"SURGICALLY INDUCED ASTIGMATISM AFTER SUPERIOR VERSUS TEMPORAL SCLERAL INCISION IN MANUAL SMALL INCISION CATARACT SURGERY - A ONE YEAR HOSPITAL BASED RANDOMISED CONTROLLED TRIAL"

By

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Dissertation submitted to the
KLE University, Belgaum, Karnataka

In Partial Fulfillment
of the requirements for the degree of

M. S. (OPHTHALMOLOGY)

Under the Guidance of

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DECLARATION

I hereby declare that this dissertation entitled **"**SURGICALLY INDUCED ASTIGMATISM AFTER SUPERIOR VERSUS TEMPORAL SCLERAL INCISION IN MANUAL SMALL INCISION CATARACT SURGERY - A ONE YEAR HOSPITAL BASED RANDOMISED CONTROLLED TRIAL**"** is a bonafide and genuine research work carried out by me under the guidance of Dr. R. K. DANDUR MS DOMS Professor and Head, Department of Ophthalmology, Jawaharlal Nehru Medical College, Nehru Nagar, Belgaum-590010.

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I bow my head in respect before God Almighty.

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LIST OF ABBREVIATIONS USED

AC	–	Anterior chamber
ATR	–	Against the rule
BSS	–	Balanced salt solution
CCC	–	Continuous curvilinear capsulorrhexis
D	–	Diopters
ECCE	–	Extracapsular cataract extraction
IOL	–	Intraocular lens
IOP	–	Intraocular pressure
LASIK	–	Laser assisted in situ keratomileusis
LRI	–	Limbal relaxing incision
PCIOL	–	Posterior chamber intraocular lens
PMMA	–	Polymethyl Methacrylate
SIA	–	Surgically induced astigmatism
SICS	–	Small Incision Cataract Surgery
SIRCs	–	Surgically induced refractive changes
UCVA	–	Uncorrected visual acuity
VA	–	Visual acuity
WTR	–	With the rule

ABSTRACT

Background and objectives

Of the total estimated 38 million blind people in the world, nine to 12 million are in India 50 to 80% of these people are blind because of cataract. In addition to the backlog, an additional 3.8 million become blind each year because of cataract. The objective of the present study was evaluate and compare the amount of induced astigmatism after superior and temporal incision in manual small incision cataract surgery (SICS).

Methodology

The present one year randomized clinical trial study was conducted in the Department of Ophthalmology, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on 100 patients undergoing manual SICS during the period of January 2008 to December 2008. The study was approved by the Ethical and Research Committee of Jawaharlal Nehru Medical College, Belgaum. The patients were assigned randomly into two groups by computer generated table namly Group 1 (SICS using superior scleral incision) and Group 2 (SICS using temporal scleral incision).

Results

In group A with superior incision the average SIA was 0.96 ± 0.68 and in group B with temporal incision the average SIA was 0.65 ± 0.59. The comparison between mean of the two groups using unpaired ‘t’ test was statistically significant ($p=0.020$) indicating group B had less SIA. Superior incision induced ATR (58%) and temporal incision induced WTR (68%).

Conclusion and interpretation

In the present study the visual rehabilitation was similar in both the groups. The UCVA was better in temporal incision as compared to superior incision group. In conclusion, temporal incision is evidently better than superior incision in minimizing surgically induced astigmatism.

Key Words

Manual Small Incision Cataract Surgery; Scleral Incision; Superior incision; Temporal Incision; Uncorrected visual acuity.

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INTRODUCTION

Of the total estimated 38 million blind people in the world, nine to 12 million are in India 50 to 80% of these people are blind because of cataract. In addition to the backlog, an additional 3.8 million become blind each year because of cataract.[1]

Cataract surgery has been there since 20 centuries. It has evolved from couching in ancient times to modern day manual Small Incision Cataract Surgery (SICS) and phacoemulsification. Phacoemulsification has become the most favoured procedure for cataract surgery in industrialized countries, In developing countries manual Small Incision Cataract Surgery is the most favoured procedure as it offers faster visual recovery and better uncorrected visual acuity (UCVA) than sutured manual extra capsular cataract extraction (ECCE).[2]

A number of studies in past years have shown that surgically induced astigmatism, particularly against the rule (ATR) astigmatism is the commonest cause of unsatisfactory UCVA after cataract surgery.[3]

The aim of cataract surgery is to provide early visual rehabilitation. The visual outcome of uneventful surgery mainly depends on the degree of postoperative astigmatism induced by the incision wound which in turn depends on the type, length and position of incision and also the method of wound closure.

In small incision cataract surgery (SICS) the most common incision taken is the superior one, but the post operative astigmatism is higher in superior incision, due to its larger size, drag on incision due to eyelid blink and effect of gravity.

The temporal site of incision is farthest from the visual axis and any flattening due to the wound is less likely to affect corneal curvature. The temporal incision is parallel to vector of forces of eyelid pressure and gravity. It induces with the rule astigmatism, which is advantageous as most of the elderly cataract patients have preoperative against the rule astigmatism.[4]

Thus this study is being done to evaluate astigmatism after superior versus temporal scleral incisions in manual SICS.

OBJECTIVE

The objective of the present study was to evaluate and compare the amount of induced astigmatism after superior and temporal incision in Manual Small Incision Cataract Surgery.

REVIEW OF LITERATURE

Manual SICS is considered an alternative to Phacoemulsification, especially in developing countries like India.

Studies done in Mumbai, where they compared superior, superotemporal and temporal incisions in manual SICS on 45 eyes have shown that mean astigmatism induced by surgery was 1.28 D X 2.9 degrees for superior incision, 0.20D X 23.7 degrees for superotemporal incision and 0.37D X 90 degrees for temporal incision. The study found that induced astigmatism was lower in temporal and superotemporal groups compared to that in the superior group.[4]

Another study done have shown by vector analysis that surgically induced astigmatism is less with an oblique incision (1.02 ± 0.66 D) than with a superior incision (1.41 ± 0.72 D).[5]

Similar studies done in Japan, comparing superior versus temporal incisions on 174 eyes of 87 patients with bilateral cataracts and concluded that in SICS, superior and temporal approaches are comparable in terms of visual rehabilitation and induction of regular and irregular astigmatism.[6]

The incision has a relaxing effect on the meridian where it is placed. The surgically induced astigmatism is against the rule for a superior location and with the rule for a temporal location. The superior corneal incision rarely allows to reach a minimum postoperative astigmatism as with a temporal location.[7]

Cataract surgery in antiquity

Cataract surgery has been performed since 20 centuries. Sushruta practiced couching as early as 800 BC. He used a blunt needle, passed through the sclera, behind the iris, to dislocate the lens downwards or backwards. The proof of success was the ability of patient to see form and figures again.

Cataract surgery developed from couching to modern day manual small incision cataract surgery and phacoemulsification after the development of intra ocular lens (IOL) by Ridley.

- In 1745 Daniel performed cataract surgery by limbal section of 180 degrees in lower half.
- Samuel sharp introduced intracapsular cataract extraction in 1753.
- Van Grafe in 1865 made a section in upper half of cornea.
- Richard Kratz first developed the scleral tunnel incision in 1980. In 1982 Kraff and Sanders proved that smaller incisions were better than larger, producing less early induced astigmatism and less late healing astigmatic shift.
- Michael McFarland published the development of a sutureless incision in March 1990. Ernest later recognized that the corneal lip of this sclero corneal tunnel acted as a one way valve which imparted self sealing property to this incision.
- Blumenthal described hydroexpression of nucleus in 1992.

History of astigmatism

Thomas young in 1801 was the first to describe ocular astigmatism. However it was some years later before Airy in 1827 corrected astigmatism using cylindrical lens. Corneal astigmatism was characterized by Knapp and also Donders in 1862. In 1864 Donders described regular astigmatism. Donders also described astigmatism after cataract surgery and soon after Snellen in 1869 suggested that placing the incision on steep axis would reduce corneal astigmatism.[8]

Advantages of manual small incision cataract surgery over conventional extracapsular cataract surgery

- Fast visual recovery.
- Small and sutureless, No photophobia and foreign body sensation.
- Self sealing incision.
- Minimal astigmatism.
- Patient rehabilitation is faster and early rehabilitation is possible.

Advantages of temporal incision

- Surgeon position on the side, working at the temporal periphery, there is no need to turn eye down, as when working over the brow and therefore the bridle sutures are not necessary.
- With the iris plane parallel to the light of microscope, the red reflex is enhanced and there is marked improvement in visualization of intraocular structures.

- This location allows greater access to the incision than when working over the brow. At this location, the lateral canthal angle is directly beneath the incision, the irrigation fluid drains naturally.
- The temporal location is farthest from the visual axis and thus the endothelial damage postoperatively is much less than superiorly placed incisions and any flattening around the wound is less likely to affect the corneal curvature at the visual axis.
- Incisions at this location are more stable with respect to against the rule drift.
- When incision is location superiorly, both gravity and eyelid blink tend to create drag on the incision. With temporal location, these forces are better neutralized.
- At this location, the astigmatism induced is “with the rule”, which is advantageous for the aged patients whose preoperative astigmatism was against the rule”.

ANATOMY OF CORNEA, SCLERA AND LIMBUS

Anatomy of cornea

The cornea is a transparent, avascular, watch glass like structure forming anterior one sixth of the outer fibrous coat of the globe.

The anterior surface of cornea is elliptical with an average horizontal diameter of 11.7 mm and vertical diameter of 11 mm. The posterior surface of cornea is circular with an average diameter of 11.5 mm. It is 0.52 mm thick in the centre and 0.67 mm thick at the periphery. The central three to five mm of cornea "the optical zone" has an anterior radius of curvature of 7.8 mm and a posterior radius of curvature of 6.5 mm.

The total refractive power of cornea is 45 D which is three fourth of the total refractive power of the eye. Its refractive index is 1.37.

Microscopically the cornea has five layers. These are an anterior epithelium of 5 to 90μ thickness, the Bowman's membrane which is 8 to 14μ thick, the stroma which forms 90% of corneal thickness and is 0.5 mm in thickness, a 40μ thick descemet's membrane and a single layer of endothelium facing the anterior chamber.

The epithelium of cornea continues across the limbus as the conjunctival epithelium and the stroma of cornea continues across the limbus as the stroma of sclera.

Surgical anatomy of limbus

Limbus is the transition zone between the peripheral cornea and anterior sclera. Structures included in the limbus are;

1. Conjunctival and limbal palisades.
2. Tenon's capsule.
3. Episclera.
4. Corneo scleral stroma.
5. Aqueous outflow apparatus.

The transition from sclera to cornea occurs over the limbus and this zone is 1 to 1.5 mm wide.

The surgical limbus is divided into two zones;

1. An anterior bluish grey zone overlying clear cornea and extending from end of Bowman's layer to Schwalbe's line.
2. A posterior white zone overlying the trabecular meshwork and extending from Schwalbe's line to scleral spur.

Anatomy of sclera

It is an opaque fibrous structure covering posterior four fifth of the globe. It is invested anteriorly by the Tenon's capsule. The tenon's capsule and conjunctiva overlying it fuse near the limbus with the sclera. The sclera is thinnest (0.3 mm) behind the insertion of rectus muscles. It is thickest (1 mm) at the posterior pole. Its thickness anterior to rectus muscle insertions is 0.6 mm and is 0.4 to 0.5 mm thick at the equator. It is an avasuclar structure except for episcleral vessels and intrascleral vascular plexus located just posterior to the limbus. A number of emissary channels penetrate the sclera for passage of arteries, veins and nerves.

Miroscopically it has three layers that is;

1. Episclera is a vascular structure which merges superficially with the conjunctiva and deep with anterior superficial sclera.
2. Stroma has collagen fibers, fibroblasts and ground substance. These collagen fibers are arranged irregularly with variable thickness and inter

fibrillar distance, accounting for the opaque nature of sclera and its elasticity.

