Dissertation on

"A STUDY TO ANALYSE THE SIGNIFICANCE OF PRESSURE-TO-CORNEA INDEX IN PSEUDOEXFOLIATION EYES WITH AND WITHOUT GLAUCOMA"

Submitted in partial fulfillment of requirements of

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CERTIFICATE

This is to certify that this dissertation entitled **"A STUDY TO ANALYSE THE SIGNIFICANCE OF PRESSURE-TO-CORNEA INDEX IN PSEUDOEXFOLIATION EYES WITH AND WITHOUT GLAUCOMA "** is a bonafide record of research work done by **Dr. S. ABIRAMI,** Post Graduate Resident in Department of Ophthalmology, Madurai Medical College, Madurai.

She has submitted this in partial fulfillment of the regulations laid down by The Tamil Nadu Dr. M.G.R. Medical University, for the award of Master of Surgery Degree Branch III (Ophthalmology), under our guidance and supervision during the academic years 2014-2017.

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I, Dr. S.ABIRAMI, hereby solemnly declare that, this dissertation titled **"A STUDY TO ANALYSE THE SIGNIFICANCE OF PRESSURE-TO-CORNEA INDEX IN PSEUDOEXFOLIATION EYES WITH AND WITHOUT GLAUCOMA"** was done by me.

I also declare that this bonafide work / a part of this work was not submitted by me / anyone else, for any award, for Degree / Diploma to any other University / Board either in India / abroad. This is submitted to The Tamilnadu Dr. M. G. R. Medical University, Chennai in partial fulfilment of the rules and regulations for the award of Master of Surgery degree Branch -III (Ophthalmology) to be held in April 2017.

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PART ONE

INTRODUCTION

Normal human central corneal thickness varies between a range of *490 µm to 560 µm.* Whereas the intraocular pressure measured by the gold standard method **'Goldmann Applanation Tonometry'** is based on the assumption that CCT is 520 µm.

The measured intraocular pressure becomes falsely high or falsely low when measured on thicker corneas or thinner corneas respectively. So, IOP has to be adjusted according to the central corneal thickness by a correction factor.

Whereas there is no linear relationship between IOP and CCT. So even if the correction factor is applied, the correction of IOP over the extreme values of CCT becomes inaccurate and not reliable. Also, none of the correction factors, so far proposed, has been universally accepted as a standard formula.

So, to overcome this error in correction of IOP by various nonstandardized formulae, and also to integrate IOP and CCT as a single risk factor for glaucoma, a new index called as **Pressure-To-Cornea Index (PCI)** was introduced.

"PCI is the ratio between the highest recordable pretreatment IOP in mm Hg to the cubic power of Central Corneal Thickness(CCT) expressed in mm."

$$PCI = \frac{\text{Pretreatment IOP (mm Hg)}}{CCT^3 \text{ (mm)}}$$

e.g., if CCT is 545 μm and measured untreated IOP is 18 mmHg, then

PCI = 18/ (0.545 x 0.545 x 0.545)

= 18 / 0.161878625

= **111.2**

GLAUCOMA

"Glaucoma is defined as a chronic progressive optic neuropathy caused by a group of ocular conditions with optic disc changes and corresponding visual field defects, intraocular pressure being the only modifiable risk factor."

CLASSIFICATION OF GLAUCOMA

1. **CONGENITAL/DEVELOPMENTAL**
2. **ACQUIRED**
    a. **OPEN-ANGLE GLAUCOMA**
        i. PRIMARY
            1. Primary open angle glaucoma
            2. Normal tension glaucoma
        ii. SECONDARY
            1. Corticosteroid – induced glaucoma
            2. Pigmentary glaucoma
            3. Exfoliation glaucoma
            4. Inflammatory glaucoma
            5. Post—traumatic
            6. Neovascular glaucoma (early stage)
            7. Ghost cell glaucoma
            8. Hemosiderotic glaucoma
            9. Angle recession glaucoma
            10. Lens-protein glaucoma
            11. Lens-particle glaucoma
            12. Phacoanaphylactic glaucoma
            13. Increased episcleral venous pressure
            14. Masquerade (tumour)

15. Silicone oil

b. ANGLE-CLOSURE GLAUCOMA

i. PRIMARY

1. With pupillary block - Acute, subacute, chronic
2. Without pupillary block – plateau iris

ii. SECONDARY

1. With pupillary block
    a. Inflammatory(with seclusion pupillae or occlusion pupillae)
    b. Phacomorphic
    c. Silicone oil
    d. Vitreous block
2. Without pupillary block
    a. Neovascular glaucoma (late stage)
    b. Iridocorneal endothelial syndrome
    c. Aqueous misdirection syndrome
    d. Epithelial downgrowth
    e. Fibrous ingrowth

c. MIXED

INTRAOCULAR PRESSURE

“Intraocular pressure (IOP) is defined as the pressure exerted by the intraocular contents on the coats of the eyeball”. It is the most important and only modifiable risk factor for glaucoma. However, glaucoma can occur even with normal IOP.

“Normal IOP is the IOP which does not lead to any glaucomatous damage to the optic nerve head” and is in the range of 10 to 21 mm Hg. **Normal diurnal variation in IOP** is 3 to 6 mm Hg. IOP > 21 mm Hg or diurnal variation more than 8 mm Hg even with normal IOP becomes a risk factor and raise the suspicion of glaucoma.

METHODS TO MEASURE IOP

Tonometry is the method of measuring IOP and the instrument used is called as tonometer. Tonometer can be

1) Indentation tonometry
    (a) Schiotz
    (b) Herrington
    (c) Grants
    (d) Maurice

2) Applanation tonometry

    i) Variable force

        (a) Goldmann

        (b) Perkins

        (c) Draeger

        (d) Mackay-Marg

    ii) Variable area

        (a) Maklakov – Kalfa

        (b) Applanometer

        (c) Tonomat

        (d) Halberg

    iii) Non contact tonometry

3) Newer modalities

    a) Ocular response analyzer

    b) Dynamic contour tonometry (pascal)

    c) Rebound tonometer

    d) Transpalpabrel tonometer

GOLDMANN APPLANATION TONOMETRY (GAT)

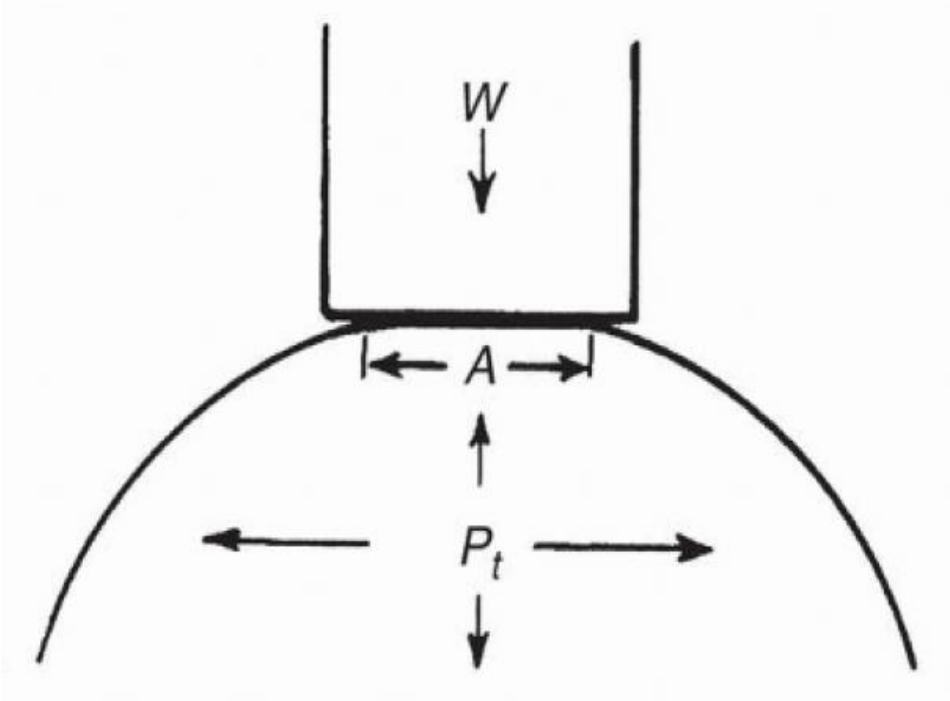
- Of these, **Goldmann applanation tonometer is considered as the GOLD STANDARD** method to measure IOP, since it is reliable and accurate, reproducible and not influenced by scleral rigidity.

- It is a constant-area applanation tonometer and determines the force necessary to flatten (or applanate) a 3.06 mm diameter area of the cornea. Also, there is minimal displacement (0.5 µl) of fluid or minimal increase in IOP with applanation, thus it is unaffected by scleral rigidity.

- It is based on the modified **Imbert-Fick's law**, also called as Maklakoff-Fick's law.

- Original Imbert-Fick's law states that "the force (**W**) against a perfectly flexible, dry, infinitely thin, perfect sphere is equal to the pressure(**Pt)** inside the sphere multiplied by the area of flattening (**A**) by the external force".

$$W = P_t X A$$



But cornea is aspherical, wet, not perfectly flexible, nor infinitely thin.

SPHERE (according to Imbert-Fick law)	**CORNEA**
• perfectly spherical • dry • perfectly flexible • infinitely thin	• aspherical • wet • not perfectly flexible • not infinitely thin

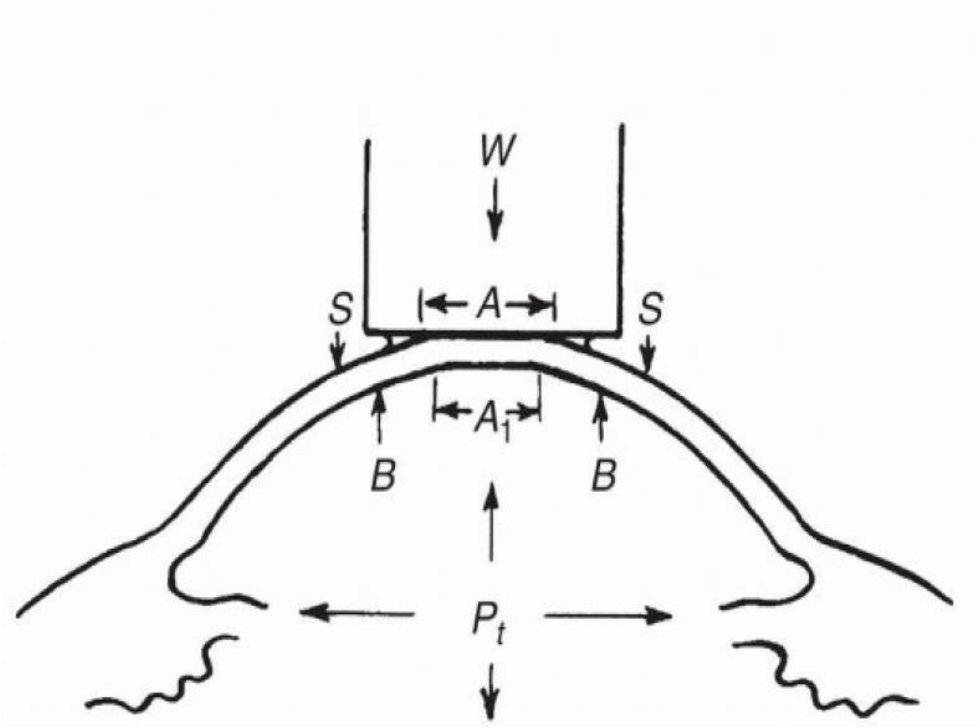
So, CORNEA fails to follow the law and additional forces come to action :-

1. The surface tension (S) of the tear film which acts towards the cornea
2. the force (B) offered by the cornea to the applanating surface away from the eye due to lack of flexibility, which is independent of the intraocular pressure.

- Also, since cornea has thickness of about 550 µm, the outer area (A) of corneal flattening differs from the inner area of flattening (A1). *Only flattening of inner corneal area (A_1) is considered as important.*

So, the Imbert-Fick's law gets modified as

$$\mathbf{W+S = P_tA_1 + B}$$



- But when $\mathbf{A_1}$= 7.35 mm^2, A = 3.06 mm and the central corneal thickness is assumed to be 520 µm, the additional forces S and B are equal and get balanced with each other and W becomes equal to P_t. So the external area of applanation is kept constant as 3.06 mm in the standard instrument.

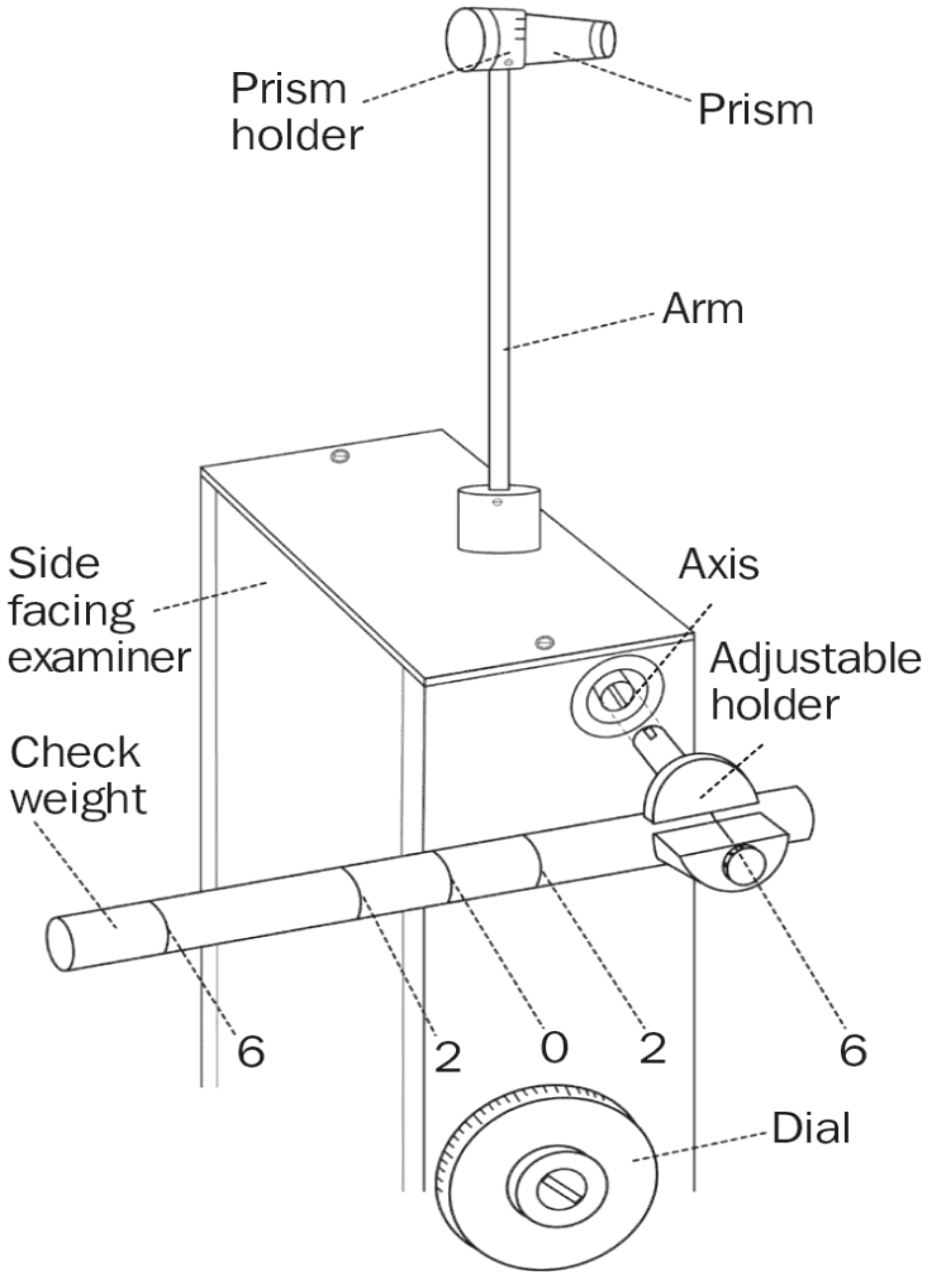
Whereas the normal central corneal thickness varies between a range of 490 µm to 560 µm. So, the measured intraocular pressure is not accurate for the corneal thickness.

It is false high on thicker corneas as in ocular hypertension or deposition of any additional tissue; false low on thinner corneas as in normal tension glaucoma, following keratorefractive surgery. So, IOP measure by GAT has to be adjusted according to the central corneal thickness by a correction factor.

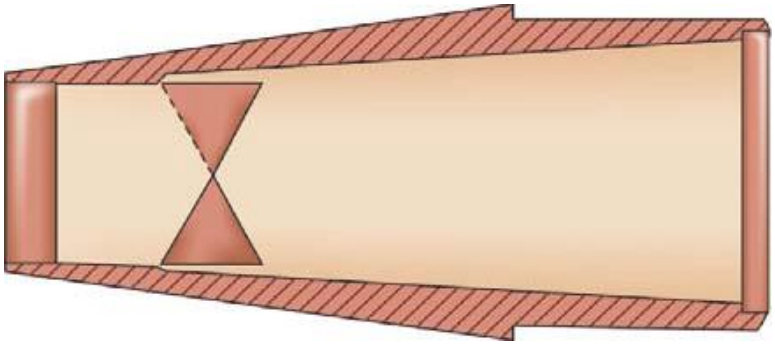
GAT - INSTRUMENT :

- ❖ The instrument is mounted on a standard slit lamp. It contains aapplanating unit which is attached by a rod, to a housing with levers to adjust the force of the biprism against the cornea.

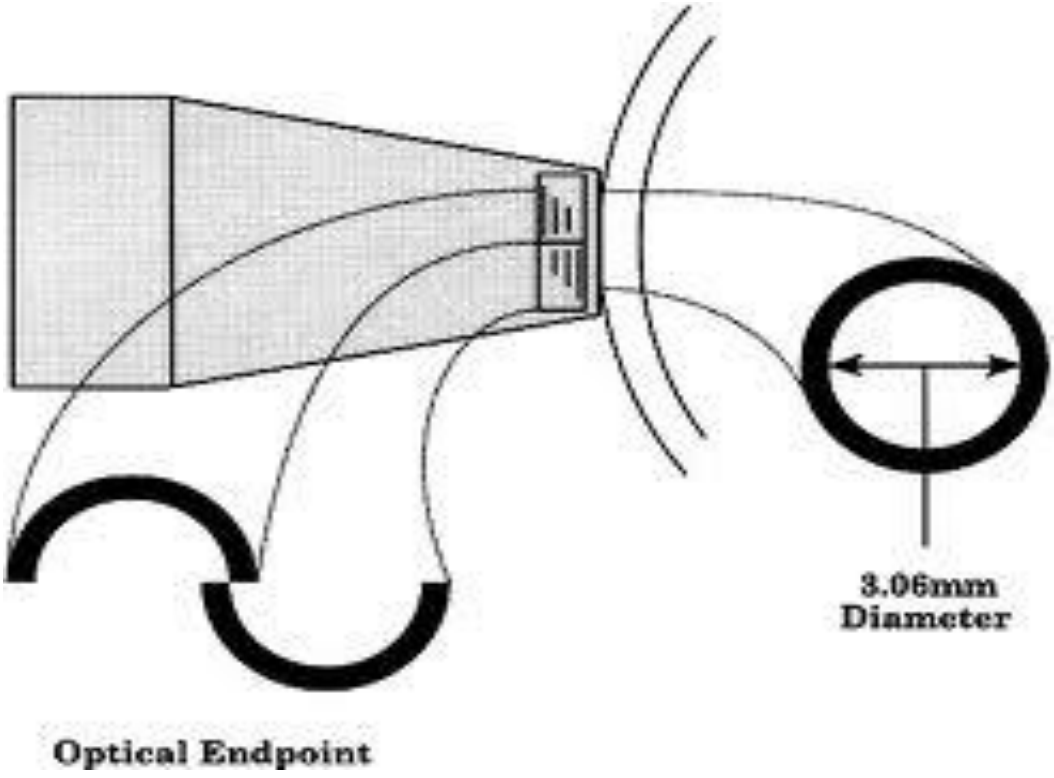
❖ Tension knob with markings, attached to the housing below, is used to adjust the force for applanation.



