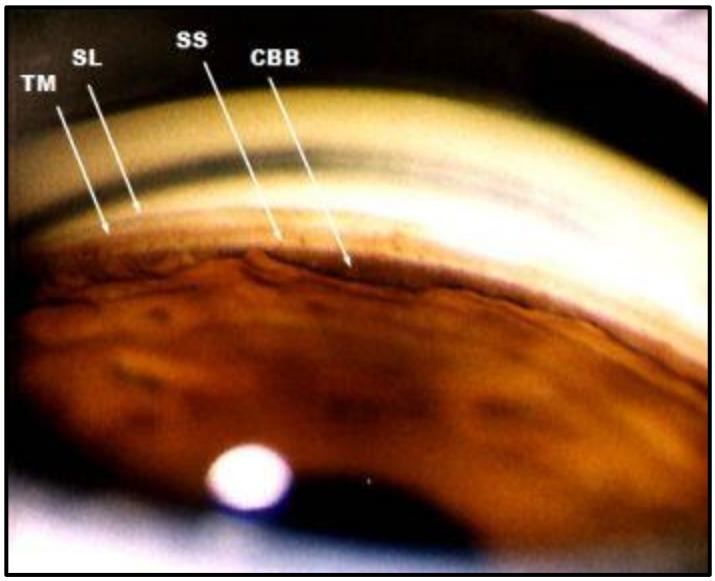


Figure 2 - Angle of Anterior chamber on Gonioscopy

GONIOSCOPY AND ANGLE GRADING

Gonioscopy is a procedure for evaluating the angle of anterior chamber (ACA), and also aids in therapeutic procedures like laser trabeculoplasty and goniotomy.

Principle [9]

As light travels from a medium having higher refractive index to one with lower refractive index, (like cornea to air) it is reflected at their interface unless the angle of incidence is less than a certain 'critical angle' which is dependent on their refractive index difference. Since the refractive index of a goniolens is equivalent to corneal refractive index, it neglects total internal reflection by replacing the tear film–air interface with a tear film–goniolens interface. Light rays can then be seen as they leave the contact lens, directly or indirectly.

Indication of gonioscopy - To rule out angle-closure or secondary causes of IOP elevation, such as angle recession, pigmentary glaucoma, neovascular glaucoma, and exfoliation syndrome.

Types of gonioscopy

1. **Indirect gonioscopy** - Indirect goniolenses have a mirror that reflect rays from the ACA such that they leave the goniolens at lesser than the critical angle. The opposite angle is viewed through the mirror which can be seen only on slit lamp.

2. **Direct gonioscopy** - Direct goniolenses construct the viewing surface of the lens in a domed or slanted conformation so the light rays leaving it strike the contact lens/air interface at a steeper than critical angle to reach the observer. It is called direct gonioscopy since light

rays from the angle are seen directly, deprived of any reflection within the lens.

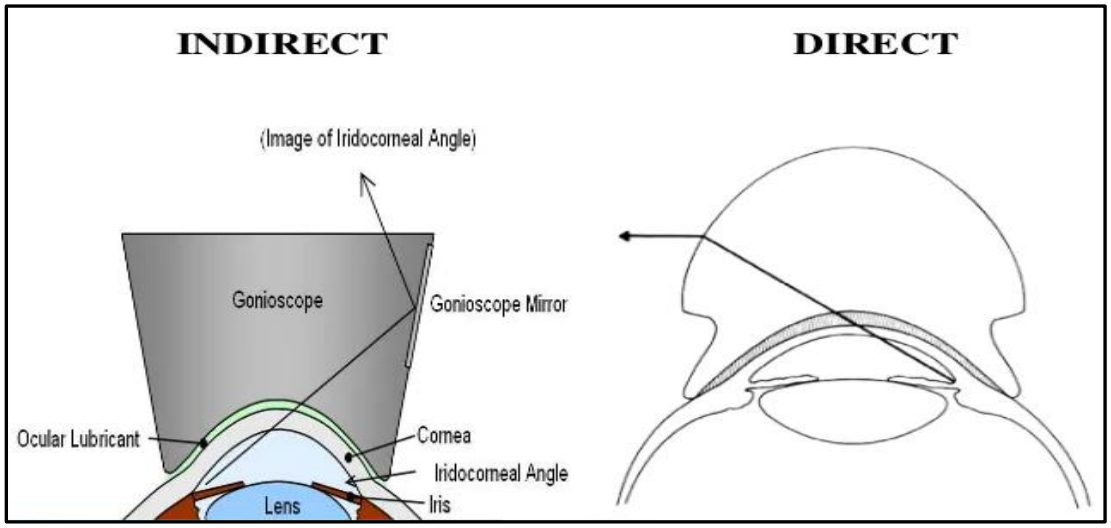


Figure 3 - Principle of indirect and direct gonioscopy

Technique:

The patient is settled at the slit lamp and counselled about the procedure. A drop of local anesthetic is instilled. A drop or two of coupling fluid (Hypromellose 0.3%) is placed on the contact surface of the goniolens. No coupling fluid is required for indirect gonioprisms. The patient is then instructed to open both eyes and look upwards. The examiner then pulls down slightly on the lower lid and places the lens on the surface of the eye. The patient is then instructed to look straight ahead. The slit lamp is fine tuned to optimize the view. All angle structures are identified in all 4 quadrants. The gonioscopic image is then interpreted. The goniolens is moved to view each section of the iridocorneal angle. On completion, suction is broken carefully by asking patient to tightly close the eyelids. The instruments are cleaned and patient's eyes irrigated.

Goniolenses (direct gonioscopy)

Lens	Description
Koeppe	Original diagnostic goniolens
Richardson- Shaffer	Koeppe lens in smaller size, used in infants
Barkan	Original goniolens used for surgeries
Thorpe	Goniolens used in operation theatre for surgery and diagnosis
Swan -Jacob	Goniolens used for surgeries in children
Layden	Used for gonioscopy in premature infants

Table 1 - Types of goniolenses

Gonioprisms (indirect gonioscopy)

Prism	Description
Goldmann single mirror	Mirror forms an angle of 62 degrees during gonioscopy
Goldmann three-mirror	One mirror used for gonioscopy, two for viewing retina
Zeiss four-mirror	All 4 mirrors form an angle of 64 degrees for gonioscopy; it needs a holder
Posner four-mirror	Modified Zeiss four-mirror gonioprism that has a handle
Sussman four-mirror	Handheld Zeiss-type gonioprism
Thorpe four-mirror	4 mirrors, forming an angle of 62 degrees for gonioscopy, needs a coupling agent
Ritch trabeculoplasty lens	Four mirrors, two inclined at 59 degrees and two at 62 degrees, with convex lens over two, used for gonioscopy and trabeculoplasty

Table 2 - Types of gonioprisms

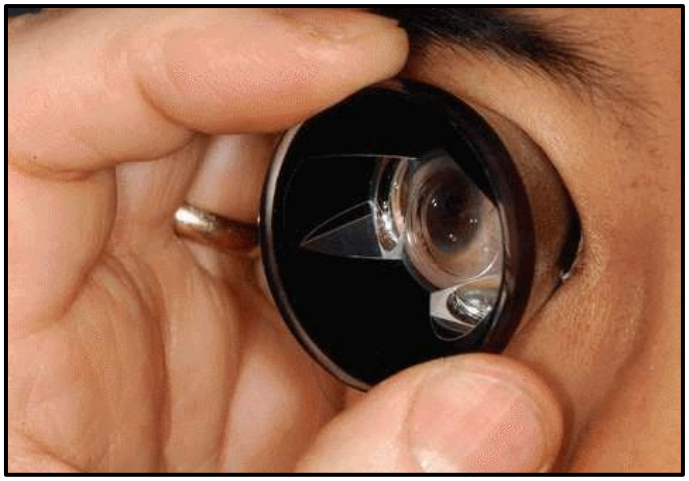


Figure 4 - Goldmann three – mirror gonioprism

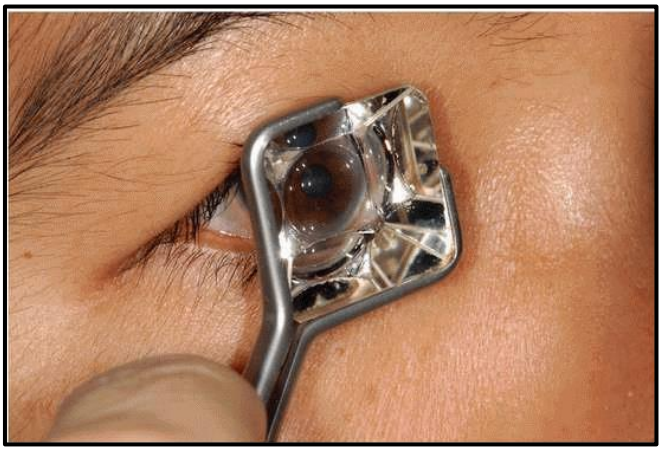


Figure 5 - Zeiss four- mirror gonioprism

The Zeiss four-mirror gonioprism has four mirrors inclined at 64 degrees for assessment of ACA, so there in no requirement to rotate it. It is straddled over an Unger holder. The newer varieties like Posner gonioprism have a permanently attached holding rod while the Sussman gonioprism are handheld. The posterior curvature of these four-mirror prisms is comparable to corneal diameter; therefore, the tear film acts like a fluid bridge, and there is no need for a coupling agent. The Goldmann- and Zeiss-type apparatuses give an indirect view of the anterior chamber angle through a mirror opposite to the quadrant being evaluated.

Grading of Anterior chamber Angle based on Gonioscopy

Many classification systems have been proposed to grade the anterior chamber angle:

1. Shaffer's classification system [10]

Shaffer's grading	Angle status	Structures visible	Width (in degrees)
GRADE 0	Closed	None	0
GRADE 1	Extremely narrow	Only Schwalbe's line (SL)	< 10
GRADE 2	Narrow	SL and Trabecular Meshwork (TM)	10-20
GRADE 3	Open	SL, TM and Scleral Spur (SS)	20-35
GRADE 4	Wide open	SL, TM, SS and Ciliary Body Band (CBB)	35-45

Table 3- Shaffer's classification system of angle

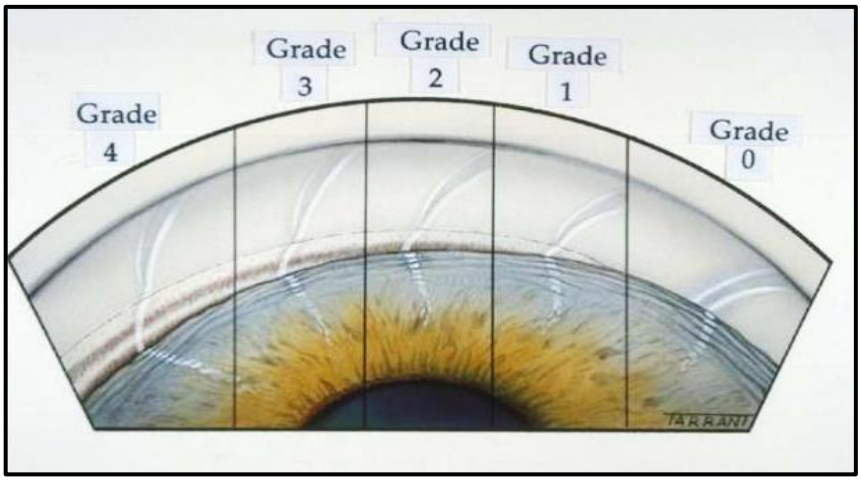


Figure 6 - Grading of angle width according to number of visible structures

2. The Scheie Classification System

Grade	Visibility	Interpretation
Wide	Wide	Open, all structures visible
I	Slightly Narrowed	Ciliary body visible, but recess obscured by the last roll of the iris
II	Apex not visible	Ciliary body not visible
III	Posterior half of trabecular meshwork not visible	Ciliary body, scleral spur, and posterior half of the trabecular meshwork not visible
IV	None of the angle structures visible	Ciliary body, scleral spur, and trabecular meshwork not visible

Table 4 - Scheie Classification System of angle

3. **Spaeth Classification**[11]

It takes four parameters into consideration:

1**. Site of iris root insertion**

A- Anterior of TM (i.e., Schwalbe's line)

B -Behind Schwalbe's line (at the level of TM)

C -Centered at the level of scleral spur

D -Deep to scleral spur (i.e., anterior to CB)

E -Extremely deep inserted into CB

2. **Width or geometric angle of iris insertion**

The angle between the intersection of imaginary tangents formed by peripheral third of iris and the inner wall of corneoscleral junction. It is graded as 10, 20, 30 degree and 40 degrees.

3. **Contour of peripheral iris near the angle**

S -Steep or convex configuration

R -Regular or flat

Q -Queer – deeply concave

4. **Intensity of trabecular meshwork pigmentation:**

Minimal or no pigment to dense pigment deposition (grade 4).

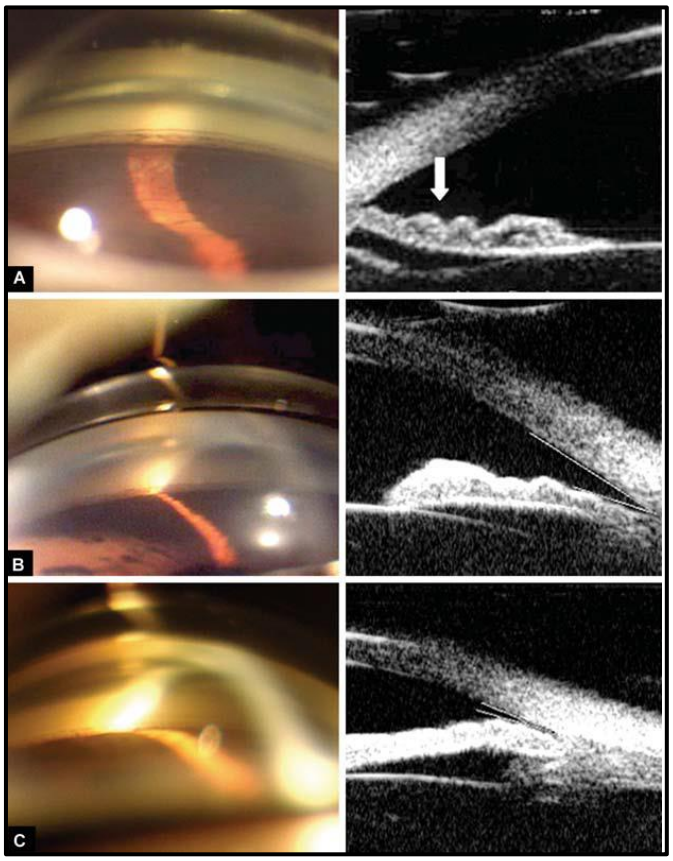


Figure 7 -SPAETH'S GRADING
(A) queer; (B) regular; (C) steep

OCULAR PARAMETERS

1. **Axial length (AL)** -It is calculated as the distance from the surface of cornea till the retinal pigment epithelium (RPE) or Bruch's membrane that is seen as an interference peak on A scan.[12] An average newborn eyeball has an AL of around 16 mm in diameter which grows into almost 19.5 mm in an infant. The eyeball expands progressively, to the length of about 24-25 mm.[3] Maximum of the AL lengthens in the first 3 to 6 months of birth and then its development gradually reduces over the next 2 years. The adult size is reached by 3 years of age. [2] In adults, axial length remains stable and unchanged. The average adult values for AL are 22-25 mm. [13]

   AL has diverse applications in ophthalmology. Estimating the normal range of AL assists to regulate the ocular refractive status and may offer an understanding of the actions to decrease the errors in calculating the IOL power. Axial Length is also related to environmental influences like near work, educational status and height of individuals. It can be linked to genetic variants.

   AL is a quantifiable variable. Methods of calculation include–

   1. Ultrasonography: Contact or Immersion techniques including amplitude (A) Scan or brightness (B) Scan

   2. Optical methods - Partial Coherence Interferometry [14]

2. **The anterior chamber depth (ACD)** - It denotes the distance between the anterior corneal surface up to the anterior surface of the lens.[15] By the age of 15 years, the anterior chamber classically reaches its maximum depth while the lens achieves its minimum thickness.[16] The anatomic features of the eye that together produce a shallow anterior chamber include a thicker lens which is placed more anteriorly, smaller corneal diameter, lesser posterior curvature of cornea and a shorter AL of the

eyeball.[17, 18, 19] The mean ACD of an adult emmetropic eye is 3-4 mm. It is seen that ACD is not a stationary dimension; it can undergo rapid, transient change.[20] The prevalence of angle-closure glaucoma increases with smaller diameter of cornea and shallower ACD.[21]

3. **The lens thickness (LT)-** It increases with age. For overall increase in LT, changes at the anterior and posterior segments of the lens may be different.[22] The anterior surface of the lens goes more anteriorly, while the posterior surface goes a little posteriorly, with an increase in the LT. Thus, the central position of the lens shifts anteriorly. [23]
4. **Vitreous chamber depth (VCD)**- It is the distance from the posterior lens surface up to the retinal pigment epithelium. It is strongly correlated with ocular axial length (AL). VCD: AL is persistently related with ocular biometry that includes the anterior segment parameters too. In comparison to a normal/shorter eye, larger proportion of a myopic eye ball is composed of the vitreous chamber.[24]

Demographic Factors affecting ocular parameters

1. **Age-**

The anterior chamber depth and volume reduces with age probably due to condensing and forward displacement of the lens. [25] The AL shows a declining trend with increase in the age in both males and females. [26] Therefore, the proportion of patients with critically narrow angles is greater in older age groups.

2. **Gender-**

Females have shallower anterior chamber compared to males. Therefore, females probably predominate the populations with pupillary block glaucoma.[27,28] Also, females have significantly shorter AL than males. [26]

3. **Diurnal Variation** -

Anterior chamber depth and volume display diurnal variation. Their values decrease in the evening. [29]

4. **Ethnicity**-

A study of patients with chronic ACG having Asian or African ethnic background showed an abnormal anterior lens position with normal lens thickness, indicating an ethnic impact on these biometric parameters. [30]

BIOMETRY [31]

One of the main steps to attain the intended refractive result is intraocular lens power calculation, which is a chief goal of current day cataract surgeries. Several devices as well as formulas are presently accessible, permitting precise estimation of the IOL power required to obtain the target refraction, and also to measure Axial Length, Anterior Chamber Depth, Lens Thickness and Vitreous Chamber Depth. For a long time, A-mode ultrasound biometry was thought to be the gold standard for estimation of AL and ACD. The IOL Master from Carl Zeiss, which is based on the principle of Partial Coherence Interferometry (PCI) was introduced in late 1990's. The latest biometry device, which came up in 2008 is the Lenstar LS 900 by Haag Streit.