3. Lamina fusca is the deep pigmented layer of sclera.

Collagen arrangement in cornea

The collagen lamellae in the cornea are oriented orthogonal to each other in the stroma with regular spacing in between them. These lamellae run from limbus to limbus across the cornea. The fibers near the limbus are all oriented tangential to the limbus and the limbal fibers are in the form of a well defined annulus which extends 1mm into the sclera. This annulus varies in width with position around the cornea. It being 1.5 mm wide superiorly, two mm wide inferiorly and maximum value midway between superior and nasal and superior and temporal cornea.[9]

Incisions and wound healing in small incision cataract surgery

Prior to the advent of silk sutures, sutureless cataract incisions were the norm in ophthalmology but they were not self sealing. In present day cataract surgery various incisions are used. These may be scleral, posterior limbal, anterior limbal, or corneal. In manual small incision cataract surgery, scleral incision is the standard choice.

Manual SICS are self sealing as sclero-corneal tunnel incision is constructed. In this incision the internal incision in anterior chamber is remote from the external scleral incision and the two are connected together by a sclero corneal tunnel. When the internal pressure of the eye is re-established, the high intraocular pressure (IOP), compared to the lower atmospheric pressure causes the tunnel to collapse and self seal.

The various incisions which are used in manual SICS vary according to their site, dimensions, design and architecture. The site of incision can be superior or superotemporal or temporal. The dimensions of the incision can vary from a 3.5 mm to a 6 mm or longer in case of rigid IOL's. Other factors which affect incision size are;

- Type of intraocular lens – incision size is small for foldable IOL, and large for rigid IOL.
- Type of cataract.- incision size will be larger for hard brown cataract
- Technique of nucleus delivery.- small incision size is enough if nucleus is divided in anterior chamber and removed in two pieces
- Skill of surgeon.
- Design of wound. - In the wound design, the internal incision is always larger than the external, giving a shape of a funnel to the wound. The inner lip of the wound normally has a width of eight to nine mm.

  The various shapes of incisions in use for manual SICS are;
- Horizontal incision or straight incision.
- Frown shaped incision.
- V shaped incision.
- M shaped incision.
- Horizontal incision with straight backwards extension.
- Horizontal incision with backward extensions perpendicular to the limbus.

MANUAL SMALL INCISION CATARACT SURGERY

Anesthesia

Most surgeons prefer peribulbar anesthesia. However other techniques which are being used are topical anesthesia with four percent paracaine drops, subconjunctival injection of two percent xylocaine with sensorcaine, sub-tenon perfusion with a canula, application of a wet cotton plaque dipped in xylocaine at the wound site, intracameral preservative free xylocaine.

Technique

After painting and draping the patient, traditionally a superior rectus bridle suture was placed but presently the surgery is done without a superior rectus suture with globe being stabilized by a grip on conjunctiva or tenons capsule. A peritomy is made with scissors and hemostasis is achieved with either thermal or wet field cautery.

Technique of wound construction

Incision

The desired size of external incision is measured with calipers about 1.5 to 2 mm behind the limbus and the incision is made using a diamond or steel blade.

Sclero corneal Tunnel

Scleral dissection is then carried out, using a crescent knife, towards the limbus, taking care to always keep the heel of crescent knife of 2.6mm down. The dissection is carried straight into clear cornea for 1mm, the tunnel is extended on either side and lateral scleral pockets are also made.

Anterior chamber entry

The anterior chamber is now entered from the centre of the internal edge of the tunnel using a 3.2 or 2.8 mm angled sharp tip keratome. The keratome is entered angled downwards with tip pointing towards the centre of pupil. As soon as the tip enters AC the blade is made parallel to iris plane and the eye is filled with viscoelastic to increase the IOP and make the globe firm. This later helps in easier creation of the capsulotomy.

Anterior Capsulotomy

A capsulotomy using can-opener method, a continuous curvilinear capsulerrhexis (CCC) method, or envelope technique is done with a 26 G needle fashioned into a capsulotome. Viscoelastic is injected in anterior chamber (AC).

The section is enlarged with keratome. The extension is made parallel to limbus and never cutting the limbus.

Hydroprocedures

Hydrodissection is done for minimizing the size of the nucleus and loosening the cortical matter. Most often, with this, one edge of the nucleus usually pops out.

Nucleus delivery

There are various methods in use for nucleus delivery in manual SICS. The most safe and commonly used method is visco-expression. Other methods are sandwich method, snare method, phacosection method and fish hook method. The nucleus is delivered out of the wound using one of the methods, taking care not to damage the endothelium.

Cortical wash

Irrigation and aspiration of AC is done either by manual or by automated system to remove the cortical matter. Anterior and posterior capsules are polished

IOL Insertion

Viscoelastic is injected in AC to deepen it and fill the capsular bag. The selected posterior chamber intra ocular lens (PCIOL) of appropriate size and power is implanted in the sulcus in cases with can-opener capsulotomy and is implanted in the bag in cases with Continuous Curvilinear Capsulorrhexis (CCC) and the IOL is dialed and centered. PCIOL can also be inserted under air. A thorough AC wash is given to remove the viscoclostic.

Method of closure

The main wound if properly constructed is self sealing if IOP increases, The stability of the wound is confirmed by injecting fresh BSS and looking for any leakage.[10,11]

Cataract Incisions and surgically induced astigmatism

An incision of the cornea or sclera creates tissue gape. This gape causes corneal flattening along the meridian of the incision and steepening in the meridian 90° away, with several factors determining the magnitude of this effect.[12]

When an incision is made on the scleral surface the two edges of the incision usually separate. This incisional gape is a normal physiological reaction to the natural elasticity of sclera and scleral shrinkage from cautery. This gape does not affect corneal astigmatism. If a flap is tunneled up to the cornea but not into anterior chamber there is still no net effect on astigmatism. The entry into the anterior chamber permits the cornea to change shape. Hence the part of a sclerocorneal tunnel which leads to corneal instability is the corneal entry site and not the external groove and tunnel.[13]

Healing of self sealing sclero-corneal tunnel

Scleral pocket incision healing is complex because the initial groove and peripheral portion of the pocket are in the sclera. The pocket then goes through the limbus into the peripheral cornea, and anterior chamber entry is corneal. Healing process is different in each of these three zones.

Immediately after an incision, corneal fibres swell in an effort to seal the opening but scleral fibres tend to contract rather than swell. About two days after a scleral tunnel incision, histocytes and vascular elements from the episclera and subconjunctival tissue moves into the incision and proliferating fibrous tissue begins to form, running at right angles to the clear cut scleral edges. After several weeks, the fibres begins to align themselves like scleral fibres but the scar is always histologically distinguishable. The sclera itself remains relatively inert.

In the limbal portion of the incision, which is entirely midstromal, stromal fibrocytes are inactive and play little or no role in wound healing. Healing of the limbal stroma also apparently depends upon fibrous ingrowth from the episclera. The stroma may take two years or more time to become normal again.

In the peripheral corneal stroma, the healing process is different. Initially after the incisional injury, there is a three to five days lag phase during which the corneal fibrocytes transform into fibroblast which then form new connective tissue. At least a month is required for consolidation.

At entry into anterior chamber, the cut edges of Descemet’s membrane do not reunite. Twenty four to 48 hours after injury, endothelial cells at the edge of the wound begin to proliferate by dividing and cover the retracted edges of Descemet’s membrane, continuing to proliferate, they form a scar over the incisional area. The proliferating endothelial cells produce a new basement membrane which, after two to three years, thickens to form a new Descemet’s membrane about half of the original thickness. Evidence suggests that scleral tunnel incisions probably do not heal any faster than limbal incisions.[14]

ASTIGMATISM

It is refractive error in which no point focus of light is formed because of unequal refraction of light rays in different meridia by the diopteric system of the eye.[9]

It accounts for about 13% of the refractive errors of human eye.

Components of astigmatism

Astigmatism can be an error of curvature, of centering, of refractive index or retinal.

Curvature astigmatism if of any high degree, has its seat most frequently in cornea. This is usually congenital and its occurrence in small degrees is almost invariable. Curvature astigmatism of lens also occurs with great frequency but in the majority of such cases such anomalies are small.

Astigmatism due to de centering occurs when the lens or the IOL is placed obliquely or slightly out of line in the optical system.

A small amount of index astigmatism occurs physiologically in lens and is usually slight.[15]

Retinal astigmatism occurs due to oblique placement of macula. Astigmatism is regular when the refractive power changes uniformly from one meridian to another.

Regular Asigmatism –

With the rule astigmatism

In with the rule (WTR) astigmatism the two principal meridian are placed at right angles to one another but the vertical meridian is steeper than horizontal. Normally the vertical meridian is rendered 0.25D steeper than horizontal.

Against the rule astigmatism

Against the rule (ATR) astigmatism refers to a condition where the horizontal meridian is steeper than the vertical meridian.

Oblique astigmatism

Oblique astigmatism is a type of regular astigmatism where the two principal meridia are not the horizontal and vertical though these are at right angles to each other.

Bioblique astigmatism

Bioblique astigmatism is a type of regular astigmatism in which the two principal meridia are not at right angles to each other.

Irregular astigmatism -

Irregular astigmatism is one in which there is an irregular change of refractive power in different meridia. There are multiple meridia which admit no geometrical analysis.[16]

Depending upon the position of two focal lines in relation to retina, regular astigmatism is further classified as;

1. **Simple astigmatism:** the rays are focused in the retina in one meridian and either in front (simple myopic astigmatism) or behind (simple hypermetropic astigmatism) the retina in the other meridian.

2. **Compound astigmatism:** the rays of light in both meridia are focused either in front (compound myopic) or behind (compound hypermetropic) the retina.

3. **Mixed astigmatism:** the light rays in one meridian are focused in front and those in the other meridian behind the retina. [17,18]

Prevalence of astigmatism and changes with age

In first months of life, infants show a high prevalence of high (6D average) ATR astigmatism (corneal) The steepest most astigmatic corneas occur in newborns with the lowest birth weight and lowest post conceptional age. As infants grow, emmetropisation of astigmatism occurs. Astigmatism shifts to low levels of WTR after four years age and pressure from eyelids on cornea over time has been suggested as a cause. Children typically display WTR astigmatism.

Young adults typically display small degrees of WTR astigmatism and in older adults shift occurs and ATR astigmatism becomes more prevalent.

Internal astigmatism remains stable throughout life and changes in astigmatism throughout life are primarily due to changes in corneal curvature.

Causes of astigmatism

1. Both genetic and environmental influences have a role in development of astigmatism.
2. Eye lid pressure has been proposed as a cause of WTR astigmatism by Grosvenor.
3. Nystagmus – people with nystagmus usually have high degrees of corneal WTR astigmatism.
4. Visual tasks – Certain visual tasks like prolonged reading habit in down gaze have a potential for inducing ATR astigmatism.
5. Surgically induced astigmatism occurs after surgeries for cataract, trabeculectomy, ptosis, scleral buckling, pterygium excision.

Effect of astigmatism on vision

Astigmatism induces distortion of image. The retinal image is distorted because of a differential magnification in the two principal meridians. There is 0.3% image distortion per diopter of astigmatism.[18]

In WTR astigmatism, the power of weaker principal meridian produces a vertical line focus. In printed matter the vertical strokes of the letter are more important for recognition for example b, d, h, also there is less space between letters than between lines.

Hence it is useful to have a better focus in vertical meridian as is there in myopic WTR astigmatism, resulting in better Snellen visual acuity.

In addition, a number of psychophysiological responses are more sensitive to vertically oriented stimuli for example stereoscopic threshold, depth determinations.

Another benefit of WTR astigmatism is that less cylinder is required in spectacle correction than ATR astigmatism of same magnitude. In corrected, astigmatic eye, retinal image distortion arises due to unequal spectacle magnification in the two principal meridia, representing 1.6% distortion per dioptre cylinder correction.

More over spectacle cylinder will be less than the ocular astigmatism when the spherical equivalent is positive and greater than the ocular astigmatism when spherical equivalent is negative. So in general myopic ATR astigmatism will result in proportionally larger spectacle correction, which will produce more distortion. A certain degree of myopic astigmatism is useful as it may produce a situation of pseudoaccommodation in psuedophakic patient.[19]

Uncorrected astigmatism causes blurred image, glare, monocular diplopia. Even with appropriate spectacle correction the meridional magnification may create distortion. The patients having preoperative astigmatism may experience difficulty adapting to axis shift induced by surgery. Any of these effects may create not only dissatisfaction with visual outcome, but also discomfort with an otherwise uneventful surgery.

