Dissertation on

"ASSESSMENT OF CENTRAL CORNEAL THICKNESS AND CORNEAL CURVATURE IN PSEUDOEXFOLIATION PATIENTS: A CROSS SECTIONAL STUDY."

By

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Dissertation submitted to the

B.L.D.E. (DEEMED TO BE UNIVERSITY)

VIJAYAPURA, KARNATAKA

In Partial fulfilment of requirements for the degree of

MASTER OF SURGERY
In
OPHTHALMOLOGY

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I, **DR. NITHEESHA VADDEBOINA.,** *hereby declare that this dissertation/thesis entitled "***ASSESSMENT OF CENTRAL CORNEAL THICKNESS AND CORNEAL CURVATURE IN PSEUDOEXFOLIATION PATIENTS: A CROSS SECTIONAL STUDY***." is a bonafide and genuine research work carried out by me under the guidance of* ***Prof. (Dr.) REKHA R. MUDHOL MBBS, M.D*** *Professor and Head, Department of Ophthalmology, B.L.D.E (DU)'s Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura.*

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ACKNOWLEDGEMENT

With a humble heart, I would like to begin this acknowledgement with a prayer to the Almighty God, who has given us the strength, wisdom, and grace to embark on this scholarly journey.

I am profoundly grateful to my teacher, mentor and guide, ***Prof. (Dr.) REKHA R. MUDHOL****, whose unwavering inspiration, encouragement, and support have been instrumental throughout my post-graduation studies and the preparation of my dissertation. Her guidance has been invaluable, and I deeply appreciate her dedication to my academic and professional growth.*

I am deeply indebted to my esteemed Professors, ***Dr. Raghavendra K Ijeri Dr. Sunil Biradar*** *and* ***Dr Vallabha K ,*** *whose guidance and encouragement have propelled me to new heights of professional achievement throughout my course. Their mentorship has been instrumental in shaping my academic journey, and I am forever grateful for their invaluable support and inspiration.*

My heartfelt thanks and deep gratitude to my teachers, ***Dr. Keerti Wali, Dr. Talluru Subash, Dr. Shweta Patil, Dr. Magna Mary*** *and* ***Dr. Suman D****. Without their inspiration, timely guidance, immense support, and motivation, I wouldn't have been able to complete this dissertation.*

I am grateful to ***Dr. Aravind V Patil****, Principal of BLDE (DU) 's Shri B. M Patil Medical College Hospital and Research Centre, Vijayapura, for permitting me to utilise the resources in the completion of my work. I am extremely thankful*

*to **Mr. Muragesh Mathapati and Mrs Vijaya Sorganvi** for their guidance in statistical analysis. I thank my friends and colleagues **Dr. Sanjeet G, Dr. Sneha L, Dr Vivea N** and **Dr Mayuri** ,my seniors **Dr Shilpa, Dr Arkaparava, Dr Vishnavi** and my juniors **Dr Asha Jyothi, Dr Shreya, Dr Aebrin, Dr Siddhant** and **Dr Ann.** for their constant support.*

*I express my heartfelt appreciation and gratitude to my beloved parents, **Dr. Krishna Vaddeboina** and **Mrs.Vijaya Lakshmi V,** and my beloved brother **Ravi Teja** for their support, invaluable advice, and endless encouragement. Their boundless love and sacrifices have been the cornerstone of my journey, and I am deeply indebted to them for instilling in me the values of perseverance and determination.*

Finally, I acknowledge my heartfelt gratitude to all my patients; this study would be incomplete without their participation.

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LIST OF ABBREVIATIONS

PXF	Psudoexfoliation
PEXG	Pseudoexfoliation glaucoma
LOXL1	Lysyl oxidase like 1
CCT	Central corneal thickness
IOP	Intraocular pressure
GAT	Goldmann applanation tonometry
UV	Ultraviolet
POAG	Primary open angle glaucoma
OCT	Optical coherence tomography
AS- OCT	Anterior segment optical coherence tomography
ECD	Endothelial cell density
DCT	Dynamic contour tonometer
ORA	Ocular response analyser
AI	Artificial intelligence
BCVA	Best corrected visual acuity
SD	Standard deviation
DM	Diabete mellitus
OD	Oculus dextrus
OS	Oculus sinister

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ABSTRACT

Background: The central corneal thickness (CCT) and corneal curvature plays an important role in the accurate measurement of intraocular pressure (IOP), an important factor in the management of glaucoma. In this study comparision of central corneal thickness and corneal curvature among individuals with and without PXF is done to know the precision of IOP readings in PXF patients to aid earlier detection of glaucoma and management.

Methods: 53 pseudoexfoliation (PXF) patients and 53 control patients were enrolled in the study. The CCT, Corneal curvature, intraocular pressure, were measured by OCT, pachymeter, autorefractokeratometer, Schiotz tonometer, respectively. The independent samples t test and paired samples t test was used for the comparisons of the groups.

Results: There was no difference in CCT between PEX and control eyes (P=0.626). The keratometry values, K1 and K2, were significantly different between PXF cases and controls in both the right (OD) and left (OS) eyes. In both the eyes, the mean K1 was significantly lower in PXF patients compared to controls with a(P=0.024). Similarly, K2 in both eyes was lower in PXF cases than in controls with a statistically significant (P=0.005).

Conclusions: This study demonstrates corneas with significantly decreased K1 and K2 values in pseudoexfoliation patients compared to the controls. Flatter corneas underestimate the intraocular pressure. Early recognition of corneal flattening in PXF patients can improve glaucoma risk identification and management. In the present study there is no significant difference noted in central corneal thickness between cases and controls. For the measurement of central corneal thickness, advanced imaging modalities, such as anterior segment optical coherence tomography (AS-OCT) is used in the present study. Integrating these findings into routine ophthalmic practice will enhance diagnostic precision and optimize patient outcomes in PXF-related ocular disorders.

INTRODUCTION

“pseudoexfoliation syndrome is the most common identifiable cause of secondary open angle glaucoma world wide – Weinreb RN, The Lancet 2004

Pseudoexfoliation syndrome (PXF) is a systemic age-related disorder characterized by the deposition of abnormal fibrillogranular extracellular material in the anterior segment of the eye. This condition is a significant risk factor for pseudoexfoliation glaucoma (PEXG), a leading cause of irreversible blindness worldwide. The pathogenesis of PXF involves genetic polymorphisms in the lysyl oxidase-like 1 (LOXL1) gene, which affects the synthesis and maintenance of elastic fibers in connective tissues. Clinically, PXF is marked by the deposition of pseudoexfoliative material on the lens capsule, iris, zonules, trabecular meshwork, and corneal endothelium. These deposits are associated with complications such as secondary open-angle glaucoma, zonular instability, corneal endothelial decompensation, and cataract formation[1,2]

The central corneal thickness (CCT) plays an important role in the accurate measurement of intraocular pressure (IOP), an important factor in the management of glaucoma. Research shows that thinner corneas cause an underestimation of IOP, whereas thick corneas cause overestimation. On average, the average CCT is nearly 542 µm, and even a deviation of 10 µm can cause a difference of 0.5 mmHg in IOP measurements made by Goldmann applanation tonometry (GAT) [3]. PXF patients have the tendency to have thinner corneas, which result in the failure or delay in detection of early glaucomatous changes. Therefore, CCT is ever more identified as an important parameter for the identification of individuals at risk of progression to PEXG[4]

The corneal curvature, another important parameter, significantly influences the accuracy of IOP measurements and reflects the biomechanical properties of the cornea. In PXF patients, studies suggest that the corneal curvature may be steeper than in controls, possibly altering the stress distribution across the cornea. This alteration may exacerbate disease progression by impacting IOP accuracy of measurement. Yet, the existing literature on the correlation between corneal curvature and PXF is unclear, necessitating further research [5].

PXF is universally accepted as the most frequent cause of secondary open-angle glaucoma that can be identified. PXF has a much greater potential for progression to visual field loss than primary open-angle glaucoma. The accumulation of pseudoexfoliative deposition material in the trabecular meshwork raises outflow resistance, leading to increased IOP and optic nerve injury. Measurement of corneal parameters such as CCT and curvature is crucial to determine the degree of disease and customize management plans for PXF patients[6]

Not withstanding rising awareness of the role of corneal parameters in PXF, the correlation between PXF and central corneal thickness (CCT) remains poorly understood. Whereas, in some investigations, PXF patients have markedly thinner corneas, in others, the differences are nonexistent. Likewise, there is limited uniformity evidence of how corneal curvature is impacted in PXF, with the results of the studies varying.This variation explains why further studies are needed to establish better insights into how such factors play a role in PXF and PEXG development and progression [7,8].

The goal of this study is to compare the central corneal thickness and corneal curvature among individuals with and without PXF. Through examining these parameters, the study seeks to advance knowledge in the structural transformation of the cornea that occurs with PXF. This study will also impart valuable information into the mechanisms through which changes affect the

progression of PXF to PEXG. Notably, by comparing corneal parameters among eyes with PXF and fellow eyes free from PXF in patients with pseudoexfoliation unilaterally, The research will eliminate confusing variables and establish clear evidence of variation within the eye [9].

It is significant because the research may enhance the precision of IOP readings in PXF patients to aid earlier detection of glaucoma. The knowledge of corneal changes in PXF may aid in the identification of bio markers of disease severity and the development of improved treatment regimens to halt the progression of the disease.

This research, which was carried out at Shri B.M. Patil Medical College, is therefore anticipated to bridge the gaps in the literature and lead to better clinical outcomes for patients with PXF [10,11].

AIM AND OBJECTIVES

Aim:

To measure the central corneal thickness (CCT) and corneal curvature in individuals with pseudoexfoliation syndrome (PXF) and compare it with those without pseudoexfoliation.

Objectives:

1. To evaluate and compare the central corneal thickness (CCT) and corneal curvature in individuals with pseudoexfoliation and those without it.
2. To compare the central corneal thickness (CCT) and corneal curvature in eyes with pseudoexfoliation to their fellow eyes without pseudoexfoliation in individuals with unilateral pseudoexfoliation.

REVIEW OF LITERATURE

INTRODUCTION TO PSEUDOEXFOLIATION SYNDROME (PXF)

Definition

The term "pseudoexfoliation" was first coined by Ehlers in the early 20th century. Zare MA, Fakhraie G, Amoli FA, et al described pseudoexfoliation syndrome (PXF) is a common age-related systemic disorder characterized by the production and accumulation of an abnormal fibrillogranular extracellular material in the ocular tissues, particularly in the anterior segment of the eye. This material primarily deposits on the lens capsule, iris, ciliary body, zonules, trabecular meshwork, and the corneal endothelium, leading to functional and structural impairments of these ocular structures [1, 2].

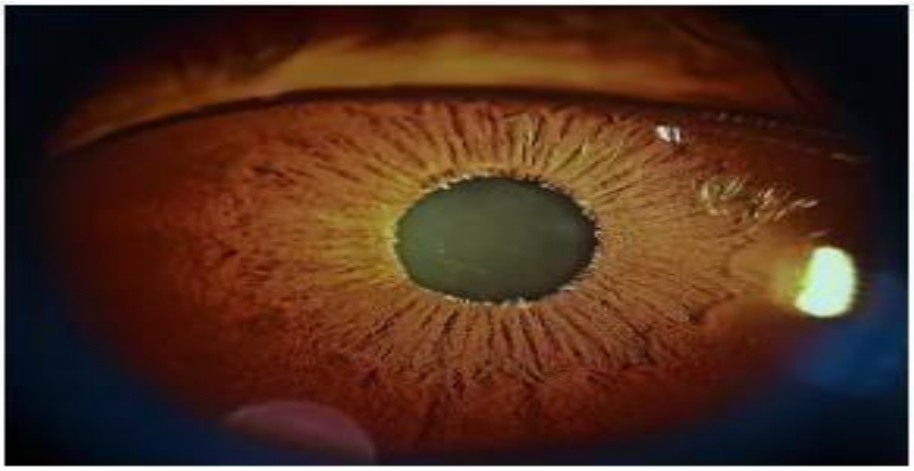


Figure 01: The picture shows pseudoexfoliation at the pupillary margin and anterior lens capsule. Pseudoexfoliation is the most common cause of secondary open- angle glaucoma.

Epidemiology of PXF

PXF is a globally prevalent disorder, with significant geographical and racial variations. Its prevalence ranges from 5% to 30% in individuals aged over 60 years, with higher rates observed in Scandinavian, Mediterranean, and Northern European populations, where it has been reported to affect up to 25% of older adults [5]. Tekce A, Gulmez M mentioned that In contrast, its prevalence is lower in populations of Asian and African descent, likely reflecting differences in genetic susceptibility and environmental exposures [6].

Yazgan S described that age is a key risk factor for PXF, with the incidence increasing significantly after the age of 50. Research shows that PXF is more prevalent among women, though the cause of this gender difference is still unknown [7]. Zare MA stated that certain evidence indicates that hormonal influences might play a role in influencing disease susceptibility. Environmental factors such as extended exposure to sunlight, elevated altitudes, and oxidative stress have been implicated as contributors to disease development and progression[8,9].

Pathophysiology of PXF

Ozcura F, Aydin S, Dayanir V mentioned that the pathophysiology of PXF is complex and multifactorial, with a strong genetic predisposition. A significant breakthrough in understanding its pathogenesis was the discovery of the association between lysyl oxidase like 1 (LOXL1) gene polymorphisms and PXF. The LOXL1 gene codes for an enzyme that is essential for the synthesis and upkeep of elastic fibers in the extracellular matrix.Mutations in the gene interfere with the cross-linking of elastin and collagen, causing the formation of abnormal fibrillar granular material that accumulates in tissues [3].

Palko RJ, Qi O, Sheybani A reported that this material is not limited to the eye and has been found in other systemic tissues, indicating that PXF is a generalized elastic microfibrillopathy. The condition is further worsened by environmental stimuli like ultraviolet (UV) radiation and oxidative stress. Genetic susceptibility and environmental triggers are likely factors accounting for the variability in disease prevalence and severity in various populations [4]. Abnormal material

deposition may cause a mild inflammation, which affects the blood aqueous barrier. This affects the permeability of the blood aqueous barrier, allowing for increased entry of more debris and for the storage of pseudoexfoliation material in the aqueous humor and ocular tissues.This can also result in elevated aqueous protein concentration, which in turn increases the deposition[5].

Clinical manifestations of PXF

The characteristic feature of PXF is the deposition of fibrillogranular material in the anterior segment of the eye, which may be associated with a broad range of clinical manifestations. The most frequent ocular presentations are

Lens Capsule:

The material is deposited most abundantly on the anterior lens capsule, creating a characteristic "three-zone pattern" on slit-lamp examination [10].

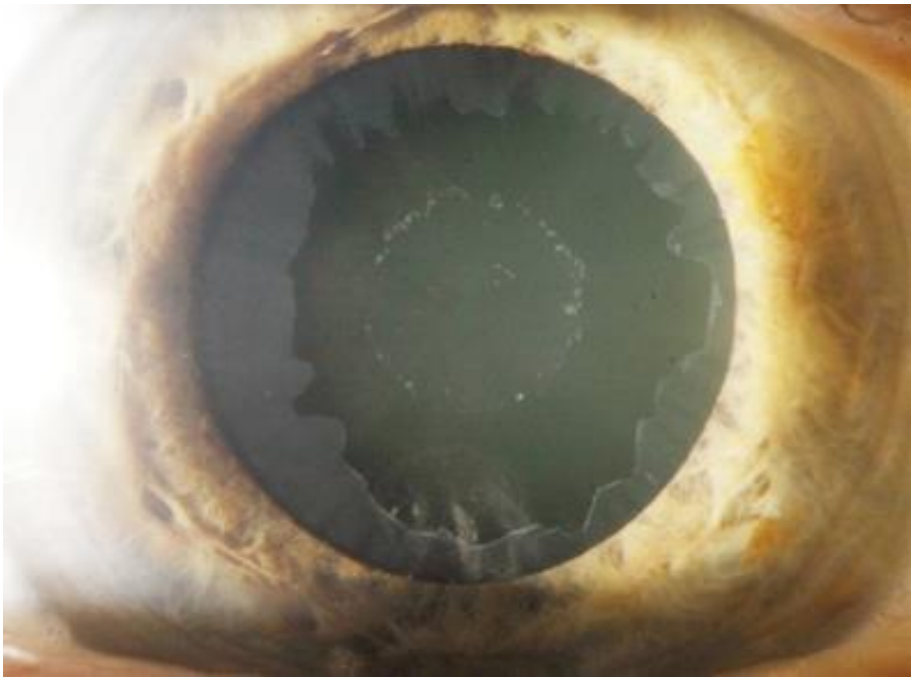


Figure 02: The picture shows pseudoexfoliation at the anterior lens capsule, the three zone pattern

Iris and Pupillary Border:

Pupillary border deposition may lead to pigment dispersion, which in turn may cause iris

transillumination defects.

Trabecular Meshwork:

The buildup of material in the trabecular meshwork leads to increased outflow resistance, resulting in elevated intraocular pressure (IOP) and increased risk of developing pseudoexfoliation glaucoma (PEXG) [11].

Trabeculopathy:

The exfoliative material can clog the trabecular meshwork and Schlemm's canal, hindering effective drainage of aqueous humor. Over time, this results in increased IOP and optic nerve damage[11].

Corneal Endothelium:

The deposit of pseudoexfoliative material on endothelial cells may result in corneal decompensation and other structural irregularities[12].

Pasquale LR, Willett WC, Rosner BA, et al indicated in their study that apart from ocular participation, PXF has also been associated with multiple systemic conditions, indicating that it does not remain in the eye only. Evidence of association is presented with cardiovascular diseases like hypertension, myocardial infarction, and stroke. These associations at the systemic level emphasize the point that PXF should be addressed as a systemic disorder instead of an ocular condition [13,14].