Types of biometry:

1. Contact Ultrasound Ocular Biometry

A-mode ultrasound contact ocular biometry was thought of as the best biometric device for a very long time. There is a special crystal implanted in its probe that oscillates and produces a high-frequency sound wave. This sound wave enters the eye and gets converted into a one-dimensional time-amplitude depiction of echoes received on the way of the beam through the eye. The distance between these spikes of various echoes which are logged on the

oscilloscope screen indirectly give the dimensions of ocular tissues like the axial length or lens thickness (LT). The peak of the spike corresponds to the strength of the ocular tissue that returns the echo. The A-mode ultrasound biometry exists in two forms: (a) contact biometry, and (b) immersion biometry.

- For Contact applanation biometry, a probe is positioned on the anterior corneal surface under topical anesthesia. Disadvantages: It is predisposed to faults because of the need to indent the cornea as well as off-axis measurements. There is a risk of spreading infections.
- For Immersion biometry, saline is filled in a scleral shell which is positioned between the probe and the eye. This is better as there is no need for corneal indentation.

Figure 8 -Contact Ultrasonic Biometry

2. Non-Contact Optical Biometry

For precise calculation of Axial Length, optical biometry is gaining popularity. Advantages include that it is quick, easy to perform, and it is a non-contact technique. The IOL Master which is based on PCI, requires a laser diode infrared light (780 nm) for the estimation of axial length. The ACD is estimated using an adjacent slit-illumination with this apparatus. The anterior curvature of cornea is measured at 6 orientation points which are arranged in a hexagonal design around the 2.3 mm optical zone. The new Lenstar LS 900 uses an 820 nm

super luminescent diode. Central corneal thickness can also be calculated with along with AL and LT. The Lenstar can even calculate retinal thickness, pupil dimensions and centration. There is a difference in the ACD dimensions of both, IOLMaster and the Lenstar. The Lenstar calculates ACD from endothelium of cornea to the anterior surface of lens. The IOL Master calculates ACD from epithelium of cornea to the anterior lens surface. These IOL Master and Lenstar LS 900 have similar results for mean AL, ACD, and Keratometry interpretations. The mean variance in AL calculations was just 0.01 mm ± 0.05 between the two apparatus (p=0.12).

The optical biometry apparatus is easy to operate but lack in providing the Axial Length calculations in cases with dense subcapsular cataracts. Since these use laser beam instead of an ultrasound wave, the dense cataracts do not permit the laser beam to pass through and reach the retina to get reflected back.

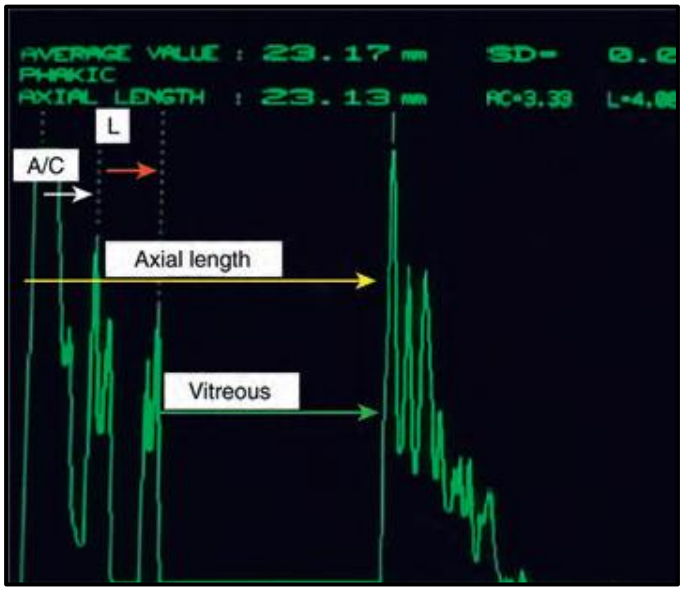


Figure 9 - Ultrasonographic monitor display (A/C, anterior chamber depth; L, lens thickness)

LENS ANATOMY [32]

The crystalline lens has a transparent and biconvex construction. It has the capacity to alter its shape. In adults, the anteroposterior diameter of the lens differs from 3.5 to 5 mm and the equatorial diameter is about 9 to 10 mm. The refractive index of the lens is about 1.39 on an average. The lens is located between the iris and the vitreous. It is held in place by the zonules, that anchor it to the ciliary body. The lens capsule is a smooth basement membrane that faces the inside of a closed cavity. This leads to the addition of any new lens fibers on the inside of the lens, thus making the lens progressively bulky throughout life. The lens capsule is highly elastic and is of variable thickness.

Epithelium is the cellular part of the lens, located anteriorly between the capsule and the fibers. Its cells undergo division to form new cells, that ultimately form the lens fibers. This is how new lens fibers are added until the epithelium is present. Lens fibers are molded by the lengthening epithelial cells. As new fibers are laid down, older fibers move inside. Since the fibers are settled in concentric layers, their tips meet at well-defined places where they form sutures. The 'erect Y' and 'inverted Y' shaped sutures of the embryonic lens are a constant feature. Lens fibers form dense areas, called nuclei, in a consecutive order. The innermost fibers form the embryonic nucleus, followed by the fetal nucleus, the infantile nucleus and lastly the adult nucleus. The adult nucleus grows continuously as new fibers are added. The lens periphery is formed by the most newly added fibers which is called the cortex.

The zonules of Zinn or the suspensory ligaments of the lens form the connection between the lens and the ciliary body. The zonular fibers insert on the anterior, equatorial and posterior parts of the lens capsule. The anterior insertions are dense and bundled. These are thick, strong fibers. The equatorial fibers are present in large numbers in young eyes, but tend to become less numerous as age advances. Posterior fibers ascend from the ora serrata or the ciliary processes, the latter being the most numerous of all zonular fibers. [33]

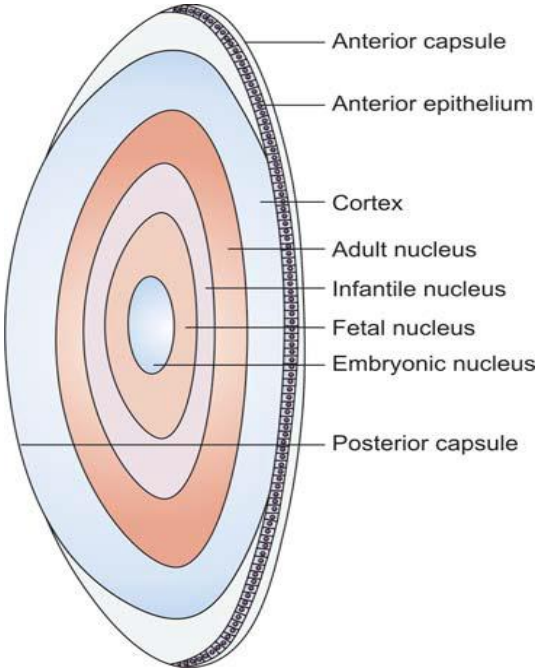


Figure 10 - Structure of the crystalline lens

Lens Transparency

The lens transmits about 80 percent of the light it receives. Factors responsible for maintaining transparency of lens-

1. Thin epithelium
2. Regularly packed cells
3. Orderly arranged protein structure
4. Relative dehydration
5. Avascularity

The lens characteristically contributes only around 18 - 20 diopters of power to the eye. As the lens ages, it undergoes numerous changes. The refractive index of the central layers rises, increasing the power of the lens and inducing myopia. Also, accommodation decays with age, lastly resulting in presbyopia as the lens ultimately loses all focusing capacity.

CATARACT

Cataract is described as the loss of transparency and opacification of crystalline lens. An opaque lens scatters the light when it passes through it and the sharpness of the image in the retina is prevented and which causes the vision to be blurred.[34]

Epidemiology of cataract

Cataract is the principal cause of vision loss in the world. The World Health Organization (WHO) has projected that 18 million people are bilaterally blind because of cataract which leads to 48% of cases of blindness globally. Cataract is also a foremost reason for visual impairment, as 33% of the population worldwide suffer with reduced vision due to this condition. [35]

The prevalence of unoperated cataract in individuals aged ≥60 years was 58% in north India and 53% in south India. The most common type was nuclear cataract i.e., 48% in north India and 38% in south India. The prevalence of the unoperated cataract augmented with age and was more in women than men. [36]

Risk factors for cataract

Type of cataract	Causes	Vulnerable people
Congenital and developmental	Heredity, gestational mal-development of lens, maternal malnutrition, infection, drugs, radiation, Fetal/infantile factors- anoxia, metabolic disorders, birth trauma, malnutrition, congenital anomalies, idiopathic	It may occur since birth or from infancy to adolescence.
Senile	Senescent changes, dehydration, systemic diseases, smoking, oxidative stress, and lack of essential dietary elements.	Elderly persons, mostly those over the age of 50 years.
Traumatic	Some physical damage to the eye lens capsule, penetration of foreign objects etc.	People working in hazardous conditions such as welders and those in glass furnaces.
Complicated	Complications of some chronic inflammatory and degenerative eye diseases.	Patients of skin diseases, allergy, uveitis, glaucoma diabetes, emphysema, asthma, etc.
Metabolic	Metabolic disorders – diabetes mellitus, galactosemia etc.	Persons deficient in certain enzymes and hormones
Toxic	Certain toxicants and drugs - steroids, NSAID's etc.	People on steroid therapy and toxic drugs.
Radiation and Electrical	Infra-red rays, X-rays, ultra violet rays, and powerful electric current etc.	Persons who come in contact with sunlight, artificial radiations, high voltage etc.

Table 5- Risk factors for cataract

Pathogenesis of cataract

Few specific mechanisms accountable for senile cataract include:

- Protein breakdown and accumulation
- Injury to fibre cell membranes
- Glutathione deficiency
- Oxidative injury
- Raised calcium level
- Atypical lens epithelial cell migration

One of the hypothesis states that constant packing of lens fibres into the capsular bag by the constantly active lens epithelium causes changes in the refractive index which will eventually lead to cataract.

With age, lens mass and thickness increases and its accommodative power reduces. With the formation of new layers of cortical fibres concentrically, the nucleus of lens becomes more compressed and hardened. This process is called as nuclear sclerosis.

Due to chemical alteration and proteolytic cleavage of crystallins there is development of high molecular weight protein masses. Large aggregates of proteins cause abrupt variations in the local refractive index of the lens, which leads to scattering of light and decline in transparency. Because of chemical alteration of the nuclear proteins there is rise in its opacity, so the lens turns yellow or brown gradually as age increases. Additional aging changes include reduced glutathione and potassium concentrations and raised sodium and calcium concentrations in the lens cell cytoplasm.

Types of age-related cataract [37]

The structural types of senile cataract are formed mainly by three basic categories:

- Cortical (or cuneiform)
- Nuclear
- Posterior subcapsular cataract (PSC)

1. Nuclear cataract- It encompasses both white scattering and brunescence entities, which usually occur together but give the impression of being distinct entities. As the human lens ages, a slow hypermetropic shift occurs, but this is offset by the occurrence of nuclear cataract.

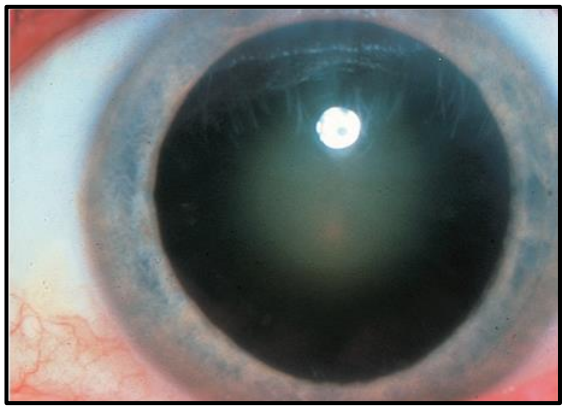


Figure 11- Nuclear cataract viewed with diffuse illumination

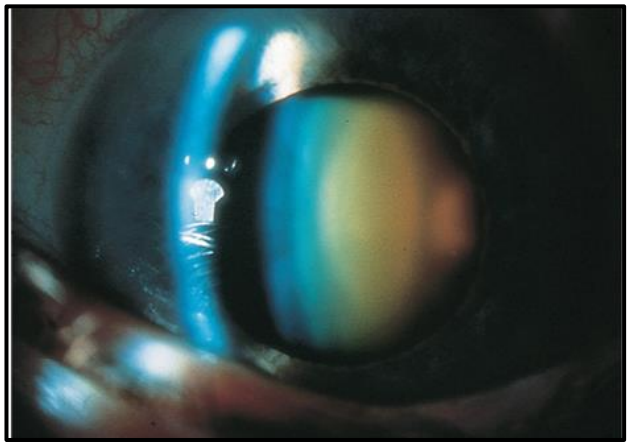


Figure 12- Nuclear cataract viewed on slit lamp

2. Cortical cataract – It can be additionally subdivided into:

- Cuneiform cataract - Occupies the peripheral part of the cortex
- Punctuate perinuclear cataract
- Cupuliform cataract – occurs in the posterior cortex

Wedge-shaped opacities (also known as cortical spokes or cuneiform opacities), have pointy termination slanted towards the center. These seem like white opacities on the slit-lamp examination and as dark shadows on seeing in retro illumination.

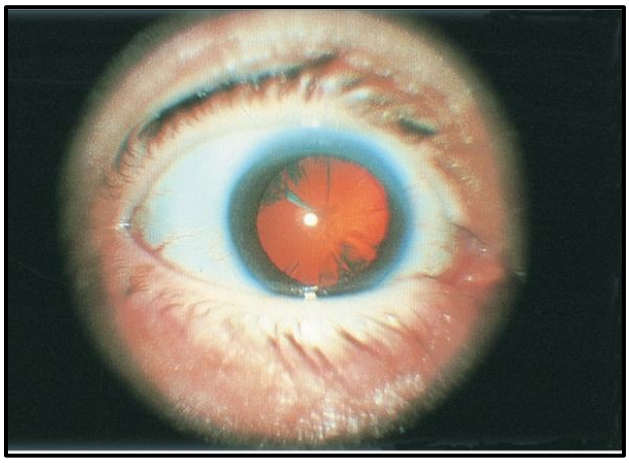


Figure 13- Cortical cataract viewed by retro illumination.

3. **Posterior subcapsular cataract**

Posterior subcapsular cataracts (PSCs) are frequently seen in younger patients comparatively. These are situated in the posterior cortical layer and cause substantial vision loss when they are axial. An elusive iridescent shine in the posterior cortical layers is seen initially with the slit lamp which appear as granular opacities and a plaque like opacity of the posterior subcapsular cortex at later stages.

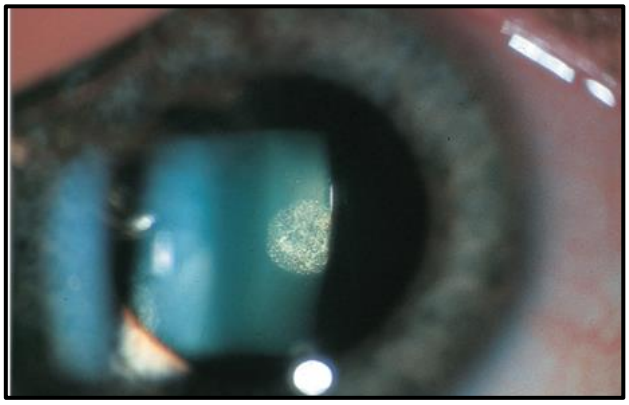


Figure 14 - Posterior subcapsular cataract (PSC) viewed at the slit lamp

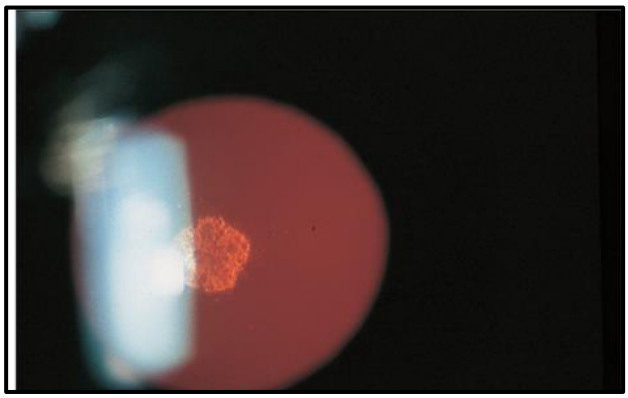


Figure 15- PSC viewed with indirect illumination

- Broadly, based on the extent of the cataractogenesis, the cataracts may be:

I. Immature

II. Mature

III. Hypermature

- **Immature cataracts** are additionally subclassified based on the site of lens opacity as - anterior polar, anterior subcapsular, cortical, nuclear, posterior subcapsular, posterior polar or a mixture of any of these.
- **Mature cataract** - When there are no clear parts remaining in a cataractous lens. It classically appears as a white reflex in the pupil and vision is reduced to hand movements or perception of light.

- **Hypermature cataract**- When disintegrated cortical material outflows from the lens capsule and leaves behind a wrinkled and shrunken capsule. On more cortical liquefaction when unrestricted movement of the nucleus occurs inside the capsular bag, the cataract is labelled as morgagnian.

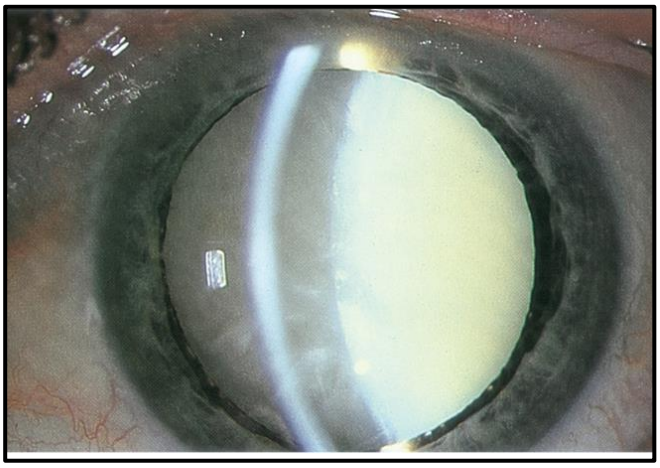


Figure 16- Mature cortical cataract

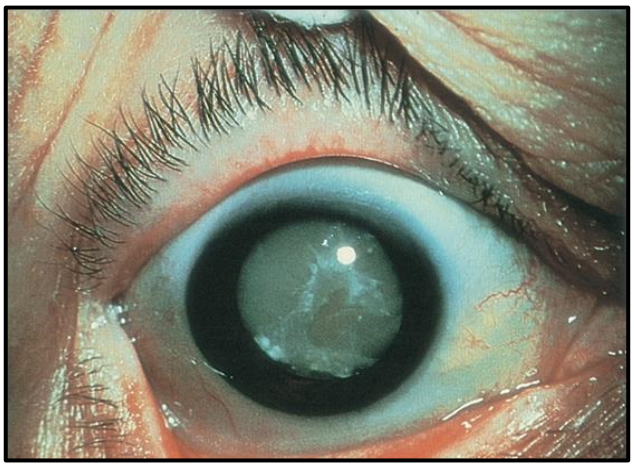


Figure 17 - Hypermature cortical cataract

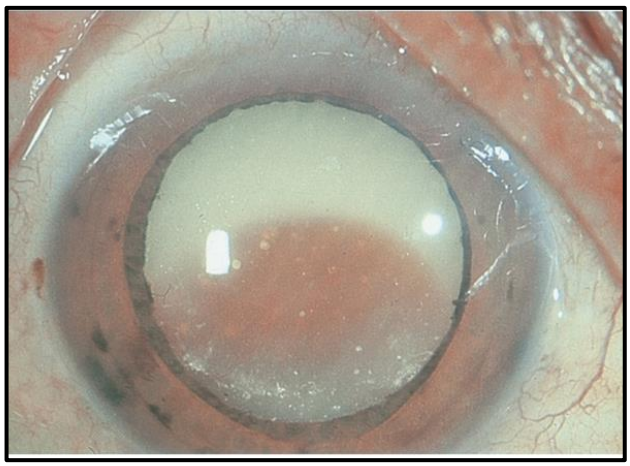


Figure 18 - Morgagnian cataract

A mature, swollen, intumescent cataract can reduce the ACD and ACA causing an increase in intraocular pressure. This mechanism leads to glaucoma called as phacomorphic glaucoma, and signifies an ocular emergency.