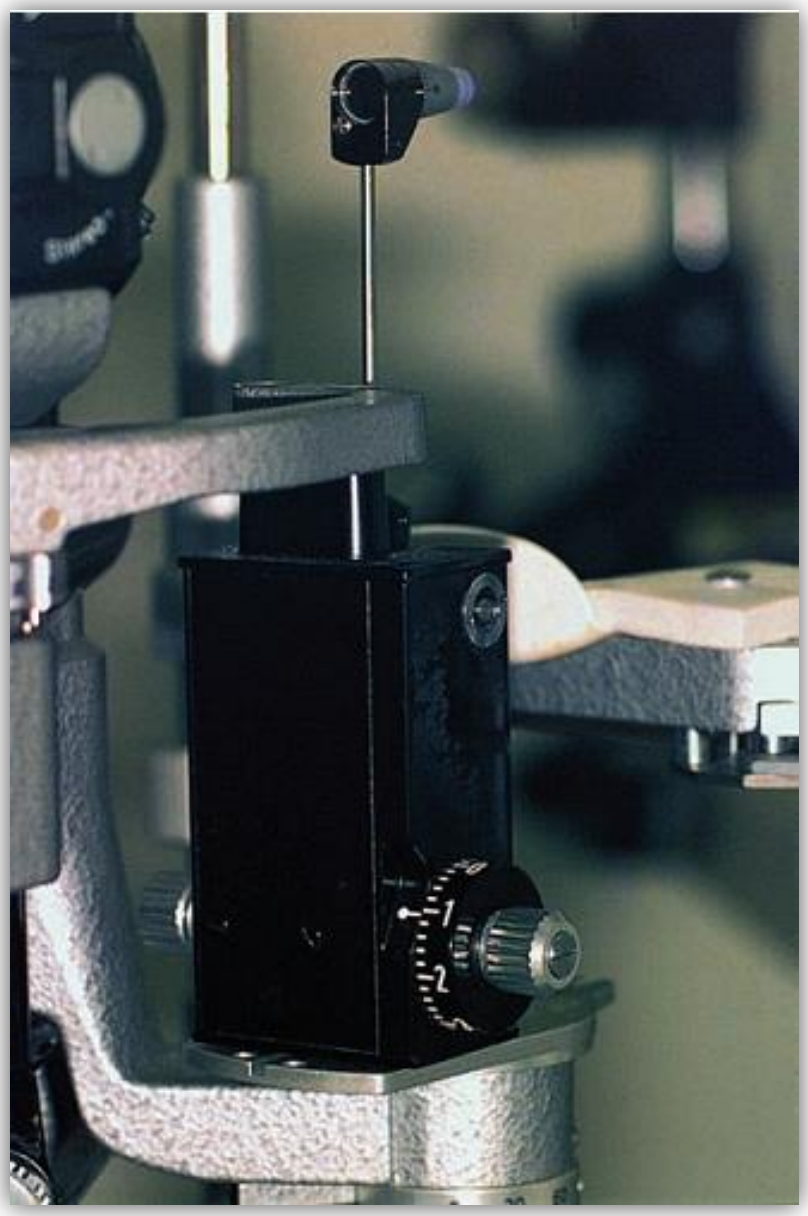
❖ Applanating unit contains two beam splitting prisms which optically convert circular area of corneal contact into 2 semicircles



Two beam splitting prisms



Optical Endpoint

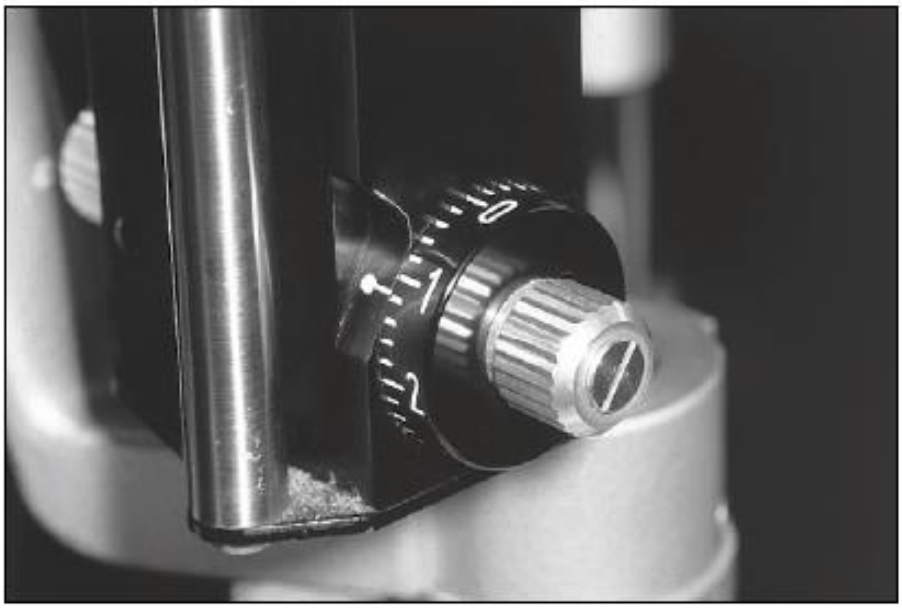


APPLANATION TONOMOTER - INSTRUMENT

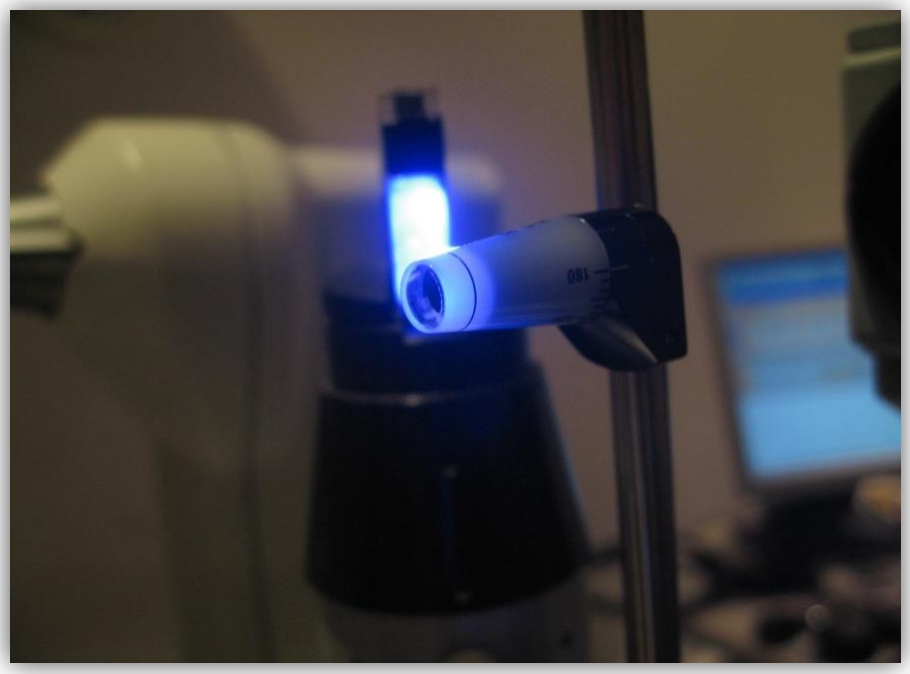
TECHNIQUE OF MEASUREMENT:

- The applanation unit is fitted on the slit lamp.

- One drop of a topical anesthetic - **0.5% proparacaine**, is instilled in each eye
- Procedure should be done in a semidark room and patient can be asked to fix at a distant target through the other eye.
- The tension knob is kept at **1 g** to prevent vibrations and damage to the corneal epithelium. **0 graduation mark** of the prism is set at the white line on the prism holder.



- The slit beam should be **widest and brightest** with the filter is switched to **cobalt-blue filter** and the angle between the illumination and the microscope should be about **60°**to make slit beam shine through the tonometer head



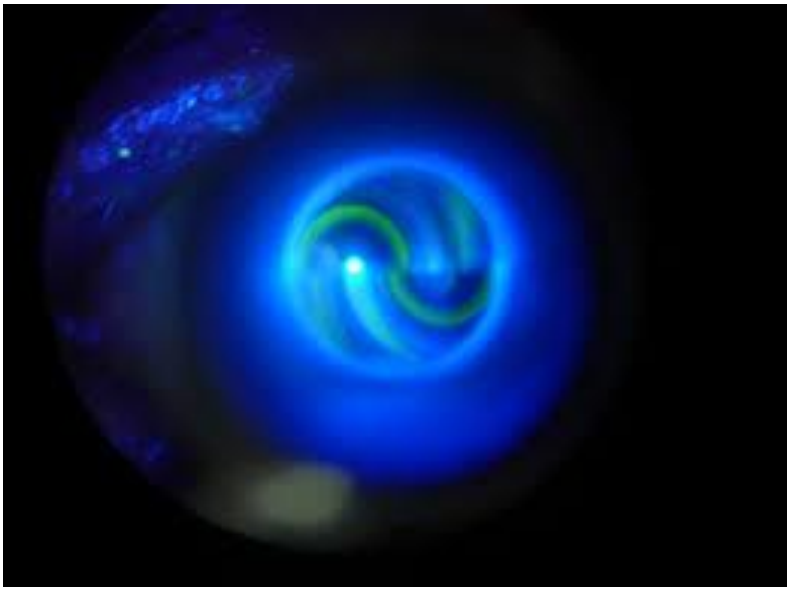
- Moistened ***1% sodium fluorescein dye*** strip is touched **on the inner fornix** and the patient should be asked to blink to spread the fluorescein-stained tear film over the cornea .

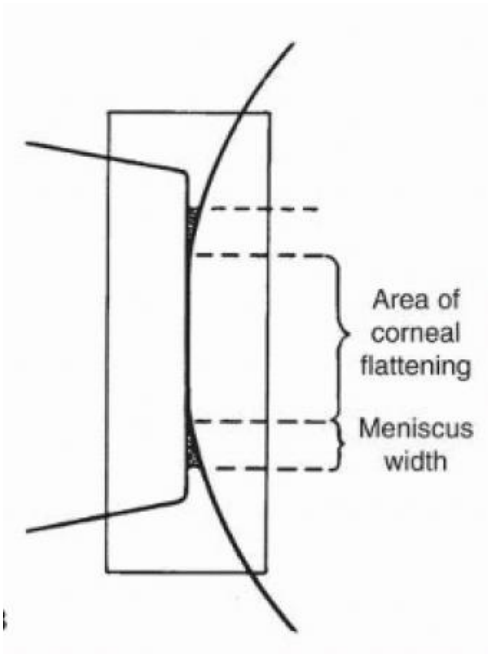
- Patient may be asked to look slightly upwards not more than **15° above the horizontal** or examiner can hold the eyelids with forefinger and thumb resting on orbital rim to prevent the applanating unit from touching the lashes or lids

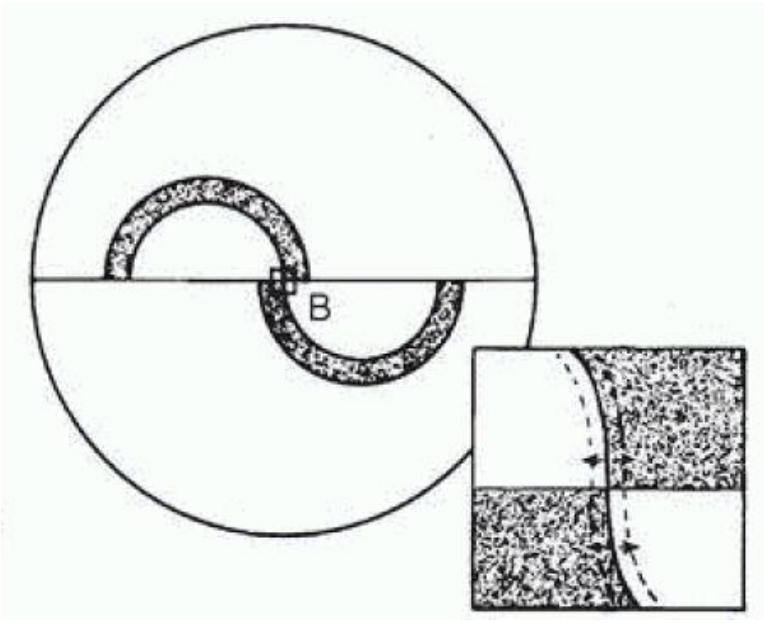
- Tonometer is kept perpendicular to the cornea and observed **monoocularly** through the biprism at **low magnification**. The instrument is advanced towards the patient until the tip of the prism gently touches the cornea and the semicircular mires are seen

- Adjust until the two semicirclesare of equal size,optimum thickness and seen in the center of the field of view.

- The tension knob is rotated until the **inner borders** of the fluorescein rings meet each other at the **midpoint of their pulsations**







- The reading measured in grams is multiplied by 10 to get the IOP in millimeters of mercury.

POSSIBLE ERRORS DURING MEASUREMENT:

1. Width of the fluorescein rings should be about one-tenth the diameter of the flattened area approximately **0.25–0.3 mm in thickness**
    a. **too narrow rings- IOP is underestimated**
        ➔ patient should be asked to blink two or three times/ additional fluorescein should be added
    b. **too wide - IOP is overestimated**
        ➔ the patient's eyelids should be blotted with a tissue/ the front surface of the prism should be dried with lint-free material
2. Corneal thickness –
    a. Thick cornea→ false high IOP

    Ocular hypertension, due to additional tissue

    b. Thin cornea →False low IOP

    Normal pressure glaucoma, Following keratorefractive surgery

    c. **Corneal edema – false low value** due to softening of the cornea although thickness is high
3. Corneal curvature –
    a. an increase of approximately 1 mm Hg for every 3 diopters (D) of increase in corneal power.

b. Marked corneal astigmatism produces an elliptical area of corneal contact.
c. To minimize this error, the biprism may be rotated until the dividing line between the prisms is 45 degrees to the major axis of the ellipse, or an average may be taken of horizontal and vertical readings.
d. with-the rule astigmatism →False low IOP; Against the-rule astigmatism →False high IOP

4. An irregular cornea distorts the semicircles and interferes with the accuracy of the IOP estimates.
5. Prolonged contact with the cornea leads to corneal injury
6. A natural bias for even numbers may cause slight errors in readings.
7. Improper caliberation

Falsely low IOP	**Falsely high IOP**
• too little fluorescein • thin cornea • corneal edema • with the rule astigmatism • 1mm Hg per 4 D • prolonged contact • Repeated tonometry	• too much fluorescein • thick cornea • steep cornea • against the rule astigmatism • 1mm Hg per 3D • Widening the lid fissure excessively • Elevating the eyes more than

	15° • pressing on the globe/squeezing the eyelids

CALIBERATION OF THE INSTRUMENT:

- GAT should be calibrated at least monthly.
- To check caliberation, there is a weight bar provided along with the instrument. It consists of five circles – middle one for drum position 0, two immediately on either side for drum position 2 and two on either sides at the ends are for drum position 6

Drum setting with corresponding position in weight bar	Check position	Movement of feeler arm
0	0	Towards examiner
	0.05	Towards patient
2	1.95	Towards examiner
	2.05	Towards patient
6	5.9	Towards examiner
	6.1	Towards patient

- If the GAT is not within 0.1 g (1 mmHg) of the correct calibration, the instrument should be repaired
- When the feeler arm is in the free movement zone, it should then move itself against the stop piece in the direction of the **patient**.

STERILIZATION

- Soak the tonometer tip in diluted sodium hypochlorite, 3% H_2O_2 or 70% isopropyl alcohol for 5-15 mins
- wipe with alcohol, H_2O_2, povidone iodine or 1: 1000 merthiolate.
- rinse in running tap water for 10 min,
- wash with soap and water
- exposure to UV light
- cover the tip with a disposable film/ Disposable tonometer tips

*disposable tips/ shields have a smooth applanating surface but not 100% protective against prion disease.

POSSIBLE INFECTIONS

- ❖ Bacteria, viruses, and other serious infections such as epidemic keratoconjunctivitis, hepatitis B, Jacob-Kreutzfeld and also HIV.

- ❖ Fluorescein preparation may be contaminated and may transfer Pseudomonas or Staphylococcus – can be prevented by using benoxinate, chlorobutanol, proparacaine or thiomersal.

PRECAUTIONS

- Tip of the tonometer should be examined for a smooth applanating surface to prevent any corneal damage
- Care should be taken to rinse off the tipcompletely, as some alcohol-based ones, can be irritating /toxic to the epithelium → corneal abrasion.
- Tonometer tip should be dry and wiped off before applying to the eye to prevent transfer of infection (e.g. Jacob-Kreutzfeld Virus) through the epithelial cells stuck on the tip.

CENTRAL CORNEAL THICKNESS

Normal corneal thickness is 0.7 to 0.9 mm at limbus and 0.49 mm and 0.56 mm at the centre. It also serves as a measure of corneal endothelial pump function and corneal rigidity. CCT acts as an independent risk factor for glaucoma and also to find out the actual IOP by applying correction factor .

FACTORS AFFECTING CCT

1. Age – higher in children and decreases with increasing age
2. Gender –higher in male than females
3. Race – thinner in African Americans than white population
4. Refractive error – may be thinner in myopes
5. Diabetes – higher

USES

1. For diagnosis and monitoring the prognosis of certain corneal disorders
2. for correction of IOP readings measured by GAT according to the thickness of the cornea.
3. To decide the type of cataract surgery(ECCE instead of phacoemulsification)to be performed in cases with corneal disorders.
4. To monitor the status of the graft following keratoplasty

5. To monitor the thickness of the cornea in diseases such as keratoconus ,pellucid marginal degeneration.

ROLE OF CCT IN GLAUCOMA

- CCT is an important independent risk factor for glaucoma. According to the Ocular Hypertension Treatment Study, low CCT serves as an important risk factor for progression from ocular hypertension to early glaucoma.
- Higher or lower CCT values can affect the IOP measured by Goldmann Applanation Tonometry. Hence, actual IOP is obtained by applying correction factor according to variation in CCT
- Higher CCT values seen in ocular hypertension → false high IOPs
- Lower CCT values in low tension glaucoma → false low IOPs
- Lower CCT values also in POAG and pseudoexfoliation syndrome
- No difference in PACG and pigmentary glaucoma patients

PACHYMETRY

Pachymetry is the method of measurement of corneal thickness.

Greek words: *Pachos* - thick, *metry* - to measure

Measurement techniques :

1. Ultrasonic methods
    i. Conventional ultrasonic pachymetry
    ii. Ultrasound Biomicroscopy (UBM)
2. Optical methods
    i. Manual Optical Pachymetry
    ii. Specular Microscopy
    iii. Scanning SlitTechnology
    iv. Optical Coherence Tomography(OCT)
    v. Optical Low Coherence Interferometry
    vi. Confocal Microscopy
    vii. Laser Doppler interferometry
3. Other Methods

i. Pentacam

ii. Pachycam

iii. Ocular response analyzer (ORA)

ULTRASONIC PACHYMETRY

Of these, **ultrasonic pachymetry is considered as the gold standard** and most commonly used since it is reproducible, faster, simpler and easy to use and also consistent and repeatable.

Principle: - Ultrasound energy is emitted from the probe tip acting as both the transmitter and receiver. Instruments functions by measuring the amount of time difference (transit time) between echoes of ultrasound pulse from the transducer and reflected signal from the front and back surface of the cornea.

Corneal thickness = (Transit time × Propagation velocity) / 2 Speed of sound in cornea-1640 m/sec is considered as standard.

PARTS –

1. Probe handle –contains piezoelectric crystal . Vibrates at frequency of 10 to 20 MHz
2. Probe tip –smooth tipped with diameter not more than 2 mm.
3. Transducer – sends ultrasound rays and receives echoes from cornea through the probe

PROCEDURE :

- Patient is explained about the procedure and asked to sit erect.
- 0.5% Topical proparacaine eye drops is instilled into the conjunctival sac and patient is asked to close the eyes.
- Patient is instructed to look at the fixation light and not to blink his eyes during the procedure.
- The ultrasound probe is placed perpendicularly on the central part of cornea till the beep sound is heard and the reading is taken.

- 5 readings are taken and the average of the readings is taken as the central corneal thickness (CCT) in microns

PRECAUTIONS :

- Probe tip should be smooth to prevent damage to the cornea
- Probe tip should not be more than 2 mm to prevent decrease in accuracy due to wider probe and wider transducer beam
- Probe should be perpendicular to the central cornea while measurement since oblique placement or lateral displacement of probe can lead to false high values.

ADVANTAGES

- Faster, simpler, easier, portable and doesn't require special training to handle
- No coupling medium required
- Minimal interobserver variation → consistent, repeatable
- Can be used intraoperatively

DISADVANTAGES

- Contact method - Cannot be done in cases of infection,
- Inaccurate if improper placement of probe
- Applanation force can decrease the thickness of the epithelium while measurement
- Corneal abnormalities such as edema may give inaccurate reading

INTRAOCULAR PRESSURE AND CENTRAL CORNEAL THICKNESS:

IOP is the only factor known to be amenable to treatment in glaucoma and glaucoma suspects.

Goldmann Applanation Tonometry(GAT) is the gold standard for clinical measurement of IOP. It is based on Imbert Fick's law, which assumes that "cornea is a perfect flexible, dry, sphere which is infinitely thin". Therefore increase in the tissue in thicker cornea makes it less compliant and subsequently leading to overestimation of IOP and viceversa .

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

In addition to this, the mathematical calculation for Goldmann applanation tonometry is based on a presumed average CCT of 520 μm, whereas the mean central corneal thickness in healthy human eyes is about 545 μm (micrometers).

Hence, the applanation tonometry readings are falsely high and falsely low in thicker corneas and thinner corneas respectively. So, the IOP values of applanation tonometry need to be adjusted according to variation in CCT from presumed average of 520 μm and a correction factor is always recommended to get the true IOP, to be considered for diagnosis and treatment.

According to a study by Ehlers and colleagues, the average error is 0.7 mm Hg per 10 μ of deviation from the mean of 520 μ, whereas another study, revealed a smaller error, of 0.19 mm Hg per 10 μ. Since the relationship between CCT and IOP is not linear, there is no standardized formula to recalculate IOP accurately, across the prevailing range of corneal thickness and intraocular pressures, to be accepted as a universal algorithm, till date.