Methods to measure astigmatism

Refraction

Refraction evaluates the entire optical system of the eye and includes any aberrations of the lens, posterior cornea, IOL or posterior capsule. Retinoscopy can determine both the magnitude as well as the axis of cylinder in astigmatism with remarkable precision.

Refractions are normally performed at the spectacle plane and not at the corneal plane. For surgically induced refractive changes (SIRCs) determined by refraction to be compared with SIRCs determined by keratometry or topography, they must be vertexed to corneal plane. Spectacle vertex distance is usually 12 mm. When correctly vertexed to cornea, astigmatism at corneal plane is almost one fourth D less. This relationship is always true for compound myopia. For compound hyperopia it is just opposite, that is astigmatism is always more by one fourth D at corneal plane than at spectacle plane.[20]

If there is zero residual spherical equivalent refraction, the cylinder will be equal to corneal astigmatism.[11]

The main refractive media of the eye are the cornea and the lens. The refractive state of the lens can be variable, particularly with cataract development. Hence retinoscopy does not give an accurate refractive status of the eye in cataract patients as well as in patients with pseudophakia.[21]

Keratometry

It is the optical process of determining the curvature of central cornea. Keratometry is expressed as diopteric power (D) or as diopteric curvature (Kd) of the cornea. These measurements give the cornea's contribution to the overall refractive state of the eye.

The first keratometer was built in 1769 by Jesse Ramsden. Then in 1854 Von Helmholtz improved upon this design. This device was built around a low power telescope that permitted measurement of the first surface corneal reflection. The ratio of apparent size of reflected image mire to the size of actual mire allows corneal curvature to be determined precisely. The first practical keratometer suited for clinical use was developed in 1881 by Javal and Schiotz.

Principle of keratometer

Strictly speaking, neither corneal curvature, nor the radius of curvature are measured directly, but these values are calculated by the apparent size of the image of the mire viewed by reflection from the anterior corneal tear film surface, which acts as a convex mirror. For a convex mirror.

$$r = 2 \times h'/h$$

Where,

r = radius of curvature of a spherical mirror

h'= Image size

h = object size

When this formula is applied to the cornea, the radius of curvature is always expressed as a positive number in millimeters.

Diopteric power (D) is calculated from r, as:

$D = (n' - n)/r$

n = Refractive index of air = 1.000

n'= Refractive index of cornea

The standardized keratometric index of refraction is 1.3375. Hence keratometers measure the anterior corneal surface but give the total diopteric power of front as well as the back surface of cornea. Keratometers use a microscope to magnify the image. However because the eye is constantly moving about, it is difficult to measure the image size against a reticule. This problem is overcome by using the principle of visible doubling. This can be achieved either by using variable doubling with fixed object size or by varying the size of external object with fixed doubling.[22]

Types of keratometers

<u>Qualitative keratometers:</u> These were first described in 1880.These are based on the principle of placido disks. They do not objectively measure the radius of curvature; hence a better description might be operative keratoscope. Examples include Hyde astigmatic ruler and troutman surgical keratometer.

<u>Quantitative keratometers:</u> These were first described by Hemholtz in 1854 These are based on the principle of keratometry and measure corneal curvature at different meridians. Thus the amount as well as axis of astigmatism can be

determined. Examples include Javal Schiotz keratometer, Bausch and Lomb, Terry Surgical keratometer and Carvalho computerized surgical keratometer.

Hand held keratometers: They give the advantage of portability and flexibility to perform measurements in different positions.

Bausch and Lomb keratometer: It is based on the principle of constant object size and variable image size. The object is a circular, illuminated mire with two plus and two minus signs. Light from the mire strikes the patients cornea and produces a diminished image behind it. This image becomes the object for the remainder of optical system.

The objective lens focuses the light from the mire image along the central axis. A four aperture diaphragm is situated near the objective lens. Beyond it are two doubling prisms – light passing through left aperture is deviated above the optical axis by base up prism. Light passing through right aperture is deviated by base down prism. Upper and lower apertures double the central image whenever the instrument is not focused. This image doubling is unique to this keratometer allowing simultaneous measurement of corneal power in two meridian without rotating the instrument. Range of this keratometer is from 36 to 52 D. Lower limit can be extended to 30 D and upper limit to 62 D by interposing a -1 D and a +1.25 D lens respectively in front of objective.

Limitations of keratometry

1. The measurements are based on a false assumption that the cornea is a spherocylinder where as in reality, cornea is aspheric.

2. It measures a very small central area of cornea (three to four mm) ignoring peripheral zones.
3. It loses its accuracy when measuring very flat or very steep cornea.
4. Irregular astigmatism cannot be measured.[22]

Although keratometric data are already at the corneal plane and do not require any vertex considerations, a different problem arises with the index of refraction used to convert the anterior radius of cornea to a refractive power. Most keratometers use a refractive index of 1.3375 for cornea. The cornea, like any meniscus lens, has a front surface power, a back surface power and an equivalent net power. The average index of refraction of the cornea is 1.376. The front surface power and the net power changes are the only clinically relevant considerations since there are no keratorefractive procedures intended to change only the back surface power.

For analyzing results in which both front and back surfaces have been changed equally, it is appropriate to use the net corneal index of refraction. Holladay has suggested use of value 1.333 determined by Binkhorst. Using this value the net corneal power will be 98.76% of the standardized keratometric values. This 1.24% error is clinically negligible when calculating changes in corneal power produced by surgical procedures, however it introduces a significant error of 0.56 D in IOL calculations.[20]

Corneal topography

This developed due to the need to visualize localized distortions in corneal curvature. This provides a graphical representation of the contour of the cornea. Various techniques used for corneal topography are;

1. Keratoscopy
2. Slit scanning corneal tomography

Refraction and keratometry indicate only one steep corneal meridian while corneal topography can identify one or more steep semimeridians which are not necessarily 180° apart. [23]

SURGICALLY INDUCED ASTIGMATISM FOLLOWING CATARACT SURGERY

Surgery -

Surgically induced astigmatism is the condition in which a patients preoperative and postoperative keratometry values differ. Since Donder's first description, it is well recognized that the wound performed during cataract surgery produces astigmatism. With the advent of sutured cataract sections and IOL implantation induced astigmatism became more of a concern.

During the evolution of change in astigmatism following cataract surgery, the patient's actual spherical equivalent remains constant. According to Gauss's law of elastic domes. For every change in curvature in one meridian there is an equal and opposite change 90° away. This corneal behavior is known as the coupling effect. Thus the corneal curvature changes not as if a single spherocylinder was placed at a single axis, but as if a plus cylinder was placed in the steeper meridian and a minus cylinder of equivalent magnitude was placed in the flatter meridian.[17]

Factors affecting surgically induced astigmatism

1. ***Incisional funnel:*** The incisional funnel is an imaginary pair of curved lines representing the relationship between astigmatism and incision length. They diverge outwards from the limbus, separating as the distance from the limbus increases. Incisions made within this funnel will for all practical purposes be astigmatically neutral. Short incisions can be made closer to the limbus and longer incisions farther away, and all will have the equivalent effect on corneal stability.[13]

   Incision length: The incision chord length of ECCE is generally 10 to 11 mm. With phacoemulsification it varies from 3mm with foldable lenses to five to seven mm with rigid PCIOL. In manual SICS it varies from 3.5 mm to 7 mm depending upon method of nucleus delivery, type of cataract and type of IOL.

   Numerous studies have demonstrated that smaller incisions induce less astigmatism. Samuelson and associates studied induced astigmatism in cadaver eyes and found that there was a nearly linear increase in corneal flattening with increasing incision length. The maximal incision length that prevented flattening of more than 0.25 D was three mm.

Among the length, location and shape of incision, incision length was the most important of these factors affecting SIA. More peripheral and shorter incisions induce less astigmatic change. Koch introduced the concept of an astigmatically neutral zone – the incisional funnel extending posteriorly from the limbus. This incorporates the linear relationship between the cube of incision length and astigmatism and the inverse relation between astigmatism and the distance of incision from the limbus to define a space within which incisions should be astigmatically neutral regardless of their length.[13]

2. ***Location:*** significant difference in SIA was seen in incisions located 1 to 1.5 mm from limbus but SIA to be insignificant for incisions with different lengths located 2.5 mm from the limbus.

   The effect of incision placement in other than superior location showed reduced ATR astigmatism on using temporal incisions.

   Why astigmatism is more in superior than in superotemporal and temporal incisions can be explained by the fact that since cornea is one mm wider than tall, hence superior incisions would be located closest to centre of cornea and temporal incisions the farthest. Moreover superior incisions are affected by the distractive forces of lid blinking and gravity.[24]

3. ***Incision Shape:*** In curvilinear limbus parallel incision nothing prevents the inferior edge of the incision from falling away from superior edge. With a straight incision the two extremes are secured in the sclera and the

inferior edge directly adjacent to the two extremes cannot sag hence potential for astigmatism is less. In frown incision the two ends are swept upwards, away from limbus, hence the effect is like the ends were slings, supporting the incision ends, hence very low potential for astigmatism is there.

The incisional funnel concept given by Koch explains the astigmatism induced by various incision shapes. The limbal parallel curvilinear incision falls out of the funnel and hence causes greater SIA as compared to the straight incision which also falls out of the funnel but because more of it is contained within the funnel, hence it causes less astigmatism. The frown incision of same size causes least astigmatism because since its ends curve posteriorly hence it tends to lie completely within the incisional funnel.[13]

4. ***Suture technique and material:*** Various authors have noted the initial induced WTR astigmatism with interrupted or continuous suture closure and have attributed it to wound compression from tight sutures, wound edema, cautery and increased IOP after surgery. Resolution of wound edema, cheese wiring of suture, loss of suture tensile strength contribute to suture decay and lead to ATR astigmatism later.[25]

5. ***Intraocular lenses:*** Study has shown that IOL's are not a common source of astigmatism. Significant lens tilt is required to induce clinically significant astigmatism.

6. ***Wound healing:*** The gradual ATR changes associated with superior incisions may be secondary to wound healing changes but the time course for final wound healing in avascular cornea and sclera is unknown.

7. ***Cautery:*** there is significant mean vertical WTR steepening after cauterization which is attributed to collagen shrinkage but this effect is found to predominate in immediate post operative period and regresses later.

Modifications of astigmatism

Various methods to modify astigmatism in manual SICS are;

1. Using cataract incision to modify pre-existing astigmatism. Incision is made at 12 o'clock if preoperative keratometry shows WTR astigmatism. In presence of ATR astigmatism, incision is made on temporal side. If astigmatism is high, the incision is paralimbal, close to limbus and long in length. If there is no astigmatism, a small, frown incision away from limbus is made.

2. Astigmatic keratotomy: In this technique arcuate shaped corneal relaxing incisions (CRIs) are used, either single or paired, placed concentric to the visual axis, at 99% of peripheral pachymetry measurements. But these have limited predictability and often result in over correction. Moving the relaxing incision off the cornea to the limbus creates limbal relaxing incisions (LRI). These can be used with any type of cataract incision and

result in smoother corneal topography and are quiet effective in astigmatism = 3 D.

3. Toric IOLs: These are foldable, toric, silicone IOLs which are implanted along with spherical IOLs in cataract patients with pre-existing astigmatism. Their limitations are that they are available in only two powers of 2 D or 3.5 D with an effective correction at corneal plane of 1.5 D or 2.25 D respectively. Moreover they have a tendency to rotate and studies show that 18 to 25% cases rotate by more than 20°, moreover they are not effective for astigmatism > 3 D.

4. Piggyback toric lenses: These are used in cases with high astigmatism Problem here is that even a small amount of rotation affects the cylinder Correction seriously. To prevent this, plate haptic lenses are used. This is a good method to reduce high preoperative astigmatism.

5. Toric lenses with LRIs: This method can be used to correct larger amounts of astigmatism. The advantage of using a toric lens is the reduction in the amount of incisional surgery required.