The lens opacities classification system (LOCS II and LOCS III) necessitates slit-lamp examination of the cataractous lens via a dilated pupil. The parameters included are nuclear color, nuclear opalescence, cortical cataract, and the posterior subcapsular component. [38, 39]

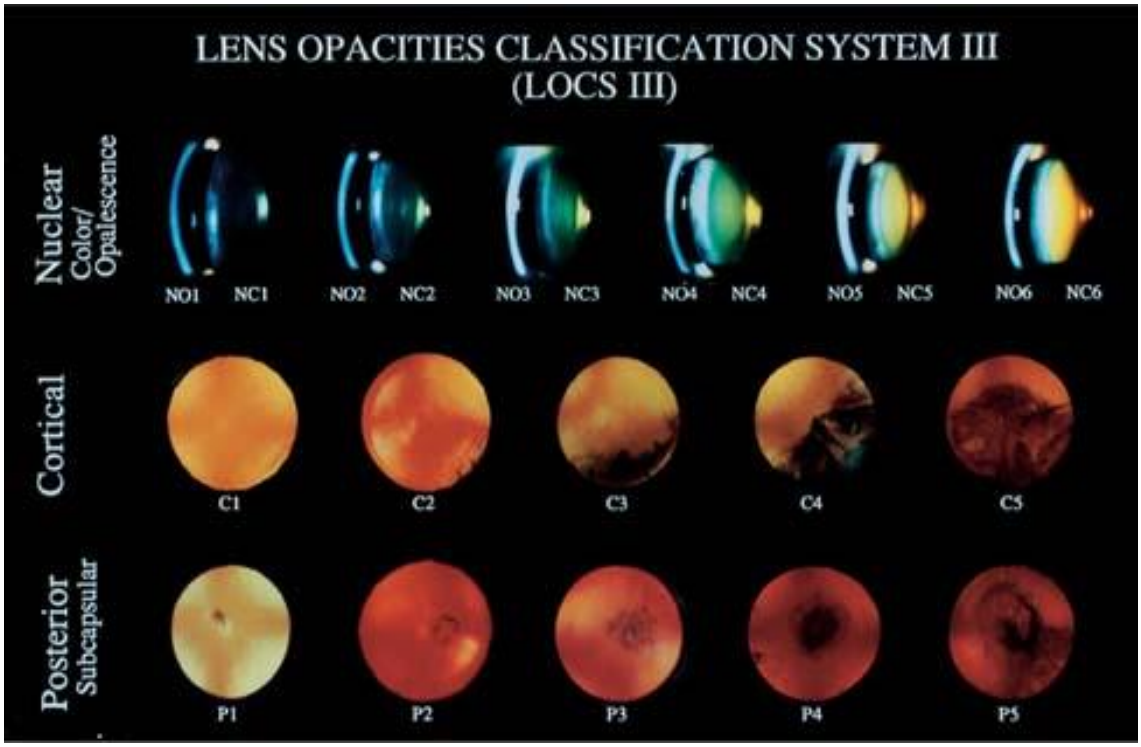


Figure 19- Lens Opacities Classification System III

Cataract surgery [32]

The cataract surgery performed is small incision cataract surgery (SICS). SICS procedures offer a convenient, cost-effective method for removal of cataract. It is essentially a collection of related procedures with the following two common denominators:

a. Extracapsular cataract extraction

b. Tunneled, self-sealing incision

It is commonly acknowledged that regional block is essential for making the scleral incision.

Steps of Surgery–

The Site

• Before cleaning and draping, the conjunctiva is irrigated with povidone iodine solution.

• A superior rectus 'bridle suture' is engaged.

The Incision

The primary groove is made on the ocular surface. The inner facet is clear corneal, to sustain the self-sealing, valvular action. A 'frown' shaped groove is made with its nearest point of approach to the limbus being 1.5 to 2 mm away, falling away on each side or a straight incision is made.

With a bevel up crescent knife the incision is extended anteriorly, and then the plane formed is progressed into clear cornea. The lateral extensions of the tunnel called side pockets, aid to direct the nucleus as it arises. The inner edge of this tunnel must extend 1 mm into clear cornea. A side port incision is created 2-3 clock hours away from main wound.

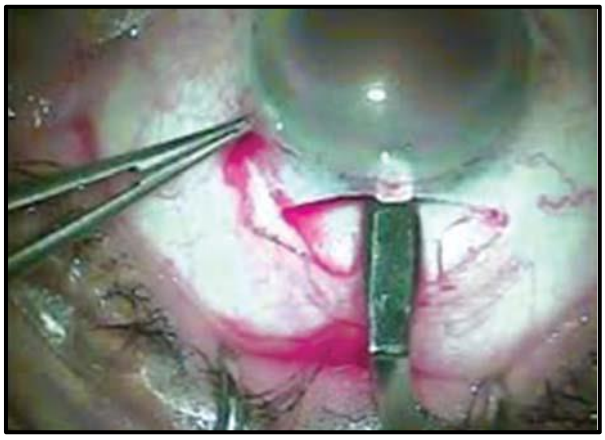


Figure 20- Creation of the self-sealing tunnel with the crescent knife

Figure 21 - Side-port entry

- As the entire tunnel is accurately defined, AC is entered with a sharp keratome and then filled with viscoelastic.

Capsulotomy

- Capsulotomy types: Can-opener or a continuous curvilinear capsulorrhexis
- Trypan blue dye is injected in AC to augment capsular perceptibility

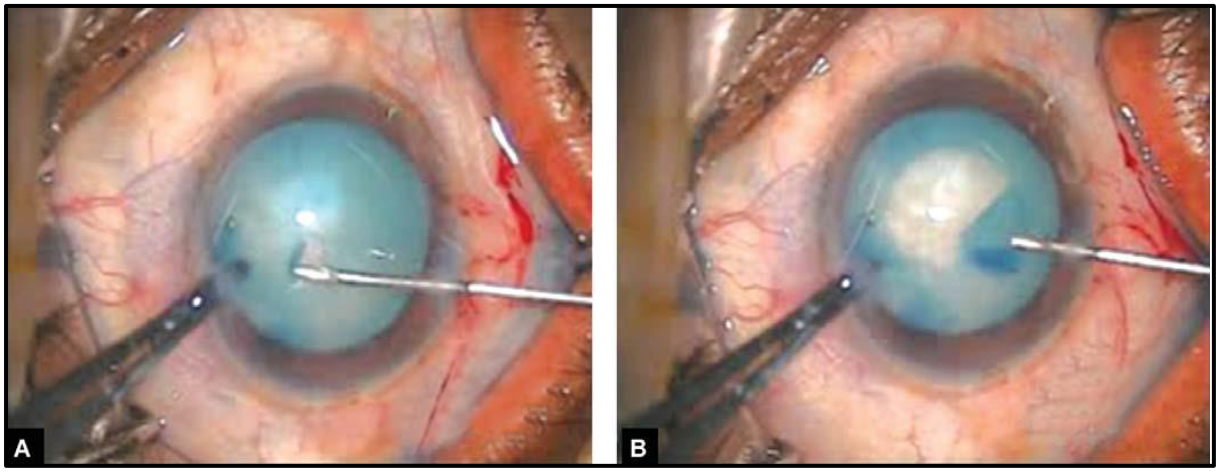


Figure 22- Rhexis in a white cataract

- The main wound is then enlarged to the wanted dimension with a 5.2 mm keratome.
- Hydrodissection or hydrodelineation is performed to free the nucleus of its attachments and then cortical wash is given to decrease its dimensions by washing off adherent cortex and epinucleus.
- After hydroprocedures, the nucleus is rotated within the capsular bag.

Nucleus Management

To bring the nucleus out of the capsular bag and into the AC:

- In can-opener capsulotomy - a spatula is introduced below the nucleus and tipping it forwards, or just a flow of viscoelastic is directed below the superior pole of the nucleus.
- In case of a CCC, first the anterior chamber is filled with viscoelastic. Using a dialer, the nucleus is then sloped to one side, while a spatula is pushed beneath the uncovered pole. With the spatula, lift the superior pole of the nucleus into the AC and then it is dialed while sustaining an upward force till the nucleus entirely comes into the AC. One more apparatus in the other hand can be used to deliver support and track.

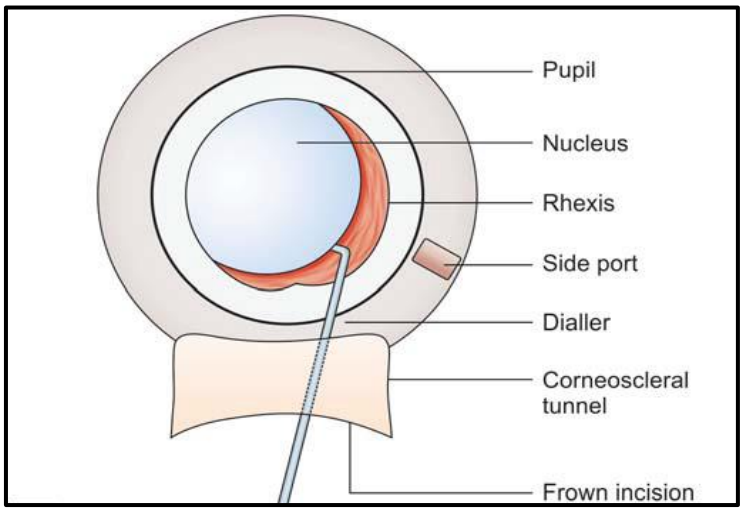


Figure 23- Manipulation of the nucleus into the anterior chamber

Nucleus can be delivered with following methods:

- In viscoexpression, as the AC is filled with viscoelastic, the nucleus is manipulated to a location close to main incision. The posterior lip of the wound is depressed, so that some viscoelastic may flow out along with the nucleus.
- The nucleus can be delivered by engaging a wire Vectis beneath it or by using an irrigating vectis and then directing it out.
- It is vital to cover both the surfaces of nucleus with viscoelastic liberally to enable its smooth delivery with negligible endothelial injury.

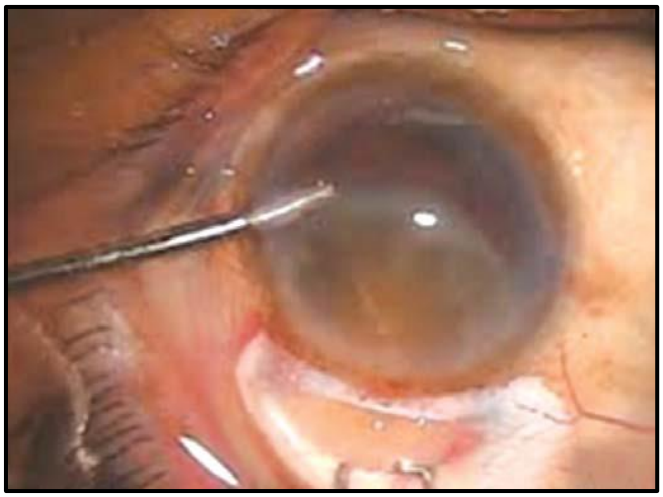


Figure 24- Extrusion of the nucleus through wound

- The residual cortex is removed using a Simcoe cannula, and the subincisional cortex can be cleaned up using a J-shaped cannula. Automated bimanual irrigation and aspiration is a safer method.

IOL Insertion

- A PCIOL is then implanted. A rigid PMMA lens is easily inserted through a 5.5mm incision. After injecting viscoelastic in AC and capsular bag, the IOL is held such that the leading haptic passes in the inferior fornix of the capsular bag and optic is also

pushed across the CCC margin. The grip on the IOL is then freed and the trailing haptic is dialed into the capsular bag.

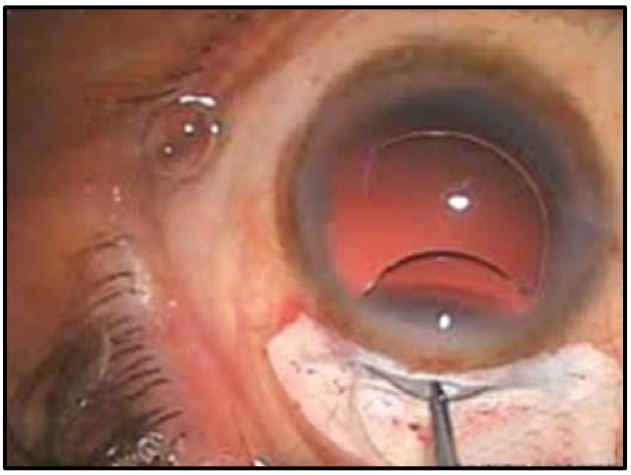


Figure 25 - Insertion of a PMMA IOL through the SICS incision

- As the IOL is well centered, viscoelastic is washed out of the eye and the incisions are hydrated to result in closure.
- The main incision is self-sealing and does not require suturing unless there is any uncertainty in the integrity of the wound. The conjunctival flap is repositioned such that it conceals the external incision.
- Steroid-antibiotic combination is then injected subconjunctivally and the eye is patched.

Post-operative management - Patient has to instill antibiotic- steroid eye drops for upto 6 weeks to avoid infection and diminish inflammation.

Changes in ocular parameters after cataract surgery

Cataract typically causes thickening of anterior cortical space of the lens which can push the iris anteriorly and decrease ACA depth.

As the age advances, lens becomes thicker and there is narrowing of anterior chamber. A

thick lens can affect aqueous humor dynamics because of the shallower AC and narrower ACA. In such cases, cataract removal is seen to upsurge the aqueous outflow. It partly corrects the anatomical as well as physiological difficulties in aqueous humor dynamics.[40]

Extraction of lens by means of cataract surgery generates more space in angle of anterior chamber and also the posterior chamber, particularly in elderly. Several studies have stated that cataract extraction can decrease IOP in glaucoma cases. Subsequent to cataract surgery, ACD and angle parameters change significantly. The configuration of angle widens, and it decreases IOP. [41,42]

Lens removal by phacoemulsification and IOL implantation make further space in posterior chamber. Widening of ACA could therefore ensue during these developments.

Some interconnected theories have been stated to occur after cataract extraction: [43]

(1) The anatomy of anterior chamber undergoes changes, since the IOL is significantly thinner compared to the crystalline lens
(2) The AC deepens, the width of anterior chamber rises allowing more aqueous humor to pass through the TM
(3) The resistance in TM diminishes and the ciliary body processes alter its position causing a reduction in IOP

The association between ACD and ACA can be partially described by the position of the lens and the IOL in the eye. Prior to cataract surgery, the natural lens touches the posterior surface of the iris. Post cataract surgery and IOL implantation, the IOL does not touch the posterior iris surface changing the ACD and ACA after cataract surgery.Few studies even showed AL shortening post cataract surgery [45] whereas some did not discover any statistical significance. [46]

One of the factors to deliberate is that alterations in choroid could lead to change in AL in eyes post cataract surgery. To some extent, choroid increases in thickness along with

increased choroidal vascularity after cataract surgery, causing decrease in AL. [47]

GLAUCOMA

The definition of glaucoma includes a group of conditions with progressive optic neuropathy. It is a long-lasting and multifactorial disorder, producing injury to retinal ganglion cells causing optic disc changes and conforming visual field defects with elevated intraocular pressure. [48]

Classification of the Glaucoma based on initial events:[49]

A. Open-angle glaucoma without other known ocular or systemic disorders:

1. Chronic open-angle glaucoma

2. Normal-tension glaucoma

B. Angle-closure glaucoma without other known ocular or systemic disorders

1. Pupillary block glaucoma

2. Combined mechanism glaucoma

C. Developmental glaucoma

1. Congenital glaucoma

2. Juvenile open-angle glaucoma (overlap with chronic open-angle glaucoma)

3. Axenfeld-Rieger syndrome

4. Peter's anomaly

5. Aniridia

6. Other developmental anomalies

D. Glaucoma associated with other ocular and systemic disorders

Open Angle glaucoma: In this category, the angle of the anterior chamber is open and normal with little structural irregularity in trabecular meshwork which leads to inadequate aqueous humor drainage and causes rise in intraocular pressure.

When there is no other causal association with this disorder, and it may be considered to be hereditary, it is termed as primary open angle glaucoma or POAG. This is the most common type of glaucoma.

Angle closure/Closed angle/Narrow angle glaucoma: In these set of conditions, the ACA of the eye is narrow because of apposition of the iris against the trabecular meshwork leading to inadequate drainage of aqueous humor and subsequently elevation of IOP. It may be primary or secondary to some ocular or systemic abnormality.

Primary Open Angle Glaucoma [50]

The definition of POAG includes a chronic progressive optic neuropathy with distinctive anatomical changes in the optic nerve head and retinal nerve fiber layer without any association with causal ocular disorder or any congenital anomalies. Consistent visual field defects can link to these changes.

The comprehensive clinical presentation of POAG is:

1. Seen in adults
2. IOP >21 mmHg at some stage.
3. On gonioscopy, Angle of anterior chamber is open
4. Signs of optic nerve head damage, like:
    i. Diffuse thinning /focal narrowing/ notching of rim of the optic disc, particularly at the inferior or superior poles.

ii. Recognized development of optic disc cupping (increased cup:disc ratio).

iii. Diffuse or localized aberrations of the peripapillary retinal nerve fiber layer (RNFL), mainly at the inferior or superior poles.

iv. Disc rim or peripapillary RNFL hemorrhages.

v. Optic disc neural rim asymmetry between the two eyes constant with loss of neural tissue.

5. Evidence of visual field defects related with optic disc damage. [51]

Normal Tension Glaucoma

It is defined by following clinical findings along with open anterior chamber angles on gonioscopy:

1. Normal IOP < 21mmHg

2. Optic disc or RNFL changes suggestive of glaucomatous damage.

3. Visual field defects consistent with glaucomatous damage.

Ocular Hypertension [52]

1. Constantly raised IOP >21mmHg
2. Normal looking optic disc and RNFL
3. Normal visual field test results
4. Open anterior chamber angles on gonioscopy

Primary Angle Closure [53]

Angle closure disease is now categorized based on the degree of angle closure, its effect on eye in view of IOP and other iris changes, and the consequence of raised IOP and resulting optic nerve and visual field damage.

