# "CORNEAL ENDOTHELIAL CHANGES IN TYPE 2 DIABETES MELLITUS RELATIVE TO STAGE OF DIABETIC RETINOPATHY"


**BY**

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**Dissertation submitted to**

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND RESEARCH, CENTRE, TAMAKA, KOLAR**

**In partial fulfillment of the requirements for the degree of**

## MASTER OF SURGERY

## IN

## OPHTHALMOLOGY

**Under the guidance of**

**DR.RASHMI.G**

**M.B.B.S M.S.**

## DEPARTMENT OF OPHTHALMOLOGY

## SRI DEVARAJ URS MEDICAL COLLEGE TAMAKA, KOLAR

**2025**

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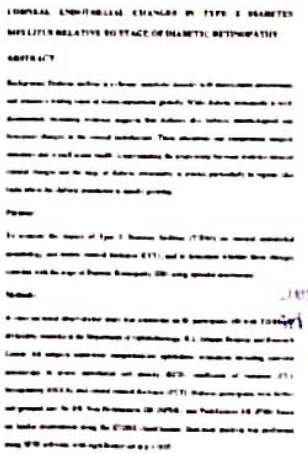

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# LIST OF ABBREVATIONS

| Abbreviation | Full Form |
|---|---|
| ECD | ENDOTHELIAL CELL DENSITY |
| CCT | CENTRAL CORNEAL THICKNESS |
| CEC | CORNEAL ENDOTHELIAL CELL |
| CV | COEFFICIENT OF VARIATION |
| HEXA | HEXAGONALITY |
| NPDR | NON PROLIFERATIVE DIABETIC RETINOPATHY |
| PDR | PROLIFERATIVE DIABETIC RETINOPATHY |
| SGH | SECOND HARMONIC GENERATION |
| DR | DIABETIC RETINOPATHY |
| T2DM | TYPE 2 DIABETES MELLITUS |
| T1DM | TYPE 1 DIABETES MELLITUS |
| AGE | ADVANCED GLYCATION END PRODUCTS |
| ME | MACULAR OEDEMA |

# ABSTRACT

**Background:**

Diabetes mellitus is a chronic metabolic disorder with multisystem involvement and remains a leading cause of vision impairment globally. While diabetic retinopathy is well-documented, increasing evidence suggests that diabetes also induces morphological and functional changes in the corneal endothelium. These alterations can compromise surgical outcomes and overall ocular health. Understanding the relationship between diabetes-induced corneal changes and the stage of diabetic retinopathy is crucial, particularly in regions like India where the diabetic population is rapidly growing.

**Purpose:**

To evaluate the impact of Type 2 Diabetes Mellitus (T2DM) on corneal endothelial morphology and central corneal thickness (CCT), and to determine whether these changes correlate with the stage of Diabetic Retinopathy (DR) using specular microscopy.

**Methods:**

A cross-sectional observational study was conducted on 80 participants (40 with T2DM and 40 healthy controls) at the Department of Ophthalmology, R.L. Jalappa Hospital and Research Centre. All subjects underwent comprehensive ophthalmic evaluation including specular microscopy to assess endothelial cell density (ECD), coefficient of variation (CV), hexagonality (HEXA), and central corneal thickness (CCT). Diabetic participants were further sub-grouped into No DR, Non-Proliferative DR (NPDR), and Proliferative DR (PDR) based on fundus examination using the ETDRS classification. Statistical analysis was performed using SPSS software, with significance set at $p < 0.05$.

**Results:**

Diabetic patients demonstrated significantly lower ECD (2411.4 vs 2885.9 cells/mm², $p < 0.001$) and hexagonality (47.0% vs 51.1%, $p < 0.001$), and higher CV (35.2 vs 51.1, $p < 0.001$) compared to controls. CCT was slightly thinner in diabetics (517.9 µm vs 530.6 µm), though not statistically significant ($p = 0.098$). Among diabetic subgroups, no statistically significant correlation was observed between the severity of DR and endothelial parameters (ECD, HEXA, CV, CCT), though trends suggested worsening metrics with advanced DR stages.

**Conclusion:**

T2DM adversely affects corneal endothelial health, evidenced by reduced ECD, increased polymegathism, and decreased hexagonality. However, the severity of DR does not show a statistically significant correlation with these parameters, suggesting that corneal endothelial dysfunction in diabetes may occur independently of retinopathy stage. These findings underscore the importance of routine corneal evaluation in diabetic patients, especially prior to intraocular surgery.

**Keywords:** Type 2 Diabetes Mellitus, diabetic retinopathy, corneal endothelium, endothelial cell density, hexagonality, coefficient of variation, central corneal thickness, specular microscopy, corneal morphology, ocular complications of diabetes.

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# INTRODUCTION

# INTRODUCTION

Diabetes mellitus is a significant health threat, attaining epidemic levels globally. India is projected to have the highest number of individuals affected by this systemic illness, with an estimated 134 million cases by the year 2045. As a metabolic disorder, diabetes mellitus impacts many bodily systems, including the ocular region. It is a primary contributor to visual impairment among the working-age demographic globally. Although retinopathy is the most prevalent complication and most researched relation of diabetes mellitus, other ocular structures are also susceptible and are impacted at various stages of the disease.[1,2]

The most acknowledged corneal consequence in diabetes mellitus (both type I and type II) is keratopathy, which arises from compromised epithelium basement membrane integrity, reduced epithelial wound healing, disrupted epithelial-stromal interactions, endothelial dysfunction, and altered corneal nerve activities. The resulting morphological and functional changes enhance the cornea's vulnerability.[3,4]

Considerable evidence shows significant impacts of diabetes mellitus (DM) on all layers of the cornea. Research has established that the diabetic cornea is susceptible to several problems, including corneal endothelial damage, recurrent corneal erosions, punctate epithelial keratopathy, persistent epithelial defects, diminished corneal sensitivity, ulcers, delayed wound healing, and superficial keratitis.[5]

Prior research identified change in morphological characteristics of the corneal endothelium in diabetic patients, including a reduction in endothelial cell density (ECD) and polymorphism (a decrease in the proportion of hexagonal cells, with the normal percentage exceeding 50%), as well as polymegathism, indicated by an elevated coefficient of variation

(CV) of cell area (normal CV values range from 0.22 to 0.31, while values above 0.4 are deemed abnormal) and an increase in central corneal thickness (CCT).[6,7]

Notably, little research has examined the correlation between the severity of diabetic retinopathy and the length of diabetes mellitus with the modified corneal endothelial characteristics.[8,9]

A recent study showed no significant alterations in these parameters concerning the severity of diabetic retinopathy (DR) and found no link with the length of diabetes mellitus (DM), HbA1c levels, and DR severity. [10]

Currently, there is no definitive evidence in the literature regarding the correlation between DR severity and these factors. The degree of diabetic retinopathy may not directly influence corneal health. This may indicate the influence of parameters such as length, severity of diabetes mellitus, and age, among others, which has been substantiated in previous research. Nonetheless, evaluating corneal health is crucial when planning a surgical procedure such as cataract surgery. The existence and severity of diabetic retinopathy may need a comprehensive pre-operative ocular evaluation, particularly within the Indian demographic, where numerous cataract procedures are conducted annually.

The present study was conducted to examine ocular endothelial alterations in type 2 diabetes mellitus in relation to the stage of diabetic retinopathy.

# AIMS AND OBJECTIVES

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## AIM

The present study was conducted to examine ocular endothelial alterations in type 2 diabetes mellitus in relation to the stage of diabetic retinopathy.

## OBJECTIVE

1. To evaluate endothelial cell density, morphology and central corneal thickness in Type 2 Diabetes patients and compare it with that of a healthy control group using specular microscopy.

2. To correlate the corneal endothelial changes with Diabetic Retinopathy staging.

# REVIEW OF

# LITERATURE

# REVIEW OF LITERATURE

## INTRODUCTION

### Anatomy and Physiology

### Anatomy of cornea:

The cornea and sclera together form the outermost layer of the eye, primarily serving to shield the internal ocular structures. The cornea, a transparent and avascular tissue, functions as a protective barrier against infections and, in combination with the tear film, creates a smooth anterior refractive surface. It provides approximately two-thirds of the eye's refractive power.

Anatomically, the cornea is horizontally oval, measuring between 11–12 mm horizontally and 9–11 mm vertically. Measurements using the ORBSCAN II system report an average horizontal corneal diameter of 11.71 ± 0.42 mm, with males averaging 11.77 ± 0.37 mm and females 11.64 ± 0.47 mm; ranges were 11.04–12.50 mm for males and 10.7–12.58 mm for females. The limbus shows maximum width at the superior and inferior regions. Structurally, the cornea is convex and aspheric, with an anterior curvature radius of about 7.8 mm and posterior curvature around 6.5 mm. It contributes about 40–44 diopters to the eye's refractive power, accounting for roughly 70% of total ocular refraction, and has a refractive index of 1.376.

Corneal thickness progressively increases from the center toward the periphery, primarily due to the higher collagen content in the peripheral stroma. Various measurement techniques have found central corneal thickness to range between 551 and 565 μm, while peripheral thickness ranges from 612 to 640 μm. Notably, corneal thickness tends to decline with age. The anterior

corneal stroma plays a critical role in preserving the cornea's curvature, offering greater resistance to changes in hydration compared to the posterior stroma.

The cornea consists of both cellular and non-cellular elements. The cellular portion is composed of epithelial cells, keratocytes, and endothelial cells, while the non-cellular part mainly includes collagen fibers and glycosaminoglycans.

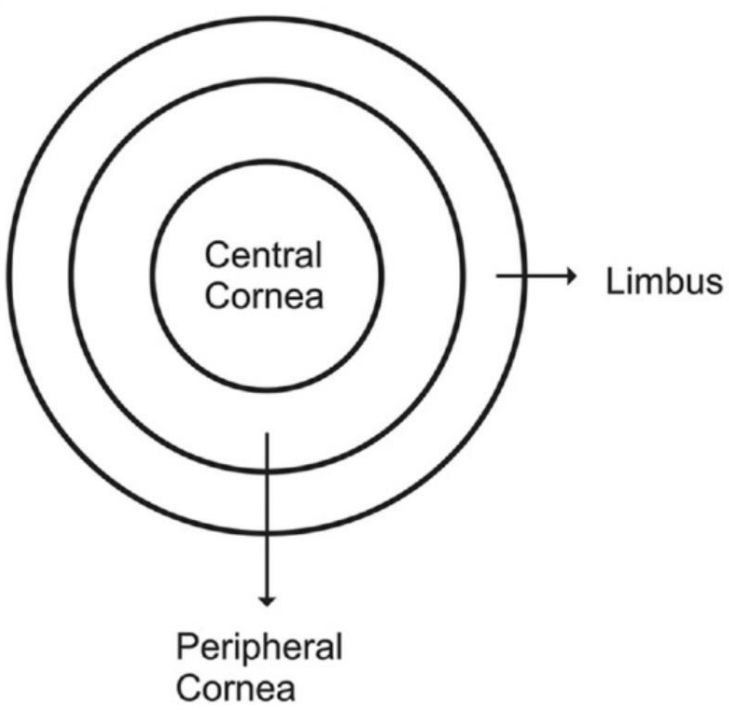



**Fig 1: Picture of cornea showing central and peripheral cornea**

The **corneal epithelium** typically consists of 5 to 7 evenly distributed layers of cells and measures approximately 50 μm in thickness. It forms a smooth and regular surface and is composed of non-keratinized, stratified squamous epithelial cells.

**Bowman's membrane** is a dense layer formed by collagen and proteoglycans. Measuring around 12 μm in thickness, it is primarily composed of Type I and Type V collagen fibers along with proteoglycans. Although often referred to as a membrane, it is actually an acellular condensation of the anterior stroma. Positioned just in front of the stroma.The

smooth layer contributes to maintaining structural integrity of the the cornea. However, it lacks the ability to regenerate after injury, and damage to it typically leads to scarring.

The **corneal stroma** constitutes about 80–85% of the cornea's thickness and provides most of its structural support. Its transparency results from the highly organized arrangement of collagen fibers and the extracellular matrix (ECM). Type I collagen is predominant in the stromal fibrils, with Type VI and Type XII collagens also present.

**Descemet's membrane**, a 7 μm thick layer, consists primarily of Type IV collagen and laminin. It is secreted continuously by endothelial cells. The anterior 3 μm, formed before birth, shows a distinct banded pattern, while the portion produced after birth is unbanded and appears amorphous. With aging, Descemet's membrane may reach up to 10 μm in thickness. It is notably elastic, curling when severed.

The **corneal endothelium** forms a single, metabolically active layer about 5 μm thick. These hexagonal cells function primarily through an endothelial pump that regulates corneal hydration. Viewed from the posterior surface, the endothelium displays a honeycomb mosaic pattern. Over time, endothelial cells flatten, stabilizing at about 4 μm thickness in adulthood, and neighboring cells are interconnected by extensive lateral interdigitations, gap junctions, and tight junctions.[11]

**Table 1: Functions of various layers of cornea.**

| Layer | Key Functions |
|---|---|
| **Epithelium** | • Barrier to chemicals and water • Barrier to microbes • Smooth optical surface for tear film and refraction • Contains Langerhans cells for immune function |

| Layer | Key Functions |
| --- | --- |
| **Bowman's Layer** | • Maintains corneal shape |
| **Stroma** | • Provides mechanical strength • Maintains transparency • Main refracting component of the cornea |
| **Descemet's Membrane** | • Serves as a resting layer for endothelial cells |
| **Endothelium** | • Maintains corneal clarity by regulating stromal hydration |

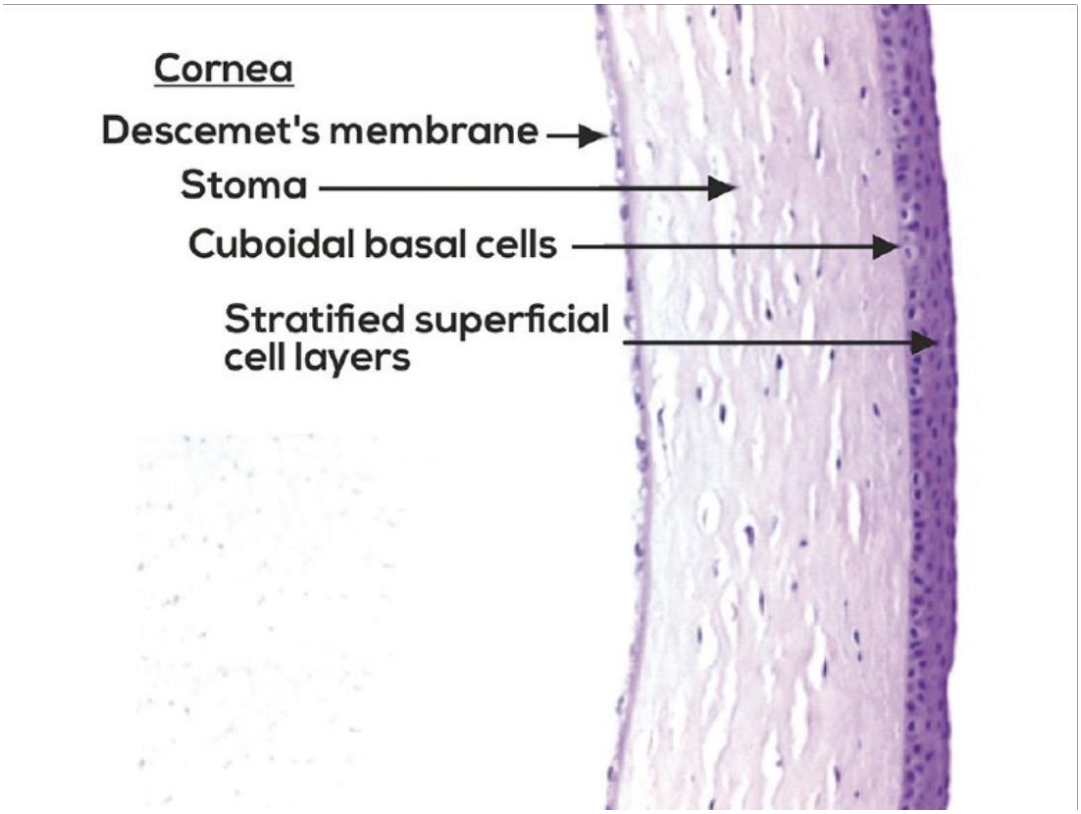



**Fig 2: Histopathology of cornea showing various layers.**[11]

**Anatomy of Corneal Endothelial Cells**

The corneal endothelium comprises a single layer of hexagonal cells, a geometry that promotes efficient and uniform distribution of membrane tension while offering a greater surface area relative to its perimeter [12]. These cells are generally arrested in the G1 phase of the cell cycle, with no documented evidence of mitotic activity under normal conditions. In response to endothelial damage, healing occurs through cell elongation and migration rather than proliferation, resulting in a continuous monolayer over the posterior corneal surface. This compensatory mechanism increases surface area and reduces the overall endothelial cell count.

Size irregularities among individual endothelial cells—referred to as polymegathism—are quantified using the coefficient of variation (CV). While an ideal cornea would have 100% hexagonal cells, a physiologically normal cornea maintains about 60% hexagonality [12]. Both endothelial cell count and hexagonality decline under stress or injury.

Endothelial morphology is assessed using several parameters: cell density (cells/mm²), polymegathism (CV), pleomorphism (percentage of hexagonal cells), and mean cell area ± standard deviation (μm²). The formula used to calculate cell density is: Density = 10 / average cell area, while polymegathism is derived from: CV = SD / mean cell area, where SD is the standard deviation of the area of endothelial cells [13].

Density of endothelial cells (ECD) declines with age at a rate of about 0.6% per year. This decline follows two phases—an initial rapid reduction followed by a slower decline. ECD starts at around 6000 cells/mm² during infancy, decreases to 3500 cells/mm² by age 5, 3000 cells/mm² between 15 and 20 years, and about 2500 cells/mm² by age 50 [13]. These changes reflect natural remodeling and senescence of endothelial cells.

