Dissertation on

COMPARISON OF CORNEAL TOPOGRAPHY WITH AUTOMATED REFRACTOMETRY IN THE ASTIGMATISM OF KERATOCONUS

Submitted in partial fulfillment of requirements of

M.S. OPHTHALMOLOGY

BRANCH - III

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CHENNAI

MARCH 2010

CERTIFICATE

This is to certify that the dissertation entitled, "**COMPARISON OF CORNEAL TOPOGRAPHY WITH AUTOMATED REFRACTOMETRY IN THE ASTIGMATISM OF KERATOCONUS"** submitted by **Dr.M.S.GOKILA,** in partial fulfillment for the award of the degree of Master of Surgery in Ophthalmology by The Tamilnadu Dr.M.G.R.Medical University, Chennai is a bonafide record of the work done by her in the Regional Institute of Ophthalmology, Government Ophthalmic Hospital, Egmore, Chennai, during the academic year 2007 – 2010.

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ACKNOWLEDGEMENT

I wish to express my sincere thanks to **Prof.Dr.J.Mohanasundaram, M.D., Ph.D., D.N.B.,** Dean, Madras Medical College, for permitting me to do this study at the Regional Institute of Ophthalmology and Government Ophthalmic Hospital, Chennai.

It is with overwhelming respect and profound gratitude I thank **Prof.Dr.M.Radhakrishnan, M.S., D.O.,** Director and Superintendent, RIOGOH, for assigning this topic and his continuing help, encouragement and valuable guidance throughout my postgraduate course in Ophthalmology.

I am greatly indebted to my Chief and my guide **Prof.K.Vasantha, M.S., F.R.C.S.,** who with her constant help, patience and affection has constantly encouraged in every way during my post graduate course and conduct of this study.

I express my gratitude to the Assistant Professors in my unit.

To **Dr.P.Rajini, M.S., D.O.,** for her effective guidance during the study and also during the course.

To **Dr.K.Mohan, M.S., D.O.,** for his support, guidance and encouragement throught my course in Ophthalmology.

To **Dr.B.Kalaiselvi, M.S.,** for always being a source of constant help and guidance in all my endeavours.

I would like to thank all the **Unit chiefs, Assistant Professors** and all my colleagues who have played a salutary sole.

Finally, I am indebted to **all my patients** for their sincere cooperation during the period of my thesis.

CONTENTS

INTRODUCTION

Keratoconus is a non inflammatory degenerative disease that compromises the structural integrity of the collagen matrix within the corneal stroma[17]. The hallmark characteristic is the development of a localized cone shaped ectasia that is accompanied by thinning of the stroma in the area of the cone. This leads to increasingly irregular astigmatism as well as a steeper corneal curvature. This causes retinal image blur and poor visual acuity. Keratoconus causes mild to severe loss of vision.

The incidence of keratoconus in the general population is approximately 2 per 100,000 (0.002%)[5]. The prevalence rate of keratoconus is 54.5 per 100,000 (0.05%)

It is a general rule that whatever test for keratoconus is performed in one eye it should always be done in the fellow eye and the results are compared.

HISTORY

With the advent of widespread refractive correction in the 17th century, interest developed in the shape of cornea and the optical properties of eye.

In **1619, Scheiner** made the first measurements of corneal shape. He held up a series of convex mirrors of different curvatures next to the eye until he found one which gave an image of same size as the image from the cornea.

In **1748**, German oculist **Burchard Mauchart** provided an early description of a case of Keratoconus, which he called as Staphyloma diaphanum.

In **1820, Cuigent** developed a **keratoscope** through which he observed the reflected image of illuminated target held in front of patients' cornea.

In **1854**, British physician **John Nottingham** clearly described Keratoconus and distinguished it from other ectasia of the cornea.

Quantification of corneal curvature became possible in **1854** with the development of **Keratometer by Von Helmholtz**.

In **1859**, British surgeon **William Bowman** used an Ophthalmoscope to diagnose Keratoconus. He also attempted to restore the vision by pulling on the iris with a fine hook inserted through the cornea and stretching the pupil into vertical site.

In **1869**, Swiss ophthalmologist **Johann Horner** wrote a thesis entitled on the **“Treatment of Keratoconus”**.

In **1882, Placido** placed an observation hole in the centre of the target. His target was a disc bearing alternate black and white concentric rings and this pattern still forms the basis of many topographic systems today.

In **1888**, the treatment of keratoconus became one of the first practical application of the newly invented **Contact Lens**.

Javal (1889) attached a placid type disc to his Keratometer which gave him the benefit of magnified keratoscopy.

In **1896 Gullstrand** applied photography to keratoscopy **(photokeratoscopy).**

In **1936, Roman Castrovigo** performed first successful corneal transplantation[17].

ANATOMY

The transparent cornea is the main structure responsible for refraction of light entering the eye. This clear transparent structure forms anterior 1/6th of the eye ball. The Cornea has 5 layers

1. The Epithelium
2. The acellular Bowman's Layer
3. Corneal Stroma
4. Descemets Membrane
5. Corneal endothelium

EPITHELIUM

It is a non-keratinised stratified squamous epithelium of 5 to7 layers thick (about 10% of corneal thickness). It has morphologically 3 layers.

a) Single layer of columnar basal cells.
b) 2 to 3 layers of wing cells.
c) 2 to 3 layers of superficial squamous cells.

Normally only the basal cells replicate, mitosis occurs in about 5% of cells at any one time. The daughter cells move apically and become the overlying wing cells.

The daughter cells then migrate anteriorly to become the flattened squamous cells, which ultimately are sloughed into tear film. It takes about 1week for the entire corneal epithelium to be replaced.

Corneal epithelial cells are tightly adherent to each other and the underlying structures by means of specialized junctions. There are three types of junctions[2].

1. Occluding
2. Communicating
3. Anchoring

At the corneo-sceleral junction (Limbus) the epithelium becomes thicker and may consist of 10 or more layers of cells.

Other than epithelial cells, neurons, melanocytes, Langerhans cells and occasional leucocytes are present within the epithelial layer. Langerhans cells are modified macrophages normally found in the peripheral corneal epithelium. They are thought to play a role in ocular hypersensitivity and other immunological phenomenon by processing antigens and presenting them to lymphocytes.

- Acts as a mechanical barrier to foreign material and micro organisms and via the Langerhans cells as an outpost for immune defense.[5]

- Creates a smooth, transparent optical surface by adsorption of tear film.
- Maintains a barrier to the diffusion of water, solutes and drugs.

BOWMAN'S MEMBRANE

It is an acellular region composed of a network of fine randomly oriented collagen fibrils. It lies between the epithelial basement membrane and cellular stroma. It is 8 to 12 µm thick and may help the cornea in maintaining fixed shape, there by enabling it to perform its optical function. During embryonic development this layer develops from basal epithelial cells but these cells lose their ability to regenerate this structure. So, once damaged it cannot be regenerated.

STROMA

It comprises 90% of corneal thickness. It is composed almost entirely of an extra-cellular matrix with keratocytes dispersed throughout and type I collagen fibrils running parallel with the surface. It is transparent fibrous and compact. Keratocytes are the predominant cell type in the stroma. They are flat cells derived from neural crest. Major extracellular material in stroma is collagen which is highly orderly arranged. Human cornea has 3 different types of collages I, V and VI.

DESCEMET'S MEMBRANE

It is the normal basement membrane secreted by the corneal endothelium. Its peripheral lamellation visible by gonioscopy is known as Schwalbe's line. It is compared predominantly of type IV collagen and glycoprotein including fibrinonectin.

- Forms a scaffold on which the endothelial cells spread themselves.
- Act as a barrier to the penetration of leukocytes and blood vessels into stroma but allows passage of water and small molecules.

CORNEAL ENDOTHELIUM

The endothelial cells form a uniform paving stone mosaic of closely apposed polygonal cells with 5 to 7 sides. These cells are 20 micrometer in diameter with 250 micrometer surface area.

The adult human endothelium has limited capacity to divide and replace aging and injured endothelial cells. Instead the endothelium enlarges reorganized, migrates and maintain tight apposition to neighbouring cells. Polymegathism describes heterogeneity in cell size. Pleomorphism describes heterogeneity in cell shape.

Decrease in cell count and increase in cell size and shape, helps to restore and maintain pump and barrier function. When cell density < 400 – 500 cells functional reservoir is minimal and corneal odema is likely to occur. It regulates the passage of aqueous into stroma and helps in maintaining deturgescence.

HISTOPATHOLOGY

All layers of the cornea show microscopic alterations, the earliest changes occur in the superficial layers of the cornea.

Epithelium: In early stage, Basal layer of epithelium is pale, edematous with pyknotic nuclei and disorganized cytoplasmic organelles. In advanced stage the cell membrane breaks up and the basal cells eventually disappear.

Bowman's Layer: Initially there is swelling and fibrillar degeneration of Bowman's Layer. In advanced stage the Bowman's layer shows multiple narrow gaps and takes on a wavy appearance.

Stroma shows abnormal thinning. Collagen fibrils are normal, with less number of collagen lamellae. Due to fibrillar degeneration, the superficial stroma is eventually destroyed and replaced by newly formed connective tissue, irregularly arranged in a wavy pattern.

Amyloid deposit occurs first beneath the epithelium, then intermittently along corneal lamellae at varying depths of the stroma.[2]

Descemet's membrane shows folds in early stage. In later stage rupture in the region of greatest ectasia occurs.

Endothelium appears normal in early stages. Late stage endothelial cells are flattened and their nuclei lie farther apart. The degree of endothelial damage correlates with the severity and duration of Keratoconus.

ETIOLOGY OF KERATOCONUS

Definite etiology is unknown. Keratoconic corneas have increased levels of numerous enzymes capable of degrading a wide variety of corneal extracellular matrix. These degradative enzymes are associated with oxidative stress. The mechanism that regulates the enzyme inhibitor interactions are not understood.

1. Degradative Enzymes and Their Inhibitors:-

The characteristic stromal thinning and loss of Bowman's layer found in keratoconic corneas are associated with increased degradative enzymes and a decline in the enzyme inhibitors.

Keratoconic corneas have increased level of lysosomal enzymes (acid esterase, and phosphatase acidic lipase) Cathepsins and matrix metalloproteinase – 2 (MMP2). The inhibitor of the enzymes such as α1 proteinase inhibitors, α2 macroglobulin tissue inhibitors of metalloproteinase I and 3 are decreased in keratoconic corneas.[17]

2. Abnormal Stromal Matrix:

Keratoconic corneas have decreased total protein and sulfated proteoglycans levels, collagen cross linking and variable total collagen content. Keratoconic corneas have non specific fibrotic changes such as elevated levels of type III Collagen, Tenascin – C, Fibrillin 1 and Keratocon.

The stromal lamellar slippage plays a significant role in keratoconus thinning and anterior protrusion. The stromal lamellae in keratoconus are distributed unevenly. Inter lamellar and intra lamellar slippage is possible.

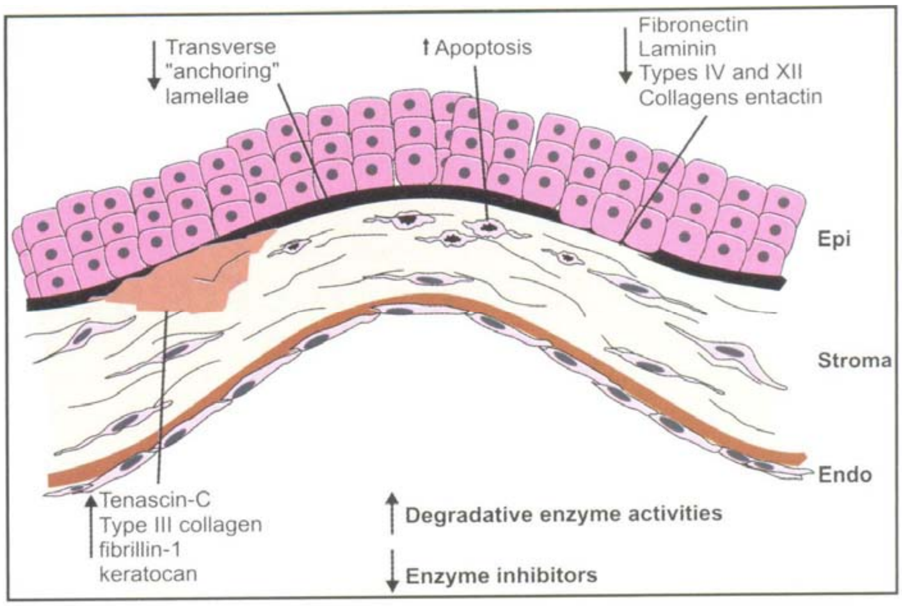


Fig. 1 shows abnormal stroma in Keratoconus

It also lacks in anchoring lamellae and the inter woven lamellae which are transversely inserted into Bowman's layer for approximately 120 µm, which is critical for maintaining corneal shape.