PRESSURE-TO-CORNEA INDEX

So, to overcome this error in correction of IOP by various nonstandardized formulae, and also to integrate IOP and CCT as a single risk factor for glaucoma, Ilie*v et al.,*introduced a new index called as **Pressure-To-Cornea Index(PCI).**

"PCI is the ratio between the highest recordable pretreatment IOP in mm Hg to the Central Corneal Thickness(CCT) in mm to the power of three".

$$PCI = \frac{\text{Pretreatment IOP (mm Hg)}}{CCT^3 \text{ (mm)}}$$

In the study by Iliev et al, PCI in normal individuals, POAG, NTG and OHT were studied. Mean PCI in controls 92.0, NTG 129.1, OHT 134.0 and POAG 173.6. PCI had a significantly higher sensitivity of 80% and specificity of 90% when compared with each of the correction formulas such as Ehlers et. al , Doughty et. al, Shimmyo et. al. PCI in the normal individuals was in the range of 80 to 100 and a range of 120–140 may be considered as the upper limit of ‘‘normality’’ according to the study.

Uses:

- To better differentiate glaucoma from non-glaucoma than each of the individual parameters alone.
- As an indicator of risk for pressure related damage to the optic nerve due to glaucoma
- To predict the susceptibility of the individual towards glaucomatous damage.
- To set the target IOP for glaucoma treatment
- To grade the severity of glaucoma.

In another study by Franco et al., it was found that PCI can also be used to grade the severity of glaucoma

PSEUDOEXFOLIATIVE SYNDROME

- Pseudoexfoliative syndrome (PXF/PXS) is a systemic disorder characterized by the excessive production and deposition of grayish-white fibrillary material.
- It can be seen on various sites in the eye such as the anterior capsule of the lens, pupillary margin, iris, zonular fibers, ciliary body, corneal endothelium, trabecular meshwork and also conjunctiva.
- Other extraocular sites of PXF material deposition include extraocular muscles, orbital septa, orbital blood vessels such as posterior ciliary arteries, vortex veins and central retinal vessels.

- It is a systemic disease and PXF material can also be found in organs such as lung, liver, kidney, heart, gallbladder, skin and cerebral meninges.
- It is also associated with high incidence of cardiovascular and cerebrovascular morbidity, increased number of Alzheimer disease, vascular disorders, hearing loss, chronic kidney disease and *Helicobacter pylori* infection.

- PXF syndrome is a common age related disorder which is found in about 30 % of those above 60 years of age with no sex predilection. Its incidence varies with ethnicity being more common in African- American population and also Indians.
- prevalence of PXF in rural south India 3.8 % to 6.7 % with an incidence of glaucoma in the range of 0 to 40%

- ❖ Prevalence of PXF is also affected by geographical, environmental, racial, genetic and environmental factors.
- ❖ It is the most common identifiable cause of open- angle glaucoma. 22 to 50% people with PXF syndrome have associated glaucoma. However, it can also cause angle closure glaucoma with incidence of associated narrow angles being 23 to 32%

- ❖ PXF syndrome is a systemic disorder so that it is always bilateral in the eyes. However, it is named as unilateral or bilateral based on the visible PXF material either over anterior lens capsule or pupillary margin or angles. Even in unilateral cases, conjunctival biopsy can demonstrate the deposited PXF material.

- ❖ About 48% of unilateral cases become bilateral in a 15 year period. In the study conducted by Arvind et al.in south Indian population, the condition was unilateral in 49.1% and bilateral in 50.9% of the cases.

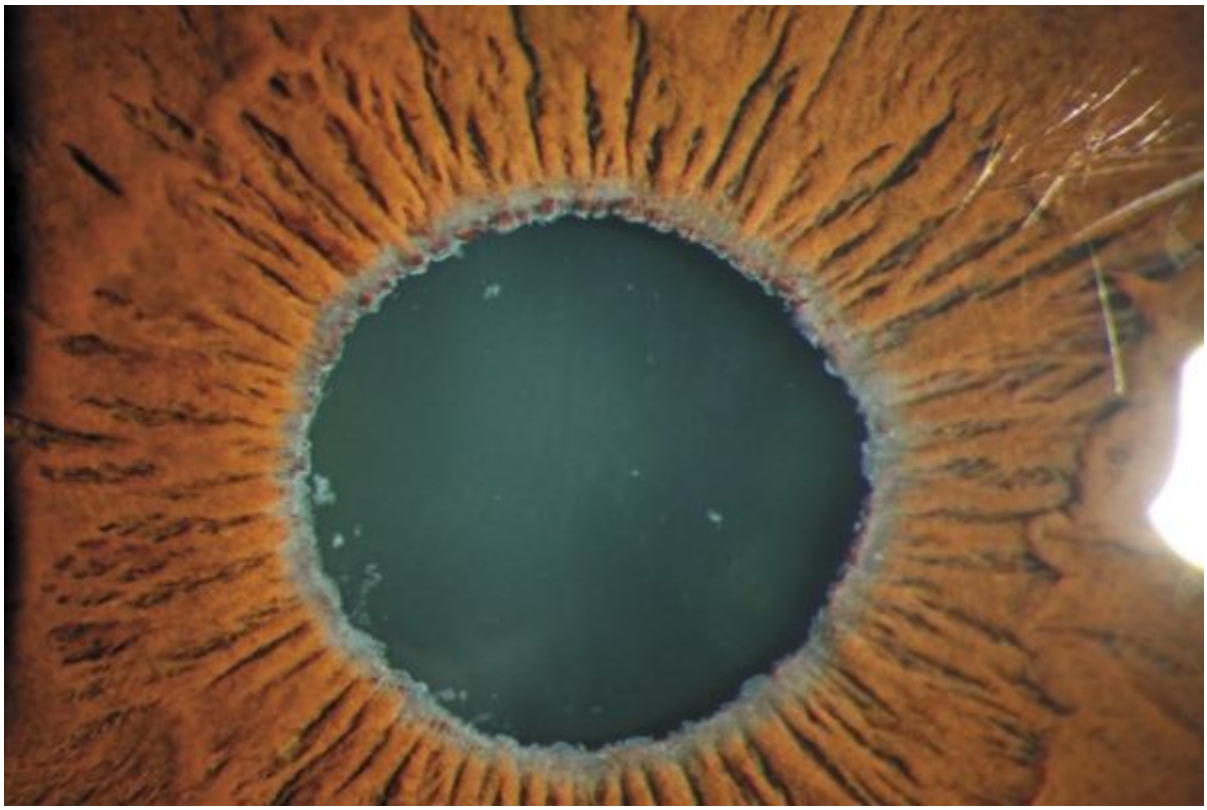
Clinical features

- **Cornea**
  - ❖ may demonstrate deposition of flakes of PXF material and pigments on the endothelium(occasionally in the form of **Krukenberg spindle**) causing increase in thickness of the cornea.

- ❖ It is associated with **decrease endothelial cell density which can present as decrease in corneal thickness**. Depending on the proportion of the pathologic change involved, cornea can either be thin or thick.
- ❖ This corneal endotheliopathy can appear in the form of guttata which is differentiated from Fuch's endothelial dystrophy by the diffuse distribution of the guttata, peripupillary iris atrophy and associated melanin dispersion in the anterior chamber.

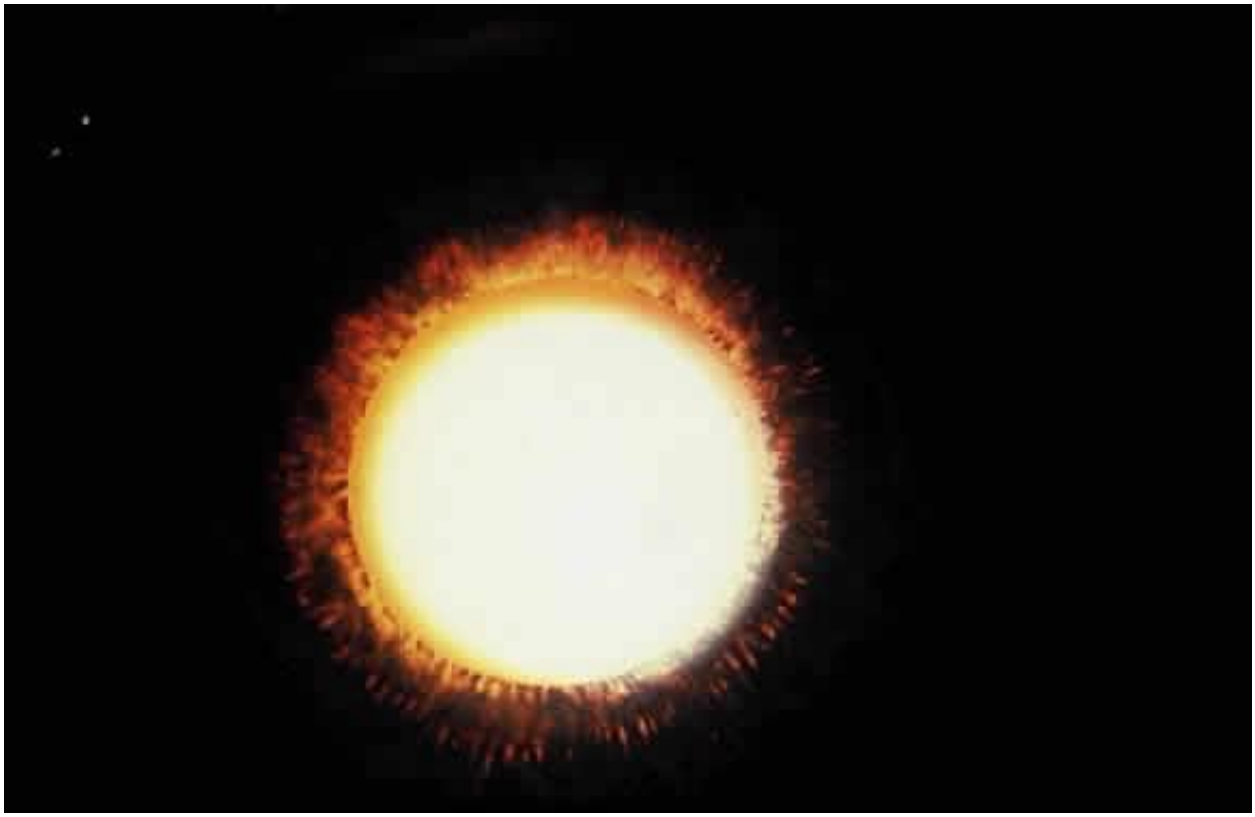
- **Iris**

  - ❖ The movement of the iris with pupillary excursions across the rough exfoliation material on the anterior lens capsule results in **pigment dispersion** from the iris pigment epithelium and increased flare in the anterior chamber due to breakdown of iris blood—aqueous barrier

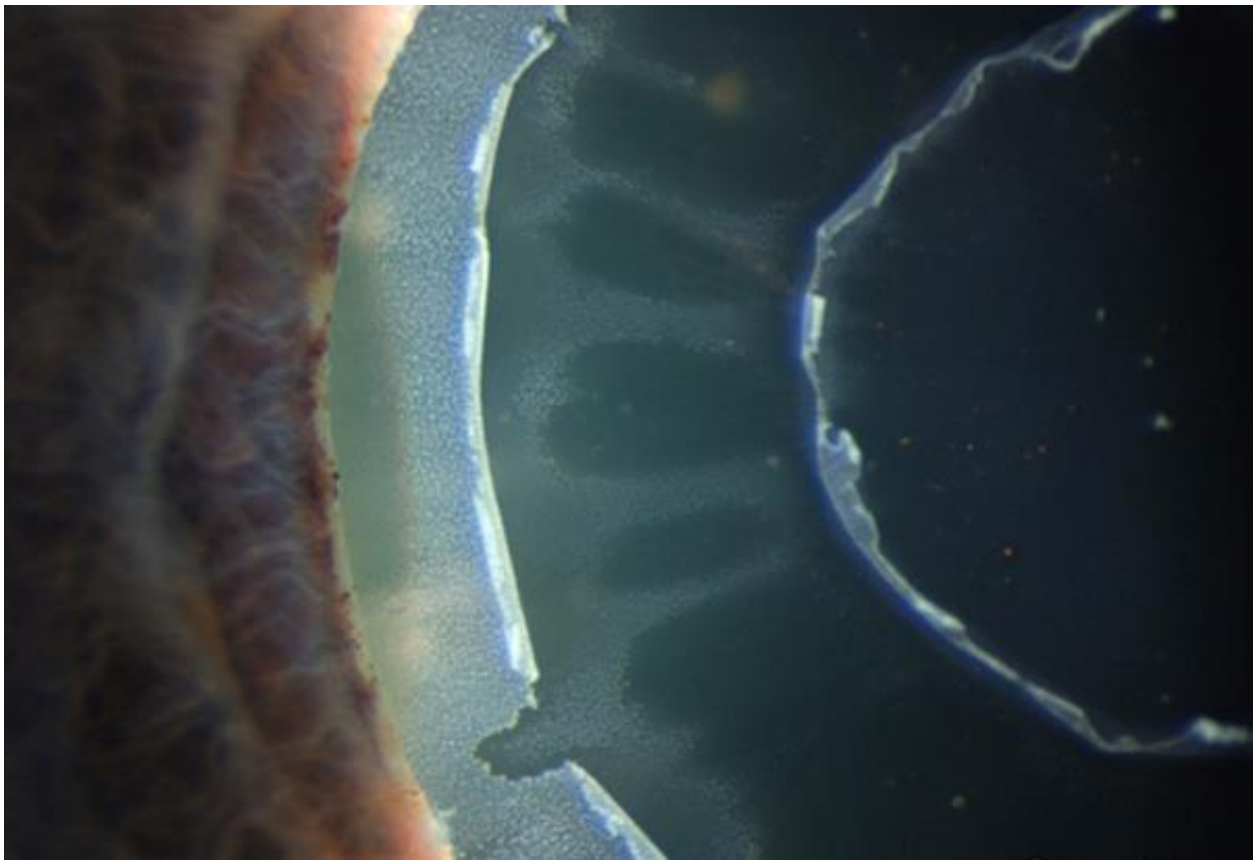


- Deposition of pigment is observed throughout the anterior segment, including the trabecular meshwork.

- Transillumination defects are usually seen in the peripupillary and sphincter regions of the iris giving rise to a ***'moth-eaten' pattern.*** This can be due to iris hypoxia caused by abnormal extracellular matrix with atrophy of pigment epithelium, stroma and muscle cells.

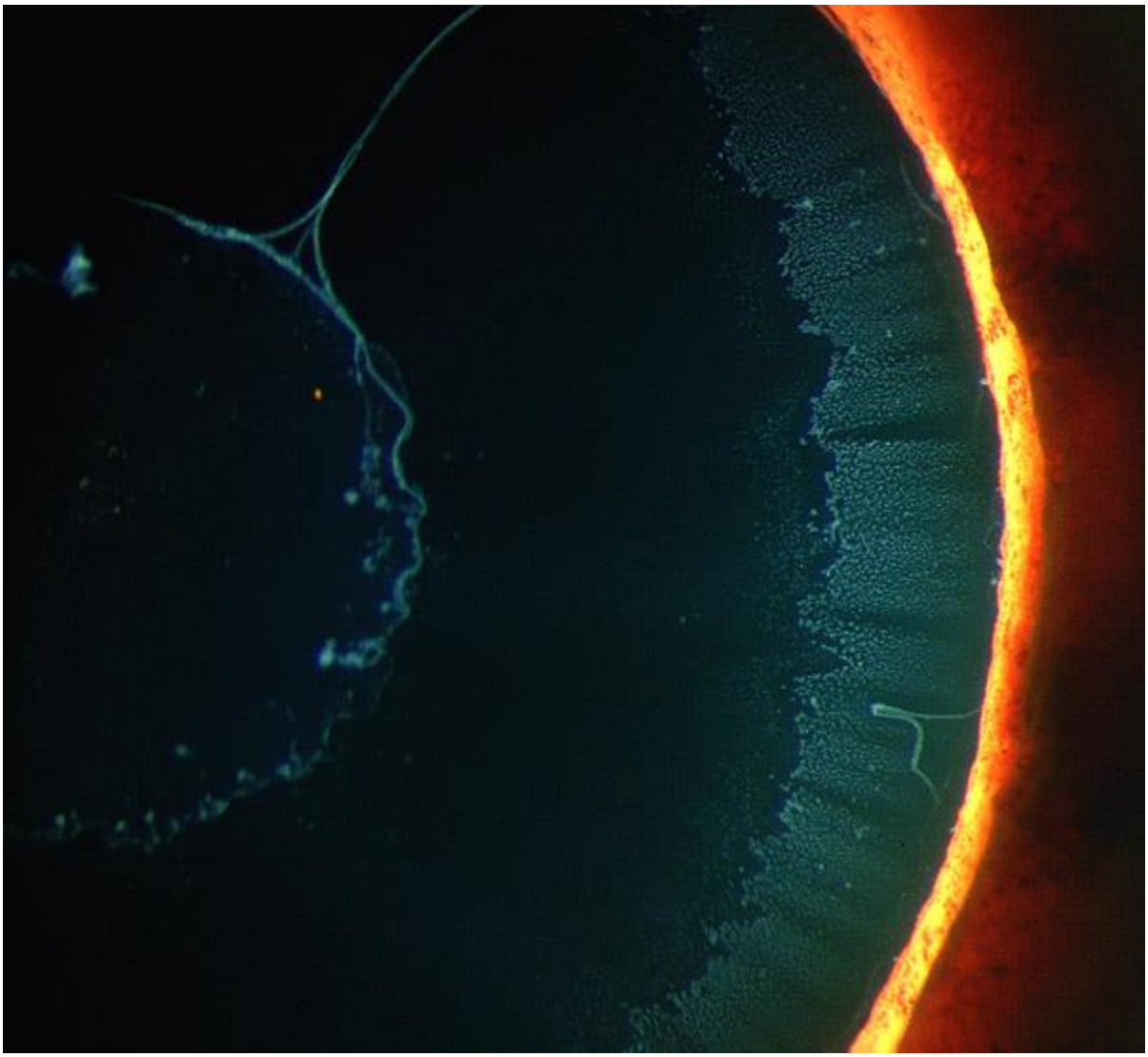


- **Lens**
  - ❖ Classic pseudoexfoliation syndrome in the anterior capsule of the lens presents with three distinct zones: a central, translucent disc with curled edges surrounded by a clear zone, and a peripheral granular zone with radial striations which can be detected only after dilatation of pupil.



PXF syndrome can be classified clinically into four stages based on deposition of PXF material on the anterior capsule of the lens.

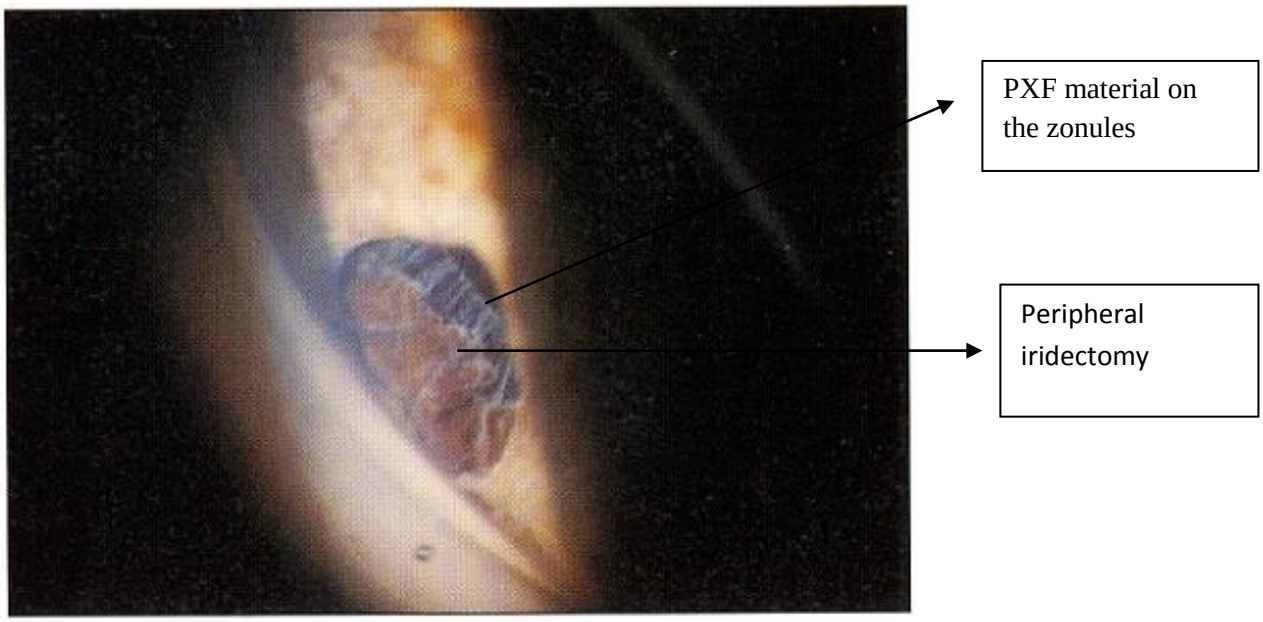
1. Preclinical stage – clinically invisible
2. Suspected pseudoexfoliation syndrome –precapsular layer with *ground glass appearance*
3. Mini-pseudoexfoliation syndrome – focal defect begins in the superonasal part of the anterior capsule
4. Classic pseudoexfoliation syndrome



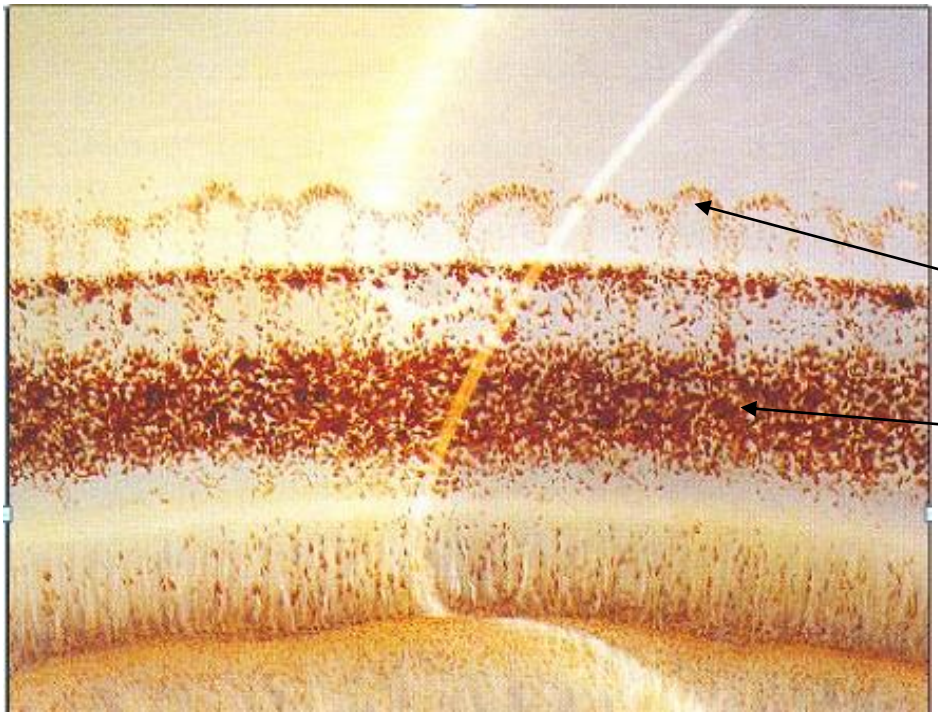
It is also associated with cataracts, nuclear cataracts being more common than cortical and supranuclear cataracts.