Environmental, genetic, and geographic factors can also influence ECD. As corneal endothelial cells lack regenerative ability, any injury is managed by the expansion and migration of neighboring viable cells. The most precise markers for endothelial stress or dysfunction are the CV and HEXA, which serve as key indicators of wound-healing potential [14].

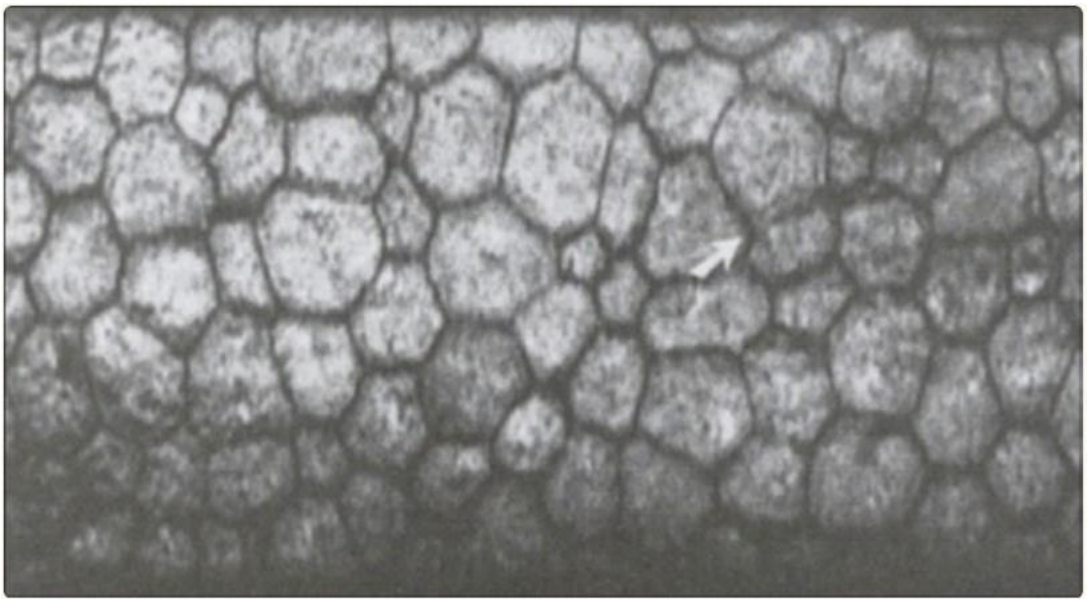


**Fig 3: Endothelial cell layer on the specular microscopy[11]**

**Corneal Endothelial Cell (CEC) Dysfunction in Diabetes**

**Ultrastructural Changes**

While many studies describe CEC shape, size, and density in diabetes, fewer explore changes at the ultrastructural level. Research using oxygen consumption rates has shown reduced mitochondrial reserve capacity in CECs from donors with insulin-dependent diabetes and complications, indicating significant mitochondrial dysfunction. Electron microscopy revealed diabetic CECs have denser mitochondria with cristae loss, swelling, and inclusion bodies—similar to findings in diabetic rat models. These mitochondrial abnormalities are

consistent with impaired mitophagy and altered mitochondrial dynamics seen in diabetic nephropathy.

**Pump Function and Cellular Junctions**

CEC pump activity, primarily driven by $Na^+/K^+$-ATPase, regulates corneal hydration. In diabetes, mitochondrial damage leads to reduced ATP production and impaired pump function. Studies show that high glucose or polyol exposure significantly lowers $Na^+/K^+$-ATPase activity, while insulin can enhance it. Other ion transporters, like $Na^+/K^+/2Cl^-$ and $Na^+$-$HCO_3^-$ cotransporters, also support corneal fluid balance but are less studied in diabetic contexts. Additionally, lactate and water efflux are linked via carbonic anhydrase and monocarboxylate transporters.

CEC junction integrity is vital for maintaining barrier function. Tight and adherens junctions—composed of proteins like claudins, occludins, ZO-1, cadherins, and catenins—regulate paracellular transport. Although direct studies in diabetic CECs are lacking, similar junctional breakdown is observed in diabetic complications such as retinopathy and blood-brain barrier dysfunction. These findings suggest that diabetes likely disrupts CEC junctions, increasing corneal permeability and compromising endothelial function. Further research is needed to clarify these mechanisms.

**Corneal Decompensation in Diabetes**

**Corneal Thickness and Hypoxic Stress**

The corneal endothelium regulates stromal hydration via tight junctions and $Na^+/K^+$-ATPase pumps. Because the stroma is hydrophilic, impaired pump activity leads to fluid buildup,

resulting in corneal edema and increased central corneal thickness (CCT), which affects vision clarity.

Numerous studies suggest diabetes mellitus (DM), especially type 1 (T1DM), is associated with reduced endothelial pump efficiency, resulting in increased CCT and corneal haze. Many investigations report thicker corneas in patients with T1DM, and to a lesser extent, type 2 diabetes (T2DM).

Duration of diabetes also influences corneal changes. Calvo-Maroto showed no CCT difference in recent-onset T2DM, but a significant increase in long-term cases. Similarly, Lee et al. found greater CCT in insulin-dependent diabetic patients, particularly after more than 10 years of disease.

Despite some inconsistencies, there is substantial evidence that diabetes—especially long-standing disease—impairs corneal endothelial function, contributing to increased corneal thickness and reduced resilience to stress. [15]

Specular microscopy specifically targets the endothelium. By using light reflection, it provides a clear image of this vital layer, allowing for the evaluation of cell density, shape, and size. The health of the endothelial cells, observed through this method, is a good indicator of the cornea's ability to maintain its necessary functions and transparency.

Given the critical nature of the endothelium and its limited regenerative potential, specular microscopy has become an invaluable diagnostic tool in ophthalmology. It is used to diagnose and monitor corneal diseases, assess damage due to contact lens wear, evaluate candidates for refractive surgery, and ensure the viability of donor corneas for transplantation.

In summary, the relationship between corneal anatomy and specular microscopy is one of necessity and enhancement. Specular microscopy augments our understanding and ability to care for this complex and vital part of the eye, directly influencing the prevention, diagnosis, and treatment of corneal pathologies.

**Corneal Endothelium Abnormalities in Diabetes**

Diabetes mellitus (DM) significantly alters the corneal endothelium, affecting both its structure and function. Common findings include reduced endothelial cell density (ECD), increased variability in cell size (polymegethism), and irregular cell shapes (pleomorphism). While hexagonality may not always differ significantly, it often reflects impaired regenerative capacity.

Functionally, diabetic corneas often show increased permeability and compromised pump activity, contributing to corneal swelling and elevated central corneal thickness (CCT). Some studies link lower ECD and increased CCT with higher HbA1c levels and the presence of diabetic retinopathy (DR), suggesting a relationship between disease control and endothelial damage.

Inflammatory cytokines such as VEGF, TNF-α, and interleukins, present in the diabetic eye, may further disrupt endothelial integrity. Hyperglycemia-induced changes, including accumulation of sorbitol and advanced glycation end-products (AGEs), impair cellular metabolism and mitochondrial function, leading to oxidative stress and endothelial decline.

At the structural level, abnormal long-spacing collagen fibrils have been observed in the Descemet membrane of diabetic corneas, likely due to AGE accumulation. These changes, visualized more clearly with second harmonic generation (SHG) imaging, may increase with

age and could potentially be reduced by antidiabetic treatments, making them promising biomarkers for disease monitoring.[16]

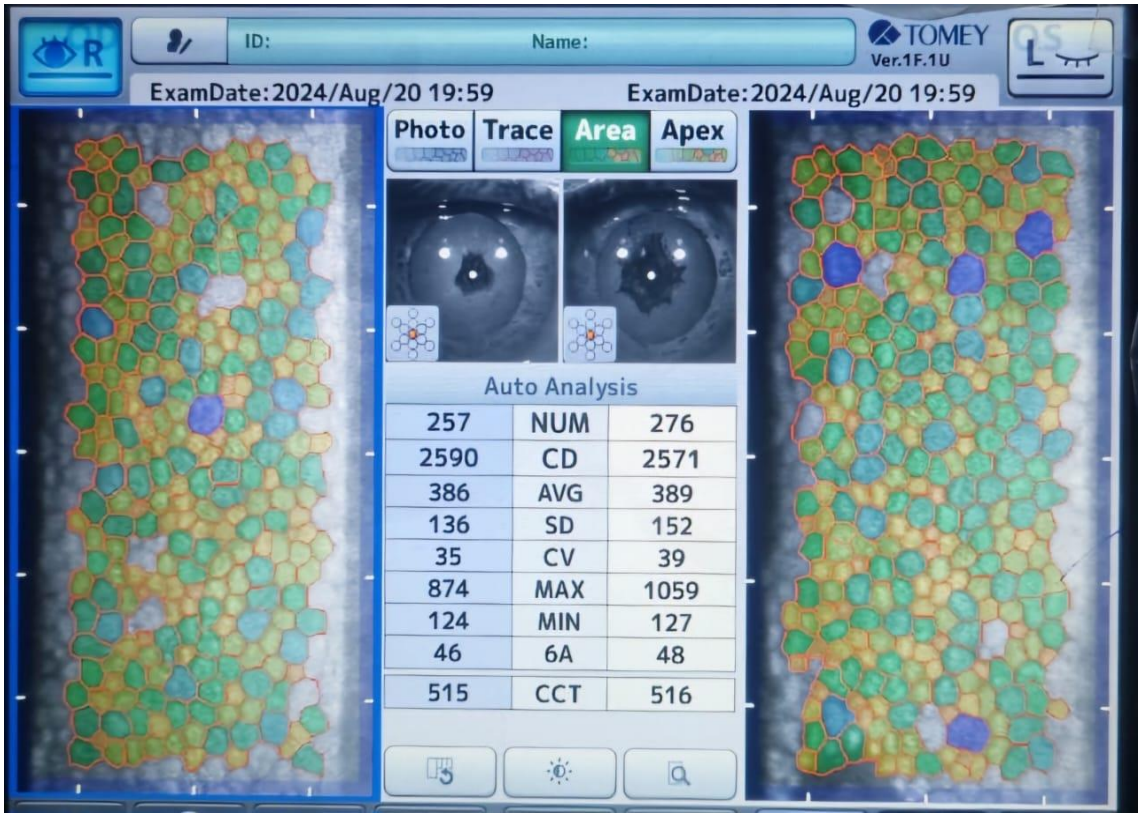



**Fig 4: Specular microscopy of patient on TOMEY OA-2000.**

**Specular microscopy**

Specular microscopy is a noninvasive modality that can document the healthy and diseased endothelium photographically. Specular microscopy is also crucial in assessing the preoperative endothelial health before high-risk surgeries, comparing various techniques, the impact of lasers during refractive surgery, and the assessment of donor cornea before transplantation. Specular microscopy represents a transformative advancement in ophthalmic imaging, providing an unparalleled window into the corneal endothelium, a critical layer of cells vital for maintaining corneal transparency and overall ocular health. This noninvasive photographic technique allows clinicians and researchers to observe and assess the

endothelial cell layer at the back of the cornea directly, offering insights that were once inaccessible without invasive methods or post-mortem analysis. [4]

The specular light reflex with the slit lamp is a routine method of evaluating corneal endothelium in the clinics. The term ‘Specularreflection’refers to a situation, where the angle of the reflected beam of light makes an equal angle with that of the incident light.The endothelial cells have a refractive index greaterthan 1.336 value forthe aqueous humor, and hence can be imaged because the endothelial layer—aqueous interface reflects 0.022% of the projected light.(17).

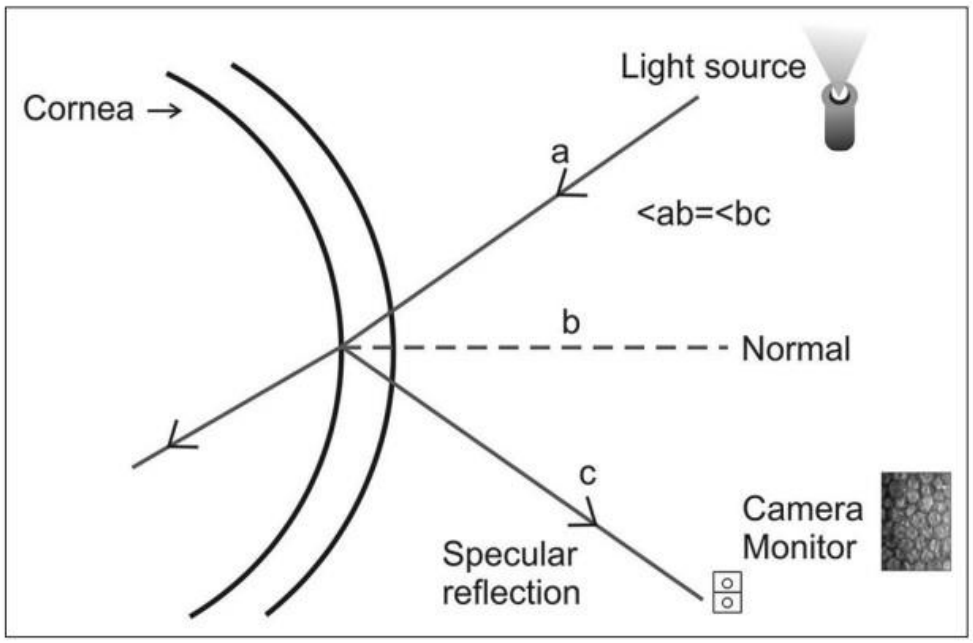



**Fig 5:** Schematic representation of principle of specular microscopy: A slit of light is focused on the endothelial surface. Specularly reflected light rays are focused onto a camera monitor to capture the image of endothelial cells. (a-incident light ray, b-normal, c-reflected light ray, ab- angle of incident light, bc- angle of the reflected light).[17]

The various endothelial pathologies where specular microscopy plays an important role include Fuchs endothelial dystrophy, corneal dystrophies, posterior polymorphous

dystrophy, pseudophakic bullous keratopathy, congenital hereditary endothelial dystrophy, viral endothelitis, ICE syndrome, trauma, uveitis and pharmacological disruption of the endothelium.

Various specular microscopes are available for documenting endothelial cell details at various magnifications and calibrations. Approximately 75 years ago, Vogt tried to obtain the endothelial cell morphology by using the reflected light of a slit lamp. However, limited magnification and rapid eye movements precluded a clear image. David Maurice first described specular microscopy in 1968. In 1975, Laing first used the specular microscope for clinical use. A year later, Baurne et al used the specular microscope at 200X for rapid endothelial examination and photography. In corneal edema, the specular reflection is masked and hampers visualization of the corneal endothelium. [18]

The endothelium is a single cell layer and is essential in preserving corneal dehydration and clarity. The cells act as a barrier to fluid from the aqueous humor and pump excess fluid from the stroma to prevent corneal swelling. Any dysfunction or decline in the cell count can lead to corneal edema and loss of visual acuity. Unlike other cells in the body, human corneal endothelial cells are post-mitotic: they do not regenerate. This places greater importance on monitoring their health and integrity to prevent and manage corneal diseases. The practice of specular microscopy in ophthalmology dates back to the early 20th century, but it was not until computer-assisted image analysis became available in the late 1970s and early 1980s that its use became more widespread.

The innovation of non-contact specular microscopes allowed for a safer, more efficient assessment of the endothelium, making the process more comfortable for patients and convenient for practitioners. In a specular microscopy exam, light is directed toward the cornea and reflected off the inner endothelial layer. This reflection captures an image that can

be analyzed for endothelial cell density (ECD), cell size (polymegathism), and shape (pleomorphism). ECD is a primary indicator of endothelial health, with a lower count suggesting a compromised cornea. Polymegathism and pleomorphism provide additional details regarding the uniformity and viability of the endothelial cells, with increased variation often indicating cellular stress or disease. [19]

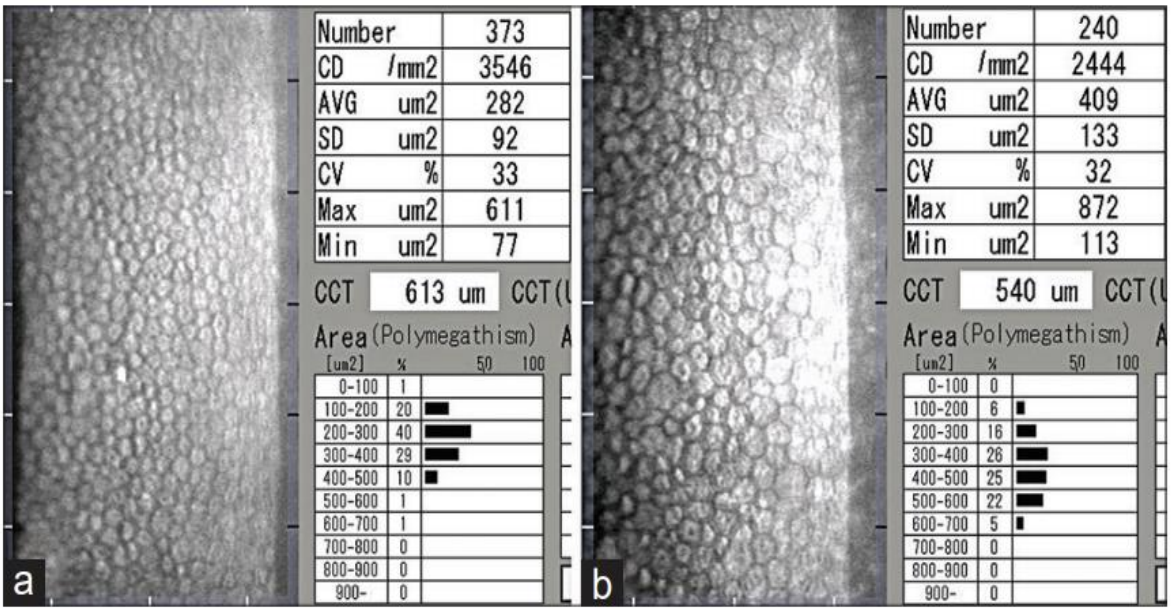



**Fig 6:** Representative specular microscopy images of the right eye of a 12-year-old (a) and a 40-year-old (b) male. Notice the difference in the mean cell area (282 versus 409 μm2 ) and the age related decline in endothelial cell density.[17]

The precision of specular microscopy has been instrumental in preoperative evaluations for intraocular surgeries, such as cataract extraction and corneal transplantation. The integrity of the endothelium is a critical determinant in patient selection and surgical prognosis, as iatrogenic trauma to this layer can have significant postoperative consequences. Consequently, the ability to accurately assess the endothelium has improved surgical outcomes and patient care. In corneal transplantation, specular microscopy is invaluable

for determining the quality of donor corneas, ensuring that only tissues with a healthy endothelium are used for grafts.