3. Transcription Factors

Two transcription factors sp1 and Kruppel like factor 6 (KLF 6) are elevated in keratoconic corneas, can repress the promotor activity of α1 proteinase inhibitor leading to lower protein levels.

4. Genetic factors

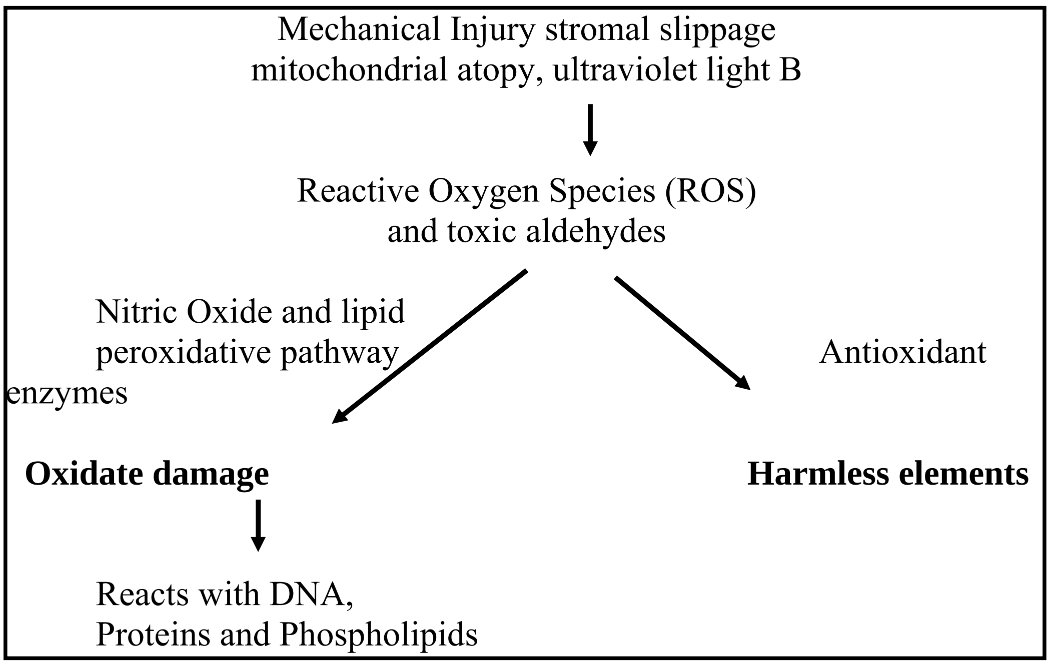
It is likely that both genetics and environment contribute to the development of keratoconus. Keratoconus is found in identical twins and multigenerational families.[2] Most families with keratoconus show autosomal dominant inheritance with variable penetration.

5. Apoptosis

Apoptosis is a biological process of programmed cell death. It is reported that 60% of keratoconic corneas have apoptotic stromal keratocytes.[17] Apoptosis occurs in the anterior stroma and other layers of keratoconic corneas. Chronic repetitive injury to the corneal epithelium stimulates stromal apoptosis. Keratoconic corneas have elevated levels of leucocyte common antigen related protein and Transmembrane phosphotyrosine phosphatase, that stimulates apoptosis and decreased level of TIMP 1, a protein that inhibits apoptosis.

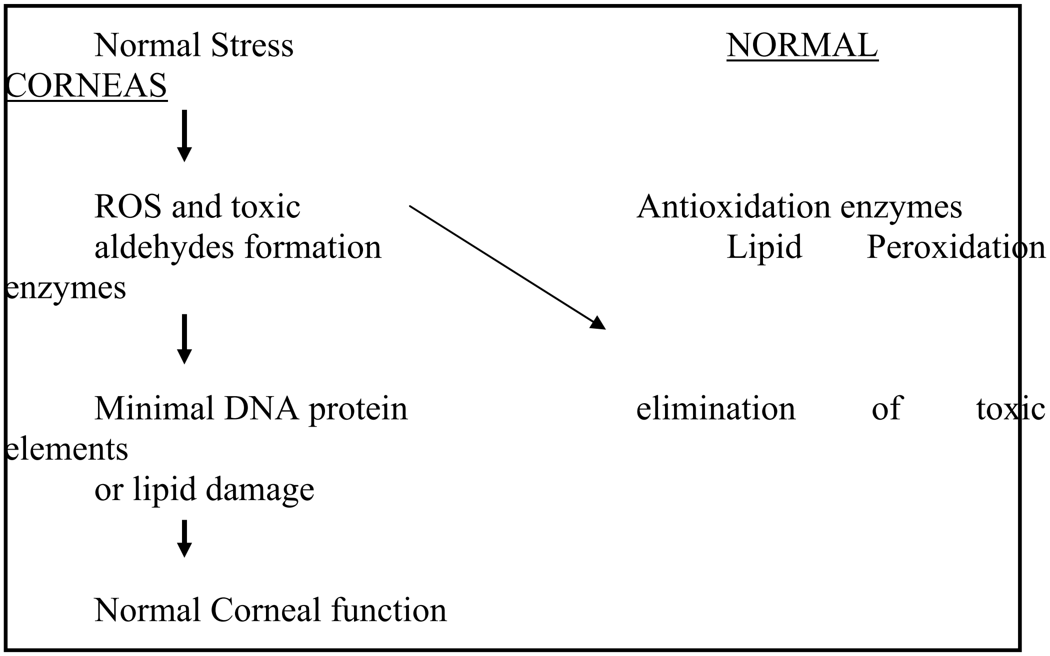
6. Oxidative Damage

Keratoconic corneas show sign of oxidative damage. There are increased levels of inducible Nitric oxide synthase, Nitrotyrosine, Melandialdehyde and Glutathione S. transferase. There are lower levels of important enzymes critical for the removal of harmful oxidants like superoxide dismutase and Aldehyde dehydrogenase class 3.

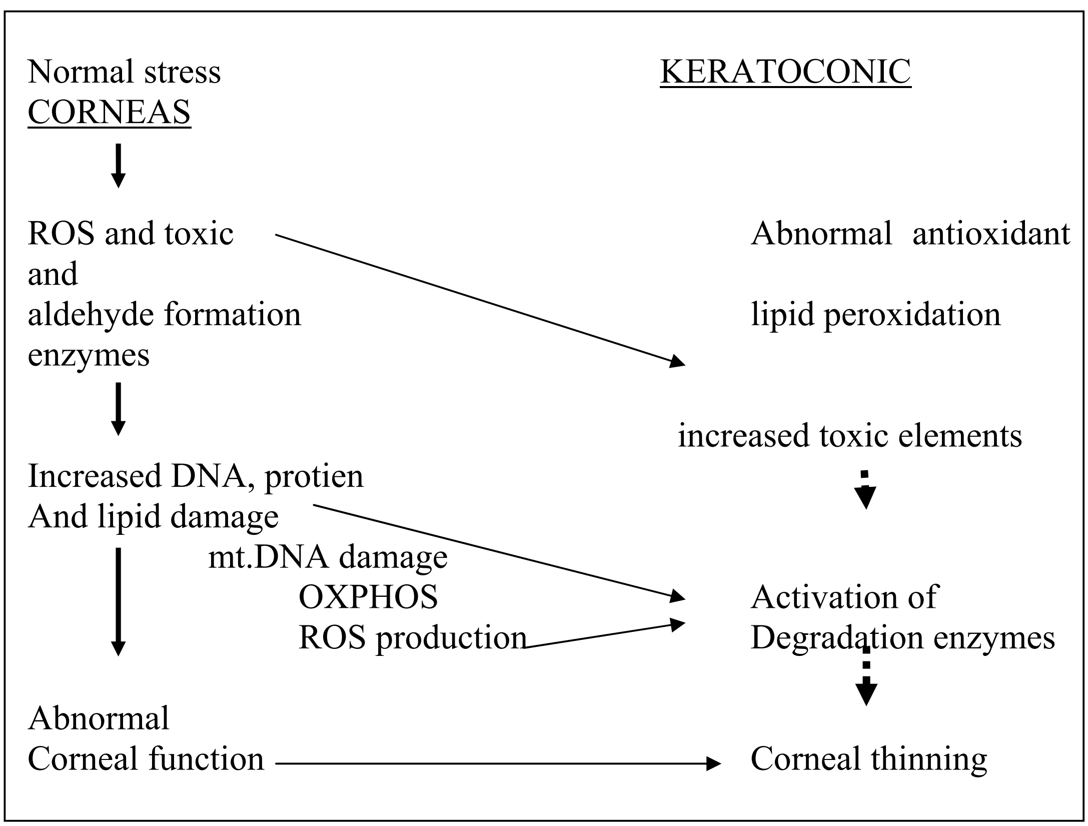


Mechanism of oxidative damage that ultimately can decrease cell function and lead to cell death.

These types of antioxidant abnormalities are associated with increased levels of Superoxide radicals O_2, Hydrogen peroxide (H2O2) and Hydroxyl radicals (OH) commonly referred to as Reactive Oxygen Species (ROS) and cytotoxic aldehydes. These elements react with proteins, DNA and lipids to cause alterations in the cellular structure and function of the cell.



In normal corneas the elimination of ROS and aldehyde by antioxidant and lipid peroxidation enzymes causes minimal damage to DNA protein & lipids



Keratoconic corneas have

(i) Oxidative and cytotoxic byproducts from both lipid peroxidation and nitric oxide pathways.
(ii) Abnormalities in levels and activities for corneal antioxidant enzymes which are responsible for elimination of ROS and toxic aldehydes.
(iii) Defect in SOD gene, an antioxidant enzyme
(iv) Increased mitochondrial DNA damage.

The overlying common pathway of Keratoconus is related to the oxidative stress pathway.[17] The Keratoconic corneas have underlying defects in their ability to process ROS and thereby undergo oxidative damage. This triggers a series of downstream events that ultimately lead to corneal thinning and loss of vision. Understanding these mechanisms will help future therapies for this debilitating corneal disorder.

CLINICAL FEATURES OF KERATOCONUS

Clinical symptom of keratoconus in a painless loss of vision which is usually gradual and progressive in nature which results in irregular myopic astigmatism.

EXTERNAL SIGNS

By gross inspection when viewed from the side the cornea assume the shape of a truncated cone.

Munson's Sign

When the patience look downwards the lower lid margin are angulated by the cone facilitating observation of the abnormality in corneal curvature. The cones are round or nipple shaped. The apex of the cone lies most commonly in lower nasal quadrant.

Rizzuti's Sign

This sign is observed by focusing a light on the nasal anterior sclera where the light is directed into cornea from the temporal direction.[9] The optics of the cone refracts the incoming light back onto the nasal sclera whereas in normal cornea this effect is not seen.

Scissoring Reflex

In retinoscopy, the optical path length through the eye is longer along the direction that light travels through the cone apex compared to the surrounding region.[5] The retinoscopic reflex will tend to appear distorted and flash unevenly as the retinoscopy light is passed across the pupil.

Slit lamp Biomicroscopy signs

Focal thinning at the cone apex is made out by viewing optical cross section produced by a thin slit beam under high magnification. Localised thinning in patient's cornea is seen as a change in the width of the optical cross section.

Fleischer's Iron ring

It partially or completely encircles the base of the cone due to accumulation of ferratin particles in corneal basal epithelial cells.

Vogt's Striae

It is a sign of corneal stretching and protrusion. It appears as thin brightly vertical lines located deep in the stroma adjacent to Descemet's layer. When depressed, Vogt's striae often disappear

Hydrops

Corneal tear in the Descemet's layer allows aqueous fluid to enter into corneal stroma. This leads to stromal odema.

Oil droplet sign

In ophthalmoscopy, dark round shadow in the corneal mid periphery is seen due to total internal reflection of light surrounding the bright red fundal reflex.

MYOPIA IN KERATOCONUS

The myopia in keratoconus is pathological duo to increase in the anteroposterior length of the eyeball. There is a rapidly progressive error resulting in high myopia. This leads to decrease in visual acuity. This error of refraction is assessed by standard methods like Retinoscopy and Refractometry.

EVALUATION OF ASTIGMATISM

Astigmatism is that condition of the eye where refraction varies in the different meridian and so a point focus of light cannot be formed upon the retina.

Anterior corneal curvature is a prolate.[2] It is not exactly spherical, since the peripheral part is substantially flatter than the central part. The central part has an average curvature of 7.8 mm.

The optical zone is nearly spherical, but keratometry shows that even in this region curvature varies in different meridians proving the apical zone to be toric. Hence the refractive system of the eye has some built in physiological astigmatism. The central optical zone is that amount of central area varying in power not more than 1 diopter differences. The average value is about 4mm.

Astigmatism may be an error of either curvature of cornea or the lens or of centering.