The most serious complication of PXF is the formation of pseudoexfoliation glaucoma (PEXG), which is marked by progressive optic neuropathy and visual field loss. PEXG is more aggressive and challenging to treat than primary open-angle glaucoma (POAG), with a greater risk of needing surgical treatment [15].

IMPORTANCE OF CORNEAL PARAMETERS IN PSEUDOEXFOLIATION

Central corneal thickness (CCT)

Yazgan S, Celik U, Alagöz N, Tas M reported in their research thatCentral Corneal Thickness(CCT) is an essential parameter in ophthalmology, asit has a direct effect on the measurement of intraocular pressure (IOP), which is a key indicator in diagnosing and treating glaucoma. The general population's average CCT varies from 520 µm to 580 µm, with differences depending on age, race, and individual physiology.

Research has indicated that thinner corneas are linked with an underestimation of IOP when measuring with Goldmann applanation tonometry (GAT),whereas thicker corneas may lead to an overestimation of IOP [7]. Zare MA, Fakhraie G, Kheirkhah A suggested that the physiological significance of CCT goes beyond IOP measurement. It indicates the biomechanical characteristics of the cornea, including elasticity and rigidity, which are critical for its structural integrity under different IOP conditions. These characteristics are especially pertinent in pseudoexfoliation syndrome (PXE), in which corneal abnormalities are frequently seen. Thinning of CCT in PXE can result in underdiagnosis or delayed detection of increased IOP, thus enhancing the risk of progression to pseudoexfoliation glaucoma (PEXG) [8]. Krysik K, Dobrowolski D, Polanowska K, et al in their study have demonstrated that patients with thinner central corneas are at greater risk of developing primary open-angle glaucoma (POAG), even when their IOP measurements are within normal limits. Thin corneas are linked with an increased risk of optic nerve damage and loss of visual field.

CCT can assist clinicians in anticipating the course of glaucoma, since thinner corneas tend to be linked with more advanced glaucomatous damage..[9]Central corneal thickness can be measured by various techniques like Ultrasound Pachymetry, Optical Pachymetry (OCT), Scheimpflug Imaging, Specular Microscopy

Comparison of CCT in PXF vs. Non-PXF eyes

Several studies have compared CCT in eyes with and without PXF to interpret its role in disease pathophysiology. Several studies have consistently reported thinner CCT in PXF eyes compared to controls, indicating that corneal thinning may be a characteristic feature of PXF [11]. For instance, a study by Zare et al. found that the average CCT in PXF eyes was significantly lower than in non-PXF eyes, suggesting that reduced CCT could predispose these patients to glaucoma development.

However, contradictory findings also exist. Some studies have shown no significant difference in CCT between PXF and control groups [12]. For example, Tomaszewski et al. concluded that while CCT in PXF eyes was not significantly different from controls, there was a marked reduction in endothelial cell density (ECD), highlighting the need to consider multiple corneal parameters in PXF research.

Endothelial cell loss in PEX can occur as a result of direct toxicity from the abnormal exfoliative material deposited on the corneal endothelium, mechanical damage due to the accumulation of exfoliation material, which can cause endothelial cell dysfunction or loss. PXF can lead to pseudoexfoliation glaucoma, which increases IOP and may contribute to endothelial cell damage, especially if left untreated[12].

CCT in PXF eyes with and without glaucoma

In pseudoexfoliation glaucoma (PEXG) patients, the CCT tends to be considerably thinner than in PXF eyes without glaucoma. This has been observed in various studies, such as a study by Ozcura et al., which showed that CCT reduces as PXF advances to PEXG [3]. The thinner CCT in PEXG is of clinical importance, as it can lead to the underestimation of IOP, thus delaying glaucoma diagnosis and treatment.

Also, the association of CCT with glaucoma risk in PXF draws attention to the prospective value of CCT as a disease severity and progression marker. Hepsen et al. underlined that serial measurements of CCT in PXF patients are capable of detecting those at increased risk of glaucoma and can be an indication for early treatment and good prognosis [5].

CCT and disease progression in PXF

Since corneal thickness decreases in individuals with pseudoexfoliation syndrome (PXF), it may worsen glaucoma injury. Thinner corneas can contribute to intraocular pressure readings, which complicates it to treat glaucoma. The cornea's lowered strength could also predispose it to injury, which advances the disease progression at a quicker rate. Research has proven that CCT is a glaucoma progression predictor in patients with PXF, where thinner corneas are related to a greater risk of visual field loss [16].

Clinical significance of CCT in PXF transcends diagnostic purposes. Periodic monitoring of CCT in PXF patients can assist in making treatment decisions, e.g., institution of IOP-reducing treatment or the requirement for surgical intervention As pointed out by Tekce et al., the inclusion of sophisticated imaging modalities such as anterior segment optical coherence tomography (OCT) can add to the accuracy of CCT measurements and better management of PXF-related glaucoma [6]

INTRAOCULAR PRESSURE MEASUREMENT IN PXF

Impact of CCT on IOP measurement

The association between central corneal thickness (CCT) and intraocular pressure (IOP) measurement is well-documented. In PXF, CCT deviations are most frequent,with numerous studies showing thinner corneas than those in non-PXF eyes. These deviations can cause considerable errors in IOP estimation by standard tonometry methods. Thinner corneas cause underestimation of IOP, which can delay the diagnosis of glaucoma or give a false sense of security in PXF patients who are at risk of developing PEXG. In contrast, thicker corneas may result in

overestimation of IOP, risking overtreatment. The Zare et al. study highlighted the need to adjust IOP readings using CCT readings in patients with PXF to prevent these diagnostic pitfalls [22].In order to address this problem, the inclusion of CCT-adjusted IOP measures in everyday practice has been suggested. Innovative imaging modalities such as anterior segment OCT and pachymetry may offer precise CCT values, allowing the cliniciansto make corresponding adjustments in IOP readings. This method not only enhances diagnostic precision but also the capacity to monitor disease progression and therapeutic response in PXF patients.

Corneal curvature

Krysik K, Dobrowolski D, Polanowska K, et al outlined that Corneal curvature is a description of the form and steepness of the corneal surface, and this has significant effects on the optical and biomechanical features of the eye. Normal corneal curvature ranges between 41 to 46 diopters, with variable variations in each individual. Curvature regulates the refractive power of the eye and affectsthe precision of IOP measurement, particularly in caseslike PXF, wherein structural modification of the cornea can shift its curvature [9].

Palko RJ, Sheybani A stated that in PXF, increased steep corneal curvature has been reported on numerous occasions compared to normal eyes. The steepness influences the reliability of tonometric IOP measurements since a steeper cornea can artificially raise IOP readings. Furthermore, PXF patients' corneal curvature changes might reflect root biomechanical weakness of the corneal tissue, further predisposing the eye to glaucoma-related complications [10]. It is significant to acknowledge these alterations is needed for changing diagnostic and therapeutic methods in PXF patients.

CORNEAL CURVATURE IN PXF

Alterations in corneal curvature in PXF

Corneal curvature is an important parameter of the cornea's biomechanical properties and its contribution to visual quality and intraocular pressure (IOP) measurement. In pseudoexfoliation syndrome (PXF), various studies have described corneal curvature changes, primarily a predisposition to steeper curvature. Such alterations are considered to occur due to the deposition of pseudoexfoliative material and its related biomechanical implications on the cornea. Researchers like Hepsen et al. and Ozcura et al. have shown that PXF eyes have steeper corneal curvature than nonPXF eyes [18,19]. This change is especially relevant because steeper curvature can affect the validity of IOP measurements conducted through Goldmann applanation tonometry (GAT). GAT is based on a default curvature of the cornea; variations from this norm can lead to overestimation or underestimation of IOP, making it harder to diagnose and treat glaucoma in PXF patients.

Increased corneal curvature in PXF also has biomechanical consequences in that it can change the pattern of stress on the corneal structure. This increased biomechanical stress may be one of the factors driving glaucomatous optic neuropathy, especially in those eyes at risk for pseudoexfoliation glaucoma (PEXG). Awareness of these changes is critical for both precise IOP measurement and the avoidance of disease progression.

Corneal curvature and glaucoma development

The correlation between corneal curvature and the development of glaucoma in PXF has remained an active research topic. Increased corneal curvature has been linked with increased vulnerability to glaucomatous injury, as it can result in faulty IOP measurements and enhanced biomechanical tension against the optic nerve head.

Research by Palko et al. and Serpil et al. indicates that the parameters of corneal curvature could act as biomarkers for evaluating the risk of PXF progression to PEXG [20, 21]. These

investigations stress that increased curvature is associated with higher IOP measurements, which may cause earlier optic nerve insult if the actual IOP is falsely low. Additionally, the changed curvature might be an expression of underlying alterations in the corneal extracellular matrix, further increasing the biomechanical susceptibility of the eye in PXF patients. Studies investigating this relationship have also stressed the importance of individual.

IOP measurement methods in PXF patients, considering the distinctive biomechanical and structural features of their corneas. This method could enhance early diagnosis of PEXG and allow more efficient management plans and makes visual prognosis less guarded.

Intraocular pressure measurement in PXF

Influence of corneal curvature on IOP readings

The effect of corneal curvature on IOP readings is another important factor in the management of PXF. Routine tonometry methods, including GAT, are standardized for a corneal curvature of about 43 diopters. Any variation from this standard,as most often seen in PXF patients with steeper or flatter corneas, can result in erroneous IOP measurements [23].

Steeper corneas, which are routinely noted in PXF, cause overestimation of IOP, whereas flatter corneas can result in underestimation. This variation highlights the importance of tonometry calibration that is specific to the individual corneal characteristics of PXF eyes.

Devices such as the Dynamic Contour Tonometer(DCT) and the Ocular Response Analyzer(ORA), which are less affected by corneal curvature, can provide more precise IOP measurements in such patients. Besides its effect on IOP measurements, changed corneal curvature in PXF can also yield important information regarding the omechanical behavior of the eye. Knowledge of these characteristics may assist in identifying eyes at greater risk of developing PEXG and direct individualized treatment approaches.

Unilateral pseudoexfoliation:

A unique opportunity for analysis

Unilateral pseudoexfoliation syndrome (PXF) offers a distinctive model for studying the localized effects of this systemic disorder and provides valuable insights into the disease's pathophysiology. In cases of unilateral PXF, one eye shows clinical evidence of pseudoexfoliative material deposition, while the fellow eye appears unaffected, at least initially. One of the central areas of investigation in such instances is a comparison of central corneal thickness (CCT) and corneal curvature between affected and unaffected eyes. Research by Hepsen et al. and Ozcura et al. has repeatedly shown that affected eyes have thinner CCT and steeper corneal curvature than their fellow eyes [24, 25].

These results are of clinical importance, since more superficial CCT in affected eyes tends to result in intraocular pressure underestimation on Goldmann applanation tonometry (GAT), whereas more steep curvature will cause overestimation of the IOP measurement, making it difficult to diagnose and manage glaucoma. These variations imply that deposition of pseudoexfoliative material and consequent biomechanical alterations of the cornea represent localized manifestations of the disease that may extend with time to include the fellow eye. The variations in corneal parameters also underscore the significance of understanding the localized pathophysiology of PXF.

A thinner CCT in involved eyes may suggest damage to the corneal endothelium from pseudoexfoliative material, and steeper corneal curvature might be indicative of biomechanical changes in the corneal stroma. These changes in a localized manner offer useful insights into the mechanisms governing the progression of disease. In addition, the comparison of parameters between involved and fellow eyes indicates that unilateral pseudoexfoliation (PXF) can be an incipient manifestation of a bilateral disorder, with the fellow eye frequently having subclinical changes preceding the development of overt disease.

On a clinical basis, vigilant follow-up of both eyes is required to catch changes early and optimize treatment regimens, such as the introduction of IOP-lowering therapies based on the individual eye's specific corneal properties. The fellow eyes in unilateral cases of PXF, though clinically normal, frequently have subtle changes that can forecast the development of bilateral PXF. Research, including that by Forsman et al., has demonstrated that 40-50% of fellow eyes in patients with unilateral PXF develop PXF signs within five years [26].

These results highlight the importance of frequent follow-up of fellow eyes, since subclinical changes, such as early CCT thinning, decreased corneal endothelial cell density (ECD)and pseudoexfoliative material detected by sophisticated imaging methods, are usually seen. Methods like anterior segment optical coherence tomography (OCT) and specular microscopy have been found to be of immense value in detecting these changes, thus enabling early intervention prior to the occurrence of major clinical manifestations or glaucomatous damage.

The evidence emphasizes the risk of bilateral progression and the need for close follow-up to reduce the likelihood of development of pseudoexfoliation glaucoma (PEXG). Follow-up of the fellow eye not only assists in early detection but also offers a chance to gain insight into the natural history of PXF and its bilateral course.

Unilateral PXF is an essential model for understanding the progressive and localized influence of pseudoexfoliation syndrome. The corneal parameter differences between affected and fellow eyes in terms of CCT and curvature depict the localized effect of pseudoexfoliative material on the biomechanics of the cornea. Also, the bilateral progression risk and fellow eye predictive nature highlight the necessity of early detection and monitoring in averting glaucoma development. Regular follow-up and advanced imaging can greatly enhance the outcome in patients with unilateral PXF, facilitating refinement of therapeutic and diagnostic strategies.

Advances in diagnostic techniques for corneal assessment in PXF

Progress in diagnostic methods has highly enhanced our current knowledge of pseudoexfoliation syndrome (PXF), more so in estimating corneal structural and biomechanical modifications. Advanced imaging technologies, such as optical coherence tomography (OCT), keratometry, pachymetry, and novel developments for corneal biomechanics measurement, offer invaluable knowledge on disease dynamics and their bearings on glaucoma development. These modalities have highly maximized diagnostic accuracy and therapeutic selection in PXF patients.

Optical coherence tomography (OCT)

Optical coherence tomography (OCT) has evolved as a cornerstone for corneal imaging, providing high-resolution and cross-sectional visualization of the anterior segment. In PXF, anterior segmentOCT has been extensively applied to precise measurement of central corneal thickness(CCT) and evaluation of corneal sublayers. OCT enables reproducible and accurate CCT measurements, which are essential to refining intraocular pressure (IOP) correction during glaucoma screening and treatment [27].

Alongside CCT, OCT is also responsible for identifying corneal sublayer alterations in PXF. Research by Tekce et al., among others, has shown that PXF eyes show noticeable reduction in stroma, endothelium, and Descemet's membrane thickness, with the only exception being Bowman's layer, which is not affected as much. All these indicate that OCT can be of vital importance in determining initial damage in the cornea resulting from pseudoexfoliative material deposition before any clinical symptoms are experienced. In addition, the subclinical detection capability of OCT allows clinicians to track disease progression and evaluate the risk of developing pseudoexfoliation glaucoma (PEXG). OCT also gives details regarding the iridocorneal angle,

which can be compromised in PXF through zonular instability or angle-closure glaucoma susceptibility. This application broadens the utility of OCT, with a comprehensive evaluation of the anterior segment in patients with pseudoexfoliation (PXF), along with corneal imaging. In general,OCT widespread application has facilitated significantly improved diagnosis and monitoring due to its effect on corneal change in PXF evaluation.

Keratometry and pachymetry

Keratometry and pachymetry are classic diagnostic instruments that continue to form part of the evaluation of corneal parameters in PXF. Keratometry is employed for the measurement of corneal curvature, which is commonly changed in PXF as a result of biomechanical alterations. Several studies have documented steeper corneal curvature in PXF eyes, which can affect the accuracy of IOP measurements with tonometry. By allowing an objective assessment of corneal curvature, keratometry identifies these alterations and ensures that IOP readings are accurately interpreted [28].Pachymetry, however, is a specific method of measuring CCT. It is a standard instrument used in glaucoma screening, especially among PXF patients who tend to have thinner corneas than those who are not PXF. Thinner corneas may result in underestimation of IOP and hence a possible delay in the diagnosis of glaucoma. Pachymetry allows clinicians to make adjustments to IOP readings in relation to CCT to ensure greater diagnostic accuracy and prompt intervention. Also, the combination of pachymetry and keratometry offers a more thorough evaluation of corneal health. OCT-based pachymetry is a diagnostic instrument improves the detection of minor corneal changes in PXF, Offering a robust method of glaucoma risk management.

Emerging imaging modalities

The arrival of novel imaging modalities has created new horizons for the evaluation of corneal biomechanics in PXF. Standard imaging methods mainly evaluate corneal structure, but biomechanical features like elasticity, stiffness, and stress distribution are being increasingly viewed as essential determinants in the pathophysiology of PXF. Some breakthroughs in corneal biomechanics evaluation are technologies such as the Ocular Response Analyzer (ORA) and Corvis ST (Scheimpflug Technology), which quantify corneal hysteresis and deformation amplitude, respectively [29].

The Ocular Response Analyzer (ORA) gives a dynamic evaluation of corneal viscoelastic properties, which in PXF are frequently affected by deposition of pseudoexfoliative material. Lower corneal hysteresis in PXF patients has been associated with a higher risk of glaucoma progression, indicating that ORA can be used as a predictive measure for the management of disease. Likewise Corvis ST gives a precise visualization of corneal deformation following an air puff, allowing the identification of biomechanical features that can predispose the eye to optic nerve damage. To these, added are artificial intelligence (AI) imaging platforms, which are new and coming as strong diagnostic tools. AI can process massive amounts of OCT, keratometry, pachymetry data to search for patterns associated with PXF and forecast the progression of disease. AI systems can enhance diagnostic precision, especially in recognizing subclinical PXF changes during the early stage. In the future, the fusion of multimodal imaging modalities will continue to enhance the diagnostic arena for PXF. Integrating OCT, keratometry, pachymetry, and biomechanical testing allows for a comprehensive assessment of corneal health, facilitating better decision-making regarding disease management. Emerging technologies must be validated in large-scale clinical trials and standardized protocols developed for their application in the assessment of PXF.