Prevalence of primary angle closure [54]

The collective prevalence of PACG in the world was 0.6% for the last 20 years. Women are found more probable to have PACG than men. The maximum prevalence of PACG was found in Asia. At present, 17.14 million people > 40 years old are estimated to have PACG worldwide, out of which 12.30 million are from Asia alone. It is projected that by 2050, the worldwide population having PACG will be 26.26 million, with 18.47 million from Asia alone.

Risk factors for angle closure:

- Female sex
- Older age
- Asian ethnicity (e.g., Chinese)

Ophthalmic risk factors: Eyes with angle closure usually has some biometric features.

The chief ocular risk factor includes-

i. Anterior segment crowding in a small eye
ii. Shallow Central anterior chamber depth (ACD)
iii. Thicker and more anteriorly positioned lens
iv. Short axial length
v. Additional anatomical risk factors that can lead to angle closure seen on Anterior Segment-OCT include- smaller anterior chamber width, area and volume, thicker irides with greater iris curvature, and a greater lens vault.[55]

EPIDEMIOLOGICAL CLASSIFICATION

1. Primary Angle Closure Suspect (PACS)

- Occludable ACA without angle closure signs (like iris atrophy, whorls, peripheral anterior synechiae) and normal IOP, optic disc and visual fields
- Eyes with a primary, unusually narrow ACA recess, in which the peripheral iris is positioned close to, without touching the posterior pigmented TM, is at risk of angle closure.

2. Primary Angle Closure (PAC)

- Occludable angle with signs of ACA closure like iris atrophy, whorls, peripheral anterior synechiae or raised IOP
- Normal optic disc and visual fields

3. Primary Angle Closure Glaucoma (PACG)

- Occludable angle with signs of angle closure like iris atrophy, whorls, peripheral anterior synechiae or raised IOP
- Glaucomatous optic neuropathy
- Corresponding visual field defects
- Primary angle closure can be appositional or synechial closure of ACA – It may be because of pupillary block where the anterior surface of lens is anterior to the plane of the iris insertion into the ciliary body.

Clinical Classification: [56]

Depending on the timing or rapidity of onset of PACG, it can be categorized into acute PACG or chronic PACG.

The clinical progression of acute PACG can be further divided based on the clinical features into following stages:

i. Preclinical
ii. Attack (including acute, subacute or intermediate attacks)
iii. Intermittent
iv. Chronic progression
v. Absolute stage

1. Acute attack stage of PACG - The iris rapidly and entirely covers the entire TM → An abrupt, symptomatic rise in IOP. It can progress to the chronic stage, if not resolved spontaneously or through medical intervention. In a subacute attack, the symptoms have reduced severity and the IOP can decrease without intervention.

2. Chronic PACG - The iris gradually covers the TM in parts, causing formation of peripheral anterior synechiae. The PAS can be distinct or multicentered initially and then progressively enlarge and join. The IOP rises slowly over a long duration. The course is often painless and asymptomatic.

PATHOGENESIS:

Genetics

The role of genetics in angle closure is reinforced by epidemiological conclusions:

First-degree relatives of angle closure cases are at more risk than others, there are high chances of inheritance of anatomical risk factors (e.g.: ACD), and ethnic disparities in the prevalence. [57]

Mechanism involved in angle closure:

I. **Relative pupillary block**

Small anterior segments are more crowded, and susceptible to a greater area of iris lens contact. [58]

In PACG, there may be either appositional or synechial contact between iris and lens causing pupillary block. This leads to resistance to flow of aqueous humor to reach the posterior chamber through the pupil → This results in a pressure gradient between the anterior chamber and posterior chamber. Due to more pressure in posterior chamber, the peripheral iris bows anteriorly → This causes complete or partial obstruction of the filtering area of the trabecular meshwork in ACA (appositional angle closure) → It ultimately causes elevation of intraocular pressure.

Extended or recurrent contact of the peripheral iris with the TM may cause formation of peripheral anterior synechiae (PAS) and functional impairment of the remaining TM.

"The angle closure may or may not be associated with elevated IOP or glaucomatous optic neuropathy, and may occur in either an acute or chronic form." [59,60]

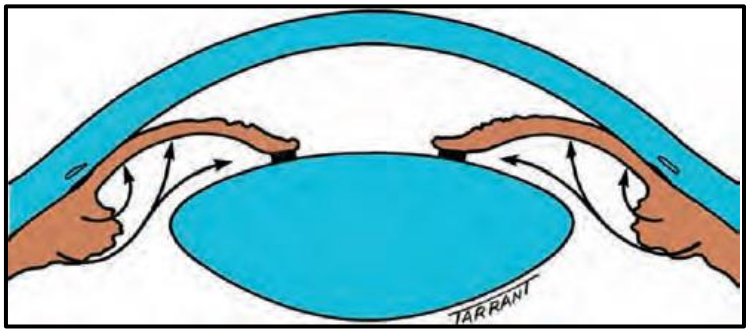


Figure 26- Angle closure due to pupillary block, with anterior iris bowing and iridocorneal contact

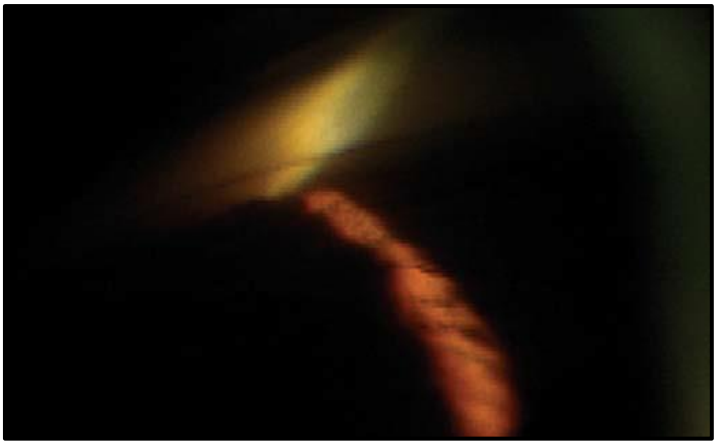


Figure 27- Occludable Angle

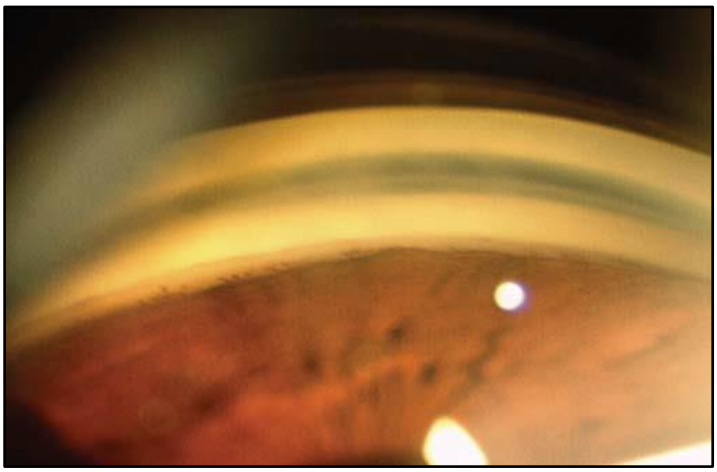


Figure 28- Peripheral anterior synechiae in chronic PACG

II. Non pupillary block [10]

- **Plateau iris** - Specific anatomical causal factors comprise plateau iris and a thicker or more anteriorly situated iris. Plateau iris configuration is considered as flat or a little convex central iris plane, which may be associated with either normal or mildly shallow central ACD. The angle recess is characteristically very narrow and has a sharp backward angulation of iris over anteriorly located and/or orientated ciliary processes.

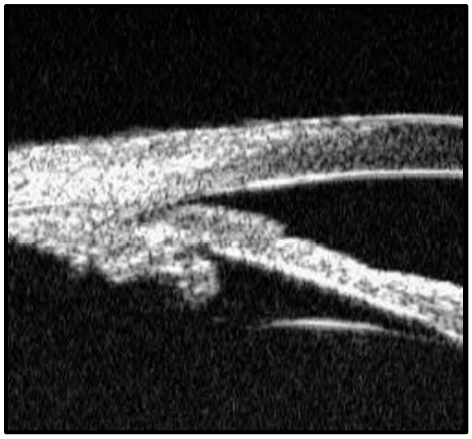


Figure 29- Ultrasound biomicroscopy in plateau iris configuration shows loss of the ciliary sulcus due to anteriorly located ciliary processes

• **Lens-induced angle-closure.** Closure of ACA due to lens-induced changes or due to any pathology behind the lens is considered as secondary angle closure.

- Lenticular causes- It comprises of only such cases where an abrupt change in lens volume or its position causes an acute or subacute elevation of IOP. Generally, it is due to quick development of lens intumescence leading to phacomorphic glaucoma or, anterior lens subluxation.
- Retrolenticular causes include-

→ Malignant glaucoma or ciliolenticular block

→ Posterior segment pathology causing secondary angle closure

III. The term **'Combined mechanism'** has been used for the blend of angle-closure and open-angle foundations for glaucoma.

<u>The pathogenesis of glaucomatous optic atrophy</u> –

This has been a matter of debate since the 1950s, when two ideas were presented in almost the same time.

1. Vasogenic theory of nerve damage:[61]

Von Jaeger proposed that the structural plus functional defects that take place in the optic nerve head of glaucomatous eye are due to ischemia. Recently, Anderson suggested the hypothesis that inhibition of autoregulation of optic nerve perfusion can augment susceptibility of optic disc to pressure-induced ischemia.

2. Mechanical Theory of nerve damage: [62]

In 1858, Muller suggested that the eye can endure quite high IOP. The lamina cribrosa is the fenestrated area in the optic nerve head. The optic nerve fibres pass into the eyeball through this weak point and are reinforced by the glial tissues. When IOP is elevated, the pressure on lamina cribrosa decreases the capillary perfusion as well as axoplasmic flow in the nerve fibres in early phases. Eventually, the direct pressure leads to atrophy of nerve fibre bundles.

3. Schnabel cavernous atrophy-

Schnabel, in 1892, came up with one more concept for glaucomatous optic atrophy. He proposed that atrophy of neural elements leads to formation of hollow spaces, that drags the optic nerve head posteriorly. [49]

Evaluation of glaucoma

Enquiry about known history of diabetes, hypertension, asthma, vasospasm, heart related disease, migraine headache or any other systemic disease should be made.[63]

OCULAR EXAMINATION

The ocular assessment focuses explicitly on the following aspects:

- **Visual acuity measurement:** The best-corrected visual acuity, at distance and at near is obtained.

- **Pupils:** Observe the pupillary reaction carefully. Relative afferent pupillary defect may be detected sometimes. [64]

Anterior segment examination:

- **Iris shadow** - On shining torchlight through the temporal limbus, parallel to the plane of iris to assess AC depth, a shallow anterior chamber is acknowledged when the convex shape of iris does not let illumination of the nasal limbus. [65]
- **Slit lamp biomicroscopy** - It is used for the evaluation of cornea (e.g.: corneal edema may be present in very high IOP), peripheral ACD, iris, lens and anterior chamber angle anatomy, and to find out any secondary causes for raised IOP.
- **Van Herick test** [66]

  → To evaluate the anterior chamber depth, van Herick's technique of grading is used.

  → After seating the patient on the slit lamp, an angle of 60 degrees is created between its illumination and the viewing beams.

  → A thin slit beam is oriented from the periphery at the limbus.

  → The ratio of the anterior chamber width to the peripheral corneal width is evaluated through this alignment of the slit beam to grading is observed.

Van Herick's grading of Angle	Ratio of gap to limbal corneal section	Angle Status
Grade 1	<1:4	Extremely Narrow
Grade2	1:4	Narrow
Grade 3	1:2	Open
Grade 4	</= 1:1	Wide Open

Table 6 - Van Herick's grading of Angle

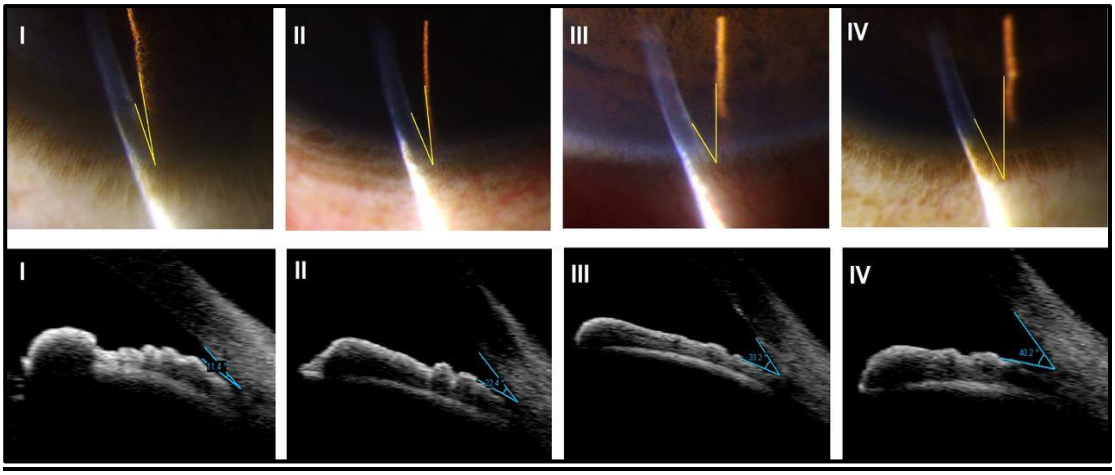


Figure 30 – Van Herick's Grading

- **Gonioscopy** – For the diagnosis of primary angle closure, an occludable angle is essential on gonioscopic evaluation. When the patient looks in a straight direction, if the posterior trabecular meshwork is not observable because of iris convexity for >/= 180 degrees, it is called an occludable angle.

  To diagnose PACG, a cautious assessment of the ACA structures is required to look for angle closure or other reasons for secondarily raised IOP like angle recession, peripheral anterior synechiae, pseudoexfoliation, pigment dispersion in angles, neovascularization of angle or inflammatory exudates. This is done with the help of gonioscopy.

- **Intraocular Pressure Measurement:** "It is defined as the pressure exerted by the intraocular contents on the coats of the eyeball." IOP is a vital factor for occurrence of glaucomatous changes, but diagnosis is not based merely on it. It is an extremely significant and the lone modifiable risk factor. There is more prevalence of POAG with rising IOP. About 1 % of population having elevated IOP develop glaucomatous damage annually. Some eyeballs are vulnerable to injury even at IOP < 18 mm Hg

while some can even stand IOP > 30 mm Hg. But glaucoma can develop even with normal IOP. IOP > 21 mm Hg or diurnal variation of IOP > 8 mm Hg even with normal range IOP is also a risk factor and increase the susceptibility to develop glaucoma. Most people have almost constant IOP values.

- **Tonometry** - Technique of measurement of IOP. Apparatus used is named tonometer.
- **Fundus Examination:** [10]

On examination with direct or indirect ophthalmoscope, following characteristic signs are observed in a case of glaucoma:

1. Glaucomatous cupping with enlarged **cup to disc ratio of > 0.5**, or
2. **Asymmetry of > 0.2 in C:D ratio between both eyes**. Permanent reduction in the quantity of optic nerve fibres, glial cells and blood vessels cause pathological glaucomatous cupping.
3. As the cupping increases, **thinning of neuroretinal rim** takes place which follows ISNT rule (thinning is order of Inferior, superior, nasal and temporal).

Non-specific signs of glaucomatous damage:

1. Baring of circumlinear vessels: It is an initial sign of neuroretinal rim thinning. A gap appears between the superficial blood vessels that course from above or below the disc.
2. Bayoneting of vessels: Kinking or winding of the vessels over the cup margin.

Figure 31- Baring of circumlinear vessels

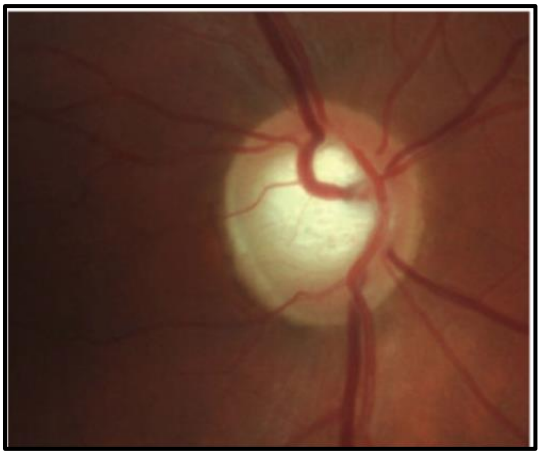


Figure 32 -Bayoneting sign

3. Laminar dot sign**:** It can be seen in normal eyes sometimes**.** Seen as glaucoma progresses. Grey dot like fenestrations form in the lamina cribrosa as the neuroretinal rim regresses.

Figure 33- Laminar dot sign

4. Disc hemorrhages**:** It is a marker of insufficient control of glaucoma. It can extend from neuroretinal rim onto the retina, generally in the inferotemporal quadrant. These may be seen in normal patients or hypertensives too.

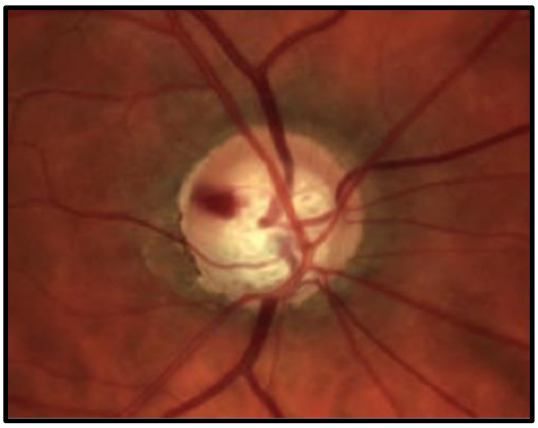


Figure 34 -Disc hemorrhage

5. Sharpened edge or rim**:** It is a sign of progressing injury. Due to the receding neuroretinal rim adjacent to the edge of the disc, disc margin outline adopts a sharper angle towards the back.
6. Peripapillary changes: These comprise of peripapillary atrophy of alpha or outer zone because of superficial RPE changes. Beta or inner zone occurs because of chorioretinal atrophy. These two zones are bigger and more common in glaucoma.

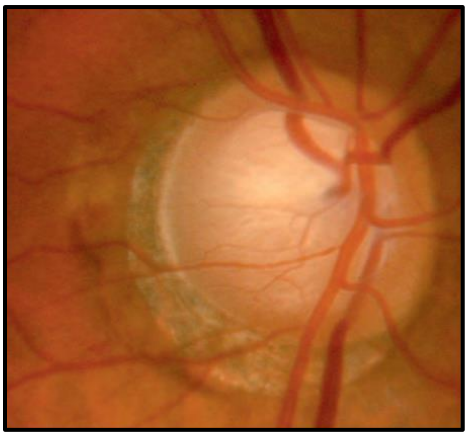


Figure 35 - Peripapillary atrophy

7. Retinal Nerve Fibre Layer Defects**:** Slight RNFL defects come before visible optic disc & field changes develop. They can be seen as either a localised wedge-shaped defect or diffuse defect. These are detected with light through red free filter, confocal CSLO, OCT, GDX.