The most common error is about 0.25D with vertical curvature greater than horizontal. This is due to constant pressure of upper eyelid on the cornea, known as *with the rule astigmatism* or *physiological astigmatism.*

Optical Condition in Astigmatism:

The configuration of rays as it passes through a toric surface is called the **Strums Conoid** with 2 focal lines instead of a single focal point separated by a focal interval.[11] The circle of least diffusion is located dioptrically midway between 2 focal lines. The length of focal interval is the measure of magnitude of astigmatism. This can be corrected by reducing these 2 focal lines into single focal point on to the retina.

TYPES OF ASTIGMATISM

A. **Regular Astigmatism:** The 2 principle meridians are at right angles to each other it can be either with the rule against the rule.

- ❖ **Simple myopic or hypermetrophic astigmatism**: One of the focal lines falls on the retina. The other may fall either in front, as in simple myopic, or behind the retina in simple hypermetrophic astigmatism.
- ❖ **Compound myopic or hypermetrophic astigmatism**: Neither of 2 lines falls on the retina, but are placed either in front as in compound myopic, or behind the retina as in compound hypermetrophic astigmatism.
- ❖ **Mixed Astigmatism**:One focal line falls in front of retina and the other focal line falls behind the retina.

B. Irregular Astigmatism:

An irregularity in the curvature of cornea is different in the various meridians and no geometrical pattern is adhered to. This is the most common type of astigmatism in keratoconus.

ASSOCIATIONS OF KERATOCONUS

Systemic Diseases	**Ocular disorder**
• Connective tissue and mesodermal dysplasia. • Marfan's Syndrome • Ehlers – Danlos sydrome. • Osteogenesis imperfecta • Congenital hip dysplasia. • Oculodento digital syndrome • Rieger's Syndrome • Crouzon's syndrome • Floppy eyelid syndrome. • Down's syndrome • Hypo thyroidism. • Turners syndrome	• Retinitis Pigmentosa • Leber's Congenital amaurosis • Blue Sclera • Congenital Cataract • Aniridia • Retinopathy of Prematurity • Fuch's dystrophy • Posterior Polymorphos dystrophy • Granular and Lattice dystrophy

Differential Diagnosis

- ❖ Keratoglobus
- ❖ Pellucid Marginal degeneration
- ❖ Posterior Keratoconus

EVALUATION OF KERATOCONUS

The various properties of cornea assessed are, its

a. Thickness
b. Contour
c. Dioptric power and
d. Radius of curvature

PACHYMETRY

Ultrasonic pachymetry shows exact thickness of cornea at different places. Thinning in inferior quadrant is diagnostic of keratoconus. Central or paracentral corneal thickness of less than 450 µm is abnormal.[15] If the reading decreases by nearly 20 µm towards the inferior periphery on successive pachymetry readings is a true index of keratoconus.

KERATOSCOPY

Keratoscopy uses a pattern of concentric rings called a "Placido disc" with approximately nine alternating bright and dark rings[7]. The rings are reflected off the anterior corneal surface via Purkinje image number one, and viewed by the clinician. The pattern of rings is analysed to assess if irregular astigmatism or keratoconus exist.

The rings appear to be thin and tightly squeezed together in those regions where the curvature was steep and broadly dispersed wherever the curvature was flat.

Normal Spherical cornea	-	The rings appeared to be circular
Corneal astigmatism	-	Appeared to be oval with short axis corresponding to steep meridian.
In Keratoconus	-	Rings were distorted and grouped more closely in cone region

Moderate and severe forms of keratoconus are easy to distinguish using these mires. But it is difficult to appreciate the subtly compressed rings in mild keratoconus and central keratoconus.

KERATOMETRY

Keratometer measures the central radius of curvature of the anterior corneal surface and provides its dioptric power. Helmholtz proposed that the central optics of the human cornea approximate a spherocylindric lens and in 1853, he introduced the first instrument for measuring corneal power.[16]

There are two principle keratometers

1. The Bausch and Lomb
2. The Javal

Optic principle

Both project a pair of illuminated mires on to corneal surface and using targets of known size and a fixed distance between the target and the cornea, measure the size and distance of reflecting mires.

The reflected mires from a steeper surface are smaller and closer than those from a flatter one. Measurement of the size of the mires permits calculation of the radius of curvature and determination of the dioptric power.

Limitations of Keratometry

- Keratometry measurements provide no information about the topography of the paracentral and peripheral corneal surface.
- Further, it does not quantify irregular astigmatism.
- It measures only the radius of curvature between two points approximately 3mm apart

AUTO REFRACTOMETER

Refraction, being the most commonly performed optical procedure, has been widely developed. Though the conventional technique of Retinoscopic Refraction is an excellent method, it is time consuming. Alternate method of finding out the Error of Refraction by the use of an optical equipment called Refractometer or Optometer is in use in the modern practice.

Optical Principle

Refractometers are based on two principles.

1. Scheiner Principle
2. Optometer Principle

Scheiner Principle:

Parallel rays of light entering an emmetropic eye are focused on retina.[11] A double aperture disc is place in front of the eye to isolate the rays into two bundles. In emmetropic eye, the two bundles of rays passing through the pupil are focused as a single spot on the retina. In myopia, the two ray bundles cross each other and form two small spots on retina. In hypermetrophic eyes the ray bundles are intercepted by the retina before they cross, and thus two small spots of lights are seen. These two small points of light are coalesced into a single point by moving the double pin hole to the far point of the eye. From the far point the refractive error is determined.

Optometer principle

In this, a single converging lens is used. Light from a target and the far side of the lens enter the eye with vergence of different amounts (zero, minus or plus depending on the position of the target).

Limitation of refractometer

The three basic factors are responsible for the limited acceptance of refractometer in clinical practice.

1. Alignment problem
2. Irregular astigmatism
3. Accommodation

Alignment Problem Both pinhole apertures must fit within patient's pupil. If the patient's fixation is not there, the reading is invalid

Irregular astigmatism The best refraction over the whole pupil may be different in contrast to small pinhole areas of the pupil.

Accommodation Accommodation by the patient alters the actual refractive status. Factors affecting accommodation include attention, fatigue and direction of gaze and blur of the retinal image.[16]

CORNEAL TOPOGRAPHY

Topography is the science of describing or representing features of a particular place in detail. Corneal Topography measures the shape or curvature of the anterior corneal surface.[7]

Methods of Measurement

- Based on principle of reflection
- Based on principle of projection

1. **Reflection based**
    - Majority of topography systems are based on this principle.
    - Examples include keratometer and Video keratoscope.
    - They measure slope of corneal surface and can use this information to calculate radius of curvature and power. It does not measure elevation.
2. **Projection based**
    - Newly developed systems make use of this principle.
    - Examples include Slit photography, Rasterstereography, Moires interference and Laser interferometry.
    - They measure the true corneal shape in terms of elevation from which slope, curvature and power can be calculated.

COMPUTER ASSISTED VIDEO KERATOSCOPY

TOPOGRAPHIC MODELING SYSTEM: (TMS)

It is based on old principle of placido disc. It incorporates many luminous concentric rings. On each ring 256 points are identified and sampled to provide data from which radius of curvature is computed. These rings give corneal reflection at 180 µm internals. It provides 7000 data points in toto. Two cones are used. 25 ring cone is for standard use. It covers 8.5mm of cornea. 31 ring cone projects rings farther peripherally and covers 11mm diameter of cornea.[7]

1. Patient positioned correctly
2. Patient fixates target
3. Placid disc illuminated
4. Mires reflected from corneal surface
5. Clinician focuses and aligns the mires
6. Clinician triggers image acquisition
7. CCD video camera records image
8. Frame grabber captures image
9. Digitization of image position of mires identified
10. Reference point established
11. Data points located
12. Algorithm applied results displayed

MEASUREMENTS

Raw image

Study of raw image captured by the camera in the topography can demonstrate focal irregularities which correspond to surface pathology or tear film abnormalities.

Height

Height is available by the principle of projection. A 3D map gives a good concept of overall shape of cornea.

Slope and curvature

They represent rate of change of height and are a much sensitive measure of variation in contour across the corneal surface.

Power

Refractive power can be calculated.

Two dimensional maps

1. **Colours**

   Warm: (Orange, Red, White) – represents steeper surfaces with greater dioptric power.

   Cool: (Blue, Black, Azure) – represents flatter surface with lesser dioptric power.

2. **Scales**

   Label on the scale gives the type of measurement which is being displayed.

   Height is expressed in mm/µm, slope (no units), curvature (mm), power (dioptre).

   - **Absolute scale** is one in which there is a fixed colour coding system. The same colour always represents the same curvatures in powers. The allocation of colour is related to distribution of corneal powers in normal population.

- **Relative scale** uses a set number of colours which are automatically adjusted to fill the range of dioptric values for the single map.
- **Adjustable scale**: this enables the operator to select the step interval and the dioptric range of the contours.

STATISTICAL INDICES

These are numbers which summarise a particular feature of the cornea.

Simulated Keratometry Reading (Sim K) provides information equivalent to that measured by keratometer. It is calculated by determining the average power along each meridian in the central (within 3mm zone) or paracentral (rings 7-9 area). The major axis is that with the greatest power and the minor axis is 90º to it.

Min K is the meridian with the lowest mean power. Cylinder is the difference between major and minor axes.

Sphero Equivalent Power is the effective refractive power of the cornea within the 3 mm pupillary zone, taking into account the Stiles - Crawford effect. It is more reliable than keratometry for calculation of power of IOL.

Asphericity is a measure of flattening or steepening of mid periphery. It is important for optical aberrations following refractive surgery.

Surface Asymmetry Index is a measure of difference in corneal powers between 2 points on the same ring 180 apart. It is calculated from the entire corneal surface. It is a usual quantitative indicator of progression of corneal diseases such as keratoconus or peripheral corneal gutters.

Inferior-superior Value – (I-SV) is calculated from the refractive power difference between five inferior and five superior points 3mm from the centre at 30 intervals.

Surface regularity index is a measure of local regularity of the corneal surface within the central 4.5mm diameter. This index correlates well with visual function.

Potential visual acuity (or) predicted corneal acuity is the estimated range of visual acuity which could be expected if the cornea was the only factor limiting vision.

Keratoconus prediction index:

It is derived from[2]

1. SimK1

2. SimK2

3. SAI

4. Differential sector index (DSI)

5. Opposite sector index (OSI)

6. Centre surround index (CSI)

7. Irregular astigmatism index (IAI)

8. Analysed area (AA)

KISA Index

The KISA index quantifies the topographic features in patients with clinical Keratoconus. It is a product of four indices[5]

1. K value, an expression of central corneal steepening
2. I-S value, an expression of inferior superior dioptric asymmetry
3. AST indices, which quantify the degrees of regular corneal astigmatism (Sim K1- K2)
4. SRAX index, an expression of irregular astigmatism occurring in Keratoconus

$$\text{KISA\%} = \frac{K \times \text{I-S} \times \text{AST} \times \text{SRAX} \times 100}{300}$$

ASTIGMATISM EVALUATION BY TOPOGRAPHY

Topography displays difference in curvature of 2 principle corneal meridians as a bow tie pattern. In normal condition, the bow tie is oriented along the steeper meridian; the colour of the bow tie is itself warmer than the surrounding corneal surface.

If the cornea were a regular spherocylindrical surface, astigmatism would be represented by a propeller profile. There are 2 reasons for bowtie aspect in which peripheral parts of the propeller tend to be reduced in dimensions.[2]

- First- the flatter periphery of the cornea tends to reduce the dioptric power over those meridians next to the steeper principal meridians.
- Second –astigmatism is confined to the central cornea and does not reach the periphery.

Size of the bowtie is not related to the amount of astigmatism. It indicates only the extent of astigmatic changes over the corneal surface. It is the colour difference between2 principal meridians that reflect the amount of astigmatism, the greater the colour difference, greater the astigmatism.[17]

- Symmetrical bow tie indicates a symmetrical cylinder.
- In asymmetrical bowtie the dioptric power is not symmetrically distributed along the 2 semi meridians.