- **Ciliary processes and zonules**- Deposition of this PXF material on the ciliary processes and zonules may lead to weakening of zonules, leading to lens subluxation, displacement or phacodonesis. They cause weakness of zonules by proteolytic

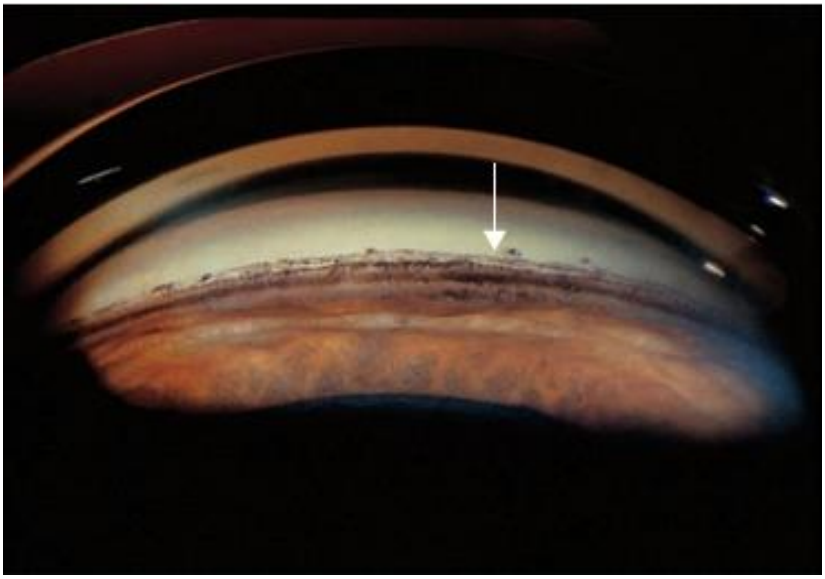
enzymes and eruption through the basement membrane and entering into zonular lamellae. This can cause increased complications during cataract surgery.



- **Gonioscopy** - Anterior chamber angle may demonstrate heavy trabecular patchy hyperpigmentation with dandruff-like PXF deposits. Pigment deposition anterior to Schwalbe's line, creating a wavy line (Sampaolesi line).



Gonioscopy picture showing heavy pigment deposition in TM and sampolesi line.



Gonioscopy with PXF material on the angle structures.

PSEUDOEXFOLIATION AND GLAUCOMA:

Pseudoexfoliative syndrome is a common cause of secondary open-angle glaucoma in many populations. Accumulation of pigment and exfoliation material in the trabecular meshwork, reduces conventional outflow of aqueous humour leading to secondary rise in IOP, which is seen in about 22–50% of cases.

This can be associated with optic disc damage and visual field defects as in primary open-angle glaucoma. The presence of pigment deposition in the superior angle, associated with loss of the pupillary ruff in an elderly patient, is highly suggestive of exfoliation syndrome.

The maximum IOP recorded and the severity are related to the amount of PXF material deposited in the juxtacanalicular part of the trabecular meshwork. Pigment dispersion may act as a contributing factor for glaucoma.

Pseudoexfoliative glaucoma has a more aggressive clinical course with higher IOPs and poorer response to treatment .

DIFFERENTIAL DIAGNOSIS

1. TRUE EXFOLIATION
2. PIGMENT DISPERSION SYNDROME

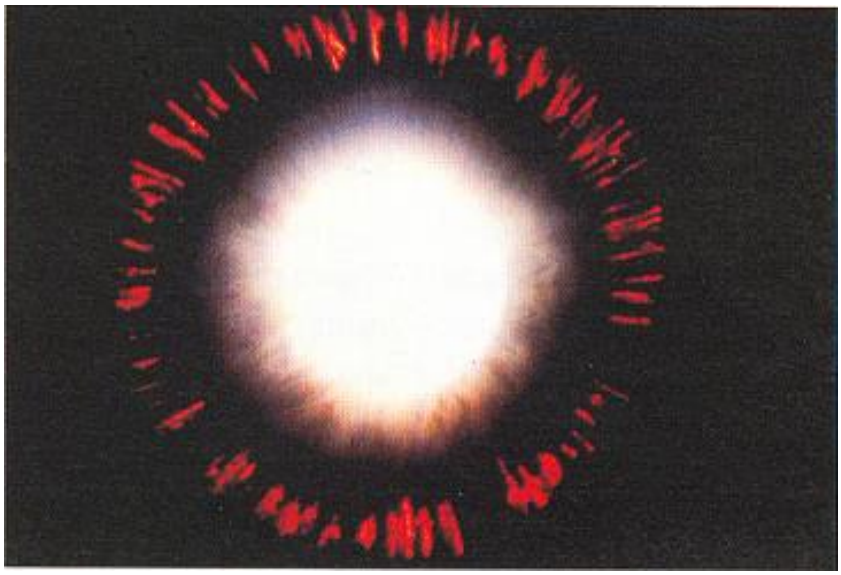
TRUE EXFOLIATION

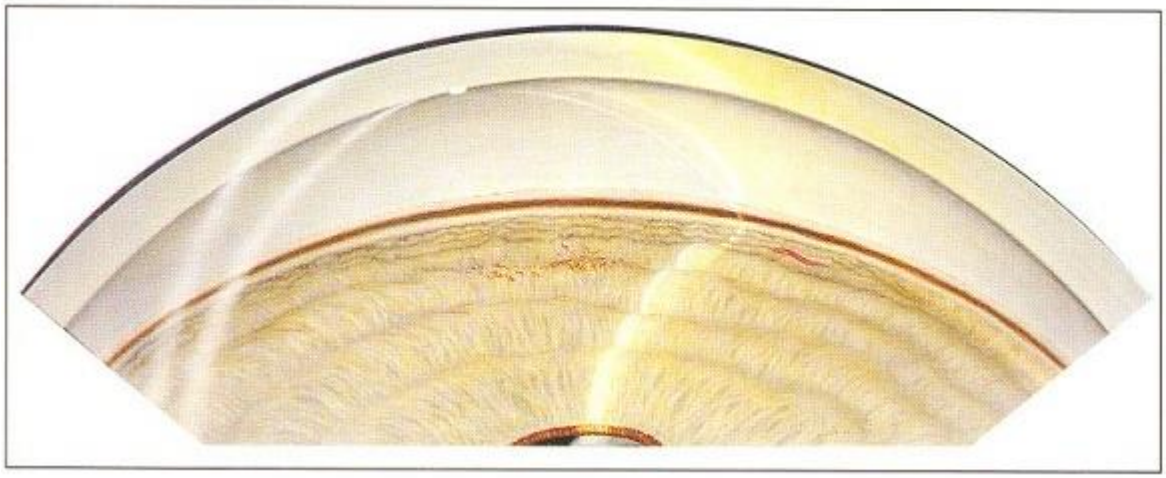
Pseudoexfoliation should be differentiated from true exfoliation or capsular delamination. It is a rare condition, characterized by the separation of superficial layers of the lens capsule from the deeper layers with scroll-like margins and thin, diaphanous membrane floating on the anterior chamber.

It is usually seen in persons with exposure to high temperatures, such as glass blowers due to long term exposure to infra red radiation or presence of foreign bodies, such as copper or brass or following trauma, following intraocular inflammation or idiopathic in advanced age. It is commonly associated with cataract but not with glaucoma. It is also called as exfoliation of the lens capsule.

PIGMENT DISPERSION SYNDROME(PDS)

PDS is caused by the dispersion of the pigments from the posterior surface of the iris into the anterior segment. This can be differentiated from PXS by its bilateral presentation, finer pigmentary deposits on iris, presence of krukenberg spindle, mid-peripheral Transillumination defect and dense pigment band in the posterior trabecular meshwork.





PRESSURE-TO-CORNEA INDEX IN PSEUDOEXFOLIATION:

Normal human central corneal thickness varies between a range of 490 µm to 560 µm. Whereas the intraocular pressure measured by the gold standard method 'Goldmann Applanation Tonometry' is based on the assumption that CCT is 520 µm.

The measured intraocular pressure becomes falsely high or falsely low based on thickness of the cornea. So, IOP has to be adjusted according to the central corneal thickness by a correction factor.

Whereas the relationship between IOP and CCT is not linear. So even if the correction factor is applied, the correction of IOP over the extreme values of CCT becomes inaccurate and not reliable. Also, none of the correction factors, so far proposed, has been universally accepted as a standard formula.

So, to overcome the error in correction of IOP by various nonstandardized formulae, and also to integrate IOP and CCT as a single risk factor for glaucoma, a new index called as **Pressure-To-Cornea Index(PCI) was introduced.**

On the other hand, pseudoexfoliation is the most common identifiable cause of secondary glaucoma. The significance is that it has a more aggressive clinical course with higher IOP readings and difficult to treat due to poor response to medications.

Further, Corneal thickness in pseudoexfoliation has been found to be variable, either thick or thin. According to some studies, in PXS eyes, regardless of the presence of glaucoma in the patients, the corneal endothelial cell density is decreased

and the central cornea is thin. However, in some other studies, PXS eyes were found to have thicker CCT. So, CCT remains to be a highly variable factor in case of pseudoexfoliation eyes irrespective of the presence of glaucoma, which in turn will affect the IOP in extreme CCT values.

As the relation between the IOP and CCT is not in a linear manner, even if the correction factor is applied, extreme less or high values of CCT will make the IOP, not comparable, not reliable and also not standardized for treatment and follow up of PXF patients. So, the PCI can be used in such PXF eyes, where corrected IOP is not accurate.

So, the diagnosis and management of glaucoma secondary to PXF remains a challenge. Our aim is to find out whether PCI can be helpful in PXF to correct the IOP due to wide variation in CCT, its distribution in PXF cases with and without glaucoma and to find out whether there is any significant difference between the two groups.

So that it can indicate the risk for the development of glaucoma in PXS and act as a predictor for glaucoma. This can help us to make the patient to undergo close follow up visits and help the consulting ophthalmologist to diagnose early and treat pseudoexfoliative glaucoma better and prevent further damage to optic nerve head.

PART TWO

AIMS AND OBJECTIVES:

- To integrate Intraocular Pressure(IOP) and Central Corneal Thickness(CCT) as a single risk factor in the form of Pressure-to-Cornea Index (PCI) for various IOP levels
- To find out the distribution of PCI in patients with and without pseudoexfoliation(PXF) and to find out whether PCI can be taken as a predictor for open angle glaucoma (OAG) secondary to pseudoexfoliation.

MATERIALS AND METHODS:

STUDY DESIGN:

Non randomized, comparative , cross-sectional study

This study was conducted among 90 eyes of patients above 40 years of age (30 PXF eyes without glaucoma(PXS), 30 eyes with glaucoma secondary to pseudoexfoliation syndrome (PXG), 30 normal subjects with no evidence of glaucoma or pseudoexfoliation), attending our department as outpatient as well as inpatient to the wards of our Govt. Rajaji Hospital, Madurai

STUDY PERIOD: 6 Months (April 2016 to September 2016)

SELECTION OF STUDY SUBJECTS: A total of 90 eyes among patients attending as outpatient and in the wards of the Department of Ophthalmology, Govt. Rajaji Hospital, Madurai who satisfy the inclusion criteria

INCLUSION CRITERIA:

1. Normal subjects above 40 years of age with no evidence of glaucoma or pseudoexfoliation (PXF)
2. All patients with pseudoexfoliation syndrome with no other factors mentioned in the exclusion criteria

EXCLUSION CRITERIA:

1. Patients already diagnosed to have POAG/ OHT/ NTG/ PACG
2. Patients with secondary glaucoma except for pseudoexfoliation
3. History of ocular surgery (cataract surgery/ corneal surgery)
4. History of ocular surface disorders
5. History of contact lens wear
6. History of trauma

7. Family history of glaucoma
8. Person with occupation with exposure to high temperatures, such as glass blowers, furnace workers, etc.

ETHICAL COMMITTEE CLEARANCE

Obtained from the Institutional Ethical Committee of GRH Madurai.

FINANCIAL SUPPORT-Nil

METHODOLOGY**:**

90 eyes of patients above 40 years of age (30 pseudoexfoliation eyes without glaucoma, 30 eyes with glaucoma secondary to pseudoexfoliation, 30 normal subjects with no evidence of glaucoma or pseudoexfoliation) were evaluated for PCI.

A detailed evaluation including history, visual acuity, slit lamp examination, gonioscopy, intraocular pressure, central corneal thickness, fields and dilated fundus examination were performed

Diagnosis of pseudoexfoliation syndrome was based on the presence of pseudoexfoliative material over the pupil or lens or both, with

normal IOP, normal fields and no optic disc changes. Patient was diagnosed to have glaucoma secondary to pseudoexfoliation with increased IOP with glaucomatous optic disc changes and field defects.

Of the patients with bilateral PXF deposition in the eyes, one eye was selected randomly for evaluation and included in the study.

Intraocular pressure was measured by Goldmann Applanation Tonometry and Central Corneal Thickness was by Ultrasound pachymetry(ACCUPACH).

Diagnosis of pseudoexfoliation syndrome and secondary glaucoma due to pseudoexfoliation are based on the IOP corrected according to central corneal thickness (CCT) by Ehlers formula, i.e, 0.7 mm Hg per 10µm difference in CCT. A difference of 20µm between optical pachymetry (Ehlers method) and ultrasound pachymetry(used in our study) was also taken into account.

OBSERVATION AND ANALYSIS

STATISTICAL METHOD:

The information collected regarding all the selected cases were recorded in a master chart.

Data analysis was done with the help of computer by using SPSS 16 software.

Using this software mean, standard deviation and ‘p’ value were calculated through One way ANOVA, Chi square test correlation coefficient from Pearson correlation.

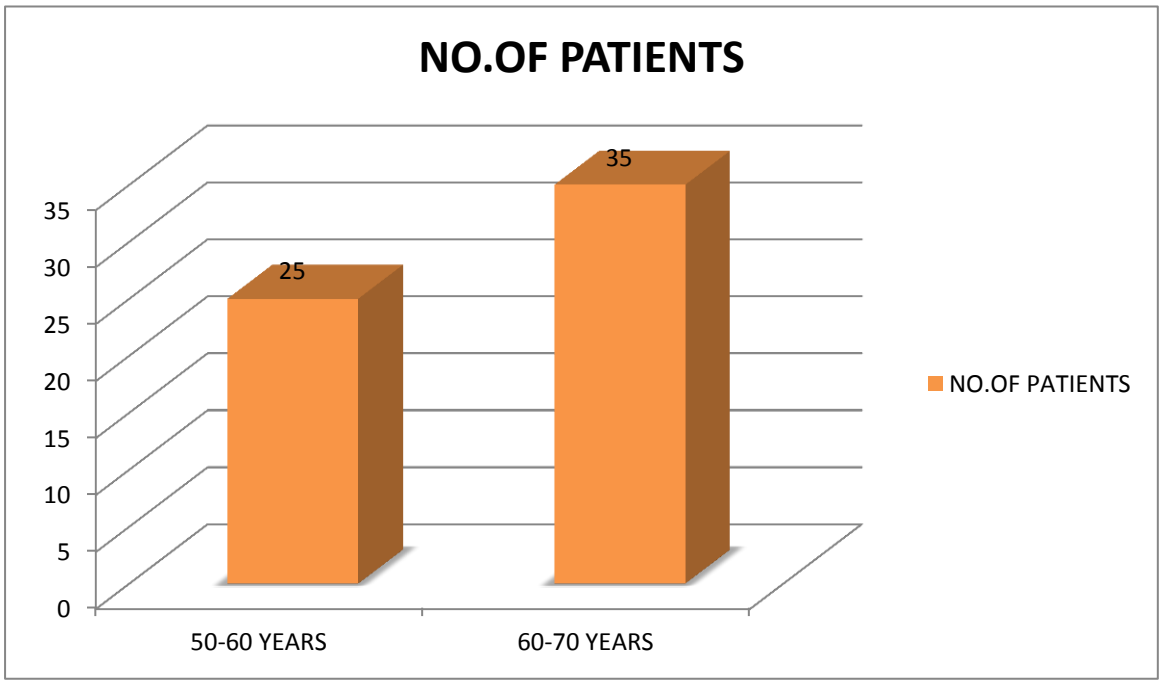
P value of < 0.05 was taken as significant.

ANALYSIS

1. AGE DISTRIBUTION OF PXF:

In our study, patients with PXF were between 50 to 70 years of age. Of these, 25 patients (41.67%) were between 50 – 60 years and 35 (58.33%) between 60 – 70 years of age. This shows an age related increase in the prevalence of PXF.

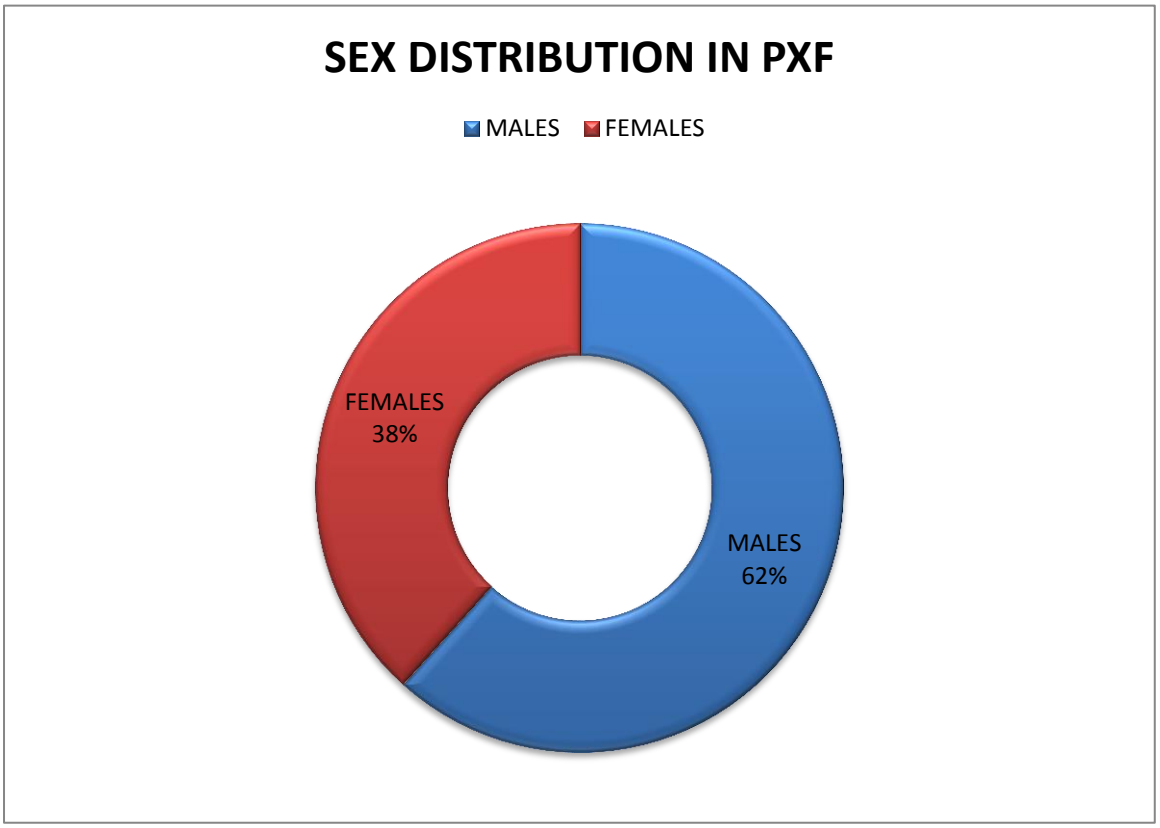
AGE DISTRIBUTION OF PXF	NO.OF PATIENTS	PERCENTAGE
50-60 YEARS	25	41.67%
60-70 YEARS	35	58.33%



2. SEX DISTRIBUTION OF PXF:

Of the sixty subjects with PXF, 37 were males and 23 were females accounting to 61.67% and 38.33% respectively. This shows a male preponderance of PXF in our study.