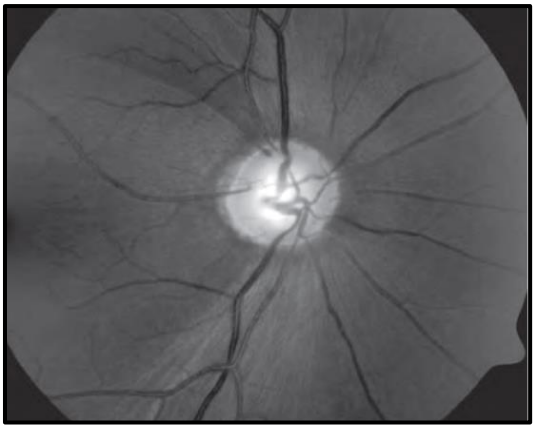


Figure 36 -Superotemporal RNFL defect in red free light

- **Perimetry:** [67]

Detection of visual field defects are an important criterion for the diagnosis of glaucoma. These are detected using a perimeter. Types of visual field defects seen most commonly in glaucoma include:

- Isopter contraction: Mild generalized constriction of central and peripheral field.
- Paracentral scotoma: Slight comparatively sharp depressions. It is the most common form of initial defect. Usually, small wing shaped defect above or below the blind spot. Best monitoring using 10-2 humphrey perimetry pattern.
- Roenne's central nasal step: It is perceived as a sensitivity variance above and beneath the horizontal midline in the nasal field.
- Extension of scotomas: It arises because of injury to adjacent areas.
- Seidel's scotoma: When paracentral scotoma joins the blind spot to form a sickle-shaped scotoma
- Arcuate scotomas: Formed by the merging of paracentral scotomas in later stages by extension of seidel's scotoma above or below the fixation point to reach the horizontal line.
- Deepening of scotomas & development of fresh scotoma.

- Ring or double arcuate scotoma: Arcuate scotomas in upper & lower halves join together.
- End stage: Just a small island of central vision (tubular vision) along with a temporal island is left. The central island typically diminishes before the more resistant temporal island progressively.

Anderson's criteria:

- Glaucoma hemifield test: Should be Outside normal limits on >/=2 successive events.
- ≥ 3 non edge points should be depressed in a position characteristic of glaucoma with p value < 5% and one of which should be have p value <1% on two successive events.
- Corrected pattern standard deviation (CPSD): It perceives the short-term variations, thus highlighting the localized defects. It accounts for intra observer variations at p<5% level.

Clinical features of angle closure glaucoma

Acute primary angle closure (APAC): [68]

Signs-

• VA is usually 6/60 to Hand movements+.

• The IOP is usually very high (40-70 mmHg)

• Conjunctival hyperemia with violaceous circumcorneal injection and chemosis

• Corneal epithelial oedema

• The AC is very shallow, aqueous cells and flare are usually present.

• An unreactive mid-dilated vertically oval pupil is classic

Clinical signs of a prior angle closure attack:

→ Partial or complete absence of the pupillary ruff

→ Iris Sphincter atrophy

→ Whorling of the iris radial pattern

→ Sectoral iris atrophy

→ Pigment dispersion in AC

→ Glaucomflecken

→ Anterior subcapsular lens opacities

The staging system for PACG: [69]

1. **Preclinical stage**: Same as PACS. When one eye had acute attack, the other eye could be diagnosed as preclinical cause. PACG is bilateral condition, therefore, the other eye is also at risk of attack.
2. **Attack stage**: Mild attacks present with subtle symptoms like colored halos, cloudy vision, pain at the root of the nose and mild ocular congestion, with small IOP spikes because of partial angle closure. Relieved with pilocarpine or sleep.

   Acute attacks present with abrupt rise in IOP even > 70 mmHg because of complete angle closure. The patient complains of sudden onset severe pain in eye with nausea, vomiting and prostrations along with rapid impairment of vision, redness and photophobia. Classical signs of acute angle closure attack seen.

3. **Intermittent stage**: Following an attack, angle opens again at least partially, and IOP can be maintained in a normal range. The eye is prone to undergo one or more attacks intermittently.
4. **Chronic stage**: These is progressive and constant rise in IOP along with glaucomatous optic nerve damage as angle closure remains for > 270 degrees with PAS

5. **Absolute stage**: The eye is painful and completely blind with ciliary flush. Cornea may develop epithelial bullae or filaments. Pupil remains fixed and dilated while IOP is very high and eyeball is stony hard.

Treatment [10,70]

Management of PACG

Three goals:

I. To remove pupillary block

II. To open the angle of anterior chamber

III. To avoid more optic nerve damage by reducing the IOP

Intermittent and Subacute Angle Closure Glaucoma

- An iridectomy or iridotomy generally dismiss the symptoms by releasing the pupillary block
- Miotic eye drops can diminish added acute attacks on long-term usage
- If high risk of developing chronic angle closure is present, treatment will be modified according to the base pressure

Primary Angle Closure Suspect

- Laser peripheral iridotomy can be performed in suspects as a procedure of choice
- If significant iridotrabecular contact persists after iridotomy -

→ Patient should be observed wit regular follow ups including gonioscopy and IOP measurement

→ Laser iridoplasty can be performed

→ Long-term pilocarpine prophylaxis (1% twice daily) is considered to prevent angle closure or pupillary block

- If symptomatic cataract is present - lens extraction might open the angle

Acute angle closure glaucoma

It is a medical emergency. Treatment aims at -

i. Rapidly reducing IOP

ii. Opening of ACA

iii. Supportive treatment, and

iv. Stopping any further acute attacks

Medical Treatment

- **Hyperosmotic agents** (e.g., Mannitol) - first line of medications that aid in lowering the IOP quickly. Mechanism of action- They increase serum osmotic pressure and extract fluid from the eye, particularly from vitreous humor. This causes vitreous dehydration leading to posterior shifting of lens and increase in ACD which helps in opening the angle of anterior chamber.

  Dosage – Mannitol (20%) - 1 to 2 g/kg body weight is administered IV over 1 hour.

  Oral glycerol - 1 mg/kg body weight watered down with an equivalent volume of cold orange juice. These drugs cause IOP reduction within half to one hour of intake and duration of action is around 5 to 6 hours.

- **Carbonic Anhydrase Inhibitors**- Acetazolamide gives good results in treating an acute attack of angle closure glaucoma. It quickly decreases the IOP and might cause opening of the angle. Dosage- 500 mg orally & 500 mg IV given initially. These act by distinctly lessening the formation of aqueous humor while the hyperosmotics draw the residual aqueous into vitreous via uveoscleral outflow.
- Additional antiglaucoma drugs used to lower IOP- Beta adrenergic blockers (e.g., timolol 0.5%), alpha agonists (e.g. apraclonidine 0.5% or 1%), prostaglandin analogues & topical carbonic anhydrase inhibitors.

- **Miotics** – These were used rigorously in an acute attack of PAG in the past. Instilling pilocarpine 2–4% eye drops a few times can cause pupillary constriction, thus helping in breaking a pupillary block attack. But, if IOP is very high (e.g., around 60 mm Hg), the iris sphincter becomes inactive and drugs become ineffective.

  Pilocarpine sometimes can even paradoxically deteriorate the state in an acute angle closure attack. If ciliary spasm occurs, it can cause anterior shift of the iris lens diaphragm, and so uveoscleral outflow reduces as anterior chamber depth decreases more.

  Thymoxamine- It is an alpha-adrenergic antagonist that paralyses the dilator pupillae. Its action is contingent upon an active iris sphincter muscle to cause pupillary constriction.

- Topical steroids like prednisolone 1% or dexamethasone 0.1% can be instilled in the affected eye to reduce inflammation

Physical Approaches

If in spite of intensive treatment with medications, the ACA remains closed and IOP does not decrease, some physical approaches can help to disrupt an acute attack. Repeatedly depressing the central cornea for 30 seconds with the help of a Zeiss four-mirror gonioscopy lens or a cotton-tipped applicator that can direct the aqueous humor into the periphery of ACA causing its opening briefly and then releasing it for 30 seconds, can decrease the IOP such that miotics may be effective.[71]

Supportive Treatment

- The patient should lie supine so that the lens descents backward as vitreous becomes dehydrated

- Parenteral antiemetics given to combat severe vomiting
- Analgesics like Pentazocine or pethidine can be given to relieve the severe pain based upon the body weight.
- Patient should be kept well hydrated.
- Before laser or surgery, topical NSAIDS initiated to decline the inflammatory reaction [71]

Iridectomy/Iridotomy – It is performed once corneal edema clears. It is the conclusive treatment to break the pupillary block. There is widening of ACA in the absence of synechiae. Laser iridotomy is the method of choice. In patients with dark brown irides, the Nd: YAG laser is optimal but can be used along with Argon laser to get an acceptable size of iridectomy. It is performed near root of iris.

Iridoplasty - Argon laser is used on peripheral iris to open the angle partly, but it cannot break the the pupillary block. This method can aid in reducing the IOP adequately temporarily even if patient has widespread synechial closure.

Cataract surgery or lens extraction – It has been suggested in patients with a large cataractous lens or intumescent lens or forward movement of lens causing apposition of angle or pupillary block.

Long-term Management

Selective or Argon laser trabeculoplasty can be performed for patients with remaining open angle glaucoma even subsequent to opening the angle, only if $< 180^{o}$ synechiae are present or when PAS do not encompass beyond the scleral spur. [72]

Goniosynechiolysis – This is another surgical choice used in patients whose angle closure

glaucoma cannot be managed medically. [73]

Filtration surgery - Trabeculectomy with or without adjunctive antimetabolites (Mitomycin C or 5- Fluorouracil) may be performed if the IOP still does not reduce in spite of extreme acceptable medication.

Placement of a **Glaucoma Drainage Device** can be considered in refractory cases or when trabeculectomy is contraindicated.

Cryotherapy – It is performed if all therapies fail and patient is left with a painful blind eye

Management of the fellow eye

After ACG attack in one eye, there is a high risk that the other eye might also undergo an acute attack within a year. Therefore, a laser peripheral iridectomy should be performed in fellow eye prophylactically.

Chronic Angle Closure Glaucoma

Laser peripheral iridotomy is indicated for all stages of chronic angle closure glaucoma. The patients with concomitant cataract, may benefit from cataract removal. Medications are initiated based on the level of IOP and optic disc changes. Surgery like filtration procedures is performed if IOP cannot be controlled medically. Diode laser transscleral cyclophotocoagulation can reduce the IOP effectively in chronic ACG case

MATERIAL & METHODS

MATERIALS AND METHODS

- **STUDY DESIGN** – Observational prospective study
- **STUDY POPULATION**- Study was conducted on patients with senile cataract admitted for cataract surgery under the department of Ophthalmology at R. L. Jalappa Hospital and Research centre attached to Sri Devaraj Urs Medical College, Kolar

- **STUDY PERIOD** – December 2019 to May 2021

I. After taking an informed consent (Annexure II) and thorough explanation of risks involved, in- depth ocular examination of all the patients was performed as follows-

1. Visual acuity recording by Snellen's chart
2. Anterior chamber, Van Herick's grading of Anterior chamber Angle (Table 6) and lens evaluation through Slit Lamp Biomicroscopy.
3. Grading of cataract was noted as nuclear sclerosis (grades1-4), capsular, subcapsular and cortical cataracts (Senile Immature, Mature or Hypermature Cataract)
4. Intraocular Pressure measurement by Goldmann Applanation Tonometer
5. Fundus evaluation through direct, indirect ophthalmoscopy and slit lamp 90D examination
6. Axial length (AL), anterior chamber depth (ACD) and lens thickness (LT), Vitreous chamber depth (VCD) were estimated by A scan biometry.
7. Gonioscopy was performed with Ziess four mirror gonioprism for Anterior Chamber Angle evaluation and its Shaffer's grading documented. (Table 3)

II. Patients were evaluated for fitness for cataract surgery. The selected patients underwent Small Incision Cataract Surgery with Posterior chamber Intraocular Lens implantation under Peribulbar block. Surgical details of any untoward events were noted. All patients were operated with the same technique.

III. Postoperatively, ACD and VCD were estimated with A scan biometry and Angle of anterior chamber evaluated through gonioscopy with same Ziess four mirror goniolens as well as its Van Herick's grading done on Slit lamp examination, on postoperative 6^{th} week follow up.

IV. Postoperative values were then compared and correlated with preoperative values of gonioscopy and Van Herick's grading for ACA. The mean difference between ACD and VCD pre and postoperatively were also estimated using statistical methods.

SAMPLE SIZE ESTIMATION

A sample size of minimum 37 patients is needed to detect a difference of 340.95 meridian in average, and SD of 527.44 Meridian between the pre and post (paired) measure with paired 80% power, using a paired t-test and assuming an error of 5% (two-sided).

STATISTICAL METHODS USED FOR THIS STUDY

Gonioscopic grade, VH grade etc., were considered as primary outcome of interest. ACA was considered as primary explanatory variable.

Descriptive analysis was carried out by mean and standard deviation for quantitative variables, frequency and proportion for categorical variables.

The association between categorical explanatory variables and quantitative outcome was assessed by comparing the mean values. The mean differences along with their 95% CI were presented. Independent sample t-test/ ANOVA was used to assess statistical significance. The association between explanatory variables and categorical outcomes was assessed by cross tabulation and comparison of percentages. Odds ratio along with 95% CI is presented. Chi square test/ Fisher's was used to test statistical significance. Univariate Binary logistic regression analysis was performed to test the association between the explanatory variables and outcome variables. P value < 0.05 was considered statistically significant. Data was analyzed by using SPSS software, V.22.

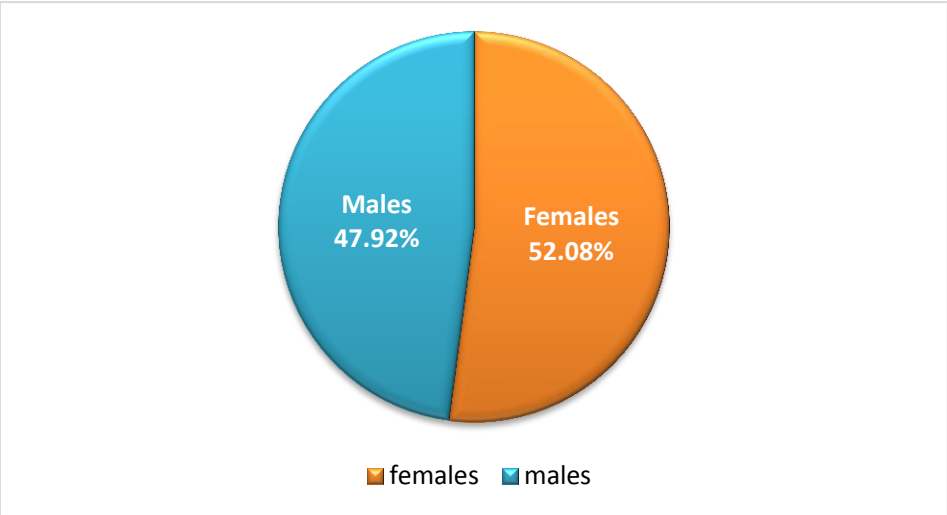
RESULTS

RESULTS

A total of 48 participants were included in the final analysis.

1. Gender wise distribution of patients:

Among the 48-study population, 23 (47.92%) participants were male and remaining 25 (52.08%) were female.



GRAPH 1: GENDER WISE DISRIBUTION OF PATIENTS

2. Age wise distribution of patients:

Parameter	Mean	Minimum	Maximum
Age (years)	56.43	50.00	85.00

Table 7- Age wise distribution of patients

As the study was performed on senile cataract patients, the patients included were ≥ 50 years old. The mean age of the 48 participants was 56.43 years, which ranged between 50 to 85 years.

3. Descriptive analysis of preoperative ocular parameters

Parameter	Mean ± SD	Median	Minimum	Maximum
Axial length (AL)	22.52 ± 0.79	22.52	19.49	24.89
Anterior Chamber Depth (ACD)	2.38 ± 0.35	2.43	1.45	3.05
Lens Thickness (LT)	3.97 ± 0.68	3.89	2.68	5.41
Vitreous Chamber Depth (VCD)	16.16 ± 1.03	16.24	13.62	18.63
Intraocular pressure (IOP)	16.88 ± 3.68	16.00	10.00	28.00

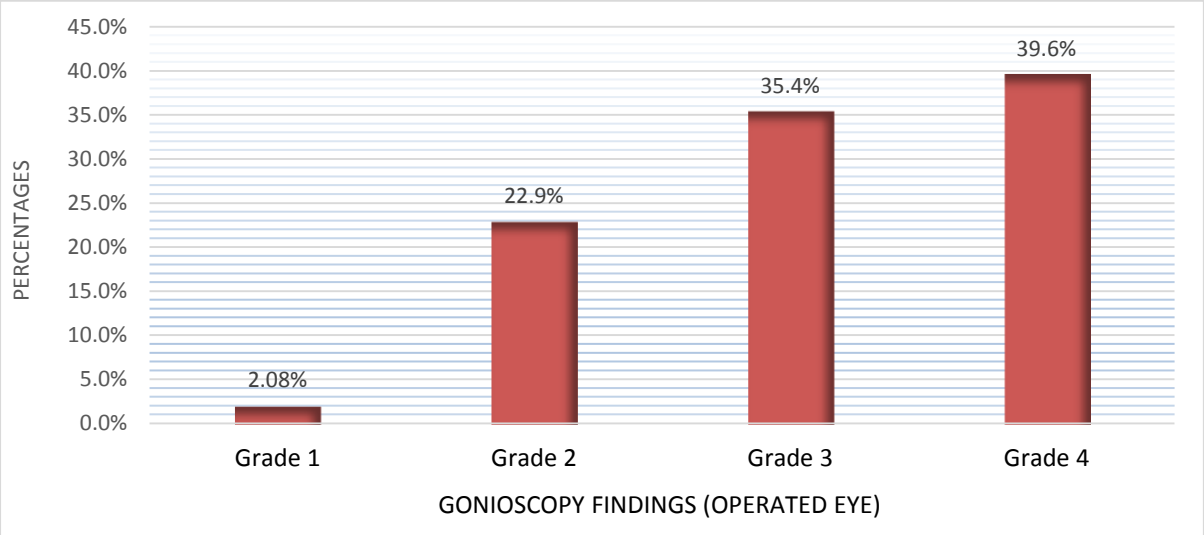
Table 8- Preoperative Ocular Parameters

On biometry, the mean preoperative values for the operated eyes were - AL was 22.52 ± 0.79, ACD was 2.38 ± 0.35, LT was 3.97 ± 0.68, VCD was 16.16 ± 1.03 and IOP was 16.88 ± 3.68 in the study population.