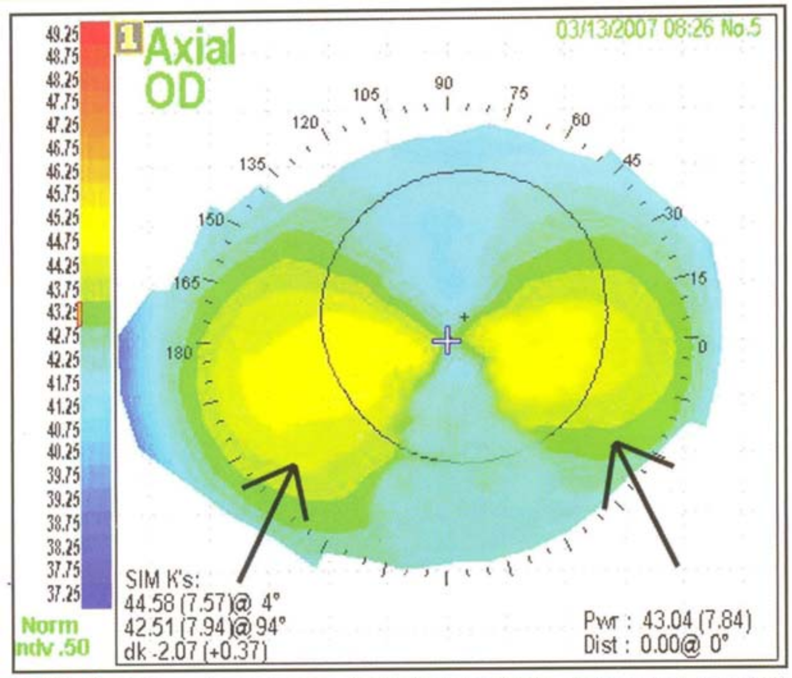


FIGURE 5-14: Normal astigmatism with the bow-tie pattern. The bow-tie is comprised of two fairly symmetrical lobes (arrows) which indicates normal astigmatism, not keratoconus.

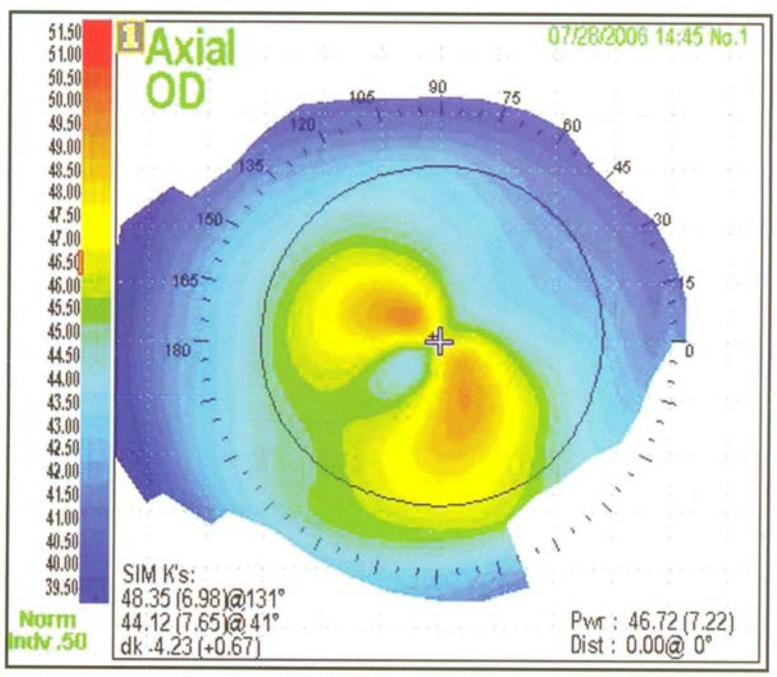


FIGURE 5-17: Keratoconus with bent bow-tie lobes. The lobes are equally sized with same steepening (red), but the bow-tie is mildly bent. Note the asymmetrically flat (blue) areas between the lobes.

CORNEAL TOPOGRAPHY IN KERATOCONUS

Corneal Topography is the current gold standard for keratoconus screening and assessment.[17]

Two essential factors involved in screening of corneal topography.

- ❖ Evaluate the range and magnitude of curvature that is present in the pattern. This is related to the severity of keratoconus.
- ❖ Evaluate asymmetry and irregularity of the contour pattern.

Peripheral Keratoconus: Bow tie pattern

Peripheral keratoconus are characterized by a pattern shaped like a bow tie (hour glass, figure of 8 or propeller) which is the most common form of keratoconus. Each side of the bow tie is called a lobe.

There are four main types of pattern:

a) Lobes of bow tie may be unequally sized with a bent axis. curvature in lobes may be equal to each other or different

b) Lobes of the bow tie may be unequal in size but lobes are not bent

c) Lobes of the bow tie are equal in size and not bent

d) Lobes may be equal in size but bent along the axis

CENTRAL KERATOCOUUS: BULL'S EYE PATTERN

In this the steepening is localized to round central (bull's eye) cone pattern with the steepest curvature near the center.

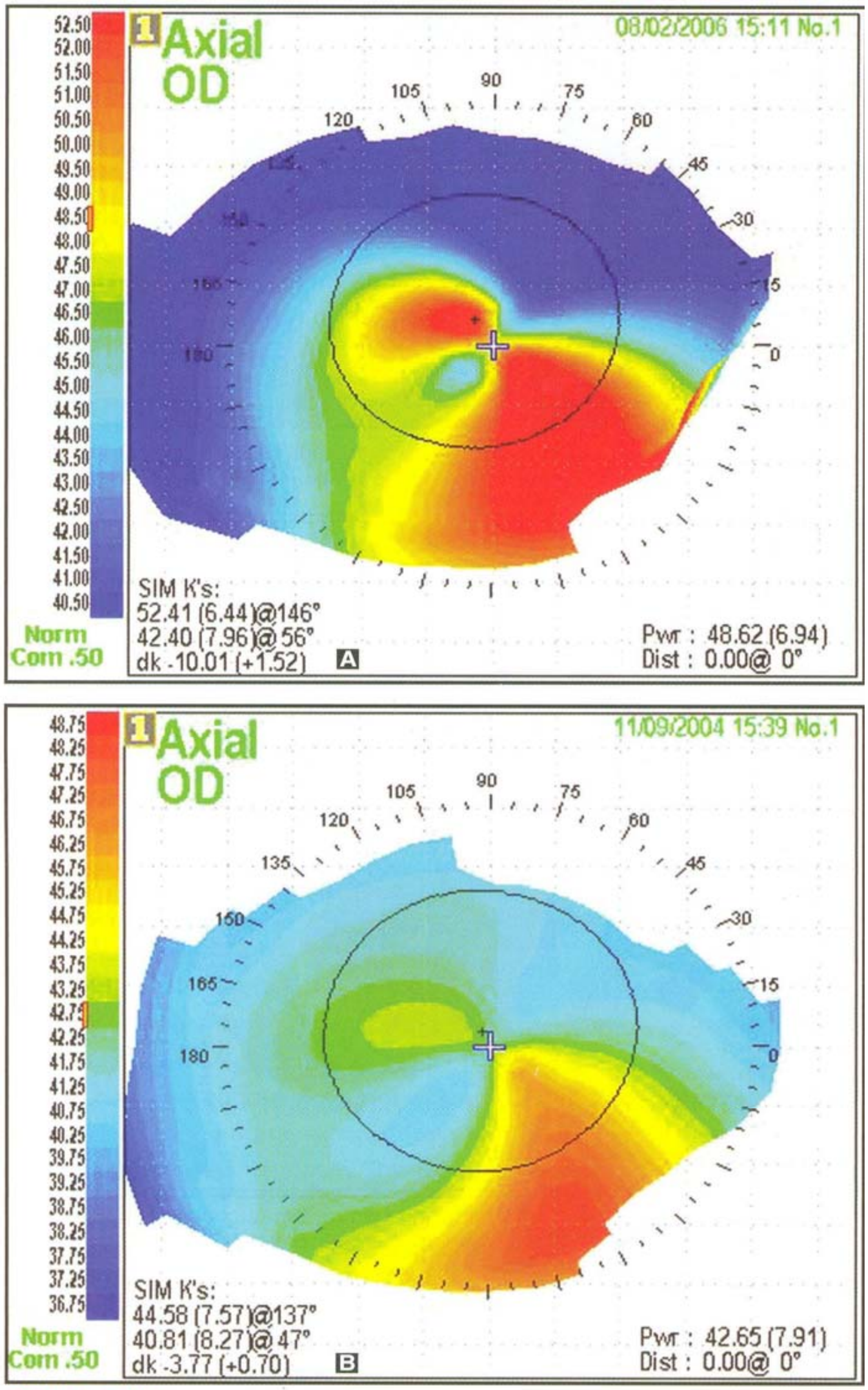


FIGURE 5-18: Keratoconus with bent bow-tie with the different sized lobes. The lobes may have same steepness (A) or different steepness (B). These are the most common forms of keratoconus.

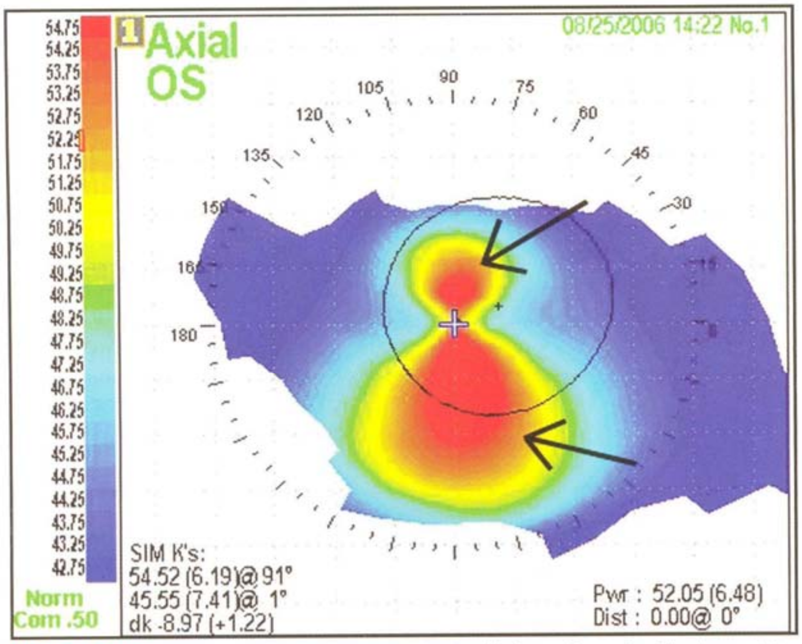


FIGURE 5-15: Keratoconus with asymmetric sized lobes of bow-tie. The lower lobe is larger than the upper lobe. Both lobes (arrows) show similar amount of steepening (red).

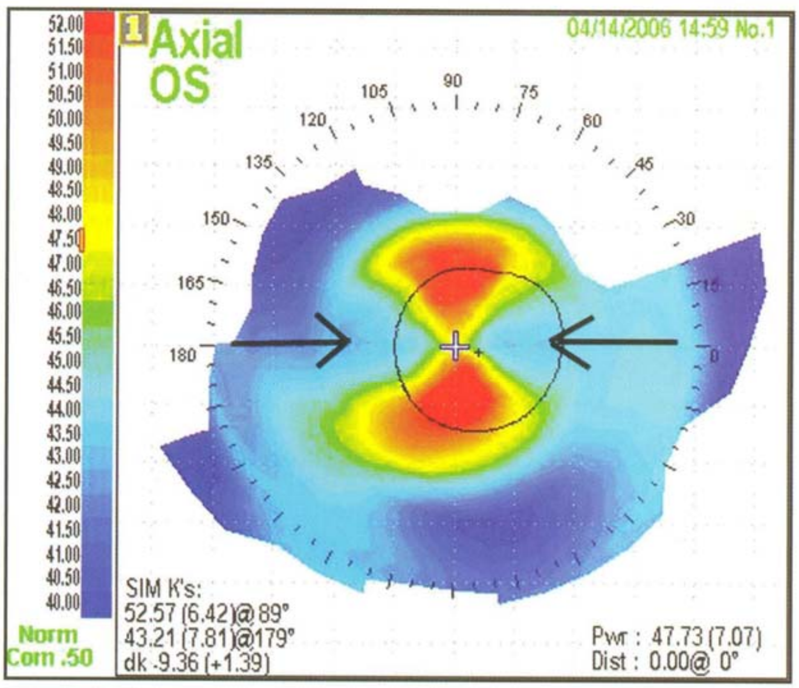


FIGURE 5-16: Keratoconus with similar sized lobes of bow-tie. The lobes are also of similar steepening (red). Note the symmetrically flat (blue) areas (arrows) between the lobes. This is an uncommon pattern of keratoconus.

DIAGNOSIS OF KERATOCONUS

External signs

Munson's sign and Rizzutti Phenomenon

Slit Lamp Findings

Stromal Thinning

Posterior stress lines (Vogt's Striae)

Iron ring (Fleischer ring)

Scaring - epithelial or subepithelial

Retro illumination Signs

Scissoring on retinoscopy

Oil droplet sign (cherleaux)

Photo keratoscopy signs

Compression of mires infero-temporally.

Compression of mires inferiorly or centrally.

Video Keratography signs

1. Increased area of corneal power surrounded by concentric areas of decreasing power.
2. Inferior superior power asymmetry
3. Scanning of the steepest radial axis above and below the horizontal meridian.

