"TO STUDY EFFECT OF PTERYGIUM ON CORNEAL ENDOTHELIAL CELL DENSITY BY SPECULAR MICROSCOPY"

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

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Under the guidance of

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2025

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ABSTRACT

PURPOSE

To evaluate the effect of pterygium on corneal endothelial cell density (CECD) using specular microscopy and assess its relationship with central corneal thickness (CCT) in affected and unaffected eyes.

METHODS

This observational cross-sectional study enrolled 83 patients with unilateral pterygium at a single center. The contralateral eyes served as controls. Specular microscopy was used to measure CECD and CCT in both pterygium and control eyes. Demographic data, including age, sex, and laterality, were collected. Statistical analysis included paired t-tests to compare CECD and CCT between groups and Pearson correlation to assess the relationship between CECD and CCT. A p-value <0.05 was considered significant.

RESULTS

The study population comprised 69.9% females, with a mean age of 55.51 years. Pterygium was predominantly right-sided (59%). Mean CECD was significantly lower in pterygium eyes (2332.83 cells/mm²) compared to control eyes (2419 cells/mm²; p<0.05). No significant difference was observed in mean CCT between pterygium (495.06 µm) and control eyes (493.22 µm; p>0.05). Within pterygium eyes, a low but significant positive correlation was found between CECD and CCT (r=0.270, p=0.014), whereas no correlation existed in control eyes (r=0.126, p=0.256).

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LIST OF ABBREVATIONS

Abbreviation	Full Form
CECD	CORNEAL ENDOTHELIAL CELL DENSITY
CCT	CENTRAL CORNEAL THICKNESS
CEC	CORNEAL ENDOTHELIAL CELL
CA	CELL AREA
LSCS	LIMBAL STEM CELLS
OSSN	OCULAR SURFACE SQUAMOUS NEOPLASIA
CV	COEFFICIENT OF VARIATION
IOP	INTRAOCULAR PRESSURE
DM	DIABETES MELLITUS
DED	DRY EYE DISEASE
FECD	FUCHS ENDOTHELIAL CORNEAL DYSTROPHY
FOV	FIELD OF VIEW

ABSTRACT

PURPOSE

To evaluate the effect of pterygium on corneal endothelial cell density (CECD) using specular microscopy and assess its relationship with central corneal thickness (CCT) in affected and unaffected eyes.

METHODS

This observational cross-sectional study enrolled 83 patients with unilateral pterygium at a single center. The contralateral eyes served as controls. Specular microscopy was used to measure CECD and CCT in both pterygium and control eyes. Demographic data, including age, sex, and laterality, were collected. Statistical analysis included paired t-tests to compare CECD and CCT between groups and Pearson correlation to assess the relationship between CECD and CCT. A p-value <0.05 was considered significant.

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The study population comprised 69.9% females, with a mean age of 55.51 years. Pterygium was predominantly right-sided (59%). Mean CECD was significantly lower in pterygium eyes (2332.83 cells/mm²) compared to control eyes (2419 cells/mm²; $p<0.05$). No significant difference was observed in mean CCT between pterygium (495.06 µm) and control eyes (493.22 µm; $p>0.05$). Within pterygium eyes, a low but significant positive correlation was found between CECD and CCT ($r=0.270$, $p=0.014$), whereas no correlation existed in control eyes ($r=0.126$, $p=0.256$).

CONCLUSION

Pterygium is associated with a significant reduction in CECD, potentially due to chronic inflammation and fibrovascular invasion. The positive correlation between CECD and CCT in pterygium eyes suggests structural corneal changes. Longitudinal studies are needed to explore disease progression and management impacts on endothelial health.

Keywords: Pterygium, Corneal Endothelial Cell Density, Specular Microscopy, Central Corneal Thickness, Ocular Surface Disorder

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INTRODUCTION

Pterygium emerges as a frequent ocular surface pathology defined by the progressive invasion of fibrovascular tissue from the conjunctiva onto the cornea, presenting a notable health concern across the globe. In countries like India, where intense sunlight and outdoor lifestyles prevail, the condition affects a significant portion of the population, with prevalence estimates ranging between 9.5% and 13%. This variability underscores the influence of environmental factors, particularly prolonged exposure to ultraviolet (UV) radiation, which acts as a primary catalyst alongside genetic susceptibilities. The resulting tissue remodeling can lead to clinical complications, including astigmatism that distorts vision, partial obstruction of the visual field, and structural changes to the cornea, collectively diminishing ocular performance and patient well-being.

The cornea, serving as the eye's principal optical component, relies on its transparent multilayered architecture to ensure clear vision. This structure consists of the epithelium, Bowman's layer, the stromal matrix, Descemet's membrane, and a vital endothelial layer. The endothelial cells, a single non-renewable stratum, are crucial for preserving corneal clarity by managing fluid equilibrium through active transport processes, such as sodium-potassium pump activity. At birth, endothelial cell density typically approximates 6000 cells/mm^2, declining steadily to around 2500 cells/mm^2 by the fifth decade of life due to natural attrition. However, pathological conditions like pterygium, with its associated chronic irritation and inflammation, may accelerate this loss, potentially precipitating corneal edema and opacity if cell numbers fall below a critical threshold.

The adjacency of pterygium to the corneal surface raises questions about its deeper impact, possibly through persistent inflammatory responses or mechanical strain, though such effects remain underexplored. Specular microscopy, a sophisticated non-invasive imaging modality, provides a detailed view of the endothelial cell mosaic, enabling precise measurement of cell density and assessment of cellular health. Preliminary studies suggest that pterygium may diminish endothelial cell density, potentially due to oxidative stress or inflammatory mediators, yet these findings are inconsistent across populations, reflecting differences in disease severity, patient demographics, and environmental exposures.

Another dimension of interest is central corneal thickness (CCT), a marker of stromal hydration and structural integrity, which may also be affected by pterygium. Measured via pachymetry, CCT variations could signal early endothelial dysfunction, yet its relationship with pterygium-induced changes lacks comprehensive analysis. Unraveling this interplay promises to illuminate how pterygium disrupts corneal physiology, offering insights that could shape clinical interventions.

Despite these observations, the subsurface consequences of pterygium on corneal endothelium and thickness remain poorly characterized, limiting the ability to optimize patient care. This study addresses this gap by investigating the effect of pterygium on corneal endothelial cell density (CECD) using specular microscopy in patients with unilateral pterygium. By comparing the affected eye with its contralateral healthy counterpart, the research aims to isolate pterygium-specific alterations while accounting for individual variability. Additionally, it will explore correlations between CECD and CCT, employing specular microscopy and pachymetry to provide a dual perspective on corneal health. This approach seeks to clarify the extent of pterygium's deeper impact, beyond its surface manifestations, and to evaluate whether endothelial compromise contributes to observed visual deficits.

The significance of this study lies in its potential to enhance the understanding of pterygium's pathophysiology, guiding the development of targeted therapies to protect endothelial function and improve surgical outcomes. By identifying early indicators of corneal damage, the findings could inform timely interventions, such as UV protection strategies or adjusted surgical protocols. Furthermore, the research underscores the need for longitudinal investigations to monitor long-term corneal changes, paving the way for preventive measures and personalized management plans. This introductory section sets the stage for a detailed exploration of methodology, results, and implications, aiming to contribute meaningfully to the field of ophthalmic science.

AIMS AND OBJECTIVES

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AIM

To evaluate the impact of pterygium on corneal endothelial cell density (CECD) and its relationship with central corneal thickness (CCT) using specular microscopy.

OBJECTIVE

To measure and compare corneal endothelial cell density (CECD) and central corneal thickness (CCT) in unilateral pterygium-affected and contralateral healthy eyes using specular microscopy.

REVIEW OF

LITERATURE

REVIEW OF LITERATURE

INTRODUCTION

The cornea is the refractive element of the eye. It consists of 5 layers: epithelium, Bowman's membrane, the stroma, Descemet's membrane, and the endothelium. The deeper endothelium separates corneal stroma from aqueous humor. It consists of 5 µm thickness flat cells. The corneal endothelial cells (CECs) are terminally differentiated cells consisting of different enzymatic pumps, which extract the water from the stroma. This regulates corneal hydration and transparency. It maintains corneal homeostasis and the nutrition of the corneal cells. Annually the endothelial cell density decreases around 0.6% by aging. There are approximately 6000 endothelial cells/mm at the birth of a human, which reduces to approximately 2500 cells/mm at 50 years.[1–3]

The pterygium prevalence was around 30% worldwide". The Indian prevalence ranges between 9.5% to 13%. It mostly occurs in the rural areas.[4] Pterygium is a type of disorder that occurs on the ocular surface. It is a degenerative disorder and a benign non-cancerous growth of the conjunctiva over the sclera. It is called a 'Surfer's eye'. The excess fibrovascular formation of the subconjunctival tissue is called pterygium, which extends medially and laterally of the cornea.[5] The three pterygium types are atrophic pterygium, intermediate pterygium, and fleshy pterygium according to its fleshiness.[6] The measurement of corneal endothelial cell (EC) density includes central endothelial cell density, corneal thickness, percentage of hexagonal cells, coefficient of variation in cell size, and cell area.[7]

The important risk factors of pterygium are exposure to ultraviolet radiation or sun exposure, p53 mutation, cellular dysregulation, and chronic irradiation. The pathologies associated with corneal endothelial cell density are Fuchs endothelial corneal dystrophy, bullous keratopathy, iridocorneal syndrome, and dry eye disease. The management procedures include pterygium excision, limbal conjunctival auto transplant, limbal stem cell transplantation, use of adjuvants like 5-fluorouracil, and post-operative care, etc.[8,9]

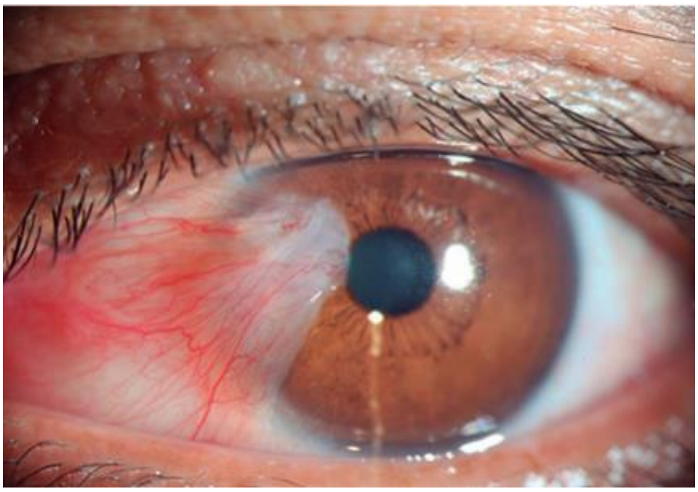
Specular microscopy was invented in the 1960s by David Maurice to visualize endothelial cells.[10] Specular microscopy is a non-invasive diagnostic modality, important in assessing corneal endothelium. It gives details about the structure of the endothelium in a healthy and pathological eye. This aids in the detection and management of corneal pathology. The technique of a specular microscope is based on specular reflection. Specular microscopy generates high-resolution and magnified images facilitating ophthalmologists to improve patient care and treatment planning.[11]

The specular microscopes are classified into contact and non-contact types. The former type visualizes the corneal endothelium by directly keeping contact with the eyes. Meanwhile, the latter type visualizes the corneal endothelium without touching the eyes directly.[11] The specular microscopes in the pterygium eyes documented a reduction in the Mean corneal endothelial cell density (CECD) than their contralateral healthy eyes.[12] Hence, the objective of the study is to assess the pterygium effect on CECD using specular microscopy.

Pterygium:

In 1000 BC, Pterygium was described and derived from the Greek words pteryx (wing) and pterygion (fin). Pterygium is a common type of disorder that occurs on the ocular surface.[13] It is a triangular form or wing-shaped growth.[8] It is a degenerative disorder and a benign non-cancerous growth of the conjunctiva over the sclera. It is mostly located on the nasal side.[14,15] It is called a 'Surfer's eye'. The Surfer's eye is the subconjunctival tissue's excess fibrovascular growth that invades the palpebral fissure of the cornea. This is due to variations in homeostasis of the ocular surface. The important pterygium components are proliferative clusters of limbal stem cells (LSCs), active fibrovascular tissue, epithelial metaplasia, inflammation, and Bowman's layer.[5] Unlike other body cells, human ECs will not generate again and are post-mitotic.[16] The pterygium causes astigmatism and visual impairment.[17]

Figure 1: Pterygium on the corneal surface.[18]



Based on the size and the extent of the corneal involvement, the pterygium was graded,

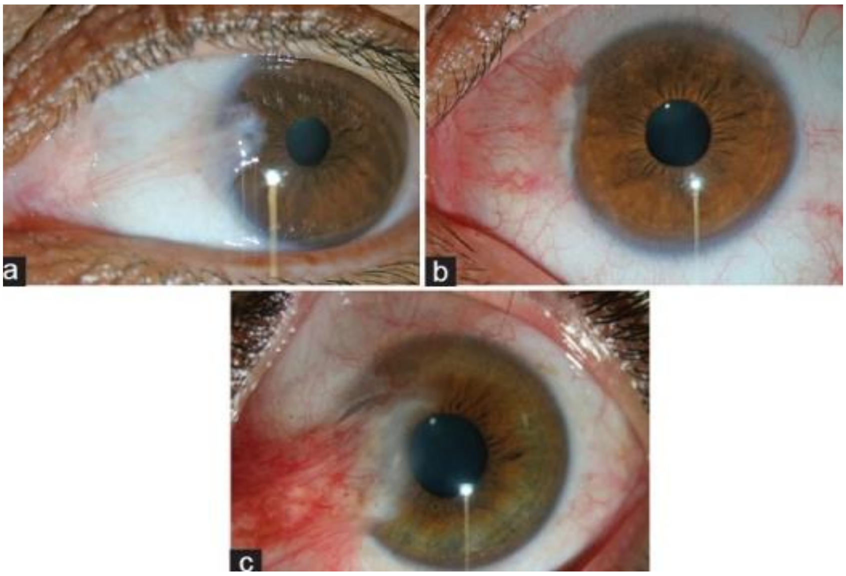
- " Grade 1: Between the limbus and midpoint of the limbus and pupillary margin.