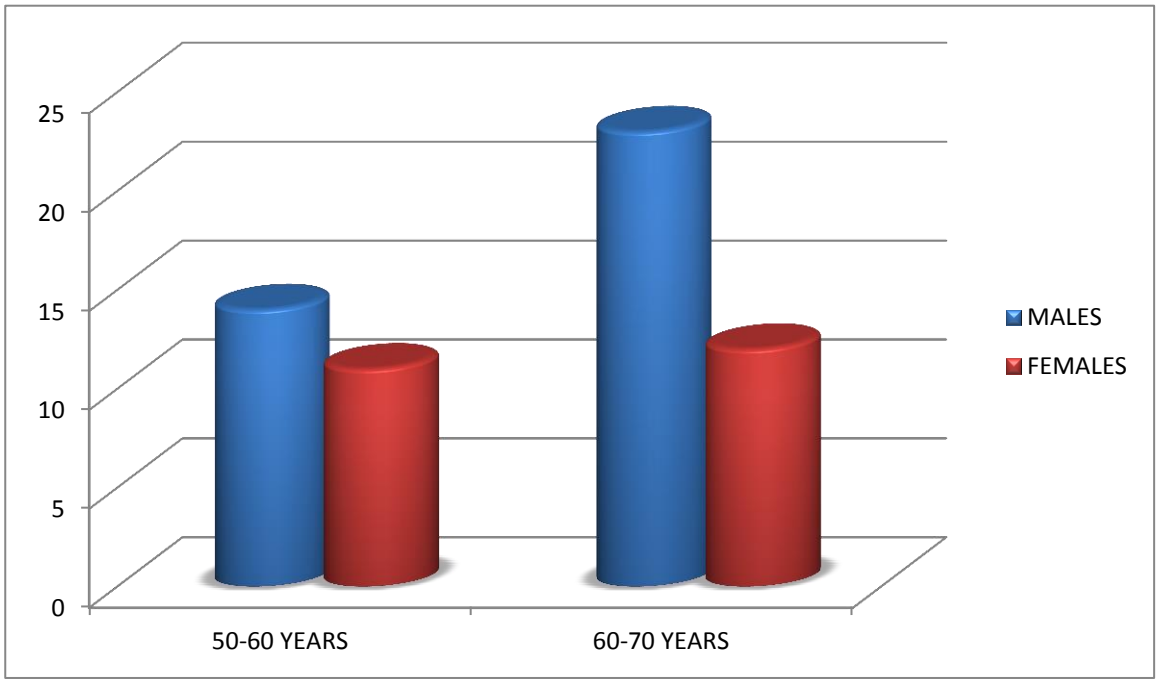
SEX DISTRIBUTION		**PERCENTAGE**
NO. OF MALES	37	61.67%
NO. OF FEMALES	23	38.33%



3. AGE AND SEX DISTRIBUTION:

In the age group of 50 – 60 years in PXF, 14 were males and 11 were females and in the group of 60 – 70 years, 23 were males and 12 were females.

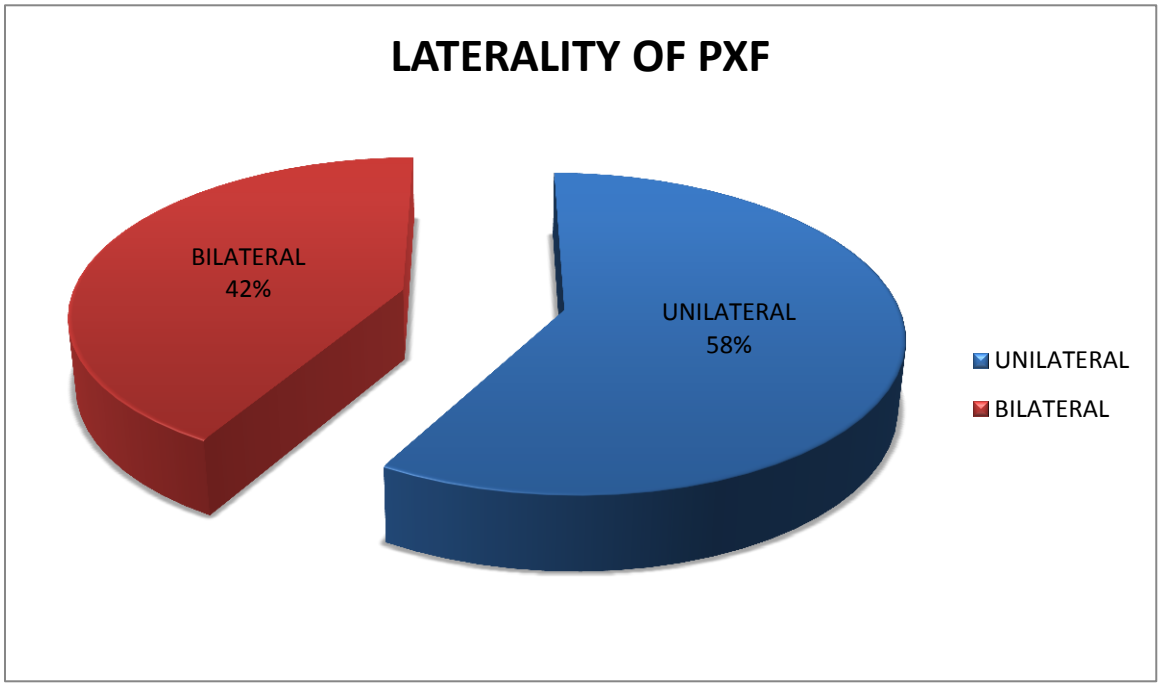
PXF SEX DISTRIBUTION ACCORDING TO AGE	MALES	FEMALES	TOTAL	PERCENTAGE
50-60 YEARS	14	11	25	41.67%
60-70 YEARS	23	12	35	58.33%

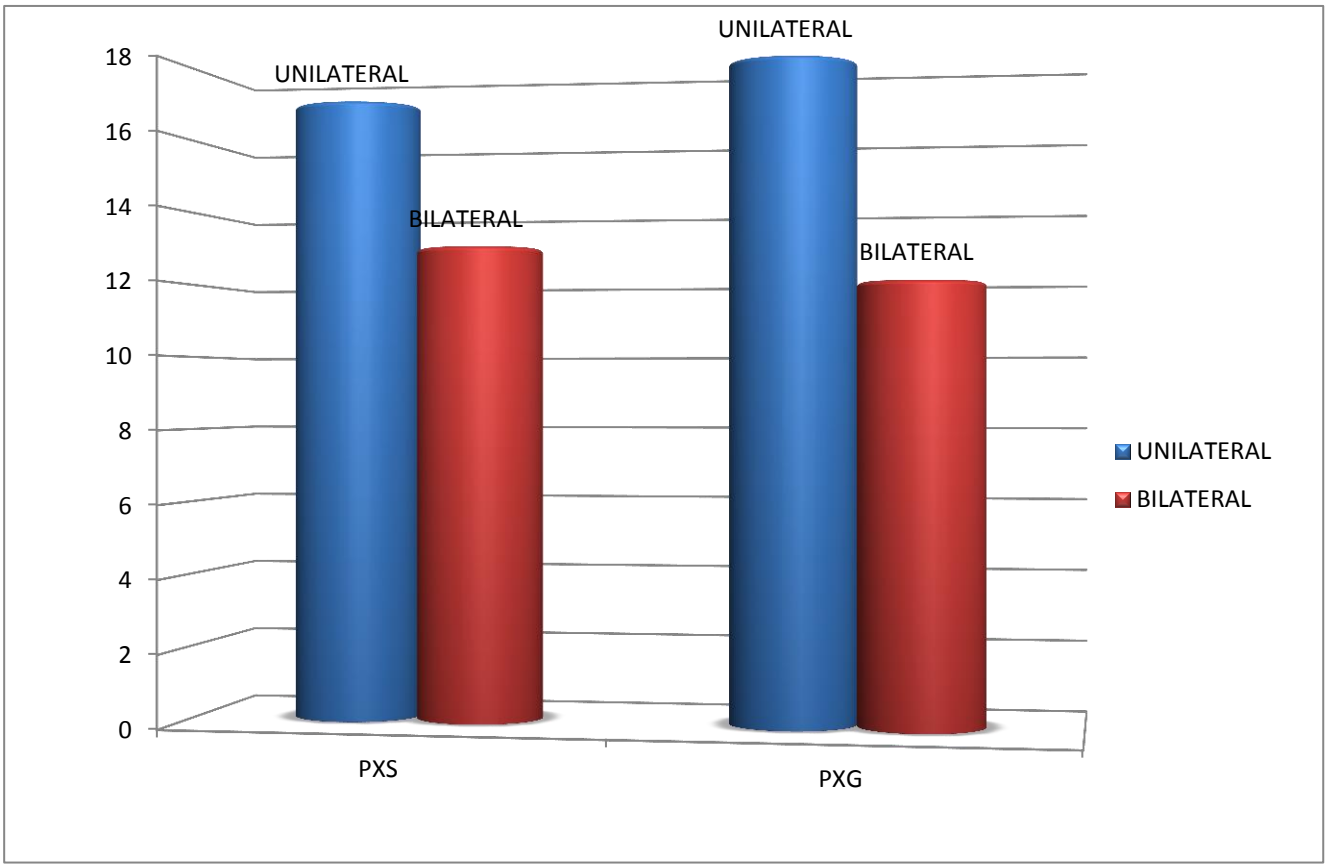


4. LATERALITY OF PXF:

Among the PXF patients, PXF material unilateral in 35 and bilateral in 25 patients which leads to a percentage of 58.33% and 41.67% respectively.

	PXS	PXG	TOTAL	PERCENTAGE
UNILATERAL	17	18	35	58.33
BILATERAL	13	12	25	41.67





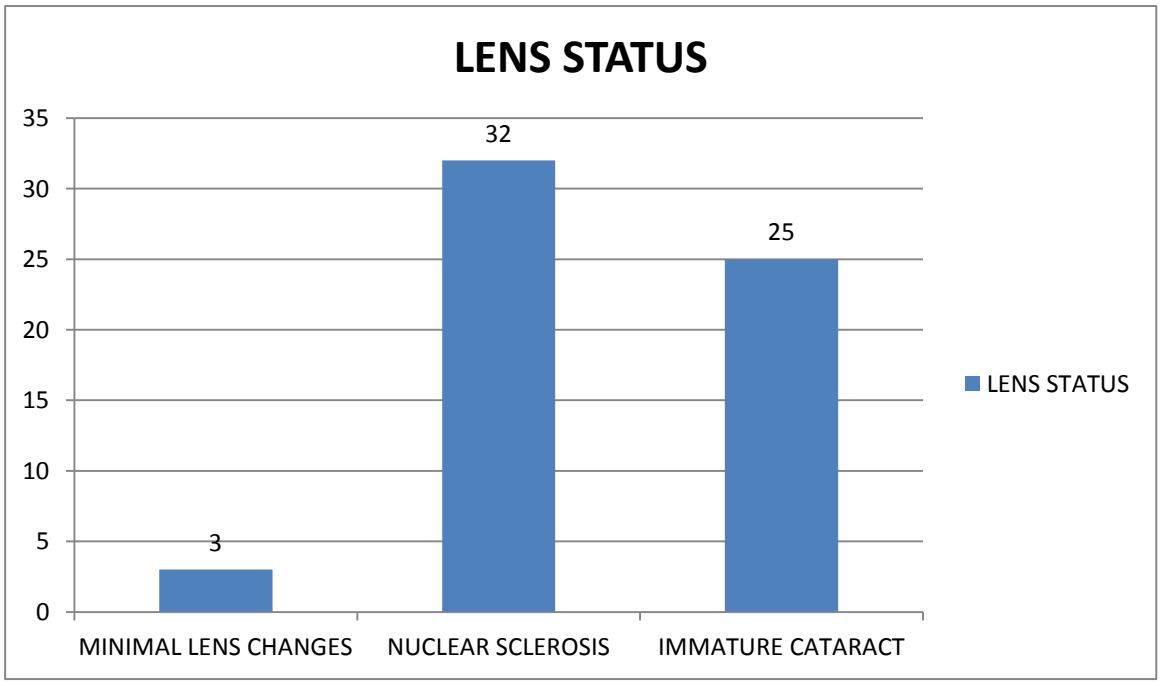
In the PXS group, 17 patients had unilateral and 13 had bilateral PXF.

In the PXG group, 18 had unilateral and 12 had bilateral PXF. In both the groups, unilateral PXF was higher in our study.

5. LENS CHANGES

- 53.33% of the PXF patients had nuclear sclerosis, 41.67% had immature cataract and 5% had minimal lens changes. This agrees with many studies where there is increased association of nuclear sclerosis.

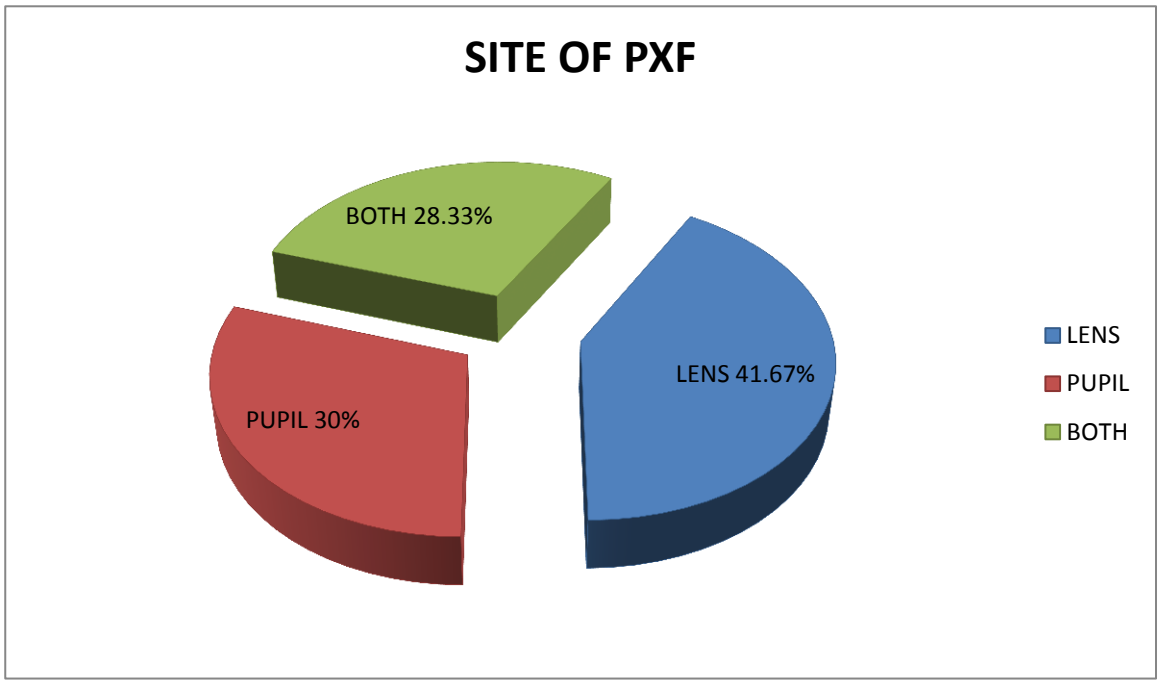
	NO. of patients	**PERCENTAGE**
MLC	3	5%
NS	32	53.33%
IMC	25	41.67%

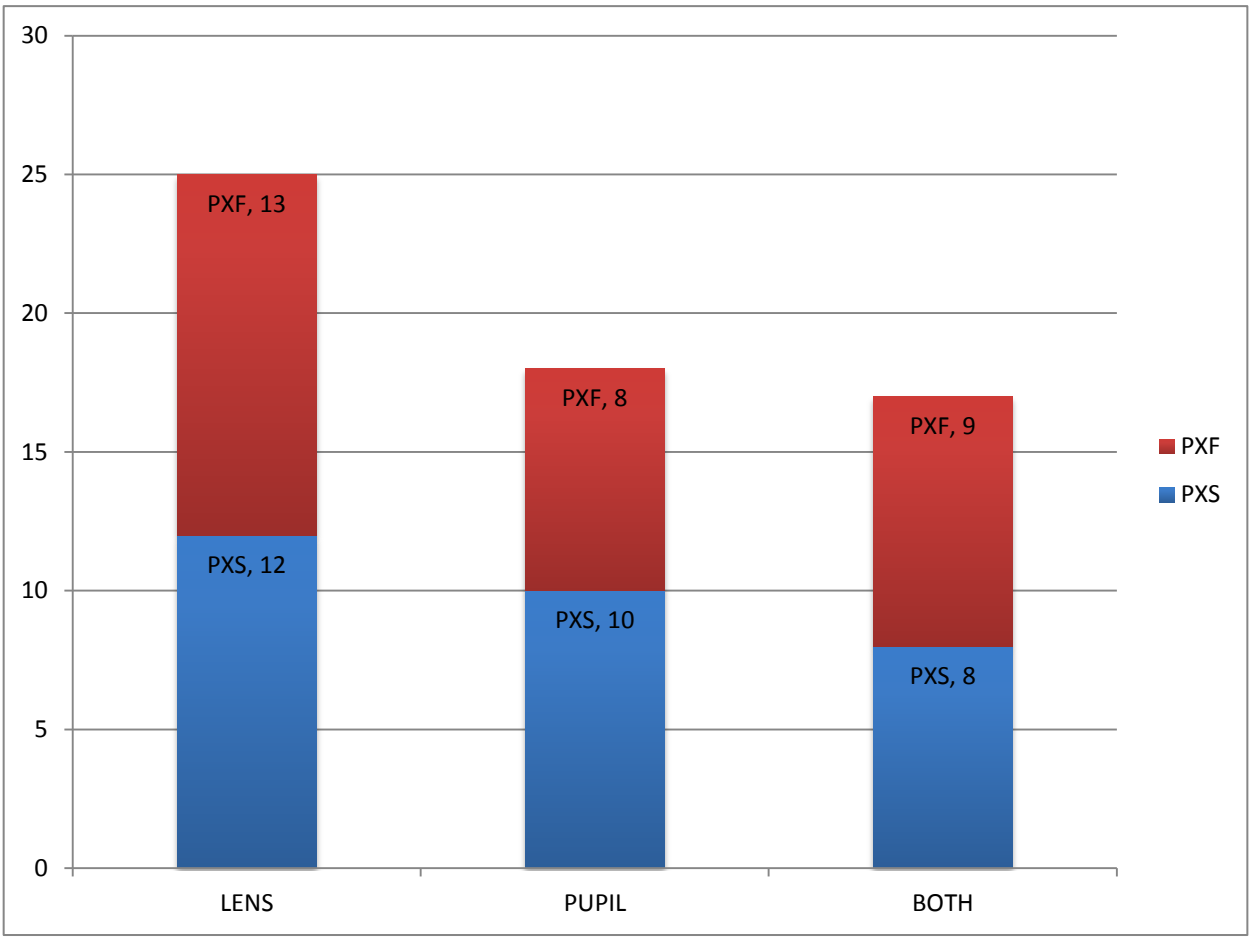


6. SITE OF PXF:

Deposition of PXF material is seen in lens in 25(41.67%) , pupil in 8 (30%) and both in 17 (28.33%) patients.

SITE OF PXF	PXS	PXF	TOTAL	PERCENTAGE
LENS	12	13	25	41.67%
PUPIL	10	8	18	30%
BOTH	8	9	17	28.33%



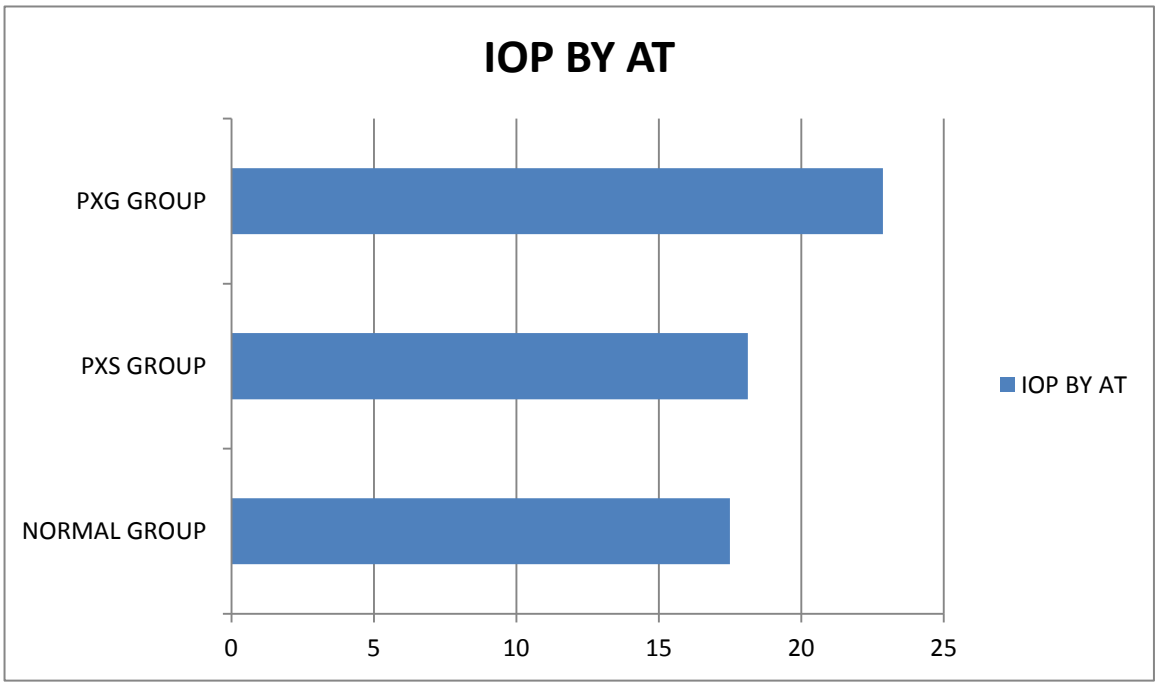


PXS group had PXF in lens, pupil and both was present in 12, 10 and 8 patients respectively.