VIDEO KERATOGRAPHY INDICES

1. K value greater than 47.2
2. Infero-Superior value greater than 1.6
3. KISA greater than 100%.

CLASSIFICATION BY CLINICAL SIGNS & VIDEO-KERATOGRAPHY

Keratoconus:

One or more of the following clinical signs[2]

- Stromal thinning
- Vogt's striae
- Fleischer ring
- Scissoring of the retinoscopic reflex with fully dilated pupil
- AB/SRAX video keratoscopic pattern.

Early Keratoconus:

- No slit lamp findings
- Scissoring reflex with a fully dilated pupil
- AB / SRAX video keratography pattern

Keratroconus Suspect:

- No clinical or retro illumination sign
- Only AB / SRAX video keratography pattern.

MANAGEMENT OF KERATOCONUS

In early cases

- Treated with glasses for visual correction
- Contact Lenses

Vision is best corrected with contact lenses, as glasses do not compensate for the unusual shape of the cornea and resultant irregular astigmatism.

Types of Contact lens:

Early Stages

- Soft toric lenses are often adequate

Advanced Stages :

- Rigid gas permeable lenses
- Multi curve spherical based lenses
- aspheric lenses
- Bispheric lenses
- Piggy back lenses
- Hybrid lenses (soft hydrophilic peripheral skirt with rigid central portion)

Intra stromal Rings

Indications

In patients with contact lens intolerance with clear visual axis.

Two polymethyl methaacrylate (PMMA) arcuate segments are inserted into the mid stroma of the cornea. The segments flatten the cornea, thus reducing the amount of myopia, making patients more contact lens tolerant.[17]

This procedure was first suggested by Barraquer is 1949 each intact segment has as arc length of 150 degrees and a hexagonal cross section with an outer diameter of 81mm and inner diameter of 68mm. Thickness of the intacts vary.

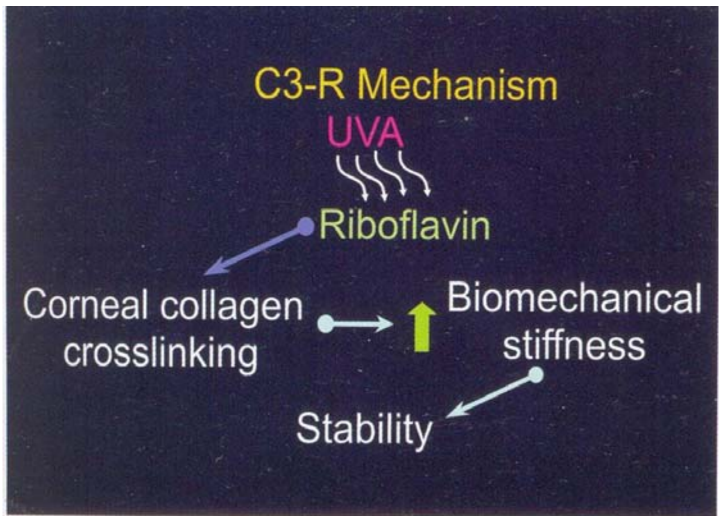
The goal of the intacts is to improve vision by reducing the irrigular corneal shape caused by the cone. It is contra indicated in uncontrolled autoimmune disorder, collagen vascular disorders and Immuno-deficiency diseases.

Potential side effects

- Keratitis – Infectious and Sterile
- Shallow intact lead to corneal thinning, sometimes foreign body sensation
- Perforation of Anterior chamber
- Neovascularisation at the incision site and into channel
- Photophobia
- Glare and Hales if pupil diameter >7mm
- Dry eyes

C_3R (Corneal Collagen Cross-linkage with Riboflavin)

The Biochemical strength of the cornea in keratoconus is considerably reduced compared to a normal cornea. Keratoconus is more common in younger patients because of high metabolic activity and low amount of natural cross-linkage.[9]



Diabetics do not typically experience keratoconus presumably due to glucose related glycation that results in accelerated cross linkage in the cornea and other tissues throughout the body.

In C_3R procedure, a specialized Riboflavin solution is administered into cornea which simultaneously is exposed to a controlled amount of Ultraviolet A light. This directly leads to thicker collagen fibres and more cross linkage between collages fibres.

Once the collagen absorbs the riboflavin solution, UVA light is required to activate riboflavin's strengthening effect on the collagen fibres. The enhanced collagen integrity also makes the treated area of the cornea resistant to inflammatory and melting processes.

Procedure:

The UVA device is periodically calibrated with UVA meter to ensure that the irradiation is 3.0 mv/cm^3+/- 0.3

Under topical anesthesia, a speculum is inserted to expose the eyes and the patient is instructed to look at the centre of the lights. The UVA light is positioned on the cornea at the proper distance from the eyes. The working distance varies according to the device used. The irradiation is performed for 30 minutes. Every fie minutes Riboflavin drops is applied and the patients are advised to keep the eyes closed for the rest of the day.

On the next day, examination after C3R with epithelium on, Slit lamp biomicroscopy the cornea appears normal or rarely a few areas of scattered punctate epitheliopathy.

CORNEAL TRANSPLANTATION

PENETRATING KERATOPLASTY

Indications

- Contact lens failure or intolerance
- Central scarring precluding good view

Procedure

The centre of cornea is marked and size of the corneal trephination area mostly of 7 yo 8 mm is determined. Before the actual trephination, a corneal button of 0.25 to 0.5mm larger is punched from the donor cornea. Trephination of the recipient cornea is then performed.[6] The donor button is placed on the cornea supported by viscoelastics using 10-0 Nylon. First cardinal (stage) interrupted sutures placed at 12O'clock position, second 180 degrees opposite to it. The button was placed on the 3rd and 4th are placed at 90 degrees from the first two sutures. A continuous suture of 4 bites per quadrant, 0.75mm from each of the wound placed 0.75 mm from each of the wound down to Descemet's membrane.

The success rate is 93% 96%. In spite of high success rate, there is still a 50% chance that they may need contact lenses because of residual myopia and post keratoplasty astigmatism.

A combination of relaxing incision and compression sutures guided by videokeratography can be used to correct the large amounts of post keratoplasty astigmatism resulting in small residual amount that are well corrected to rigid gas permeable lenses.

LASIK is used to treat post keratoplasty myopia and astigmatism. LASIK should be done only on patient with stable refraction more than D of cylinder. This is to be done at least 6 months post removal of all corneal sutures. This procedure produces significant scarring and is therefore not advisable.[17]

Complications:

- Graft rejection
- Post operative astigmatism
- Fixed dilated pupil (Urrets-Zavalia's syndrome) and
- Slow healing
- Irregularity of the surface of graft
- Secondary Glaucoma
- Recurrence of keratoconus

EPIKERATOPLASTY

Lamellar graft lathed to a uniform thickness of 0.3mm and it is sutured to the top of the cornea, to flatten the cone.

There is still a role of epikeratoplasty, because of superior quality of vision, in select high risk circumstances, such as patients with Down's syndrome.

Extra ocular procedure is preferred because of risk of wound rupture and graft rejection.

LAMELLAR KERATOPLASTY

In Keratoconus, Lamellar Keratoplasty can enhance the vision by replacing the anterior portion of the cornea with a thicker, structurally intact, anterior corneal donor graft. The posterior portion of the patient's cornea is not disrupted. The healing time is faster than penetration Keratoplasty. Lamellar Keratoplasty is a less invasive and safer procedure. Sutures are removed after three months. The risk of rejection is less when compared with Penetrating Keratoplasty.

Complications of this procedure include the occurrence of subepithelial ingrowth, which might lead to graft dehiscence.

AIM OF THE STUDY

- To compare the astigmatism in Keratoconus patients by Corneal Topography and Automated Refractometry and Subjective values.
- To assess the astigmatism in the visual axis in comparison with the position of the cone.

INCLUSION CRITERIA

- Patients with clinical features of keratoconus
- In Keratometry: Dioptric power more than 45 D
- Corneal Topographically confirmed cases
- In Refraction: patients with irregular astigmatism
- No history of previous ocular surgery
- No history of corneal injury

EXCLUSION CRITERIA

- Patients with the history of Corneal injury
- History of previous ocular surgery

MATERIALS AND METHODS

The study was conducted at the **Regional Institute of Ophthalmology and Govt. Ophthalmic Hospital, Chennai** between July 2008 and October 2009. It is a retrospective study.

35 eyes of 20 patients were included in the study. The patients underwent estimation of Uncorrected Visual Acuity, Keratometry, Topography, Automated Refractometry and Subjective Refraction initially. A detailed ocular and slit lamp examination was performed. The parameters obtained from topography and Automated Refractometry were analysed and the cylinder values were compared. The acceptance with the cylinder values derived from Topography and Automated refractometry were recorded in 35 eyes. The patient's Best Corrected Visual Acuity was recorded. In unilateral presentation of 5 cases the other eye V/A, K reading, topography values were analysed to rule out forme truste type of keratoconus.

OBSERVATIONS AND ANALYSIS

The results were analysed as follows:

Laterality:

Keratoconus is a bilateral condition. It starts in one eye at the time of onset. Among 20 patients in this study group, 5 patients had unilateral presentation of Keratoconus and 15 had bilateral presentation.

In unilateral cases, the other eye V/A is all 5 eyes was 6/9. Kreading valve is less than 45D and topographically also, the PPK value is less than 90%.

Unilateral	5 patients
Bilateral	15 patients

GENDER DISTRIBUTION

The incidence of Keratoconus is greater in males than in females. In this study group of 20 patients, there were 11 males and 9 females.

Males	11 patients
Females	9 patients

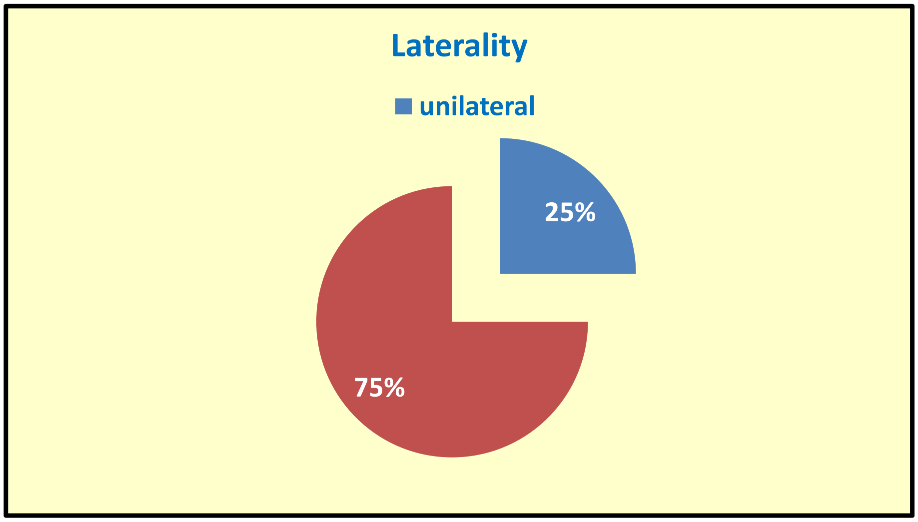


Fig 1 shows 75% of the patients presented with bilateral Keratoconus and only 25% presented unilaterally. [2] **Herbowitz Waring, *Corneal disorers – clinical diagnosis and management,* 2nd edition, chaper 12**

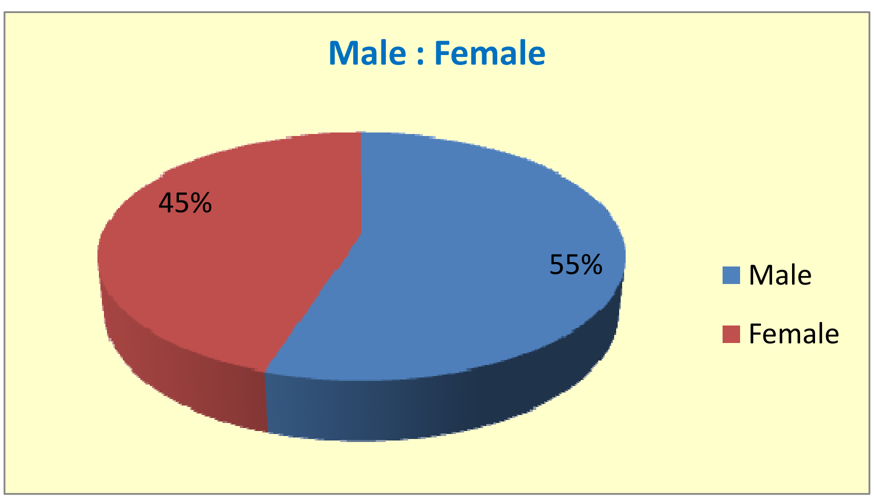


Fig. 2 shows 45% females and 55% males were affected among the study group. [2]

AGE OF PRESENTATION

Keratoconus commonly presents during the second decade of life.[18]