- Grade 2: The head of the pterygium is present between the midpoint of the limbus and pupillary margin (nasal and temporal papillary margins for nasal and temporal pterygium, respectively).
- Grade 3: crossing the pupillary margin. ”[19]

The pterygium was also graded based on the severity of redness,

- Grade 1: The redness is absent
- Grade 2: The redness is moderate and distributed
- Grade 3: The redness is significantly present.[20]

Figure 2: Pterygium redness severity by slit-lamp photographs: a) grade1, b) grade 2, c) grade 3.[20]

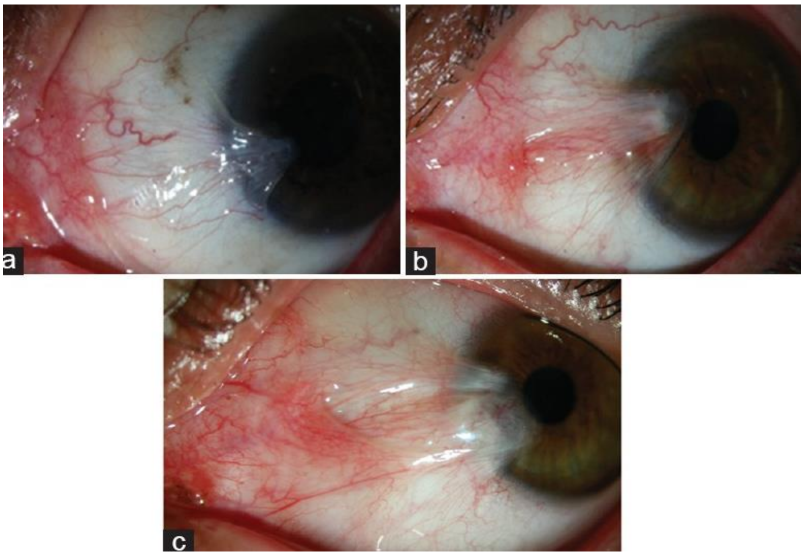


The pterygium fleshiness was also graded,

- Grade T1: Atrophic pterygium (the body of the lesion does not obscure the episcleral vessels)
- Grade T3: Fleshy pterygium (the vessels of the episclera are completely closed)

- Grade T2: Intermediate of 1 and 3 T grades (vessels of the episclera are partially obscured).[6]

Figure 3: Pterygium fleshiness grade by slit-lamp photographs: a) grade T1, b) grade T2, c) grade T3.[20]



Visual disturbances due to intrusion over the pupil or induced astigmatism are the primary reasons for surgery. The other reasons include chronic redness, eye movement restriction, cosmetic concerns, and foreign bodies.[21]

Burden/Prevalence:

The global prevalence of pterygium ranges between 0.3% to 29%. The prevalence was increased in the "pterygium belt" located at 37° northern latitude and southern equator.[4] Approximately 10% of pooled global prevalence is seen.[17] The prevalence rate in India ranges between 9.5% to 13%.[4] The prevalence in Andhra Pradesh is 11.7%.[22] The prevalence in rural central India is 13% among people with 30 years and older.[23] The pterygium on the unilateral eye has a prevalence of about 13%, and the bilateral is 6.7%.[24] From a rural Indian population study, the prevalence in the age group 30 to 39 years increases from 6.7% to 25% in the age group 70 to 79 years.[25] It mostly develops in the rural areas. The prevalence in Singapore is 10%, in Japan is 30.8%, and in China's rural areas is 33%. Males were more highly affected than females, as they worked outdoors for a longer time.[17,26]

Risk Factors/Causes[27,28]

Primary risk factors:

- **UV exposure:** UV radiation, particularly UV-B, rapidly develops pterygium. UV radiation induces limbal stem cell mutation, leading to corneal fibrovascular proliferation. This process involves the activation of matrix metalloproteinases and inflammatory pathways, contributing to tissue remodeling and pterygium progression. This results in the reduction of CECD. This causes oxidative stress and cellular damage in corneal tissues. It causes DNA damage affecting the overall health and density of the corneal endothelium.[29,30]
- **Chronic irradiation (dust, wind):** Longer exposure to dust and wind can lead to chronic irritation of the ocular surface, leading to pterygium development. This can cause microtrauma, oxidative damage, and inflammation, promoting the growth of conjunctival tissue onto the cornea.[31]
- **Genetic factors:** Family history and gene polymorphisms of TP53 gene cells play an important role in cycle regulation and apoptosis, which is linked to the development of pterygium.[28]
- **Viral infections:** The human papillomavirus (HPV) and herpes simplex virus (HSV) were reported to be present in the specimen of pterygium. The presence of these two viruses can be indicative of a neoplastic condition.[32] The overall prevalence of HPV in pterygia is 18.6%.[33] The high-risk strains are HPV16 and HPV18, which develop

cancer and are often reported genotypes in pterygium.[34] Familial predisposition related to gene polymorphisms like MMP-1, VEGF.

Demographic risks:

- Older age
- Male sex
- Dark skin
- Outdoor jobs (dry or hot weather)
- Rural residency
- Smoking

Pathogenesis:[35]

Environmental factors:

1. **Ultraviolet radiation:**

- Exposure to UV rays leads to damage of DNA, oxidative stress, and free radicle formation.
- Promotes abnormal gene expression and signaling pathways (e.g., MAP kinase pathway).

2. **Human Papillomavirus infection:**

- May play a synergistic role in genetically predisposed hosts.
- HPV16/18 E6 proteins can inactivate tumor suppressor genes like p53.

3. **Climate and occupation:**

- Equatorial regions, dry and hot climate, and outdoor works.

Genetic factors:

1. **Mutations in Tumor Suppressor Genes:**

- p53 mutations indicate neoplastic growth when observed in pterygium tissue.
- The UV exposure is the major contributor to p53 mutation.
- The pollutant called benzo(a)pyrene (BaP) facilitates p53 mutation via specific DNA adduct development.[36]
- Specific polymorphisms in the p53 gene, such as at codon 72, have been related to increased susceptibility to pterygium.[37]
- Overall, p53 mutations play a central role in pterygium formation by enabling uncontrolled growth of cells, resisting apoptosis, and impairing DNA repair, often driven by environmental insults like UV radiation.

2. **DNA Repair Gene Dysregulation:**[38]

- In pterygium tissues, the genes involved in DNA repair are RAD50, RAD51, and XRCC2.
- UVR-induced double-strand breaks abnormally activate these repair mechanisms.

3. **Matrix Metalloproteinases (MMPs):**

- Increased MMP-2, MMP-9, and reduced inhibitors (TIMP1) lead to remodeling of ECM.[39]

Molecular and cellular factors:

1. **Cell Proliferation and Migration:**

- Upregulation of proteins such as PCNA and mutated p53 drives unchecked proliferation.[40]
- MAP kinase and interleukin-4 pathways facilitate inflammation and growth.[41]
- Abnormal activation of fibroblast and inflammatory cytokines play critical roles.

2. **Angiogenesis:**[42]

- Increased Vascular Endothelial Growth Factor (VEGF) levels.
- Anti-angiogenic therapies targeting VEGF show mixed results.

3. **Oxidative Stress:**

- Chronic exposure to UV rays generates free radicals and cellular component damage.

Table 1: Hypotheses of Pathogenesis:[35]

Factor	Mechanism	Effect
UV Radiation	DNA damage, free radicals	Proliferation and apoptosis imbalance
Genetic Mutations	p53 mutations, RAD50 overexpression	Uncontrolled cell growth
Environmental Pathogens	HPV infection	Enhances genetic mutations
Cellular Dysregulation	MMPs, VEGF activation	Angiogenesis and invasion

Diagnosis:[8]

- Clinical examination involves the identification and growth of wing-shaped structures with the fibrovascular components.
- Specular microscope in CECD examination.

- The slit-lamp and confocal microscope visualize the primitive cell groups of pterygia.[43]
- Ocular examinations such as visual acuity, extraocular movements (EOM), anterior segment assessment, and refraction assessment are to be performed.
- Oblique torchlight illumination and slit-lamp examination diagnose the size, location, extent, vascularity, and corneal involvement areas of pterygium.
- Castroviejo's calipers measure the limbus chord.
- Schirmer's exam and tear film break-up time evaluate the dry eyes.
- Stocker's line should be noted.
- Histopathology and ultra-high resolution optic coherent tomography (OCT) help in distinguishing benign from malignant lesions by optical cross-sectional biopsy.[44]
- The differential diagnosis of pterygium is ocular surface squamous neoplasia (OSSN) or limbal squamous cell carcinoma (SCC), corneal phlyctenule, elevated pinguecula, limbal dermoid, nodal scleritis, a papilloma.[28]

Management:[8]

Pterygium excision:

- Using the conjunctival scissors, the body of the pterygium is excited, and by using a 15° Bard Parker blade the pterygium head is excited from the cornea. The tenons and the subtenon tissues should be excited with care. The diamond burr removes the pterygium tissues that are remained over the corneal surface.[25]
- Pterygium excision along with conjunctival autograft and fibrin glue results in a lesser recurrence rate, better cosmetic outcome, and does not take longer time for surgery.[25]

Post-operative care:

- The avoidance of sunlight, dust, wind, and UV rays by using UV protection and sunglasses can prevent pterygium. After surgery, this measure can prevent recurrence.
- In areas with chemical pollution, eye protection equipment should be worn.[25]
- The inflammation and preventing the complications include topical steroids and antibiotics are given as tapering doses for a month.[25]
- Beta-irradiation with one to more applications.
- Surgical methods include lamellar keratoplasty and fibrin glue.[4]
- Other methods include cautery, laser therapy (Argon laser), tenon's layer excision, excimer, and radiotherapy.

Table 2: Management methods of pterygium:[4,8,45]

S. No.	Method	Description
1	Medical Management	Includes the use of artificial tear drops, decongestants, NSAIDs, and topical steroids to manage inflammation, discomfort, and cosmetic concerns.
2	Avulsion Technique	Involves freeing the pterygium from the sclera and tearing it from the cornea. Residual tissue is polished with a diamond burr. Recurrence rate: 23%-75%.
3	Simple Excision	Removes the pterygium, but it reoccurs frequently with a rate of 30%-100%.
4	Bare Sclera Method	The pterygium is excised and the scleral bed is not covered so that it can regrow itself. High recurrence rates (24%-89%) have been documented.
5	Primary Closure	Excise the pterygium, followed by a tenonectomy and conjunctival closure. Recurrence rate: ~2.1%.

6	Transplantation of the Pterygium Head	The head and body of the pterygium are reoriented to reduce recurrence. High recurrence rates were observed.
7	Conjunctival Autograft	Uses a graft from the patient's conjunctiva to cover the excised area. Recurrence rates vary from 5%-31%.
8	Conjunctival Rotational Autograft	Rotates a section of conjunctiva to cover the bare sclera. Recurrence rate: ~16.6%.
9	Limbal Conjunctival Autotransplant	Combines conjunctival and limbal tissue grafts to reduce recurrence (0%-15%).
10	Limbal Stem Cell Transplantation	Restores limbal epithelial cells to prevent recurrence.
11	Amniotic Membrane Grafting	Utilizes an amniotic membrane to cover the excised area and prevent recurrence.
12	Use of Adjuvants	Includes mitomycin C, 5-fluorouracil, and thiotepa to reduce recurrence rates in conjunction with surgical methods.

Outcomes/Complications:[4]

The complications due to surgical procedures include:

- Recurrence: This varies based on the technique or procedure performed. The autograft shows a lesser recurrence rate.