The technique has also revolutionized the management of corneal dystrophies and endothelial disorders such as Fuchs endothelial dystrophy and posterior polymorphous corneal dystrophy. In these conditions, specular microscopy can track disease progression and guide the timing of surgical interventions. In cases of acute or chronic corneal edema, the clarity provided by specular microscopy into the endothelial cell's health is paramount in formulating a treatment strategy.

Moreover, specular microscopy is not limited to disease management, as it plays a significant role in the fitting and managing of contact lenses, particularly in long-term wearers where endothelial damage is a concern. It offers the means to monitor the long-term effects of contact lens wear on the endothelium, enabling early detection of adverse reactions and preventing potential complications. [20]

Specular microscopy provides quantitative and qualitative data that enhance research and clinical practice. In drug trials, the technique offers a metric for assessing drug toxicity in the cornea. Specular microscopy also aids in evaluating the impact of various ocular surgeries on the endothelium, thus influencing surgical techniques and postoperative care.

However, specular microscopy is not without limitations. Image quality can be affected by factors such as corneal clarity, patient cooperation, and the presence of corneal pathology. In such cases, alternative methods like confocal microscopy may be necessary. Moreover, interpreting specular images requires significant expertise, as misinterpretation can lead to erroneous clinical decisions. Technological advancements continue to refine specular microscopy. Today, newer models boast increased automation, better image resolution, and

user-friendly interfaces that streamline the process and enhance accuracy. Current research aims to develop software capable of more detailed analyses, potentially identifying endothelial changes before they manifest clinically.

**Diabetic retinopathy (DR)**

Diabetic retinopathy (DR) is a significant cause of vision loss globally and the primary cause of visual impairment in individuals aged 25 to 74 years. Visual impairment resulting from diabetic retinopathy (DR) may be attributed to macular oedema (ME- retinal thickness and swelling affecting the macula), haemorrhage from neovascularisation, retinal detachment, or neovascular glaucoma.

**Pathogenesis**

**Structural anatomic retinal changes**:

Diabetes-induced structural alterations in the retina encompass the depletion of retinal pericytes, thickening of the capillary basement membrane, and the formation of microaneurysms, which are outpouchings of capillary walls. The anatomical alterations may result in the occlusion of retinal capillaries and arterioles, leading to retinal ischaemia and the compromise of the blood-retinal barrier, therefore enhancing vascular permeability and, consequently, retinal oedema. In the latter stages of the disease, the increasing onset of retinal ischaemia results in the proliferation of new blood vessels, the formation of fibrous tissue, and the contraction of vitreous and fibrous growths, ultimately causing retinal traction and detachment.[21,22]

**Retinal microthrombosis**:

Retinal microthrombosis results in the obstruction of retinal capillaries and subsequent capillary leakage. The heightened adherence of leukocytes to the retinal vascular

endothelium is one of the initial alterations seen in the retina prior to the emergence of clinically evident diabetic retinopathy and may contribute to augmented vascular permeability. The compromise of endothelial integrity results in retinal ischaemia, followed by the release of growth factors including IGF-1, platelet-derived growth factor (PDGF), fibroblast growth factor (FGF), and vascular endothelial growth factor (VEGF).[23]

**Altered retinal blood flow**:

Chronic hyperglycemia may increase retinal blood flow. Retinal blood flow is autoregulated and remains stable until the mean arterial pressure increases by roughly 40 percent over baseline. Chronic hyperglycemia impairs this autoregulatory system. The subsequent rise in retinal blood flow from hyperglycemia and the impairment of autoregulatory mechanisms leads to heightened shear stress on the retinal blood vessels, potentially stimulating the production of vasoactive substances, vascular leakage, and increased fluid accumulation in the outer retinal layers, culminating in macular oedema.[24]

**Retinal neurovascular alterations**:

The effective operation of the retina depends on a complex interplay between photoreceptors and neurones that transmit electrochemical signals to the brain, aided by glial cells and vascular tissue. This neural function relies on a complicated interaction of retinal cells, which encompasses the establishment of a blood-retinal barrier. The clinical diagnosis of diabetic retinopathy (DR) is often marked by retinal vascular irregularities; nevertheless, neurological impairments have been demonstrated to manifest early in the disease progression. Neurosensory alterations have been identified before to the manifestation of detectable retinopathy by electroretinography (ERG). Initial diabetes-related ERG results encompass decreased b-wave amplitudes and modifications in the oscillatory potential,

characterised by lower amplitudes and delays in peak timing. Electrophysiologic alterations manifest early in diabetes and may serve as predictors of proliferative illness, which can result in degenerative changes and considerable vision impairment.[25–27]

**Sorbitol**:

Glucose that enters cells is partially metabolised to sorbitol by the enzyme aldose reductase; sorbitol is then converted to fructose, a process that occurs at a rather slow rate. The significance of sorbitol synthesis and buildup in the pathophysiology of diabetic retinopathy remains unclear. The finding that a polymorphism adjacent to the transcription site of the aldose reductase gene correlates with the early development of retinopathy in some type 2 diabetes patients supports a possible pathogenic function for this pathway.[28]

The use of NADPH in sorbitol production may alter NADPH-to-NADP ratios and induce oxidative stress, while the resultant sorbitol accumulation can affect Na/K-ATPase activity, disrupt phosphatidylinositol metabolism, elevate prostaglandin synthesis, and modify the activity of protein kinase C isoforms. Protein kinase C plays a crucial role in the aetiology of retinopathy by potentially mediating VEGF activity, regulating vascular permeability, and contributing to the buildup of sorbitol.[29,30]

The buildup of sorbitol in lens cells is exacerbated by prolonged hyperglycemia. This results in increased intracellular osmolality, prompting water influx into the cells and subsequent cell swelling, and a reduction in intracellular myoinositol, both of which can disrupt cellular metabolism. The buildup of sorbitol may play a significant role in cataract development caused by hyperglycemia, since the expansion of lens fibre cells might result in their rupture.[31]

**Advanced glycation end products**

In chronic hyperglycemia, excess glucose interacts with free amino acids or serum and tissue proteins. This nonenzymatic mechanism first produces reversible early glycation products, which subsequently transform into irreversible advanced glycation end products (AGEs) by an Amadori rearrangement. Serum concentrations of AGEs are elevated in diabetic patients, resulting in tissue buildup of AGEs that may cross-link with collagen, ultimately precipitating microvascular problems. The accumulation of age has been associated with the development of cataracts.[32]

The interaction between advanced glycation end products (AGEs) and their receptor (RAGE) produces reactive oxygen species, leading to vascular inflammation. Elevated amounts of reactive oxygen species have been seen in the vitreous fluid of individuals with proliferative diabetic retinopathy (PDR), demonstrating a connection between increased reactive oxygen species and the progression of PDR. Evidence indicates that in vitro suppression of the renin-angiotensin system with an angiotensin II receptor blocker (ARB) might mitigate AGE-induced inflammatory responses in endothelial cells by reducing the formation of reactive oxygen species.[33,34]

Diabetic retinopathy is frequently asymptomatic until the advanced stages. Due to the potential for fast progression and the therapeutic benefits for visual enhancement, avoidance of further visual impairment, and mitigation of disease advancement, routine screening for retinal disease in diabetic patients is essential.

## CLINICAL MANIFESTATIONS

### Visual symptoms

Numerous people with diabetic retinopathy (DR) exhibit no symptoms until the advanced stages, at which point effective therapy may no longer be viable. Due to the potentially rapid progression of the condition and the therapeutic benefits for symptom alleviation and deceleration of disease advancement, it is crucial to routinely test diabetic patients for the onset of retinal degeneration.

In advanced stages of diabetic retinopathy (DR), patients may exhibit various symptoms contingent upon the specific ocular condition, such as a curtain-like obstruction due to vitreous haemorrhage, the presence of floaters during the clearance of such haemorrhages, and diminished visual acuity unresponsive to refractive correction in cases of macular oedema (ME).

### Ophthalmologic features

The progression of clinical diabetic retinopathy is intricate and results from several interconnected variables that cause harm to the retinal neurovascular unit. The neurovascular unit is a concept that emphasises the functional interconnection between retinal neuronal cells and the retinal vasculature. Clinically observable characteristics predominantly arise from two fundamental alterations in the retinal vessels: aberrant permeability and vascular occlusion leading to ischaemia and subsequent neovascularisation. Numerous investigations have shown that diminished retinal neuronal function may be assessed before the emergence of clinical retinopathy.[35–37]

The retina is among the most metabolically active organs in the body and is especially vulnerable to basal membrane dysfunction and ischaemia. Retinal pericytes and

microvascular endothelial cells are diminished during an initial stage of diabetes. Thickening of the retinal basement membrane represents an early alteration in diabetic retinopathy, akin to observations in glomeruli.[38,39]

The loss of retinal pericytes and microvascular cells, together with the dysfunction of the basement membrane, correlates with the development of retinal capillary microaneurysms and increased vascular permeability. Microaneurysms (hypercellular outpouchings of retinal capillaries with compromised walls, partially attributable to pericyte loss) and the effusion of lipid and proteinaceous substances ("hard" exudates) are the first clinical manifestations of diabetic retinopathy (DR).

**Neovascularization**

The preliminary phase of cellular death and increased capillary permeability may be succeeded by cycles of regeneration and additional cellular death, resulting in progressive microvascular occlusion and ischaemic damage, accompanied by the subsequent release of vasoproliferative agents (including vascular endothelial growth factor [VEGF], erythropoietin, among others) in the ischaemic retinal region. These diffusible substances stimulate the formation of new vessels (neovascularisation) from the neighbouring retinal arteries in a futile effort to revascularize the damaged region. This procedure is linked to the subsequent clinical alterations:

The intraluminal proliferation of cells, alterations in platelet function, aggregation of erythrocytes and leukocytes, and elevated plasma fibrinogen levels lead to arterial blockage and rupture. This may result in little flame-shaped and blot haemorrhages close to the occlusion, as well as intraretinal infarcts ("cotton wool" or "soft exudates") distant to the occlusion.

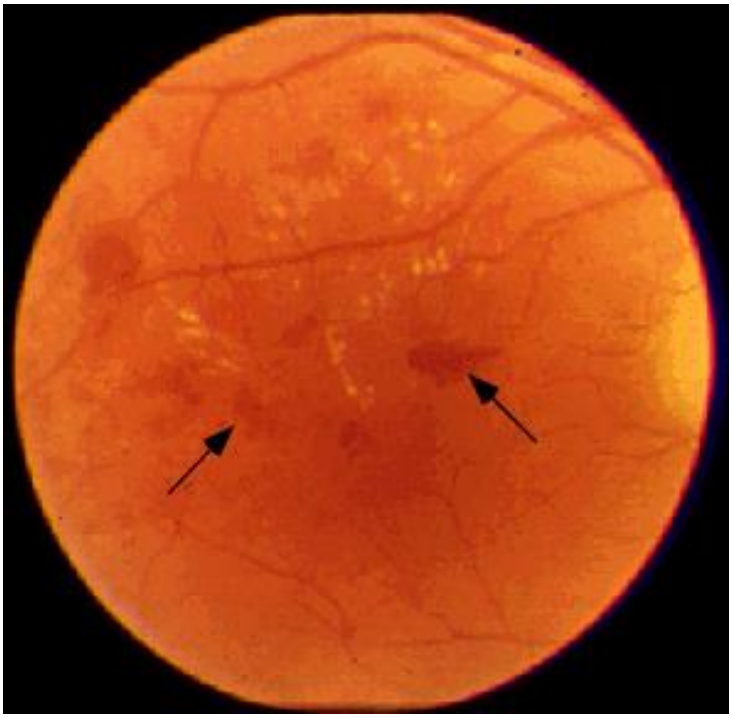


**Fig 7: Retinal blot hemorrhages: Appearance on fundus photograph**

Diabetic retinopathy exhibiting several blot haemorrhages (shown by arrows). These lesions result from vascular blockage and rupture.

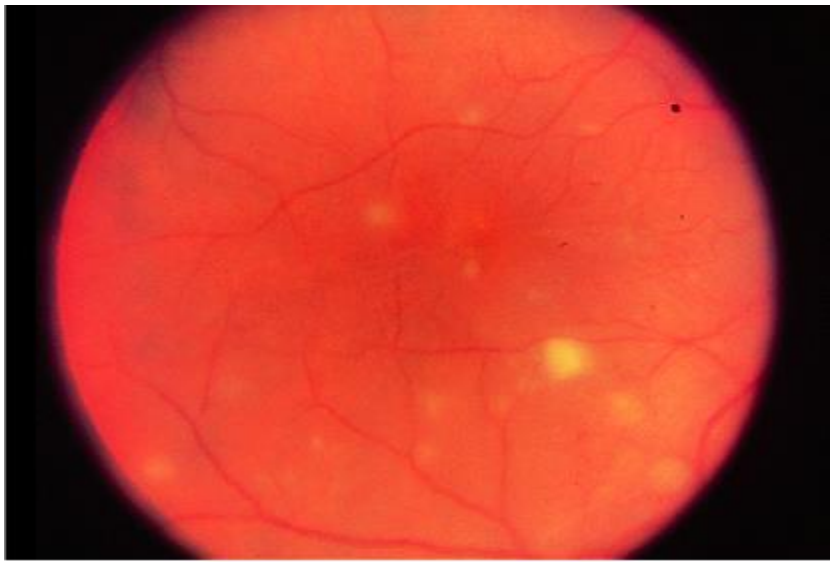


**Fig 8:Cotton wool spots**

Cotton wool patches signify retinal ischaemia. The differential diagnosis include diabetes, hypertension, acquired immunodeficiency syndrome (AIDS), and retinal vascular alterations associated with systemic lupus erythematosus.

● The proliferation of endothelial cells in retinal veins leads to significant alterations in vein calibre, resulting in the creation of convoluted loops.

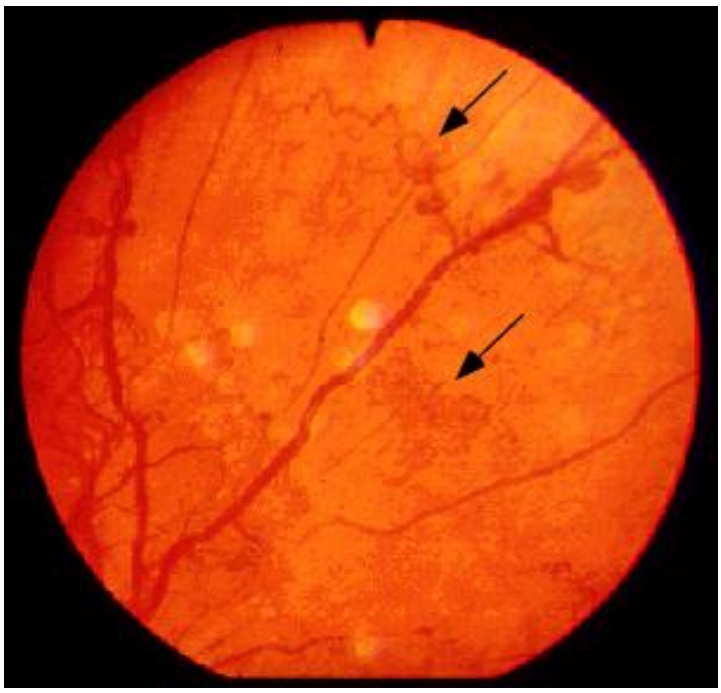


**Fig 9: Early diabetic retinal neovascularization: Appearance on fundus photograph**

**Proliferative retinopathy**

Proliferative diabetic retinopathy (PDR) is characterised by neovascularisation (abnormal new blood vessels) originating from the optic disc and/or retinal vessels, along with the resultant complications such as preretinal and vitreous haemorrhage, following fibrosis, and tractional retinal detachment. PDR may occur in the context of preexisting or concurrent severe non-proliferative alterations or may emerge independently of significant NPDR.

Diabetic macular oedema may also manifest in conjunction with proliferative diabetic retinopathy.

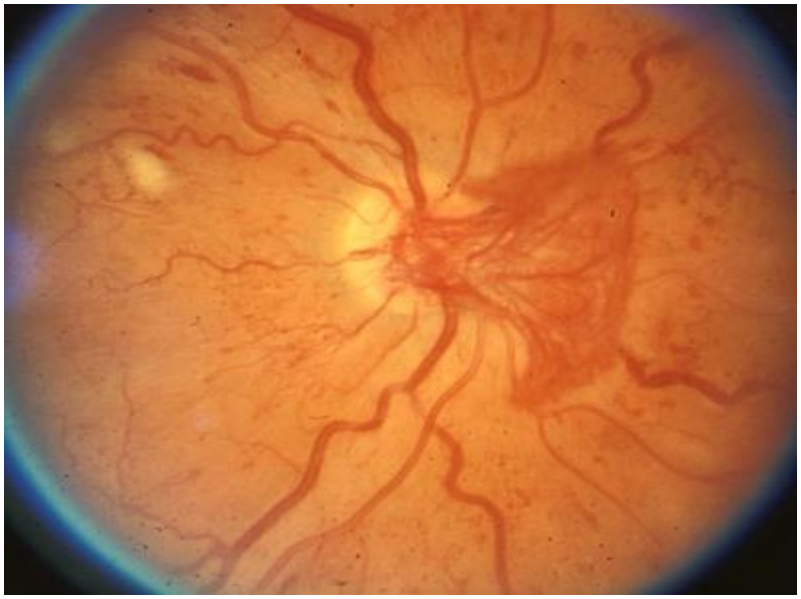


**Fig10: Proliferative diabetic retinopathy displaying prominent neovascularization at the disc (NVD): Appearance on fundus photograph**

Colour fundus picture of proliferative diabetic retinopathy with significant neovascularisation at the optic disc (NVD).