Less than 10 years	Nil
10 – 20 years	10 patients
20 -30 years	9 patients
> 30 years	1 patient

In this study there were no patients below the age of 10. There were 10 patients in the age group between 10 and 20 years, 9 patients in the age group of 20 to 30 years and one patient more than 30 years of age

KERATOMETRY

- Based on keratometry reading, the 35 eyes presenting with keratoconus were graded as Mild, Moderate and Severe.
- In Mild grades, the K value was < 48 D. There were 9 eyes in this grade.
- 18 eyes with K values ranging from 48 D to 54 d were graded as Moderate.
- Eight eyes were graded as Severe and had K values more than 54 D

Mild	< 48 D	9 eyes
Moderate	48 – 54D	18 eyes
Severe	> 54 D	8 eyes

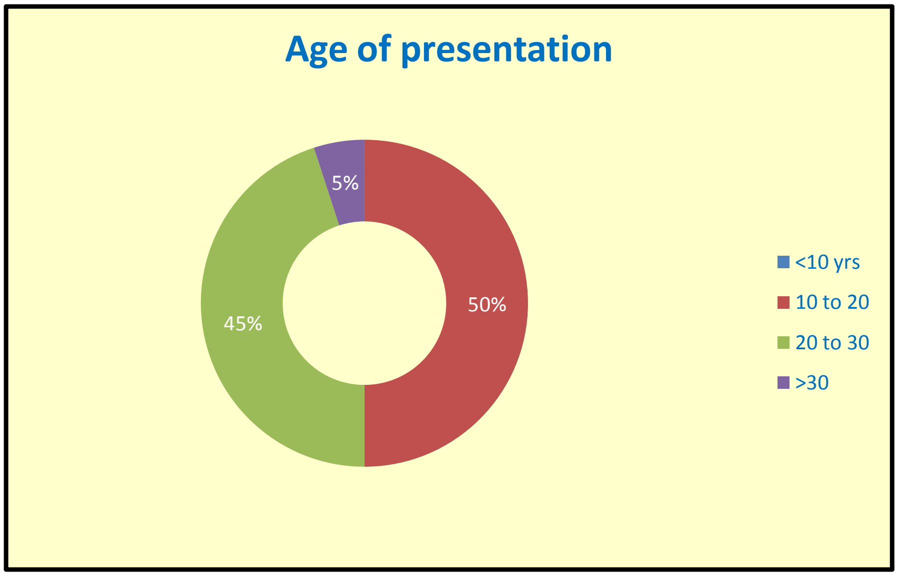


Fig.3 shows a majority (50%) of the patients in the age group of 10 to 20 years.

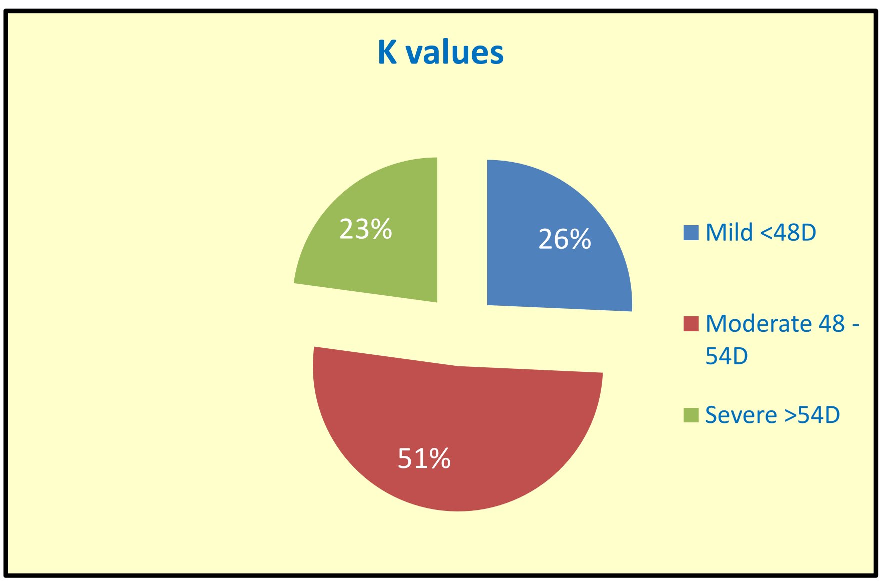


Fig.4 shows the majority of the eyes had moderate to severe K values

UNCORRECTED VISUAL ACUITY

Based on uncorrected visual acuity, 35 eyes of 20 patients were grouped into 3 groups.

In **Group I**, the Uncorrected Visual Acuity was less than 6/60 and 15 eyes were classified into this group.

In **Group II**, the Uncorrected Visual Acuity ranged between 6/60 and 6/24. Thirteen eyes were classified into this group.

In **Group III**, the Uncorrected Visual Acuity range was between 6/18 and 6/12 with seven eyes classified into this group.

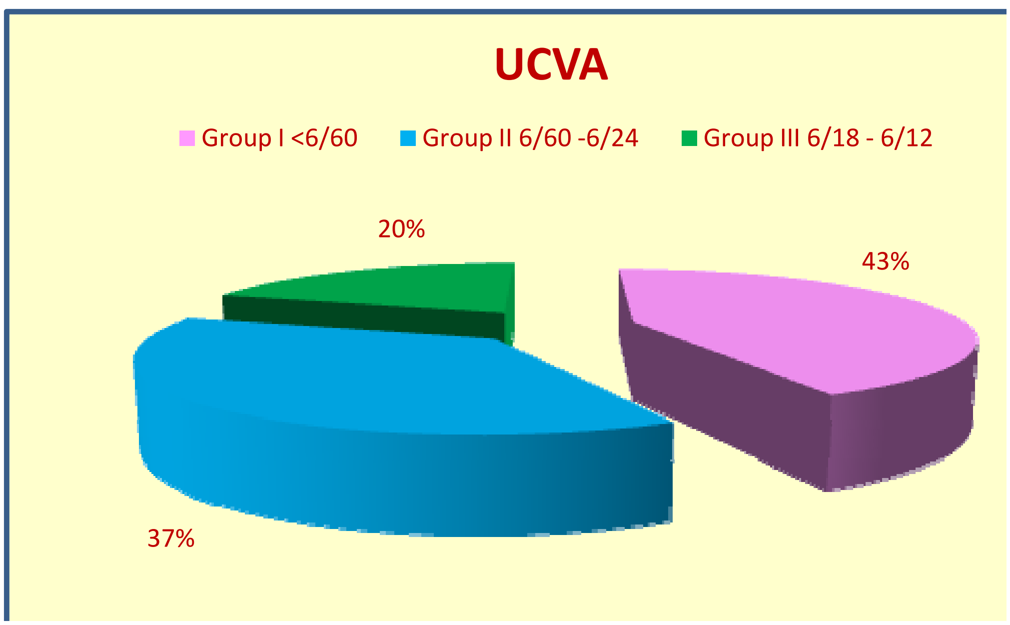


Fig.5 shows most of the eyes had uncorrected visual acuity <6/60

Analysis of Group I (15 eyes)

There were fifteen eyes in Group I. Their Automated Refractometry and Topography cylinder values were compared.

Topographic cylinder values were higher than Automated Refractometry cylinder values in 11 eyes.

Topographic cylinder values and Automated Refractometry cylinder values were the same in 2 eyes.

Topographic cylinder values were lower than Automated Refractometry cylinder values in 2 eyes.

Visual correction was done with glasses based on Automated Refractometry cylinder values in all these 15 eyes. Fourteen eyes showed visual improvement whereas one eye did not improve in vision because of corneal opacity.

Among the 14 eyes which had visual improvement, 8 eyes needed cylinder correction ranging from -3 to -6.5D, with 4 eyes achieving 6/60 vision, 2 eyes achieving 6/18 and another 2 eyes 6/12 vision.

Three eyes needed cylinder correction ranging from **-7 to -8.5D**, with one eye each achieving 6/60, 6/36 and 6/24 vision.

Three eyes needed cylinder correction ranging from **-9 to -11**, with all eyes achieving 6/60 vision.

Cylinder	**No. of eyes**	**Visual Improvement**
-3 to -6.5	8 eyes	6/60 – 4 6/18 – 2 6/12 – 2
-7 to -8.5	3 eyes	6/60 – 1 6/36 - 1 6/24 – 1
-9 to -11	3 eyes	6/60 – 3
	1 eye	No improvement

Analysis of Group II (13 eyes)

There were thirteen eyes in Group II. Their Automated Refractometry and Topography cylinder values were compared.

Topographic cylinder values were higher than Automated Refractometry cylinder values in 10 eyes.

Topographic cylinder values and Automated Refractometry cylinder values were the same in 3 eyes.

Visual correction was done with glasses based on Automated Refractometry cylinder values in all these 13 eyes. Eleven eyes showed visual improvement whereas two eyes did not improve in vision because of high myopic astigmatism.

Among the 12 eyes which had visual improvement,

8 eyes needed cylinder correction ranging from **-1.5 to -4D**, with 4 eyes achieving 6/12 vision, 2 eyes achieving 6/9 and another 2 eyes 6/6 vision.

Two eyes needed cylinder correction ranging from **-4.5 to -6.0**, with both achieving 6/12 vision.

One eye needed cylinder correction with **-11.0D** and achieved 6/24 vision.

Cylinder	**No. of eyes**	**Visual improvement**
-1.5 to -4	8 eyes	6/12 – 4 6/9 – 2 6/6 – 2
-4.5 to -6.0	2 eyes	6/12 – 2
-6.5 to -8.0	Nil	-
-8.5 to -11.0	3 eyes	6/24 – 1 No improvement – 2

Group III (7 eyes)

There were seven eyes in Group III. Their Automated Refractometry and Topography cylinder values were compared.

Topographic cylinder values were higher than Automated Refractometry cylinder values in 5 eyes.

Topographic cylinder values were lower than Automated Refractometry cylinder values in 2 eyes.

Visual correction was done with glasses based on Automated Refractometry cylinder values in all these 7 eyes. Five eyes showed visual improvement whereas two eyes did not improve in vision because of high myopic astigmatism.

Among the 5 eyes which improved, **3 eyes needed** cylinder correction ranging from **-1.0 to -3.0 D**, with all three achieving 6/6 vision.

Two eyes needed cylinder correction ranging from **-3.5 to -6.5 D**, with both achieving 6/9 vision.

Cylinder	**No. of eyes**	**Visual improvement**
-1.0 to -3.0 D	3 eyes	6/6 – 3
-3.5 to -6.5 D	2 eyes	6/9 – 2
	2 eyes	No improvement

HIGH MYOPIA

10 out of 35 eyes presented with high myopia.

The spherical dioptric power ranged from -5.0 D to -18.0D.

High myopia with astigmatism was difficult to correct with glasses alone.

-5 to -6 D	5 eyes
-9 D	2 eyes
-10D	1 eye
-13.5 D	1 eye
-18 D	1 eye

Between -5 to -6 D, five eyes were seen. Two eyes had dioptric power of

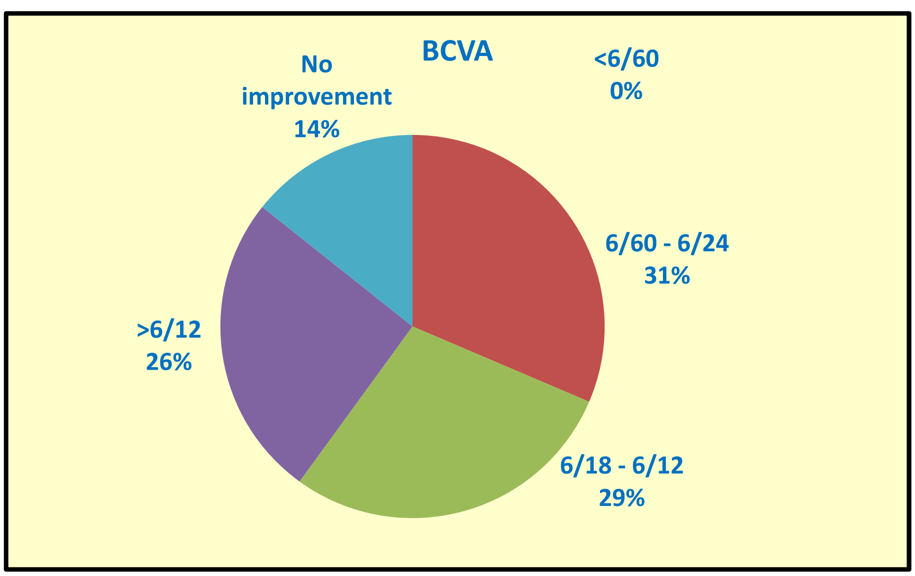
- 9 D and an eye each had the powers of -10 D, -13.5 D and -18 D.