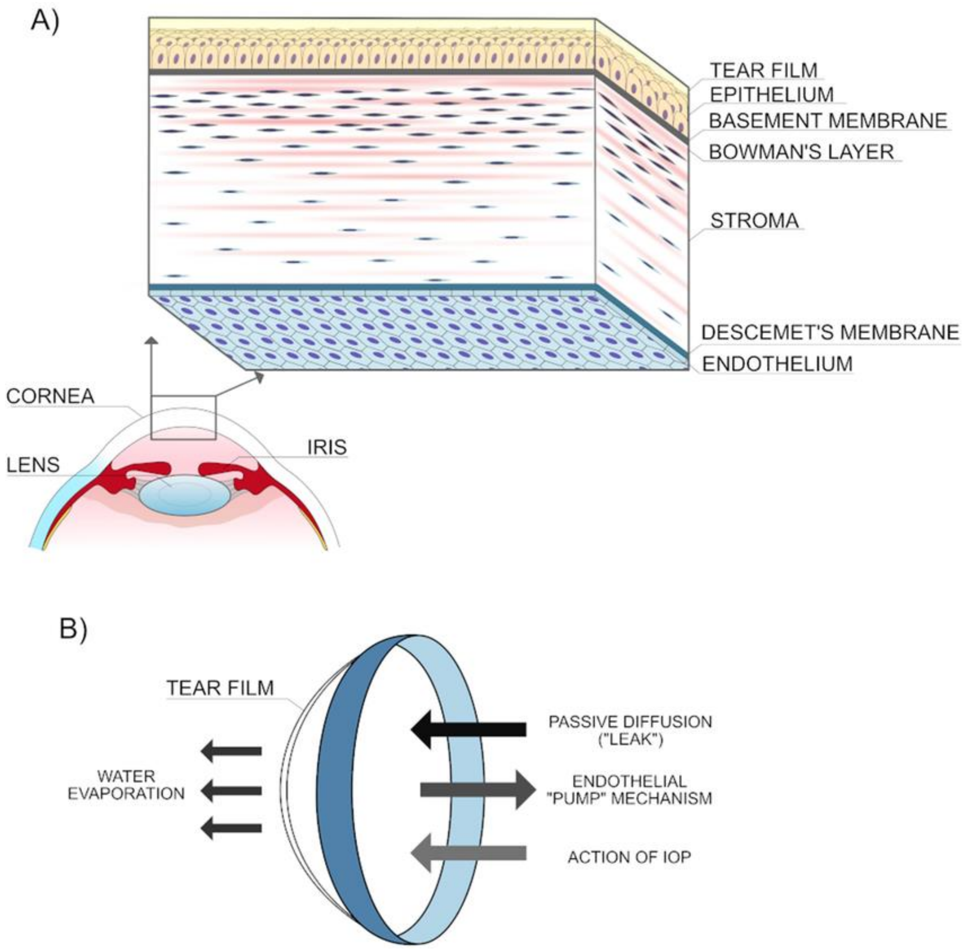
- Astigmatism and aberration
- Ocular surface squamous neoplasia (OSSN)
- Excess bleeding
- Symblepharon
- Dellen
- Buttonhole of the conjunctiva graft, graft edema, necrosis, retraction.
- Perforation caused by suture needle in the globe, sutural granuloma.
- Medial rectus muscle injury
- Pyogenic granuloma
- Persistent epithelial defect, epithelial inclusion cyst.
- Subconjunctival hematoma, fibrosis.
- Scleral necrosis, corneoscleral thinning, infectious scleritis.
- Secondary glaucoma (severe)
- Iritis
- Cataract
- Corneal edema, perforation, scarring, and endophthalmitis

Corneal endothelial cell density:

Anatomy of Corneal endothelial cell:[1,2]

The cornea is the eye's refractive element containing five layers, namely the outer epithelium, the basement Bowman's membrane, the stroma, the basement Descemet's membrane, and the deeper endothelium. The endothelium separates the corneal stroma from aqueous humor. It consists of 5 μm thickness flat cells, forming a uniform single layer over a membrane (amorphous collagenous) called Descemet's membrane. These flat cells cover the complete concavity of the cornea up to trabecular meshwork. The corneal endothelial cells (CECs) are terminally differentiated cells consisting of different enzymatic pumps, which extract the water from the stroma. This regulates corneal hydration and transparency. It maintains corneal homeostasis and the nutrition of the corneal cells. They are polarized flat cells that divide the cornea and the aqueous humor. The apex of CEC is in contact with aqueous humor and is a hexagonal structure, whereas the base is irregular.[46] Annually, the endothelial cell density decreases by around 0.6% by aging. There are approximately 6000 endothelial cells/mm at the birth of a human, which reduces gradually to 3000 nearly in two decades and 2500 in five decades.[3]

Figure 4: A) Anatomy of corneal layer, B) Fluid flow in the cornea.[47]



The endothelial cell morphology is analyzed using,

- Polymegathism (coefficient of variation)
- Pleomorphism (percentage of hexagonal cells)
- Cellular density (cells/mm)
- Cell area +/- SD (μm).[48]

Formula:

- Cell density (CD) = 10^6/ average cell area

  [CD: cell/mm^2; cell area: μm^2; 10^6 - convert units of measure].

- Coefficient of variation (CV) = Standard deviation of mean cell area ($SD_{cell\ area}$)/ mean cell area, μm^2

Physiology of Corneal Endothelial cell:[49]

The primary physiological role of CEC is,

- **Membrane formation:** The endothelium forms the Descemet membrane by collagen matrix secretion.[50]
- **Pumping activity:** This maintains the transparency and health of the cornea.[50]
- **Supply:** Through the endothelium, the supply of nutrients, glucose diffusion, and other solutes occurs in the aqueous humor.[51]
- **Role in Transparency**: Corneal transparency is maintained by corneal endothelium by developing a state of relative stromal dehydration.
- **Stromal Hydration Dynamics**:

- Imbibition Pressure: The stromal proteoglycan matrix generates a pressure of approximately 60 mm Hg that draws water into the cornea.[52]

- ❖ **Water Flow Regulation**:
  - The tight epithelial junction reduces the entry of water from the tear film into the stroma.
  - There will be a free flow of aqueous humor into the stroma when there is a lack of continuous tight junctions between endothelial cells.[52]
- ❖ **Pump-Leak Concept:**
  - Leak: The imbibition pressure facilitates the stromal water accumulation.
  - Pump: The active ions (e.g., Na^+/K^+-ATPase) are transported by the ECs, which drive water again into the aqueous humor, counteracting stromal swelling.[52]
- ❖ **Barrier function:** The extra fluids are prevented by the CECs to enter the stroma. It is an essential process for transparency, as it maintains corneal dehydration.[53]
- ❖ **Aerobic Metabolism Role**: For the transport of fluid, the endothelium depends on aerobic metabolism, but when the cornea gets cooled, it can temporarily stop.[54]
- ❖ **Energy Production**: The mitochondria supply the energy by ATP production.
- ❖ **Oxygen Source**: The endothelial cells mainly get the oxygen from the anterior chamber (Oxygen level: 55 mm Hg) rather than the tear film (Oxygen level: 155 mm Hg).
- ❖ **Water Movement**: Water passively moves across the endothelium.
- ❖ **Passive Assistance to Dehydration:** The tear film evaporation higher the tear osmolarity and pulls water from the stroma. The IOP compresses the stroma and pushes the water out, leading to intact endothelium.
- ❖ **Short Circuit Current**: A measurable current of 27 $\mu A/cm^2$ reflects the transport of active ions.
- ❖ **Bicarbonate's Role**: These ions are important in endothelial pumps and in fluid transport.[55]

❖ **Role of sodium**: Removing sodium from the aqueous humor, inhibits the flow of fluid and decreases the short-circuit current.

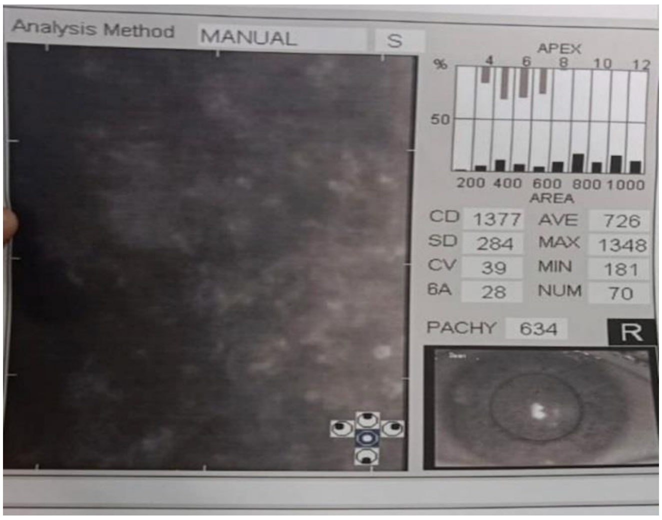
❖ Sodium-Bicarbonate Linkage plays an important role.[56]

Pathologies of Corneal endothelial cell density:[9,57]

Fuchs endothelial corneal dystrophy (FECD):

FECD is a degenerative disease involving the slow deterioration of CECs and guttae formation on Descemet's membrane. As ECs are minimized, the cornea can become edematous, leading to decreased vision. The condition is often bilateral and more prevalent in older adults.

Figure 5: Specular microscope image of FECD.[58]



Posterior polymorphous corneal dystrophy (PPCD/PPMD):

PPCD is an inherited condition where corneal endothelial cells exhibit epithelial-like characteristics, including multilayering and the formation of desmosomes. This transformation can reduce the endothelial action, causing edema and secondary glaucoma due to the extension of abnormal cells into the trabecular meshwork.

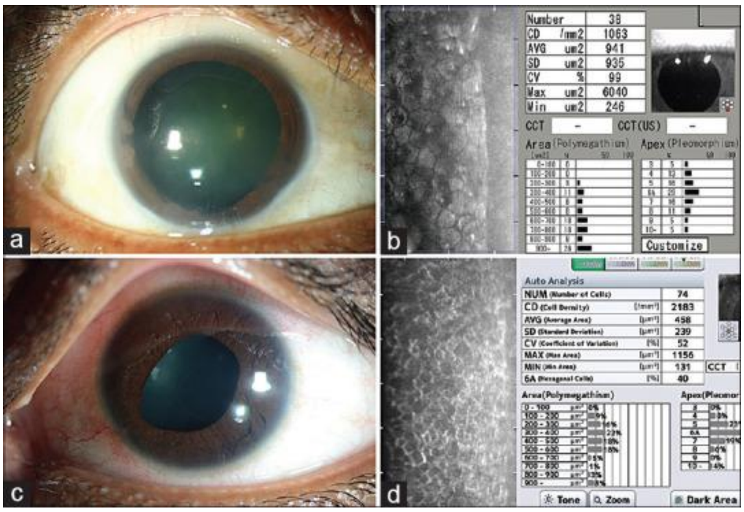
Bullous keratopathy:

The dysfunction of endothelium leads to inadequate fluid regulation within the cornea, causing stromal and epithelial edema, which causes bullous keratopathy. The blisters, or bullae consisting of fluid, can form on the corneal surface, resulting in pain and visual disturbances. Common causes are surgical trauma, particularly from cataract extraction, and advanced FECD.

Iridocorneal endothelial (ICE) syndrome:

ICE syndrome encompasses a spectrum of disorders marked by abnormal CEC proliferation, which can migrate onto the iris and anterior chamber angle. This aberrant behavior may result in iris abnormalities, angle-closure glaucoma, and edema in the cornea. The exact etiology is not clear, though associations with herpes simplex virus have been reported.

Figure 6: ICE syndrome in the specular microscope: a) and c) Slit-lamp photo, b) and d) specular image.[11]



Glaucoma:

Elevated intraocular pressure (IOP) in glaucoma can accelerate the loss of endothelial cells. Both the disease itself and certain treatments, such as long-term use of topical medications, have been implicated in endothelial damage. Studies suggest that IOP may contribute to endothelial cell reduction.

Diabetes mellitus (DM):

Systemic diseases like DM can adversely affect corneal endothelial cells. DM patients may exhibit reduced ECD and morphological changes, potentially due to chronic hyperglycemia-induced oxidative stress and microvascular complications.

Dry eye disease (DED):

Chronic inflammation associated with DED has been linked to ECD reduction. Inflammatory mediators may induce endothelial cell apoptosis or dysfunction, decreasing corneal integrity and transparency.

Ocular Surgeries (e.g., Cataract Surgery, Trabeculectomy):

Procedures like cataract extraction and IOP-lowering surgeries can damage endothelial cells. Factors such as surgical technique, instrument choice, and intraoperative complications facilitate the loss of endothelial cells.

Contact Lens Wear:

Prolonged wearing of contact lenses can reduce ECD due to hypoxia and mechanical stress.

Endothelial Cell Degeneration from Aging:

Factors like ECD age, naturally make the cornea susceptible to stress and injury.

Herpes Simplex and Herpes Zoster Keratitis:

Viral infections can directly affect the endothelial cells and lead to chronic inflammation and cell loss.

Toxic Anterior Segment Syndrome (TASS):

Non-infectious inflammation following IO surgery damages endothelial cells.

Methods to measure:

Table 3: Measurements taken to measure Corneal Endothelial Cell Density (CECD):[7,59]

Parameter	Description	Units
Central Endothelial Cell Density (ECD)	To evaluate the overall health and CECs density in the center.	Cells per square millimeter (cells/mm²)
Corneal Thickness (CCT)	To analyze its correlation with ECD, as thinner corneas may have lower ECD.	Micrometers (µm)
Percentage of Hexagonal Cells	To assess the ECs structure and uniformity, an indicator of healthy endothelium.	Percentage (%)

CV in Cell Size	Assessment of ECs size variation, an indicator of endothelial cell health and stability.	Percentage (%)
Cell Area (CA)	To determine the average size of corneal endothelial cells, which can change in response to cell loss or damage.	Micrometers squared (μm²)

Other measurements include:[7,59]

Peripheral ECD: To assess regional differences in cell density, especially superior and temporal areas.

Corneal Curvature: To determine the influence of steepness on ECD measurements.

Axial Length: To evaluate its relationship with ECD; longer axial lengths may decrease ECD.

Horizontal Corneal Diameter: To explore any influence of corneal size on ECD.

Anterior and Posterior Corneal Shape: To identify potential optical artifacts in ECD measurement.