PXG group had PXF in lens, pupil and both was present in 13,8 and 9 petients respectively.

7. INTRAOCULAR PRESSURE:

- Mean IOP in the normal, PXS and PXG group 17.5, 18.133 and 22. 867 mmHg respectively with a statistically significant difference between the three groups.

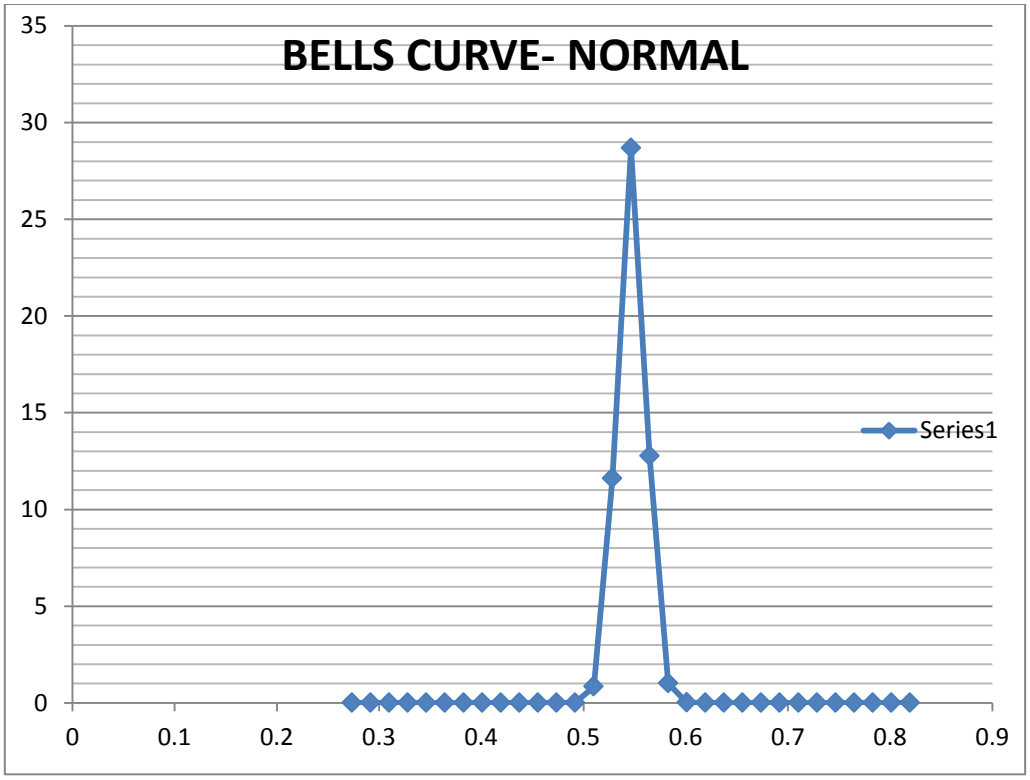


	Mean IOP by AT	**S.D**
Normal controls	17.5	2.129
PXS	18.133	1.57
PXG	22.867	3.954

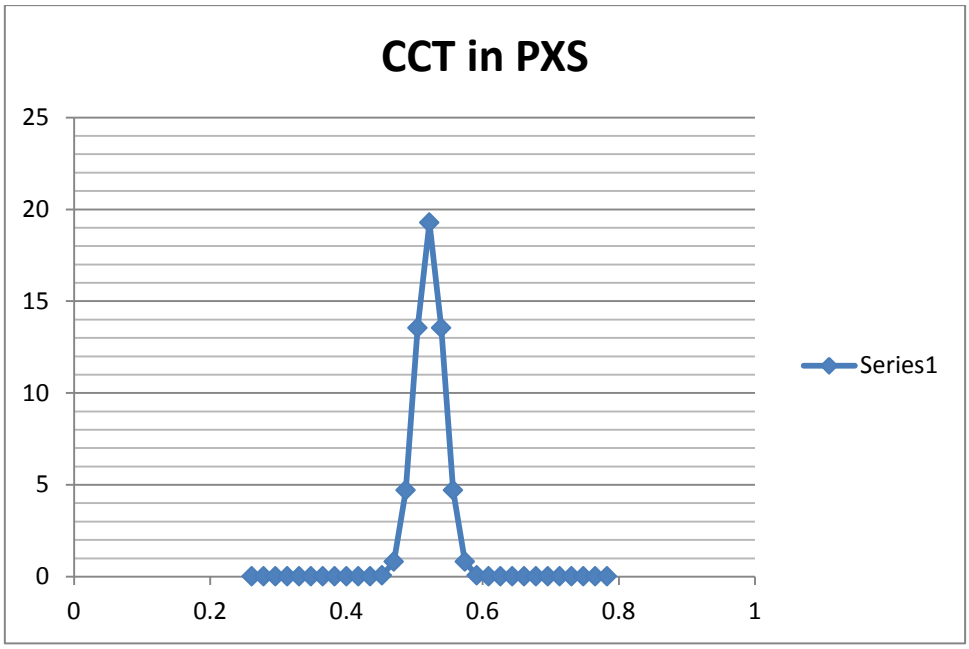
8. CCT VARIATION IN THREE GROUPS

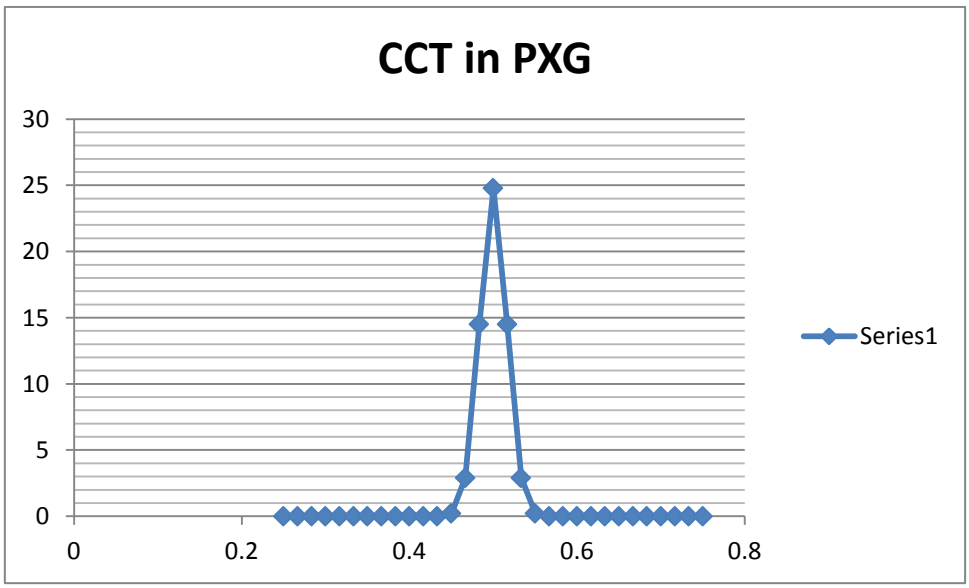
The CCT value in normal showed normal distribution with. a mean of 547 µm with S.D of 13.9 µm,.

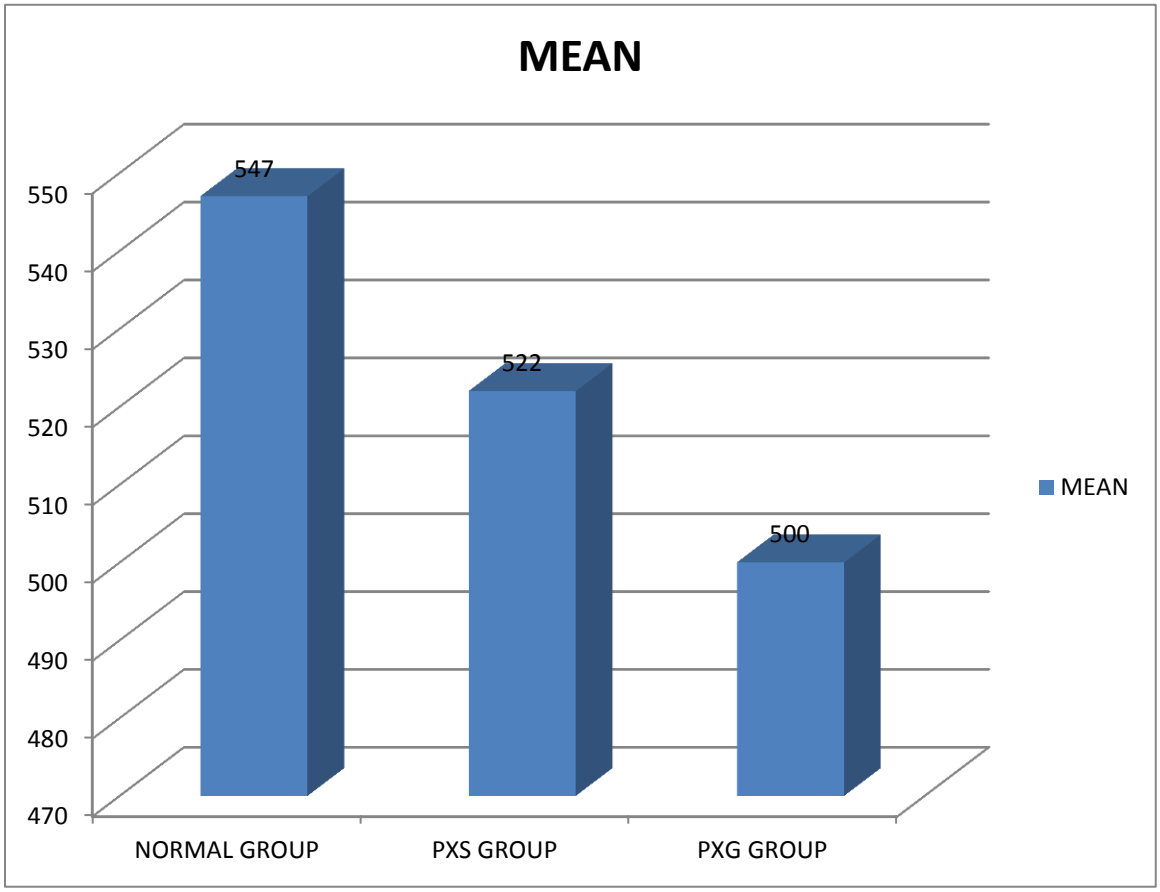
CCT	MEAN	SD	P VALUE	SIGNIFICANCE
NORMAL	0.547	0.0139	<0.001	SIGNIFICANT
PXS	0.522	0.0207		
PXS	0.522	0.0207	<0.001	SIGNIFICANT
PXG	0.500	0.0161		



In the PXS group, Bells curve showed a mean of 522 µm with S.D of 20.7 µm and in the PXG group ,showed a mean of 500 µm with S.D. of 16.1 µm .



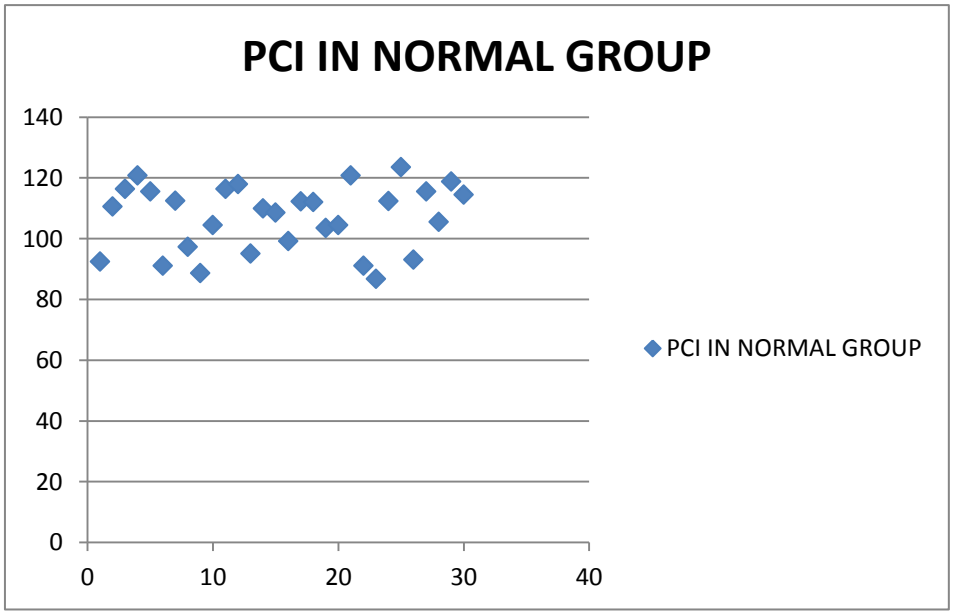


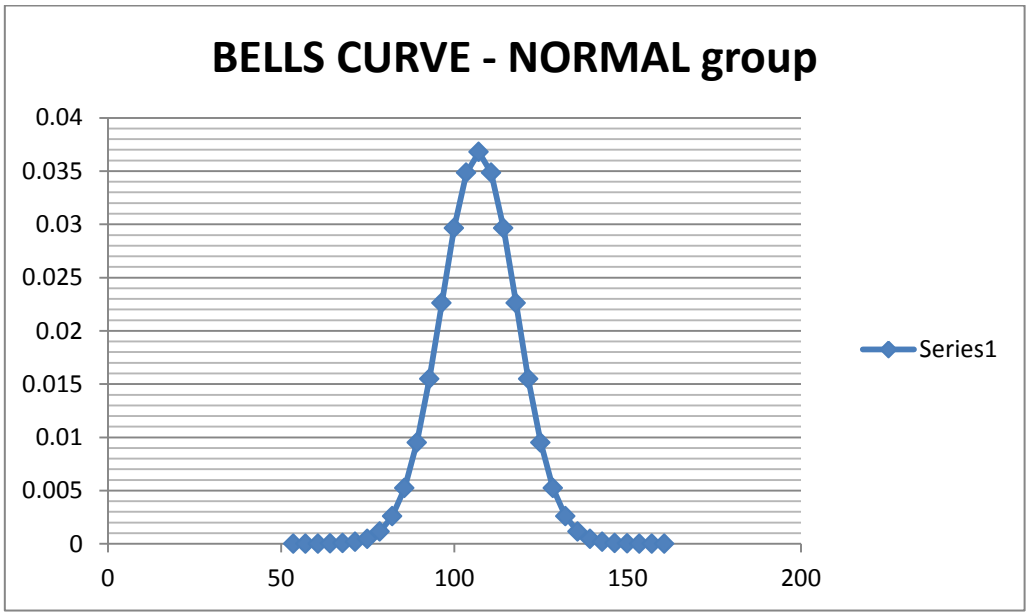


On comparing the mean CCT values of the three groups, there was a statistically significant difference between the normal and PXS groups, and PXS and PXG groups with higher mean value in normal than PXS group which is higher than the PXG group.

11. PCI IN NORMAL GROUP

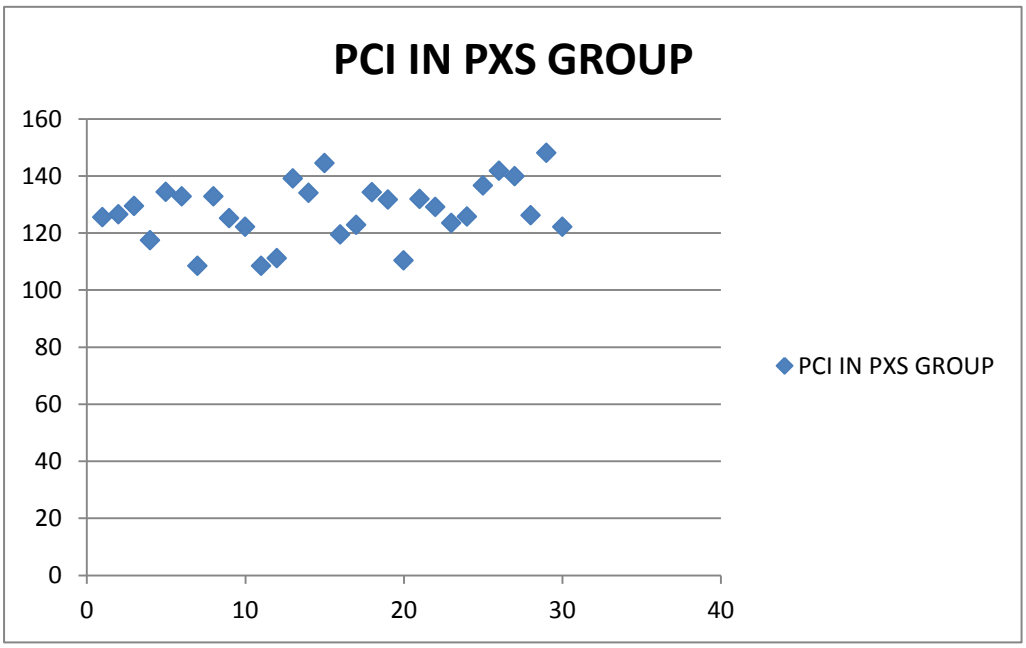
Pressure-to-Cornea Index (PCI) in 30 normal subjects showed a mean value of 107.074 with S.D. 10. 845. Minimum value was 86.01 and maximum value was 123.549.

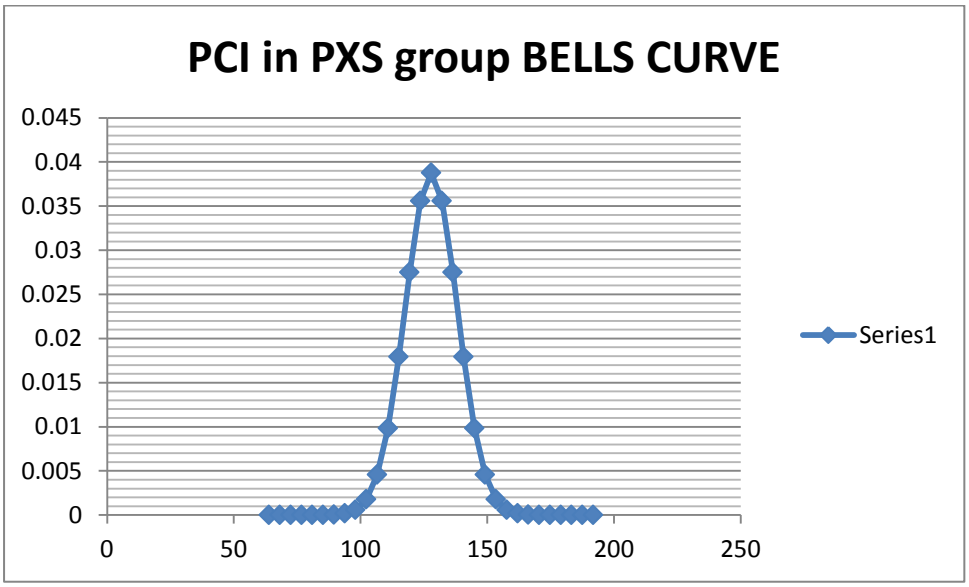




12. PCI IN PXS GROUP:

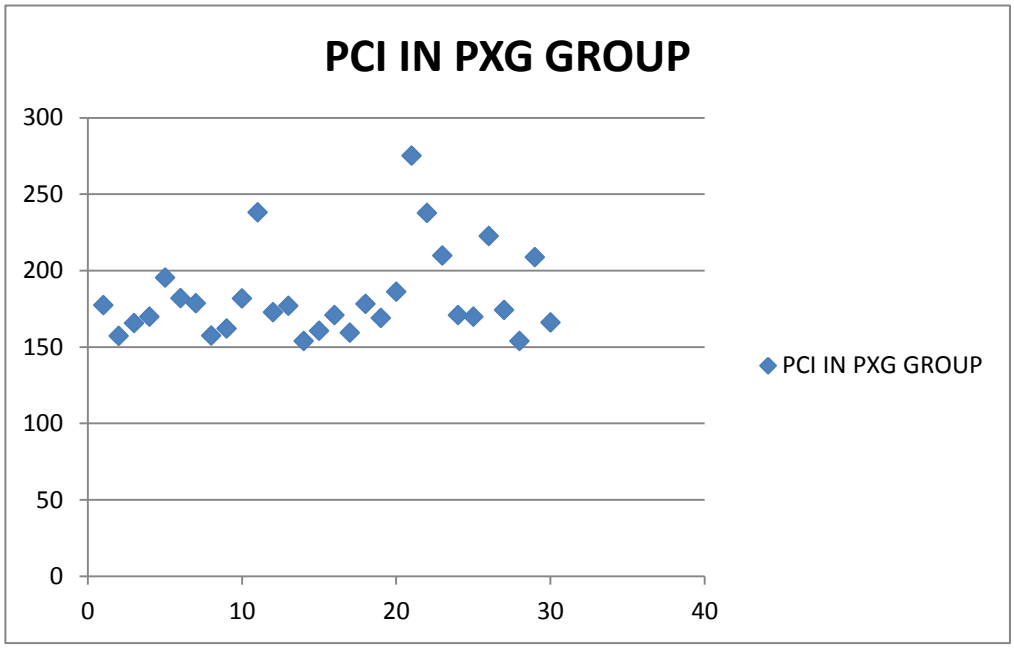
Pressure-to-Cornea Index (PCI) in PXS subjects showed a mean value of 127.899 with S.D of 10.295 .Lowest value was 108.563 and highest value was 148.095.