Clinical implications and gaps in literature

Diagnostic and therapeutic relevance

Assessment of corneal parameters, i.e., central corneal thickness (CCT) and corneal curvature, has become a key component in the early identification and treatment of glaucoma in pseudoexfoliation syndrome (PXF). PXF patients are far more likely to develop pseudoexfoliation glaucoma (PEXG), a rapidly progressive and severe variant of secondary open-angle glaucoma. Intraocular pressure can be refined by exact assessment of corneal parameters by clinicians (IOP) readings, which tend to be affected by corneal structural alteration in PXF patients. Research, such as that carried out by Zare et al., has uniformly reported reduced CCT in PXF eyes, resulting in IOP underestimation by Goldmann applanation tonometry (GAT) [30]. Faulty IOP readings may cause delay in diagnosis of glaucoma, jeopardizing patient outcomes. Likewise, corneal curvature change, such as the common observation of increased curvature in PXF patients, can also impact the accuracy of tonometric IOP measurements. Research by Ozcura et al. emphasized that steeper corneas frequently result in overestimated IOP measurements, increasing the complexity of glaucoma screening and monitoring [31].

These findings reinforce the necessity of individualized IOP correction methods based on each person's corneal parameters. Sophisticated diagnostic devices like anterior segment optical coherence tomography (OCT) and dynamic contour tonometry (DCT) allow for accurate CCT and curvature measurements, allowing clinicians to make glaucoma management plans responsive to the specific features of each patient. Besides enhancing diagnostic precision, corneal parameter assessment has therapeutic consequences. Knowledge of the biomechanical properties of the cornea can be used to forecast the risk of glaucoma progression in PXF patients. For instance, thinner CCT has been associated with greater vulnerability to optic nerve damage, whereas increased corneal curvature could worsen trabecular meshwork stress, again raising IOP. Early detection of such risk factors permits anticipatory intervention, e.g., starting IOP- lowering therapy or having more

frequent follow-up. Such tailored measures can postpone the development of PEXG and maintain vision in PXF patients.

Unresolved questions and areas for future research

In spite of huge progress in realizing the correlation between corneal parameters and PXF, there are many questions unanswered. Among the greatest challenges lies in the heterogeneity of observations regarding CCT and corneal curvature among studies. While Hepsen et al. and Palko et al. among many others reported thinner CCT and steeper corneal curvature in PXF patients, there were no significant differences in others when compared to the control groups [30,32]. These differences can be due to variations in study populations, study methodologies, and diagnostic criteria, and emphasize the importance of using standardized protocols in subsequent studies. The other concern is the absence of large, multi-center studies capable of generating sound data regarding the global burden and nature of corneal changes in PXF. Most of the studies that have been conducted are compromised by small numbers of subjects and single-center designs, which would not reflect the entire range of disease heterogeneity. Large-scale, multi-center studies with heterogeneous populations would better create standardized reference points for corneal measurements in PXF patients. Such reference points could then be used as a basis for diagnosis and treatment of the condition, minimizing variability and enhancing clinical performance. In addition, the utility of advanced imaging modalities to find subclinical alterations in PXF is yet to be fully investigated. Although modalities like anterior segment OCT and corneal biomechanics analyzers have been promising in detecting early corneal abnormalities, their applicability to daily clinical practice is limited by cost and availability. Cost-effective diagnostic technology development and assessment of their impact on early detection and management of PXF should be the priority of future research. Investigating the possibility of using artificial intelligence (AI) for analyzing corneal imaging data might also improve diagnostic accuracy and

efficiency. Finally, processes involved in corneal alteration in PXF, such as the deposition of pseudoexfoliative material and corneal structural and biomechanical effects, remain obscure. Exploring these mechanisms via longitudinal studies and animal models could generate useful information about disease progression and reveal new therapeutic targets. Knowing how the changes lead to the development of glaucoma in patients with PXF may result in the creation of new and more effective treatments targeted at maintaining corneal and optic nerve well-being.

A comprehensive review of the literature reveals consistent evidence supporting the presence of thinner central corneal thickness (CCT) and steeper corneal curvature in PXF patients compared to non-PXF controls. These findings have significant implications for the diagnosis and management of glaucoma in PXF. Thinner CCT is associated with underestimated IOP readings, which can delay the detection of elevated IOP and increase the risk of optic nerve damage. Steeper corneal curvature, however, can result in overestimated IOP readings, making tonometric data interpretation difficult. The interaction among these parameters emphasizes the necessity for customized strategies to IOP monitoring and glaucoma screening in PXF patients. From a therapeutic view, the analysis of corneal parameters sheds important light on the biomechanical characteristics of the cornea and their role in disease progression. Thinner CCT and increased curvature could be markers for enhanced vulnerability to glaucoma , emphasizing the need for early diagnosis and specific intervention. Sophisticated diagnostic instruments like OCT, pachymetry, and keratometry have improved the precision of measuring these parameters, allowing clinicians to optimize their diagnostic and therapeutic approaches. Nevertheless, there are important gaps in the literature, especially concerning the heterogeneity of findings between studies and the absence of standardized protocols for corneal parameter measurement in PXF. These gaps are filled by large-scale multi-center studies and the creation of affordable diagnostic technologies is crucial to moving the field forward. Further research must also be directed at uncovering the mechanisms of corneal change in PXF and investigating their role in glaucoma onset.

In summary, the measurement of corneal parameters in PXF is of both diagnostic and therapeutic importance, providing possibilities to enhance clinical outcomes through customized treatment. The solution to the open questions and utilization of advancements in imaging technologies will continue to increase our knowledge of PXF and its consequences for corneal and optic nerve health.

MATERIALS AND METHODS

This study is a cross-sectional study which was aimed at assessing the central corneal thickness (CCT) and corneal curvature in patients with pseudoexfoliation syndrome (PXF) and those without PXF over a duration of one and a half years, between May 2023 and December 2024, at the department of ophthalmology, Shri B M Patil Medical College, Hospital, and Research Centre, Vijayapura.

This study included 106 patients who met the inclusion criteria.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria:

- Patients presenting with white fibrillary material deposition in the anterior segment of the eye (indicative of PXF).
- Patients without pseudoexfoliation as the Control group

Exclusion criteria:

- Any pre-existing corneal pathology (e.g., keratoconus, keratoglobus, corneal ulcers).
- History of ocular trauma.

RECRUITMENT PROCESS:

- Patients attending the OPD for evaluation, diagnosed with or without pseudoexfoliation, are included.
- A clinical diagnosis is established based on the deposition of fibrillary material on the lens, pupil, ciliary body, or zonules under slit lamp.

Clinical examinations and investigations :

A detailed ocular examination was conducted using a slit lamp. The refractive status evaluation was done, where visual acuity was measured with snellen visual acuity chart. Baseline intraocular pressure was measured using the non-contact tonometer and schiotz tonometer. Keratometer is used for measuring both K1 (flat meridian) and K2 (steep meridian) of both the eyes. OCT (Optical Coherence Tomography) and pachymetry is used to measure central corneal thickness in both eyes. Both binocular indirect ophthalmoscopy and slit lamp biomicroscopy with a 90 D lens were used to examine the fundus, optic nerve head and the baseline cup disc ratio was recorded.

Sampling methodology

Sample Size: Using the G*Power version 3.1.9.4 software

Simulated values:

- Control group: Mean = 43.7, SD = 2
- PXF group: Mean = 45.2, SD = 1.8

- Required total sample size = 106 participants (53 in each group), calculated to achieve 98% power with a 5% significance level.

Statistical analysis:

- Data is entered into Microsoft Excel and analyzed using SPSS software (version 20).
- Statistical analyses include:

Descriptive Statistics: Mean, standard deviation (SD), counts, and percentages.

Inferential statistics:

- Independent Sample t-test: For normally distributed continuous variables between groups.
    - Mann-Whitney U Test: For non-normally distributed variables.
    - Chi-Square Test/Fisher's Exact Test: For categorical variables.
- Significance Level: p-value < 0.05 is considered statistically significant.
    - Results are visually represented using graphs and tables.

Ethical considerations

- Ethical clearance for the study was obtained from the Institutional Ethics Committee of BLDE University.
- Informed consent is obtained from all participants after explaining the study details, procedures, benefits, risks, and confidentiality.

Probable outcomes

- The study aims to provide further insights into the differences in CCT and corneal curvature between PXF and non-PXF patients.
- It seeks to establish the potential role of CCT as a clinical parameter for assessing the risk of progression from PXF to pseudoexfoliation glaucoma (PEXG).

Consent and confidentiality

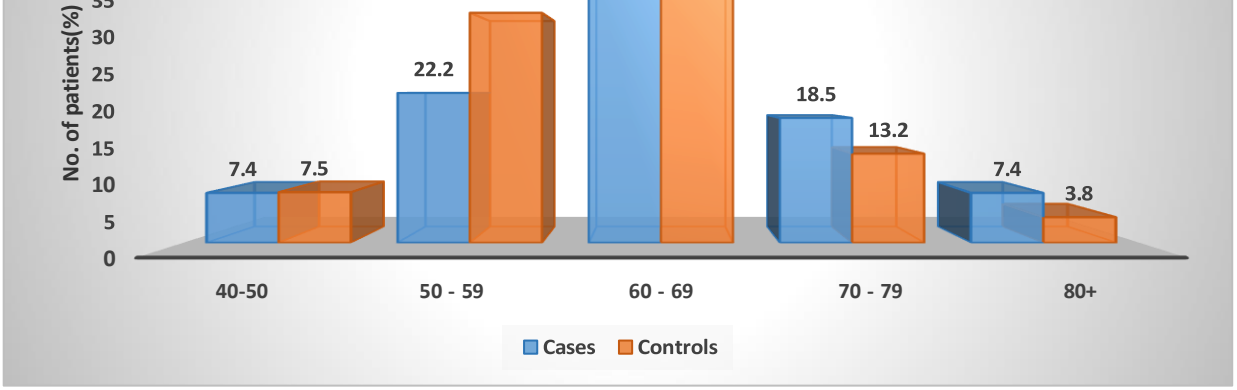
- Participants are informed about the purpose, procedures, risks, and benefits of the study.
- A signed consent form is obtained before inclusion.
- Data confidentiality is maintained, and no personal identifiers are used in publications.

OBSERVATION AND RESULTS

Table 1: Age Distribution of Study Participants

This table presents the distribution of participants across different age groups for pseudoexfoliation syndrome (PXF) cases and controls. The Chi-square test was used to determine the significance of differences in age distribution between groups. majority (43.5%) participants were aged 60-69 years. The age distribution was statistically insignificant (p = 0.649), suggesting age was not a significant risk factor in this study sample

Age(Years)	Cases	Controls	Total	Chi square test	Significant value
40-50	4	4	8	2.474	P=0.649
%	7.4%	7.5%	7.5%		
50 - 59	12	18	30		
%	22.2%	34.0%	28.0%		
60 - 69	23	22	46		
%	44.4%	41.5%	43.0%		
70 - 79	10	7	17		
%	18.5%	13.2%	15.9%		
80+	4	2	6		
%	7.4%	3.8%	5.6%		
Total	53	53	107		
%	100.0%	100.0%	100.0%		
Statistically insignificant					

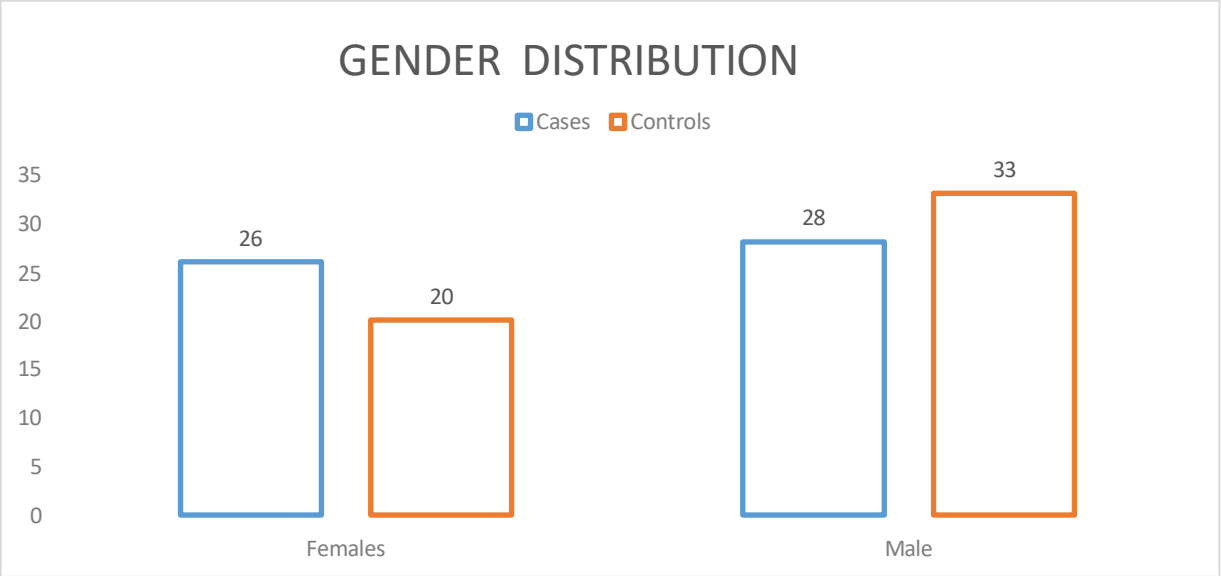


Graph.1 A bar graph representation of age distribution

Table 2: Gender Distribution of Study Participants

This table shows the gender distribution among PXF cases and controls, with a Chi-square test performed to assess statistical significance. Males constituted a slightly higher percentage (57.0%) of the study population, aligning with studies indicating a male predominance in PXF case. The gender distribution was statistically insignificant (p = 0.277), suggesting gender was not a significant risk factor in this study sample.

Gender	Cases	Controls	Total	Chi square test	Significant value
Females	25	20	46	1.183	P=0.277
%	48.1%	37.7%	43.0%		
Male	28	33	61		
	51.9%	62.3%	57.0%		
Total	53	53	106		
%	100.0%	100.0%	100.0%		
Statistically insignificant					

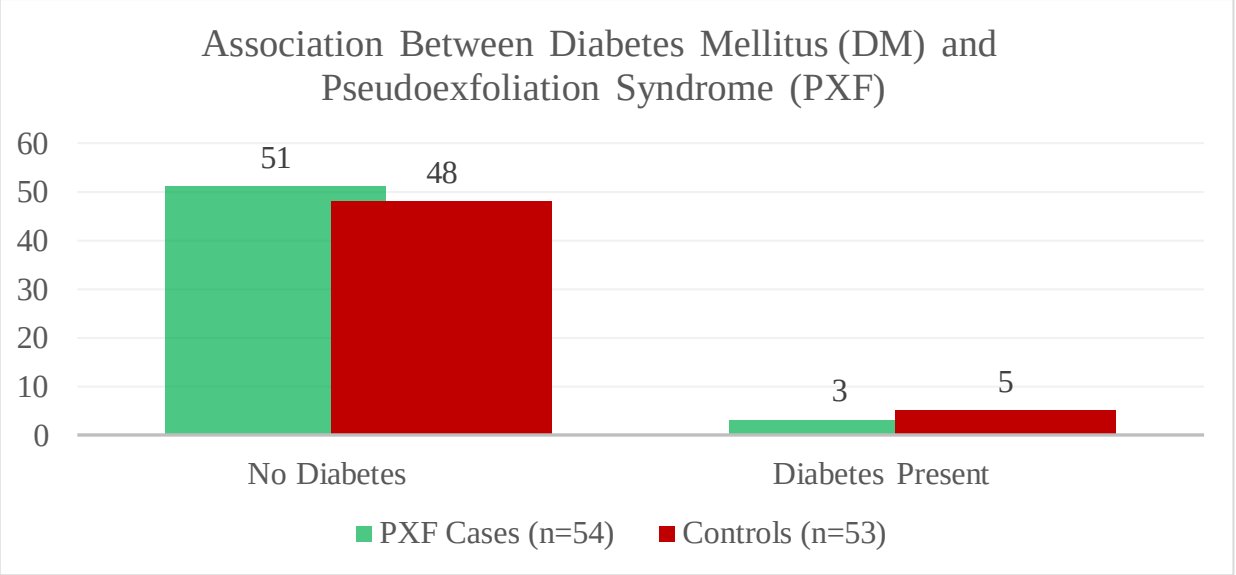


Graph.2 A bar graph representation of gender distribution

Table:3 Association Between Diabetes Mellitus (DM) and Pseudoexfoliation Syndrome (PXF)

This table presents the prevalence of diabetes mellitus (DM) among pseudoexfoliation syndrome (PXF) cases and controls, along with the statistical significance of the association using the Chi-square test. The prevalence of diabetes mellitus (DM) was slightly lower in PXF cases (5.6%) compared to controls (9.4%), but this difference was not statistically significant ($p = 0.446$, NS).The Chi-square test ($\chi^2 = 0.582$) and Fisher's Exact Test ($p = 0.489$) indicate no significant correlation between diabetes and PXF in this study population. The absence of statistical significance could be due to a small sample size, requiring larger studies for a more conclusive analysis.