4. Descriptive analysis of preoperative gonioscopy findings

Gonioscopy Findings (Operated Eye)	Frequency	Percentages
Grade 1	1	2.08%
Grade 2	11	22.92%
Grade 3	17	35.42%
Grade 4	19	39.58%

Table 9 - Preoperative Gonioscopy Findings



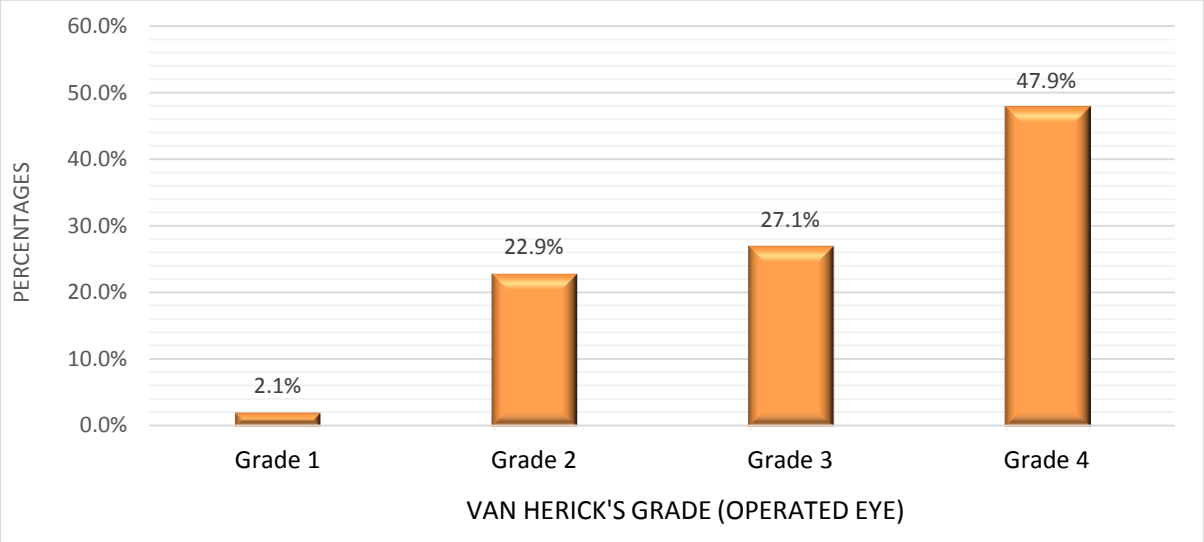
GRAPH 2: PREOPERATIVE GONIOSCOPY FINDINGS

On performing gonioscopy preoperatively, 19 (39.58%) participants had ACA Shaffer's grade 4, followed by grade 3 in 17 (35.42%) and grade 2 in 11 (22.92%) participants while only 1 participant had grade 1 angle preoperatively.

5. <u>Descriptive analysis of preoperative Van Herick's grade</u>

Van Herick'S Grade (Operated Eye)	Frequency	Percentages
Grade 1	1	2.08%
Grade 2	11	22.92%
Grade 3	13	27.08%
Grade 4	23	47.92%

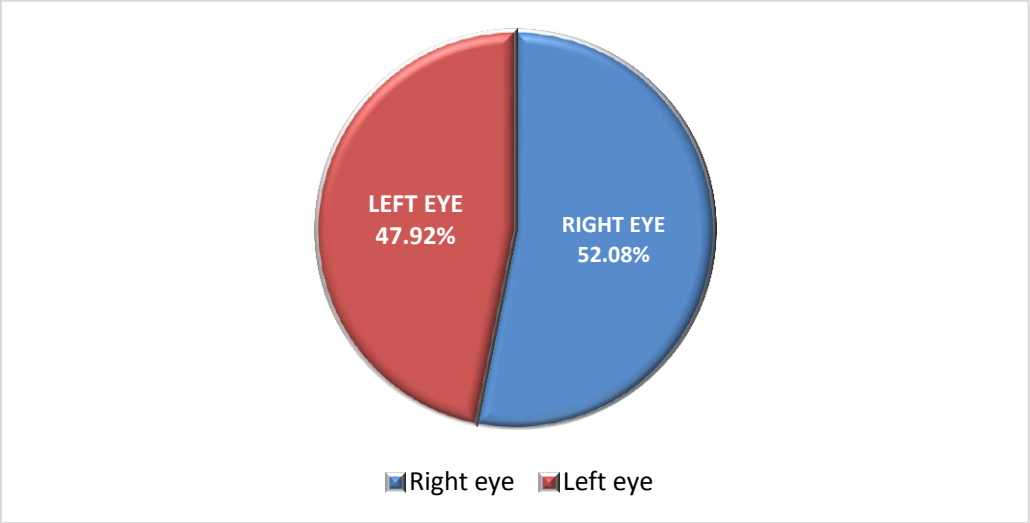
Table 10 - Preoperative Van Herick's Grade



GRAPH 3: PREOPERATIVE VAN HERICK'S GRADING

On Van Herick's grading through slit lamp preoperatively, 23 (47.92%) participants had grade 4 angle, 13 (27.08%) participants had grade 3 angle. 12 participants had shallow AC, of which, 11 (22.92%) had grade 2 and only 1 participant had grade 1 angle.

6. The laterality of operated eye



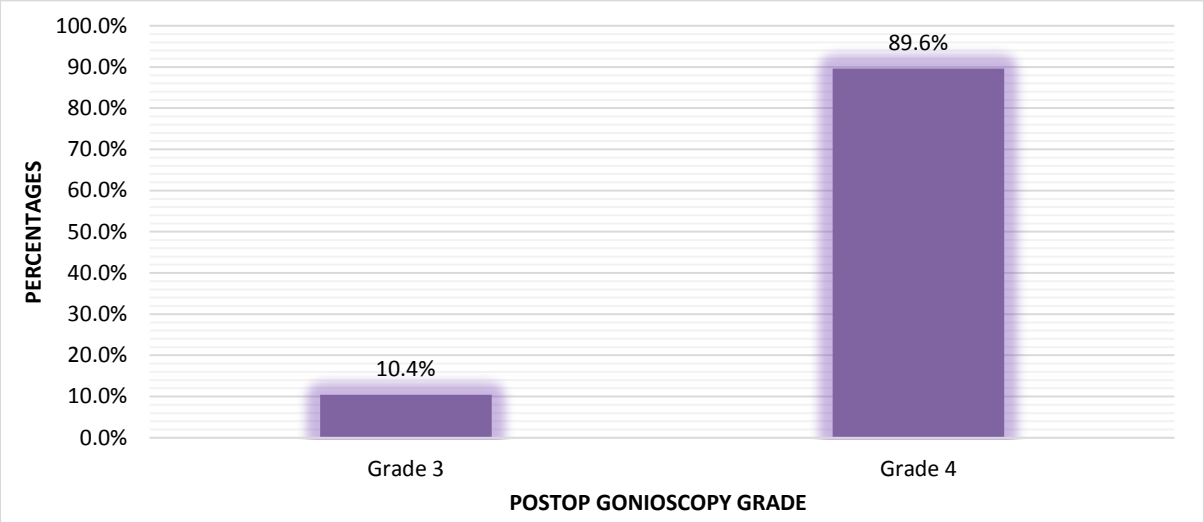
GRAPH 4: LATERALITY OF OPERATED EYE

Among the study population, 25 (52.08%) were operated in the right eye and 23 (47.92%) were operated in the left eye. Laterality did not have any association with other findings.

7. Descriptive analysis of postoperative gonioscopy findings

Postoperative Shaffer's Grade (Operated Eye)	Frequency	Percentages
Grade 3	5	10.42%
Grade 4	43	89.58%

Table 11- Postoperative Gonioscopy Findings



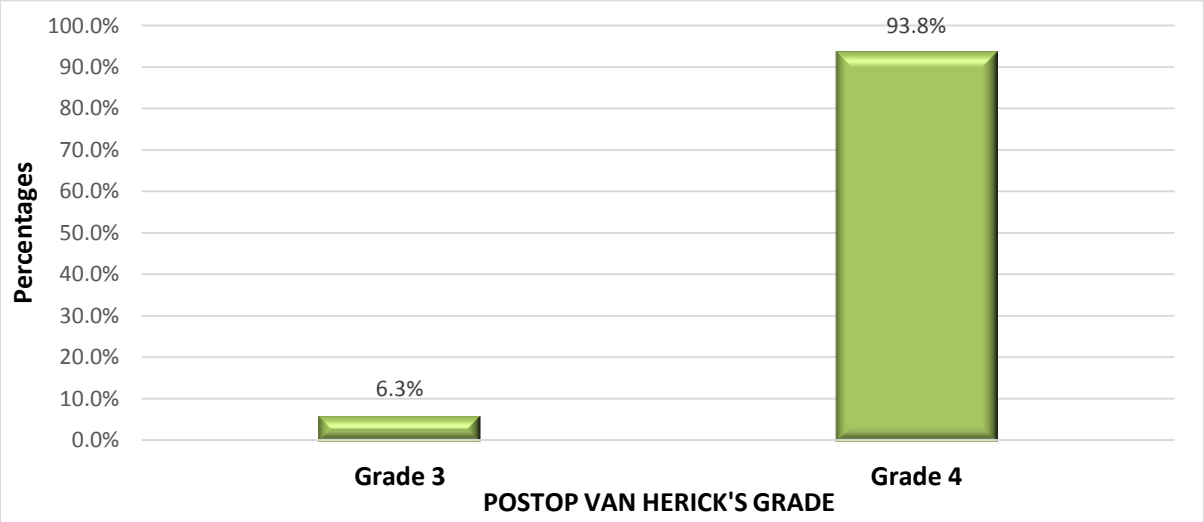
GRAPH 5: POSTOPERATIVE GONIOSCOPY FINDINGS

After cataract surgery, the shaffer's grade on performing gonioscopy was grade 4 in 43 (89.58%) and grade 3 (10.42%) in 5 participants.

8. <u>Descriptive analysis of postoperative Van Herick's grade</u>

Postoperative VH Grade (Operated Eye)	Frequency	Percentages
Grade 3	3	6.25%
Grade 4	45	93.75%

Table 12- Postoperative Van Herick's Grade



GRAPH 6: POSTOPERATIVE VAN HERICK'S GRADE

Postoperatively, 45 (93.75%) participants had Van herick's grade 4 angles while only 3 (6.25%) participants had grade 3 angle. None of the participants had grade 2 or grade 1 angle i.e., narrow angle.

Inferential statistics:

1. Comparison of gonioscopy findings pre- and post- cataract surgery (N= no. of participants)

Preoperative Gonioscopy Findings	Postoperative Gonioscopy findings	
	Grade 3	Grade 4
Grade 1 (N=1)	0 (0%)	1 (100%)
Grade 2 (N=11)	3 (27.27%)	8 (72.73%)
Grade 3 (N=17)	0 (5.88%)	17 (100%)
Grade 4 (N=19)	0	19 (100%)

Table 13- Gonioscopy Findings Pre- and Post- Cataract Surgery

Out of 19 participants with grade 4 in gonioscopy findings preoperatively, all (100%) participants remained grade 4 postoperatively. Out of 17 participants with grade 3 in gonioscopy findings preoperatively, all 17 (100%) participants had postoperative gonioscopy findings as grade 4. Out of the 11 patients with grade 2 angle preoperatively, 3 (27.27%) had grade 3 and 8 (72.73%) had grade 4 angle postoperatively. 1 patient with grade 1 angle before surgery became grade 4 (100%) post-surgery. A good association was found between cataract extraction and deepening of angle.

2. Comparison of van herick's grade pre- and post-cataract surgery

Preoperative Van Herick'S Grade	Postoperative VH Grade	
	Grade 3	Grade 4
Grade 1 (N=1)	0 (0%)	1 (100%)
Grade 2 (N=11)	3 (27.27%)	8 (72.73%)
Grade 3 (N=13)	0 (0%)	13 (100%)
Grade 4 (N=23)	0 (0%)	23 (100%)

Table 14- VAN HERICK'S GRADE PRE- AND POST- CATARACT SURGERY

Out of 23 participants with VH grade 4 preoperatively, all of 23 (100%) participants had post-op VH grade 4. Out of 13 participants with VH grade 3 preoperatively, all of them 13

(100%) participants had post-operative VH grade 4. Out of the 11 patients with VH grade 2 preoperatively, 3 (27.27%) had grade 3 and 8 (72.73%) had VH grade 4 postoperatively. 1 patient with VH grade 1 before cataract surgery became grade 4 (100%) after surgery.

3. Comparison of mean ACD and VCD at pre and post cataract surgery

Parameter	Mean ± SD	Mean Difference	P-value
ACD for operated eye			
Pre operative (mm)	2.38 ± 0.35	0.53	<0.001
Post operative (mm)	2.91 ± 0.34		
VCD for operated eye			
Pre operative (mm)	16.16 ± 1.03	1.15	<0.001
Post operative (mm)	17.32 ± 0.91		

TABLE 15- MEAN ACD AND VCD AT PRE AND POST CATARACT SURGERY

The mean of ACD for operated eye pre-operatively was 2.38 ± 0.35mm which increased to 2.91 ± 0.34mm post-operatively, the difference between pre and post-operative values was 0.53mm which was statistically significant (p value <0.001). The mean of VCD for operated eye pre-operatively was 16.16 ± 1.03mm that increased to 17.32 ± 0.91mm post-operatively, the difference between pre and post- operative values was 1.15mm which was statistically significant (p value <0.001). There is a significant increase in the depth of anterior and posterior chambers after cataract extraction and PCIOL implantation.

DISCUSSION

DISCUSSION

Both, cataract as well as glaucoma are very common ocular problems in elderly. Its occurrence significantly rises with ageing. Hence, a great proportion of glaucoma cases have cataract too. Several glaucoma cases undergo surgery for cataract removal. Subsequent to cataract surgery, ACD and angle parameters change significantly. Extraction of lens through cataract surgery makes further space in posterior chamber and in the angle of anterior chamber, particularly in aged people. Post cataract surgery, conformation of angle expands, and IOP reduces.[74]

A study by Simsek A et al., showed the preoperative mean ACA value to be 42.09 ± 7.49^0 which increased to 51.46 ± 5.63^0 three months after the surgery. The same study observed the values of AC Depth and AC Volume as 2.79 ± 0.45 mm and 124.73 ± 25.72 mm^3 preoperatively which showed statistically significant change to 3.45 ± 0.6 mm and 162.52 ± 23.79 mm^3, respectively on 3 months postoperative follow up.[45]

Our study included 48 participants that underwent cataract surgery and PCIOL implantation, out of which 23 were males and 25 were females. As per this study, the change in angle of anterior chamber after cataract removal, as observed on gonioscopy and VH grading, was seen in all the cases. While 1 patient showed noteworthy change in gonioscopic and VH grade from grade 1 (extremely narrow) to grade 4 (wide open), majority of the patients had open angle (grade 4) preoperatively that showed little difference post cataract surgery. Thus, the narrower the ACA before cataract removal, the more the difference in ACA postoperatively. 89.58% (43) patients showed Shaffer's grading of grade 4 on gonioscopy and 93.75% (45) patients showed grade 4 VH grading postoperatively while 10.42% (5)

patients became grade 3 on Shaffer's grading and only 6.25% (3) on VH grading but no patients had a narrow angle (grade 1 or grade 2) after removal of cataract. In his study, Pereira also found a substantial increase in the opening of angle after cataract removal. There was a brilliant association between the ACA preoperative and post cataract surgery values: "the shallower the preoperative AC, the greater the postoperative deepening; the narrower the preoperative angle, the greater the postoperative opening of the angle". [75]

With age, the lens becomes thicker while the anterior chamber becomes narrower. This can cause difficulty in drainage of aqueous humor and consequent increase in IOP. Several studies have stated that cataract extraction can decrease IOP in glaucoma cases. As removal of cataract is expected to widen the configuration of angle, the aqueous drainage improves and IOP reduces.[34, 41,42]

The preoperative mean Anterior chamber depth as per our study was 2.38 ± 0.35mm in eyes with cataract, which increased to 2.91 ± 0.34mm after cataract removal, showing a mean difference of 0.53mm which was statistically significant ($p<0.001$). The vitreous chamber depth (VCD) in cataractous eye was 16.16 ± 1.03mm with mean increase in VCD to 17.32 ±0.91mm, showing a difference of 1.15mm in VCD after cataract surgery and PCIOL implantation, which was also clinically significant ($p<0.001$). Post cataract removal and exchange with a thinner intraocular lens, the iris moves backwards causing an extension of anterior chamber and angle between iris and cornea. There is a deficiency in literature about VCD but some studies offer new understandings about this. The study by Takkar B. et al. verified that VCD occupies larger portions of the eye with increase in axial length. [24] As per our study, there was more difference in VCD (1.15mm) compared to ACD (0.53mm) after cataract extraction and PCIOL implantation which also proves that removal of cataract cause

changes in both anterior and posterior chambers.

The study by Vu AT et al., showed mean increase in ACD postoperatively as 1.538 ± 0.312 mm after 1 month of cataract surgery, and 1.592 ± 0.293 mm after 3 months. Angle opening distance (AOD), which is another parameter of measuring ACA with AS-OCT was also significantly increased. The average value for AOD500 was 0.183 ± 0.088 μm before surgery and 0.370 ± 0.090 μm after 1 month and 0.388 ± 0.132 μm after third month of cataract surgery. AOD750 also increased from 0.278 ± 0.105 μm to 0.569 ± 0.108 μm at the first month and 0.576 ± 0.149 μm at the third month in the same study. [76]

This was in accordance with our study that showed augmentation in angle of anterior chamber and ACD post cataract surgery.

Angle closure is usually recognized in eyes having a shallow AC and narrow angle. The lens has an important participation in such eyes, as proved by many studies. One of the processes leading to angle closure is thought to be due to increased lens volume. It is also stated that lens curvature has a superior part in angle closure than increase in lens diameter. A constant rise in lens volume and its curvature are assumed to be connected to the pathogenesis of angle closure predominantly in middle aged women. Thus, lens extraction can have a significant role in the treatment and prevention of PACG.[77] A shallow ACD and a short axial length (AL) have been related to Primary Angle Closure disease in various biometric studies.[78]

The two main causal mechanisms considered in the pathogenesis of Primary Angle Closure include pupillary block and nonpupillary block. One of the main parameters that plays a crucial role in occurrence of PACG is the crystalline lens and its thickness (LT) and relative lens position, as seen in various studies.[79] Rise in the curvature of front lens surface and lens volume or thickness is expected to intensify the amount of iridolenticular contact causing

increase in pupillary block, and ACA crowding.

The study by Wang X et al. established that there is decrease in the anterior radius of curvature of lens, with augmented lens volume, increased lens thickness, and reduced ACD in eyes having Primary Angle Closure than normal eyes. The Lens Thickness was 4.57 ± 0.28 mm in normal eyes, 4.87 ± 0.33 mm in eyes with PACS and 4.96 ± 0.25 mm in eyes with PAC/PACG ($P < 0.001$).[80] In our study the mean LT was found to be 3.97±0.68mm, which reduced significantly post cataract removal.