Acute visual loss in proliferative diabetic retinopathy (PDR) may arise if haemorrhage from aberrant capillaries into the vitreous obstructs the light pathway to the retina; although, the blood is frequently reabsorbed, and vision may improve spontaneously over a period of weeks to months. Permanent vision loss may result from retinal detachment, macular ischaemia, or a combination of these events.

In the initial stages of proliferative diabetic retinopathy, new blood vessels appear as delicate loops or networks, although they do not fulfil the requirements for the high-risk classification.

High-risk proliferative diabetic retinopathy (PDR) is characterised by moderate to severe neovascularisation of the optic disc (exceeding one-third to one-half of the disc area), any neovascularisation of the optic disc accompanied by vitreous or preretinal haemorrhage, or moderate to severe neovascularisation in other retinal regions (covering at least one-half of the disc area) in the presence of vitreous or preretinal haemorrhage. Untreated high-risk proliferative diabetic retinopathy (PDR) leads to a 60 percent probability of significant visual impairment within five years. ME may manifest with varying degrees of PDR and should be incorporated into the comprehensive treatment plan.

**Macular edema**

Macular oedema can manifest at any phase of diabetic retinopathy. It is characterised by retinal thickness and oedema affecting the macula, which may be observed with specialised fundus examination with stereoscopic vision, fluorescein angiography, and most directly using optical coherence tomography (OCT), a noninvasive, low-energy laser imaging tool.

Diabetic macular oedema is classified as center-involved (retinal thickness in the macula affecting the central subfield zone) or non-center involved.[34-36]

## The ETDRS classification of Diabetic retinopathy: [40]

## Table 2: ETDRS classification of diabetic retinopathy.

**TABLE A6-1: Classification of Diabetic Retinopathy in the Early Treatment of Diabetic Retinopathy Study**

| Disease Severity Level | Findings Observable upon Dilated Ophthalmoscopy |
|---|---|
| Mild nonproliferative retinopathy | At least one microaneurysm, and definition not met for moderate NPDR, severe NPDR, early PDR, or high-risk PDR |
| Moderate nonproliferative retinopathy | Hemorrhages and/or microaneurysms > standard photograph 2A; and/or soft exudates, venous beading, or IRMA definitely present; not meeting criteria for more severe forms |
| Severe nonproliferative retinopathy | Cotton-wool spots, venous beading, and IRMA present in >=2 fields (fields 4-7); or two of the above present in >=2 fields + hemorrhages/microaneurysms > standard photo 2A in at least one of these fields; not meeting criteria for PDR |
| Early proliferative retinopathy | New vessels; but not meeting criteria for high-risk PDR |
| High-risk proliferative retinopathy | NVD >= 1/4 to 1/3 disc area (standard photo 10A) with/without vitreous or preretinal hemorrhage; or NVE >= standard photo with hemorrhage |

**TABLE A6-2: Diabetic Macular Edema Disease Definitions in the Early Treatment of Diabetic Retinopathy Study**

| Disease Severity Level | Findings Observable upon Dilated Ophthalmoscopy |
|---|---|
| Diabetic macular edema apparently absent | No apparent retinal thickening or hard exudates in posterior pole |
| Diabetic macular edema apparently present | Retinal thickening and/or hard exudates in posterior pole |
| Clinically significant macular edema (CSME) | Thickening of retina within 500 microns of the macular center; or hard exudates within 500 microns of center with associated thickening; or >=1 disc area of thickening, any part of which is within 1 disc diameter of macular center |

**Similar studies in the past:**

**In a study by Durukan I** to assess the morphological characteristics of corneal endothelial cells and their correlation with the stages of diabetic retinopathy in diabetes mellitus (DM). This prospective, cross-sectional study comprised patients with type 2 diabetes mellitus and age-matched controls. Patients with diabetic retinopathy (DR) were categorised into no DR, non-proliferative DR, and proliferative DR according to fundus observations. Endothelial measures were acquired via specular microscopy (Topcon SP-3000P, Japan). The endothelial cell density, mean cell area, coefficient of variation of cell area, and percentage of hexagonal cells were assessed. Central corneal thickness (CCT) was assessed via an ultrasonic pachymeter. The endothelial cell parameters and central corneal thicknesses of the diabetes mellitus and control groups were compared, and a subgroup analysis of the diabetes mellitus patients was conducted. Enhanced measures must be implemented to mitigate the risk of endothelial decompensation before intraocular surgery, particularly in individuals with proliferative diabetic retinopathy.[41]

In a study by **Toprak I, Fenkci SM, Fidan Yaylali G** et al. aimed to examine the impact of microalbuminuria on the corneal endothelium in diabetic individuals devoid of retinopathy. This cross-sectional study included 100 individuals with type 2 diabetes mellitus (DM) devoid of diabetic retinopathy and 92 control persons without diabetes. Forty-five individuals had microalbuminuria, whereas fifty-five participants tested negative for microalbuminuria. Endothelial measurements were acquired by specular microscopy.Endothelial cell density, average area, coefficient of variation, maximum area, minimum area, hexagonality, and corneal thickness were compared among the groups based on microalbuminuria, duration of diabetes mellitus, medication, HbA1c, body mass index, serum lipid and protein profiles, as well as diagnoses of hypertension and hyperlipidaemia.

Patients with diabetes mellitus exhibiting both positive and negative microalbuminuria, devoid of retinopathy, appear to have comparable corneal endothelial measures to controls. Patients with a HbA1c over 7 percent should be assessed for deterioration in corneal endothelial cell morphology, even in the absence of diabetic retinopathy, since this may be crucial prior to anterior segment surgery.[42]

In a study by **El-Agamy and Alsubaie** aimed to examine corneal endothelial cell density (ECD), morphological characteristics, and central corneal thickness (CCT) in individuals with type 2 diabetes mellitus (DM) against age-matched nondiabetic control patients utilising the EM-3000 Specular Microscope. This study was a prospective, hospital-based, nonrandomized, case-control, observational, and quantitative investigation. The study comprised 57 patients (57 eyes) with type 2 diabetes mellitus and 45 control (nondiabetic) participants (45 eyes). All eyes underwent examination of the corneal endothelium structure and central corneal thickness (CCT) by noncontact specular microscopy with the EM-3000 Specular Microscope. The endothelial structure was analysed for endothelial cell density (ECD), coefficient of variation of cell area (CV), and proportion of hexagonal cells. This study demonstrated that type 2 diabetes mellitus significantly reduces endothelial cell density and increases coefficient of variation (polymegathism). Furthermore, the corneas of diabetic individuals have an elevated central corneal thickness (CCT) and a reduced proportion of hexagonal cells compared to normal patients, but without statistical significance.[10]

A study by **Jha A, Verma A, Alagorie AR** was undertaken to assess central corneal thickness, endothelial cell density, and shape in individuals with diabetes mellitus (DM). Evaluated corneal endothelium, namely central corneal thickness (CCT), endothelial cell density (ECD), coefficient of variation in cell size (CV), and hexagonality (Hex) using specular microscopy in patients with type 2 diabetes mellitus, compared to age-matched

controls. The impact of diabetic retinopathy (DR) severity, length of diabetes mellitus (DM), and glycosylated haemoglobin (HbA1c) levels was also examined. Diabetes mellitus adversely affects corneal endothelium and thickness. The existence of diabetic retinopathy may need a comprehensive corneal assessment, particularly while preparing for intraocular surgery.[43]

A study by **Pandey S, Singh A, Vannadil H et al.** was undertaken to evaluate corneal metrics between diabetics and age-matched non-diabetics, as well as to link these characteristics with the length of diabetes, glycated haemoglobin (HbA1c) levels, and the severity of diabetic retinopathy (DR). A comparison research was performed at a tertiary eye-care facility from January 2020 to December 2020. Two hundred patients (400 eyes) with type 2 diabetes (100) and age- and sex-matched non-diabetics (100) were included. The study of corneal endothelium is essential in routine clinical practice and offers significant data regarding the health of the corneal endothelium in various intraocular procedures. Uncontrolled diabetes mellitus adversely affects the cornea, with 70% of diabetics experiencing problems such as keratopathy. The study indicated that prolonged diabetes duration elevated HbA1c levels, and inadequate glycaemic management adversely impacted corneal morphology. Our research demonstrated a significant decrease in ECD and 6A in individuals with diabetes relative to those without diabetes. A significant decrease in corneal endothelial cell numbers, density, and hexagonality was seen in individuals with type-2 diabetes relative to non-diabetics. [44]

# MATERIALS AND METHODS

# MATERIALS AND METHODS

**SOURCE OF DATA**

This cross-sectional observational study involves a minimum of 72 patients meeting the inclusion criteria in the Department of Ophthalmology at R. L. Jalappa Hospital and Research, Kolar, from June 2023 to August 2024, following ethical clearance from the Institutional Ethical Committee of Sri Devaraj Urs Medical College and written informed consent from the participants.

**STUDY DESIGN**: Prospective study.

**INCLUSION CRITERA:**

1) Patients with Type 2 Diabetes Mellitus < 60 years of age.

2) Healthy Control group

**EXCLUSION CRITERIA:**

1. Prior intraocular surgery, focal or Pan retinal Photocoagulation and periocular or intravitreal injection of any medication,
2. History of Glaucoma, Uveitis, Hyperopia or Myopia > 3.0 D and Astigmatism > 1.0 D
3. Corneal diseases such as keratoconus, Fuch's endothelial dystrophy, Corneal opacities, Dry eye etc.
4. History of Contact lens usage.
5. Use of chronic topical ophthalmic medications.
6. Other systemic diseases apart from DM.

**METHOD OF COLLECTION OF DATA:**

Each patient was assessed by detailed history and clinical examination of both the eyes were done by various methods as follows-

1. Visual acuity by Snellen's chart for distant vision.
2. Near vision.
3. Slit lamp biomicroscopy.
4. Fundus examination by + 90D lens assisted slit lamp biomicroscopy and indirect ophthalmoscopy and fundus will be graded according to ETDRS classification of Diabetic Retinopathy.
5. Central corneal thickness using Specular Microscopy.
6. Assessment of endothelial morphology by Specular Microscopy.( ECD, Polymegathism and Hexagonality)

Patients were divided into 2 groups:

1) Patients with Diabetes Mellitus.

2) Control group

Endothelial findings of both groups were documented.

Further the Patients with DM were segregated and classified according to the stage of DR

Group 1 includes no Diabetic Retinopathy.

Group 2 includes Non Proliferative Diabetic Retinopathy.

Group 3 includes Proliferative Diabetic Retinopathy.

The study subjects were evaluated by Specular Microscopy ,the following parameters were measured:

• Endothelial cell density (cells/mm2)

• % of hexagonality

• Polymegathism

• Central corneal thickness (mm)

**SAMPLE SIZE ESTIMATION**:

The estimation was derived from the disparity in Mean ECD between the control group and cases in the research of Durukan I, which examined corneal endothelial alterations in type 2 diabetes mellitus in relation to diabetic retinopathy. Clinical and Experimental Optometry. July 1, 2020; 103(4): 474–8. Cell densities were 2501 ± 302 cells/mm² and 2295 ± 311 cells/mm². A sample size of 36 was determined for each group using a 95% confidence limit and 80% power, employing the formula provided and MedCalc sample size software. Each group will comprise about 40 cases, accounting for a 10% nonresponse rate from a sample size of 36 plus 3.6.

Sample Size Estimation Formula:

$$N = 2\,SD2(\,Z\alpha/2 + Z\beta)2d2$$

Where Zα/2 is the critical value of the Normal distribution at α/2 (e.g. for a confidence level of 95%, α is 0.05 and the critical value is 1.96).Zβis the critical value of the Normal distribution at β (e.g. for a power of 80%, ß is 0.2 and the critical value is 0.84), SD is the

standard deviation from previous study population variance, and d is the largest difference between two mean

**STATISTICAL METHODS USED FOR THIS STUDY :**

Data will be entered into Microsoft excel data sheet and will be analyzed using SPSS 22 version .software. Categorical data will represented in the form of Frequencies and proportions. Chi-square will be the test of significance. Continuous data will be represented as mean and standard deviation. Independent t test will be the test of significance to identify the mean difference between two groups. P value <0.05 was considered as statistically significant.

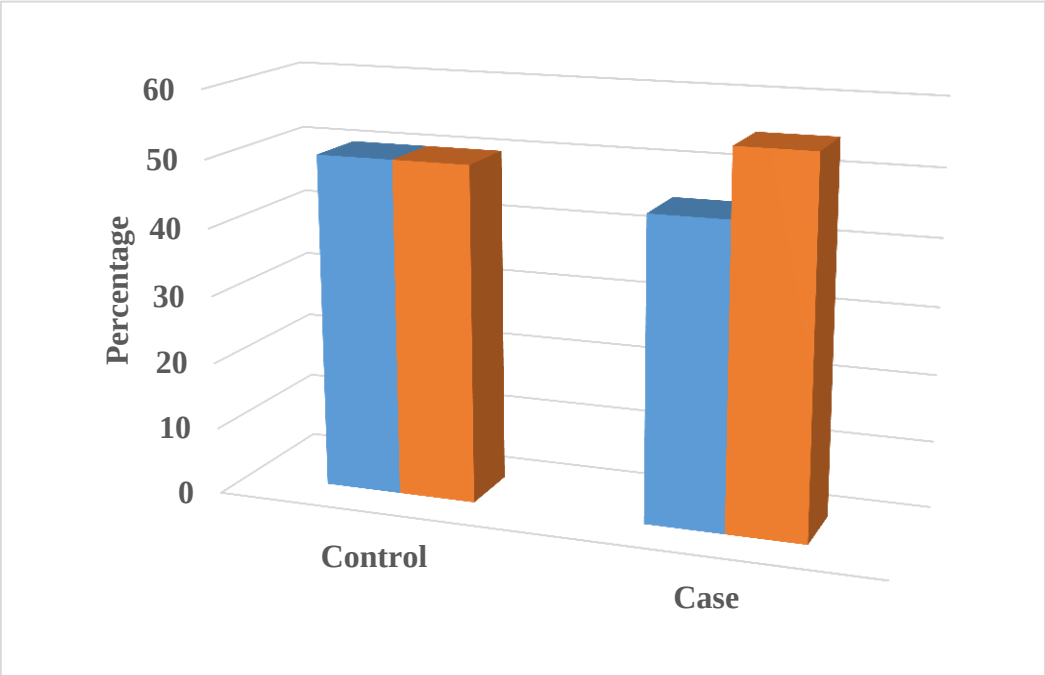
# RESULTS

# RESULTS

**Table 3**:Distribution of subjects according to sex among cases and control

| | Case | | Control | |
|---|---|---|---|---|
| | N | % | N | % |
| Female | 20 | 50% | 18 | 45% |
| Male | 20 | 50% | 22 | 55% |

P Value 0.823, there was no statistically significant difference found between Control and case with respect to sex.

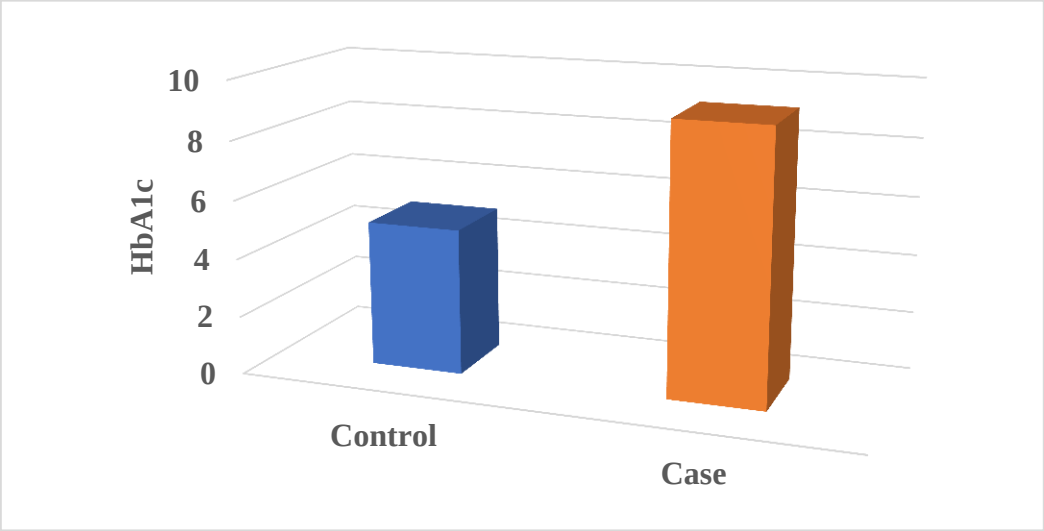



**Graph 1:** Bar graph depicting the gender distribution percentages in the Diabetic (case) and non-diabetic (control) groups.