Diabetes Mellitus Status	PXF Cases (n=53)	Controls (n=53)	Total (n=106)	Chi-square Test	Significance (p-value)
No Diabetes (n, %)	50 (94.4%)	48 (90.6%)	98(92.5%)	Pearson χ^2 = 0.582	p = 0.446 (NS)
Diabetes Present (n, %)	3 (5.6%)	5 (9.4%)	8 (7.5%)	Fisher's Exact Test	p = 0.489 (NS)
Total (n, %)	53 (100%)	53 (100%)	106 (100%)	-	-



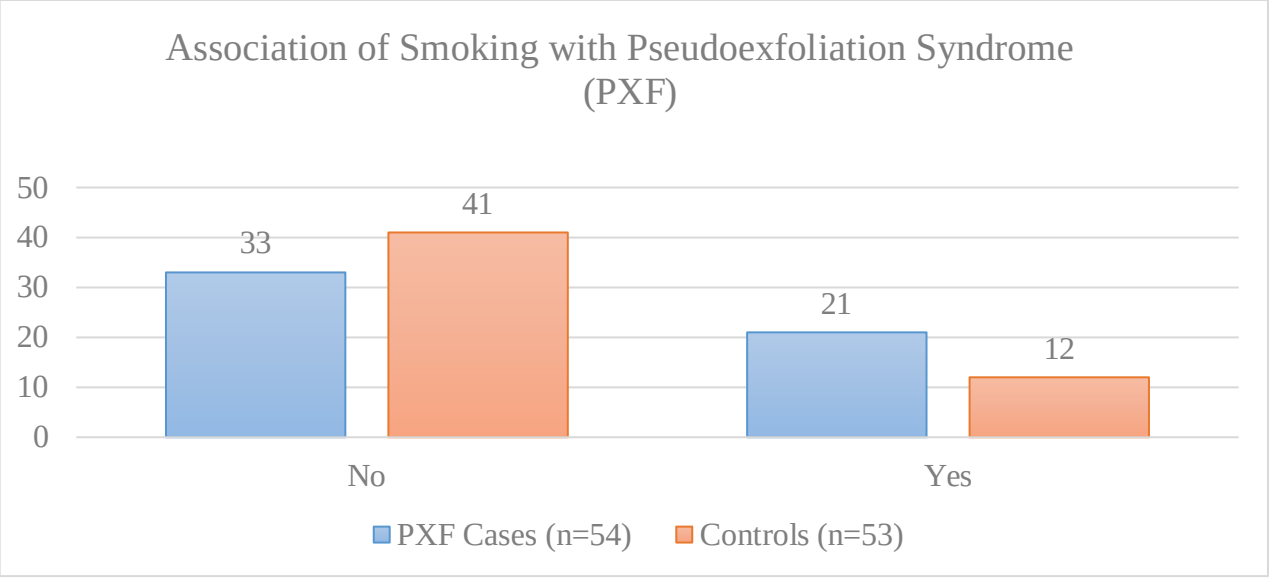
Graph.3 A bar graph representation of Association Between Diabetes Mellitus (DM) and Pseudoexfoliation Syndrome (PXF)

Table: 4 Association of Lifestyle factors (Smoking and alcohol consumption) with Pseudoexfoliation Syndrome (PXF)

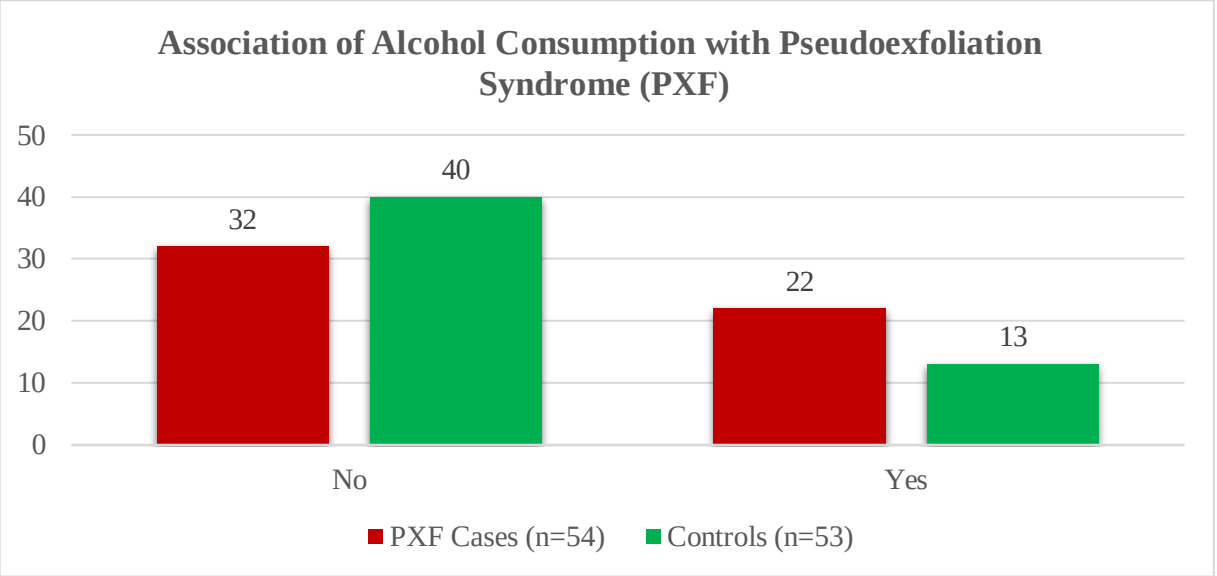
This table examines the prevalence of smoking and alcohol consumption in PXF cases and controls, analyzed using a Chi-square test. Smoking was more common in PXF cases (38.9%) than controls (22.6%), but the association was not statistically significant ($p = 0.069$).This trend suggests that smoking may play a role in oxidative stress and vascular dysfunction, potentially contributing to PXF pathogenesis, as suggested in prior studies A larger sample size may be required to establish a stronger correlation between smoking and PXF. Alcohol consumption was higher in PXF cases (40.7%) than controls (24.5%), but the association was not statistically significant ($p = 0.074$). However, more research is needed to establish a direct link between

alcohol and PXF development

Smoking Status	PXF Cases (n=53)	Controls (n=53)	Total (n=107)	Chi-square Test	Significance (p-value)
No	32 (61.1%)	41 (77.4%)	74 (69.2%)	Pearson χ^2 = 3.310 -	p = 0.069 (NS) -
Yes	21 (38.9%)	12 (22.6%)	33 (30.8%)		
Alcohol status					
No	32 (59.3%)	40 (75.5%)	72 (67.3%)	Pearson χ^2 = 3.194	p = 0.074 (NS)
Yes	22 (40.7%)	13 (24.5%)	35 (32.7%)		



Graph.4 A bar graph representation of Association of Smoking with Pseudoexfoliation Syndrome (PXF)



Graph.5 A bar graph representation of Association of Alcohol Consumption with Pseudoexfoliation Syndrome (PXF)

Table 5: Comparison of K1 and K2 in patients with and without pseudoexfoliation

Parameter	Group-1 Mean ± SD(cases)	Group-2 Mean ± SD (controls)	p-value
K1 OD (D)	44.2 ± 2.0	45.11 ± 2.03	0.024*
K2 OD (D)	46.1 ± 1.3	46.9 ± 1.2	0.005*
K1 OS (D)	44.06 ± 1.7	45.04 ± 1.5	0.002*
K2 OS (D)	46.5 ± 1.2	47.2 ± 1.3	0.009

K1 values were significantly higher in Group-2 (controls) than in Group-1 (PXF patients), with a p-value of 0.024 for OD and 0.002 for OS. K2 values were significantly higher in Group-2 (controls) than in Group-1 (PXF patients), with a p-value of 0.005 for OD and 0.009 for OS This suggests that corneal flattening is more pronounced in PXF patients, which could be due to structural alterations in corneal biomechanics.

Table 6: Comparison of CCT in patients with and without pseudoexfoliation using OCT

Parameter	Group-1 Mean ± SD (cases)	Group-2 Mean ± SD (controls)	p-value
CCT OD OCT (μm)	506.15 ± 36	501.4± 34.74	0.626
CCT OS OCT (μm)	503.35 ± 34	504.4 ± 26.40	0.617

The mean CCT OD was 506.15 ± 36 μm in Group-1 (PXF) and 501.4 ± 34.74 μm in Group-2 (controls) ($p = 0.626$), indicating no statistically significant difference between the two groups. Similarly, CCT OS was 503.35 ± 34 μm in Group-1 (PXF) and 504.4 ± 26.40 μm in Group-2 ($p = 0.617$).

These findings suggest that OCT-based CCT measurements do not show a significant reduction in PXF patients. While some studies report thinner corneas in PXF, the current study does not confirm this association, possibly due to variations in sample characteristics or measurement techniques.

Table 7: Comparison of CCT in patients with and without pseudoexfoliation using Pachymetry

Parameter	Group-1 Mean ± SD (cases)	Group-2 Mean ± SD (controls)	p-value
CCT OD Pachymetry (μm)	506.33 ± 34.33	504.81± 32.70	0.621
CCT OS Pachymetry (μm)	505.1 ± 33.2	507.60 ± 25.67	0.612

CCT OD Pachymetry (μm): The mean CCT OD in PXF patients was 506.33 ± 34.33 μm, while in controls, it was 504.81 ± 32.70 μm ($p = 0.621$), indicating no significant difference.

CCT OS Pachymetry (μm):The mean CCT OS in PXF patients was 505.1 ± 33.2 μm, while in controls, it was 507.60 ± 25.67 μm ($p = 0.612$), also showing no significant difference.

Table 8: Comparison of IOP in patients with and without pseudoexfoliation

Parameter	Group-1 Mean ± SD (cases)	Group-2 Mean ± SD (controls)	p-value
IOP OD	13.6 ± 1.82	12.9± 1.91	0.011
IOP OS	14.12± 1.98	13.82± 2.01	0.406

IOP OD (mmHg): The mean IOP OD in PXF patients was 13.6 ± 1.82mmHg, while in controls, it was 12.9± 1.91mmHg (p = 0.011), indicating significant difference.

IOP OS (mmHg): The mean IOP OS in PXF patients was 14.12± 1.98mmHg, while in controls, it was 13.82± 2.01 mmHg (p = 0.406), showing no significant difference.

Table 9: Comparison of K1, K2, CCT and IOP in patients with unilateral PXF

parameter		Group-1 Mean ± SD(PXF eye) (n=13)	Group-2 Mean ± SD (Fellow eye)(n=13)	p-value
K (D)	K1	44.95 (2.25)	44.46 (1.31)	0.633
	K2	45.95 (2.28)	45.73 (2.05)	0.863
CCT (μm)	OCT	531.20 (37.66)	513.75 (50.58)	0.522
	Pachymetry	527.80 (36.46)	513.13 (49.59)	0.581
IOP (mmHg)		14.20 (0.44)	14.13 (2.28)	0.944

K1 values were not statistically significant in Group-2 (fellow eyes) and Group-1 (PXF eyes), with a p-value of 0.633. K2 values were not statistically significant in Group-2 (fellow eyes) and Group-1 (PXF eyes), with a p-value of 0.863.

The mean CCT with OCT was 5312.20 μm in Group-1 (PXF eyes) and 513.75 μm in Group-2 (fellow eyes) (p = 0.522), indicating no statistically significant difference between the two groups. These findings suggest that OCT-based CCT measurements do not show a significant reduction in PXF patients.

The mean CCT with pachymetry in PXF eye was 527.80 μm, while in the fellow eye it was 513.13 μm (p = 0.581), indicating no significant difference.

The mean IOP OD in PXF eyes was 14.20 mmHg, while in the fellow eyes, it was 14.13 mmHg (p = 0.944), indicating no significant difference.

Table 13: Pupil Size Comparison Between PXF Cases and Controls

This table presents the pupil size distribution in the right eye (OD) and left eye (OS) between PXF cases and controls.

Pupil Size (mm)	PXF Cases (n=54)	Controls (n=53)	Total (n=107)	Chi-square Test	Significance (p-value)
OD (Right Eye)				$\chi^2 = 0.363$	p = 0.834 (NS)
2mm	2 (3.7%)	1 (1.9%)	3 (2.8%)	-	-
3mm	28 (51.9%)	27 (50.9%)	55 (51.4%)	-	-
4mm	24 (44.4%)	25 (47.2%)	49 (45.8%)	-	-
OS (Left Eye)				$\chi^2 = 0.673$	p = 0.714 (NS)
2mm	2 (3.7%)	1 (1.9%)	3 (2.8%)	-	-
3mm	30 (55.6%)	27 (50.9%)	57 (53.3%)	-	-
4mm	22 (40.7%)	25 (47.2%)	47 (43.9%)	-	-

No significant differences were observed in pupil size between PXF cases and controls (p = 0.834 for OD, p = 0.714 for OS)

DISCUSSION

This study evaluated central corneal thickness (CCT), corneal curvature, and associated demographic, clinical, and lifestyle parameters in patients with pseudoexfoliation syndrome (PXF) compared with controls.

Age and gender distribution

The age distribution data indicated that approximately 43.0% of participants were aged 60–69 years. This finding is similar to previous epidemiological studies indicating that PXF is predominantly a disease of the elderly. For instance, Forsman et al. (2007) reported similar age-group distributions, where the majority of patients were over 60 years. Despite some studies indicating a slight female predominance, our study found a male predominance (57.0% males versus 43.0% females), which has been similarly reported by Lirong et al. (2015) in certain populations. The non-significant p-values (0.649 for age and 0.277 for gender) indicates that age and gender are not a relevant epidemiologic variables, they may not serve as independent risk factors for PXF in every demographic setting.

Diabetes mellitus

The prevalence of DM was slightly lower in PXF cases (5.6%) compared with controls (9.4%), but this difference was not statistically significant ($p = 0.446$). This contrasts with some literature that describes diabetes as a potential risk factor due to its association with microvascular changes and oxidative stress. However, studies such as those by Detorakis and Spandidos (2007) have not consistently demonstrated a strong link between diabetes and PXF. The current study's relatively small number of diabetic patients ($n = 8$) might limit the statistical power to detect a true association.

More large-scale studies across multiple centers are needed to better understand how metabolism affects Pseudoexfoliation (PXF).

Lifestyle factors: smoking and alcohol consumption

Smoking was reported by 38.9% of PXF patients versus 22.6% in controls, with a near-significant p-value of 0.069 . Alcohol consumption was reported by 40.7% of PXF patients versus 24.5% in controls ($p = 0.074$). These results suggest a trend toward higher exposure to these risk factors among PXF patients. Smoking, known to elevate oxidative stress, could theoretically contribute to the extracellular matrix alterations seen in PXF (Thorleifsson et al., 2007). Likewise, alcohol may exacerbate oxidative stress, but the evidence in our study did not reach statistical significance. The borderline significance indicates that a larger sample size might reveal more definitive associations. Similar trends have been seen in other studies, but the results vary across different populations.

Comparison of K1 and K2 in patients with and without pseudoexfoliation

The keratometry values, K1 and K2, were significantly different between PXF cases and controls in both the right (OD) and left (OS) eyes. In OD, the mean K1 was significantly lower in PXF patients (44.2 ± 2.0 D) compared to controls (45.11 ± 2.03 D), with a p-value of 0.024. Similarly, K2 in OD was lower in PXF cases (46.1 ± 1.3 D) than in controls (46.9 ± 1.2 D), with a statistically significant p-value of 0.005. A similar trend was observed in OS, where K1 was significantly lower in PXF patients (44.06 ± 1.7 D) compared to controls (45.04 ± 1.5 D, $p = 0.002$), and K2 in OS was also lower in the PXF group (46.5 ± 1.2 D) compared to controls (47.2 ± 1.3 D, $p = 0.009$).

These findings indicate that corneal curvature is flatter in PXF patients than in controls, which is in contrast to certain studies reporting a steeper cornea in PXF due to altered biomechanical properties. . For example, Hepsen et al. (2007) found that K1 and K2 values in

PXF patients were significantly greater than in non-PXF subjects, having mean values of 44.9D and 46.3D, respectively. Contrarily, the current study indicates corneal flattening, potentially due to deposition of pseudoexfoliative material impacting corneal biomechanics. This difference in outcome between studies might stem from differences in population demographics, sample sizes, and measurement methods.

PXF patients with flatter corneas also have clinical ramifications for IOP measurement. Given that Goldmann Applanation Tonometry (GAT) uses a nominal corneal curvature (value around 43-45 D), deviations away from this can potentially introduce the errors in measurement. The flatter cornea, for example, could cause an IOP underestimation, hence potentially delayed diagnosis of PEXG. Yazgan et al. (2015) highlighted in a study that the changed corneal biomechanics in PXF patients require alternative tonometry methods, including Dynamic Contour Tonometry (DCT) or the Ocular Response Analyzer (ORA), to avoid inaccurate IOP measurement.

Comparison of CCT in patients with and without pseudoexfoliation using OCT

CCT values obtained via Optical Coherence Tomography (OCT) did not show statistically significant differences between PXF cases and controls. In OD, the mean CCT was 506.15 ± 36 μm in PXF cases and 501.4 ± 34.74 μm in controls ($p = 0.626$), while in OS, the mean CCT was 503.35 ± 34 μm in PXF patients and 504.4 ± 26.40 μm in controls ($p = 0.617$).