Specular microscopy:[11]

Specular microscopy was invented in the 1960s by David Maurice to visualize endothelial cells.[10] Specular microscopy is an essential tool in ophthalmology that allows in-vivo assessment of corneal endothelium, which observes endothelial cell morphology. It is a non-invasive diagnostic modality with details about the structure and morphology of the endothelial cells in healthy and pathological eyes. This aids in the detection and management of corneal pathology, either in the eye bank or clinical setting. It gives peculiar and distinctive images of the endothelium. Fluctuations in endothelial cells denote the presence of disease. This captures high-resolution and magnified images facilitating ophthalmologists to improve patient care and treatment planning.

In the examination, the light points to the cornea, which is reflected from the inner endothelium. This reflection captures the images of endothelial cell size, cell density, and shape. The endothelial cell density (ECD) is the primary measurement of the endothelium.[60]

Specular microscopy plays a crucial role in diagnosing Fuchs dystrophy and other dystrophies of the cornea and polymorphous. It also diagnoses congenital genetic dystrophy of the endothelium, pseudophakic bullous keratopathy, trauma, ICE syndrome, uveitis, and other ECs pharmacological disruptions.[16]

Figure 7: A) Specular microscope, B) Healthy corneal endothelium image:[61]

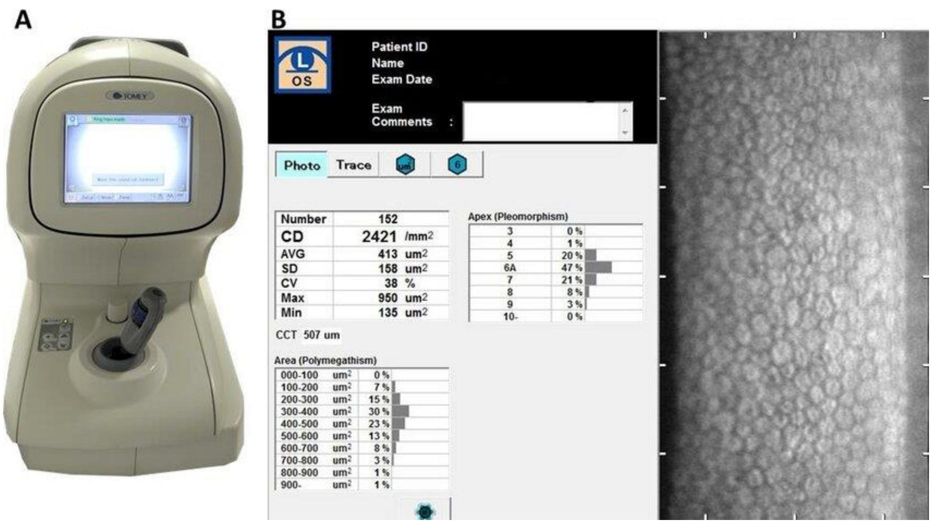
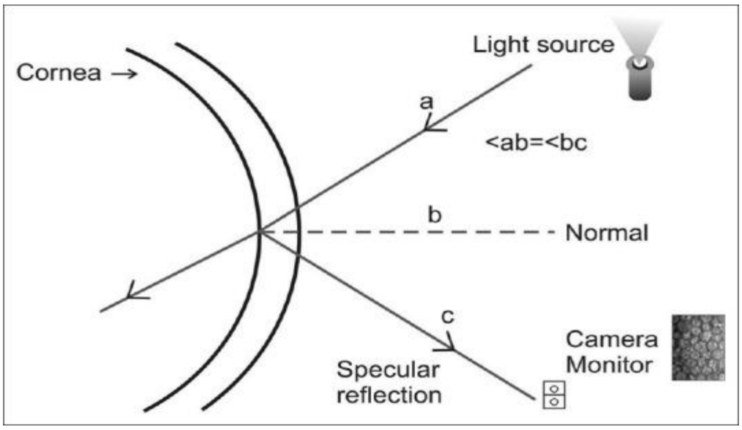


Figure 8: Principle of specular microscope (a) light incidence, (b) normal, (c) light reflection, (ab) light incidence angle, (bc) light reflection angle.[11]



Types of Specular Microscopy:[11]

1. **Contact specular microscope:**[60]

- The contact specular microscope visualizes the corneal endothelium and cells using the lens that is in direct contact with the eyes. The objective lens of the microscope touches the cornea (contact). It uses a contact lens to flatten/ applanate the cornea and capture the images of the corneal endothelium. By capturing a small area of the corneal cells, the images are created. Depending on how clear and flat the contact lens holds the cornea, the image quality depends. The film is then developed to show the details of the endothelial cells. The cells are magnified on the film. The magnification of the cells on the film is calibrated for accurate measurements. In this procedure, topical anesthesia is given to patients to numb the cornea and for patient comfort.
- **Advantages:** This microscope provides images with high magnification and resolution. It is effective in detailed studies of cellular morphology and density.
- **Applications:** This is used to assess the donor endothelium, monitor the surgical procedures and techniques, and detect the corneal endothelial pathologies.
- **Complication:** Corneal abrasion, infection.

2. **Non-contact specular microscope:**[60]

- The non-contact microscope visualizes the corneal endothelium and cells without touching the eyes directly. To avoid contact with eyes, this microscope uses a slit lamp to capture the image. Without contacting the eye, this microscope captures the endothelium by focusing the light beam and taking photographs. This method uses a special technique to correct the corneal curvature, ensuring that the image is not distorted. The developed images of the endothelial cells are similar to those images in the contact method but this uses different types of film and development processes. In this procedure, topical anesthesia is not required for the patient.
- **Advantages:** As it is non-contact, it is best to examine the sensitive eyes and eyes that have undergone recent surgeries. It pictures the larger field of cells and facilitates the study of cell density. The process of examination using this microscope is easier to perform and quicker.
- **Applications:** In patients who are not able to make eye contact it is a suitable method, it pictures the complete cornea including the periphery, and it is best for quicker and repeated examination.
- **Complications:** Discomfort from bright eyes, and eye fatigue.

Figure 9: Non-contact specular microscope.[60]

3. **Wide field specular microscope:**[62]

- To overcome the disadvantages of conventional specular microscopy, the wide-field specular microscope was introduced. It provides an expanded field of view (FOV) up to a diameter of 0.9 mm. Evaluating the corneal endothelium in detail improves the clinical and research applications. This operates using a scanning mirror system, which expands the FOV and maintains the uniform image contrast at the same time. The technique used in this system is the slit illumination technique, where light is specularly reflected from the layers of the endothelium. The light across the endothelium is scanned using a rotating mirror, which produces a reconstructed image of about 2000 per second.
- **Advantages:** Production of images with uniform contrast and brightness, size variations in cells can also be assessed easily, easy relocation of landmarks on endothelial layers, larger FOV, and fewer images are enough for endothelial state assessment.

4. **Horizontal microscope: (clinical use)**

   The horizontal microscope is mainly used in clinical settings for patient examinations. This visualizes and captures the corneal endothelium without contacting the eye and provides high-resolution images. This ensures the comfort of the patient and reduces the risk of infection.[11]

5. **Upright microscope: (in eye banks)**

   The upright microscope is primarily used in eye banks. This is employed to help in assessing the donor corneas. This microscope often positions the corneal tissue in an upright direction for imaging. This helps in the detailed evaluation of the ECD and its morphology, determining the tissue suitability for transplantation.[11]

General complications of the microscope: Allergic reactions, tearing of blinking reflux, psychological distress, and the complications are higher in patients with preexisting ocular conditions.[58]

Technique:

The technique of a specular microscope is specular reflection.The light is projected to the corneal endothelium, and reflected light is captured to form an image. The refractive index is high in the ECs compared to the aqueous humor, allowing them to reflect a small percentage of the incident light, which helps in visualizing and evaluating the endothelial layer.[11]

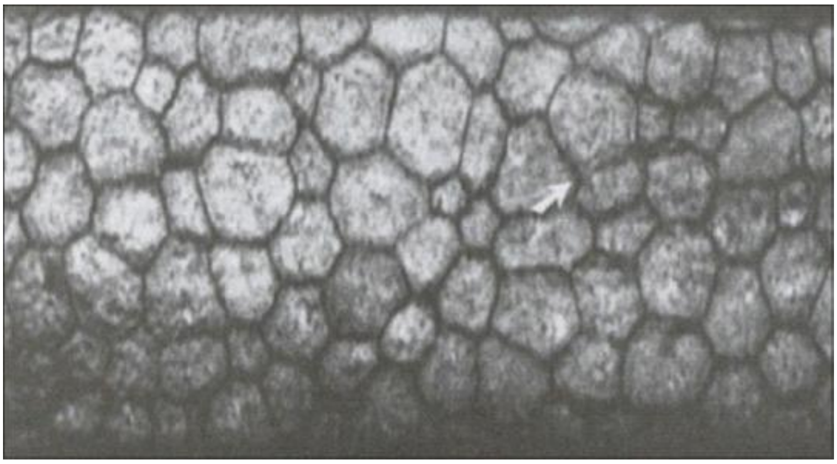
- The procedure is explained to the patients completely to relieve their anxiety.
- The cornea should be scanned in the center, superior, inferior, nasal, and temporal quadrants.
- A slit beam of light from the specular microscope is directed to the cornea. From the tissues, the directed light is reflected.
- The posterior surface receives a specular or mirror-like reflection. This is obtained by examining the differences in the refractive index of the ECs and the aqueous humor.
- Compared to the incident light ray, the reflected light is around 0.02 percent.
- The specular microscope consists of four distinct zones, evaluated by the slit beam.
  - Zone 1: Epithelium/ Coupling fluid of lens.
  - Zone 2: Corneal stroma.
  - Zone 3: Endothelium.
  - Zone 4: Aqueous humor.
- Dark boundary: Area between zone 3 and 4.
- Light boundary: Area between zone 3 and 2.

Methods of getting endothelial information are,[11,63]

- **Frame method:** Cell counting inside the frame, evaluates the cell density. The border cell errors that occur can be eliminated by adjusting the size of the frame.
- **Corner method:** Involves locating the intersections of cell borders in the endothelial image.
- **Center-to-center method:** Identification of the ECs central dot and analyses of the surrounding cells.
- **Flex center method:** Uses flexible criteria to locate the central cell and surrounding cells for counting.
- **Comparison method:** The cell density is assessed by comparing the correct marker with the different cell densities in the hexagonal pattern visually.
- **Analysis:** Tracing analysis, digested cell analysis, and computerized analysis.

Automated Specular Microscopy: The individual cell layers are automatically analyzed and well-delineated. If the boundaries of the cells are not seen, the specular count is performed by manual method. The interobserver variability for excellent-quality images of the endothelium can be up to 6%, and for acceptable quality, it is 6% to 11%.[11]

Figure 10: Specular microscopy visualizing endothelial cell layer.[50]



Pterygium on Corneal Endothelial Cell Density:

- Pterygium, a benign growth of corneal conjunctival tissues, is associated with CECD alteration. Several studies have investigated this relationship, yielding varying results. Maximum studies resulted in a reduction of CECD in pterygium eyes compared to their contralateral healthy normal eyes. The CECD decrease correlated with the extent of corneal invasion by the pterygium.[12] Also, in a prospective study, there was no significant correlation between CECD of pterygium eyes and contralateral healthy eyes. This reports that the pterygium effect on CECD may vary in the different populations.[64]
- The complications caused by the topical application of mitomycin-C during pterygium surgery can cause corneal edema and perforation.[65] The prevention of recurrence after surgery includes beta irradiation, which causes complications like scleral ulceration and radiation-induced cataracts.[66]
- The association between pterygium and CECD is complex and may be influenced by factors such as the extent of corneal involvement and UV exposure. Treatments like surgical interventions and adjunctive therapies like MMC and beta irradiation also cause complications. These reports show the importance of individual assessment and careful consideration of treatment options.

Similar studies in the past:

Hsu M et al.[12] (2010-2012) assessed the relation between pterygium and CECD by specular microscopy. This retrospective cross-sectional study comprises 90 unilateral pterygium (primary) patients. The contralateral eyes were used as control eyes. The median pterygium percentage was 12.35% in pterygium eyes. The median CECD difference between pterygium eyes and control eyes was -9.75%. The median ECD was significantly reduced in pterygium eyes (2232 cells/mm^2) compared to normal eyes (2462.5 cells/mm^2) ($p<0.01$). The coefficient of variation (CoV) was higher in pterygium eyes (30) than in normal eyes (27). A significantly positive correlation was seen between CECD reduction and pterygium percentage in the cornea ($r= 0.68$, $p<0.05$).

Sousa et al.[67] (2015-2016) evaluated the patients with single-eye pterygium using non-contact specular microscopy and their corneal endothelial cell density (CECD) consequences. The cross-sectional study included 61 subjects with 122 eyes. The other normal eyes of the patients were taken as controls. Maximum females with 53%. The average age (in years) was 51. The median percentage of pterygium in the affected eyes was 9.7%. The average endothelial cell density (ECD) (cells/mm) of the pterygium eyes (2451.8) was significantly lower than normal eyes (2549.9) ($p<0.05$). Between pterygium invasion and ECD, a significant negative correlation was found ($r= -0.55$).

Li X et al.[30] (2016) assessment enrolled 76 patients with unilateral primary pterygium. The contralateral eyes were considered as control eyes. The average age (in years) was 66. Females contribute 67%. The average CECD (cell/mm^2) of pterygium patients (2417.5) was significantly reduced compared to normal eyes (2575.5) ($p<0.01$). The ECD difference (%) between pterygium eyes and normal eyes was 5.7%. A negative correlation was found between reduced CECD and pterygium percentage in the cornea ($r= -0.05$, $p= 0.63$).