6. Spectacle: An astigmatic error of = 0.5 D usually requires correction. Uncorrected, the Snellen visual acuity (VA) may reduce to 6/9 to 6/18 by an error of one to two D. Patients who have adapted to a life time of cylinder axis may not tolerate spectacle correction of a surgically induced axis change. Moreover spectacle correction may produce meridional aniseikonia, which becomes problematic with binocular vision.

7. Contact lenses may be satisfactory for many patients but superior wound gape with horizontal steepening may cause inferior ride of lens.

8. Other methods to reduce astigmatism are photorefractive keratotomy (PRK), wedge resection and laser assisted in situ keratomileusis (LASIK).

CALCULATION AND ANALYSIS OF SURGICALLY INDUCED ASTIGMATISM

To estimate the effect on corneal curvature induced by cataract surgery, the difference between preoperative and postoperative keratometry needs to be calculated. Various methods are used to calculate SIA from this. These methods are;

1) Subtraction method: This is the simplest method to calculate SIA. It compares the numerical value of astigmatism before and after surgery. The induced astigmatism is the difference between the two.

$$\Delta M = M1 - M2$$

Where

ΔM = Induced astigmatism

M1 = Pre operative corneal astigmatism.

M2 = Post operative astigmatism.

This method does not consider the axis of astigmatism. Hence in situations where the axis is different after surgery it gives erroneous results.

2) Algebraic method

ΔMalg = M1alg – M2alg

Where

M1alg and M2alg change signs in accordance with the direction of the steeper corneal meridian. For steep meridian between 90°±45 a plus sign is added and for all other values of steep meridian, M is denoted a minus sign. This method describes WTR and ATR change but gives no information regarding the angle of the axis.

3) **Cravy's method** calculates SIA as:

Cravy ΔK = (Δx) + (Δy)

Where,

Δx = x1 – x2

And x1 = M1 cos a1

x2 = M2 cos a2

Δ y = y1 – y2 where

Y1 = M1 sin a1

Y2 = M2 sin a2

This system reports the WTR and ATR changes.

4) **The vector method:** The vector method described by Jaffe is based on a variation of a technique of finding the sum of oblique cylinders in which the cylinder is represented on a graph by a vector. Vector gives information

regarding both amplitude and direction. The sum of two obliquely crossed cylinders can be found by treating the component powers of the two cylinders as vector in a vector diagram, but while doing so the vectors representing cylinder powers are directed at angles twice the actual angle of orientation before the eye. To calculate SIA after cataract surgery the preoperative and postoperative astigmatism values are treated as vectors and represented a vector diagram at twice their axis angles. If K1 is preoperative astigmatism at axis Φ1 and K3 is postoperative astigmatism at axis Φ3 then K1 and K3 are represented in a diagram at axis 2Φ, and 2Φ3. The ends of K1 and K3 are joined together which gives K2 (SIA).

A line is plotted parallel to baseline so the direction of K2 can be measured around the end of K1.

The resultant angle is then halved to get the axis of SIA. In these calculations, it makes no difference whether one uses positive or negative cylinders as the signs are kept the same in each calculation.[16]

5) A more highly precise method of measuring SIA uses rectangular and polar coordinates. The x, y polar coordinates are determined for preoperative (K1) postoperative (K3) astigmatism where;

$X = K \cos \theta$

$Y = K \sin \theta$

K is the astigmatism.

θ is the angle of steep meridian. The rectangular coordinates for SIA (K2) are calculated as:

K2 = K3 – K1 = XK2, YK2

Finally K2 is calculated as $\sqrt{X^2K_2 + Y^2K_2}$

The axis of K2 is calculated as

Θ = arc tan y/x

6) **The law of sines and cosines**: It is another trignometric method used to calculate SIA where amplitude of SIA (K2) is found by law of cosines and angle θ is found by law of sines.

7) **The lensometer method:** Here the SIA is calculated by using cylinders from trial lens set and combining the two at the correct axis on the lensometer and reading the answer off the instrument.

8) **The vector decomposition method:** This method reports the WTR and ATR components from the values generated from astigmatic magnitude not considering axis.[26]

9) **The polar value method:** First described by Naeser is based on the concept of surgically induced flattening and torque of the preoperative cylinder. This converts keratometric values to a polar value, allowing expression of astigmatism as a single figure.

10) **Alpins method:** In 1997 Alpins gave a new method which encompasses all requirements of polar value method but belongs to rectangular coordinate group. This method uses both the preoperative corneal topographic and refractive values.

11) **Holladay et al** in 1992 gave a ten step method involving complex calculations, based on the oblique cross cylinders for calculating SIA.

In 1998 Holladay gave a new method based on a Cartesian coordinates system for calculation of individual and aggregate data. He also proposed that SIA data be displayed using doubled angle polar plots. In this method, each data set is converted to Cartesian coordinates of x and y.

Where,

X = cylinder x cos (2x axis)

Y = cylinder x sin (2x axis)

The mean value or the centroid of a set of x and y values is determined by finding mean of x and y values independently so that.

$$\text{Mean of x} = \frac{\sum_{i=1}^{n} xi}{n}$$

$$\text{Mean of y} = \frac{\sum_{i=1}^{n} yi}{n}$$

Then these mean values are converted from Cartesian coordinates back to standard polar notation for astigmatism. Hence

Cylinder = $\sqrt{x2 + y2}$

Angle = ½ x Arctan (y/x)

If xy > 0 then axis = angle

x<0 then axis = angle + 90°

x >0 and y <0 then axis = angle + 180°

The astigmatic data along with the centroids are depicted on Doubled angle polar plot. A centroid intuitively found at the centre of data cluster represents a high predictability of incision and an astigmatically neutral procedure.

The Jaffe Vector method calculates SIA accurately for individual patients but in analysis of aggregate data the astigmatic direction is disregarded. The Naeser, Alpins and the Holladay Cartesian coordinate based method have been proven to be the correct methods for reporting of aggregate astigmatic data.

METHODOLOGY

The present study was conducted in the Department of Ophthalmology, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients undergoing manual SICS during the period of January 2008 to December 2008.

Study design

One year randomized clinical trial.

Study period

The present study was conducted during January 2008 to December 2008.

Method of collection of data

Source of Data

Patients undergoing manual SICS at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum.

Sample size

A sample size of 100 cases (50 in each group).

Sampling procedure

A sample size of 100 cases was calculated considering Using the formula;

$$n = \frac{2 \times (Z_{alpha} + Z_{beta})^2 \times (S1^2 + S2^2)}{(p1 - p2)^2}$$

Selection criteria

Inclusion Criteria

- Patients undergoing manual SICS with posterior chamber IOL, at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum.
- Age group between 50 to 80 years.
- Patients with cataract upto Grade 3 nuclear sclerosis.
- Patients willing to give informed consent.

Exclusion Criteria

- Patients having hard brown cataract who cannot undergo SICS, but need Conventional Extracapsular cataract extraction.
- Cataracts other than senile cataract like complicated cataracts, traumatic cataracts, congenital cataracts.
- Patients with intraoperative and postoperative complications like vitreous loss, Persistent corneal edema, wound gaping, infections.

Procedure

The study is conducted in Department of Ophthalmology at KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during one year duration. Patients with uncomplicated senile cataract were enrolled. Patients with coexisting glaucoma, uveitis, subluxated lens, traumatic cataract and posterior segment pathology were excluded. The study was approved by the Ethical and Research Committee of Jawaharlal Nehru Medical College, Belgaum.

After finding the suitability as per inclusion and exclusion criteria patients were selected for the study and briefed about the nature of the study, the interventions used and written informed consent was obtained (Annexure–I). Further, descriptive data of the participants like name, age, sex, detailed history, were obtained by interviewing the participants and clinical examination and necessary investigations were recorded on predesigned and pretested proforma (Annexure-II). The patients were assigned randomly into two groups according to the site of incision by computer generated table of two.

- Group 1 - Patients undergoing manual SICS using superior scleral incision.
- Group 2 - Patients undergoing manual SICS using temporal scleral incision.

Preoperatively all the below mentioned investigations were done. All patients were operated using peribulbar anaesthesia. Both groups were implanted posterior chamber polymethyl meth acrylate (PMMA) IOL. The postoperative astigmatism was evaluated on days that is, day one, day 15 and day 45. The magnitude of astigmatism was calculated using vector method.

Preoperative evaluation

All clinically diagnosed patients were admitted one day prior to surgery. A detailed history was elicited and recorded.

- Keratometry was done using manual Bausch and Lomb keratometer. Axial length was measured with a sonomed 'A' scan unit and the IOL power was calculated using SRK II formula.

- A thorough anterior segment evaluation was done using the slit lamp.
- Visual acuity, both unaided as well as aided using spectacles or pin hole was checked with snellen's visual acuity chart. After pupillary dilatation, the cataract was assessed and graded. A thorough posterior segment evaluation was done and retinoscopy was performed.
- IOP was measured using a schiotz indentation tonometer. Patency of lacrimal passages was checked using lacrimal sac syringing.

All patients received one hourly topical antibiotic (ciprofloxacin) eye drop one day prior to surgery hourly. Tropicamide 0.8% and phenylephrine 5% eye drops were instilled for mydriasis, every 15 minutes, starting two hours prior to surgery. Systemic oral antibiotics (T. Ciprofloxacin 500 mg) were given on night before surgery and on the day of surgery in morning.

Surgical technique

All cases were done under local peribulbar anesthesia. Under all aseptic precautions the eye to be operated was painted with povidone iodine and spirit and was draped. A wire speculum was placed and a superior rectus bridle suture was placed and secured. A fornix based conjunctival flap was made at the chosen incision location with corneoscleral scissors and hemostasis was achieved by cautery of bleeding vessels.

The extent of incision was marked on the sclera with calipers and a 6.5 mm straight incision was made 1.5 mm posterior to the surgical limbus with 11 number surgigal blade. Scleral tunnel was constructed using a crescent knife and dissection continued 1 mm into clear cornea. Anterior chamber was entered from the anterior limit of sclero corneal tunnel using a 3.2 mm entry keratome without loosing the AC. Viscoelastic was injected into the anterior chamber. A capsulotomy was done either by can opener technique Hydrodissection was done. The tunnel was extended with keratome. Nucleus was prolapsed into anterior chamber and delivered out using sandwich technique or irrigating vectis. Cortical matter was aspirated using a classical simcoe cannula. A 6 mm optic, Polymethyl Methacrylate (PMMA), modified C loop IOL of appropriate power was implanted. Viscoelastic was aspirated with simcoe. AC formed with ringer lactate and side port opening sealed by stromal hydration or left as such.

Conjunctiva and Tenon's capsule were reposited back over the wound. Antibiotic steroid eye drops were administered six times per day and gradually tapered over six weeks.

A detailed postoperative examination of the patients was done on 1st day, first week, first month and three months. Keratometry and VA was checked on all follow-ups. Refraction readings were noted from first week onwards. A final subjective refraction was done at two months and the spectacles prescribed. Cases with steep axis at 90° ± 30° were considered WTR and those with steeper axis at 0/180° ± 30 were considered ATR. Patients with steeper axis in between these were considered oblique astigmatism.

The amplitude of preoperative astigmatism and postoperative astigmatism was calculated from the difference in keratometric values in the steeper and flatter meridian, using the plus cylinder notation. Astigmatism was considered a vector with a magnitude equal to this value, directed towards the steeper meridian. The amplitude of SIA was also calculated from pre and postoperative vectors using the vector method.

STATISTICAL ANALYSIS

Statistical analysis

Unpaired ‘t’ test was used to compare mean astigmatism induced by the two groups.