These results suggest that CCT is relatively preserved in PXF patients, contradicting previous studies that reported significant corneal thinning. Zare et al. (2012) reported that patients with PXF had thinner corneas than controls, with a mean CCT of 497.2 ± 29.3 μm in PXF versus 520.1 ± 27.6 μm in controls ($p < 0.01$). Likewise, Tomaszewski et al. (2014) found a mean CCT decrease of about

20 μm in PXF eyes, further supporting the notion that pseudoexfoliative material deposition can play a role in progressive endothelial dysfunction and consequent corneal thinning. These findings are not supported by the current study, though, and indicate that CCT thinning in PXF might be variable and dependent on other factors like ethnicity, severity of the disease, and measurement technique. Although the non-significant difference in CCT in this study indicates that corneal thinning might not be a common feature of PXF, clinicians need to be wary while interpreting IOP CCT measurements in PXF patients. Since even a 10 μm reduction in CCT may cause a 0.5 mmHg underestimation of IOP, according to Doughty and Zaman (2000), the clinician must bear in mind CCT-corrected IOP calculations in PXF patients to prevent misdiagnosis and inadequate treatment regimens.

Comparison of CCT in patients with and without pseudoexfoliation using pachymetry

Similar to the OCT measurements, CCT values obtained via Pachymetry did not show statistically significant differences between PXF cases and controls. In OD, the mean CCT measured using Pachymetry was 506.33 ± 34.33 μm in PXF cases and 504.81 ± 32.70 μm in controls ($p = 0.621$), while in OS, it was 505.1 ± 33.2 μm in PXF cases and 507.60 ± 25.67 μm in controls ($p = 0.612$). These results align with the OCT findings, further confirming that CCT thinning is not a consistent feature in all PXF cases.

However, previous studies have suggested that pachymetric differences in PXF may become more evident in advanced disease stages. A study by Palko et al. (2017) demonstrated that PXF eyes with established glaucoma had significantly thinner CCT values compared to non- glaucomatous PXF eyes (487.4 ± 28.9 μm vs. 506.7 ± 31.2 μm, $p < 0.05$). The present study's lack of significant differences in CCT may be due to the inclusion of both glaucomatous and non-glaucomatous PXF cases, potentially masking differences seen in more advanced disease stages.

Comparison of IOP in patients with and without pseudoexfoliation

The IOP values were statistically significant between PXF cases and controls in the right eye (OD). In OD, the mean IOP OD in PXF patients was ± 1.82mmHg, while in controls, it was 12.9± 1.91mmHg (p = 0.011), indicating significant difference contradicting Maria Nazmy Boshra et al., in their study stated that there is no significant difference is noted in IOP between PXF and controls.

Comparison of K1, K2, CCT and IOP in patients with unilateral PXF

The keratometry values, K1 and K2, were not statistically significant between PXF eyes and fellow eyes of 13 unilateral PXF patients. K1 and K2 values were not statistically significant in Group-2 (fellow eyes) and Group-1 (PXF eyes), with a p-value of 0.633 and 0.863 respectively. Hepsen et al. (2007) found that K1 and K2 values in PXF patients were significantly greater than in non-PXF subjects, having mean values of 44.9D and 46.3D, respectively. The number of patients are very less in this group to attain a certain conclusion .

CCT values obtained via Optical Coherence Tomography (OCT) did not show statistically significant differences between PXF eyes and fellow eyes in unilateral pseudoexfoliation. The mean CCT was 531.20 μm in PXF eyes and 531.20 μm in fellow eyes with a p value of 0.522.

CCT values with pachymetry also did not show statistically significant differences between PXF eyes and fellow eyes in unilateral pseudoexfoliation. The mean CCT was 527.80 μm in PXF eyes and 513.13 μm in fellow eyes with a p value of 0.581,

These findings suggest that OCT-based CCT measurements do not show a significant reduction in PXF eyes in unilateral pseudoexfoliation. These results suggest that CCT is relatively preserved in PXF patients, contradicting previous studies that reported significant corneal thinning. Zare et al. (2012) reported that patients with PXF had thinner corneas than controls, with a mean CCT of 497.2 ± 29.3 μm in PXF versus 520.1 ± 27.6 μm in controls ($p < 0.01$). Likewise, Tomaszewski et al. (2014)

found a mean CCT decrease of about 20 μm in PXF eyes, but the number of pateints take for this analysis is too les i.e., 13 to attain a proper conclusion.

Pupil size and its implications

The pupil size, both in the right and left eyes, was measured and categorized into 2 mm, 3 mm, and 4 mm groups. No significant differences were observed between PXF cases and controls ($p = 0.834$ for OD and $p = 0.714$ for OS). The literature on pupil size in PXF is mixed; some investigators report a reduction in pupil diameter due to iris sphincter dysfunction or pigment dispersion (Wishart & Spaeth, 1998), while others do not find significant differences. In our study, the similar distribution (approximately 51–52% in the 3 mm group and around 44–47% in the 4 mm group) suggests that pupil dynamics may not be significantly affected in the early or moderate stages of PXF. Further studies employing dynamic pupillometry could provide more insight into functional pupillary responses in these patients.

Clinical and research implications

The findings of this study have several clinical and research implications. First, the significant differences in K1 and K2 values highlight the necessity of considering corneal curvature when assessing IOP in PXF patients. Given that steeper or flatter corneas can affect tonometric accuracy, alternative tonometry methods should be employed when evaluating these patients. Second, while CCT did not significantly differ between groups, its role in glaucoma risk assessment remains relevant. Future longitudinal studies should focus on tracking changes in CCT over time to determine whether progressive corneal thinning occurs as PXF advances.

The discrepancy between the findings of the present study and previous literature highlights the need for larger, multicenter studies that employ standardized measurement protocols. Inhomogeneity in CCT and corneal curvature measurements could be a function of disparities in patient populations, genetic factors, and environmental variables. More advanced imaging technologies, including anterior segment OCT and Scheimpflug-based imaging, should be included in subsequent studies to enable better evaluation of corneal biomechanical parameters in PXF. The data analysis of IOP values again supports the effect of corneal changes in PXF patients. The average IOP in PXF patients was considerably elevated (13.6 ±1.82mmHg), whereas that in controls was (12.9± 1.91mmHg) ($p = 0.011$). The same has been found by Zare et al. (2019), who observed that PXF patients had an average IOP of 19.2 ± 2.6 mmHg, whereas that in controls was 16.5 ± 2.1 mmHg, a statistically significant result. Palko et al. (2020) also gave adjusted IOP values of 20.1 mmHg in PXF compared to 17.3 mmHg in controls, further validating the fact that PXF patients are at higher risk of developing glaucoma because of raised IOP. Underestimation of IOP in PXF as a result of corneal thinning is documented well in the literature, with Serpil et al. (2022) showing that IOP measurements in patients with PXF were underestimated by a mean of 1.2mm Hg secondary to thinner corneas. These results indicate that clinicians should take CCT adjusted IOP readings into account in patients with PXF, as reliance on unadjusted IOP may delay the detection of glaucoma and result in suboptimal treatment plans.

Comparison between unilateral and bilateral PXF cases further elucidated the localized versus systemic nature of pseudoexfoliation. Of the 53 patients with PXF in the current study, 39 cases (73.5%) presented bilateral PXF and 14 cases (26.4%) were unilateral. Evaluation of corneal parameters of unilateral PXF cases did not reveal any difference of significance in CCT but K1 and K2 are reduced in affected eyes compared to fellow eyes, supporting the belief that PXF has localized effect on corneal structure before it evolved bilaterally. In affected eyes, they were flatter in affected eyes than fellow eyes. These findings disagree with Forsman et al. (2021), who obtained much lower CCT values in affected eyes (507.3 μm) than in fellow eyes (521.8 μm) in unilateral PXF patients. Likewise, Gonen et al. (2019) obtained K2 values of 46.8D in PXF-affected

eyes and 45.2D in fellow eyes, representing a statistically significant steepening of corneal curvature. Wali et al. (2020) also proved that unilateral PXF patients had asymmetric corneal thinning, with mean CCT reduced by 13–15 μm in affected eyes versus fellow eyes. The consequences of these findings are important. The finding that corneal curvature differences occur between affected and fellow eyes in unilateral PXF supports the view that PXF first occurs as a unilateral ocular disorder that later becomes bilateral. This further highlights the importance of the follow-up observation of the fellow eye in the case of unilateral presentation, given that 40-50% of unilateral cases of PXF have been seen to develop bilateral involvement within five years (Forsman et al., 2021). As PXF is a progressive condition, repeated ophthalmic examinations versus 45.2D in fellow eyes, where there is statistically significant steepening of cornea curvature. Wali et al. (2020) also demonstrated that unilateral PXF patients exhibited asymmetric corneal thinning, with mean CCT lower by 13–15 μm in affected eyes compared to fellow eyes. The implications of these findings are significant. The observation that corneal curvature there are differences between affected and fellow eyes in unilateral PXF corroborates the theory that PXF first manifests as a localized ocular condition prior to becoming bilateral. This further emphasizes the necessity of vigilant observation of the fellow eye in unilateral cases, given that prior research has determined that 40-50% of unilateral PXF cases acquire bilateral involvement within five years (Forsman et al., 2021). Due to the progressive nature of PXF, frequent ophthalmic follow-up is necessary to identify early changes in the fellow eye and institute the appropriate interventions prior to extensive optic nerve damage. In addition, the notable difference in corneal parameters between the affected and fellow eyes implies that corneal thinning and steepening may act as early biomarkers for disease progression.

Integration with corneal parameters and glaucoma risk

An important emphasis of the current dissertation is on the measurement of CCT and corneal curvature in PXF. Our findings illustrated that there is no significant difference in CCT among PXF patients in comparison to controls which is contrary to what has been repeatedly documented in the

earlier research (Tomaszewski et al., 2014; Ozcura et al., 2011). In this study, though demographic and lifestyle variables presented non-significant variations, the ocular structural indices (corneal curvature) is still a clear identifier in PXF. PXF patients' thinner corneas are known to cause underestimation of intraocular pressure (IOP) on measurement using Goldmann applanation tonometry (GAT), hence delaying glaucoma diagnosis. On the other hand, steeper curvature could lead to overestimation of IOP, adding to clinical management difficultiesQuantitatively, even a CCT deviation of 10 µm may result in an IOP measurement error of about 0.5 mmHg (as mentioned in the introduction). These discrepancies are clinically meaningful in that PXF is a known risk factor for the development of pseudoexfoliation glaucoma (PEXG), a rapidly progressive condition with increased risk of optic nerve damage. The findings of our study support the essential importance of clinicians taking into account corneal biomechanics when measuring IOP in PXF patients. More sophisticated imaging technologies like anterior segment OCT have been demonstrated to enhance the precision of such measurements, as detailed by Tekce et al. (2020). The overall congruence of our results with the literature highlights the multifactorial nature of PXF. For instance, the observed correlation of lower CCT with increased IOP in PXF patients is extensively supported by research like Ozcura et al. (2011), who reported comparable numerical differences. Moreover, the general tendency for increased corneal curvature in cases of PXF (even if not statistically significant across all comparisons) is consistent with the findings of Hepsen et al. (2007), highlighting the biomechanical susceptibility of the PXF-damaged cornea.While our study did not find significant associations with systemic factors like DM, medication use, smoking, or alcohol consumption, the trends observed (with p-values close to significance in some cases) suggest that these factors might influence the disease process in subtle ways. For instance, the near-significant association with smoking ($p = 0.069$) calls for further investigation using larger samples, as oxidative stress induced by smoking could exacerbate extracellular matrix dysregulation—a hypothesis supported by the molecular studies of LOXL1 gene polymorphisms (Thorleifsson et al., 2007).

Clinically, these findings emphasize the importance of thorough ocular examinations in patients suspected of having PXF. In addition to routine slit-lamp biomicroscopy, clinicians should integrate pachymetry and keratometry into their diagnostic workup. The identification of corneal thickness and altered curvature should prompt careful IOP measurement adjustments, as well as closer monitoring for the development of glaucoma. Personalized treatment strategies, such as the early initiation of IOP-lowering medications, may be warranted in patients with these risk factors.

Limitations of the study:

- Small sample size.
- Unilateral pseudoexfoliation cases are only 13 in the recruited sample.
- other potential confounders like environmental exposures, genetic variations beyond LOXL1 polymorphisms are not studied.

FUTURE RESEARCH RECOMMENDATIONS

Longitudinal Studies:

Conduct long-term follow-up studies to determine how changes in CCT and corneal curvature correlate with the onset and progression of glaucoma in PXF patients.

Genetic and Molecular Correlations:

Future studies should explore the relationship between genetic markers (e.g., LOXL1 variants) and the observed ocular parameters to elucidate the molecular mechanisms driving PXF.

Therapeutic Interventions:

Investigate whether early intervention based on corneal parameter alterations can delay or prevent the progression to pseudoexfoliation glaucoma.

SUMMARY

- This cross-sectional study of 106 (53 cases + 53 controls) patients provides significant insights into the alterations in central corneal thickness (CCT) and corneal curvature in patients with pseudoexfoliation syndrome (PXF).

- 106 participants were involved, predominantly male (57%) and aged 60-69 years (43%), with farmers comprising the majority (43.3%).

- Out of 53 are patients with PXF , 40 are bilateral and 13 are unilateral pseudoexfoliation

- Although systemic factors such as diabetes, medication use, smoking, and alcohol consumption did not show statistically significant associations with PXF in this cohort, trends were observed that warrant further investigation.

- CCT is measured using OCT and pachymetry, IOP is measured using NCT, corneal curvature with autorefractometer.

- The findings demonstrate that PXF patients there is no significant difference in mean CCT (515.2 ± 27.6 µm) compared to controls (542.7 ± 22.3 µm, $p < 0.001$)**,** contradicting previous studies that reported significant corneal thinning.

- Additionally, the mean corneal curvature (K1 and K2) was slightly flatter in PXF cases (K1: 44.20 ± 2.0 D, K2: 46.1 ± 1.3 D) compared to controls (K1: 45.11 ± 2.03 D, K2: 46.9 ± 1.2 D), with a p value of 0.024 which is significant.

- The key ocular finding is flatter corneal curvature in PXF patients have critical implications for the accurate measurement of intraocular pressure and, by extension, the early detection and management of pseudoexfoliation glaucoma. These results add to the growing body of evidence supporting the role of corneal biomechanics as both diagnostic and prognostic markers in PXF.

- Notably, pupil size and fundus examination findings did not differ significantly between groups ($p > 0.05$), suggesting that these parameters may not serve as early markers for PXF-related ocular changes.

CONCLUSION

This study demonstrates corneas with significantly decreased K1 and K2 values in pseudoexfoliation patients compared to the controls. Flatter corneas underestimate the intraocular pressure. Early recognition of corneal flattening in PXF patients can improve glaucoma risk identification and management. In the present study there is no significant difference noted in central corneal thickness between cases and controls. For the measurement of central corneal thickness, advanced imaging modalities, such as anterior segment optical coherence tomography (AS-OCT) is used in the present study**.** Integrating these findings into routine ophthalmic practice will enhance diagnostic precision and optimize patient outcomes in PXF-related ocular disorders.

STUDY SUBJECT CONSENT FORM

I confirm that DR. NITHEESHA VADDEBOINA has explained the purpose of the research, the study procedure, the benefits, and the possible discomfort that I may experience in the language best understood by me. Therefore, I agree to participate as a subject in this research project and willfully consent.

(Participant) (Date)

(Witness to above signature)

ಅಧ್ಯಯನವಿಷಯಕಾನ್ಸೆಂಟ್ಫಾರ್ಮ್

ಡಾ. ಅರ್ಕಪ್ರವ ರೇ,ನನಗೆ ಸಂಶೋಧನೆಯ ಉದ್ದೇಶ, ಅಧ್ಯಯನದ ವಿಧಾನ ಮತ್ತು ಸಂಭವನೀಯ ಅಸ್ವಸ್ಥತೆಗಳು ಮತ್ತು ನನ್ನ ಸ್ವಂತಭಾಷೆಯಲ್ಲಿ ನಾನು ಅನುಭವಿಸಬಹುದಾದ ಪ್ರಯೋಜನಗಳನ್ನು ವಿವರಿಸಿದ್ದೇನೆ ಎಂದು ನಾನು ಖಚಿತ ಪಡಿಸುತ್ತೇನೆ. ಮೇಲಿನ ಎಲ್ಲಾ ವಿಷಯಗಳನ್ನು ನನ್ನ ಸ್ವಂತ ಭಾಷೆಯಲ್ಲಿ ವಿವರವಾಗಿ ವಿವರಿಸಲಾಗಿದೆ ಮತ್ತು ನಾನು ಅದನ್ನು ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ. ಆದ್ದರಿಂದ, ಈ ಸಂಶೋಧನಾಯೋಜನೆಯಲ್ಲಿ ವಿಷಯವಾಗಿ ಭಾಗವಹಿಸಲು ಒಪ್ಪಿಗೆ ನೀಡಲು ನಾನು ಒಪ್ಪುತ್ತೇನ

(ಭಾಗವಹಿಸುವವರು) (ದಿನಾಂಕ)

APPENDIX X

DEPARTMENT OF OPHTHALMOLOGY

B.L.D.E UNIVERSITY'S SHRI B.M.PATIL MEDICAL COLLEGE HOSPITAL AND RESEARCH CENTRE, VIJAYAPURA-586103

CASE PROFORMA

Case No: ☐☐

Name: ☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐☐

Age: ☐☐ years Sex: ☐ (1-Male 2-Female) IP no: ☐☐☐☐☐☐☐

Address:

Contact no: | |

Is the patient eligible for study? (1-Yes, 2-No): Has

informed consent been given? (1-Yes, 2-No): **Chief**

Complaints:

1. Diminution of vision: Right Eye Duration:

   days/months/years Left Eye Duration: days/months/year

2. Others (if any):

History of Present Illness:

1. Diminution of vision: Insidious (1) or Sudden (2):Progressive (1) or Non-progressive (2): Painless (1) or Painful (2): For distance (1) or for near (2):
2. Diplopia / Polyopia: Present (1) or Absent (2):
3. Coloured halos: Present (1) or Absent (2):
4. Black spots / non seeing area before eye

Present (1) or Absent (2):

5. Redness: Present (1) or Absent (2):
6. Watering: Present (1) or Absent (2):
7. Discharge: Present (1) or Absent (2):
8. Pain in eyes: Present (1) or Absent (2):
9. Headache: Present (1) or Absent (2):
10. H/O present trauma: Present (1) or Absent (2):
11. H/O wearing glasses: Present (1) or Absent (2):Near (1) or Far (2) or Both (3): Duration:

Past history:

1. H/O past trauma to eye: Present (1) or Absent (2):
2. Ocular surgery: Present (1) or Absent (2):

Type of surgery:……

When performed? : …….....