The retrospective analysis of **Zhang et al.**[68] (2019) comprises 521 individuals and CECD was measured using a specular microscope. The average age (in years) was 71. Female predominance was 59%. Among these pterygia was diagnosed in 22%

(114/521). The average ECD (cell/mm^2) was similar between pterygium eyes (2600) and normal eyes (2602) and was not significant (p =0.96).

The prospective study of **Ahmed E.S et al**.[69] (2018-2019) included 40 unilateral pterygia patients with 80 eyes. They divided 20 patients with an initial stage of pterygia (group 1), 20 patients with completely developed pterygia (group 2), and their 40 contralateral eyes as controls (normal) (group 3). Males were 65%. They used a specular microscope for measurement. Group 2 (44) showed a significantly increased pterygium percentage (average) compared to group 1 (10.4) ($p<0.05$). The average corneal power (KM) was significantly higher in group 3 (44.4) compared to group 1 (43.4) and group 2 (42.7) ($p<0.05$). The average CECD was significantly decreased in group 2 (2156.2) than in group 1 (2496.7) and 3 (2498) ($p<0.01$).

Saif et al.[70] (2020) evaluated the CECD in pterygium patients using a specular microscope. This cross-sectional study involved 20 patients with single-eye pterygium and their other normal eye was considered as control eye. The average age (in years) was 45. Male predominance was 65%. The average size of pterygium was 6.7 mm^2. Reduced average ECD (cell/mm^2) was measured in pterygium eyes (1271) compared to normal eyes (1931) and was insignificant (p=0.14). Between pterygium size and ECD, the correlation was weak positive. The average CoV was higher in pterygium eyes (33) than normal eyes (31.3) and was not significant (p=0.31).

Kereem et al.[71] (2021) investigated the CECD and their alterations due to primary pterygium. This prospective study comprises 81 unilateral pterygium patients. The average age (in years) was 52. The male population was 56%. They found a significant reduction in the average CECD (cell/mm^2) of pterygium eyes (2385.8) compared to normal eyes (2487.9) ($p<0.05$). The average CoV (%) of pterygium eyes (34.8) was lesser than normal eyes (35.2) and was not significant ($p=0.17$).

The cross-sectional study of **Zaidi et al.**[31] (2021) included 100 unilateral pterygium patients. The fellow normal eyes were used as controls. The average age (in years) was 44. The male population was 62%. The device used was non-contact specular microscopy. The average CECD in pterygium eyes (2411.6 cells/mm^2) was significantly decreased than normal eyes (2751.4 cells/mm^2) ($p<0.01$). Among 3 types of Pterygia, the reduction of CECD was more common in the fleshy type (grade 3) (2261 cells/mm^2), followed by the intermediate type (grade 2) (2413 cells/mm^2) and the atrophic type (grade1) (2459 cells/mm^2), was insignificant ($p= 0.06$).

The prospective study of **Kumar M et al.**[72] (2023) comprises 100 unilateral pterygium patients. Males contribute 53%. Pterygium patients in grade IV (N= 9) level of the disease have a lower average ECD (2158), compared to grade III (N= 33) (2243.7) followed by grade II (N= 38) (2556.9) and grade I (N= 20) (2706.2). The study found most of the patients were in grade II pterygium.

Abdulhadi Y et al.[73] (2024) investigated the relationship between primary pterygium and CECD using specular microscopy. This cross-sectional study enrolled 50 patients with pterygium in a single eye. The average age (in years) was 54. Male predominance was 74%. The other normal eye of the patient serves as a control. A significantly lesser CECD (average) was found in pterygium eyes (2561.9) compared to normal eyes (2656.3) ($p<0.001$).

MATERIALS AND METHODS

MATERIALS AND METHODS

STUDY AREA: R.L.J Hospital and Research Centre adjoining Sri Devaraj URS Medical College.

STUDY POPULATION: After obtaining approval from Institutional ethics committee, people diagnosed with pterygium who come under our Inclusion criteria was taken up for the study.

STUDY DESIGN: Cross sectional study

Sample Size: 83 patients

TIME FRAME TO ADDRESS THE STUDY: May 2023 to October 2024

INCLUSION CRITERIA:

All patients with pterygium of:

1.Patient with unilateral pterygium of any age

2.Progressive pterygium encroaching greater than 3 mm onto the cornea

3.Vision loss attributable to the pterygium

EXCLUSION CRITERIA:

1. Recurrent pterygium
2. Patients with glaucoma
3. Patients with uveitis

4. Patients with H/o of trauma
5. Patients with H/o of contact lens user

Methodology:

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

I. Visual Acuity by Snellen's chart for distant vision and near vision by jaeger's chart.

II. Slit lamp bio microscopy for assessing the Anterior segment..

III. Fundus examination by direct and indirect ophthalmoscopy, including optic disc evaluation

IV. Keratometry by autorefractometer

V. IOP by Non contact tonometer

VI. Specular microscopy

Statistical Analysis:

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.

Statistical software: MS Excel, SPSS version 22 (IBM SPSS Statistics, Somers NY, USA) used to analyze data. EPI Info (CDC Atlanta), Open Epi, Med calc and Medley's desktop were used to estimate sample size,odds ratio and reference management in the study.

RESULTS

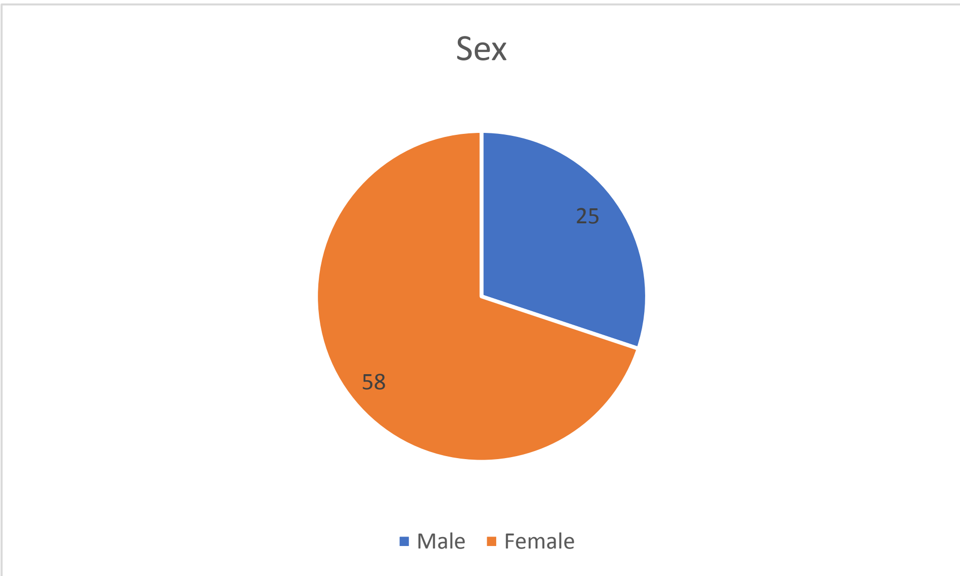
RESULTS

Most of the patients in the present study were females (69.9%), while 30.1% were males.

Table 4 :- Gender Distribution

	Frequency	Percent
Male	25	30.1
Female	58	69.9
Total	83	100

Graph 1: Graph showing distribution according to sex

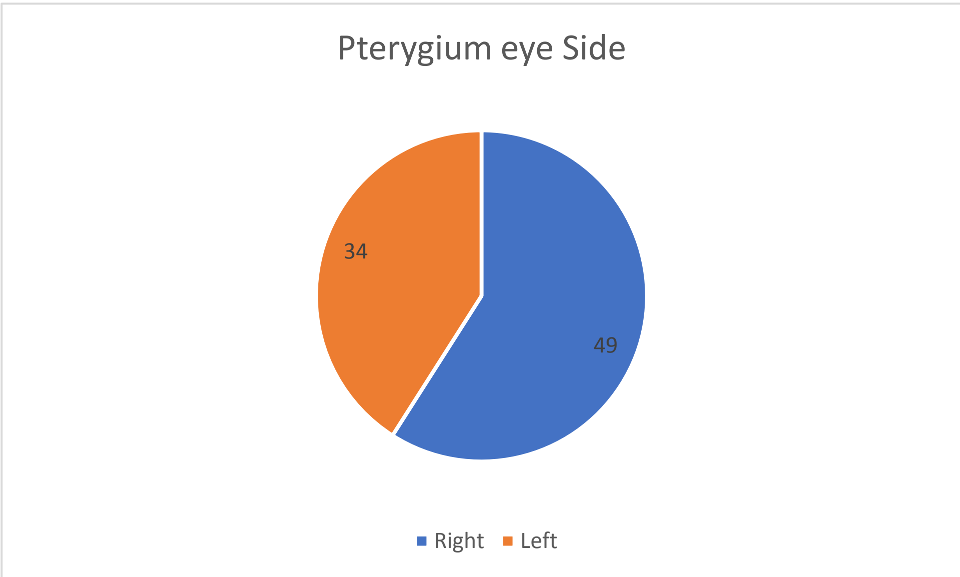


Pterygium was on the right eye in most of the patients (59%)

Table 5 :- Frequency of Eye Involvement

	Frequency	Percent
Right	49	59.0
Left	34	41.0
Total	83	100.0

Graph 2 : Graph showing distribution according to frequency of eye involved



The average patient age was 55.51 years.

Table 6 :- Descriptive Statistics of Age

	Mean	Median	SD	IQR
Age	55.51	56	11.55	50,64

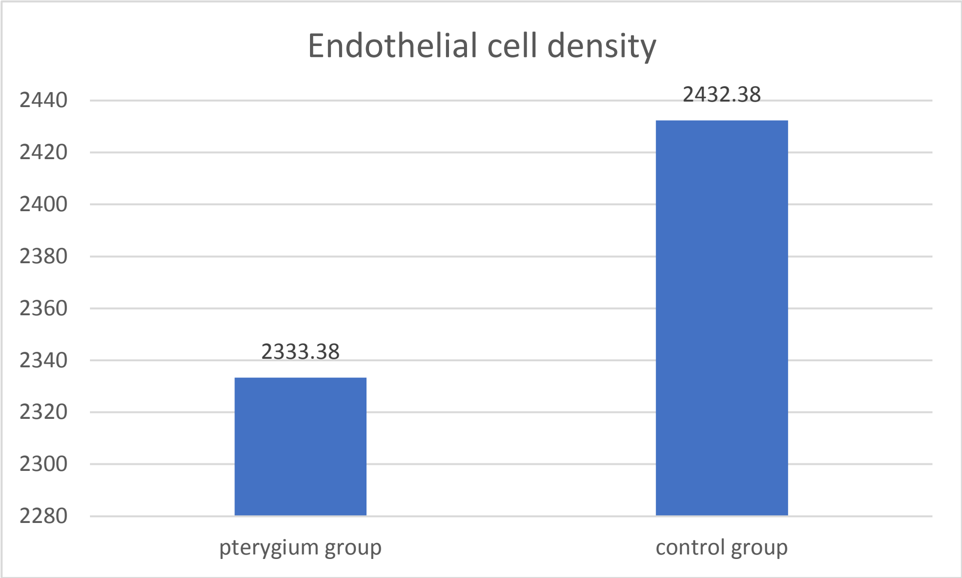
The mean ECD in pterygium and control eyes were 2332.83 and 2419, respectively.

The mean CCT in pterygium and control eyes were 495.06 and 493.22, respectively.

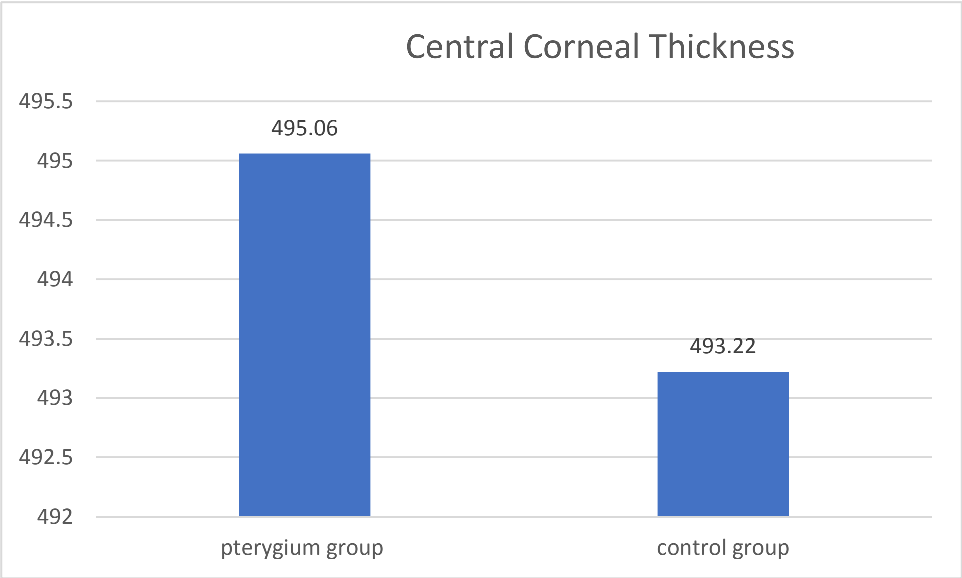
Table 7:- Statistical Summary of Pterygium Impact on Endothelial Cell Density and Corneal Thickness

	Pterygium eye				Control eye			
	Mean	Median	SD	IQR	Mean	Median	SD	IQR
PTERYGIUM EYE ECD	2332.83	2312.00	236.237	2156,2488	2419.00	2390.00	213.468	2269,2560
PTERYGIUM EYE CCT	495.06	492.00	32.835	475,520	493.22	491.00	32.064	471,516

Graph 3 :- Graph showing distribution of Endothelial Cell Density in Pterygium and Control Eyes



Graph 4 :- Graph showing distribution of Central Corneal Thickness in Pterygium and Control Eyes



Pterygium eyes had significantly lower endothelial cell density than control eyes. No significant difference was observed between the eyes in CCT.