**Table 4:** Comparison of various parameters among cases and control

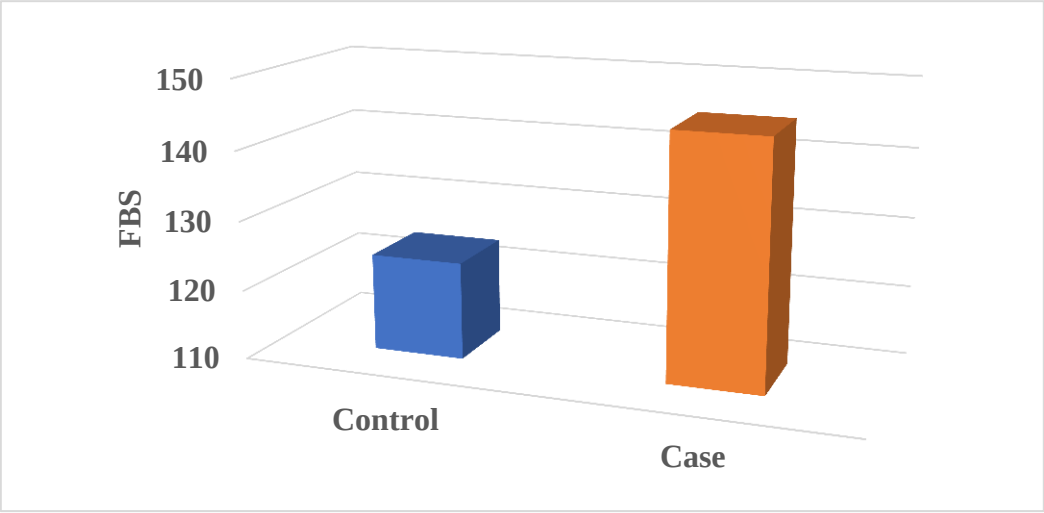
| | GROUP | | | | P value |
|---|---|---|---|---|---|
| | Case | | Control | | |
| | Mean | SD | Mean | SD | |
| Age | 64 | 11 | 64 | 10 | 0.776 |
| FBS | 145 | 39 | 124 | 29 | 0.007 |
| PPBS | 196 | 57 | 149 | 24 | 0.001 |
| HbA1c | 9.2 | 2.3 | 5.0 | .5 | <0.001 |
| CCT | 517.9 | 31.8 | 530.6 | 36.1 | 0.098 |
| HEXA | 47.0028 | 9.0135 | 34.0594 | 3.5616 | <0.001 |
| CV | 35.1933 | 4.8030 | 51.1384 | 9.0867 | <0.001 |
| ECD | 2411.4 | 213.1 | 2885.9 | 297.0 | <0.001 |

P Value 0.776, there was no statistically significant difference found between Control and case with respect to age.



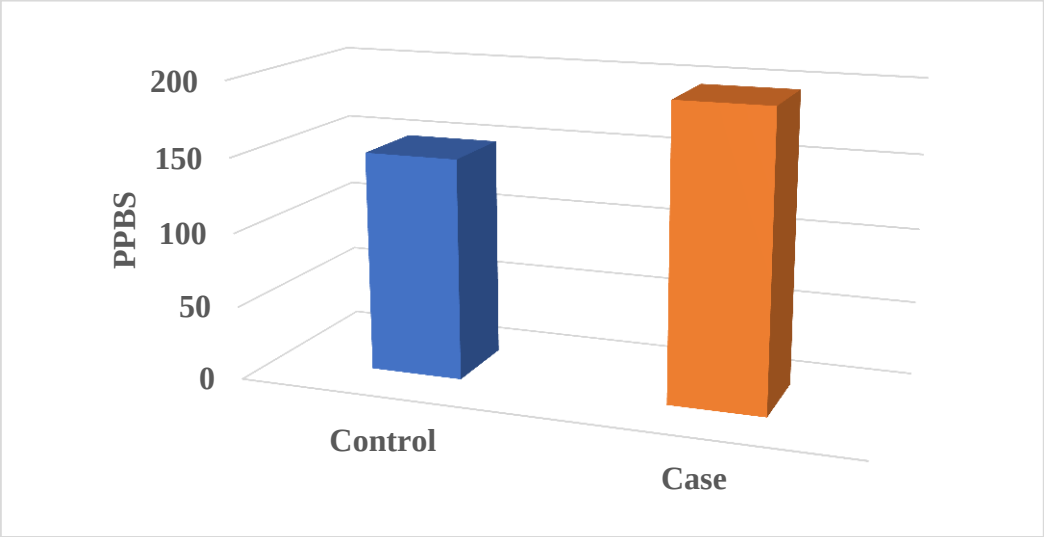

**Graph 2:** Bar graph illustrating the differences in HbA1c levels between the diabetic (case) and non-diabetic (control) groups.

P Value <0.001, there was a statistically significant difference found between Control and case with respect to HbA1c.



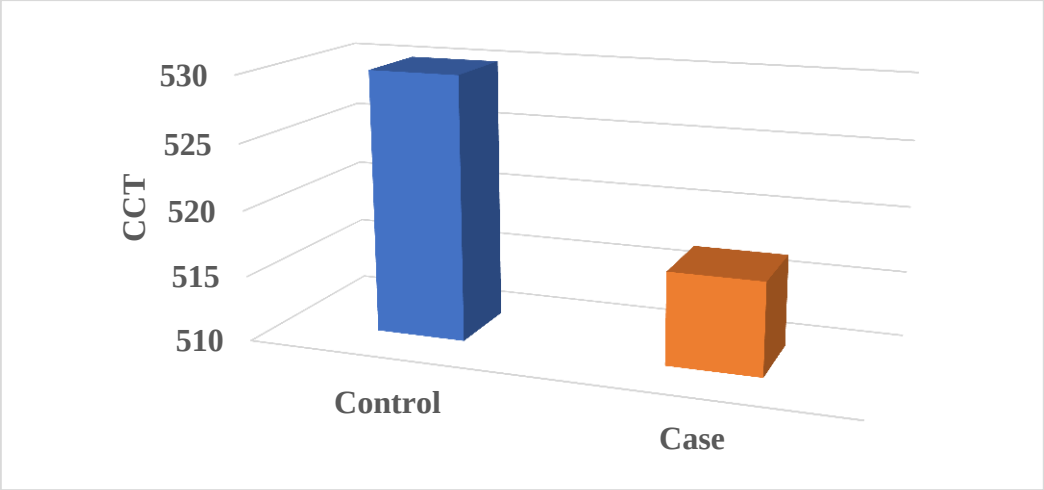

**Graph 3:** Bar graph illustrating the differences in FBS levels between the diabetic (case) and non-diabetic (control) groups.

P Value 0.007, there was a statistically significant difference found between Control and case with respect to FBS.



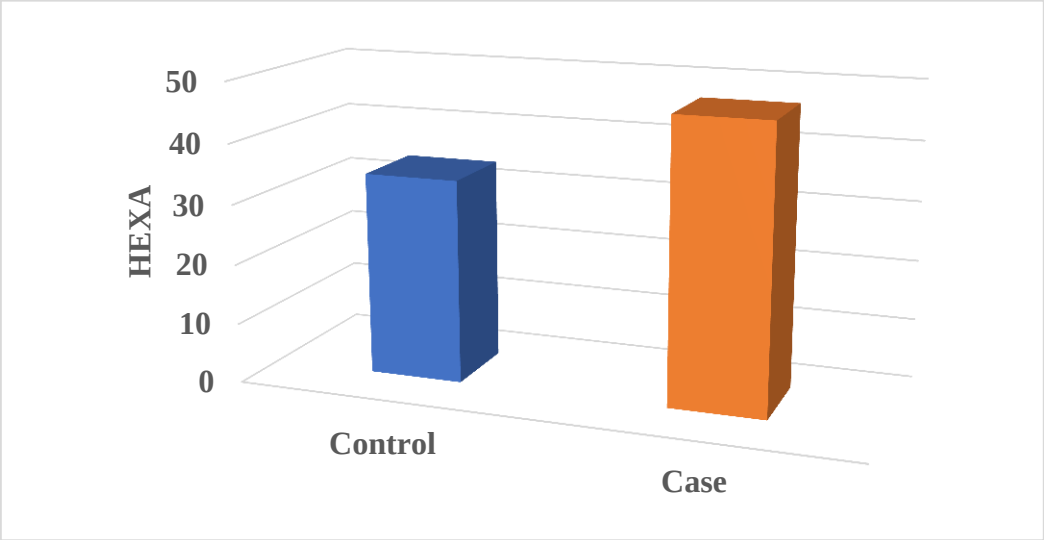

**Graph 4:** Bar graph illustrating the differences in PPBS levels between the diabetic (case) and non-diabetic (control) groups.

P Value 0.001, there was a statistically significant difference found between Control and case with respect to PPBS.



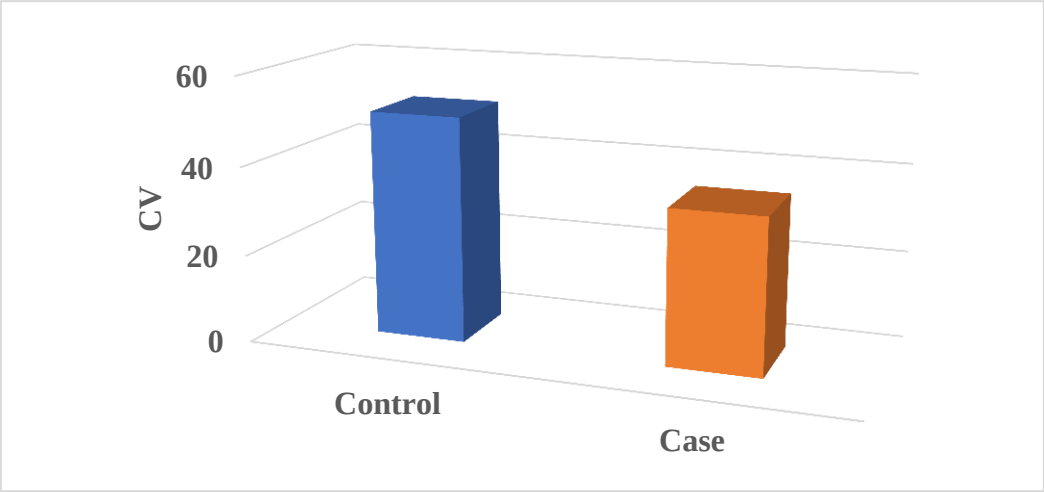

**Graph 5:** Bar graph illustrating the differences in CCT values between the diabetic (case) and non-diabetic (control) groups.

P Value 0.098, there was no statistically significant difference found between Control and case with respect to CCT.



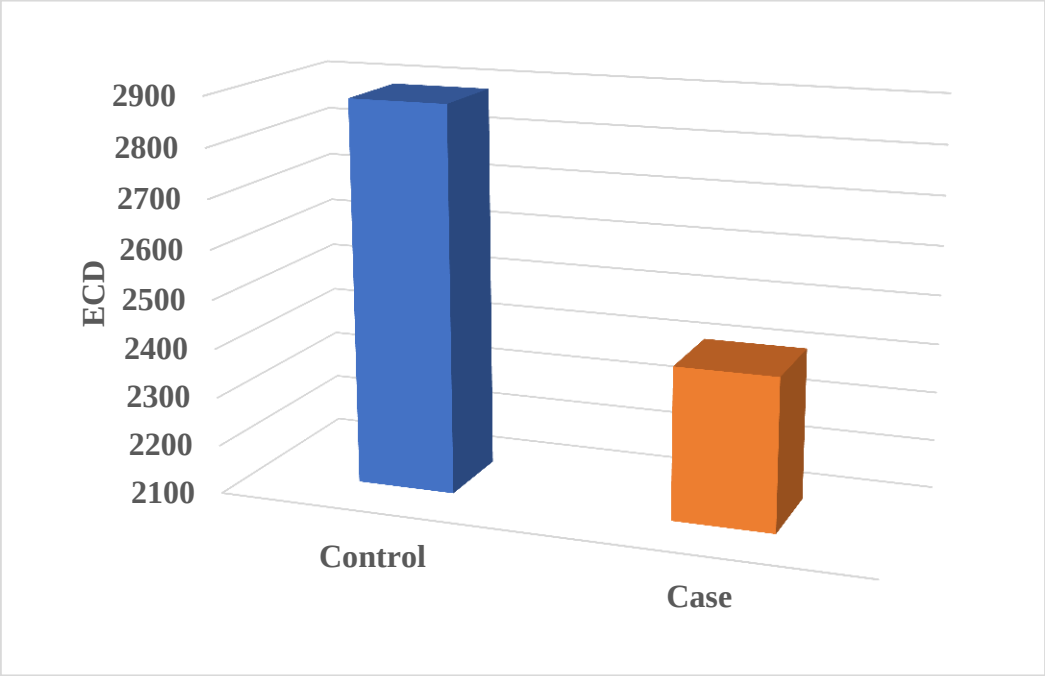

**Graph 6:** Bar graph illustrating the differences in HEXA values between the diabetic (case) and non-diabetic (control) groups.

P Value <0.001, there was a statistically significant difference found between Control and case with respect to HEXA.




**Graph 7:** Bar graph illustrating the differences in CV values between the diabetic (case) and non-diabetic (control) groups.

P Value <0.001, there was a statistically significant difference found between Control and case with respect to CV.




**Graph 8:** Bar graph illustrating the differences in ECD values between the diabetic (case) and non-diabetic (control) groups.

P Value <0.001, there was a statistically significant difference found between Control and case with respect to ECD

**Table 5:** Comparison of various parameters according to retinal Changes in all subjects case and controls together

| | No DR | | NPDR | | PDR | | P value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Age | 63 | 10 | 67 | 11 | 65 | 11 | 0.776 |
| FBS | 128 | 35 | 141 | 33 | 156 | 34 | 0.007 |
| PPBS | 153 | 27 | 198 | 60 | 222 | 62 | 0.001 |
| HbA1c | 6.0 | 1.9 | 8.1 | 2.0 | 10.9 | 2.2 | <0.001 |
| CCT | 528.7 | 33.4 | 518.8 | 37.2 | 512.1 | 34.2 | 0.098 |
| HEXA | 36.5791 | 6.9677 | 49.5713 | 9.8962 | 46.9075 | 7.7228 | <0.001 |
| CV | 47.0678 | 11.0547 | 36.0153 | 5.2405 | 34.9584 | 2.8070 | <0.001 |
| ECD | 2758.0 | 365.4 | 2439.4 | 162.8 | 2428.2 | 214.2 | <0.001 |

**Table 6:** Comparison of various parameters according to retinal Changes in cases

| | No DR | | NPDR | | PDR | | P value |
|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | |
| Age | 60 | 9 | 67 | 11 | 65 | 11 | 0.222 |
| FBS | 138 | 48 | 141 | 33 | 156 | 34 | 0.454 |
| PPBS | 168 | 32 | 198 | 60 | 222 | 62 | **0.047** |
| HbA1c | 8.8 | 1.7 | 8.1 | 2.0 | 10.9 | 2.2 | **0.003** |
| CCT | 522.7 | 23.4 | 518.8 | 37.2 | 512.1 | 34.2 | 0.703 |
| HEXA | 44.3321 | 9.1033 | 49.5713 | 9.8962 | 46.9075 | 7.7228 | 0.328 |
| CV | 34.5429 | 6.0031 | 36.0153 | 5.2405 | 34.9584 | 2.8070 | 0.722 |
| ECD | 2364.4 | 263.4 | 2439.4 | 162.8 | 2428.2 | 214.2 | 0.632 |

P Value 0.222, there was no statistically significant difference found between Severity of retinal changes with respect to age.

P Value 0.454, there was no statistically significant difference found between Severity of retinal with respect to FBS.

P Value 0.047, there was a statistically significant difference found between Severity of retinal with respect to PPBS.

P Value 0.003, there was a statistically significant difference found between Severity of retinal with respect to HbA1c.

P Value 0.703, there was no statistically significant difference found between Severity of retinal with respect to CCT.

P Value 0.328, there was no statistically significant difference found between Severity of retinal with respect to HEXA.

P Value 0.722, there was no statistically significant difference found between Severity of retinal with respect to CV.

P Value 0.632, there was no statistically significant difference found between Severity of retinal with respect to ECD.

**Corneal Morphological Differences Between Diabetics and Controls**

An analysis of the cornea was performed for each eye. Patients with diabetes exhibited significant variations in corneal endothelial parameters in comparison to the control group.

- The measurement of Central Corneal Thickness (CCT) revealed that individuals with diabetes exhibited a thinner average thickness of 517.90 µm compared to the control group, which had an average thickness of 530.64 µm. However, this difference did not reach statistical significance, as indicated by a p-value of 0.098.

- The hexagonality percentage, which serves as an indicator of the uniformity of endothelial cell shape, was found to be significantly reduced in individuals with diabetes, recording a value of 46.96%, in contrast to the control group, which exhibited a higher value of 51.09%. This finding suggests a greater degree of irregularity in cell morphology among the diabetic population, with a p-value of 0.045 indicating statistical significance.

- The Endothelial Cell Density (ECD) observed in individuals with diabetes was markedly reduced, measuring at 2429.54 cells/mm², in contrast to the control group, which exhibited a higher ECD of 2886.46 cells/mm². This difference was accompanied by a highly significant p-value of less than 0.001, indicating a strong statistical significance in the findings.

- The Coefficient of Variation (CV) analysis indicated that there was no statistically significant difference (p=0.555), which implies that the variability in cell size was comparable across the different groups examined.

- The observed pattern exhibited a reflection of that found in the right eye. Individuals with diabetes exhibited a thinner central corneal thickness (CCT) of 516.40 µm compared to 529.14 µm. Additionally, they demonstrated lower hexagonality at 48.66% in contrast to 52.79%. Furthermore, there was a significant reduction in endothelial cell density (ECD), with values of 2423.74 cells/mm² versus 2880.66 cells/mm². The disparity observed in ECD was once more found to be highly significant, with a p-value of less than 0.001.

- The comparison of CV revealed no significant differences, with a p-value of 0.394.

The results of this study consistently indicate a loss of endothelial cells associated with diabetes, alongside notable morphological disruptions, particularly characterised by a reduction in cell density and regularity.

# DISCUSSION

# DISCUSSION

## Study Population and Demographics

The research encompassed a cohort of 40 individuals diagnosed with diabetes (cases) alongside 40 non-diabetic participants (controls), thereby establishing a well-structured comparative framework for analysis. The composition of the diabetic cohort exhibited a perfectly balanced gender distribution, comprising an equal number of 20 males and 20 females. Within the control group, a marginal male predominance was observed, with males constituting 55% of the sample compared to 45% for females. The cohort of individuals with diabetes exhibited a greater prevalence of participants aged 60 years and older, accounting for 65% of the group, in contrast to the control group, which comprised only 50% of individuals within the same age bracket. However, it is noteworthy that this observed difference did not reach statistical significance, as indicated by a p-value of 0.175. The distribution of age and gender indicates a satisfactory demographic alignment between the groups, thereby allowing for a more assured attribution of the observed differences in corneal parameters to the diabetic status of the participants.