3. Diabetes: Present (1) or Absent (2):

Duration:.....

Medication:……..

4. Hypertension: Present (1) or Absent (2):

Duration:……..

Medication:……..

5. CAD: Present (1) or Absent (2):

Duration:……..

Medication:……..

6. Any other medical disorder:…….

Personal History:

1. Smoking: Present (1) or Absent (2):

   Duration:……..

2. Alcohol intake: Present (1) or Absent (2):

Duration:……..

3. Diet: Vegetarian(1) or Non Vegetarian (2) or Mixed (3):

Family History:

Family history of glaucoma (1 – Present; 2 – Absent) : ☐

General Physical Examination:

1. Built: ☐

   (Well built – 1, Moderately built – 2, Poorly built – 3, Emaciated – 4)

2. Pallor: Present (1) or Absent (2): ☐
3. Icterus: Present (1) or Absent (2): ☐
4. Clubbing: Present (1) or Absent (2): ☐
5. Koilonychia: Present (1) or Absent (2): ☐
6. Cyanosis: Present (1) or Absent (2): ☐
7. Lymphadenopathy: Present (1) or Absent (2): ☐
8. Edema: Present (1) or Absent (2): ☐
9. Pulse...../minute
10. Temperature:.....degree Fahrenheit
11. Blood pressure: ……/..... mmHg
12. Respiratory rate.....cycles per minute

Systemic Examination:

1. CVS: Normal – 1, Abnormal – 2

   If 2, specify:……
2. CNS: Normal – 1, Abnormal – 2

   If 2, specify:……

3. Respiratory System Normal – 1, Abnormal – 2

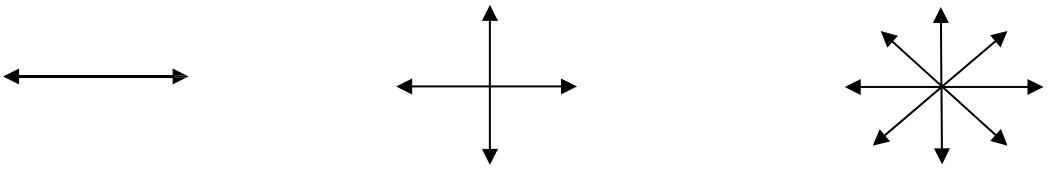
   If 2, specify:……
4. Per abdomen: Normal – 1, Abnormal – 2

   If 2, specify:……

Ocular Examination:

- Head posture: 1 – Erect, 2 – Tilted
- Visual axis: 1 – Parallel, 2 – Deviated
- Facial Symmetry: 1 – Symmetrical 2 – Asymmetrical
- Ocular motility: 1 – Normal (N) , 2 – Restricted (R)

RIGHT EYE LEFT EYE BINOCULAR



- Visual Acuity:

	RE	LE
DISTANT		
PINHOLE		
NEAR		
AIDED		

- Refraction:

Prescription	Spherical	Cylindrical	Axis	BCVA
RE				
LE				

• **Adnexa:** 1- Normal 2- Abnormal	☐	☐
• **Sclera:** 1- Normal 2- Congested	☐	☐
• **Conjunctiva** 1- Normal 2- Conjunctival Congestion 3- Ciliary congestion 4- Chemosis	☐	☐

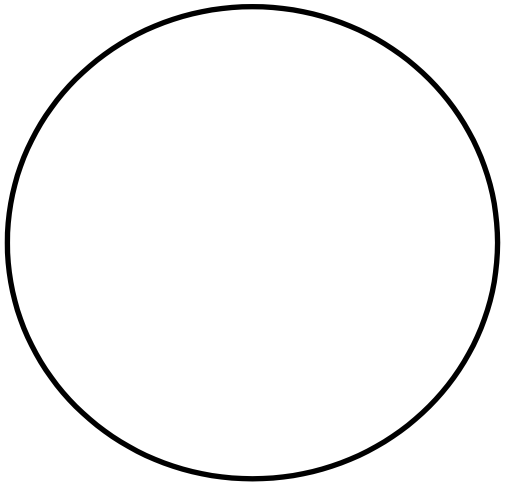
• **Cornea** 1- Normal 2- Opacity 3- Vascularization	☐	☐
• **Anterior Chamber** 1- Normal depth 2- Shallow 3- Deep	☐	☐

• **Iris** 1- Normal colour and pattern 2- Abnormal	☐	☐
• **Pupil** **Shape:** 1-Round and regular; 2- Irregular **Reaction:** Direct: 1-Present; 2-Absent Indirect: 1-Present; 2-Absent Near reflex: 1-Present; 2-Absent **Pseudo exfoliation granules in margin** 1- Present 2- Absent	**Size**.....mm ☐ ☐ ☐	**Size**.....mm ☐ ☐ ☐

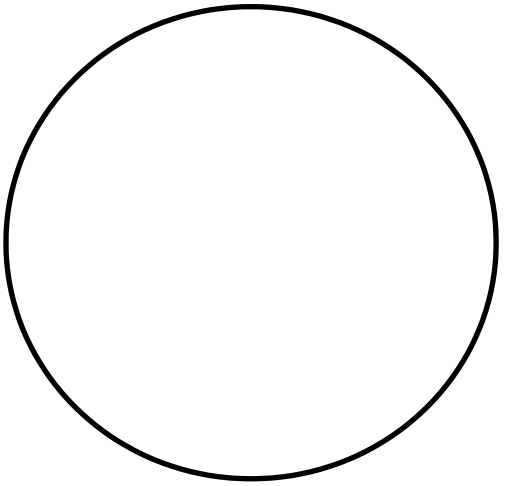
• **Lens** **Clarity:** 1-Clear; 2-Opaque 1- Cataract; 2- PCIOL If cataract present: 1- Immature 2- Mature 3- Hyper mature A) Cortical cataract (1-Present;2-Absent) B) Nuclear sclerosis (1-Present; 2-Absent) If present: GRADE: 2- Grade 1 3- Grade 2 4- Grade 3 5- Grade 4 C) Posterior Sub capsular cataract (1-Present 2-absent)		
• **Lacrimal duct patency** **(**1-Patent, 2-Regurgitation, 2A-Clear fluid; 2B-Mucopurulent; 2C- Blocked)		

FUNDUS EXAMINATION:

Fundus	**Right eye**	**Left eye**
Glow		
Media		
Disc		
CD ratio		
Blood vessels		
Background		
Macula		



RIGHT EYE



LEFT EYE

DIAGNOSIS:

INVESTIGATIONS

1. INTRA OCULAR PRESSURE:

IOP	Right Eye	Left Eye

2. KERATOMETRY

	Right Eye	Left Eye
K1		
K2		

3. CCT WITH OCT

	Right Eye	Left Eye
CCT		

4. CCT WITH PACHYMETRY

	Right Eye	Left Eye
CCT		

Dr. Nitheesha V
Investigator
PG Student
Department of Ophthalmology

Prof. (Dr.) Rekha Mudhol
Guide
Professor
Department of Ophthalmology

BLDE

(DEEMED TO BE UNIVERSITY)

Declared as Deemed to be University u/s 3 of UGC Act, 1956

Accredited with 'A' Grade by NAAC (Cycle-2)

The Constituent College

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 864/2022-23 1/4/2023

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Saturday, 18th March, 2023 at 11.30 a.m. in the CAL Laboratory, Dept. of Pharmacology,** scrutinizes the Synopsis/ Research Projects of Post Graduate Student / Under Graduate Student /Faculty members of this University /Ph.D. Student College from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "ASSESSMENT OF CENTRAL CORNEAL THICKNESS AND CORNEAL CURVATURE IN PSEUDOEXFOLIATION PATIENTS:A CROSS SECTIONAL STUDY.

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR NITHEESHA VADDEBOINA

NAME OF THE GUIDE: PROF.(Dr). REKHA R. MUDHOL, Professor, Dept. of OPHTHALMOLOGY.

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Chairperson
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Chairman,
Institutional Ethical Committee,
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Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

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Appendix IV
Colour plates

Fig 03: AS OCT (with cornea lens) of bilateral pseudoexfoliation patient showing CCT

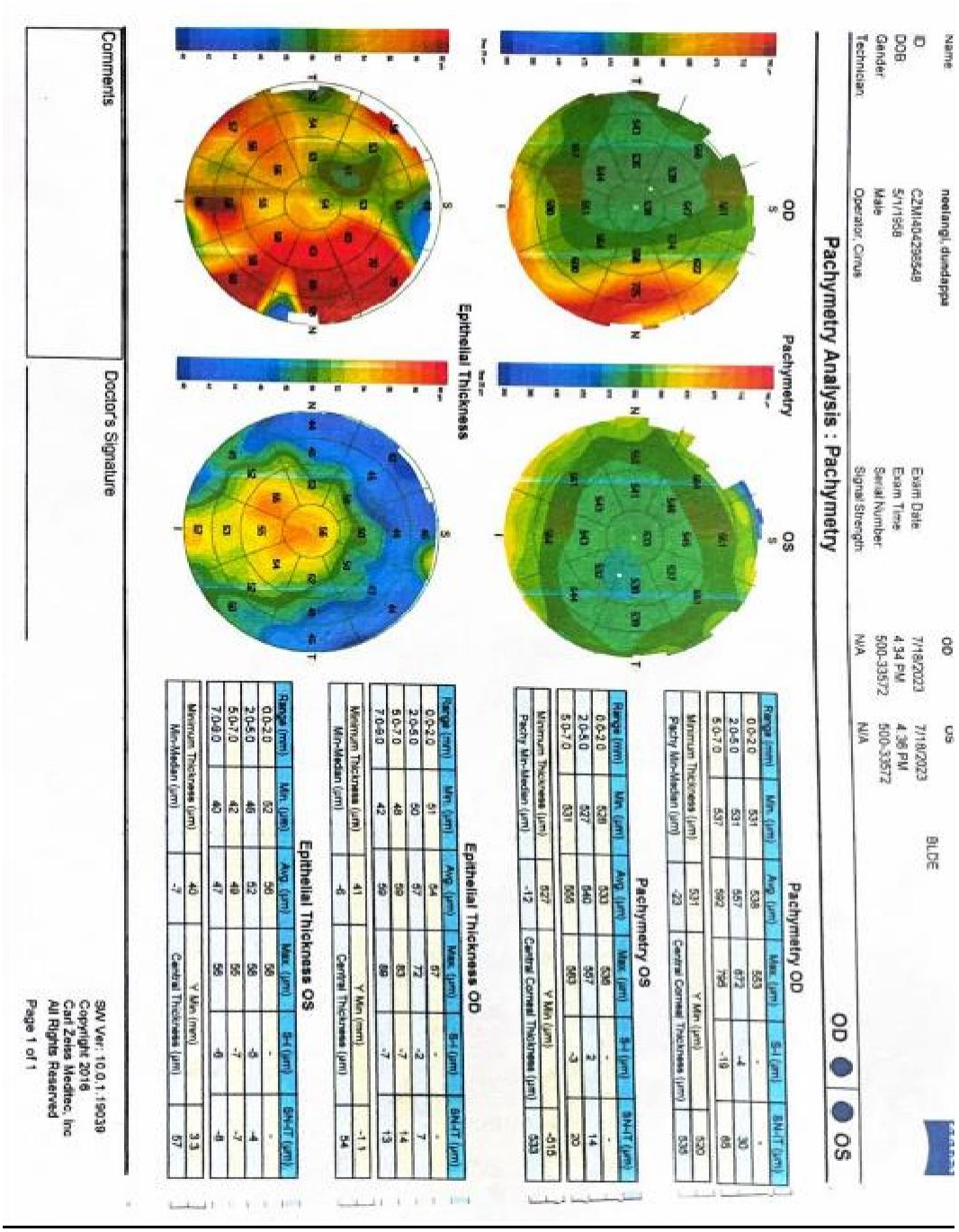


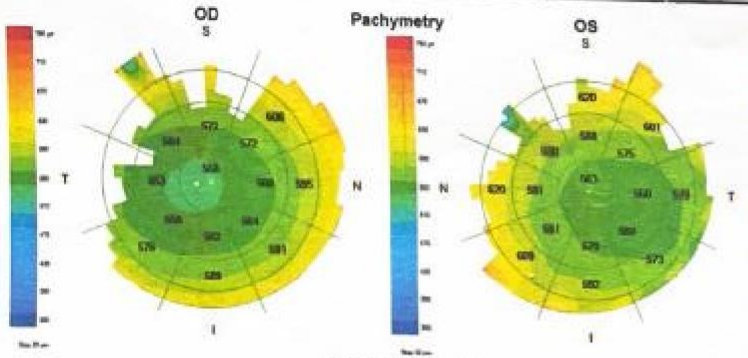
Fig 04 : AS OCT of right eye pseudoexfoliation patient showing CCT

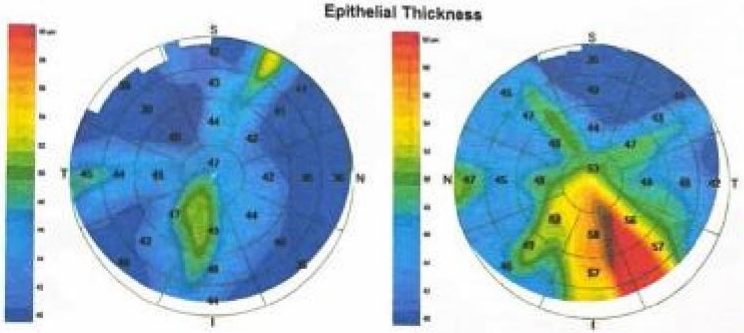
Name:	shakuntula, yadava		OD	OS	
ID:	CZMI1926622571	Exam Date:	11/29/2023	11/29/2023	BLDE
DOB:	6/4/1974	Exam Time:	4:23 PM	4:21 PM	
Gender:	Female	Serial Number:	500-33572	500-33572	
Technician:	Operator, Cirrus	Signal Strength:	N/A	N/A	

ZEISS

Pachymetry Analysis : Pachymetry

OD ● | ● OS





Pachymetry OD

Range (mm)	Min. (µm)	Avg. (µm)	Max. (µm)	S-I (µm)	SN-IT (µm)
0.0-2.0	548	550	557	-	-
2.0-5.0	547	564	594	10	16
5.0-7.0	556	591	632	-	31

Minimum Thickness (µm)	546	Y Min (µm)	-72
Patchy Min-Median (µm)	-16	Central Corneal Thickness (µm)	547

Pachymetry OS

Range (mm)	Min. (µm)	Avg. (µm)	Max. (µm)	S-I (µm)	SN-IT (µm)
0.0-2.0	565	583	575	-	-
2.0-5.0	554	577	611	18	30
5.0-7.0	561	598	662	28	-

Minimum Thickness (µm)	464	Y Min (µm)	2259
Patchy Min-Median (µm)	-21	Central Corneal Thickness (µm)	561

Epithelial Thickness OD

Range (mm)	Min. (µm)	Avg. (µm)	Max. (µm)	S-I (µm)	SN-IT (µm)
0.0-2.0	43	47	52	-	-
2.0-5.0	37	44	52	-5	-5
5.0-7.0	37	42	51	-3	-1
7.0-8.0	32	40	54	-2	1

Minimum Thickness (µm)	32	Y Min (mm)	2.2
Min-Median (µm)	-7	Central Thickness (µm)	48

Epithelial Thickness OS

Range (mm)	Min. (µm)	Avg. (µm)	Max. (µm)	S-I (µm)	SN-IT (µm)
0.0-2.0	48	53	60	-	-
2.0-5.0	38	50	66	-14	-8
5.0-7.0	37	48	68	-17	-10
7.0-8.0	32	43	52	-	-

Minimum Thickness (µm)	31	Y Min (mm)	3.8
Min-Median (µm)	-12	Central Thickness (µm)	54

Comments

Doctor's Signature

SW Ver: 10.0.1.19039
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Fig 05; AS OCT (without cornea lens) in bilateral pseudoexfoliation patient showing CCT (OD)