THE BEST CORRECTED VISUAL ACUITY

Based on the Best Corrected Visual Acuity, the 35 eyes were grouped into 4 groups, with respect to V/A ranging.

Between V/A 6/60 and 6/24, eleven eyes were seen. Ten eyes between V/A 6/18 and 6/12 were also seen. There were nine eyes of V/A more than 6/12. Five eyes showed no improvement.

< 6/60	**nil**
6/60 – 6/24	**11 eyes**
6/18 – 6/12	**10 eyes**
>6/12	**9 eyes**
No improvement	**5 eyes**



Comparing the Astigmatism between Topography and Subjective Values

- 26 out of 35 eyes had higher cylinder values in Corneal Topography when compared to Automated Refractometry subjective values.
- Five eyes had same cylinder values in both methods.
- Four eyes had higher cylinder values in Automated Refractometry Subjective method.

Comparing the distance of Cone from the Pupillary Axis

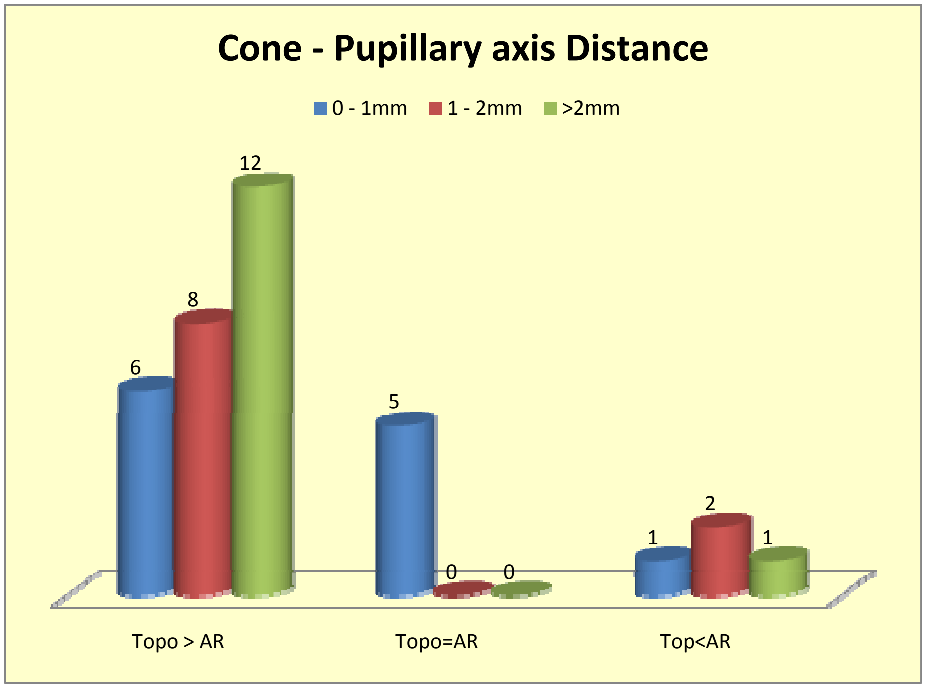
In 26 eyes with high cylinder value in Topography, the distance of cone from the pupillary axis were from

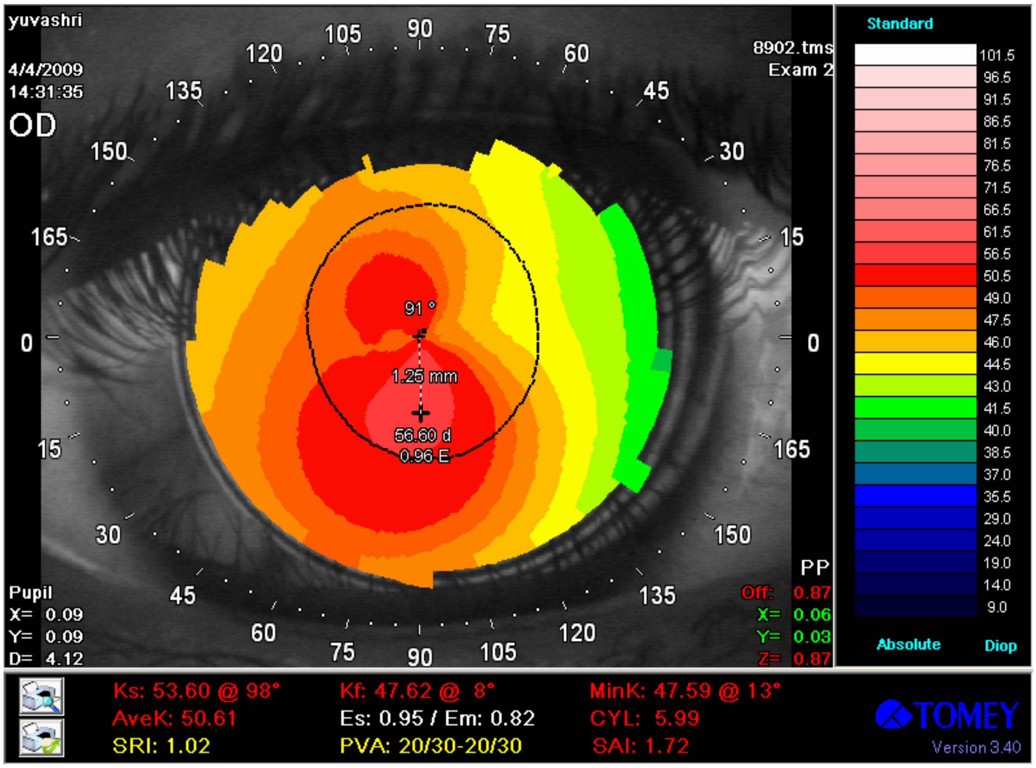
- 0 to 1mm – 6 eyes
- 1 to 2mm – 8 eyes
- 2mm – 12 eyes

In 5 eyes with same cylinder values both in topography and Automated Refractometry, the distance of cone from the papillary axis ranged from 0 to 1 mm.

In 4 eyes with higher cylinder value in Automated Refractometry, the distance of cone from the papillary axis were

- 0 to 1 mm – 1 eye
- 1 to 2mm – 2 eyes
- >2 mm – 1 eye

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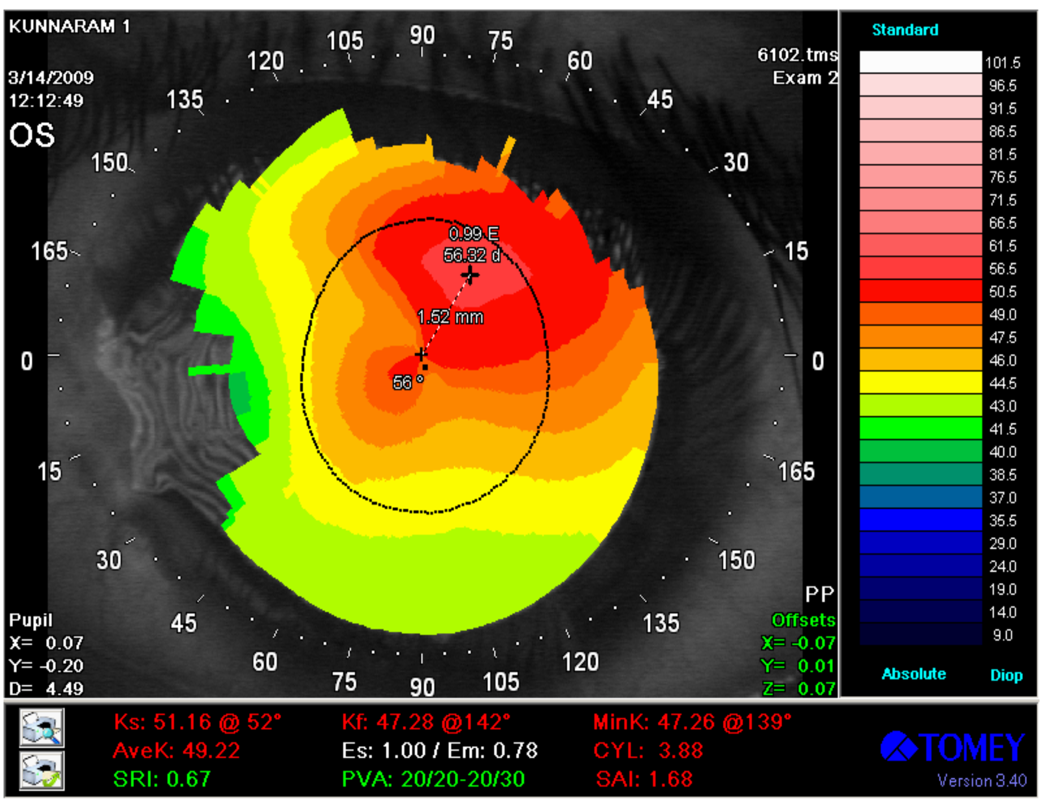
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Kf: 47.28 @142°
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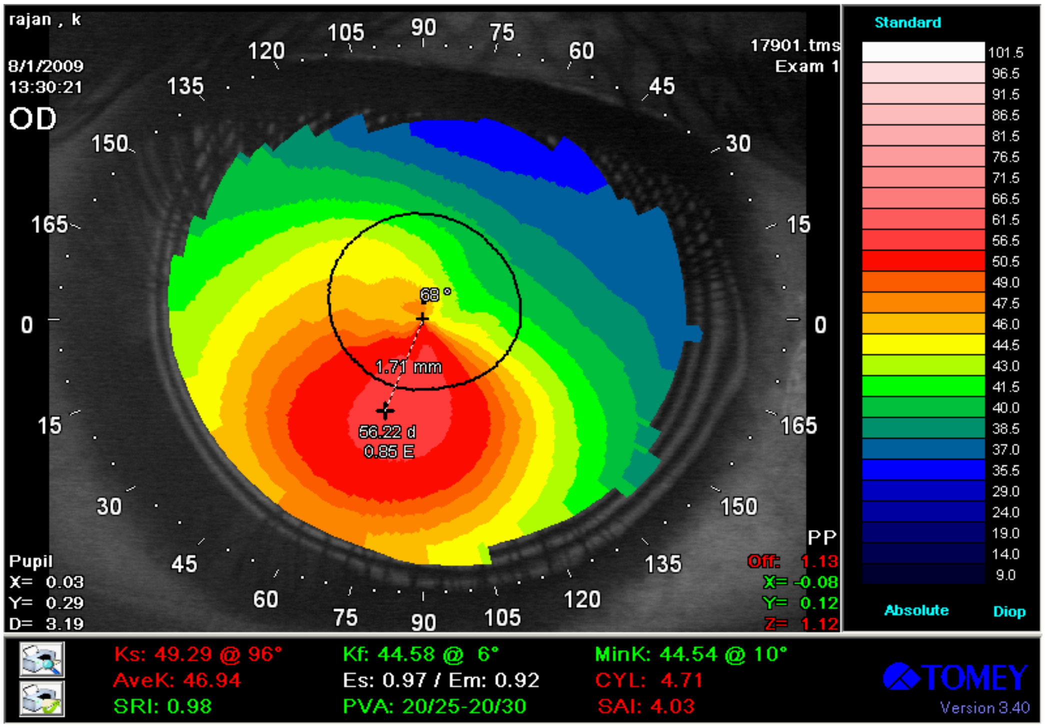
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40.0
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37.0
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29.0
24.0
19.0
14.0
9.0
Absolute
Diop
68 °
1.71 mm
56.22 d
0.85 E
Pupil
X= 0.03
Y= 0.29
D= 3.19
PP
Off: 1.13
X= -0.08
Y= 0.12
Z= 1.12
Ks: 49.29 @ 96°
AveK: 46.94
SRI: 0.98
Kf: 44.58 @ 6°
Es: 0.97 / Em: 0.92
PVA: 20/25-20/30
MinK: 44.54 @ 10°
CYL: 4.71
SAI: 4.03
TOMEY
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RESULTS

- In this study, bilateral presentation was more than unilateral. 75% of the patients presented with bilateral Keratoconus and only 25% presented unilaterally.
- A majority (50%) of the patients were in the age group of 10 to 20 years.
- 45% females and 55% males were affected among the study group.
- Majority of the eyes (51%) had moderate grade of K values (48 – 54 D).
- The Uncorrected Visual Acuity (UCVA) was < 6/60 in 43% of cases.
- Comparing the astigmatism between Corneal Topography and Automated Refractometry, 26 out of 35 eyes (74%) showed higher cylinders value in Topography reading. 5 eyes had same values and in 4 eyes the AR value was higher.
- In 5 eyes, where the cone was present in the centre, the Automated Refractometry and Corneal Topographic cylinder values were found to be the same. In the remaining 30 eyes, where the cone was not at the centre, the cylinder values were different.

- Overall 85% (30 out of 35 eyes) improved after correction with spectacles. 5 out of 35 eyes (15%) did not improve with spectacles, because of high myopic astigmatism.
- 26 out of 35 eyes (74%) accepted lower cylinder than revealed by corneal topography.