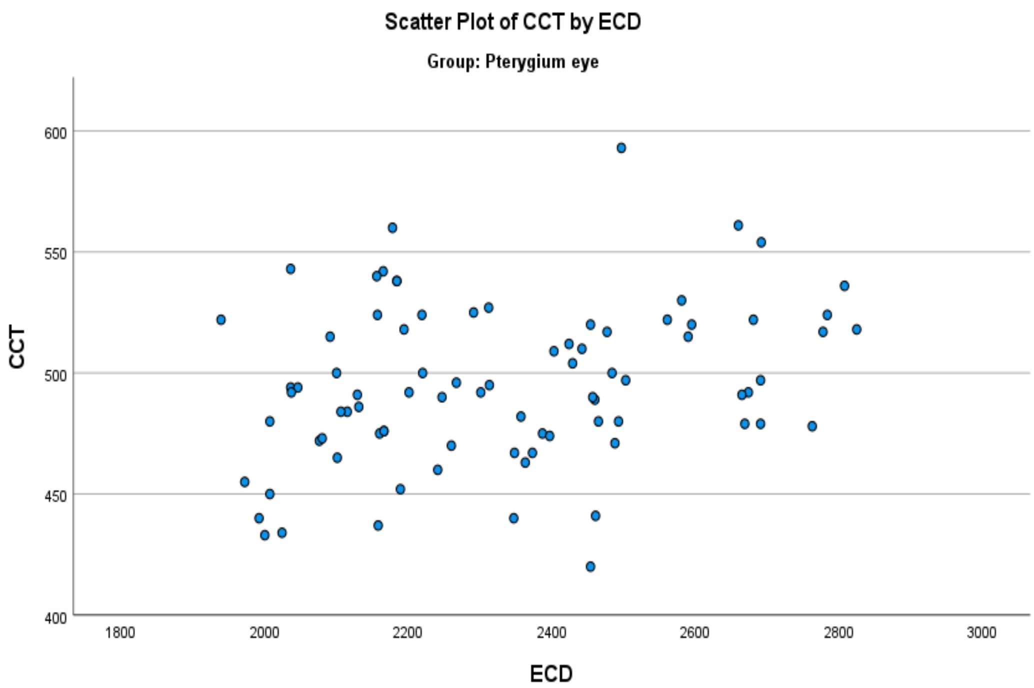
Table 8 :- Rank-Based Comparison of Endothelial Cell Density and Central Corneal Thickness in Pterygium vs. Control Eyes

	Group	N	Mean Rank	P value
PTERYGIUM EYE ECD	Pterygium eye	83	74.53	**0.016**
	Control eye	83	92.47	
	Total	166		
PTERYGIUM EYE CCT	Pterygium eye	83	85.17	0.653
	Control eye	83	81.83	
	Total	166		

Graph 5 : Graph showing Correlation between CCT and ECD in Pterygium eyes

Within the pterygium eyes, there was a low but significant positive correlation between CCT and ECD.

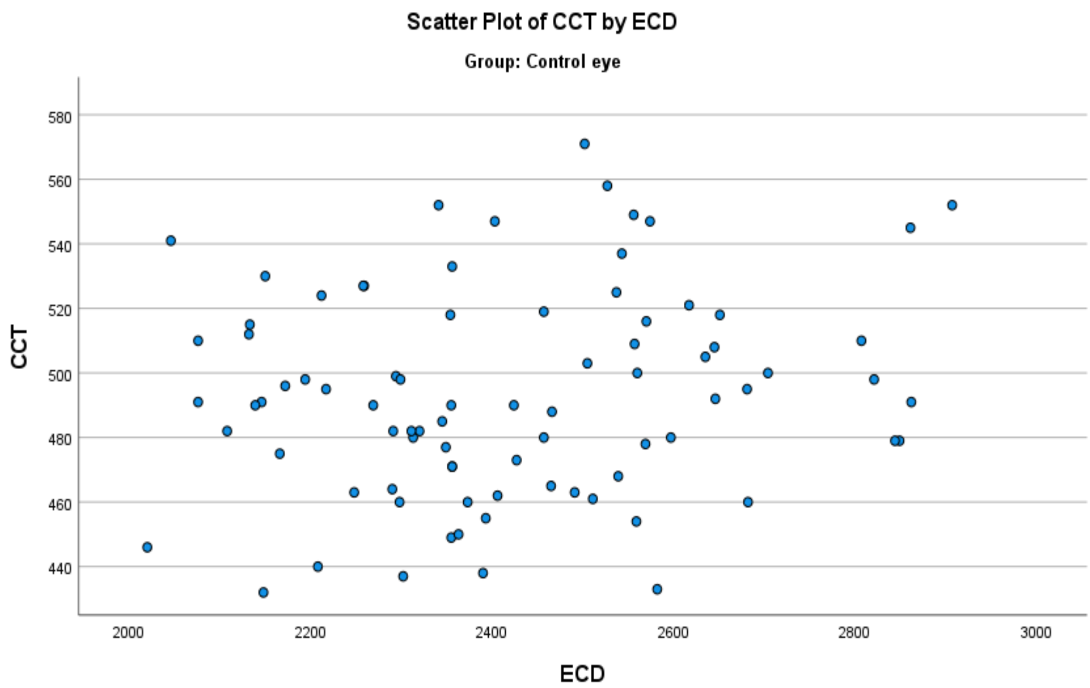
Correlation coefficient=0.270 (p=0.014)



There was no correlation between CCT and ECD in the control eyes.

correlation coefficient=0.126 (p=0.256)

Graph 6 : Graph showing Correlation between CCT and ECD in Pterygium eyes



DISCUSSION

DISCUSSION

Pterygium is a common ocular surface disorder characterized by fibrovascular growth extending onto the cornea, potentially affecting corneal endothelial cell density and overall corneal health. In our study, we assessed the impact of pterygium on corneal ECD using specular microscopy, comparing our findings with existing literature. We analyzed demographic patterns, laterality of eye involvement, and ECD differences between pterygium and normal eyes using a observational cross sectional design. The variations in severity, study population characteristics, and methodology influenced the observed differences across studies.

Specular microscopy has emerged as a valuable tool for measuring endothelial cell density in eyes with pterygium. Pterygium, a common ocular surface disorder characterized by the growth of fibrovascular tissue over the cornea, can significantly alter corneal morphology and function. Specular microscopy provides high-resolution imaging and precise cell counting, allowing for detailed evaluation of endothelial integrity. Studies have shown that ECD tends to be lower in eyes with pterygium compared to healthy eyes, suggesting potential endothelial damage or stress caused by the condition. The reduced ECD may result from chronic inflammation, mechanical stress, or oxidative damage associated with the progression of pterygium. By enabling objective and accurate measurement of ECD, specular microscopy helps in understanding the extent of corneal involvement in pterygium and guiding clinical decision-making regarding surgical intervention and postoperative care.

Demography:

Table 9:- Comparison of Mean Age and Standard Deviation Across Studies

Sl.No	Author	Mean Age	Standard deviation
1.	Saif et al[70]	45	8
2.	Li X et al[30]	66	9.1
3.	Mofta et al[73]	54	11.9
4.	Current study	55.5	11.55

Table 10 :- Gender Distribution of Participants Across Studies

Sl.No	Author	Male	Female
1.	Saif et al[70]	65%	35%
2.	Li X et al[30]	33%	67%
3.	Mofta et al[73]	74%	26%
4.	Current study	30.1%	69.9%

Table 11 :- Comparative Distribution of Eye Involvement: Right vs. Left Eye Across Studies

Sl.No	Author	Right eye	Left eye
1.	Saif et al[70]	65%	35%
2.	Current study	59%	41%

We enrolled 83 pterygium patients with majority females (69.9%) with average age 55.5 years. **Saif et al.**[70] enrolled 20 pterygium eyes and compared them with the other normal eyes to compare the parameters. The average age was 45 years which is lower than our study inclusion and two-third were males (65%) which is higher than our study male gender proportion. **Li X et al.**[30] enrolled 76 patients with unilateral primary pterygium with average age as 66 years and majority females (67%) which is similar to our study. **Mofta et al.**[73] enrolled patients with mean age 54 years similar to our study.

Among the study patients in our study, 59% had right eye involvement. Similar to our study, **Saif et al.**[70] included 65% of patients with pterygium in right eyes.

Endothelial cell density:

Table 12 :- Endothelial Cell Density Comparison: Case vs. Control Across Studies

Sl.No	Author	Endothelial Cell Density(cells/mm^2)	
		Case	Control
1.	Hsu M et al [12]	2232	2462.5
2.	Sousa et al[67]	2451.8	2549.9
3.	Li X et al[30]	2417.5	2575.5
4.	Zaidi et al [31]	2411.6	2751.4
5.	Mofta et al [73]	2561.9	2656.3
6.	Ahmed E.S et al [69]	2156	2498
7.	Zhang et al [68]	2600	2602
8.	Kereem et al [71]	2385	2487
9.	Current Study	2332.8	2419

The mean ECD in pterygium eyes was 2332.83 which is significantly reduced than the control eyes (2419). In a similar comparison study conducted by **Hsu M et al.**[12] the ECD was significantly lower in pterygium eyes compared to control eyes (2232 vs 2462.5). Though the findings were similar, the ECD values of pterygium eyes of our study (2332) was lower than the comparison study which shows the difference in severity of the disease between the study patient inclusion. In the study results of **Sousa et al.**[67] the average ECD of the pterygium eyes (2451.8) was significantly lower than normal eyes (2549.9). Similarly, **Li X et al.**[30] documented that average CECD of pterygium patients (2417.5) was significantly reduced compared to normal eyes (2575.5). **Zaidi et al.**[31] similarly documented that the average CECD in pterygium eyes (2411.6 cells/mm^2) was significantly decreased than normal eyes (2751.4 cells/mm^2). In comparison to other studies, Zaidi et al. conducted study by assessing the ECD parameter thrice to adjust for variability.

Mofta et al.[73] observed a significantly lesser CECD in pterygium eyes (2561.9) compared to normal eyes (2656.3). The reduced ECD in pterygium eyes in comparison to control eyes were compared to our study results.

The reduction in endothelial cell density in pterygium-affected eyes compared to normal eyes was a key finding in our study. The decline in ECD can be attributed to chronic inflammation, fibrovascular invasion, and potential oxidative stress caused by the growth of the pterygium onto the cornea. These factors may lead to endothelial cell damage or loss over time, affecting corneal transparency and function. Pterygium impacts the deeper layers of the cornea, including the Descemet membrane, which reduces the thickness, leading to a lowering of ECD.[67] This could be due to variations in the severity and progression of pterygium in different study populations. More advanced pterygium may cause more significant damage to endothelial cells, leading to a more significant decline in ECD.

Additionally, environmental factors, genetic predisposition, and patient age could also influence these differences. Overall, our study adds to the growing evidence that pterygium affects endothelial cell health, and understanding these changes can help in better disease management and treatment strategies. In addition, studies documented that the exposure ultraviolet radiation impacts the values of ECD. However, we did not adjust for the confounder of UV exposure.

Saif et al.[70] observed that the ECD median values as 531 and 2488, however the difference was not significant. In comparison, the ECD in our study was higher in the pterygium eyes. **Zhang et al.**[68] using a similar model of assessment using spectral microscopy observed that the average ECD (cell/mm^2) was similar between pterygium eyes (2600) and normal eyes (2602) and was not significant. The difference might be due to the inclusion of older patients in Zhang et al study with mean age 71 years in comparison to our study (55 years).

Ahmed E.S et al.[69] documented that the average ECD was lower in completely developed pterygium eyes (2156) compared to partially developed pterygium (2496) and control eyes (2498). Similar to the finding, **Zaidi et al.**[31] observed that the reduction of CECD was more in severe grade 3 (2261 cells/mm^2), followed by the intermediate type (grade 2) (2413 cells/mm^2) and the atrophic type (grade 1) (2459 cells/mm^2). The prospective study of **Kumar M et al.**[72] with 100 pterygium eyes observed that the patients in grade IV level of the disease have a lower average ECD (2158), compared to grade III (2243.7) followed by grade II (2556.9) and grade I

(2706.2). The findings suggest that the ECD decreases with an increase in severity. However, our study did not compare the ECD across the grades of pterygium.

Kereem et al.[71] observed in 81 pterygium eyes that average ECD was comparable with the control eyes (2385 vs 2487). The average ECD of pterygium was higher than our study (2332), suggesting that the severity of the disease was higher than comparison study.