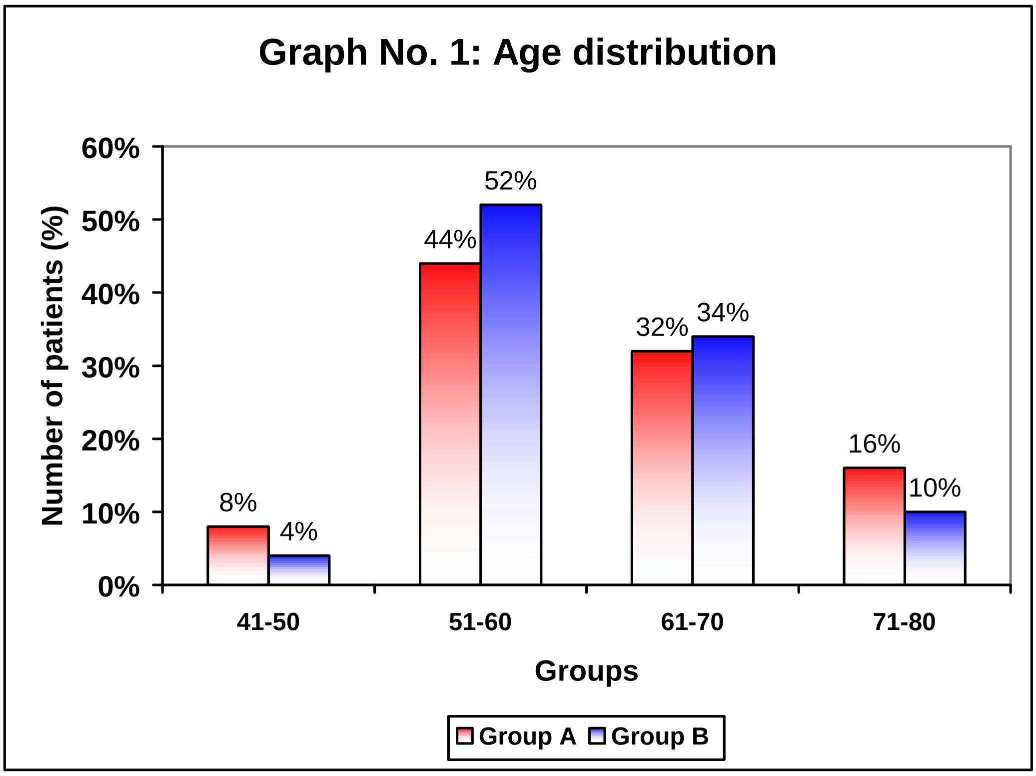
RESULTS

The present study was conducted on 100 patients who underwent MSICS at Department of Ophthalmology, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during study period. The patients were divided into two groups that is Group A (Patients who underwent MSICS with superior incision) and Group B (Patients who underwent MSICS with temporal incision). The data obtained was tabulated as below.

Preoperative and post operative keratometric readings and refraction were used for analysis. All calculations were performed using SIA calculator version 1.0, a free software programme.

Table No 1: Age distribution

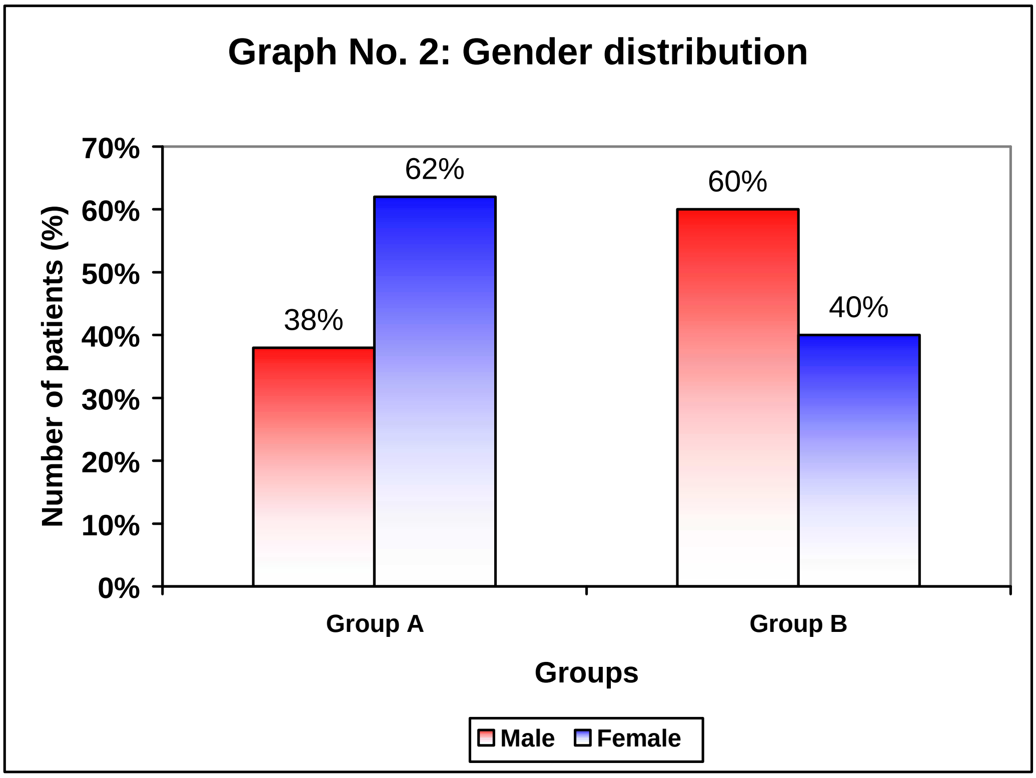
Age (Years)	Group A		Group B	
	No.	Percentage	No.	Percentage
41 – 50	04	8%	02	4%
51 – 60	22	44%	26	52%
61 – 70	16	32%	17	34%
71 – 80	08	16%	05	10%
Total	50	100%	50	100%



In the present study the mean age in both the groups was 55 ± 2.0 years. Majority of the patients in group A were in the range of 50 to 60 years that is 44%. Also in group B majority were in age group of 50 to 60 years that is 52%.

Table No 2: Gender distribution

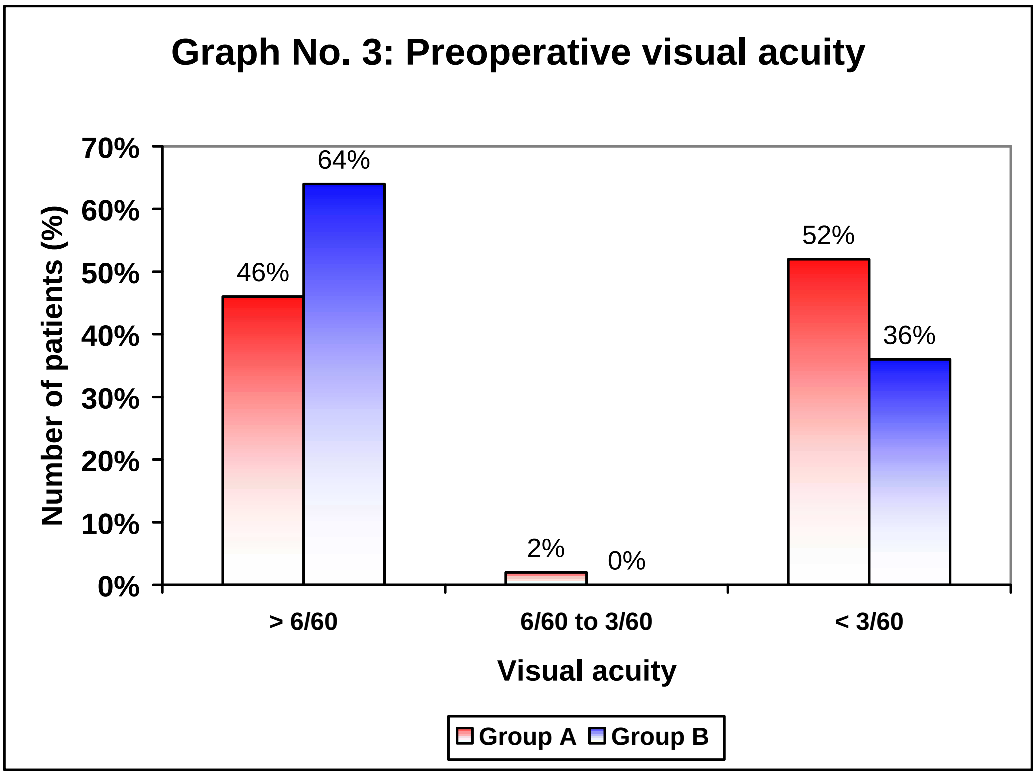
Gender	Group A		Group B	
	No.	Percentage	No.	Percentage
Males	19	38%	30	60%
Females	31	62%	20	40%
Total	50	100%	50	100%



In group A 62% of patients were females and 38% were male with male:female ratio of 1:1.6. In group B 60% were males and 40% were females with male:female ratio of 1.5:1.

Table No. 3: Preoperative visual acuity

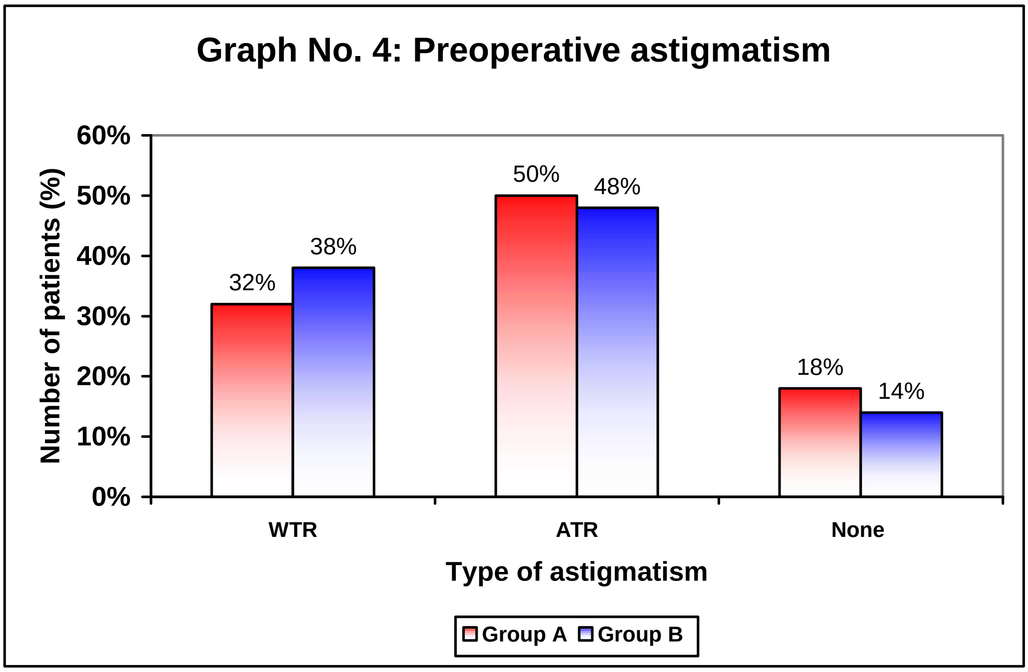
Visual acuity	Group A		Group B	
	No.	Percentage	No.	Percentage
> 6/60	23	46%	32	64%
6/60 to 3/60	01	2%	00	00%
< 3/60	26	52%	18	36%
Total	50	100%	50	100%



In group A majority of patients (52%) were in the range of less than 3/60 followed by 46% with more than 6/60. Whereas in group B majority (64%) had preoperative visual acuity in the range more than 6/60 followed by 36% in the range of less than 3/60.