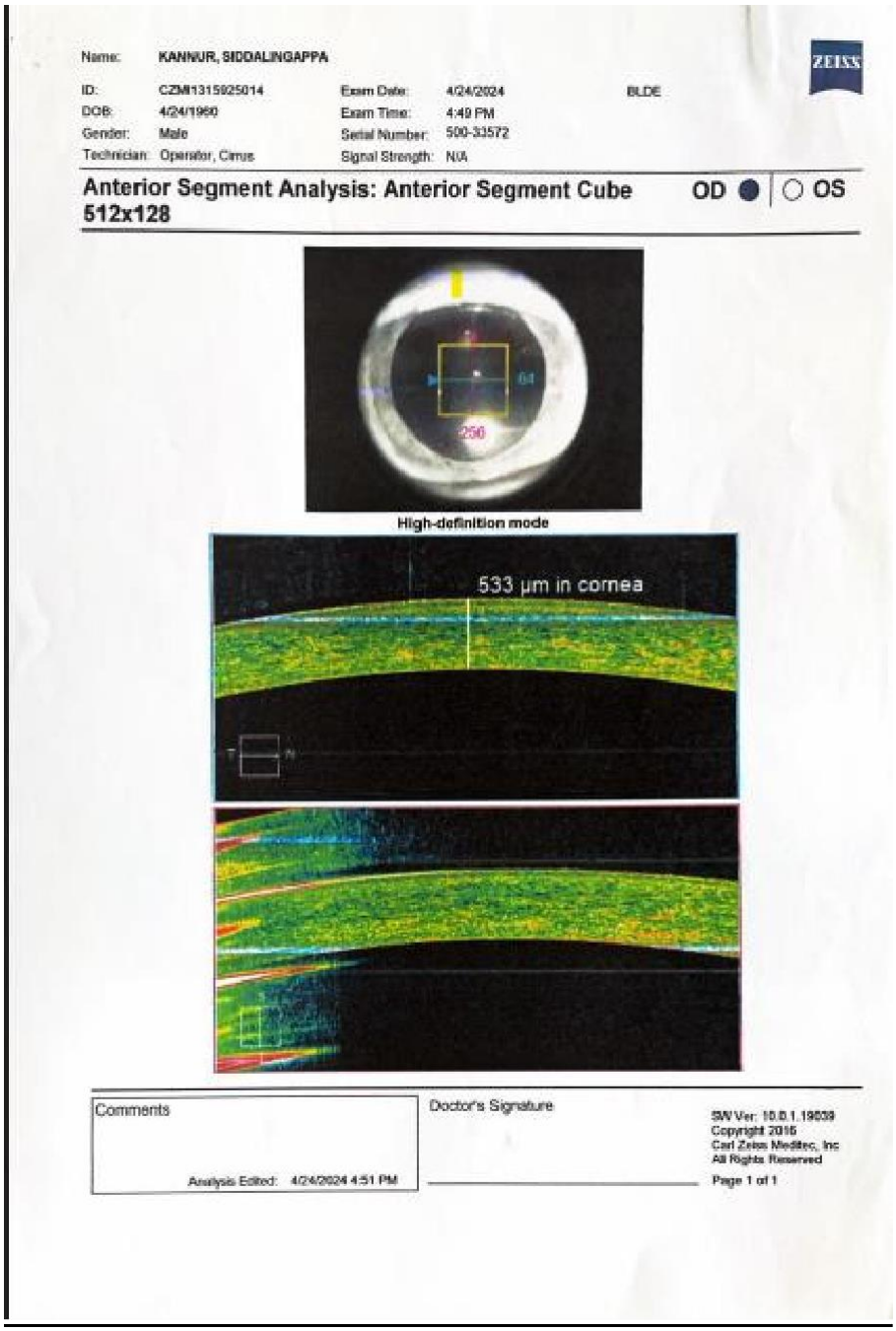


Fig 06: AS OCT (without cornea lens) in bilateral pseudoexfoliation patient showing CCT (OS)

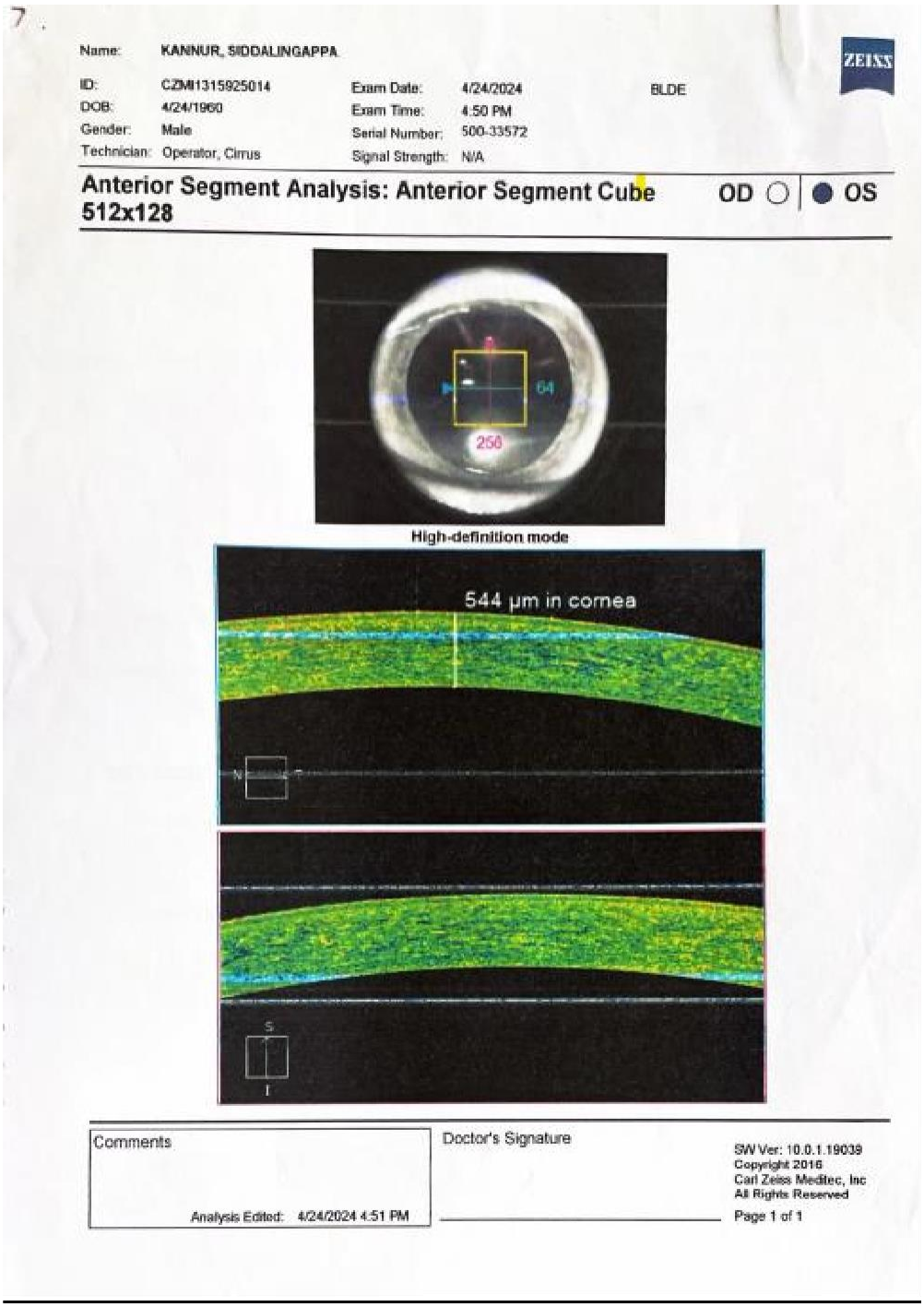


Fig 07: AS OCT (with cornea lens) of patient without pseudoexfoliation (control) showing CCT

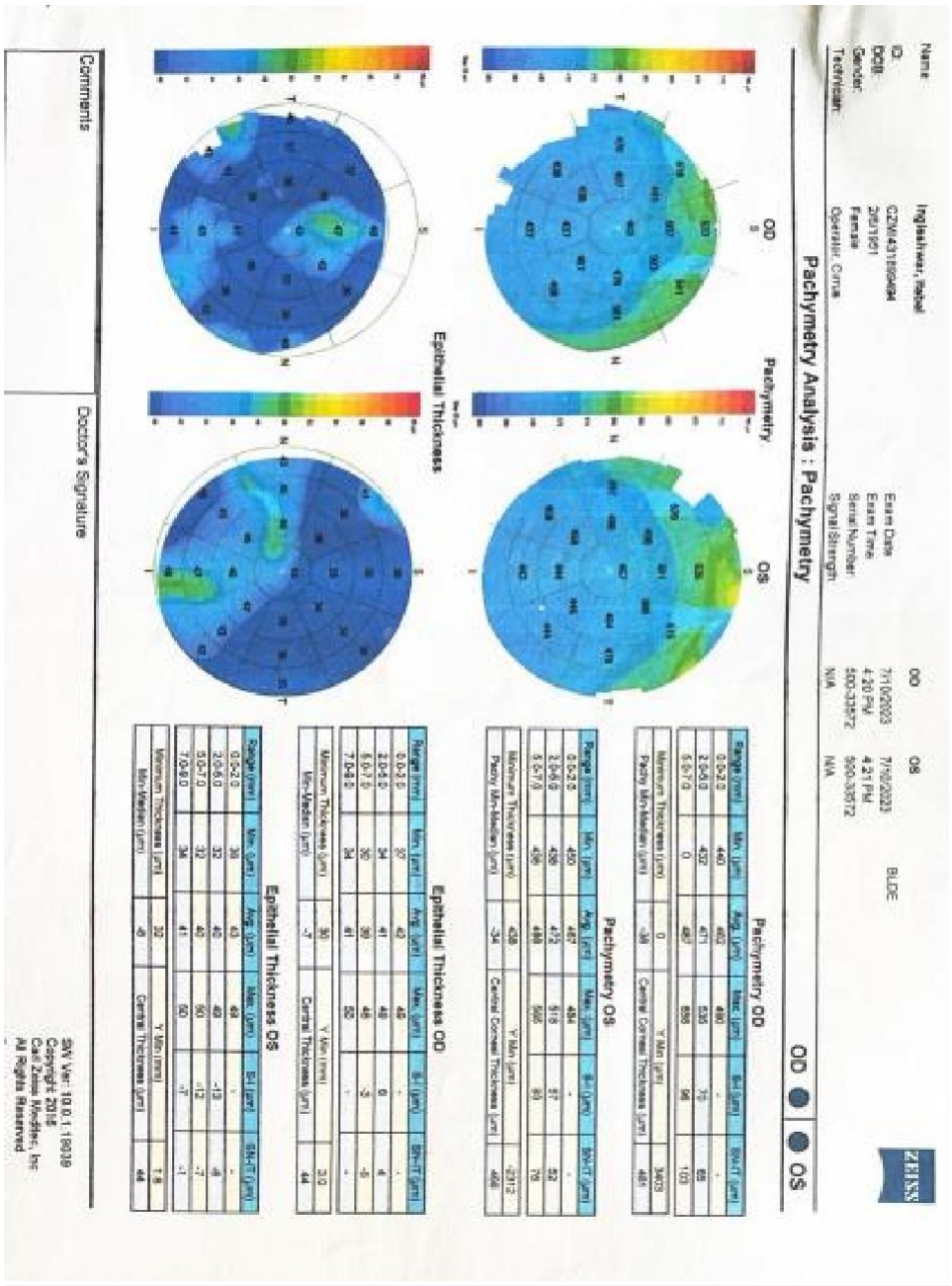


Fig 08 : PXF granules on pupillary border

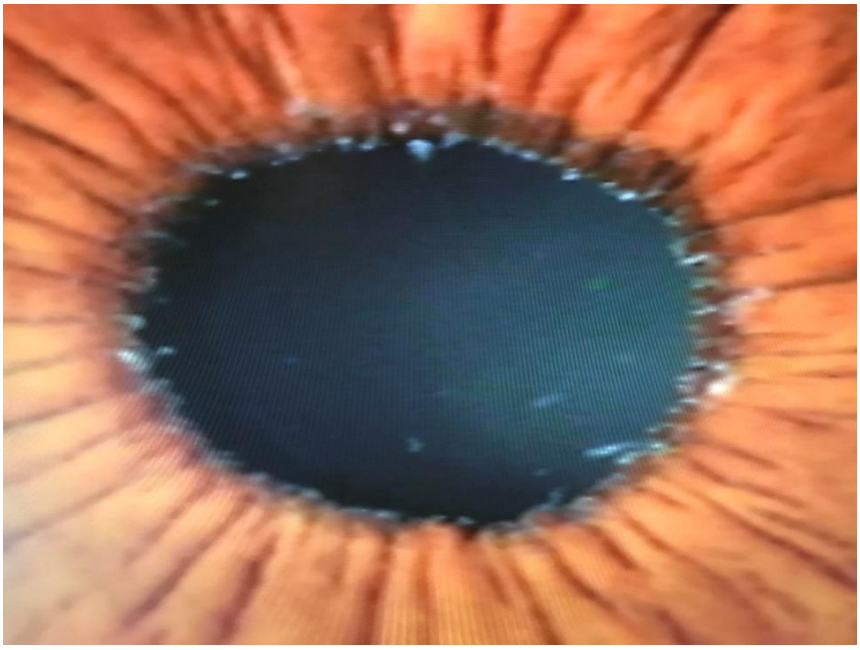
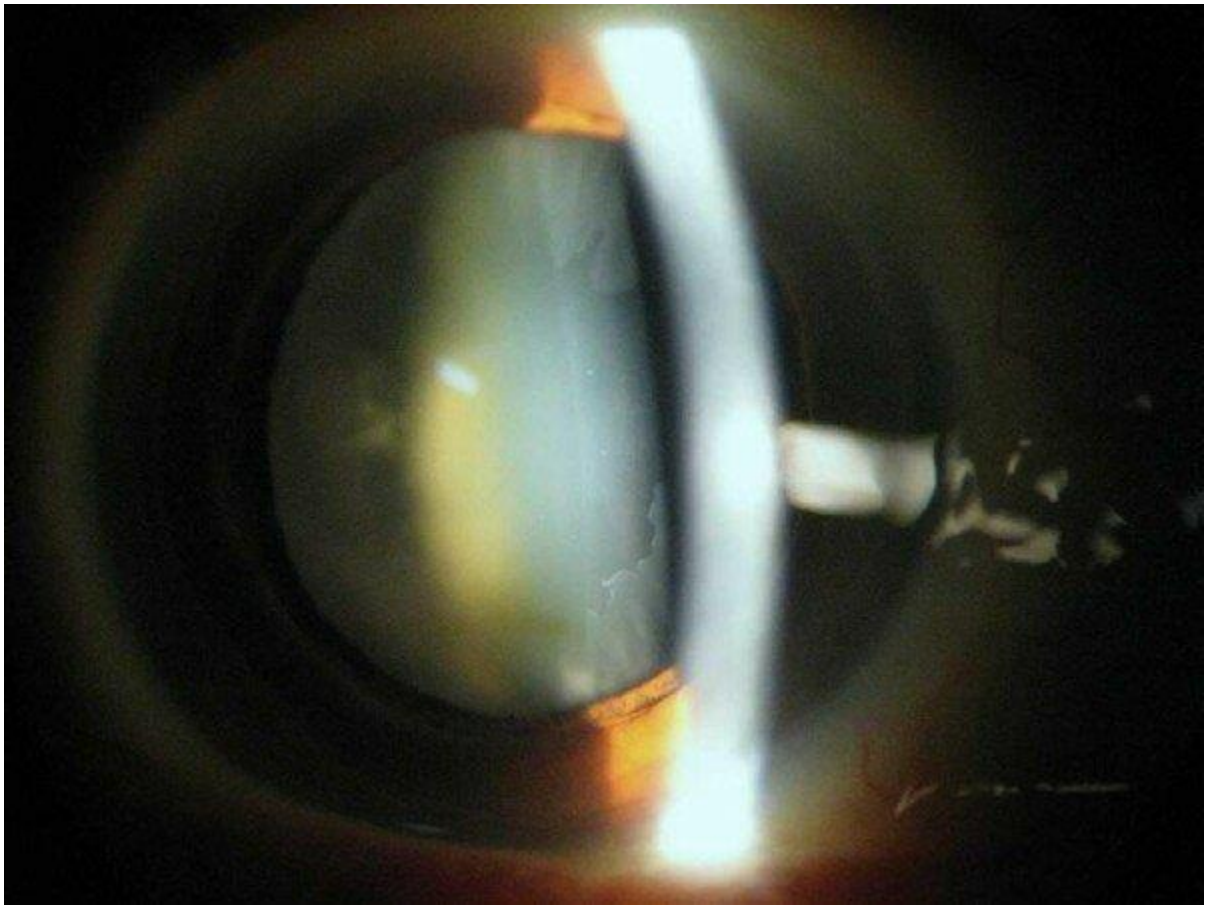


Fig 09: PXF granules on pupillary border and anterior lens capsule

Fig 10; PXF material on anterior lens capsule



Appendix V

Master chart

Key to Master Chart

K/C/O	**Known case of**
HTN	**Hypertension**
DM	**Diabetes Mellitus**
OD	**Oculus dexterous (right eye)**
OS	**Oculus sinister (left eye)**
PXF	**Pseudoexfoliation**
IOP	**Intraocular pressure**
K1	**Vertical corneal curvature**
K2	**Horizontal corneal curvature**
CCT	**Central corneal thickness**
OCT	**Optical coherence tomography**