In our study, within the pterygium eyes, there was a low but significant positive correlation between CCT and ECD (Correlation coefficient=0.27), while there was no correlation in the control eyes. This suggests that in pterygium, with decrease in CCT, ECD also tends to be slightly lower. This relationship could indicate that structural changes in the cornea due to pterygium may have an indirect effect on endothelial cell health. **Saif et al.**[70] study observed that the mean CCT was similar in pterygium and normal eyes (505 and 503), and the finding was comparable to our results.

We observed that despite the presence of pterygium, CCT does not seem to differ significantly between affected and normal eyes. However, the presence of a correlation between CCT and ECD in pterygium eyes, suggests that the pathological process of pterygium may subtly influence both parameters, possibly due to chronic irritation, inflammation, or metabolic changes in the cornea. Further research is required to explore the clinical significance of this correlation and its potential implications for disease progression and management.[74] Since these studies are conducted at a single point of time to assess the ECD and CCT which gives the outcomes at the same time and follow-up changes are not captured. This makes difficult to make the causal inference for the change in ECD over time with the influence of severity, age, gender and other factors.

Table 13 :- Central Corneal Thickness Comparison: Case vs. Control Across Studies

Sl.No	Author	Central Corneal Thickness(microns)	
		Case	Control
1.	Li X et al [30]	541	531
2.	Mofta et al [73]	516	506
3.	Kilic et al[75]	532	533
4.	Current study	495	493

In our study, the mean CCT between the groups were comparable (495.06 vs 493.22). However, in the study results of **Li X et al.**[30] the CCT values in the pterygium patients were significantly higher than in control eyes (541 vs 531). However, the difference in values might be due to the assessment of CCT values in Li X et al. study is conducted after the procedure of UV exposure. In comparison, our study was conducted as a cross sectional design prior to the undertaking of the procedure. The difference in CCT values suggests that the mean CCT was lower in our study and the parameters increase following the managements. Our study showed that the presence of pterygium does not significantly affect CCT. Therefore, the difference in CCT between pterygium and control eyes in Li X et al study could be due to changes following pterygium surgery rather than the pterygium itself. This suggests that post-surgical corneal alterations might explain the difference in thickness.

In the study results of **Mofta et al.**[73] control eyes have higher CCT values than pterygium eyes (516 vs 506), which is similar to our study results. Kilic et al.[75] study observed that mean CCT values were similar in pterygium and control eyes (532 and 533). The findings were comparable to our study observations.

LIMITATION:

- The present study was conducted in one center, hence the generalizability to other care levels was limited
- We did not follow up patients to understand the change in endothelial cell density over the time and impact of management procedures
- The current study did not compare and estimate the ECD values of different grades of pterygium and correlate with the stages of progression.
- Since we excluded recurrent pterygium, patients with glaucoma, uveitis, and contact lens usage, the ECD generalizability was limited.

CONCLUSION

CONCLUSION:

In conclusion, using specular microscopy, our study documented a significant reduction in endothelial cell density in eyes affected by pterygium compared to normal eyes, reinforcing the impact of pterygium progression in the cornea. We observed a positive correlation between central corneal thickness and endothelial cell density within pterygium eyes, further emphasizing the potential structural changes in the cornea. We highlighted the need for further longitudinal cohort studies to assess disease progression and its impact on endothelial cell density and management procedures.

SUMMARY

SUMMARY

This cross-sectional 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 April 2023 to November 2024. It investigated the effect of pterygium on corneal endothelial cell density (CECD) and its relationship with central corneal thickness (CCT) in 83 patients with unilateral pterygium, using specular microscopy to compare affected eyes with contralateral healthy eyes.

The study population of 83 patients was predominantly female, with 69.9% being women compared to 30.1% men, reflecting a significant gender disparity. The mean age of the participants was 55.51 years, indicating that pterygium primarily affected middle-aged to older individuals. Pterygium was more frequently observed in the right eye, occurring in 59% of cases, suggesting a possible laterality preference in its presentation.

A significant reduction in corneal endothelial cell density (CECD) was observed in pterygium-affected eyes (2332.83 cells/mm^2) compared to control eyes (2419 cells/mm^2, $p<0.05$), indicating that pterygium contributes to endothelial cell loss. No significant difference was found in central corneal thickness (CCT) between pterygium eyes (495.06 µm) and control eyes (493.22 µm, $p>0.05$), suggesting pterygium has minimal impact on corneal thickness. A low but significant positive correlation was identified between CECD and CCT in pterygium eyes ($r=0.270$, $p=0.014$), but not in control eyes ($r=0.126$, $p=0.256$), implying that structural corneal changes in pterygium may link endothelial density and thickness.

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ANNEXURE

ANNEXURE I

CASE PROFORMA	
Name:	Case No:
Age:	Date:
Sex:	1P No:
Occupation:	
Address:	

Chief complaints:

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:

Pulse – c) RR –

BP – d) Temp –

Systemic examination:

CVS – c. RS –

PA – d. CNS –

OCULAR EXAMINATION		
	RE	**LE**
Head Posture **Ocular Posture** **Facial Symmetry**		
Ocular Movements		
Visual Acuity Distant Near		
Anterior Segment **Grade of pterygium**		
Fundus (IDO & Slit Lamp +90D)		
Keratometry K1 K2		
Treatment		
. **IOP**		
. **Specular microscopy**		

ANNEXURE II

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

INFORMED CONSENT FORM

Case no:

IP no:

TITLE: TO STUDY EFFECT OF PTERYGIUM ON CORNEAL ENDOTHELIAL CELL DENSITY BY SPECULAR MICROSCOPY

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

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

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

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

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

ಶ್ರೀ ದೇವರಾಜ್ ಅರಸ್ ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ, ಟಮಕ, ಕೋಲಾರ - 563101.

ತಿಳಿವಳಿಕೆ ಸಮ್ಮತಿ ನಮೂನೆ

ಶೀರ್ಷಿಕೆ: "ಸ್ಪೆಕ್ಯುಲರ್ ಮೈಕ್ರೊಸ್ಕೋಪಿ ಮೂಲಕ ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೀಲಿಯಲ್ ಸೆಲ್ ಸಾಂದ್ರತೆಯ ಮೇಲೆ ಟೆರಿಜಿಯಮ್ ಪರಿಣಾಮವನ್ನು ಅಧ್ಯಯನ ಮಾಡಲು"ಈ ಸಂಶೋಧನೆಗೆ ರೋಗಿಯ ಗುರುತಿನ ಸಂಖ್ಯೆ:

ಐಪಿ ಸಂಖ್ಯೆ:

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

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

ಸಂಗ್ರಹಿಸಿದ ಮಾಹಿತಿಯನ್ನು ಸಂಶೋಧನೆಗೆ ಮಾತ್ರ ಬಳಸಲಾಗುತ್ತದೆ.

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

ಈ ಸಂಶೋಧನೆಯಿಂದ ಹೊರಬರುವ ಮಾಹಿತಿಯನ್ನು ವೈದ್ಯರು ಯಾವುದೇ ಜರ್ನಲ್ನಲ್ಲಿ ಅಥವಾ ಕಾನ್ಫರೆನ್ಸ್ನಲ್ಲಿ ಪ್ರಕಟಿಸಲು ಅನುಮತಿ ಸೂಚಿಸಿರುತ್ತೇನೆ

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

ಈ ಸಂಶೋಧನಾ ಯೋಜನೆಯ ಭಾಗವಹಿಸುವಿಕೆ ನನಗೆ ಯಾವುದೇ ಹಣಕಾಸಿನ ಹೊರೆ ಒಳಗೊಂಡಿರುವುದಿಲ್ಲ.

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

ANNEXURE III

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

PATIENT INFORMATION SHEET

TITLE: TO STUDY THE EFFECT OF PTERYGIUM ON CORNEAL ENDOTHELIAL CELL DENSITY BY SPECULAR MICROSCOPY

This information is to help you understand the purpose of the study titled "**To Study The effect of pterygium on corneal endothelial cell density by specular microscopy**". As you're 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 this study?

Is to study the effect of unilateral primary pterygium on corneal endothelial cell density.

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

Absolutely no risks are associated with various investigations involved in this study such as

i) Slit lamp biomicroscopy

ii) Specular microscopy

2. What is the benefit for me as a participant?

Participation in this research study may not change the final outcome of your eye condition. However, patients in the future may benefit as a result of the knowledge gained from this study. You will not be charged extra for any of the procedures performed during the research study. Your taking part in this study is entirely voluntary. You may refuse to take part in the study or you may stop your participation in the study at any time, without a penalty or loss of any benefits to which you were otherwise entitled before taking part in this study.

CONFIDENTIALITY

Your medical information will be kept confidential by the study doctor and will not be made publicly available. All information collected from you will be strictly confidential used only by your doctor or ethics review board for research purpose, paper presentation and publication. It will not be disclosed to any outsider except if it is required by the law. This study seeks ethical committee approval and will be started only after their formal approval.

For further information, /clarification please contact Dr. Lakshmi Haneela Nutakki, Sri Devaraj Urs Academy of Higher Education and Research, Tamaka, Kolar – 563101

CONTACT DETAILS:

Dr.Manjula.T.R

Dr. Lakshmi Haneela Nutakki

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SDUMC, Kolar -563101

Mobile No:9030339988

Email ID: honeyhaneela@gmail.com

ಶ್ರೀ ದೇವರಾಜ್ ಅರಸ್ ಉನ್ನತ ಶಿಕ್ಷಣ ಮತ್ತು ಸಂಶೋಧನಾ ಸಂಸ್ಥೆ, ಟಮಕ, ಕೋಲಾರ - 563101.

ರೋಗಿಯ ಮಾಹಿತಿ ಪತ್ರ

ಶೀರ್ಷಿಕೆ: "ಸ್ಪೆಕ್ಯುಲರ್ ಮೈಕ್ರೋಸ್ಕೋಪಿ ಮೂಲಕ ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೆಲಿಯಲ್ ಕೋಶ ಸಾಂದ್ರತೆಯ ಮೇಲೆ ಟೆರಿಜಿಯಮ್ ನ ಪರಿಣಾಮವನ್ನು ಅಧ್ಯಯನ ಮಾಡಲು"

"ಸ್ಪೆಕ್ಯುಲರ್ ಮೈಕ್ರೋಸ್ಕೋಪಿಯಿಂದ ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೆಲಿಯಲ್ ಕೋಶ ಸಾಂದ್ರತೆಯ ಮೇಲೆ ಟೆರಿಜಿಯಮ್ ನ ಪರಿಣಾಮವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು"

ಎಂಬ ಶೀರ್ಷಿಕೆಯ ಅಧ್ಯಯನದ ಉದ್ದೇಶವನ್ನು ಅರ್ಥಮಾಡಿಕೊಳ್ಳಲು ಈ ಮಾಹಿತಿಯು ನಿಮಗೆ ಸಹಾಯ ಮಾಡುತ್ತದೆ. ಈ ಸಂಶೋಧನಾ ಅಧ್ಯಯನದಲ್ಲಿ ಸ್ವಯಂಪ್ರೇರಣೆಯಿಂದ ಪಾಲ್ಗೊಳ್ಳಲು ನಿಮ್ಮನ್ನು ಆಹ್ವಾನಿಸಲಾಗಿರುವುದರಿಂದ, ಅಧ್ಯಯನದ ಉದ್ದೇಶ, ಕಾರ್ಯವಿಧಾನ, ಪ್ರಯೋಜನಗಳು ಮತ್ತು ಅನಾನುಕೂಲತೆಗಳನ್ನು ನೀವು ಓದುವುದು ಮತ್ತು ಅರ್ಥಮಾಡಿಕೊಳ್ಳುವುದು ಬಹಳ ಮುಖ್ಯ .

1. ಈ ಅಧ್ಯಯನದ ಉದ್ದೇಶವೇನು?

   ಕಾರ್ನಿಯಲ್ ಎಂಡೋಥೀಲಿಯಲ್ ಕೋಶ ಸಾಂದ್ರತೆಯ ಮೇಲೆ ಏಕಪಕ್ಷೀಯ ಪ್ರಾಥಮಿಕ ಟೆರಿಜಿಯಮ್‌ನ ಪರಿಣಾಮವನ್ನು ಅಧ್ಯಯನ ಮಾಡುವುದು.

2. ಯಾವ ವಿವಿಧ ತನಿಖೆಗಳನ್ನು ಬಳಸಲಾಗುತ್ತಿದೆ?

   ಯಾರಾದರೂ ಸಹವರ್ತಿ ಇದ್ದಾರೆಯೇ ಅಪಾಯಗಳು?

   ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಒಳಗೊಂಡಿರುವ ವಿವಿಧ ತನಿಖೆಗಳೊಂದಿಗೆ ಸಂಪೂರ್ಣವಾಗಿ ಯಾವುದೇ ಅಪಾಯಗಳು ಸಂಬಂಧಿಸಿಲ್ಲ ಉದಾಹರಣೆಗೆ

   i)ಸ್ಲಿಟ್ ಲ್ಯಾಂಪ್ ಬಯೋಮೈಕ್ರೋಸ್ಕೋಪಿ

   ii)ಸ್ಪೆಕ್ಯುಲರ್ ಮೈಕ್ರೋಸ್ಕೋಪಿ

3. ಭಾಗವಹಿಸುವವನಾಗಿ ನನಗೆ ಏನು ಪ್ರಯೋಜನ?