Table No. 4: Preoperative astigmatism

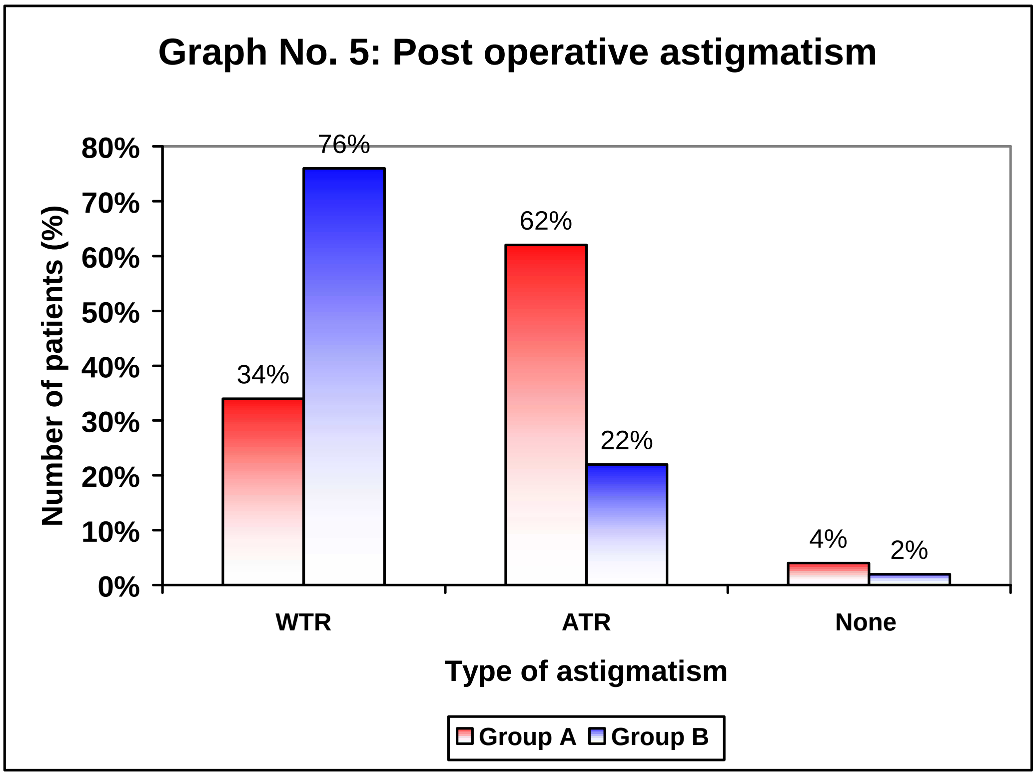
Astigmatism	Group A		Group B	
	No.	Percentage	No.	Percentage
WTR	16	32%	19	38%
ATR	25	50%	24	48%
None	09	18%	07	14%
Total	50	100%	50	100%



In this study majority (50%) of the patients in group A had ATR astigmatism followed by 32% WTR astigmatism and 9% of the patients had nil preoperative astigmatism. In group B, majority (48%) of the patients had ATR astigmatism followed by 38% who had WTR astigmatism. Seven patients (14%) were reported to have no astigmatism.

Table No. 5: Postoperative astigmatism

Astigmatism	Group A		Group B	
	No.	Percentage	No.	Percentage
WTR	17	34%	38	76%
ATR	31	62%	11	22%
None	02	4%	01	2%
Total	50	100%	50	100%

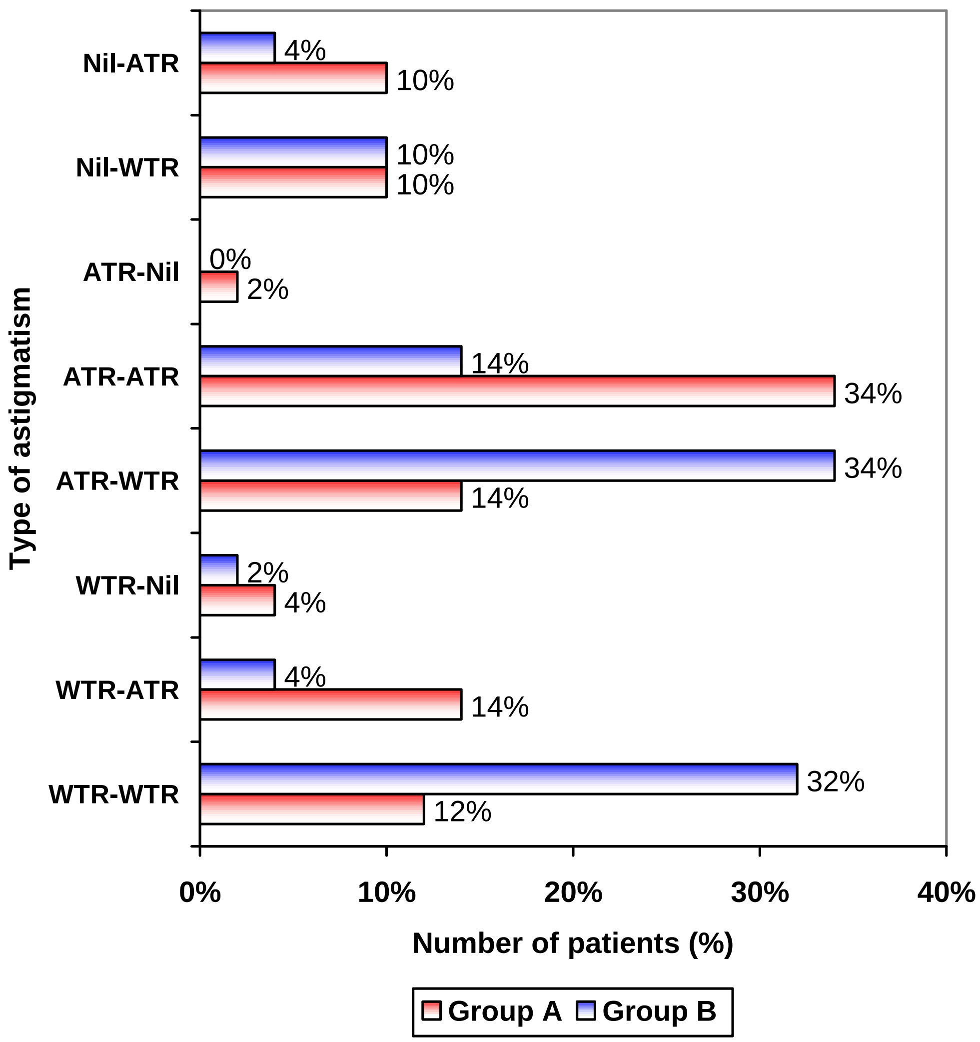


In group A 62% of the patients developed ATR astigmatism post operatively followed by 34% developed WTR astigmatism and four percent of the patients did not develop post operative astigmatism. In group B, 76% of the patients developed WTR astigmatism followed by 22% ATR astigmatism. One patient (2%) did not develop post operative astigmatism.

Table No. 6: Comparison of astigmatic change from pre operative to post operative state between group A and B

Change of astigmatism	Group A		Group B	
	No.	Percentage	No.	Percentage
WTR - WTR	06	12%	16	32%
WTR – ATR	07	14%	02	4%
WTR – Nil	02	4%	01	2%
ATR – WTR	07	14%	17	34%
ATR - ATR	17	34%	07	14%
ATR – Nil	01	2%	00	00%
Nil – WTR	05	10%	05	10%
Nil – ATR	05	10%	02	4%
Total	50	100%	50	100%

Graph No. 6: Comparison of astigmatic change from pre operative to post operative state between group A and B



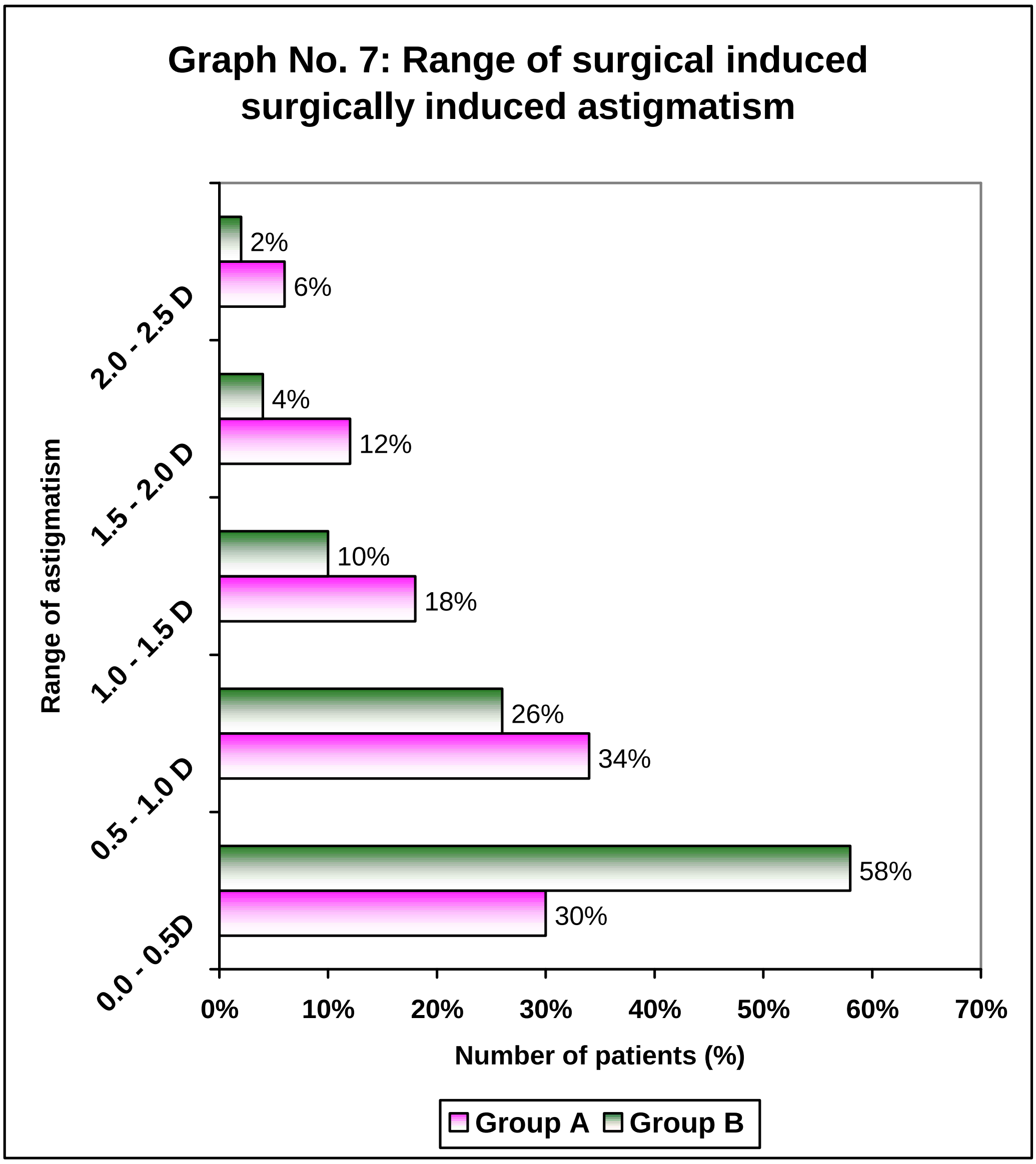
Of the patients having a preoperative WTR astigmatism six patients (12%) of group A and 16 patients (32%) of group B continued to remain so postoperatively. Seven patients (14%) of group A and two patients (4%) of group B showed a post operative ATR drift. Two patients (4%) of group A and one patient (2%) of group B showed no astigmatism postoperatively.

Of the patients having ATR astigmatism preoperatively, seven patients (14%) of group A and 17 patients (34%) of group B shifted towards WTR astigmatism. Seventeen patients (34%) of group A and seven patients (14%) of group B continued to remain ATR even after surgery. One patients of group A shifted to nil astigmatism.

Of the patients having no astigmatism preoperatively, five patients (10%) of group A and five patients (10%) of group B developed WTR astigmatism postoperatively. Also five patients (10%) of group A and two patients (4%) of group B developed a ATR astigmatism after surgery.