## Glycemic Profile

Consistent with our hypotheses, the cohort of individuals with diabetes exhibited markedly inferior glycaemic regulation in comparison to the control group comprising non-diabetic participants. The average HbA1c level was recorded at 9.23%, which signifies the presence of chronic hyperglycemia. A significant proportion of individuals with diabetes, specifically 60%, exhibited HbA1c levels exceeding 8%. This finding suggests a concerning trend of inadequate long-term glycaemic management among this population.

In contrast, the control group exhibited glycaemic parameters that approached normalcy, with a mean fasting blood sugar (FBS) level recorded at 124 mg/dl, a postprandial blood sugar (PPBS) level of 148.8 mg/dl, and a mean haemoglobin A1c (HbA1c) of 5.04%. These values all fall within the acceptable ranges indicative of non-diabetic status. All control subjects exhibited HbA1c levels below 6.5%, thereby further confirming their status as non-diabetic individuals.

**Influence of Glycemic Parameters on Corneal Morphology Within Diabetics**

- The investigation further categorised corneal parameters within the diabetic cohort according to fasting blood sugar (FBS), postprandial blood sugar (PPBS), and haemoglobin A1c (HbA1c) levels:

- The analysis of CCT revealed a tendency towards a reduction in thickness correlated with deteriorating glycaemic indices, particularly noted in the case of HbA1c; however, it is important to highlight that these observed trends did not reach statistical significance.

- The analysis revealed that endothelial cell density and hexagonality did not exhibit consistent or statistically significant correlations with fasting blood sugar (FBS), postprandial blood sugar (PPBS), or HbA1c levels.

It is noteworthy that individuals exhibiting the highest levels of fasting blood sugar (FBS) and haemoglobin A1c (HbA1c) also demonstrated a marginally elevated endothelial cell density (ECD). However, this seemingly paradoxical observation did not reach statistical significance, indicating that additional variables may influence endothelial health in diabetic patients beyond the scope of glycaemic regulation alone.

**Correlation with Diabetic Retinopathy (DR)**

- The examination of corneal morphology was conducted with respect to the severity of diabetic retinopathy. A non-significant trend was noted, indicating a decrease in central corneal thickness (CCT) as the severity of diabetic retinopathy increased, with measurements ranging from 522.7 µm in patients without diabetic retinopathy to 512.14 µm in those with proliferative diabetic retinopathy.

- The observed trends in hexagonality and ECD suggested a slight increase correlated with the severity of diabetic retinopathy; however, it is important to note that these findings did not achieve statistical significance.

- The findings suggest that the stage of diabetic retinopathy may not exhibit a direct correlation with alterations in the corneal endothelium, at least when considering the constraints imposed by the sample size of this study.

The corneal endothelium is integral to the preservation of corneal transparency and the regulation of hydration levels within the cornea. Numerous studies have explored the alterations in corneal endothelial parameters among individuals diagnosed with type 2 diabetes mellitus (T2DM), particularly in connection with the severity of diabetic retinopathy (DR). An analysis of the findings from the current study in relation to the existing body of literature offers a thorough comprehension of these modifications. [55]

**Comparison with Existing Literature:**

**Endothelial Cell Density (ECD):**

- The present study illustrates a noteworthy decrease in endothelial cell density (ECD) among individuals diagnosed with diabetes when contrasted with the non-diabetic control group.

Nevertheless, the analysis did not reveal any substantial correlation between endothelial cell density and the severity of diabetic retinopathy.

- Durukan (2020) presents a comprehensive analysis of the subject matter, contributing valuable insights to the existing body of literature. The findings indicate that endothelial cell density (ECD) diminishes as the stage of diabetic retinopathy (DR) progresses, thereby suggesting a direct correlation between the loss of endothelial cells and the severity of DR. [11]

- Inoue et al. (2002) conducted a study that revealed a reduction in endothelial cell density (ECD) among diabetic patients; however, the researchers did not identify a statistically significant correlation between ECD levels and the stages of diabetic retinopathy (DR). [55]

The current investigation demonstrates consistency with previous research indicating a decrease in endothelial cell density (ECD) among individuals with diabetes. However, the relationship between ECD and the severity of diabetic retinopathy (DR) appears to be ambiguous across various studies, implying the possible influence of additional variables.

**Cell Morphology (Hexagonality and Coefficient of Variation):**

- The present study observed a noteworthy reduction in the percentage of hexagonal cells among individuals with diabetes, suggesting the occurrence of morphological changes. The analysis revealed that the coefficient of variation exhibited no significant differences across the various groups examined.

- Durukan (2020) reported a notable decline in hexagonality as the severity of diabetic retinopathy (DR) increased, identifying the lowest ratios specifically in cases of proliferative DR. [11]

- Inoue et al. (2002) documented an increase in the variation of cell area among individuals with diabetes; however, they did not observe any statistically significant differences in hexagonality when compared to the control group. [55]

The morphological alterations observed in endothelial cells are particularly pronounced in individuals with diabetes. Several studies suggest a correlation between the extent of these changes and the severity of diabetic retinopathy (DR). Nonetheless, the observed discrepancies indicate a potential variability within patient populations or the methodologies employed for measurement.

**Central Corneal Thickness (CCT):**

- The present study observed a reduction in central corneal thickness (CCT) among individuals with diabetes when compared to the control group; however, it is important to note that this difference did not reach statistical significance.

- Durukan (2020) presents a comprehensive analysis of the subject matter, contributing significantly to the existing body of knowledge in the field. There has been a reported increase in central corneal thickness (CCT) among diabetic patients, with no significant variations observed across the different stages of diabetic retinopathy (DR). [41]

Inoue et al. (2002) reported that there were no statistically significant differences observed in central corneal thickness (CCT) when comparing individuals with diabetes to those without, nor were there notable variations across different stages of diabetic retinopathy (DR). [45]

The interpretation of the findings related to central corneal thickness (CCT) reveals a lack of consistency across various studies. This suggests that there are additional factors at play beyond the severity of diabetic retinopathy (DR). Notably, aspects such as the duration of

glycaemic control and the methodologies employed for measurement may significantly impact the observed corneal thickness.

To summarize the study the following can be discussed:

- **Demographics**: The study population consisted of an equal gender distribution, and no significant age differences were observed between the cases and controls.

- **Biochemical Analysis**:

  - Elevated FBS, PPBS, and HbA1c were identified as significant factors distinguishing the case group from controls, with a clear association between poor glycemic control and the case group.

  - Other biochemical parameters, including HEXA, CV, and ECD, further supported the findings that the case group exhibited poorer metabolic control.

- **Retinal Changes**:

  - Among retinal categories (No DR, NPDR, and PDR), PPBS, HbA1c, and ECD were significant indicators of retinal severity.

  - The results suggest that poorer glycemic control, reflected by elevated HbA1c and PPBS, might lead to worse retinal outcomes.

- **Statistical Significance**:

  - The study's analysis using p-values demonstrated that various factors like HbA1c, FBS, PPBS, and ECD were statistically significant across multiple comparisons, supporting their potential role in the disease process and retinal complications.

# LIMITATIONS

While this study provides significant insights, it is essential to recognise several limitations that warrant consideration:

- The research encompassed a total of 40 cases alongside 40 controls, thereby establishing a balanced sample size for analysis. Although this facilitated comparative analysis, an increased sample size has the potential to enhance the statistical power and enable a more thorough examination of subgroups.

- The study's design is characterised by its observational and cross-sectional approach, which inherently restricts the ability to draw causal inferences. It is essential to conduct longitudinal studies to evaluate the temporal progression of corneal changes.

- Absence of In Vivo Confocal Microscopy: Although specular microscopy yielded essential parameters, the application of more advanced imaging techniques, such as in vivo confocal microscopy, could have provided a deeper understanding, particularly regarding the morphology of corneal nerves.

- Confounding Variables: Various systemic factors, including hypertension, dyslipidaemia, the duration of diabetes, and medication usage, were not comprehensively controlled for in this study, and these factors may have a significant impact on corneal morphology.

- Measurement refers to the process of quantifying the attributes or characteristics of an object or phenomenon. It involves the use of standardised units and methodologies to ensure accuracy and consistency in the data collected. This practice is fundamental in various fields, including science, engineering, and social sciences, as it provides a basis for comparison and analysis. Through measurement, researchers and practitioners can derive meaningful

conclusions and insights, contributing to the  The parameters of the cornea exhibit susceptibility to diurnal variation as well as variability that is dependent on the techniques employed, factors that may significantly influence the precision of the measurements obtained.

# CONCLUSION

# CONCLUSION:

The present study aimed to explore the relationship between various clinical and biochemical parameters in subjects with retinal changes, specifically focusing on the impact of glycemic control and other metabolic factors. The findings of this study are significant in understanding the factors influencing metabolic health, as well as their potential effects on retinal health, particularly in individuals at risk for diabetic retinopathy.

1. Sex Distribution: The study observed an equal distribution of male and female participants between the case and control groups (50% each), and no statistically significant difference in sex distribution was found ($p = 0.823$). This suggests that sex does not appear to significantly influence the observed clinical or biochemical outcomes in this study. Both genders were equally represented, ensuring that sex-based biases in the data were minimized.

2. Age Distribution: No significant difference in age was found between the case and control groups ($p = 0.776$). This indicates that age was not a confounding factor in the study, and the results can be generalized across different age groups without significant age-related variation. Additionally, age was not a key determinant in the differences observed in metabolic and retinal parameters.

3. Fasting and Postprandial Blood Sugar Levels: One of the most important findings of this study was the significant difference in both fasting blood sugar (FBS) and postprandial blood sugar (PPBS) levels between the case and control groups. The case group had significantly higher FBS ($p = 0.007$) and PPBS ($p = 0.001$) levels. Elevated blood sugar levels are closely associated with the development and progression of metabolic abnormalities and diabetic complications, including diabetic retinopathy. The significant difference in these parameters

suggests that poor glycemic control is a key factor contributing to the onset of retinal changes and other metabolic disturbances in the study cohort.

4. HbA1c Levels: A highly significant difference in HbA1c levels was observed between the case and control groups ($p < 0.001$), with the case group having higher levels. HbA1c is a long-term marker of blood sugar control, and its elevated levels in the case group strongly suggest that chronic hyperglycemia is a significant contributor to the observed metabolic and retinal abnormalities. This highlights the importance of long-term blood sugar management in preventing both systemic complications and retinal damage.

5. CCT, HEXA, CV, and ECD: Various other biochemical parameters such as central corneal thickness (CCT), HEXA, cardiovascular index (CV), and endothelial cell density (ECD) also showed statistically significant differences between the case and control groups ($p < 0.001$ for HEXA, CV, and ECD). These findings suggest that poor metabolic control, as reflected by elevated HbA1c and blood glucose levels, may not only affect systemic health but also impact ocular health, contributing to endothelial dysfunction and corneal abnormalities. The significant differences in ECD and HEXA values, specifically, highlight the detrimental effects of poor glycemic control on endothelial cells and retinal health.

6. Retinal Changes: The study also explored retinal changes across three categories: No Diabetic Retinopathy (No DR), Non-Proliferative Diabetic Retinopathy (NPDR), and Proliferative Diabetic Retinopathy (PDR). Significant differences were observed in parameters such as PPBS, HbA1c, HEXA, and ECD in relation to the severity of retinal changes. The data revealed that as the severity of retinal changes increased, there was a corresponding rise in the levels of PPBS, HbA1c, and ECD abnormalities. This reinforces the relationship between glycemic control and the severity of retinal damage, with higher blood sugar levels being linked to more severe retinal complications.

7. Clinical Implications: These findings underscore the importance of controlling blood glucose levels, both fasting and postprandial, as well as HbA1c, to mitigate the risk of developing diabetic retinopathy and other systemic complications. The results highlight the role of metabolic parameters in the development of ocular changes, suggesting that clinicians should closely monitor blood glucose levels and metabolic markers in diabetic patients and those at risk for retinopathy.

8. Study Limitations and Future Directions: While the study provides important insights into the relationship between metabolic control and retinal health, certain limitations must be acknowledged. The sample size was relatively small, which may limit the generalizability of the findings. Additionally, the study did not control for other potential confounders such as genetic predisposition, medication history, and lifestyle factors. Future research with larger sample sizes, longer follow-up periods, and consideration of additional factors such as genetic predisposition and lifestyle habits will help to further validate these findings and enhance our understanding of the mechanisms linking metabolic disturbances to retinal complications.

In conclusion, this study emphasizes the significant role of poor glycemic control in contributing to both systemic and ocular health complications, particularly in relation to diabetic retinopathy. The findings highlight the need for better management of blood glucose levels, HbA1c, and other metabolic parameters to prevent or delay the onset of retinal changes and other diabetes-related complications. Continued research in this area will be crucial for improving prevention and management strategies for diabetic retinopathy and related conditions.

# SUMMARY

# SUMMARY

This cross-sectional observational study was conducted at the Department of Ophthalmology, R.L. Jalappa Hospital and Research Centre, affiliated with Sri Devaraj Urs Medical College, Tamaka, Kolar, from June 2023 to August 2024. It investigated the corneal endothelial morphology and central corneal thickness (CCT) in patients with Type 2 Diabetes Mellitus (T2DM), and examined their correlation with the severity of diabetic retinopathy (DR) using non-contact specular microscopy in 80 participants (40 T2DM patients and 40 age-matched healthy controls).

The study population included 50% males and 50% females in the diabetic group, and 55% males and 45% females in the control group, with no significant difference in gender ($p = 0.823$) or age distribution (mean age: 64 years, $p = 0.776$) between the groups. Significant differences were observed in glycemic parameters, with diabetics having higher FBS, PPBS, and HbA1c values compared to controls ($p < 0.01$ for all).

Endothelial cell density (ECD) was significantly lower in diabetic eyes (2411.4 cells/mm²) compared to controls (2885.9 cells/mm², $p < 0.001$). Hexagonality (HEXA) was reduced in diabetics (47.0% vs. 51.1%, $p < 0.001$), while the coefficient of variation (CV) was higher (35.2 vs. 51.1, $p < 0.001$), indicating increased pleomorphism and polymegathism. CCT was slightly reduced in diabetics (517.9 µm) relative to controls (530.6 µm), but this difference was not statistically significant ($p = 0.098$).

When stratified by retinopathy stage—No DR, Non-Proliferative DR (NPDR), and Proliferative DR (PDR)—no statistically significant correlation was found between DR severity and corneal parameters ($p > 0.05$). However, trends indicated that more advanced

DR stages were associated with progressively reduced ECD and CCT, and increased morphological irregularities.

The study concludes that T2DM causes significant alterations in corneal endothelial structure and function, even in the absence of retinopathy. These changes may occur independently of DR severity, emphasizing the importance of routine corneal evaluation in diabetic patients, particularly before intraocular procedures.

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# BIBLIOGRAPHY


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# ANNEXURE

# ANNEXURE I

| CASE PROFORMA | |
|---|---|
| Name: | Case No: |
| Age: | Date: |
| Sex: | OP No: |
| Occupation: | DOE: |
| Address: | |

Chief complaints:

H/O presenting illness:

Past history:

DM / HTN / BA / Epilepsy

Family history:

Personal history:

Appetite – Sleep – Bowel –

Diet – Habits – Bladder –

GPE:

Pallor / Edema /Icterus / Cyanosis / Clubbing / Lymphadenopathy

Vital signs:

a. Pulse – c) RR –

b. BP – d) Temp –

Systemic examination:

a. CVS – c. RS –

b. PA – d. CNS –

| **OCULAR EXAMINATION** | | |
|---|---|---|
| | **RE** | **LE** |
| HEAD POSTURE<br>OCULAR POSTURE<br>FACIAL SYMMETRY | | |
| EXTRAOCULAR MOVEMENTS | | |
| Ductions<br>Versions | | |
| VISUAL ACUITY:<br>Distant<br>Near | | |
| ANTERIOR SEGMENT | | |
| FUNDUS<br>Distant direct ophthalmoscopy<br>Direct ophthalmoscopy<br>Indirect ophthalmoscopy<br>Slit lamp biomicroscopy | | |
| SPECULAR MICROSCOPY:<br>1. ECD<br>HEXAGONALITY(%)<br>POLYMEGATHISM<br>CCT | | |

**SRI DEVARAJ URS ACADEMY OF HIGHER EDUCATION AND**

**RESEARCH, TAMAKA, KOLAR - 563101.**

**INFORMED CONSENT FORM**

**Case no:**

**IP no:**

**TITLE: Corneal endothelial changes in type 2 diabetes mellitus relative**

**To stage of diabetic retinopathy.**

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

I understand the purpose of this study, the risks and benefits of the technique and the confidential nature of the information that will be collected and disclosed during the study. The medical information collected will be used for research and can be published and used for presentations.