ಈ ಸಂಶೋಧನಾ ಅಧ್ಯಯನದಲ್ಲಿ ಭಾಗವಹಿಸುವಿಕೆಯು ನಿಮ್ಮ ಕಣ್ಣಿನ ಸ್ಥಿತಿಯ ಅಂತಿಮ ಫಲಿತಾಂಶವನ್ನು ಬದಲಿಸಬಾರದು. ಆದಾಗ್ಯೂ, ಭವಿಷ್ಯದಲ್ಲಿ ರೋಗಿಗಳು ಈ ಅಧ್ಯಯನದಿಂದ ಪಡೆದ ಜ್ಞಾನದ ಫಲಿತಾಂಶವಾಗಿ ಪ್ರಯೋಜನ ಪಡೆಯಬಹುದು. ಸಂಶೋಧನಾ ಅಧ್ಯಯನದ ಸಮಯದಲ್ಲಿ ನಡೆಸಿದ ಯಾವುದೇ ಪ್ರಕ್ರಿಯೆಗಳಿಗೆ ನಿಮಗೆ ಹೆಚ್ಚುವರಿ ಶುಲ್ಕ ವಿಧಿಸಲಾಗುವುದಿಲ್ಲ. ಈ ಅಧ್ಯಯನದಲ್ಲಿ ನಿಮ್ಮ ಪಾಲ್ಗೊಳ್ಳುವಿಕೆಯು ಸಂಪೂರ್ಣವಾಗಿ ಸ್ವಯಂಪ್ರೇರಿತವಾಗಿದೆ. ಅಧ್ಯಯನದಲ್ಲಿ ಪಾಲ್ಗೊಳ್ಳಲು ನೀವು ನಿರಾಕರಿಸಬಹುದು ಅಥವಾ ಈ ಅಧ್ಯಯನದಲ್ಲಿ ಪಾಲ್ಗೊಳ್ಳುವುದಕ್ಕೆ ಮುಂಚಿತವಾಗಿ ನೀವು ಯಾವುದೇ ಅರ್ಹತೆಯಿಂದ ಯಾವುದೇ ದಂಡ ಅಥವಾ ನಷ್ಟವಿಲ್ಲದೆಯೇ ಯಾವುದೇ ಸಮಯದಲ್ಲಿ ನೀವು ಭಾಗವಹಿಸುವಿಕೆಯನ್ನು ನಿಲ್ಲಿಸಬಹುದು.

ಗೌಪ್ಯತೆ

ನಿಮ್ಮ ವೈದ್ಯಕೀಯ ಮಾಹಿತಿಯನ್ನು ಅಧ್ಯಯನ ವೈದ್ಯರು ಗೌಪ್ಯವಾಗಿಡುತ್ತಾರೆ ಮತ್ತು ಸಾರ್ವಜನಿಕವಾಗಿ ಲಭ್ಯವಿಲ್ಲ. ನಿಮ್ಮಿಂದ ಸಂಗ್ರಹಿಸಿದ ಎಲ್ಲಾ ಮಾಹಿತಿಯನ್ನು ಸಂಶೋಧನೆ ಉದ್ದೇಶಕ್ಕಾಗಿ ನಿಮ್ಮ ವೈದ್ಯರು ಅಥವಾ ನೀತಿಸಂಹಿತೆ ಮಂಡಳಿ ಮಾತ್ರ ಗೌಪ್ಯವಾಗಿ ಬಳಸುತ್ತದೆ ಮತ್ತು ಅದು ಕಾನೂನಿನ ಮೂಲಕ ಅಗತ್ಯವಿದ್ದರೆ ಹೊರತುಪಡಿಸಿ ಯಾವುದೇ ಬಾಹ್ಯಗೆ ಬಹಿರಂಗಪಡಿಸುವುದಿಲ್ಲ. ಈ ಅಧ್ಯಯನವು ನೈತಿಕ ಸಮಿತಿಯ ಅನುಮೋದನೆಯನ್ನು ಅಪೇಕ್ಷಿಸುತ್ತದೆ ಮತ್ತು ಅವರ ಔಪಚಾರಿಕ ಅನುಮೋದನೆಯ ನಂತರವೇ ಪ್ರಾರಂಭಿಸಲಾಗುವುದು.

ಹೆಚ್ಚಿನ ಮಾಹಿತಿಗಾಗಿ ಸಂಪರ್ಕಿಸಿ

ಡಾ.ಮಂಜುಳಾ ಟಿ.ಆರ್,

ಡಾ. ಲಕ್ಷ್ಮಿ ಹನೀಲ ನೂತಕ್ಕಿ

ಎಸ್ ಡಿ ಯು ಎಮ್ ಸಿ.

ಟಮಕ, ಕೋಲಾರ

ಸಂಪರ್ಕ ಸಂಖ್ಯೆ: 9030339988

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,

PNP-Progressive Nasal Pterygium , ECD-Endothelial Cell Density , CCT – Central Corneal Thickness

UHID	NAME	SEX	AGE	SIDE INVOLVED	DIAGNOSIS	GRADE	ECD		CCT	
							PTERYGIUM EYE	CONTROL	PTERYGIUM EYE	CONTROL
236962	SARASWATHAMMA	F	50	RE	RE:PNP1MM	0	2595	2635	520	505
249756	SUJATHA	F	55	LE	LE:PNP1MM	0	2007	2355	450	449
271156	NEELAMMA	F	60	RE	RE:PNP2MM	1	2000	2298	433	460
229832	SHARADHA	F	50	RE	RE:PNP1.5MM	0	2313	2466	495	488
260117	CHIKKAMUNIYAMMA	F	60	RE	RE:PNP1MM	0	2465	2569	480	478
261425	VENKATESH BG	M	65	RE	RE:PNP1MM	0	2036	2172	494	496
261439	PRAMEELAMMA	F	50	LE	LE:PNP2MM	1	2007	2355	480	490
261430	AMARAVATHI	F	38	LE	LE:PNP1MM	0	2691	2704	497	500
261418	PRAMEELA	F	38	RE	RE:PNP1MM	0	2127	2166	479	475
261414	JAYAMMA	F	71	LE	LE:PNP1.5MM	0	2424	2457	512	519
261948	KONDAPPA	M	68	RE	RE PNP1.5MM	0	2460	2646	489	492
261958	MUNEER ABBAS	M	69	LE	LE:PNP2.5MM	2	2561	2617	522	521
261961	MAILAKKA	F	60	RE	RE PNP1.5MM	0	2488	2539	471	468
262840	NANJUNDAPPA	M	65	LE	LE:PNP2MM	1	2387	2597	475	480
268377	TULASI RAME GOWDA	M	60	RE	RE:PNP1.5MM	0	2166	2356	476	471
261903	NARAYANSWAMY	M	45	RE	RE:PNP2MM	1	2347	2582	440	433
277116	ADEMMA	F	60	LE	LE:PNP3MM	2	2674	2862	492	491
277114	NARAYANAPPA	M	56	RE	RE:PNP 2 MM	1	2581	2651	530	518
282725	SUBRAMANI	M	40	RE	RE:PNP2MM	1	2101	2406	465	462
285714	GANGAMMA	F	64	RE	RE:PNP3MM	2	2076	2465	472	465
285719	NARSAMMA	F	72	LE	LE:PNP1.5MM	0	2373	2491	467	463
190933	PARVATHAMMA	F	55	RE	RE:PNP 2MM	1	2493	2559	480	454
375595	BHAGYAMMA	F	56	LE	LE:PNP2MM	1	2046	2146	494	491
371770	PAVAN	M	26	LE	LE:PNP2.5MM	2	2165	2341	542	552
508828	SUBRAMANI	M	34	LE	LE:PNP3MM	2	2036	2556	543	549

369350	THIRUMALESHAPPA	M	54	RE	RE:PNP2MM	1	2429	2681	504	495
476143	KRISHNAMMA	F	60	LE	LE:PNP2.5MM	2	2194	2557	518	509
373822	NARAYANASWAMY	M	59	LE	LE:PNP3MM	2	2201	2502	492	571
339594	SHANKAR BABU	M	58	LE	LE:PNP2MM	1	2442	2574	510	547
294103	THOLISAMMA	F	55	RE	RE:PNP1.5MM	0	2348	2682	467	460
417525	NARASAMMA	F	52	RE	RE:PNP 1MM	0	2665	2849	491	479
549384	GNYAMAMMA	F	60	LE	LE:PNP3MM	2	2669	2457	479	480
448242	CHOWDAMMA CH	F	45	RE	RE:PNP2.5MM	2	2160	2390	475	438
265621	PARVATHAMMA	F	51	RE	RE:PNP2MM	1	2763	2844	478	479
267365	NARAYANAMMA	F	66	LE	LE:PNP2.5MM	2	2457	2320	490	482
202142	DHANAMMA	F	52	RE	RE:PNP3MM	2	2166	2356	476	471
520025	VENKATAPPA	M	70	RE	RE:PNP2MM	1	2184	2259	538	527
519571	ADEMMA	F	54	RE	RE PNP2.5MM	GARDE 2	2178	2403	560	547
501793	KRISHNAPPA	M	58	LE	LE:PNP1.5MM	0	2363	2294	463	499
510006	GANGAMMA	F	50	LE	LE:PNP2MM	1	2241	2076	460	491
501786	BETTAMMA	F	69	RE	RE:PNP1.5MM	0	2267	2345	496	485
501794	CHINNAPPA	M	58	RE	RE:PNP2.5MM	2	2115	2313	484	480
497944	ALLAUDDIN	M	54	RE	RE:PNP3MM	2	2260	2511	470	461
487744	VEERAMMA	F	60	LE	LE:PNP2MM	1	2312	2132	527	512
452052	NAGAMMA	F	64	LE	LE:PNP1MM	0	2397	2349	474	477
494420	SHOBHA	F	27	RE	RE:PNP2.5MM	2	2681	2807	522	510
447191	ANJAMMA	F	64	RE	RE:PNP2MM	1	2220	2424	500	490
448088	RADHIKA	F	49	RE	RE:PNP2MM	1	2403	2505	509	503
445712	THIMAKKA	F	55	LE	LE:PNP1MM	0	2301	2139	492	490
451244	BHAGYAMMA	F	66	RE	RE:PNP1MM	0	2100	2299	500	498
500860	VENKATARAVANAMMA	F	43	LE	LE:PNP1MM	0	2291	2150	525	530
452049	PARVATHAMMA	F	39	RE	RE:PNP2MM	1	2778	2821	517	498
441783	WASEEM PASHA	M	40	RE	RE:PNP1MM	0	2454	2560	520	500

501621	MANJAMMA	F	53	RE	RE:PNP1.5MM	0	1992	2020	440	446
520486	GULNAZ	F	30	RE	RE:PNP2MM	1	2184	2258	538	527
519581	GOPAL REDDY	M	55	RE	RE:PNP2MM	1	2357	2427	482	473
519586	MUNIVENKATAPPA	M	79	RE	RE:PNP 2MM	1	2037	2108	492	482
519583	VENKATARATHNAMMA	F	55	RE	RE:PNP2MM	1	2497	2527	593	558
519591	SUSHEELAMMA	F	49	LE	LE:PNP1MM	0	2461	2373	441	460
514702	KESHAVULU	M	51	LE	LE:PNP2MM	1	2477	2356	517	533
514562	KRISHNAPPA	M	82	RE	RE:PNP2MM	1	2091	2217	515	495
509965	ANJINAPPA	M	39	RE	RE:PNP1.5MM	0	2825	2537	518	525
508803	THIMAKKA	F	60	LE	LE:PNP1MM	0	2590	2570	515	516
481251	MUNIVENKATAMMA	F	65	LE	LE:PNP2MM	1	2247	2076	490	510
508165	AMARAVATHI	F	35	LE	LE:PNP1MM	0	2219	2212	524	524
266855	NAGARATHNAMMA	F	70	RE	RE:PNP2MM	1	2157	2354	524	518
451244	BHAGYAMMA	F	60	RE	RE:PNP2MM	1	2106	2290	484	464
484142	YALLAMMA	F	34	RE	RE:PNP1MM	0	2692	2907	554	552
514667	SHANTHAMMA	F	52	LE	LE:PNP2MM	1	2503	2194	497	498
441778	PAPAMMA	F	59	LE	LE:PNP1MM	0	2156	2046	540	541
509955	ANJAPPA	M	50	LE	LE:PNP1MM	0	2660	2543	561	537
507642	GOWRAMMA	F	78	RE	RE:PNP1.5MM	0	1939	2133	522	515
275682	CHANDRAMMA	F	60	RE	RE:PNP1MM	0	2024	2393	434	455
497932	MAHABOOB BEE	F	57	RE	RE:PNP2MM	1	2129	2291	491	482
500917	RAJAMMA	F	55	LE	LE:PNP1MM	0	2784	2645	524	508
256271	ADILAKSHMAMMA	F	53	RE	RE:PNP2MM	1	2080	2248	473	463
472453	VENKATRAMAPPA	M	63	LE	LE:PNP1MM	0	2158	2148	437	432
527576	MUNIYAMMA	F	70	LE	LE:PNP1.5MM	0	2454	2208	420	440
293564	NAGAMANI	F	45	RE	RE:PNP 2.5MM	2	2808	2861	536	545
526101	SIDDAMMA	F	71	RE	RE:PNP1MM	0	1972	2363	455	450
545961	LAKSHMAMMA	F	54	RE	RE:PNP1MM	0	2189	2302	452	437

525101	GANGAMMA	F	60	RE	RE:PNP1MM	0	2131	2311	486	482
445407	NAGAMMA	F	64	LE	LE:PNP2MM	1	2484	2269	500	490