Table No. 7: Range of surgical induced surgically induced astigmatism

Range of SIA	Group A		Group B	
	No.	Percentage	No.	Percentage
0.00 – 0.5 D	15	30%	29	58%
0.5 – 1.0 D	17	34%	13	26%
1.0 – 1.5 D	09	18%	05	10%
1.5 – 2.0 D	06	12%	02	4%
2.0 – 2.5 D	03	6%	01	2%
Total	50	100%	50	100%

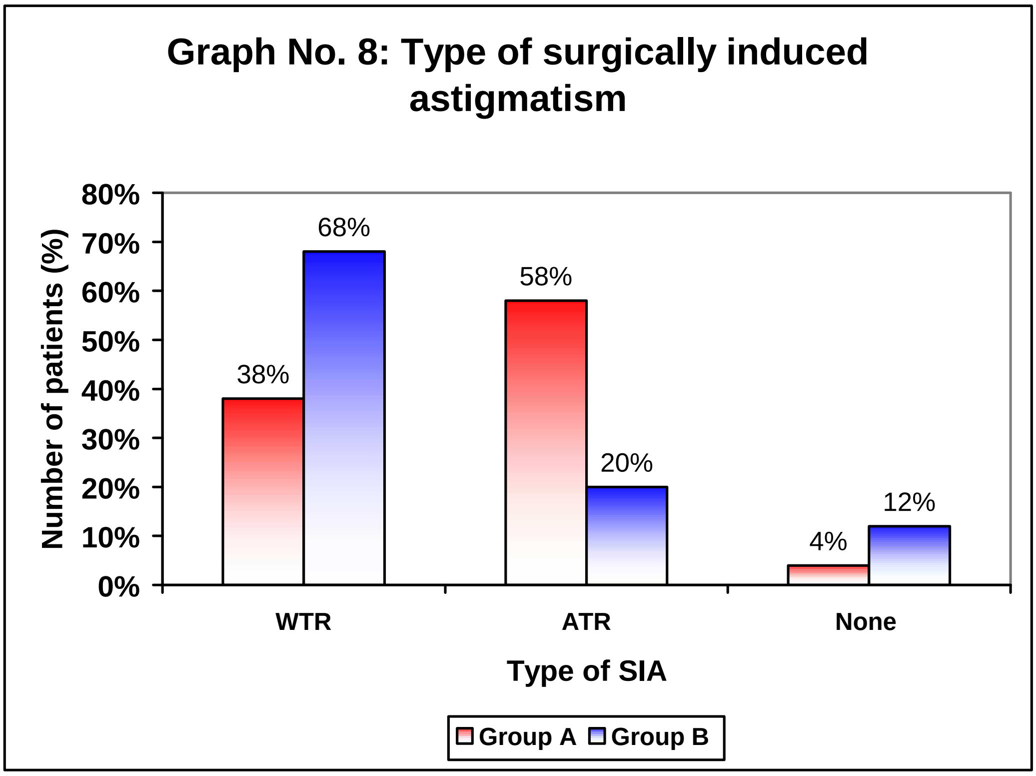


In group A majority (34%) of the patients had SIA in the range of 0.5 to 1.0 D followed by 30% in the range of 0.0 to 0.5 D, 18% had 1.0 to 1.5 D, 12% had 1.5 to 2.0 D and six percent 2.0 to 2.5 D.

In group B majority (58%) of the patients had SIA in the range of 0.0 to 0.5 D followed by 26% in the range of 0.5 to 1.0 D, 10% had 1.0 to 1.5 D, four percent had 1.5 to 2.0 D and two percent 2.0 to 2.5 D.

Table No. 8: Type of surgically induced astigmatism

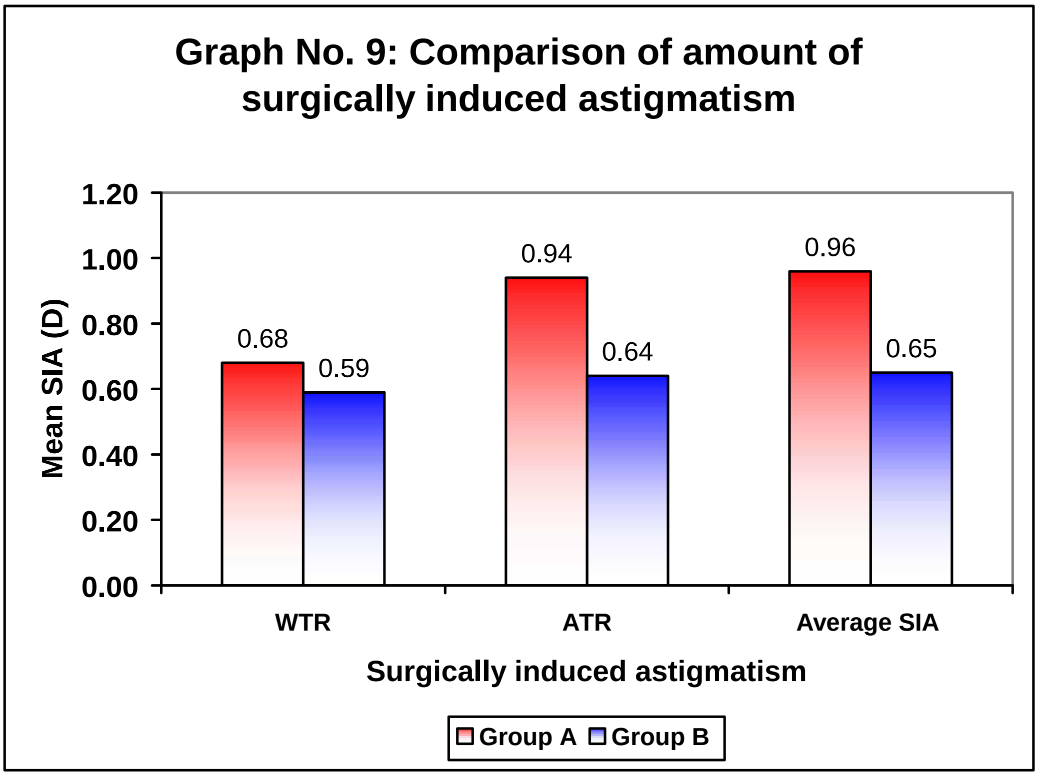
Range of SIA	Group A		Group B	
	No.	Percentage	No.	Percentage
WTR	19	38%	34	68%
ATR	29	58%	10	20%
None	02	04%	06	12%
Total	50	100%	50	100%



In group A 19 patients (38%) developed WTR astigmatism and 29 patients (58%) developed ATR astigmatism. Two patients had no SIA. In group B 34 patients (68%) developed WTR astigmatism and 10 patients (20%) developed ATR astigmatism. Six patients (12%) had no SIA.

Table No. 9: Comparison of amount of surgically induced astigmatism

Type of SIA	Group A		Group B	
	Mean	S.D.	Mean	S.D.
WTR	0.68	0.40	0.59	0.51
ATR	0.94	0.55	0.64	0.54
Average SIA	0.96	0.68	0.65	0.59



In the present study among group A mean of WTR type SIA was 0.68 ± 0.40 and ATR type was 0.94 ± 0.55. In group B the mean of WTR type SIA was 0.59 ± 0.51 and ATR type was 0.64 ± 0.54. In the present study the average SIA recorded in group A was 0.96 D ± 0.68 X 139.41 degrees and in group B it was 0.65 D ± 0.59 X 96.21 degrees.

Table No. 10: Comparison of post operative best corrected visual acuity at followup

Range of visual acuity	Follow up	Group A		Group B	
		No.	Percentage	No.	Percentage
6/60 to 6/36	**Day 1**	4	8%	05	10%
	15 days	1	2%	00	00%
	45 days	1	2%	00	00%
6/24 to 6/18	**Day 1**	15	30%	14	28%
	15 days	15	30%	14	28%
	45 days	15	30%	14	28%
6/12 to 6/6	**Day 1**	31	62%	30	60%
	15 days	34	68%	36	72%
	45 days	34	68%	36	72%

On day 1 post operatively in 62% of patients in group A and 60% in group B had visual acuity between 6/12 to 6/6.

After two weeks and six weeks (that is 15^{th} post operative day and 45 post operative day) 68% patients in group A and 72% patients in group B had visual acuity between 6/12 to 6/6.

Table No. 11: Comparison of post operative uncorrected visual acuity at follow up

Range of visual acuity	Follow up	Group A		Group B	
		No.	Percentage	No.	Percentage
6/60 to 6/36	**Day 1**	10	20%	07	14%
	15 days	6	12%	02	04%
	45 days	6	12%	02	04%
6/24 to 6/18	**Day 1**	14	28%	23	46%
	15 days	16	32%	18	36%
	45 days	18	36%	18	36%
6/12 to 6/6	**Day 1**	26	52%	20	40%
	15 days	28	56%	30	60%
	45 days	26	52%	30	60%

On day 1 post operatively in 52% of patients in group A and 40% in group B had visual acuity between 6/12 to 6/6.

After six weeks (that is 45 post operative day) 52% patients in group A and 60% patients in group B had visual acuity between 6/12 to 6/6.

DISCUSSION

The present study was conducted on 100 patients who underwent MSICS at Department of Ophthalmology, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum during study period. The patients were divided into two groups that is Group A (Patients who underwent MSICS with superior incision) and Group B (Patients who underwent MSICS with temporal incision).

Cataract surgery has been there since 20 centuries. It has evolved from couching in ancient times to modern day manual Small Incision Cataract Surgery (SICS) and phacoemulsification. Phacoemulsification has become the most favoured procedure for cataract surgery in industrialized countries, In developing countries manual Small Incision Cataract Surgery is the most favored procedure as it offers faster visual recovery and better uncorrected visual acuity (UCVA) than sutured manual extra capsular cataract extraction (ECCE).

Preoperative and post operative keratometric readings and refraction were used for analysis. All calculations were performed using SIA calculator version 1.0, a free software programme.

The major cause of poor unaided visual acuity following cataract surgery is the surgically induced astigmatism. The goal of modern cataract surgery is to minimize corneal shape changes postoperatively. This requires an exact evaluation of corneal curvature and astigmatism.

Hence, modern cataract surgery, in its quest for providing the best uncorrected visual acuity to the patient and minimizing surgically induced astigmatism has become a refractive surgery today. With the goal not only to remove the cataract but also to minimize astigmatism induced by surgery and to reduce the preoperative astigmatism, if any, in the patient.

The results of this study show that there is minimal astigmatism in manual small incision cataract surgery and that surgically induced astigmatism can be modified by modification of the incision location.

In the present study group A had 62% of patients females and 38% were male with male:female ratio of 1:1.6. In group B 60% were males and 40% were females with male:female ratio of 1.5:1. In both the groups majority of the patients were in the age group of 50 to 60 years. The mean age in both the groups was 55 ± 2.0 years.

In group A majority of patients (52%) were in the range of less than 3/60 followed by 46% with more than 6/60. Whereas in group B majority (64%) had preoperative visual acuity in the range more than 6/60 followed by 36% in the range of less than 3/60.

In this study majority (50%) of the patients in group A had ATR astigmatism followed by 32% WTR astigmatism and 9% of the patients had no preoperative astigmatism. In group B, majority (48%) of the patients had ATR astigmatism followed by 38% who had WTR astigmatism. Seven patients (14%) were found to have no astigmatism.

Similar profile of pre operative astigmatism was observed in a study which evaluated SIA post operative and uncorrected visual acuity with superior and temporal incision among 90 patients with pre operative astigmatism.[7]

In group A 62% of the patients developed ATR astigmatism post operatively followed by 34% developed WTR astigmatism and four percent of the patients did not develop post operative astigmatism. In group B, 76% of the patients developed WTR astigmatism followed by 22% ATR astigmatism. One patient (2%) did not develop post operative astigmatism.

These results were in conformity with a study conducted on 90 patients which evaluated SIA astigmatism and uncorrected visual acuity with superior and temporal incision. The authors noted that SIA is ATR for superior location and WTR for temporally located incision. The study also reported that superior incision rarely allows to reach a minimum post operative astigmatism as with temporal incision.[7]

Another study conducted to assess change in horizontal and vertical meridians of cornea after cataract surgery using five different incision types found that, the six mm superior sclero corneal tunnel induces ATR astigmatism and that temporal sclero corneal tunnels induce WTR astigmatism. The induced astigmatism in 6mm sclero corneal tunnel group stabilized at 6 weeks.[24]

Another study reported incision in the sclera causes flattening immediately adjacent to it and also perpendicular to the incision as a results of coupling effect meridonial 90^0 away is steepened.[27]

In group A 30% of the patients had SIA in the range of 0.0 to 0.5 D, 38% in the range of 0.5 to 1.0 D followed by, 18% had 1.0 to 1.5 D, 12% had 1.5 to 2.0 D and six percent 2.0 to 2.5 D.

In group B majority (58%) of the patients had SIA in the range of 0.0 to 0.5 D followed by 26% in the range of 0.5 to 1.0 D, 10% had 1.0 to 1.5 D, four percent had 1.5 to 2.0 D and two percent 2.0 to 2.5 D.