In a study by Yun-Hsuan Lin et. al., patients with acute PACG, underwent early or late phacoemulsification with IOL implantation alone or subsequent to laser peripheral iridotomy (LPI), respectively. VA and ACD enhanced in both groups. The angle width augmented in all the groups after phacoemulsification or LPI. The mean Shaffer grading for the anterior chamber angle increased from 0 to 3.17 in group A and from 0 to 3.30 in group B after treatment while ACD increased from 2.25 to 3.73mm in group A and from 2.18 to 3.41mm in group B, respectively.[81] Early cataract surgery seemed to be better in averting consequent rise in IOP and attained a lesser rate of IOP failure than LPI. Thorough preoperative and postoperative gonioscopy recognize the existence and degree of PAS and forecast the IOP variations over a long time.

As per H.Zhang et al., lens extraction and IOL implantation along with goniosynechialysis or endocyclophotocoagulation could be performed in eyes having widespread PAS in order to attain an improved IOP control.[82]

A study published in December 2019 by Anh Tuan Vu et al., evaluated the change in ACD and ACA after phacoemulsification through AS-OCT in Primary Angle Closure Suspects

(PACS). The average of ACD before surgery only was 2.082mm, but 1 month after surgery ACD was measured at 3.620mm. It was found that phacoemulsification surgery with foldable IOL implantation significantly increases the ACD and enlarges the angle in the PACS eyes.[76] According to the Effectiveness in Angle-closure Glaucoma of Lens Extraction (EAGLE) study, clear-lens extraction obtained superior effectiveness in controlling IOP than conventional LPI; thus, it was suggested as an option for the first-line treatment for patients with PAC or PACG.[83] P. Tarongoy in his study, demonstrated that lens removal with IOL implantation executed within weeks or later after few weeks to months following LPI, meaningfully dropped IOP, enhanced vision, augmented ACD and ACA width, and reversed pathogenesis of PAC due to both pupillary and nonpupillary block processes.[84]

A study by Zu C et.al., showed that cataract surgery is beneficial in patients with medically uncontrolled filtered PACG, in which it can be executed as the primary procedure of choice and the reasons for the results obtained following surgery might be connected to the anterior chamber deepening, widened drainage angle, and improved aqueous fluid flow to the trabecular meshwork.[85]

Contrary to the assumption of our study, in one of the studies, two patients presented with angle closure many years after cataract extraction. The first patient presented with acute IOP elevation and closed iridocorneal angle that resolved with a laser iridotomy. The second patient presented with an insidious course of high IOP and progressive narrowing of the iridocorneal angle. This showed that although rare, angle closure in eyes with PCIOLs is a dangerous complication that can occur many years after cataract extraction.[86]

The limitations of our study included a smaller number of participants from whom data was collected. A bigger sample size with more eyes with narrower angles is required to understand true association of angle change and cataract surgery. Gonioscopy and Van

Herick's grading being subjective tests can lead to errors in findings. Assessing the change in IOP could give better association with glaucoma due to narrow angles.

The strengths of study are that it is an approach to find the association between cataract surgery and prevention of glaucoma in future. It strengthens the approach of cataract extraction as treatment modality in cases of Angle closure Glaucoma. It also finds the association between ACA and other ocular parameters like ACD, LT and VCD.

CONCLUSION

CONCLUSION

This study proved that ACA and ACD change significantly following cataract surgery with PCIOL implantation in patients with senile cataract. All patients underwent an increase in angle of anterior chamber as well as ACD post cataract surgery which created more space in anterior chamber. The thickness of cataractous lens causes reduction in ACA width. As lens thickness reduces due to replacement with thinner IOL post-surgery there is an increase in ACA width along with anterior and vitreous chamber depth. Patients with smaller axial length have smaller ACD and ACA is narrower compared to patients with greater axial length. So, the patients with narrow angle or chances of angle closure in future on undergoing cataract surgery, also benefit by preventing future development of PAC/PACG or by treatment of a preexisting case. Cataract or lens removal could be considered as a preventive or first line treatment for glaucoma in patients with narrow angles. Further studies can demonstrate the changes in angle and ocular parameters from clear lens extraction.

SUMMARY

SUMMARY

A total of 48 patients with senile cataract were included in the study and evaluated for cataract surgery as well as underwent further intraocular pressure (IOP) measurement, Van Herick's grading of AC, gonioscopy, biometry and fundus evaluation. The grade of cataract, angle of anterior chamber Shaffer's grading and ocular parameters including AL, ACD, LT AND VCD were noted and patient underwent small incision cataract surgery with PCIOL implantation in eye with denser cataract. Same parameters were again evaluated after six weeks of cataract surgery. This study was conducted in the department of ophthalmology at our hospital between January 2019 and May 2020.

In our study, both genders were almost equal participants and belonged to age ≥ 50 years. The average age noted was 56 years. Preoperative gonioscopy and VH grading showed narrow angles in 11 (22.92%) patients and closed angle in 1 patient (2.08%), of which all (100%) became grade 3 or 4 postoperatively. There was a good association between cataract removal and deepening of ACA.

The mean ACD of the eyes increased from 2.38 ± 0.35mm preoperatively to 2.91 ± 0.34mm post-operatively which was statistically significant (p value <0.001). The mean VCD of increased from 16.16 ± 1.03mm preoperatively to 17.32 ± 0.91mm post-operatively which was statistically significant (p value <0.001). There is a significant increase in the depth of anterior and posterior chambers after cataract extraction and PCIOL implantation.

Thus, our study showed significant difference (increase) in ACA as well as ACD and VCD after cataract surgery and PCIOL implantation. We also found that narrower the ACA before surgery, more is the difference after cataract removal. This proves that cataract surgery helps

in preventing any future angle closure attacks as well as in treating any existing angle closure. It strengthens the notion that cataract surgery can be considered as a treatment modality for angle closure glaucoma and early cataract removal should be opted for.

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ANNEXURE

ANNEXURE I

CASE PROFORMA

Group:	Case no:
Name:	Date:
Age:	IP no:
Sex:	DOA:
Occupation:	DOS:
Address:	

Chief complaints:

History of Presenting illness:

Past history:

DM/HTN/BA/Epilepsy

Family history:

Personal history:

Appetite – Sleep – Bowel –

Diet – Habits – Bladder –

GPE:

Pallor / Edema /Icterus / Cyanosis / Clubbing / Lymphadenopathy

Vital signs:

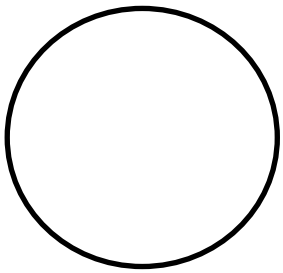
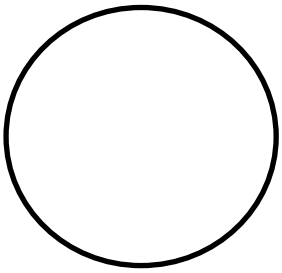
a. Pulse – c) RR –

b. BP – d) Temp –

Systemic examination:

a. CVS – c. RS –

b. PA – d. CNS –

OCULAR EXAMINATION			
	RE		**LE**
1. Head posture 2. Ocular posture 3. Facial symmetry			
4. Ocular movements			
5. Visual Acuity a) Distant b) Near			
6. Anterior Segment 7. Type of cataract			
8. Fundus (IDO & Slit Lamp +90D)			
9. Axial Length			
10. Anterior Chamber Depth			
11. Lens Thickness			
12. Intraocular Pressure			
13. Lab Investigations a. RBS b. Blood urea c. Serum Creatinine			
14. ANGLE OF ANTERIOR CHAMBER through gonioscopy			
GRADE OF ANGLE (Van Herick's)			

POSTOPERATIVE OCULAR EXAMINATION

ANTERIOR CHAMBER DEPTH		
VITREOUS CHAMBER DEPTH		
ANGLE OF ANTERIOR CHAMBER THROUGH GONIOSCOPY		
GRADE OF ANGLE (VAN HERICK'S)		

ANNEXURE II

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR - 563101.

INFORMED CONSENT FORM

Group:

Case no:

IP no:

TITLE: **'EVALUATION OF DIFFERENCE IN THE ANTERIOR CHAMBER ANGLE FOLLOWING CATARACT SURGERY IN SENILE CATARACT'**

I, the undersigned, agree to participate in this study and authorize the collection and disclosure of my personal information as outlined in this consent form.

I understand the purpose of this study, the risks and benefits of the technique and the confidential nature of the information that will be collected and disclosed during the study.

The information collected will be used only for research.

I have had the opportunity to ask questions regarding the various aspects of this study and my questions have been answered to my satisfaction.

I understand that I remain free to withdraw from this study at any time and this will not change my future care.

Participation in this research project does not involve any financial burden to me.

Name	Signature	Date	Time
Patient:			
Witness1:			
Witness 2:			
Primary Investigator/ Doctor:			

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR - 563101.

ತಿಳಿವಳಿಕೆಸಮ್ಮತಿನಮೂನೆ

ಈ ಸಂಶೋಧನೆಗೆ ರೋಗಿಯ ಗುರುತಿನ ಸಂಖ್ಯೆ:

ಐಪಿ ಸಂಖ್ಯೆ:

'ಸೆನೆಲ್ ಕ್ಯಾಟರಾಕ್ಟ್ನಲ್ಲಿ ಕ್ಯಾಟರಾಕ್ಟ್ ಸರ್ಜರಿಯನ್ನು ಅನುಸರಿಸುವ ಆಂಟಿಯರ್ ಚೇಂಬರ್ ಆಂಗಲ್ನಲ್ಲಿನ ವ್ಯತ್ಯಾಸದ ಮೌಲ್ಯಮಾಪನ '

ಅಂಗೀಕರಿಸಿದ ನಾನು, ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಪಾಲ್ಗೊಳ್ಳಲು ಒಪ್ಪುತ್ತೇನೆ ಮತ್ತು ಈ ಸಮ್ಮತಿಯ ರೂಪದಲ್ಲಿ ವಿವರಿಸಿರುವಂತೆ ನನ್ನ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯ ಸಂಗ್ರಹಣೆ ಮತ್ತು ಬಹಿರಂಗಪಡಿಸುವಿಕೆಯನ್ನು ದೃಢೀಕರಿಸುತ್ತೇನೆ.

ನಾನು ಈ ಅಧ್ಯಯನದ ಉದ್ದೇಶ, ತಂತ್ರಗಳ ಅಪಾಯಗಳು ಮತ್ತು ಪ್ರಯೋಜನಗಳನ್ನು ಮತ್ತು ಅಧ್ಯಯನದಲ್ಲಿ ಸಂಗ್ರಹಿಸಿದ ಮತ್ತು ಬಹಿರಂಗಪಡಿಸುವ ಮಾಹಿತಿಯ ಗೌಪ್ಯತೆಗೆ ನಾನು ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ.

ಸಂಗ್ರಹಿಸಿದ ಮಾಹಿತಿಯನ್ನು ಸಂಶೋಧನೆಗೆ ಮಾತ್ರ ಬಳಸಲಾಗುತ್ತದೆ.

ಈ ಅಧ್ಯಯನದ ವಿವಿಧ ಅಂಶಗಳನ್ನು ಕುರಿತು ಪ್ರಶ್ನೆಗಳನ್ನು ಕೇಳಲು ನನಗೆ ಅವಕಾಶವಿದೆ ಮತ್ತು ನನ್ನ ತೃಪ್ತಿಗೆ ನನ್ನ ಪ್ರಶ್ನೆಗಳಿಗೆ ಉತ್ತರ ನೀಡಲಾಗಿದೆ.

ಈ ಸಂಶೋಧನಾ ಉದ್ದೇಶಕ್ಕಾಗಿ ಕ್ಯಾಟರಾಕ್ಟ್ ಶಸ್ತ್ರಚಿಕಿತ್ಸೆಯ ನಂತರ ಶೀಘ್ರದಲ್ಲೇ ಅಧ್ಯಯನದಲ್ಲಿ 4 ಮಿಲಿ ರಕ್ತವನ್ನು ದಾನ ಮಾಡಲು ನಾನು ಸ್ವಯಂಪ್ರೇರಣೆಯಿಂದ ಒಪ್ಪುತ್ತೇನೆ.

ನಾನು ಈ ಅಧ್ಯಯನದಿಂದ ಯಾವುದೇ ಸಮಯದಲ್ಲಿ ಹಿಂತೆಗೆದುಕೊಳ್ಳಲು ಮುಕ್ತವಾಗಿರುತ್ತೇನೆ ಮತ್ತು ಇದು ನನ್ನ ಮುಂದಿನ ಕಾಳಜಿಯನ್ನು ಬದಲಿಸುವುದಿಲ್ಲ ಎಂದು ನಾನು ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ.

ಈ ಸಂಶೋಧನಾ ಯೋಜನೆಯ ಭಾಗವಹಿಸುವಿಕೆ ನನಗೆ ಯಾವುದೇ ಹಣಕಾಸಿನ ಹೊರೆ ಒಳಗೊಂಡಿರುವುದಿಲ್ಲ.

ಹೆಸರು	ಸಹಿ	ದಿನಾಂಕ	ಸಮಯ
ರೋಗಿಯ:			
ಸಾಕ್ಷಿ 1:			
ಸಾಕ್ಷಿ 2:			
ಪ್ರಾಥಮಿಕ ತನಿಖೆದಾರ / ಡಾಕ್ಟರ್:			

ANNEXURE III

SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR - 563101.

PATIENT INFORMATION SHEET

TITLE- **'EVALUATION OF DIFFERENCE IN THE ANTERIOR CHAMBER ANGLE FOLLOWING CATARACT SURGERY IN SENILE CATARACT'**

This information is to help you understand the purpose of the study 'Evaluation of Difference in The Anterior Chamber Angle Following Cataract Surgery in Senile Cataract'

You are invited to take part voluntarily in this research study, it is important that you read and understand the purpose, procedure, benefits and discomforts of the study.

1. The purpose of this study is to evaluate the difference in the anterior chamber angle before and after cataract surgery in senile cataract.

2. Absolutely no risks are associated with the various investigations to be done which are fasting blood sugar, post prandial blood sugar, hba1c, complete blood count, renal function test, eye examination like intraocular pressure, lens power calculation and retinal checkup.

3. Comparing the preoperative and postoperative anterior chamber depth and anterior chamber angle grading in cataract patients would be of importance in contributing towards studies that say cataract surgery leads to ACA widening. The identification of such benefits is treating narrow angle and preventing risk of developing PACG later and would be of importance in the determination of cataract surgery as an option to treat glaucoma, to reduce the occurrence of the same, thus reducing the burden of severe visual impairment. Such observation may also be of importance in interpreting and/or planning treatment for protection of vision in patients undergoing cataract surgery.

Participation in this research study may not change the final outcome of your eye condition. However, patients in the future may benefit as a result of knowledge gained from this study. You will not be charged extra for any of the procedures performed during the research study. Your taking part in this study is entirely voluntary.

You may refuse to take part in the study or you may stop your participation in the study at any time, without any penalty or loss of any benefits to which you were otherwise entitled before taking part in this study.

CONFIDENTIALITY

Your medical information will be kept confidential by the study doctor and staff and will not be made publicly available. Your original records may be reviewed by your doctor or ethics review board. For further information, /clarification please contact Dr. MANJULA T.R., SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, TAMAKA, KOLAR – 563101

DOCTOR'S DETAILS:

DR. MANJULA T.R., MBBS, MS.

PROFESSOR & HOD

DEPARTMENT OF OPHTHALMOLOGY,

SDUMC, KOLAR – 563101

MOBILE NO: 9886591772

DR. KARISHMA AGGARWAL, MBBS

POSTGRADUATE

M.S. OPHTHALMOLOGY,

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ಶ್ರೀದೇವರಾಜ್ಅರಸ್ಉನ್ನತಶಿಕ್ಷಣಮತ್ತುಸಂಶೋಧನಾಸಂಸ್ಥೆ,

ಟಮಕ, ಕೋಲಾರ - 563101.

ಶೀರ್ಷಿಕೆ:- ಸೆನೆಲ್ ಕ್ಯಾಟರಾಕ್ಟ್ನಲ್ಲಿ ಕ್ಯಾಟರಾಕ್ಟ್ ಸರ್ಜರಿಯನ್ನು ಅನುಸರಿಸುವ ಆಂಟಿಯರ್ ಚೇಂಬರ್ ಆಂಗಲ್ನಲ್ಲಿನ ವ್ಯತ್ಯಾಸದ ಮೌಲ್ಯಮಾಪನ '

ರೋಗಿಯ ಮಾಹಿತಿ ನಮೂನೆ :-

ಈ ಮಾಹಿತಿಯುಅಧ್ಯಯನದ ಉದ್ದೇಶವನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ನಿಮಗೆ ಸಹಾಯಮಾಡುವುದು "ಸ್ಟಾಪ್ಮತ್ತುಕ್ಲೋಪ್ನ ಪರಿಣಾಮಕಾರಿತ್ವ ಮತ್ತು ಸುರಕ್ಷತೆಯನ್ನು ಹೋಲಿಸಲು ಮತ್ತು ಫೇಕೊಎಮ್ಯುಲ್ಸಿಕೇಶನ್ನಲ್ಲಿ ಫ್ಯಾಕೋಚಾಪ್ಲ್ಯೂ ಕ್ಲಿಯೊಟಮಿತಂತ್ರಗಳನ್ನು" ಹೋಲಿಸುವುದು.
ಈಸಂಶೋಧನಾಅಧ್ಯಯನದಲ್ಲಿಸ್ವಯಂಪ್ರೇರಿತವಾಗಿಪಾಲ್ಗೊಳ್ಳಲುನಿಮ್ಮನ್ನುಆಹ್ವಾನಿಸಲಾಗಿದೆ, ಅಧ್ಯಯನದಉದ್ದೇಶ, ಕಾರ್ಯವಿಧಾನ, ಪ್ರಯೋಜನಗಳುಮತ್ತುಅಸ್ವಸ್ಥತೆಗಳನ್ನುನೀವುಓದುವುದುಮತ್ತುಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದುಮುಖ್ಯವಾಗಿದೆ.

1. ವಯಸ್ಸಾದ ಕಣ್ಣಿನ ಪೊರೆಯಲ್ಲಿ ಕಣ್ಣಿನ ಪೊರೆ ಶಸ್ತ್ರಚಿಕಿತ್ಸೆಯ ಮೊದಲು ಮತ್ತು ನಂತರ ಮುಂಭಾಗದ ಚೇಂಬರ್ ಕೋನದಲ್ಲಿನ ವ್ಯತ್ಯಾಸವನ್ನು ಮೌಲ್ಯಮಾಪನ ಮಾಡುವುದು ಈ ಅಧ್ಯಯನದ ಉದ್ದೇಶವಾಗಿದೆ.