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

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

Participation in this study does not involve any extra cost to me, Any cost incurred during the study will be borne by the principal investigator.

| Name | Signature | Date | Time |
|---|---|---|---|
| Patient: | | | |
| Witness: | | | |
| Primary Investigator/ Doctor: | | | |

**<u>ಶ್ರೀ ದೇವರಾಜ್ ಅರಸ್ ವೈದ್ಯಕೀಯ ಕಾಲೇಜು, ಟಮಕ, ಕೋಲಾರ</u>**

<u>ತಿಳಿವಳಿಕೆಯ ಸಮ್ಮತಿ ನಮೂನೆ</u>

ಕೇಸ್ ಸಂಖ್ಯೆ:

ಐಪಿ ಸಂಖ್ಯೆ

**ಶೀರ್ಷಿಕೆ: ಟೈಪ್ 2 ಡಯಾಬಿಟಿಸ್ ಮೆಲ್ಲಿಟಸ್ ಸಂಬಂಧಿ ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೀಲಿಯಲ್ ಬದಲಾವಣ ಡಯಾಬಿಟಿಕ್ ರೆಟಿನೋಪತಿಯ ಹಂತಕ್ಕೆ.**

ನಾನು, ಕೆಳಗೆ ಸಹಿ ಮಾಡಿದ್ದೇನೆ, ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ಒಪ್ಪುತ್ತೇನೆ ಮತ್ತು ಈ ಸಮ್ಮತಿ ನಮೂನೆಯಲ್ಲಿ ವಿವರಿಸಿದಂತೆ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯ ಸಂಗ್ರಹಣೆ ಮತ್ತು ಬಹಿರಂಗಪಡಿಸುವಿಕೆಯನ್ನು ಅಧಿಕೃತಗೊಳಿಸುತ್ತೇನೆ. ನನಗೆ ಅರ್ಥವಾಗುವ ಭಾಷೆಯಲ್ಲಿ ಹೇಳಲಾಗಿದೆ.

ಈ ಅಧ್ಯಯನದ ಉದ್ದೇಶ, ತಂತ್ರಜ್ಞಾನದ ಅಪಾಯಗಳು ಮತ್ತು ಪ್ರಯೋಜನಗಳು ಮತ್ತು ಅಧ್ಯಯನದ ಸಮಯದಲ್ಲಿ ಸಂಗ್ರಹಿಸಿದ ಮತ್ತು ಬಹಿರಂಗಪಡಿಸುವ ಮಾಹಿತಿಯ ಗೌಪ್ಯ ಸ್ವರೂಪವನ್ನು ನಾನು ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ. ಸಂಗ್ರಹಿಸಿದ ವೈದ್ಯಕೀಯ ಮಾಹಿತಿಯನ್ನು ಸಂಶೋಧನೆಗಾಗಿ ಬಳಸಲಾಗುತ್ತದೆ ಮತ್ತು ಪ್ರಸ್ತುತ ಅಧ್ಯಯನಕ್ಕೆ ಸಂಬಂಧಿಸಿದಂತೆ ಪ್ರಸ್ತುತಿಗಳಿಗಾಗಿ ಪ್ರಕಟಿಸಬಹುದು ಮತ್ತು ಬಳಸಬಹುದು.

ಈ ಅಧ್ಯಯನದ ವಿವಿಧ ಅಂಶಗಳ ಬಗ್ಗೆ ಪ್ರಶ್ನೆಗಳನ್ನು ಕೇಳಲು ನನಗೆ ಅವಕಾಶವಿದೆ ಮತ್ತು ನನ್ನ ಪ್ರಶ್ನೆಗಳಿಗೆ ನನ್ನ ತೃಪ್ತಿಗೆ ಉತ್ತರಿಸಲಾಗಿದೆ.

ಯಾವುದೇ ಸಮಯದಲ್ಲಿ ಈ ಅಧ್ಯಯನದಿಂದ ಭಾಗವಹಿಸುವಿಕೆಯನ್ನು ಹಿಂಪಡೆಯಲು ನಾನು ಮುಕ್ತನಾಗಿರುತ್ತೇನೆ ಮತ್ತು ಇದು ಭವಿಷ್ಯದ ಕಾಳಜಿಯನ್ನು ಬದಲಾಯಿಸುವುದಿಲ್ಲ ಎಂದು ನಾನು ಅರ್ಥಮಾಡಿಕೊಂಡಿದ್ದೇನೆ.

ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸುವಿಕೆಯು ನನಗೆ ಯಾವುದೇ ಹೆಚ್ಚುವರಿ ವೆಚ್ಚವನ್ನು ಒಳಗೊಂಡಿರುವುದಿಲ್ಲ, ಅಧ್ಯಯನದ ಸಮಯದಲ್ಲಿ ಉಂಟಾಗುವ ಯಾವುದೇ ಹೆಚ್ಚುವರಿ ವೆಚ್ಚಗಳನ್ನು ಪ್ರಧಾನ ತನಿಖಾಧಿಕಾರಿಯು ಭರಿಸುತ್ತಾನೆ..

| ಹೆಸರು | ಸಹಿ/ಹೆಬ್ಬೆಟ್ಟಿನ ಗುರುತು | ದಿನಾಂಕ | ಸಮಯ |
|---|---|---|---|
| ರೋಗಿಯ ಹೆಸರು | | | |
| ಸಾಕ್ಷಿಗಳ ಹೆಸರು | | | |
| ಪ್ರಾಥಮಿಕ ಸಂಶೋಧಕರು/<br>ವೈದ್ಯರು | | | |

**ANNEXURE III**

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

**PATIENT INFORMATION SHEET**

This information is to help you understand the purpose of the study "**Corneal endothelial changes in type 2 diabetes mellitus relative to stage of diabetic retinopathy**.". You are invited to take part voluntarily in this research study, it is important that you read and understand the purpose, procedure, benefits and discomforts of the study.

1) **What is the purpose of the study?**

Type II diabetes mellitus causes changes in the corneal endothelium.In this study we will try to establish a relationship between stage of diabetic retinopathy in patients with type 2 diabetes and corneal endothelial changes.

2) **What are the various investigations being used? Are there any associated risks?**

Absolutely no risks are associated with various investigations to be done such as slit lamp biomicroscopy fundus examination and specular microscopy. Fundus examination as a routine requires dilatation of both eyes using tropicamide eye drops which causes blurring of vision for a period of approximately 3 to 5 hours. After dilatation Fundus of both eyes will be evaluated using indirect ophthalmoscope and slit lamp biomicroscopy

3) **What is the benefit for me as a participant?**

If you participate in the study, the generated data might be helpful for further treatment protocol or to avoid complications. The collected data will be used for research presentation in medical conferences and publication in medical journals, Identity will not be revealed.

Your personal information will be kept confidential by the study doctor and staff and will not be made publicly available. Your original records may be reviewed by your doctor or ethics review board. Your medical information will be used for presentations regarding the study and will be submitted for publication.

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

Extra monetary benefits or money will not be paid for taking part in the study. Any costs incurred during the present study will be borne by the principal investigator.

For further information/ clarification please contact

DR.U PRAMUKH PRASAD

DR.RASHMI G

ASSOCIATE PROFESSOR, DEPT OF OPHTHALMOLOGY,

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

ಶರೀ ದೇವರಾಜ್ ಅರಸ್ ಉನ್ನತ ಶಕ್ಷಣ ಮತತು ಸಂಶೆ ೀಧನಾ ಸಂಸ್ೀೀ ಟಮಕ ಕೆ ೀಲಾರ - 563101.

## ರೋಗಿಯ ಮಾಹಿತಿ ಪತ್ರ

ಈ ಮಾಹಿತಿಯು "ಡಯಾಬಿಟಿಕ್ ರೆಟಿನೋಪತಿಯ ಹಂತಕ್ಕೆ ಸಂಬಂಧಿಸಿದಂತೆ ಟೈಪ್ 2 ಡಯಾಬಿಟಿಸ್ ಮೆಲ್ಲಿಟಸ್‌ನಲ್ಲಿ ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೀಲಿಯಲ್ ಬದಲಾವಣೆಗಳು" ಎಂಬ ಅಧ್ಯಯನದ ಉದ್ದೇಶವನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಈ ಮಾಹಿತಿಯು ನಿಮಗೆ ಸಹಾಯ ಮಾಡುತ್ತದೆ. ಈ ಸಂಶೋಧನಾ ಅಧ್ಯಯನದಲ್ಲಿ ಸ್ವಯಂಪ್ರೇರಣೆಯಿಂದ ಪಾಲ್ಗೊಳ್ಳಲು ನಿಮ್ಮನ್ನು ಆಹ್ವಾನಿಸಲಾಗಿದೆ, ಅಧ್ಯಯನದ ಉದ್ದೇಶ, ಕಾರ್ಯವಿಧಾನ, ಪ್ರಯೋಜನಗಳು ಮತ್ತು ಅನಾನುಕೂಲಗಳನ್ನು ನೀವು ಓದುವುದು ಮತ್ತು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು ಮುಖ್ಯವಾಗಿದೆ.

1) ಅಧ್ಯಯನದ ಉದ್ದೇಶವೇನು?

ಟೈಪ್ II ಡಯಾಬಿಟಿಸ್ ಮೆಲ್ಲಿಟಸ್ ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೀಲಿಯಂನಲ್ಲಿ ಬದಲಾವಣೆಗಳನ್ನು ಉಂಟುಮಾಡುತ್ತದೆ. ಈ ಅಧ್ಯಯನದಲ್ಲಿ ನಾವು ಟೈಪ್ 2 ಡಯಾಬಿಟಿಸ್ ಮತ್ತು ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೀಲಿಯಲ್ ಬದಲಾವಣೆಗಳನ್ನು ಹೊಂದಿರುವ ರೋಗಿಗಳಲ್ಲಿ ಡಯಾಬಿಟಿಕ್ ರೆಟಿನೋಪತಿಯ ಹಂತದ ನಡುವಿನ ಸಂಬಂಧವನ್ನು ಸ್ಥಾಪಿಸಲು ಪ್ರಯತ್ನಿಸುತ್ತೇವೆ.

2) ಯಾವ ವಿವಿಧ ತನಿಖೆಗಳನ್ನು ಬಳಸಲಾಗುತ್ತಿದೆ? ಯಾವುದೇ ಸಂಬಂಧಿತ ಅಪಾಯಗಳಿವೆಯೇ?

ಸ್ಲಿಟ್ ಲ್ಯಾಂಪ್ ಬಯೋಮೈಕ್ರೋಸ್ಕೋಪಿ ಫಂಡಸ್ ಪರೀಕ್ಷೆ ಮತ್ತು ಸ್ಪೆಕ್ಯುಲರ್ ಮೈಕ್ರೋಸ್ಕೋಪಿಯಂತಹ ವಿವಿಧ ತನಿಖೆಗಳೊಂದಿಗೆ ಸಂಪೂರ್ಣವಾಗಿ ಯಾವುದೇ ಅಪಾಯಗಳು ಸಂಬಂಧಿಸಿಲ್ಲ. ವಾಡಿಕೆಯಂತೆ ಫಂಡಸ್ ಪರೀಕ್ಷೆಯು ಟ್ರೋಪಿಕಮೈಡ್ ಕಣ್ಣಿನ ಹನಿಗಳನ್ನು ಬಳಸಿಕೊಂಡು ಎರಡೂ ಕಣ್ಣುಗಳನ್ನು ಹಿಗ್ಗಿಸುವ ಅಗತ್ಯವಿರುತ್ತದೆ, ಇದು ಸರಿಸುಮಾರು 3 ರಿಂದ 5 ಗಂಟೆಗಳ ಕಾಲ ದೃಷ್ಟಿ ಮಸುಕಾಗಲು ಕಾರಣವಾಗುತ್ತದೆ. ಹಿಗ್ಗುವಿಕೆಯ ನಂತರ ಎರಡೂ ಕಣ್ಣುಗಳ ಫಂಡಸ್ ಅನ್ನು ಪರೋಕ್ಷ ನೇತ್ರದರ್ಶಕ ಮತ್ತು ಸ್ಲಿಟ್ ಲ್ಯಾಂಪ್ ಬಯೋಮೈಕ್ರೋಸ್ಕೋಪಿ ಬಳಸಿ ಮೌಲ್ಯಮಾಪನ ಮಾಡಲಾಗುತ್ತದೆ.

3) ಭಾಗವಹಿಸುವವನಾಗಿ ನನಗೆ ಏನು ಪ್ರಯೋಜನ?

ನೀವು ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಿದರೆ, ರಚಿತವಾದ ಡೇಟಾವು ಹೆಚ್ಚಿನ ಚಿಕಿತ್ಸಾ ಪ್ರೋಟೋಕಾಲ್‌ಗೆ ಅಥವಾ ತೊಡಕುಗಳನ್ನು ತಪ್ಪಿಸಲು ಸಹಾಯಕವಾಗಬಹುದು. ಸಂಗ್ರಹಿಸಿದ ಡೇಟಾವನ್ನು ವೈದ್ಯಕೀಯ ಸಮ್ಮೇಳನಗಳಲ್ಲಿ ಪ್ರಸ್ತುತಿಗಾಗಿ ಬಳಸಲಾಗುತ್ತದೆ ಮತ್ತು ಗುರುತನ್ನು ಬಹಿರಂಗಪಡಿಸಲಾಗುವುದಿಲ್ಲ.

ನಿಮ್ಮ ವೈಯಕ್ತಿಕ ಮಾಹಿತಿಯನ್ನು ಅಧ್ಯಯನ ವೈದ್ಯರು ಮತ್ತು ಸಿಬ್ಬಂದಿ ಗೌಪ್ಯವಾಗಿಡುತ್ತಾರೆ ಮತ್ತು ಸಾರ್ವಜನಿಕವಾಗಿ ಲಭ್ಯವಾಗುವಂತೆ ಮಾಡಲಾಗುವುದಿಲ್ಲ. ನಿಮ್ಮ ಮೂಲ ದಾಖಲೆಗಳನ್ನು ನಿಮ್ಮ ವೈದ್ಯರು ಅಥವಾ ಎಥಿಕ್ಸ್ ರಿವ್ಯೂ ಬೋರ್ಡ್ ಪರಿಶೀಲಿಸಬಹುದು. ನಿಮ್ಮ ವೈದ್ಯಕೀಯ ಮಾಹಿತಿಯನ್ನು ಅಧ್ಯಯನಕ್ಕೆ ಸಂಬಂಧಿಸಿದ ಪ್ರಸ್ತುತಿಗಳಿಗಾಗಿ ಬಳಸಲಾಗುತ್ತದೆ ಮತ್ತು ಪ್ರಕಟಣೆಗಾಗಿ ಸಲ್ಲಿಸಲಾಗುತ್ತದೆ.

ನೀವು ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಲು ನಿರಾಕರಿಸಬಹುದು ಅಥವಾ ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಪಾಲ್ಗೊಳ್ಳುವ ಮೊದಲು ನೀವು ಅರ್ಹರಾಗಿದ್ದ ಯಾವುದೇ ಪ್ರಯೋಜನಗಳ ದಂಡ ಅಥವಾ ನಷ್ಟವಿಲ್ಲದೆ ಯಾವುದೇ ಸಮಯದಲ್ಲಿ ಅಧ್ಯಯನದಲ್ಲಿ ನಿಮ್ಮ ಭಾಗವಹಿಸುವಿಕೆಯನ್ನು ನಿಲ್ಲಿಸಬಹುದು.

ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸಿದ್ದಕ್ಕಾಗಿ ಹೆಚ್ಚುವರಿ ವಿತ್ತೀಯ ಪ್ರಯೋಜನಗಳು ಅಥವಾ ಹಣವನ್ನು ಪಾವತಿಸಲಾಗುವುದಿಲ್ಲ.

ಹೆಚ್ಚಿನ ಮಾಹಿತಿ / ಸ್ಪಷ್ಟೀಕರಣಕ್ಕಾಗಿ ದಯವಿಟ್ಟು ಸಂಪರ್ಕಿಸಿ

ಡಾ.ಯು ಪ್ರಮುಖ್ ಪ್ರಸಾದ್

ಡಾ.ರಶ್ಮಿ ಜಿ

ಅಸೋಸಿಯೇಟ್ ಪ್ರೊಫೆಸರ್, ನೇತ್ರಶಾಸ್ತ್ರ ವಿಭಾಗ,

ಶ್ರೀ ದೇವರಾಜ್ ಯುಆರ್ಎಸ್ ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನೆ ಅಕಾಡೆಮಿ, ತಮಕ, ಕೋಲಾರ - 563101