DISCUSSION

Keratoconus presents as irregular myopic astigmatism. In irregular astigmatism the curvature of the cornea is different in various meridians, and no geometrical pattern is adhered.

Corneal topography used in this study is based on the principle of the Placido disc. In astigmatism Topography displays the difference in curvature of two principal corneal meridians as a bowtie pattern.

Two essential factors are involved in keratoconus screening and assessment.

1. First is to evaluate the asymmetry and irregularity of the contour pattern.
2. Second is to evaluate the range and magnitude of curvature that is present in the pattern.

The colour coded topographic maps permit a more detailed evaluation of the corneal contour. This technique is useful for detecting corneal irregularities in the early stage of keratoconus and may identify patients who do not have slit lamp evidence of the disease.

Keratoconic topographic alterations can be of two types

1. In the first type 75% changes are peripheral, with steepening of corneal contour extending to the limbus. The apex of the cone,

defined as the point of maximal power, frequently does not correspond to the geometric centre of the steepest area.

2. In the second group, 25% steepening is confirmed primarily to the central cornea, with relative sparring of the peri-limbal area.

Corneal topographic analysis is important in diagnosing and also to know the overall contour of the cornea. When comparing the cylinder values obtained from both the Topography and Automated Refractometry subjective, the cylinder values obtained from topography is always high. This is because, it covers the whole cornea and also the eccentric presentation of the cone.

In Automated Refractometry reading, the central 4mm of the cornea is taken. The cylinder values are normally less, unless the cone is present in the centre.

The advantage of Topography is that, even mild forms can be detected at an earlier stage.

The patient accepts the cylinder values of Automated Refractometry better than the topography.

CONCLUSION

This study clearly demonstrates that the corneal topographic assessment of astigmatism shows higher values, which are not acceptable to the patients.

Astigmatism correction with Automated Refractometry derived cylindrical values, were accepted well by the study group. This is probably because the cylindrical value assessed by corneal topography is confounded by the position of the cone with reference to the visual axis, whereas that obtained by AR is the one that is at the visual axis.

This proves the usefulness of Automated Refractometry in astigmatism correction in keratoconus, even though Corneal Topography has the advantages of early detection of this condition.

In centers where a video-keratoscope is not available, the AR machine can be used for visual rehabilitation.

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PROFORMA

Name Age/Sex C.C. No.

OP No.

Date:

Presenting complaints:

Defective vision R/L eye:

Duration:

History of presenting illness:

Past history:

H/O ocular surgery:

H/O wearing spectacles:

H/O Contact Lens

Family History:

Personal History:

General Examination:

Local Examination:

1. Head posture:
2. Facial Symmetry:
3. Visual Axes:

Slit Lamp Examination	RE	LE
• Lids		
• Conjunctiva		
• Cornea		
• Anterior chamber		
• Iris		
• Pupil		
• Lens		

UCVA

Keratometry

Automated Refraction

Subjective Refraction

Corneal Topography

Fundus

Intra Ocular Pressure

BCVA

KEY TO MASTER CHART

M	-	Male
F	-	Female
R	-	Right
L	-	Left
RE	-	Right Eye
LE	-	Left Eye
UCVA	-	Uncorrected Visual Acuity
K value	-	Keratometry value
BCVA	-	Best Corrected Visual Acuity
Sph	-	Spherical power
Cyl	-	Cylindrical power
K_s	-	Steeper axis
K_f	-	Flatter axis

No.	Name	CC No.	Age sex	R/L	UCVA	K value	Refractometry subjective			Topography			BCVA
							Sph	Cyl	Axis	K_s	K_f	Axis	
1.	**Kalaivani**	494	23/ F	RE	6/36	+ 50.25	-2.0	-5.0	10˚	56.79 @ 140˚	47.85@14˚	8.94	6/12
2.	**Sudhakhar**	1916	19/M	RE	6/18	+48.50	-0.5	-0.75	60˚	49.93 @149	45.98@59˚	1.97	6/6
3.				LE	3/60	+52.50	-3.0	-4.0	150˚	55.23@120˚	49.10@48˚	6.23	3/60
4.	**Manikandan**	4270	18/M	RE	3/60	+48.75	-1.0	-3.0	155˚	52.37@66˚	45.22@155˚	7.14	6/60
5.				LE	6/18	+49.50	-0.5	-1.0	90˚	51.44@7˚	47.30@97˚	4.14	6/9
6.	**Harikrishnan**	1940	34/M	LE	6/60	+48.00	-5.0	-6.0	115˚	51.09@49˚	42.14@139˚	8.95	6/60
7.	**Manohar**	1539	16/M	RE	4/60	+55.50	-9.0	-3.0	160˚	61.86@77˚	57.1@167˚	4.76	6/60
8.				LE	6/60	+48.00	-1.0	-1.5	110˚	50.10@77˚	46.14@167˚	3.97	6/12
9.	**Saranya**	1532	16/F	RE	5/60	+50.50	-6.0	-5.0	180˚	61.91@87˚	50.10@171˚	11.81	6/60
10.				LE	3/60	+61.00	-4.0	-2.0	110˚	64.15@66˚	56.77@150˚	7.37	6/60
11.	**Anandhakumari**	1532	13/F	RE	6/18	+53.00	-4.0	-4.25	128˚	66.35@100˚	56.19@10˚	10.16	6/18
12.				LE	6/18	+53.00	-3.75	-6.25	152˚	67.35@76˚	60.85@166˚	6.5	6/18
13.	**Muthuraman**	1541	12/M	RE	4/60	+55.00	-5.50	-9.0	175˚	58.46@80˚	51.71@176˚	8.74	6/24
14.				LE	6/12	+52.00	-3.0	-6.5	177˚	55.3@86˚	50.30@176˚	5.27	6/9
15.	**Amudha**	1516	29/F	RE	1/60	+54.00	-18.75	-9.0	70˚	59.00@162˚	52.94@72˚	6.07	2/60
16				LE	6/60	+48.50	-5.50	-2.0	130˚	50.57@45˚	48.09@135˚	2.48	6/9
17	**Rajan**	1764	24/M	RE	6/24	+45.00	-1.0	-3.50	50˚	49.47@89˚	45.08@179˚	4.41	6/9

No.	Name	CC No.	Age sex	R/L	UCVA	K value	Refractometry subjective			Topography			BCVA
							Sph	Cyl	Axis	K_s	K_f	Axis	
18				LE	6/18	+43.50	-1.0	-2.0	110˚	47.07@82˚	42.39@172˚	4.68	6/9
19	**Senthil**	1587	23/M	RE	6/24	+46.25		+1.5	170˚	54.12@101˚	49.73@11˚	4.4	6/9
20				LE	6/36	+43.25		-1.5	10˚	54.93@97˚	49.7@7˚	5.2	6/18
21	**Kannan**	1443	23/M	RE	1/60	+63.00	-1.5	-7.0	15˚	68.36@105˚	58.04@15˚	10.32	6/60
22	**Arun Kumar**	1637	24/M	RE	5/60	+48.50	-0.75	-5.51	52˚	52.21@143˚	46.36@53˚	5.85	6/18
23	**Bharani**	1784	15/M	RE	3/60	+57.50	-7.0	-6.0	10˚	66.03@110˚	54.24@20˚	11.79	6/18
24				LE	5/60	+50.75	-2.0	-6.0	150˚	68.9@76˚	60.73@166˚	8.17	6/6
25	**Kayalvizhi**	1763	17/F	RE	6/36	+57.25	-3.25	-6.0	25˚	63.85@119˚	54.09@74˚	9.76	6/12
26				LE	6/60	+57.25	-3.0	-11.0	160˚	66.82@69˚	55.65@159˚	1.17	6/12
27	**Chandini**	1522	13/F	RE	6/18	+47.50	-0.75	-4.5	20˚	48.81@134˚	44.87@44˚	3.94	6/9
28				LE	6/24	+51.50	-3.75	-9.0	163˚	60.07@76˚	50.39@166˚	9.68	6/24
29	**Sophia**	2091	15/F	RE	2/60	+59.00	-10.0	-2.0	100˚	65.84@73˚	57.04@163˚	8.44	6/36
30				LE	6/24	+46.50	-1.0	-1.5	105˚	49.84@62˚	48.91@152˚	0.93	6/12
31	**Nandhini**	1431	26/F	RE	2/60	+48.25	-3.0	-6.0	46˚	53.15@132˚	46.92@42˚	6.23	6/18
32				LE	6/60	+48.75	-5.5	-6.5	130˚	61.21@55˚	52.53@145˚	8.59	6/12
33	**Selvam**	1747	23/M	RE	6/60	+52.00	-4.0	-6.0	177˚	55.72@80˚	47.47@176˚	8.25	6/9
34				LE	2/60	+54.50	-4.0	-4.0	130˚	59.08@87˚	50.54@177˚	8.54	6/60
35	**Yuvashree**	965	13/F	RE	2/60	+53.00	-4.5	-4.0	160˚	56.21@77˚	49.38@167˚	6.83	6/60

LIST OF SUGERIES PERFORMED

Sl. No.	Name	Age/ Sex	OP/ IP No.	Diagnosis	Surgery performed
1	Muniyammal	65/F	401447	RE-IMC, LE-MC	LE ECCE with PCIOL
2	Lakshmi	62/F	401789	RE-MC, LE-IMC	RE ECCE with PCIOL
3	Vadivel	55/M	402429	BE-MC	LE ECCE with PCIOL
4	Subammal	58/F	404643	BE-IMC	LE ECCE with PCIOL
5	Logammal	80/F	405761	RE-MC, LE-IMC	RE ECCE with PCIOL
6	Muthu	71/M	406987	BE-MC	LE ECCE with PCIOL
7	Dhanabackiyam	65/F	407834	RE-IMC, LE-PSCC	RE ECCE with PCIOL
8	James	63/M	408345	BE-IMC	LE ECCE with PCIOL
9	Chokkalingam	55/M	409738	RE MC, LE Aphakia	RE SICS with PCIOL
10	Meenakshi	65/F	410839	RE NC, LE IMC	RE SICS with PCIOL
11	Manickam	75/M	410972	BE NC	RE SICS with PCIOL
12	Hari	55/M	410298	RE HMC, LE MC	RE SICS with PCIOL
13	Thengammal	63/F	411286	RE Aphakia, LE NC	LE ECCE with PCIOL
14	Murugaiah	57/M	411378	BE PCC	RE ECCE with PCIOL
15	Hameed	61/M	420784	BE IMC	LE SICS with PCIOL
16	Jayalakshmi	63/F	421638	RE Pseudo-aphakia, LE NC	LE SICS with PCIOL

Sl. No.	Name	Age/ Sex	OP/ IP No.	Diagnosis	Surgery performed
17	Saroja	58/F	422391	RE IMC, LE Pseudo-aphakia	RE SICS with PCIOL
18	Balakrishnan	62/M	430263	BE MC	RE SICS with PCIOL
19	Salima bee	80/F	431836	RE NS, LE Pseudo-aphakia	RE SICS with PCIOL
20	Rajendran	55/M	432846	BE IMC	LE SICS with PCIOL
21	Raju	25/M	417456	RE Corneo scleral tear	Suturing of corneoscleral tear
22	Annammal	55/F	368752	RE Pterygium	RE Pterygium excison with Amniotic membrane grafting
23	Rathinal	55/F	387451	LE Fungal corneal ulcer with Panopthalmitis	LE Evisceration
24	Sekar	21/M	418251	LE Upper eye marginal tear	LE Lid tear suturing done
25	Ponnusamy	65/M	35710	Lagophthalmos facial palsy with exposure kertitis	LE Lateral tarrsoraphy done
26	Muniyammal	60/F	451725	RE Dacryocystitis	RE Dacryocystectomy done
27	Shakunthala	45/F	418725	LE Dacryocystitis	LE External DCR done. Dacryocysto rhinostomy done
28	Vasanthamal	55/F	497152	RE Fungal corneal ulcer	RE TKP done (Therapeutic Keratoplasty)
29	Rathinavel	60/M	492727	LE Fungal corneal ulcer	LE Lens removal with TKP done
30	Murugavel	55/M	327512	RE Upperlid Chalazion	RE Chalazion I & C done

BE	**-**	Both Eyes
RE	**-**	Right Eye
LE	**-**	Left Eye
IMC	**-**	Immature Cataract
MC	**-**	Mature Cataract
SICS	**-**	Small Incision Cataract Surgery
PCIOL	**-**	Posterior Chamber Intra Ocular Lens
HMC	**-**	Hyper Mature Cataract
PSCC	**-**	Posterior Subcapsular Cortical Cataract
NC	**-**	Nuclear Cataract
ECCE	**-**	Extra Capsular Cataract Extraction