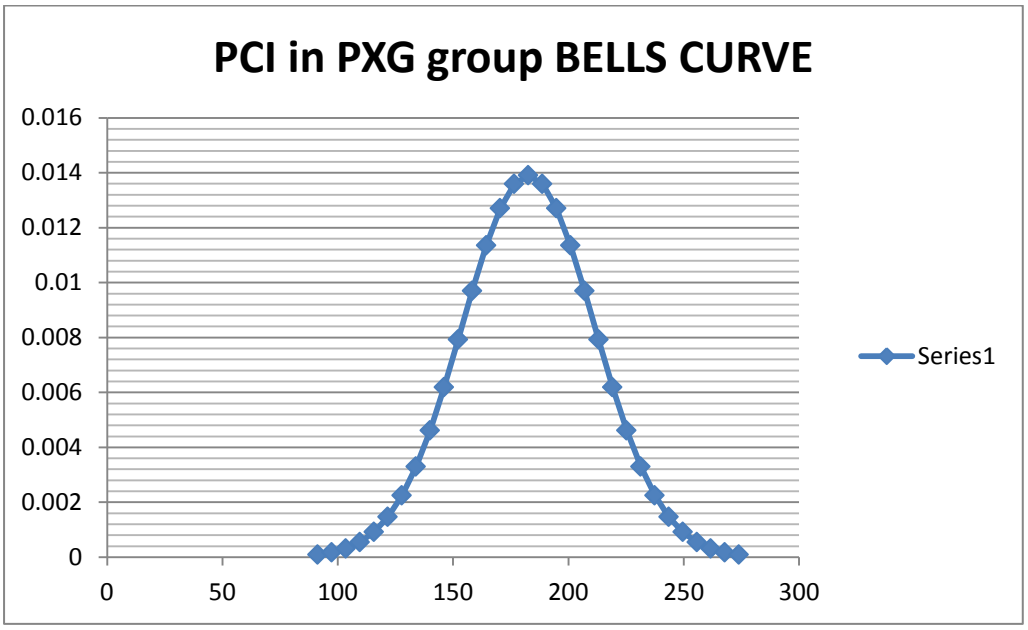




13. PCI IN PXG GROUP:

Pressure-to-Cornea Index (PCI) in PXG subjects showed a mean value of 182. 654 With S.D of 28.700. Minimum value was 153.744 and maximum value was 275.119.



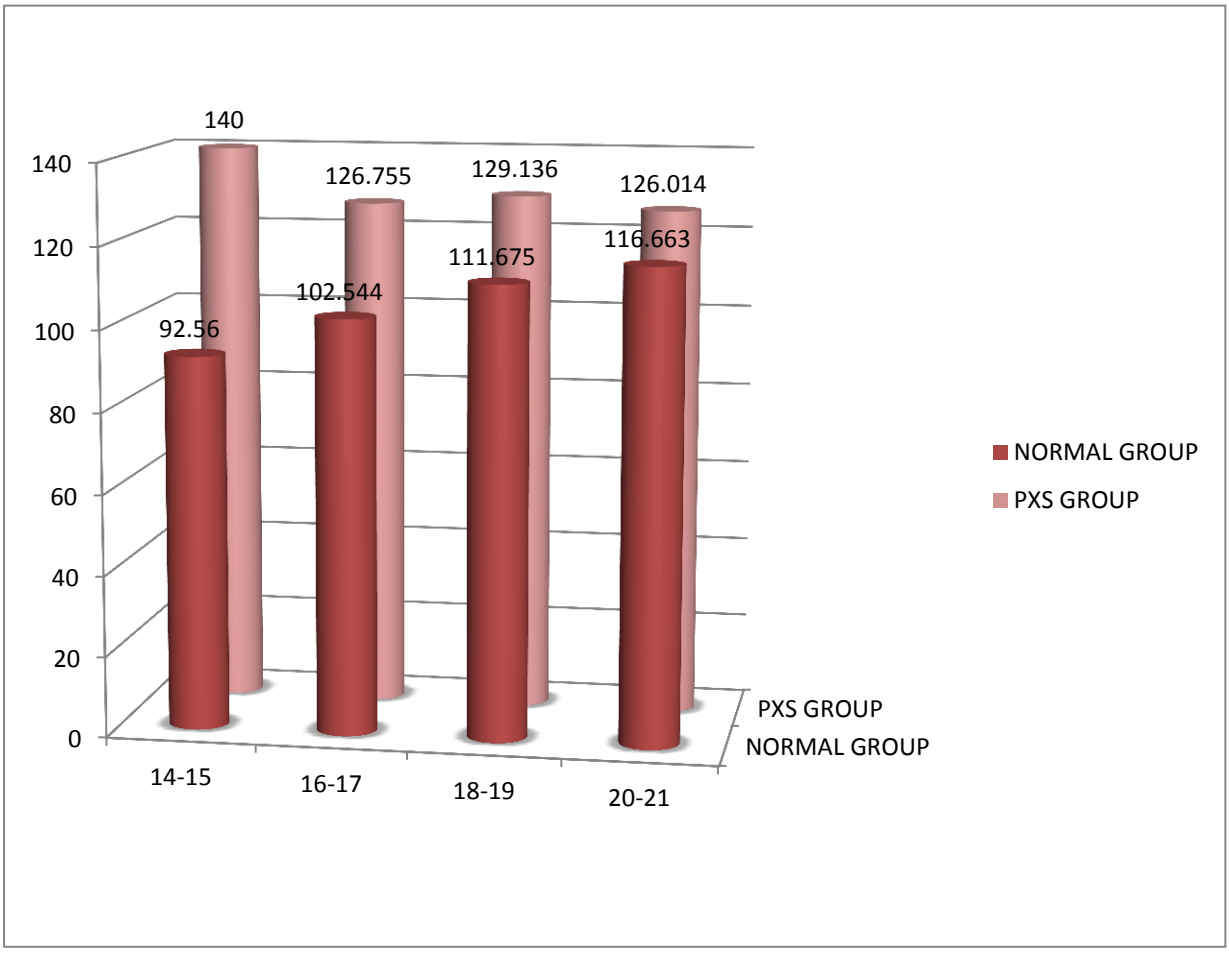


14. COMPARISON OF PCI IN NORMAL AND PXS GROUP:

To minimize variations in PCI due to IOP bias, PCI between normal controls and PXS group, and PCI between PXS group and PXG group were analyzed for statistical significance at various IOP levels.

HIGHEST PRETREATMENT IOP VALUE RANGE (in mm Hg)	NORMAL GROUP			PXS GROUP			P VALUE	SIGNIFICANCE
	n	MEAN PCI	SD	N	MEAN PCI	SD		
14-15	5	92.56	4.007	1	140	0	<0.001	SIGNIFICANT
16-17	9	102.544	9.274	11	126.755	15.045	<0.001	SIGNIFICANT
18-19	8	111.675	7.017	11	129.136	6.637	<0.001	SIGNIFICANT
20-21	8	116.663	4.976	7	126.014	5.285	<0.001	SIGNIFICANT

Between the normal and the PXS group, PCI at all the IOP ranges of 14-15, 16-17, 18-19, 20-21 (mmHg) showed a highly significant difference with a p value <0.001

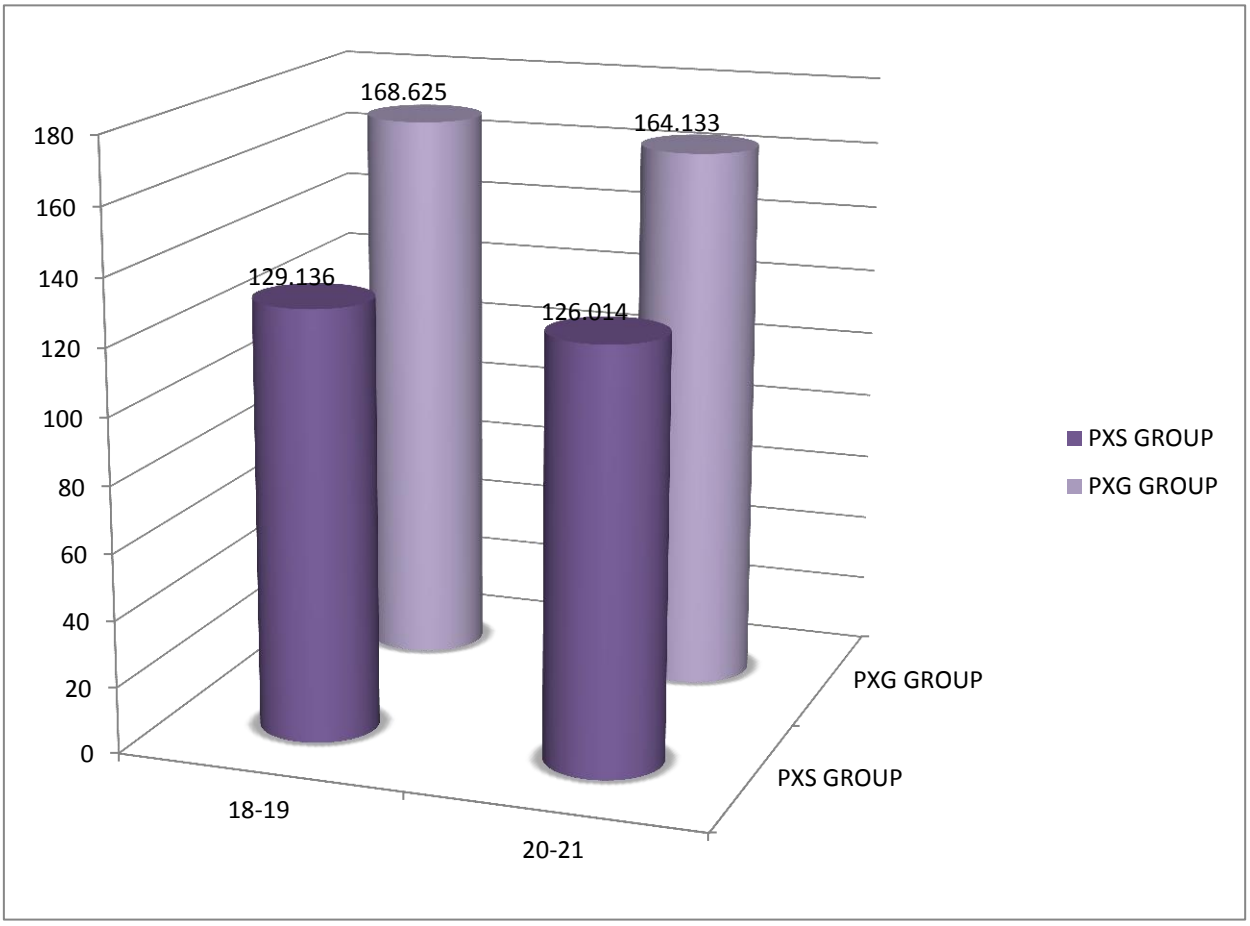


15. COMPARISON OF PCI IN PXS AND PXG GROUP:

Between the PXS group and PXG group of mean PCI was compared at IOP levels 18-19 mm Hg and 20 – 21 mm Hg..

HIGHEST PRETREATMENT IOP VALUE RANGE (in mm Hg)	PXS GROUP			PXG GROUP			p VALUE	SIGNIFICANCE
	N	MEAN PCI	SD	N	MEAN PCI	SD		
14-15	1	140	0	0	-	-	-	-
16-17	11	126.755	15.045	0	-	-	-	-
18-19	**11**	**129.136**	**6.637**	**8**	**168.625**	**8.872**	**<0.001**	**SIGNIFICANT**
20-21	**7**	**126.014**	**5.285**	**9**	**164.133**	**8.436**	**<0.001**	**SIGNIFICANT**
22-23	0	-	-	2	174.45	5.162	-	-
24-25	0	-	-	1	176.8	0	-	-
26-27	0	-	-	5	191.68	19.118	-	-
28-29	0	-	-	3	228.1	16.888	-	-
30-31	0	-	-	2	242.4	46.245	-	-

In the PXS and PXG group, there was a highly significant difference ($p<0.001$) in the IOP ranges of 18-19 and 21-22 mmHg.



SUMMARY

- In our study, all the patients with PXF were between 50 to 70 yrs, of which

41.67% were between 50 – 60 years and 58.33% between 60 – 70 years of age.

- There were 37 males and 23 females among the 60 patients with PXF, accounting to 61.67% and 38.33% respectively. This shows a male preponderance in PXF in our study.
- Among the 25 patients with PXF in the age group of 50 – 60 years, 14 were males and 11 were females and of the 35 patients in the age group of 60 – 70 years, 23 were males and 12 were females.

- Deposition of PXF material was unilateral in 35 and bilateral in 25 patients which leads to a percentage of 58.33% and 41.67% respectively.

  In the PXS group, 17 patients had unilateral and 13 had bilateral PXF.

  In the PXG group, 18 had unilateral and 12 had bilateral PXF. In both the groups, unilateral PXF was higher in our study.

- 53.33% of the PXF patients had nuclear sclerosis, 41.67% had immature cataract and 5% had minimal lens changes. This agrees with many studies where there is increased association of nuclear sclerosis.
- PXF material is seen in lens in 25(41.67%), pupil in 8 (30%) and both in 17 (28.33%) patients.

PXS group had PXF in lens, pupil and both was present in 12, 10 and 8 patients respectively.

PXG group had PXF in lens, pupil and both was present in 13,8 and 9 petients respectively.

- Mean IOP in the normal, PXS and PXG group 17.5, 18.133 and 22. 867 mmHg respectively

- The CCT value in normal showed normal distribution with. a mean of 547 µm with S.D of 13.9 µm,.

  In the PXS group, Bells curve showed a mean of 522 µm with S.D of 20.7 µm and in the PXG group ,showed a mean of 500 µm with S.D. of 16.1 µm .

  On comparing the mean CCT values of the three groups, there was a statistically significant difference between the normal and PXS groups, and PXS and PXG groups with higher mean value in normal than PXS group which is higher than the PXG group.

- Pressure-to-Cornea Index (PCI) in 30 normal subjects showed a mean value of 107.074 with S.D. 10.845. Minimum value was 86.01 and maximum value was 123.549.

- Pressure-to-Cornea Index (PCI) in PXS subjects showed a mean value of 127.899 with S.D of 10.295. Lowest value was 108.563 and highest value was 148.095.
- Pressure-to-Cornea Index (PCI) in PXG subjects showed a mean value of 182. 654 With S.D of 28.700. Minimum value was 153.744 and maximum value was 275.119.

- To minimize variations in PCI due to IOP bias, PCI between normal controls and PXS group, and PCI between PXS group and PXG group were analyzed for statistical significance at various IOP levels.

  Between the normal and the PXS group, PCI at all the IOP ranges of 14-15, 16-17, 18-19, 20-21 (mmHg) showed a highly significant difference with a p value <0.001

- In the PXS and PXG group, there was a highly significant difference ($p<0.001$) in the IOP ranges of 18-19 and 21-22 mmHg.

DISCUSSION

- In our study, all the patients with PXF were between 50 to 70 yrs, of which

41.67% were between 50 – 60 years and 58.33% between 60 – 70 years of age which shows an increased prevalence with age as noticed in several other studies.

- There were 37 males and 23 females among the 60 patients with PXF, accounting to 61.67% and 38.33% respectively. This shows a male preponderance in PXF in our study.

  In several studies there was a high male to female ratio whereas in some studies there was no sex predilection. One study in Finland showed a female preponderance (16.2%) compared to males (14%)

- Deposition of PXF material was unilateral in 35 and bilateral in 25 patients which leads to a percentage of 58.33% and 41.67% respectively in our study.

  This is similar to the results of the study in south Indian eyes with PXF by Vijayalakshmi et al. 54.2% unilateral and in 45.7% bilateral disease was noticed in the study.

  Whereas in the study conducted by Arvind et al.in south Indian population, PXF was unilateral in 49.1% and bilateral in 50.9% of the cases.

- 53.33% of the PXF patients had nuclear sclerosis, 41.67% had immature cataract and 5% had minimal lens changes.

  This agrees with the several studies by Shreya M et al, Vijayalakshmi et al, Thomas et al where there was increased association with nuclear sclerosis in PXF patients.

- PXF material is seen in lens in 25(41.67%), pupil in 8 (30%) and both in 17 (28.33%) patients

- Mean IOP in the normal, PXS and PXG group 17.5, 18.133 and 22. 867 mmHg respectively with a statistically significant difference between the three groups.

- The mean CCT value of normal group was 547 µm with S.D of 13.9 µm, PXS group was 522 µm with S.D of 20.7 µm and PXG group was 500 µm with S.D. of 16.1 µm .

  There was a highly significant statistical difference between the CCT of normal and PXS groups, and PXS and PXG groups. So, in our study, CCT was significantly lower in PXS and PXG patients when compared with normal people.

In the study by Inoue *et al.*, in PXS eyes, regardless of the presence of glaucoma, CCT was thin due to decreased endothelial cell density. However, in another study by Ibrahim *et al.*, PXS eyes were found to have thicker CCT probably due to pseudoexfoliation material.

- Pressure-to-Cornea Index (PCI) in 30 normal subjects showed a mean value of 107.074 with S.D. 10.845.

  Minimum value was 86.01 and maximum value was 123.549.

  75 % of the normal subjects showed a mean of 115. 591.

  Whereas in the study by Iliev et al., most of the normal subjects had a PCI between 80 to100.

- Pressure-to-Cornea Index (PCI) in PXS group showed a mean value of 127.899 with S.D of 10.295.

  Lowest value was 108.563 and highest value was 148.095.

  75 % of the PXS group showed a mean of 134.351.

- Pressure-to-Cornea Index (PCI) in PXG group showed a mean value of 182. 654 With S.D of 28.700.

  Minimum value was 153.744 and maximum value was 275.119.

75 % of the PXG group showed a mean of 5.982.

This agrees, with the PCI values in the POAG group with a peak between 157 to 178 in the Iliev et al study

- To minimize variations in PCI due to IOP bias, PCI between normal controls and PXS group, and PCI between PXS group and PXG group were analyzed for statistical significance at various IOP levels.

- Between the normal and the PXS group, PCI at all the IOP ranges of 14-15, 16-17, 18-19, 20-21 (mmHg) showed a highly significant difference with a p value <0.001

- On comparison of mean PCI between PXS patients and PXG patients at IOP levels 18-19 mm Hg and 20 – 21 mm Hg showed a significant difference with a p value <0.001.

- Hence, both the comparisons, i.e. one between normal and PXS and another between the PXS and PXG group showed highly significant difference.

- This shows that PCI can differentiate between PXS and PXG better than the diagnosis of PXG based on high IOP levels.
- PCI is high in cases of glaucoma and low in non glaucoma cases.
- PCI can be helpful especially in PXF patients to reduce the errors in IOP across the variable range of CCT values due to non-standardized formulae used.
- This can be highly helpful in PXS patients with high PCI, to have a close follow up schedules and for early diagnosis and treatment of pseudoexfoliative glaucoma, so that further damage to optic nerve head can be prevented.

CONCLUSION

Since high IOP and low CCT acts as independent risk factors for glaucoma, PCI an index between IOP and CCT acts as a unified risk factor and indicator of glaucoma in PXF patients.

Increased PCI values in PXG patients can also indicate the severity of glaucoma and also the better indicator of the response to treatment.

High PCI in eyes with pseudoexfoliation syndrome without glaucoma can act as a predictor for glaucoma, even before increase in IOP or optic disc/ field changes. This shows the individual susceptibility of the person with PXS to develop secondary glaucoma.

Hence, PCI can be useful for the consulting ophthalmologist to have a close follow up and for early diagnosis and treatment of pseudoexfoliative glaucoma, so that further damage to optic nerve head can be prevented.