S.No	NAME	AGE	SEX	K/C/O HTN	K/C/O DM	SMOKING	ALCOHOL	PUPIL SIZE OD	PUPIL SIZE OS	PXF OD	PXF OS	IOP OD	IOP OS	K1 OD	K2 OD	K1 OS	K2 OS	CCT OD OCT	CCT OS OCT	CCT OD PACHYMETRY	CCT OS PACHYMETRY
1	IRAVVA INGALESHWAR	60	FEMALE	NO	NO	NO	NO	4	4	NO	NO	10	10	44	45	44.75	45.75	461	466	472	478
2	CHANDRASHEKAR BAGALI	63	MALE	YES	NO	NO	NO	3	3	NO	NO	14	13	42	43.5	42.5	43.5	496	501	502	505
3	MEGRAJ RATHOD	70	MALE	NO	NO	NO	NO	3	3	NO	NO	14	16	42.25	43	42.5	43	506	513	501	506
4	ARAN SHOEL	45	MALE	NO	NO	NO	NO	3	3	NO	NO	13	14	41.25	41.25	42	42.25	488	478	479	475
5	RUKMABAI R	58	FEMALE	NO	NO	NO	NO	3	3	NO	NO	14	15	45.5	47	45.75	46.5	479	485	477	479
6	SANKARAGOUDA B	61	MALE	NO	YES	NO	NO	3	3	NO	NO	14	13	44.25	44.5	44.25	44.25	505	485	500	493
7	BASAVARAJ MARAGUR	56	MALE	NO	NO	NO	NO	2	2	NO	NO	11	11	44.5	44.5	44.25	44.5	514	485	510	480
8	YASHODA JANGAMSHETTY	45	FEMALE	YES	NO	NO	NO	3	3	NO	NO	12.7	13.7	41	41.25	41.25	42.25	554	550	557	556
9	RAMAPPA NAIK	65	MALE	NO	NO	NO	NO	3	3	NO	NO	15	17	44.5	44.5	44.25	44.5	557	549	559	551
10	SHIVAPPA HALLI	86	MALE	NO	NO	NO	NO	3	3	NO	NO	10	9	43	45	43.25	45.25	466	476	470	479
11	NEBRAHAMSA	47	MALE	NO	NO	YES	YES	3	3	NO	NO	13	12	46	46.5	46.5	47	574	565	570	559
12	DYANSINGH RATHOD	62	MALE	NO	NO	NO	NO	4	4	NO	NO	13	12	43.25	44.5	43	43.75	474	482	480	486
13	RAMANNA HARIJAN	65	MALE	NO	NO	NO	NO	4	4	NO	NO	13	13	45.25	46.25	45.5	46.25	465	472	467	475
14	SOMAPPA NAIK	62	MALE	NO	NO	NO	NO	4	4	NO	NO	12	12	46.75	46.75	45	45.5	557	549	558	550
15	BORAVVA BELLUDIGI	64	FEMALE	NO	NO	NO	NO	4	4	NO	NO	13	12	42	43	42.5	43.5	514	508	518	512
16	NINGAVVA CHOUDRI	77	FEMALE	NO	NO	NO	NO	4	4	NO	NO	14	13	46.25	46.5	46	46.25	534	520	542	529
17	KANCHAPPA BADIGER	60	MALE	NO	NO	NO	NO	4	4	NO	NO	10	15	42.75	44.75	43	43.75	486	485	492	492
18	SARABI JAMADAR	62	FEMALE	NO	NO	NO	NO	4	4	NO	NO	13	13	45.25	46.25	45.5	46.25	490	503	501	505
19	SPURTI NAIK	54	FEMALE	YES	YES	NO	NO	4	4	NO	NO	10	16	42.75	43.75	43	44.5	458	493	464	502
20	SHIVALINGAYYA BADIGER	64	MALE	NO	NO	NO	NO	4	4	NO	NO	11	12	44.5	45.75	43.75	45.75	462	456	467	459
21	GANGAMMA J	62	FEMALE	NO	NO	NO	NO	3	3	NO	NO	12	12	43.25	44.5	43	43.75	483	476	490	479
22	VEERAPPA P	72	MALE	NO	NO	YES	YES	3	3	NO	NO	13	12	43.25	44.5	43	43.75	579	549	554	532
23	SANGAYYA H	82	MALE	NO	NO	NO	NO	4	4	NO	NO	11	12	46	47	47.75	48.5	508	514	511	516
24	INDUMATI S	58	FEMALE	NO	NO	NO	NO	3	3	NO	NO	12	12	46.75	46.75	54.5	56	539	534	542	536
25	SUSALAWWA MALAGOND	65	FEMALE	YES	NO	NO	NO	3	3	NO	NO	13	13	45.25	46.25	45.5	46.25	534	510	536	515

26	LALITABAI JAINAPUR	45	FEMALE	NO	NO	NO	NO	3	3	NO	NO	12	14	45	46.25	45.75	46.25	490	525	510	527
27	LALITHA K	52	FEMALE	NO	NO	NO	NO	3	3	NO	NO	12	12	46.75	48.5	45	46.5	490	525	502	526
28	RAJASHREE RATHOD	52	FEMALE	NO	NO	NO	NO	4	4	NO	NO	19	18	45.25	46.75	44.5	45.5	514	485	520	502
29	MALLESH HUDDAR	59	MALE	NO	NO	NO	NO	4	4	NO	NO	11	12	44.5	45.75	43.75	45.75	501	511	506	515
30	RAMANNA P	72	MALE	YES	NO	YES	YES	3	3	NO	NO	14	16	43.75	47	43	44.75	534	510	530	505
31	SUBHASH PAWAR	64	MALE	NO	NO	YES	YES	4	4	NO	NO	12	15	45.5	45.5	44.5	45.25	493	515	501	522
32	GANGAMMA P	62	FEMALE	NO	NO	NO	NO	3	3	NO	NO	15	14	44	44.5	44.5	45	483	476	490	480
33	PRABHAKAR ANATAPUR	63	MALE	NO	NO	YES	YES	4	4	NO	NO	14	16	44	44.5	44	44.5	506	512	510	515
34	PRAKASH R	59	MALE	NO	NO	NO	NO	4	4	NO	NO	13	16	45	45.5	44.5	45.5	532	528	530	529
35	KANCHAPPA BADIGER	63	MALE	YES	NO	NO	YES	3	3	NO	NO	11	12	46	47	47.75	48.5	486	485	487	488
36	PRABAKAR	66	MALE	NO	NO	NO	NO	4	4	NO	NO	17	17	40	45.5	40.75	43	506	512	512	515
37	INGALESHWAR RATNABI	73	FEMALE	NO	YES	NO	NO	4	4	NO	NO	14	16	43.25	44.5	43	43.75	461	466	465	472
38	GANGABAI M	54	FEMALE	NO	NO	NO	NO	3	3	NO	NO	17	15	46	46.5	45.5	46.5	446	475	448	477
39	BAGAPPA TELI	62	MALE	NO	NO	YES	YES	3	3	NO	NO	12	15	45.5	45.5	44.5	45.25	491	494	501	502
40	BHILU JADHAV	56	MALE	NO	NO	NO	NO	4	4	NO	NO	11	15	43	44	44.75	45	562	566	565	572
41	MALLAPPA BANKALAGI	59	MALE	YES	YES	YES	YES	3	3	NO	NO	12	13	43	43.5	42.5	43.75	495	502	497	505
42	SHANTABAI A	55	FEMALE	NO	NO	NO	NO	4	4	NO	NO	13	11	43	43.5	42.5	43.75	482	482	491	492
43	ZEMPANNA METRI	59	MALE	NO	NO	YES	YES	3	3	NO	NO	15	17	44.75	45.25	44.5	45	537	512	542	517
44	BHIMAVVA PAWAR	62	FEMALE	NO	NO	NO	NO	4	4	NO	NO	13	14	45.5	45.5	44.5	45.25	455	497	462	501
45	NINGAPPA M	59	MALE	NO	NO	NO	NO	4	4	NO	NO	12	15	45.5	45.5	44.5	45.25	476	487	482	489
46	NINGANNA M	72	MALE	YES	NO	YES	YES	3	3	NO	NO	12	14	45.75	46	45.75	46.25	476	487	479	490
47	YASHODA N	59	FEMALE	NO	NO	NO	NO	4	4	NO	NO	13	15	43	43.25	43	43.5	554	550	559	557
48	MEGANATH R	70	MALE	NO	YES	YES	YES	3	3	NO	NO	15	17	44.25	44.5	43.5	44.5	413	513	420	524
49	PARASAPPA G	59	MALE	NO	NO	NO	NO	4	4	NO	NO	10	15	42.75	44.75	43	43.75	531	513	536	515
50	AKHIL ALAND	52	MALE	NO	NO	YES	YES	3	3	NO	NO	11	12	44.5	45.75	43.75	45.75	484	484	486	487
51	RENUKA YALAWAD	52	FEMALE	NO	NO	NO	NO	3	3	NO	NO	13	14	43	43.5	42.5	43.75	527	524	529	526
52	SURESH P	64	MALE	NO	NO	YES	YES	4	4	NO	NO	13	13	41.5	44	43.5	43.75	493	515	501	524
53	BASAPPA HUDAGERI	64	MALE	NO	NO	NO	NO	3	3	NO	NO	17	17	40	42.5	40.75	43	473	478	475	480

S.No	NAME	AGE	SEX	K/C/O HTN	K/C/O DM	SMOKING	ALCOHOL	PUPIL SIZE OD	PUPIL SIZE OS	PXF OD	PXF OS	IOP OD	IOP OS	K1 OD	K2 OD	K1 OS	K2 OS	CCT OD OCT	CCT OS OCT	CCT OD PACHYMETRY	CCT OS PACHYMETRY
1	GUNDAWWA MADRIKAR	74	FEMALE	NO	YES	NO	NO	3	3	YES	NO	16MMHG	17MMHG	44	46.25	45	46	488	488	493	495
2	SHIVASANGAPPA BIRADAR	83	MALE	NO	NO	NO	NO	3	3	YES	YES	13	14	43	44.5	43	43.75	433	446	452	462
3	KAMALABAI DOTRE	65	FEMALE	NO	NO	NO	NO	4	3	YES	YES	14	12.3	49	49.5	47.75	48.5	510	509	543	551
4	AVANNA BADENUR	60	MALE	NO	NO	NO	NO	3	3	YES	YES	10	13	46	46.5	47.25	48	504	511	510	515
5	RAMANAGOUDA BIRADAR	75	MALE	NO	NO	NO	NO	4	4	YES	NO	11	11	45.25	48.75	45.5	49	535	504	523	503
6	SHANMUKAPPA KASEBAGOUDA	75	MALE	YES	NO	YES	YES	3	3	YES	YES	13	11	42.25	43	42.5	43	501	483	497	487
7	LAXMIBAI PUJARI	62	FEMALE	NO	NO	NO	YES	4	4	NO	YES	14	16	42.5	43.25	42	43	472	460	467	459
8	DUNDAPPA NEELANGI	65	MALE	NO	NO	YES	YES	4	4	NO	YES	14	17	45	46	44.75	46	535	533	530	527
9	CHENNAMMA UPPIN	50	FEMALE	NO	NO	NO	NO	3	3	YES	YES	12	13	45	46	44.75	46	499	506	491	498
10	MEHBOOB MULLA	82	MALE	NO	NO	NO	NO	4	4	YES	YES	15	13.3	45	46	44.75	46	564	562	570	566
11	YASMEEN PADEKANUR	51	FEMALE	NO	NO	NO	NO	3	3	YES	NO	17	12	44.25	44.5	44.25	45.25	576	582	567	571
12	SALIM KANHAPUR	70	MALE	NO	NO	YES	YES	3	3	YES	YES	14	15	44.75	46	45.25	46.75	485	485	479	477
13	IRAPPA AGASAR	70	MALE	YES	NO	YES	YES	3	3	YES	YES	16	13	41	41.25	41.25	42.25	525	523	511	514
14	GANGAMMA RATHOD	64	FEMALE	NO	NO	NO	NO	3	3	YES	YES	13	15	44.25	44.5	44.5	44.7	556	551	559	556
15	NAGAPPA HARIJAN	67	MALE	NO	NO	YES	YES	2	2	YES	YES	13.7	12	46.75	46	47	48	498	502	499	503
16	VEERABHADRAPPA PATTAR	60	MALE	YES	NO	YES	YES	3	3	YES	YES	11	13	44.12	45	43.25	43.75	512	470	515	472
17	BHIMRAY TALIKOTI	72	MALE	NO	NO	YES	YES	3	3	YES	NO	16	15.7	44.5	44.87	44.87	44.87	508	508	511	510
18	SHAKUNTALA YADHAV	62	FEMALE	NO	NO	NO	NO	4	3	YES	NO	13.7	12	42.5	43.25	42	43.25	547	561	551	570
19	RAJASHEKAR BAGALI	64	MALE	NO	NO	YES	YES	4	4	YES	YES	14	17	44.25	44.5	43	44.25	496	501	500	504
20	SAIDAPPA JAHIR	64	MALE	NO	NO	YES	YES	3	3	YES	YES	14	16	46	47.5	46.5	47.5	491	491	479	482
21	RAMABAI INGALESHWAR	82	FEMALE	NO	NO	NO	NO	4	4	YES	YES	17	19	42	42.5	42.5	43	461	466	470	472
22	CHANDRASHEKAR RATHOD	48	MALE	NO	NO	YES	YES	3	3	YES	YES	12	13	43	45	43.25	45.25	552	555	550	553

23	SACHIN ILEGAR	59	MALE	NO	NO	NO	NO	3	3	YES	NO	13.3	12	43.25	43.75	44	45.5	494	502	498	505
24	SUDHARANI SONAR	59	FEMALE	NO	NO	YES	YES	3	3	YES	NO	11	13.3	45.25	46	44.5	45.25	413	416	410	415
25	BHARATHI JAGAJANAGI	44	FEMALE	NO	NO	NO	NO	3	3	YES	YES	15	15	42	42.5	42.5	43.5	508	495	510	500
26	MALLAMMA BIRADAR	64	FEMALE	NO	NO	NO	NO	3	3	YES	YES	14	15	41.5	42	41.5	42.5	432	443	430	439
27	GANGU HIREMATH	64	FEMALE	NO	NO	NO	NO	3	3	YES	YES	13	15	44	44.5	44.5	45	513	525	515	530
28	SUMITRA SHANKAR	59	FEMALE	NO	NO	NO	NO	4	4	NO	YES	14	15	48.25	49.25	48	49	577	538	565	530
29	SHARANAPPA NAIKODI	59	MALE	YES	NO	YES	YES	4	4	YES	YES	14	16	45.75	47	45	47	547	547	539	540
30	SANGANNA HUGAR	61	MALE	NO	YES	YES	YES	4	4	NO	YES	16	14	40.75	42	41.5	42.5	505	498	501	496
31	DANAWWA ANDEWADI	57	FEMALE	NO	NO	NO	NO	4	4	YES	YES	12	13	42.5	43	42.75	44	509	509	505	507
32	SHEETABAI PATIL	70	FEMALE	NO	NO	YES	YES	4	4	YES	YES	10	10	44.25	45	44.25	45	490	490	496	494
33	SHASNMUKAPPA KASEBGOUDA	72	MALE	NO	NO	YES	YES	4	4	YES	YES	14	13	43	43.5	44	44.5	501	483	501	494
34	VEERANAGOUDA PARANNAVAR	64	MALE	NO	NO	YES	YES	4	4	YES	YES	14	13	44.25	44.5	44.5	44.5	525	531	527	529
35	CHANDU LAMANI	60	MALE	NO	NO	NO	NO	3	3	YES	YES	13	14	42	43.5	43.5	43.5	497	509	501	507
36	KASTURI HADIMURU	62	FEMALE	NO	NO	NO	NO	3	3	YES	YES	10	12	42.25	43	43.5	43.5	452	457	456	462
37	MUDDAVVA BIRADAR	60	FEMALE	NO	NO	NO	NO	3	3	YES	YES	13	15	43	43.5	44	44	462	469	465	471
38	SIDDALINGAPPA KANNUR	60	MALE	NO	NO	NO	NO	3	3	YES	YES	14	13	44	44.5	43.5	43.5	533	544	536	546
39	SUSHILABAI SALUNKE	74	FEMALE	NO	NO	NO	NO	4	4	YES	YES	13	12	43.75	44.25	43.5	45	502	503	498	500
40	SAHEBBI NADAF	80	FEMALE	NO	NO	NO	NO	4	4	YES	YES	11	10	48.5	49.25	48.75	49.5	484	502	479	497
41	EBRAHIM PATHAK	42	MALE	YES	NO	YES	YES	4	4	YES	YES	19	17	44	45	45	45.5	574	565	550	560
42	SANGAYYA HIREMATH	75	MALE	NO	NO	YES	YES	3	3	YES	YES	12	14.3	41.25	43.5	42	42.5	508	514	510	516
43	BASAVVA PATTEPUR	68	MALE	NO	NO	NO	NO	2	2	YES	YES	12	14	46.75	49	46.5	47.5	472	484	476	487
44	NINGAMMA CHOUDRI	49	FEMALE	NO	YES	NO	NO	3	3	NO	YES	14	18	45.75	46.75	45.5	46.5	534	520	537	529
45	MALLAVVA METI	68	FEMALE	NO	NO	NO	NO	3	3	YES	YES	13	14	45.25	46.25	45	45.75	543	452	547	462
46	SHIVANNA HALLI	63	MALE	NO	NO	NO	NO	4	4	YES	YES	15	13	42	42.5	42.5	43	466	476	471	484
47	RUKMABAI ALASANGI	60	FEMALE	NO	NO	NO	NO	4	4	YES	YES	15	16	43	44	43	44.5	479	485	480	485

48	SANKARAGOUDA B	61	MALE	NO	NO	YES	YES	4	4	YES	YES	13	15	45.25	46.25	45.5	46.25	509	485	506	483
49	BILLU LAMANI	63	MALE	NO	NO	YES	YES	4	4	NO	YES	15	14	43.25	44.5	43	43.75	538	529	540	532
50	PARVATI HUSANSAGI	53	FEMALE	NO	NO	NO	NO	4	4	YES	NO	15	14	46.75	48.5	45.5	46.5	549	534	552	541
51	BAGHIRADHI BILLADI	51	FEMALE	NO	NO	NO	NO	4	4	YES	YES	14	16	42.25	43	42.5	43.5	509	504	506	503
52	RUKMABAI SAINSAKALE	59	FEMALE	NO	NO	NO	NO	3	3	YES	YES	16	17	43.25	44	43.5	44.5	473	481	475	485
53	BHIMABAI DOLE	50	FEMALE	NO	NO	NO	NO	3	 3	YES	YES	14	16	45	45.5	44.5	45.5	514	520	518	522

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