2. ಫಾಸ್ಟಿಂಗ್ಬ್ಲಡ್ಶುಗರ್, ಪೋಸ್ಟ್ಪ್ರಾಂಡಿಯಲ್ಬ್ಲಡ್ಶುಗರ್, ಎಚ್ಬಿಎ 1 ಸಿ, ಇಂಟ್ರಾಕ್ಯುಲರ್ಒತ್ತಡ, ಲೆನ್ಸ್ವಿದ್ಯುತ್ಶಕ್ತಿ ಮತ್ತು ರೆಟಿನಲ್ತಪಾಸಣೆಮುಂತಾದ ಕಣ್ಣಿನಪರೀಕ್ಷೆ ಇವುಗಳನ್ನು ಮಾಡಬೇಕಾದ ಹಲವಾರು ತನಿಖೆಗಳೊಂದಿಗೆ ಸಂಪೂರ್ಣವಾಗಿ ಯಾವುದೇ ಅಪಾಯಗಳು ಸಂಬಂಧಿಸಿವೆ.

3. ಕಣ್ಣಿನ ಪೊರೆ ರೋಗಿಗಳಲ್ಲಿ ಪೂರ್ವಭಾವಿ ಮತ್ತು ಶಸ್ತ್ರಚಿಕಿತ್ಸೆಯ ನಂತರದ ಮುಂಭಾಗದ ಚೇಂಬರ್ ಆಳ ಮತ್ತು ಮುಂಭಾಗದ ಚೇಂಬರ್ ಆಂಗಲ್ ಗ್ರೇಡಿಂಗ್ ಅನ್ನು ಹೋಲಿಸುವುದು ಕಣ್ಣಿನ ಪೊರೆ ಶಸ್ತ್ರಚಿಕಿತ್ಸೆ ಎಸಿಎ ವಿಸ್ತರಣೆಗೆ ಕಾರಣವಾಗುತ್ತದೆ ಎಂದು ಹೇಳುವ ಅಧ್ಯಯನಗಳಿಗೆ ಕೊಡುಗೆ ನೀಡುವಲ್ಲಿ ಮಹತ್ವದ್ದಾಗಿದೆ.

ಅಂತಹ ಪ್ರಯೋಜನಗಳ ಗುರುತಿಸುವಿಕೆಯು ಕಿರಿದಾದ ಕೋನಕ್ಕೆ ಚಿಕಿತ್ಸೆ ನೀಡುವುದು ಮತ್ತು ನಂತರ ಪಿಎಸಿಜಿಯನ್ನು ಅಭಿವೃದ್ಧಿಪಡಿಸುವ ಅಪಾಯವನ್ನು ತಡೆಯುವುದು ಮತ್ತು ಗ್ಲುಕೋಮಾಗೆ ಚಿಕಿತ್ಸೆ ನೀಡಲು, ಅದೇ ಸಂಭವವನ್ನು ಕಡಿಮೆ ಮಾಡಲು ಕಣ್ಣಿನ ಪೊರೆ ಶಸ್ತ್ರಚಿಕಿತ್ಸೆಯನ್ನು ನಿರ್ಧರಿಸುವಲ್ಲಿ ಮಹತ್ವದ್ದಾಗಿರುತ್ತದೆ ಮತ್ತು ಇದರಿಂದಾಗಿ ತೀವ್ರ ದೃಷ್ಟಿಹೀನತೆಯ ಹೊರೆ ಕಡಿಮೆಯಾಗುತ್ತದೆ . ಕಣ್ಣಿನ ಪೊರೆ ಶಸ್ತ್ರಚಿಕಿತ್ಸೆಗೆ ಒಳಗಾಗುವ ರೋಗಿಗಳಲ್ಲಿ ದೃಷ್ಟಿ ರಕ್ಷಣೆಗಾಗಿ ಚಿಕಿತ್ಸೆಯನ್ನು ವ್ಯಾಖ್ಯಾನಿಸಲು ಮತ್ತು / ಅಥವಾ ಯೋಜಿಸಲು ಇಂತಹ ವೀಕ್ಷಣೆಯು ಮಹತ್ವದ್ದಾಗಿರಬಹುದು.

ಗೌಪ್ಯತೆ

ನಿಮ್ಮವೈದ್ಯಕೀಯಮಾಹಿತಿಯನ್ನುಅಧ್ಯಯನದವೈದ್ಯರುಮತ್ತುಸಿಬ್ಬಂದಿಗೌಪ್ಯವಾಗಿಡಲಾಗುವುದುಮತ್ತುಸಾರ್ವಜನಿಕವಾಗಿಲಭ್ಯವಿರುವುದಿಲ್ಲ.
ನಿಮ್ಮಮೂಲದಾಖಲೆಗಳನ್ನುನಿಮ್ಮವೈದ್ಯರುಅಥವಾನೈತಿಕವಿಮರ್ಶೆಮಂಡಳಿಪರಿಶೀಲಿಸಬಹುದು.

ಹೆಚ್ಚಿನ ಮಾಹಿತಿಗಾಗಿ ಸಂಪರ್ಕಿಸಿ

ಡಾ. ಕೆ. ಕಾಂತಮಣಿ

ಎಸ್ಡಿ ಯು ಎ ಮ್ಸಿ.

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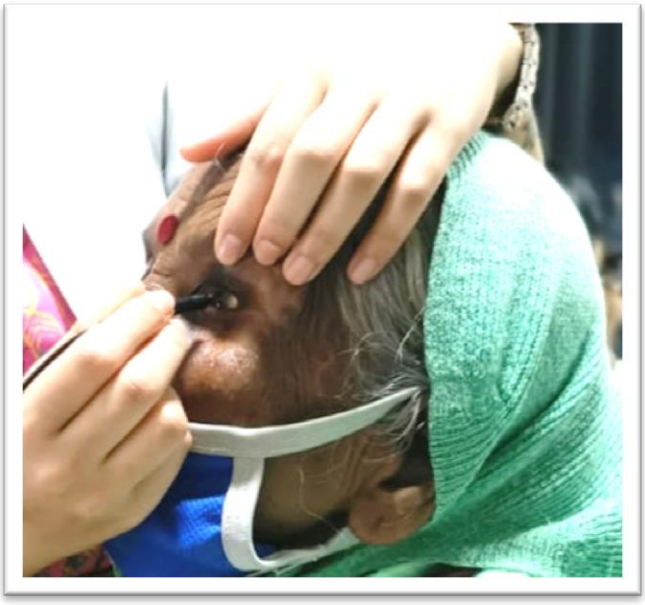
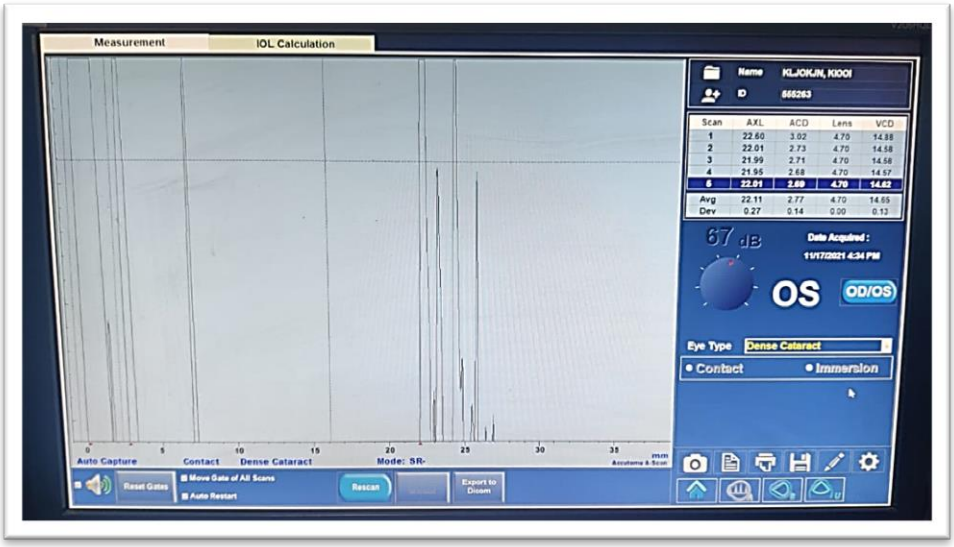
ANNEXURE IV

PHOTOGRAPHS

PHOTOGRAPH 1: SLIT LAMP EXAMINATION



PHOTOGRAPH 2. BIOMETRY BEING PERFORMED FOR OCULAR PARAMETERS AND IOL POWER



PHOTOGRAPH 3: OCULAR PARAMETERS VALUES OBTAINED ON A SCAN ULTRASONOGRAPHY

PHOTOGRAPH 4: ZEISS FOUR-MIRROR GONIOPRISM

PHOTOGRAPH 5: GONIOSCOPY OF RE DONE BY ZEISS FOUR-MIRROR GONIOPRISM

PHOTOGRAPH 6: CATARACT EXTRACTION BY SMALL INCISION CATARACT SURGERY

ANNEXURE V:

KEY TO MASTER CHART

1. SR NO: SERIAL NUMBER
2. IP: IN PATIENT NUMBER
3. M: MALE
4. F: FEMALE
5. OE: OPERATED EYE
6. AL: AXIAL LENGTH
7. ACD: ANTERIOR CHAMBER DEPTH
8. LT: LENS THICKNESS
9. VCD: VITREOUS CHAMBER DEPTH
10. IOP: INTRAOCULAR PRESSURE
11. PREOP: PREOPERATIVE
12. POSTOP: POSTOPERATIVE
13. VH: VAN HERICK'S
14. MM: MILLIMETER
15. RE: RIGHT EYE
16. LE: LEFT EYE
17. NS: NUCLEAR SCLEROSIS
18. PSC: POSTERIOR SUBCAPSULAR CATARACT
19. SMC: SENILE MATURE CATARACT
20. SHMC: SENILE HYPERMATURE CATARACT

CASE NO.	IP no.	NAME	AGE	SEX	TYPE OF CATARACT(OE)	PREOP AL (OE)	PREOP ACD (OE)	PREOP LT (OE)	PREOP VCD (OE)	IOP (OE)	GONIOSCOPY GRADE (OE)	VH GRADE (OE)	EYE OPERATED	POSTOP GONIO (OE)	POST OP VH GRADE(OE)	POSTOP ACD (OE)	POSTOP VCD (OE)
1	794640	NARASAMMA	65	F	NS4	21.21	2.24	4.51	14.46	14	GRADE 3	GRADE 4	RE	GRADE 4	GRADE 4	3.31	15.43
2	802709	NARAYANAPPA	85	M	NS 2-3+CORTICAL+ PSC	22.25	2.45	3.72	16.08	14	GRADE 3	GRADE 4	RE	GRADE 4	GRADE 4	2.75	17.05
3	804442	RAMESH	48	M	SMC	21.79	2.41	3.9	15.48	20	GRADE 3	GRADE 3	LE	GRADE 4	GRADE 4	2.52	16.92
4	805214	GANGAMMA	66	F	NS3-4+CENTRAL PSC	22.42	2.42	3.1	16.9	16	GRADE 3	GRADE 3	RE	GRADE 4	GRADE 4	3.12	16.85
5	812432	VENKATAMMA	85	F	NS4	23.13	3.02	4.39	15.72	18	GRADE 3	GRADE3	RE	GRADE 4	GRADE 4	2.45	17.67
6	814719	VENKATESHAPPA	77	M	SMC	24.89	2.81	3.45	18.63	16	GRADE 3	GRADE 3	LE	GRADE 4	GRADE 4	3.15	19.16
7	819945	AYUB KHAN	57	M	NS3 +PSC	23.17	2.96	3.14	17.07	16	GRADE 3	GRADE 3	RE	GRADE 4	GRADE 4	3.24	17.42
8	820492	LEELAVATHI	65	F	NS2 +PSC	19.49	2.19	3.68	13.62	28	GRADE 2	GRADE 2	RE	GRADE 3	GRADE4	2.45	14.07
9	821456	MUNIYAMMA	60	F	SMC	23.05	2.45	4.96	15.63	19	GRADE 1	GRADE 2	LE	GRADE 4	GRADE 4	2.65	17.45
10	823167	GANGAPPA	65	M	NS1+PSC+CORTICAL	22.43	2.45	4.68	15.3	11	GRADE 3	GRADE 4	LE	GRADE 4	GRADE 4	2.65	17.31
11	823465	SHANKARAPPA	60	M	NS2 +PSC +CORTICAL	22.11	2.45	3.66	16	14	GRADE 4	GRADE 4	LE	GRADE 4	GRADE4	2.58	17.28
12	824508	Rathnamma	56	F	NS2 +PSC	22.34	2.56	3.56	16.22	14	GRADE 3	GRADE 4	RE	GRADE 4	GRADE4	2.6	17.02
13	824540	LAKSHMAMMA	60	F	SMC	23.65	2.76	3.78	17.11	22	GRADE 3	GRADE 3	LE	GRADE 4	GRADE 4	2.8	17.95
14	825631	MURTHY	60	M	PSC+NS2	22.48	2.67	3.24	16.57	13	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	2.64	16.88
15	826092	jayamma	58	F	SMC	21.52	1.82	4.82	14.88	20	GRADE 2	GRADE 2	LE	GRADE 3	GRADE 3	2.42	16.14
16	826891	RAJAPPA	58	M	PSC +NS2	22.42	2.42	3.1	16.9	16	GRADE 3	GRADE 3	RE	GRADE 4	GRADE 4	3.12	17.16
17	827564	RAJA	53	M	PSC+NS2	22.43	2.43	3.23	16.9	14	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	3.2	17.09
18	828814	chikkavenkatamma	60	F	PSC +NS2	23.15	2.96	2.68	17.5	16	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	3.12	18.22
19	829050	SUBBAREDDY	55	M	SMC	22.36	2.45	5.04	14.86	20	GRADE 2	GRADE 2	RE	GRADE 4	GRADE 4	2.82	17.64
20	830654	CHINNAMMA	65	F	NS4	22.69	2.7	4.43	15.55	16	GRADE 3	GRADE 3	LE	GRADE 4	GRADE 4	2.96	17.85
21	832652	RAJAMMA	67	F	NS 3-4	22.52	2.45	4.19	15.87	15	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	2.74	17.86
22	834520	RAGHUNATH REDDY	65	M	SMC	22.48	2.81	4.11	15.55	24	GRADE 2	GRADE 2	LE	GRADE 4	GRADE 4	3.26	17.32
23	834961	Narayanappa	66	M	NS3 +CORTICAL	23.28	2.41	3.05	17.81	14	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	2.6	18.78
24	835408	GOWRAMMA	60	F	NS2 + PSC	20.87	2.25	3.74	14.87	21	GRADE 2	GRADE2	RE	GRADE 4	GRADE 3	2.5	16.47
25	836432	PARVATHAMMA	63	F	NS4	22.52	2.79	4.64	15.08	16	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	2.95	17.67
26	836704	MUNIVENKATSWAMY	72	M	SMC	22.82	2.45	5.41	14.95	20	GRADE 3	GRADE 3	RE	GRADE 4	GRADE 4	2.64	18.28
27	836708	CHINAKKA	54	F	SMC	21.33	2.45	4.47	14.4	15	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	2.65	16.78
28	838542	PARVATHAMMA	64	F	NS3 +PSC	23.04	2.7	4	16.24	16	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	2.86	18.28
29	863520	bahun	54	M	NS3+PSC	22.78	2.3	3.45	16.45	12	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	2.46	18.38
30	873134	Devamma	56	F	NS3+ PSC	22.52	2.43	3.06	17.01	14	GRADE 3	GRADE 3	RE	GRADE 4	GRADE4	2.53	17.89
31	875442	VENKATMUNIYAPPA	64	M	NS3+PSC+CORTICAL	21.76	3.05	4.7	14.01	16	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	3.54	15.62
32	873192	RAJANNA	65	M	SMC	22.84	1.85	4.8	16.19	20	GRADE 2	GRADE 2	LE	GRADE 4	GRADE 4	3.4	17.09
33	878188	CHOWDAMMA	56	F	NS4	22.76	2.32	4.68	15.76	14	GRADE 3	GRADE 3	LE	GRADE 3	GRADE 3	2.8	17.82
34	878760	VENKATRAMAPPA	70	M	SHMC	23.15	1.9	5.01	16.24	22	GRADE 2	GRADE 2	RE	GRADE 4	GRADE 4	3.45	17.2
35	888611	FAROOQ ALI	50	M	SMC	22.52	2.05	4.15	16.32	16	GRADE 3	GRADE 3	LE	GRADE 4	GRADE 4	2.95	17.12
36	889162	JANAKI	58	F	NS3 +CORTICAL	22.45	2.55	3.32	16.58	10	GRADE 4	GRADE 4	RE	GRADE 4	GRADE4	3.16	16.46

CASE NO.	IP no.	NAME	AGE	SEX	TYPE OF CATARACT(OE)	PREOP AL (OE)	PREOP ACD (OE)	PREOP LT (OE)	PREOP VCD (OE)	IOP (OE)	GONIOSCOPY GRADE (OE)	VH GRADE (OE)	EYE OPERATED	POSTOP GONIO (OE)	POST OP VH GRADE(OE)	POSTOP ACD (OE)	POSTOP VCD (OE)
37	891235	GOWRAMMA	64	F	NS4	23.1	2.46	4.12	16.52	14	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	3.34	17.5
38	892005	harman	74	M	SMC	22.65	1.45	4.8	16.4	24	GRADE 2	GRADE 1	LE	GRADE 3	GRADE 4	2.85	18.15
39	893114	JAYAMMA	68	F	NS3+PSC+CORTICAL	22.8	2.45	3.25	17.1	15	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	3.25	17.5
40	894556	rajamma	57	F	SMC	22.84	1.95	4.25	16.64	20	GRADE 2	GRADE 2	RE	GRADE 4	GRADE 4	2.25	18.14
41	900124	THEJUS	62	M	NS3+PSC	22.52	2.25	3.24	17.03	16	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	3.25	17.22
42	900452	ACHAMMA	65	F	NS4	22.78	2.35	3.36	16.82	14	GRADE 4	GRADE 4	RE	GRADE 4	GRADE 4	3.35	16.82
43	901521	ramappa	56	m	NS3+ PSC	22.46	1.78	3.35	17.33	23	GRADE 2	GRADE 2	RE	GRADE 4	GRADE 3	2.24	17.98
44	901673	JAYAMMA	71	F	SMC	21.89	2.23	4.05	15.61	16	GRADE 3	GRADE 3	RE	GRADE 4	GRADE 4	3.05	16.7
45	903421	MARY JANE	48	F	NS3 + PSC	22.54	2.15	3.88	16.51	16	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	3.35	17.01
46	904562	gauramma	64	F	SHMC	22.68	1.56	4.98	16.14	19	GRADE 2	GRADE 2	LE	GRADE 4	GRADE 4	2.85	17.69
47	905462	FARHAN	67	M	NS4	23.14	2.25	3.45	17.44	17	GRADE 4	GRADE4	RE	GRADE 4	GRADE 4	3.44	17.62
48	903050	devrajappa	53	M	NS3 +PSC	23.16	2.14	3.86	17.16	15	GRADE 4	GRADE 4	LE	GRADE 4	GRADE 4	3.04	17.98