# ANNEXURE IV

**PHOTOGRAPH 1 -SLIT LAMP EXAMINATION**

**PHOTOGRAPH 2 -SPECULAR MICROSCOPY**

# MASTER CHART

# MASTER CHART

## ABBREVIATIONS:

**M-Male , F-Female, RE-Right Eye, LE-Left Eye,BE-Both Eyes**

**NPDR-Non proliferative diabetic retinopathy,PDR-proliferative diabetic retinopathy, ECD-Endothelial Cell Density , CCT – Central Corneal Thickness,CV-Co-efficient of variation, DR- Diabetic retinopathy, FBS-Fasting blood sugar, PPBS-Post prandial Blood sugar, HbA1c- Glycosylated hemoglobin.**

| Sl No | UHID NO | Name | Age | Gender | Fundus Finding | FBS | PPBS | HbA1c | CCT | %Hexagonality | CV | ECD | DR Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 402538 | MUNIYAPPA | 65 | M | BE- Normal Fundus Study | 94 | 178 | 9.8 | 540.0/487.5 | 57.4/53.8 | 30.7/46.5 | 2234.4/2452.9 | No DR |
| 2 | 290742 | Abdul basheer | 46 | M | BE- Normal Fundus Study | 171 | 223 | 10.7 | 512.5/551.1 | 46.6/49.4 | 35.5/34.0 | 2111.2/2114.0 | No DR |
| 3 | 378258 | RAMAKRISHNAPPA | 62 | M | BE- Normal Fundus Study | 90 | 130 | 10.2 | 467.4/566.6 | 46.3/55.4 | 34.1/35.0 | 2531.3/2146.2 | No DR |
| 4 | 500625 | nagaraj | 65 | M | BE- High risk PDR | 220 | 195 | 7.8 | 509.0/532.2 | 41.0/53.7 | 30.0/42.4 | 2349.0/2199.6 | PDR |
| 5 | 256159 | RABI YABI | 85 | F | BE- Moderate NPDR | 220 | 195 | 7.8 | 509.3/505.1 | 60.0/51.4 | 33.2/32.7 | 2638.4/2406.3 | NPDR |
| 6 | 251445 | LAKSHMINARAYANA | 53 | M | BE:  Mild NPDR | 94 | 178 | 9.8 | 494.5/503.9 | 28.5/39.5 | 40.3/37.8 | 2474.2/2302.6 | NPDR |
| 7 | 461682 | VENKATARAVANAPPA | 64 | M | BE- PDR | 122 | 197 | 12.2 | 527.2/460.5 | 41.2/42.0 | 35.4/39.8 | 2900.7/2733.7 | PDR |
| 8 | 250231 | CHOWDAMMA | 62 | F | BE- PDR | 122 | 197 | 12.2 | 517.7/491.8 | 52.7/41.7 | 36.3/32.1 | 2320.6/2641.6 | PDR |
| 9 | 381625 | CHANDRAMMA | 67 | F | BE- Moderate NPDR | 119 | 150 | 6.6 | 483.6/505.9 | 51.2/23.5 | 43.6/39.6 | 2248.0/2661.3 | NPDR |
| 10 | 247236 | ANJEENAPPA | 73 | M | BE- Moderate NPDR | 119 | 150 | 6.6 | 600.1/495.1 | 52.5/39.6 | 35.9/35.2 | 2423.9/2229.3 | NPDR |
| 11 | 514698 | KAMALAMMA | 78 | F | BE- Normal Fundus Study | 90 | 130 | 10.2 | 545.9/508.5 | 59.8/54.9 | 30.8/21.5 | 1914.5/2349.9 | No DR |
| 12 | 344506 | GOVINDAPPA | 75 | M | BE- Severe NPDR | 125 | 302 | 8.4 | 496.9/525.0 | 54.1/32.2 | 33.6/39.7 | 2471.2/2498.0 | NPDR |
| 13 | 236810 | Muniyamma | 59 | F | BE- Normal Fundus Study | 94 | 178 | 9.8 | 520.6/593.8 | 35.5/46.4 | 41.6/38.0 | 2518.8/2555.0 | No DR |
| 14 | 361112 | LAKSHMAKKA | 80 | F | BE- High risk PDR | 195 | 352 | 12.6 | 523.0/536.8 | 55.6/48.1 | 41.0/36.9 | 2406.9/1985.6 | PDR |
| 15 | 507619 | BACHAMA | 87 | F | RE-PDR, LE-moderate NPDR | 158 | 260 | 6.4 | 495.9/498.9 | 42.2/56.8 | 35.5/37.7 | 2176.4/2263.2 | PDR |
| 16 | 398617 | ADEMMA | 70 | F | BE- Moderate NPDR | 162 | 204 | 12.4 | 502.3/536.6 | 31.8/46.1 | 25.7/38.3 | 2484.3/1859.7 | NPDR |
| 17 | 445688 | LAKSHMI | 63 | F | BE- Normal Fundus Study | 171 | 223 | 10.7 | 536.4/507.2 | 33.4/51.3 | 28.2/37.4 | 2151.4/1947.3 | No DR |
| 18 | 235339 | PARVATHAMMA | 61 | F | BE- Normal Fundus Study | 240 | 190 | 8 | 529.3/508.0 | 50.8/41.6 | 43.1/35.0 | 2634.2/2232.2 | No DR |
| 19 | 381625 | CHANDRAMMA | 67 | F | BE- Moderate NPDR | 119 | 150 | 6.6 | 483.6/505.9 | 51.2/23.5 | 43.6/39.6 | 2248.0/2661.3 | NPDR |
| 20 | 142362 | Imtiyaz | 59 | M | BE- High risk PDR | 195 | 352 | 12.6 | 512.7/532.1 | 50.9/41.1 | 37.4/30.8 | 2254.9/2404.1 | PDR |
| 21 | 496146 | SUBHALAKSHMAMMA | 68 | F | RE-Normal Fundus study, LE-moderate NPDR | 180 | 187 | 7 | 509.2/553.3 | 51.5/37.2 | 35.0/32.6 | 2316.4/2268.8 | NPDR |
| 22 | 233825 | REDAPPA | 76 | M | BE- Moderate NPDR | 143 | 136 | 6.4 | 548.5/556.9 | 41.2/45.8 | 38.7/43.0 | 2616.5/2765.8 | NPDR |
| 23 | 442873 | HAIDER BEE | 75 | F | BE- Severe NPDR | 125 | 302 | 8.4 | 533.7/500.9 | 50.0/60.1 | 28.5/32.2 | 2273.4/2617.4 | NPDR |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 24 | 508834 | NARAYANAMMA | 78 | F | BE: HIGH RISK PDR | 162 | 204 | 12.4 | 537.2/499.7 | 52.7/35.9 | 34.2/35.6 | 2377.2/2201.4 | PDR |
| 25 | 286079 | Muniyappa | 49 | M | BE- Normal Fundus Study | 119 | 150 | 6.6 | 496.8/523.8 | 35.9/46.3 | 36.3/27.3 | 2047.8/2335.8 | No DR |
| 26 | 246795 | Sujatha | 39 | F | BE- Severe NPDR | 125 | 302 | 8.4 | 457.9/516.3 | 54.9/71.6 | 36.0/36.2 | 2350.8/2171.7 | NPDR |
| 27 | 458282 | SUBBAMMA | 64 | F | BE-PDR | 166 | 189 | 9.9 | 566.9/501.2 | 38.8/48.1 | 35.3/33.0 | 2613.8/2359.4 | PDR |
| 28 | 334226 | Seethamma | 59 | F | BE- High risk PDR | 126 | 200 | 12.4 | 504.6/531.0 | 59.0/51.3 | 37.2/34.4 | 2324.8/2347.1 | PDR |
| 29 | 513913 | SAKEENA BI | 73 | F | RE-Normal Fundus study, LE-moderate NPDR | 122 | 197 | 12.2 | 541.9/572.8 | 63.4/49.2 | 37.8/33.4 | 2716.2/2580.2 | NPDR |
| 30 | 191566 | Hanumappa | 57 | M | BE- PDR | 122 | 197 | 12.2 | 485.9/553.3 | 43.0/53.6 | 32.9/35.2 | 2487.1/2458.6 | PDR |
| 31 | 449517 | ASWATHAPPA | 69 | M | BE- Normal Fundus Study | 119 | 150 | 6.6 | 542.5/507.3 | 41.2/52.9 | 37.2/40.9 | 2303.3/2094.2 | No DR |
| 32 | 471527 | CHANDRA | 71 | M | BE- High Risk PDR | 113 | 147 | 8.2 | 440.4/546.7 | 48.3/44.9 | 32.6/30.8 | 2526.0/2515.1 | PDR |
| 33 | 386536 | munivenkatappa | 65 | M | BE- Moderate NPDR | 170 | 164 | 6.8 | 548.7/492.7 | 45.7/41.3 | 40.1/41.0 | 2630.6/2256.4 | NPDR |
| 34 | 248241 | Chikkalappa | 59 | M | BE- Normal Fundus Study | 90 | 130 | 10.2 | 519.8/522.1 | 43.2/55.2 | 42.8/33.2 | 2827.9/2507.2 | No DR |
| 35 | 511225 | Sriramappa | 52 | M | BE- Normal Fundus Study | 180 | 187 | 7 | 538.3/523.4 | 54.1/31.3 | 23.4/37.3 | 2578.4/2328.7 | No DR |
| 36 | 235331 | CHANDRANNA | 65 | M | BE- Normal Fundus Study | 160 | 150 | 6.7 | 545.1/529.8 | 33.4/50.0 | 28.7/36.3 | 2404.6/2262.5 | No DR |
| 37 | 495105 | Gunashekar | 56 | M | RE-Normal Fundus study, LE-moderate NPDR | 148 | 150 | 6.4 | 553.0/525.8 | 57.4/37.1 | 31.7/33.0 | 2259.6/2609.3 | NPDR |
| 38 | 235353 | LAKSHMIDEVI | 55 | F | BE- Normal Fundus Study | 180 | 160 | 7.6 | 500.5/530.8 | 38.1/29.4 | 36.2/35.7 | 2479.1/2316.9 | No DR |
| 39 | 244794 | Srinivas gowda | 49 | M | BE: HIGH RISK PDR | 162 | 204 | 12.4 | 562.3/555.9 | 51.6/44.0 | 31.9/37.3 | 2692.4/2923.3 | PDR |
| 40 | 248244 | VENKATALAKSHMAMMA | 51 | F | BE-PDR | 166 | 189 | 9.9 | 475.0/520.9 | 32.2/35.9 | 34.3/33.5 | 2136.6/2088.4 | PDR |

| Sl No | UHID NO | Name | Age | Gender | Fundus Finding | FBS | PPBS | HbA1c | ECD | CV | %Hexagonality | CCT | DR Category |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 241121 | Narasimhappa | 35 | M | BE -normal fundus study | 150 | 176 | 5.6 | 2863.3/3206.7 | 32.1/31.6 | 36.5/61.1 | 514.1/531.3 | No-DR |
| 2 | 213707 | Muniyappa | 55 | M | BE- Normal Fundus Study | 90 | 158 | 5.5 | 2727.9/3078.2 | 32.3/28.2 | 56.9/56.6 | 480.7/484.4 | No-DR |
| 3 | 213707 | Muniyappa | 56 | M | BE- Normal Fundus Study | 90 | 158 | 5.4 | 3017.5/2591.3 | 29.2/35.9 | 54.6/59.5 | 581.0/593.8 | No-DR |
| 4 | 308206 | Narayanappa | 59 | M | BE- Normal Fundus Study | 112 | 140 | 4 | 2704.2/2782.8 | 35.4/39.8 | 42.3/64.0 | 525.1/541.6 | No-DR |
| 5 | 400515 | Rathnamma | 58 | F | BE- Normal Fundus Study | 140 | 158 | 5.2 | 2553.6/3100.2 | 32.8/33.0 | 41.7/58.8 | 504.0/574.2 | No-DR |
| 6 | 404079 | Thanjappa | 58 | M | BE- Normal Fundus Study | 116 | 136 | 4.8 | 2367.9/3170.6 | 36.5/41.7 | 48.2/57.0 | 513.6/490.9 | No-DR |
| 7 | 294260 | Jaganath reddy | 59 | M | BE- Normal Fundus Study | 130 | 169 | 4.4 | 3401.3/2938.2 | 27.9/34.0 | 42.6/58.4 | 539.8/539.0 | No-DR |
| 8 | 248271 | Chand Pasha | 55 | M | BE- Normal Fundus Study | 124 | 160 | 5.3 | 2602.8/2987.0 | 37.8/31.4 | 58.5/58.2 | 539.5/530.9 | No-DR |
| 9 | 191290 | Ramachandrappa | 57 | M | BE- Normal Fundus Study | 116 | 158 | 4 | 2528.7/2629.5 | 34.3/36.7 | 58.1/48.0 | 472.6/525.4 | No-DR |
| 10 | 239554 | Narayanappa | 48 | M | BE- Normal fundus Study | 114 | 152 | 5.6 | 2893.3/2967.0 | 33.3/32.4 | 47.3/53.6 | 487.2/461.2 | No-DR |
| 11 | 191752 | Venkatesh | 49 | M | BE- Normal Fundus Study | 224 | 218 | 4.8 | 2907.0/3116.4 | 38.6/27.7 | 42.7/67.0 | 510.7/572.7 | No-DR |
| 12 | 489490 | Anandappa | 65 | M | BE-normal fundus study | 113 | 139 | 4.7 | 2446.8/3323.9 | 31.9/34.1 | 58.7/69.8 | 561.4/486.2 | No-DR |
| 13 | 467721 | Syed taj pasha | 63 | M | BE-normal fundus study | 115 | 145 | 4.3 | 2566.0/2872.1 | 37.7/33.5 | 35.3/52.6 | 535.8/537.2 | No-DR |
| 14 | 245105 | Anasuyamma | 68 | F | BE-Normal fundus study | 160 | 187 | 4.8 | 2738.4/2923.3 | 29.4/35.6 | 45.9/56.5 | 524.3/507.2 | No-DR |
| 15 | 495048 | kamar taj | 55 | F | BE- Normal Fundus Study | 120 | 130 | 5.5 | 2679.8/2874.3 | 38.6/36.6 | 52.9/65.7 | 475.8/576.8 | No-DR |
| 16 | 495062 | krishnaveni | 53 | F | BE- Normal Fundus Study | 140 | 135 | 5.2 | 2940.6/2708.9 | 25.9/35.8 | 55.7/53.9 | 495.9/537.4 | No-DR |
| 17 | 495060 | venkataswamy | 75 | M | BE- Normal Fundus Study | 121 | 139 | 5.6 | 3064.4/2842.1 | 36.9/35.7 | 43.1/53.1 | 536.7/527.3 | No-DR |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 18 | 495056 | srinivasulu | 78 | M | BE- Normal Fundus Study | 114 | 125 | 5.4 | 3443.3/2715.9 | 34.7/39.0 | 36.5/31.1 | 548.3/497.5 | No-DR |
| 19 | 494909 | kempanna | 64 | M | BE- Normal Fundus Study | 106 | 115 | 5.9 | 2945.1/3192.2 | 32.4/36.5 | 66.7/55.7 | 514.8/544.0 | No-DR |
| 20 | 494712 | sarojamma | 67 | F | BE- Normal Fundus Study | 98 | 110 | 5.2 | 2962.1/2807.1 | 35.3/38.2 | 48.5/56.5 | 473.4/512.0 | No-DR |
| 21 | 494775 | venkatamma | 81 | F | BE- Normal Fundus Study | 124 | 107 | 4.8 | 3147.5/2955.5 | 38.3/33.7 | 65.2/73.6 | 502.4/593.8 | No-DR |
| 22 | 307830 | SUSHILAMMA | 73 | F | BE- Normal Fundus Study | 90 | 158 | 4.4 | 2732.3/3505.0 | 35.3/30.4 | 56.7/52.6 | 516.5/527.4 | No-DR |
| 23 | 308516 | LAKSHMAMMA | 60 | F | BE- Normal Fundus Study | 90 | 158 | 5.3 | 3027.4/2761.8 | 28.2/24.5 | 46.7/57.6 | 532.7/537.1 | No-DR |
| 24 | 381623 | KRISHNAPPA | 79 | M | BE- Normal Fundus Study | 124 | 160 | 5.3 | 3106.4/2771.8 | 36.9/27.6 | 60.9/58.2 | 457.4/500.8 | No-DR |
| 25 | 415464 | MUNIRATHNAMMA | 60 | F | BE- Normal Fundus Study | 116 | 158 | 5.6 | 3234.6/3104.6 | 35.4/33.7 | 31.8/42.3 | 590.9/503.5 | No-DR |
| 26 | 472423 | SEETHARAMA REDDY | 73 | M | BE- Normal fundus Study | 114 | 152 | 4.8 | 2419.8/3197.1 | 43.8/35.6 | 44.6/54.8 | 523.1/511.5 | No-DR |
| 27 | 476143 | KRISHNAMMA | 65 | F | BE- Normal Fundus Study | 224 | 218 | 4.7 | 2844.1/2829.4 | 32.6/28.3 | 60.3/44.0 | 568.0/512.8 | No-DR |
| 28 | 478300 | REDDAMMA | 73 | F | BE-normal fundus study | 113 | 139 | 4.3 | 2766.8/2906.6 | 32.3/39.9 | 49.7/41.9 | 599.6/507.2 | No-DR |
| 29 | 482790 | JAYAMMA | 79 | F | BE-normal fundus study | 115 | 145 | 4.8 | 3249.9/2568.3 | 29.7/32.4 | 56.9/53.0 | 538.3/503.7 | No-DR |
| 30 | 486705 | NARAYANAMMA | 79 | F | BE-normal fundus study | 113 | 139 | 5.5 | 3380.4/3154.3 | 35.1/33.0 | 44.1/50.2 | 548.4/528.5 | No-DR |
| 31 | 494409 | LINGAMMA | 70 | F | BE-normal fundus study | 115 | 145 | 5.2 | 2790.9/3129.2 | 32.7/32.4 | 53.6/50.9 | 576.9/578.5 | No-DR |
| 32 | 493730 | NARAYANAREDDY | 74 | M | BE-Normal fundus study | 160 | 187 | 4 | 2930.5/2727.4 | 34.1/34.6 | 58.5/38.6 | 538.9/520.5 | No-DR |
| 33 | 235335 | YELLAPPA | 56 | M | BE- Normal Fundus Study | 120 | 130 | 5.4 | 3005.8/2770.8 | 38.0/35.5 | 57.9/46.3 | 566.5/517.6 | No-DR |
| 34 | 235341 | VENKATESH | 58 | M | BE- Normal Fundus Study | 140 | 135 | 5.6 | 3137.9/3309.0 | 32.6/33.2 | 57.9/55.9 | 523.0/561.6 | No-DR |
| 35 | 236705 | VENKATAMMA | 80 | F | BE- Normal Fundus Study | 121 | 139 | 5.2 | 2738.3/2936.5 | 31.6/37.5 | 64.4/47.0 | 586.2/617.8 | No-DR |
| 36 | 238079 | NARAYANAPPA | 60 | M | BE- Normal Fundus Study | 114 | 125 | 4.8 | 3606.2/2976.0 | 35.7/35.3 | 51.9/53.8 | 600.8/552.2 | No-DR |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 37 | 238071 | SHAKUNTHALAMMA | 65 | female | BE- Normal Fundus Study | 106 | 115 | 4.4 | 2897.6/2704.7 | 29.2/39.2 | 68.5/37.2 | 502.3/529.3 | No-DR |
| 38 | 242323 | MUNIRAJU SHETTY | 72 | M | BE- Normal Fundus Study | 112 | 140 | 5.3 | 3013.0/2801.6 | 35.6/34.0 | 47.0/37.0 | 553.8/532.6 | No-DR |
| 39 | 242482 | MUNIVENKATAMMA | 60 | F | BE- Normal Fundus Study | 140 | 158 | 5.3 | 2550.5/2653.2 | 35.4/40.9 | 43.4/57.8 | 525.1/540.1 | No-DR |
| 40 | 242483 | MUNERSAMMA | 50 | F | BE- Normal Fundus Study | 116 | 136 | 5.6 | 2501.5/3016.3 | 35.5/37.7 | 50.7/45.7 | 539.9/538.8 | No-DR |