PART THREE

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ABBREVIATIONS

IOP - Intraocular Pressure

CCT – Central Corneal Thickness

PCI – Pressure-to-Cornea Index

PXF - Pseudoexfoliation

PXS – Pseudoexfoliation Syndrome

PXG – Pseudoexfoliative Glaucoma

GAT – Goldmann Applanation Tonometry

POAG – Primary Open Angle Glaucoma

OHT – Ocular Hypertension

NTG - Normal Tension Glaucoma

PACG – Primary Angle Closure Glaucoma

PROFORMA

Name: **Age:** **Sex:**

Glaucoma clinic No.:

Address: **Phone No:**

Presenting complaints:

Defective vision **Duration** **OD/OS/OU**

Pain **OD/OS/OU**

Redness **OD/OS/OU**

Coloured haloes **OD/OS/OU**

Headache

Frequent change of spectacles

H/O DM/ HT/ BA/ IHD/ CKD/ PVD/ CVA **Duration -**

Drugs -

H/O Topical medication(ocular)

H/O Trauma

H/O Cataract/Glaucoma Surgery/LASER (PI)

H/O Steroid oral/topical/nasal sprays

Family history of glaucoma Yes/No

OD	**Slit lamp examination**	**OS**
	Lids	
	Conjunctiva	
	Cornea	
	Anterior chamber	
	Iris	
	Pupil	
	Lens	
	Visual acuity	

OD		OS
	IOP by NCT	
	IOP by AT	
	CCT	
	Gonioscopy	
	<u>Fundus examination</u> **Media** **Disc** **CD Ratio** **Vessels** **N/B/PPA/LDS/ NRR/ BCLV** **Macula**	
	Refraction by retinoscopy	
	Subjective vision	

	<u>Automated Perimetry</u> **<u>(HFA)</u>** **Reliabillity Indices** **MD** **PSD**	
	Colour vision	
	Pressure – Cornea Index **(IOP/ CCT3)**	

Diagnosis:

Treatment: MEDICAL -

SURGICAL -

Notes:

MASTER CHART

S.NO	NAME	AGE	SEX	BCVA	PXF - LATERALITY	RE/LE	LENS	SITE OF PXF	IOP BY AT	CCT	PCI	EHLERS FORMULA	FIELD & DISC CHANGES	DIAGNOSIS
1	RAJENDRAN	55	M	6/12	-	RE	IMC	-	14	0.533	92.45840744	14.7	ABSENT	NORMAL
2	PETCHIAMMAL	65	F	6/18	-	LE	NS	-	16	0.525	110.5712126	16.7	ABSENT	NORMAL
3	AMMASITHEVAR	62	M	6/9	-	LE	MLC	-	20	0.556	116.3605113	18.6	ABSENT	NORMAL
4	MARIAMMAL	53	F	6/9	-	RE	MLC	-	21	0.558	120.8694923	19.6	ABSENT	NORMAL
5	PANDI	67	M	6/12	-	LE	NS	-	18	0.538	115.5914411	18	ABSENT	NORMAL
6	MAYANDI	56	M	6/12	-	RE	IMC	-	16	0.56	91.10787172	14.6	ABSENT	NORMAL
7	ANDICHI	72	F	6/24	-	RE	NS	-	16	0.522	112.4885901	17.4	ABSENT	NORMAL
8	MARIYAPPAN	69	M	6/24	-	LE	NS	-	14	0.524	97.30477992	14.7	ABSENT	NORMAL
9	ANNAKAAMU	67	F	6/18	-	RE	IMC	-	16	0.565	88.71042077	13.9	ABSENT	NORMAL
10	MAILIYAMMAL	72	F	6/18	-	LE	NS	-	16	0.535	104.4861282	16	ABSENT	NORMAL
11	PANDIRAJ	73	M	6/12	-	LE	IMC	-	21	0.565	116.4324273	18.9	ABSENT	NORMAL
12	SRIRANGAM	56	M	6/12	-	RE	NS	-	19	0.544	118.020351	19	ABSENT	NORMAL
13	PONNAMMAL	67	F	6/12	-	RE	IMC	-	14	0.528	95.11001892	14.7	ABSENT	NORMAL
14	RAJANGAM	75	M	6/18	-	LE	NS	-	18	0.547	109.9791924	17.3	ABSENT	NORMAL
15	PALPANDI	52	M	6/6	-	RE	CLEAR	-	20	0.569	108.5658399	17.9	ABSENT	NORMAL
16	THAVASIYAMMAL	62	F	6/12	-	RE	IMC	-	18	0.566	99.27118625	15.9	ABSENT	NORMAL
17	CHINNAPONNU	58	F	6/18	-	LE	IMC	-	17	0.533	112.2709233	17.7	ABSENT	NORMAL
18	MANIKANDAN	53	M	6/18	-	LE	IMC	-	20	0.563	112.0739842	18.6	ABSENT	NORMAL
19	RANGARAJ	68	M	6/12	-	LE	NS	-	18	0.558	103.602422	16.6	ABSENT	NORMAL
20	MUNIYAMMAL	64	F	6/18	-	RE	IMC	-	16	0.535	104.4861282	16	ABSENT	NORMAL
21	THAVASI THEVAR	59	M	6/12	-	RE	IMC	-	20	0.549	120.8684526	19.3	ABSENT	NORMAL
22	CHINNAMMAL	53	F	6/12	-	RE	IMC	-	15	0.548	91.14851209	14.3	ABSENT	NORMAL
23	RAMAR	68	M	6/18	-	LE	NS	-	15	0.557	86.80118887	13.6	ABSENT	NORMAL
24	AZHAGAR	64	M	6/18	-	RE	NS	-	18	0.543	112.4276198	18	ABSENT	NORMAL
25	PARAMESHWARAN	59	M	6/12	-	LE	IMC	-	20	0.545	123.5493568	19.3	ABSENT	NORMAL
26	KILIYAMMAL	64	F	6/18	-	RE	NS	-	16	0.556	93.08840904	14.6	ABSENT	NORMAL
27	GANESAN	65	M	6/12	-	RE	NS	-	18	0.538	115.5914411	18	ABSENT	NORMAL
28	VELLAISAMY	71	M	6/24	-	LE	NS	-	17	0.544	105.5971561	17	ABSENT	NORMAL
29	MARY	66	F	6/24	-	RE	NS	-	18	0.533	118.8750953	18.7	ABSENT	NORMAL
30	DEVIYAMMAL	63	F	6/18	-	LE	IMC	-	20	0.559	114.4971224	18.6	ABSENT	NORMAL

S.NO	NAME	AGE	SEX	BCVA	PXF - LATERALITY	RE/LE	LENS	SITE OF PXF	IOP BY AT	CCT	PCI	EHLERS FORMULA	FIELD & DISC CHANGES	DIAGNOSIS
31	MAYAN	67	M	6/24	U/L	RE	IMC	PUPIL	21	0.551	125.534905	20.3	ABSENT	PXS
32	KARUPPAIYAH	62	M	6/18	U/L	RE	IMC	LENS	18	0.522	126.5496639	19.4	ABSENT	PXS
33	JAYAKODI	58	F	6/12	B/L	LE	NS	PUPIL	16	0.498	129.5483704	18.8	ABSENT	PXS
34	MAYANDI	70	M	6/36	U/L	RE	NS	LENS	18	0.535	117.5468943	18	ABSENT	PXS
35	VENDHAN	56	M	6/18	U/L	LE	NS	PUPIL	17	0.502	134.3809695	19.8	ABSENT	PXS
36	PALANIYAMMAL	66	F	6/24	B/L	LE	IMC	LENS	19	0.523	132.8154305	20.4	ABSENT	PXS
37	SARAVANAKUMAR	54	M	6/9	U/L	RE	MLC	LENS	17	0.539	108.5631974	17	ABSENT	PXS
38	MUTHUPILLAI	60	F	6/18	B/L	RE	NS	BOTH	19	0.523	132.8154305	20.4	ABSENT	PXS
39	RADHAKRISHNAN	56	M	6/12	U/L	RE	NS	BOTH	17	0.514	125.1870958	19.1	ABSENT	PXS
40	RAKKAYEE	64	F	6/24	B/L	LE	IMC	LENS	20	0.547	122.1991026	19.3	ABSENT	PXS
41	AYYAR	68	M	6/24	B/L	RE	IMC	PUPIL	17	0.539	108.5631974	17	ABSENT	PXS
42	SIVARAMAN	60	M	6/18	U/L	LE	NS	LENS	16	0.524	111.2054628	17.4	ABSENT	PXS
43	SEKAR	58	M	6/18	U/L	RE	IMC	BOTH	19	0.515	139.1015322	20.4	ABSENT	PXS
44	BAKKIYAM	60	F	6/24	U/L	RE	NS	PUPIL	18	0.512	134.1104507	20.1	ABSENT	PXS
45	RAMADURAI	64	M	6/36	B/L	LE	IMC	BOTH	17	0.49	144.4976158	20.5	ABSENT	PXS
46	KARUPPAN	65	M	6/24	U/	RE	NS	LENS	18	0.532	119.5467044	18.7	ABSENT	PXS
47	SIVAN	61	M	6/18	B/L	RE	IMC	LENS	20	0.546	122.8717567	19.3	ABSENT	PXS
48	GOKILA	59	F	6/18	U/L	LE	NS	PUPIL	19	0.521	134.3508539	20.4	ABSENT	PXS
49	GOPALAN	63	M	6/24	U/L	LE	NS	LENS	18	0.515	131.7803989	19.4	ABSENT	PXS
50	MUTHUMEENA	57	F	6/18	B/L	RE	IMC	PUPIL	17	0.536	110.3963087	17	ABSENT	PXS
51	PITCHAIYAMMAL	64	F	6/24	B/L	LE	NS	BOTH	16	0.495	131.9180995	18.8	ABSENT	PXS
52	KARTHIKEYAN	58	M	6/24	U/L	LE	NS	PUPIL	20	0.537	129.1537851	20	ABSENT	PXS
53	GOPAL SAMY	60	M	6/18	B/L	RE	IMC	LENS	20	0.545	123.5493568	19.3	ABSENT	PXS
54	BOSAMMAL	64	F	6/18	U/L	LE	NS	BOTH	18	0.523	125.8251447	19.4	ABSENT	PXS
55	CHINNATHEVAR	68	M	6/24	U/L	RE	IMC	BOTH	20	0.527	136.646386	20.7	ABSENT	PXS
56	RAKKU	69	F	6/36	B/L	RE	IMC	LENS	17	0.493	141.8757478	20.5	ABSENT	PXS
57	PANDIYAMMAL	62	F	6/18	B/L	RE	NS	BOTH	15	0.475	139.9620936	19.2	ABSENT	PXS
58	KALATHEVAR	66	M	6/24	U/L	LE	NS	PUPIL	19	0.532	126.188188	19.7	ABSENT	PXS
59	PERUMAL	63	M	6/12	B/L	LE	MLC	LENS	17	0.486	148.0949037	20.5	ABSENT	PXS
60	MUNIYAPPAN	68	M	6/24	U/L	LE	NS	PUPIL	21	0.556	122.1785369	19.6	ABSENT	PXS

S.NO	NAME	AGE	SEX	BCVA	PXF - LATERALITY	RE/LE	LENS	SITE OF PXF	IOP BY AT	CCT	PCI	EHLERS FORMULA	FIELD & DISC CHANGES	DIAGNOSIS
61	THANGAVEL	54	M	6/18	U/L	RE	NS	PUPIL	19	0.475	177.2853186	23.2	PRESENT	PXG
62	MUNIYANDI	60	M	6/18	U/L	RE	NS	BOTH	20	0.503	157.1542175	22.8	PRESENT	PXG
63	RAJAMOHAN	61	M	6/24	B/L	LE	IMC	LENS	19	0.486	165.5178335	22.5	PRESENT	PXG
64	SARASWATHI	57	F	6/12	U/L	RE	MLC	LENS	19	0.482	169.6729014	23.2	PRESENT	PXG
65	BOMMIYAMMAL	64	M	6/18	U/L	LE	IMC	BOTH	27	0.517	195.3854119	28.4	PRESENT	PXG
66	SEETHAMMAL	60	F	6/24	B/L	LE	IMC	BOTH	19	0.471	181.84061	23.9	PRESENT	PXG
67	LAKSHMI	55	F	6/12	U/L	RE	NS	PUPIL	20	0.482	178.6030541	24.2	PRESENT	PXG
68	RAJAVEL	62	M	6/18	B/L	RE	NS	LENS	21	0.511	157.382556	23.1	PRESENT	PXG
69	NEELA KRISHNAN	57	M	6/18	U/L	LE	IMC	LENS	20	0.498	161.935463	22.8	PRESENT	PXG
70	MEENAKSHI	63	F	6/12	B/L	RE	NS	BOTH	26	0.523	181.7474312	27.4	PRESENT	PXG
71	KARUTHA SAMY	70	M	6/24	B/L	RE	NS	BOTH	28	0.49	237.9960731	31.5	PRESENT	PXG
72	VALLIYAMMAL	68	F	6/36	U/L	RE	IMC	LENS	26	0.532	172.678573	26.7	PRESENT	PXG
73	THAVAMANI	65	M	6/24	U/L	LE	NS	PUPIL	25	0.521	176.7774393	26.4	PRESENT	PXG
74	MARIMUTHU	66	M	6/24	U/L	RE	IMC	LENS	21	0.515	153.7437988	22.4	PRESENT	PXG
75	PANDISELVI	58	F	6/12	B/L	RE	NS	PUPIL	19	0.491	160.5125982	22.5	PRESENT	PXG
76	NAGURAMMAL	63	F	6/24	U/L	LE	IMC	BOTH	22	0.505	170.823866	24.1	PRESENT	PXG
77	PANDIYAN	59	M	6/24	B/L	LE	IMC	PUPIL	21	0.509	159.2450523	23.2	PRESENT	PXG
78	PARAMASIVAM	60	M	6/18	B/L	RE	NS	LENS	22	0.498	178.1290093	24.8	PRESENT	PXG
79	DEVASENA	64	F	6/18	U/L	LE	IMC	LENS	21	0.499	169.0120455	23.8	PRESENT	PXG
80	SIVAPERUMAL	62	M	6/24	U/L	LE	IMC	LENS	26	0.519	185.9821545	27.4	PRESENT	PXG
81	VALLI	60	F	6/18	U/L	LE	NS	BOTH	31	0.483	275.1188209	35.2	PRESENT	PXG
82	RAAMAKKAL	61	F	6/24	B/L	RE	NS	LENS	29	0.496	237.6582903	31.8	PRESENT	PXG
83	SHIVA PANDI	62	M	6/24	B/L	RE	IMC	PUPIL	30	0.523	209.7085745	31.4	PRESENT	PXG
84	MOULEESWARAN	60	M	6/36	U/L	RE	NS	LENS	19	0.481	170.7333539	23.2	PRESENT	PXG
85	MEENAMMAL	60	F	6/24	U/L	LE	IMC	BOTH	19	0.482	169.6729014	23.2	PRESENT	PXG
86	KABALEESWARAN	58	M	6/18	U/L	LE	IMC	BOTH	27	0.495	222.6117929	29.8	PRESENT	PXG
87	RAZIA BANU	61	F	6/18	B/L	RE	NS	LENS	21	0.494	174.1961082	23.8	PRESENT	PXG
88	KRISHNAN	63	M	6/24	U/L	LE	NS	PUPIL	19	0.498	153.8386899	21.8	PRESENT	PXG
89	SIVANAANDI	69	M	6/36	U/L	RE	NS	LENS	29	0.518	208.6453541	30.4	PRESENT	PXG
90	MOHAMED NIAZ	62	M	6/36	B/L	RE	NS	PUPIL	21	0.502	166.0000211	23.8	PRESENT	PXG

KEYS TO MASTER CHART

M-MALE F-FEMALE

RE-RIGHT EYE

LE-LEFT EYE

BCVA- BEST CORRECTED VISUAL ACUITY

PXF - PSEUDOEXFOLIATION

U/L – UNILATERAL

B/L - BILATERAL

MLC-MINIMAL LENS CHANGES

IMC-IMMATURE CATARACT

NS- NUCLEAR SCLEROSIS

IOP – INTRAOCULAR PRESSURE

AT- APPLANATION TONOMETRY

CCT- CENTRAL CORNEAL THICKNESS

PCI – PRESSURE-TO-CORNEA INDEX

PXS – PSEUDOEXFOLIATION SYNDROME

PXG – PSEUDOEXFOLIATION GLAUCOMA

MADURAI MEDICAL COLLEGE
MADURAI, TAMILNADU, INDIA -625 020
(Affiliated to The Tamilnadu Dr.MGR Medical University, Chennai, Tamil Nadu)

ETHICS COMMITTEE CERTIFICATE

Name of the Candidate	:	Dr.S.Abirami
Course	:	PG in M.S., Ophthalmology
Period of Study	:	2014-2017
College	:	MADURAI MEDICAL COLLEGE
Research Topic	:	A study to analyse the significance of pressure-to-cornea index in pseudoexfoliaion eyes with and without glaucoma
Ethical Committee as on	:	10.06.2016

The Ethics Committee, Madurai Medical College has decided to inform that your Research proposal is accepted – Exclude HIV cases

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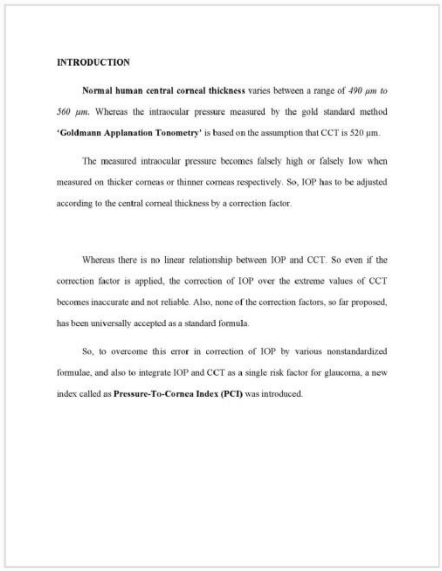


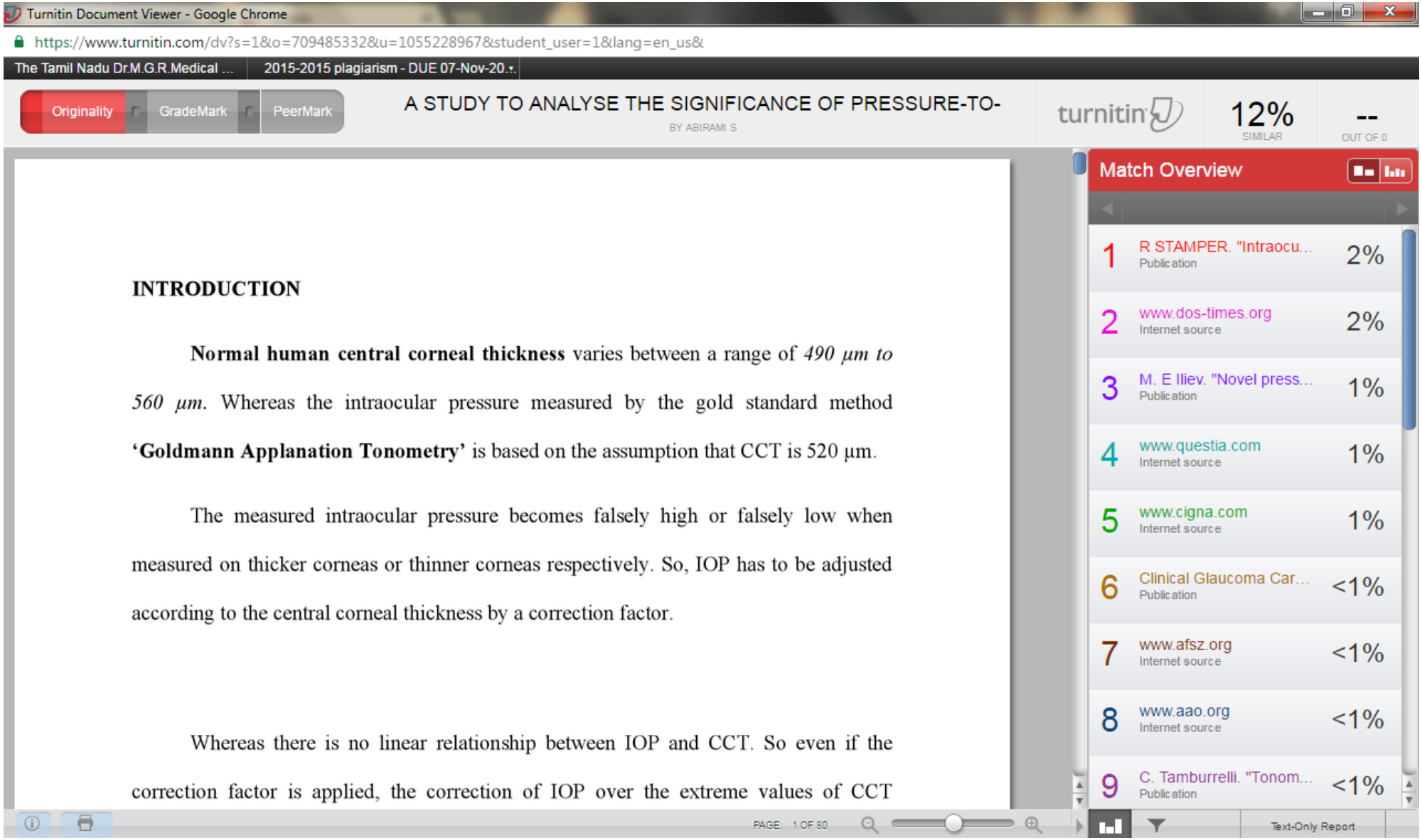
INTRODUCTION

Normal human central corneal thickness varies between a range of *490 µm to 560 µm*. Whereas the intraocular pressure measured by the gold standard method **'Goldmann Applanation Tonometry'** is based on the assumption that CCT is 520 µm.

The measured intraocular pressure becomes falsely high or falsely low when measured on thicker corneas or thinner corneas respectively. So, IOP has to be adjusted according to the central corneal thickness by a correction factor.

Whereas there is no linear relationship between IOP and CCT. So even if the correction factor is applied, the correction of IOP over the extreme values of CCT becomes inaccurate and not reliable. Also, none of the correction factors, so far proposed, has been universally accepted as a standard formula.

So, to overcome this error in correction of IOP by various nonstandardized formulae, and also to integrate IOP and CCT as a single risk factor for glaucoma, a new index called as **Pressure-To-Cornea Index (PCI)** was introduced.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Normal human central corneal thickness varies between a range of 490 µm to 560 µm. Whereas the intraocular pressure measured by the gold standard method 'Goldmann Applanation Tonometry' is based on the assumption that CCT is 520 µm.
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