Superior location of the incision result in a corneal scar that is closer to visual axis. The effect of gravity and eyelid blink create drag on the incision. These factors impart significant corneal shape changes resulting in high SIA. These forces are neutralized better with Temporally placed incisionsu is not only away from the visual axis but also free from the effect of gravity and lid blink thus leading to less SIA. Since the temporal incision is parallel to the vector of the forces and with the WTR astigmatism induced by temporal incision is advantageous because most elderly cataract patients have preoperative ATR astigmatism. Whereas, temporal incision being away from the visual axis and more stable is less likely to effect corneal curvature resulting in less astigmatism.[4]

In the present study of the patients having a preoperative WTR astigmatism six patients (12%) of group A and 16 patients (32%) of group B continued to remain so postoperatively. Seven patients (14%) of group A and two patients (4%) of group B showed a post operative ATR drift. Two patients (4%) of group A and one patient (2%) of group B showed no astigmatism postoperatively.

Similar results were reported in a study indicating WTR astigmatism by vector analysis on the first postoperative day in sutureless superior incision than with sutureless temporal incision. Present study too shows more number of superior group cases with WTR astigmatism on the first postoperative day. This can be attributed to collagen shrinkage due to excessive cautery.[28]

In another study they have found that there was a 50% reduction in induced astigmatism when cautery was limited to the episclera posterior to the insertion of tenons fascia and not carried all the way to the corneoscleral limbus.[29]

In the present study the average SIA recorded in group A was 0.96 D X 139.41 degrees with standard deviation of 0.68 D and in group B it was 0.65 D X 96.21 degrees with standard deviation of 0.59 D. Hence temporal incision showed less significant SIA than superior incision.

A study conducted in Mumbai to assess SIA in MSICS using a six mm frown incision, 1.50 mm from limbus at different locations. Authors reported SIA of 1.36 ± 1.03 D in superior incisions, 0.51 ±0.49 D in superotemporal incisions and 0.40 ± 0.40 D in temporal incisions by vector method. They also analyzed SIA by Holladay Cartesian coordinate system and reported SIA of 1.28 at 2.9° in superior group, 0.20 D at 23.7° in superotemporal group and 0.37D at 90° in temporal group. These values correlated well the results of present study.[4]

Another study conducted to assess six to 8.5 mm incisions in MSICS using superior or superotemporal sites found SIA of 1.41 ± 0.72 D in superior incision group and 1.02 ± 0.66 D in superotemporal group by Vector method which shows slightly higher results than our study. This is probably because the incision length was between six to seven mm in this study.[5]

In another study the mean induced astigmatism was 0.6 + 0.3 D for 6mm incision group.[30]

On day 1 post operatively in 62% of patients in group A and 60% in group B had visual acuity between 6/12 to 6/6.

After two weeks and six weeks (that is 15th post operative day and 45 post operative day) 68% patients in group A and 72% patients in group B had BCVA between 6/12 to 6/6.

After six weeks (that is 45 post operative day) 52% patients in group A and 60% patients in group B had UCVA between 6/12 to 6/6.

The visual rehabilitation was similar in both the groups. The UCVA was better in temporal incision as compared to superior incision group. Similar results were reported in several studies.

High astigmatism is an important cause of poor uncorrected visual acuity after cataract surgery.[31]

Limitations

The limitations of the present were surgeries were done not by a single surgeon but by multiple surgeons.

Recommendations

Similar study with surgeries done by a single surgeon and extended followup period would focus more light on post operative SIA with temporal incision.

CONCLUSION

In this study MSICS caused low astigmatism and the type of astigmatism induced depended upon the site and size and shape of incision.

The following conclusions were drawn from the study.

- The incidence of post operative astigmatism following MSICS with PCIOL implantation with temporal scleral incision is less than superior scleral incision.
- The average surgically induced astigmatism was less with temporal incision as compared to superior incision.
- In group A with superior incision the average SIA was 0.96 ± 0.68 and in group B with temporal incision the average SIA was 0.65 ± 0.59. The comparison between mean of the two groups using unpaired ‘t’ test was statistically significant (p=0.020) indicating group B had less SIA.
- Superior incision induced ATR (58%) and temporal incision induced WTR (68%).
- In group A four percent of patients showed no astigmatism whereas in group B 12% of patients showed no astigmatism postoperatively.
- In the present study the visual rehabilitation was similar in both the groups. The UCVA was better in temporal incision as compared to superior incision group.

In conclusion, temporal incision is evidently better than superior incision in minimizing surgically induced astigmatism.

SUMMARY

Cataract surgery has been there since 20 centuries. It has evolved from couching in ancient times to modern day manual SICS and phacoemulsification. The objective of the present study was to evaluate and compare the amount of induced astigmatism after superior and temporal incision a in manual Small incision cataract surgery.

The present one year randomized clinical trial was conducted in the Department of Ophthalmology, KLES Dr. Prabhakar Kore Hospital and Medical Research Centre, Belgaum on patients undergoing cataract surgery during the period of January 2008 to December 2008. The patients undergoing manual SICS were selected for the study. The patients were assigned randomly into two groups according to the site of incision by computer-generated table of two. Group A consisted of patients undergoing manual SICS using superior scleral incision and group B had patients undergoing manual SICS using temporal scleral incision.

The result showed that in group A with superior incision the average SIA was 0.96 ± 0.68 and in group B with temporal incision the average SIA was 0.65 ± 0.59. The comparison between mean of the two groups using unpaired 't' test was statistically significant (p=0.020) indicating group B had less SIA.

Superior incision induced ATR (58%) and temporal incision induced WTR (68%). In group A four percent of patients showed nil astigmatism whereas in group B 12% of patients showed nil astigmatism postoperatively. Visual rehabilitation was earlier following temporal incision in MSICS.

The relative increase in astigmatism in group A with superior incision is due to proximity of incision to optical centre resulting into comparatively increased corneal changes. The influence of eyelid pressure, gravity and extraocular muscle action were less significant. In group B lesser amount of SIA due to location of incision away from optical axis and flattening at incision site is less.

In the present study the visual rehabilitation was similar in both the groups. The UCVA was better in temporal incision as compared to superior incision group.

In conclusion, temporal incision is evidently better than superior incision in minimizing surgically induced astigmatism.

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ANNEXURE I

CONSENT FORM

CONSENT FOR PARTICIPATION IN RESEARCH STUDY

Mr/Mrs/Ms____

You are invited to participate in our research study titled "**Surgically induced astigmatism after superior versus temporal scleral incision in manual small incision cataract surgery, a one year hospital based randomised control trial.**" conducted by Dr. Harshavardhan Patil, Post Graduate in M.S. Ophthalmology under the guidance of Dr. R.K. Dandur, M.S., D.O.M.S., Professor in the Department of Ophthalmology, J .N. Medical College, Belgaum.

Respected Sir/Madam we request you to enroll yourself to participate in our study as you are eligible for doing so.

Your participation in research is voluntary. Your decision whether or not to participate in the study will not affect your relationship with J.N. Medical College. If you decide to participate you are free to withdraw at any time

The purpose of research is to to quantify and compare the induced corneal astigmatism in extracapsular cataract extraction and small incision cataract surgery.

If you agree to enroll yourself in this study, you will be asked to give detailed history history. Then you will be clinically examined in detail by slit lamp examination, fundoscopy, tonometry for measurement of intraocular pressure, syringing for patency of the lacrimal sac, keratometry and A scan ultrasonography and investigations like Blood pressure measurement, urine analysis for albumin & sugar and blood sugar will be done. Then you will be asked to undergo either of the two, Superior or temporal scleral incisions in manual small incision cataract surgery, based entirely on randomization. Whichever group is allotted to you, you will have to agree upon it. You would be asked to follow up on specified dates when your progress would be monitored and document

Rare complications of cataract surgery include enndophthalmitis, vitreous loss, globe perforation, retrobulbar haemorrhage, expulsive haemorrhage for which all necessary precautions will be taken.

Your participation may benefit you and others suffering from same ailment in future, by helping us learn more about the disease process and better treatment modalities.

There will not be any extra cost incurred by the participant. The participant will however have to pay for the investigations which are the part of the existing management protocol for this ailment. There is no commitment for any reimbursement or any other compensation for the participant.

The only people to know that you are a research subject are members of the research team. No information about you or information provided by you during the research will be disclosed to others without your written permission.

When the results of the research are published or discussed, in a conference, no information will be displayed that would disclose your identity. Any information that is obtained in connection with this study and that can be identified with you will remain confidential.

If you have any questions about the research you may please contact:

1) Chief investigator, Dr. Harshavardhan Patil, P.G., Department of Ophthalmology, JNMC,Belgaum. Contact No. 9844911874

2) Dr. R.K. Dandur, Professor, Guide, Department of Ophthalmology, JNMC, Belgaum.

Ph: 9448138855

If you need any further information regarding your rights as a study participant contact

Dr. V.D.Patil ,Principal, JNMC, Belgaum and chairman of Institutional Ethics Committee. Ph. 0831-2471350

Consent for participation in research trial

I, Mr./Ms./Mrs ________________________________ voluntarily agree for the participation as a subject of study. By signing this consent form I am not giving up any of my legal rights, I may withdraw from the study anytime. I am signing the consent form after having read or been read for me in vernacular language, including the risks and the benefits and having all my questions answered.

Subject Name: ______________________

Signature or the Left Thumb Print of Subject: _________________________

Witness Name: _____________________

Signature of Witness: ________________

Investigators Name: ______________________

Signature of Investigator: ________________

Date: ________________

Place: ________________

ANNEXURE II

PROFORMA

NAME: ____

AGE: _________ yrs

SEX: ☐ (1-Male; 2-Female)

ADDRESS: ____

IP NO: ____________________

DATE OF ADMISSSION: ______________

DATE OF DISCHARGE: _______________

IS THE PATIENT ELIGIBLE FOR STUDY? ☐ 1-YES 2-NO

HAS INFORMED CONSENT BEEN GIVEN? ☐ 1-YES 2-NO

FINAL RESULT INFORMATION:

- 1. Ineligible
  2. eligible, refusal
  3. eligible, participating

☐☐☐ **PATIENT ID NO**

Doctors name: ________________________________

Doctors signature: ______________________________

Date: / /

DATA COLLECTION INSTRUMENT

PATIENT ID NO ☐☐☐

Chief complaints:

Diminution of vision Duration: _____ months/years

RE ☐ LE ☐

History of present illness:

1. Diminution of vision — 1. Gradual or 2. Sudden ☐
   - 1. Progressive or 2. Static ☐
   - 1. Painless or 2. Painful ☐
   - 1. For distance or 2. For near ☐
2. Diplopia/polyopia — 1. Present, 2. absent ☐
3. Coloured haloes — 1. present, 2. absent ☐
4. Black spots before the eyes — 1. present, 2. absent ☐
5. Watering: — 1. present, 2. absent ☐
6. Redness : — 1. present, 2. absent ☐
7. H/o wearing spectacles: — (1-Distance; 2-Near; 3-Both) ☐

   Duration:________ months/years

Past history:

Trauma to the eye: 1. present, 2. absent ☐

Ocular surgery: 1. present, 2. absent ☐

Type of surgery _______________ Duration: months/years ____

Diabetes: 1. present, 2.absent Duration: ________ months/years

Hypertension: 1. present, 2. absent Duration: ________ months/years

Any other medical disorder: __________________

Personal history:

Smoking : 1. present, 2. absent ☐ Duration:________ months/years

Alcoholism: 1. present, 2. absent ☐ Duration:________ months/years

General physical examination:

General appearance:1. well built, 2.moderately built, 3.poorly built, 4.emaciated

Pallor: 1. present, 2. absent ☐ if present 1.mild, 2. moderate, 3. severe ☐

Pulse: ____/minute

BP: ________ mm of Hg

Temperature: _____°Fahrenheit

Respiratory rate: ___/minute

Systemic examination:

CVS: 1-Normal 2-Abnormal; If abnormal, specify:________________________

RS: 1-Normal 2-Abnormal; If abnormal, specify:________________________

CNS: 1-Normal 2-Abnormal; If abnormal, specify:________________________

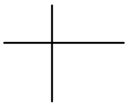
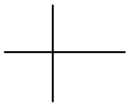
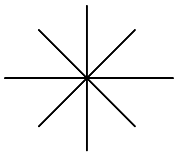
Per abdomen: 1-Normal 2-Abnormal; If abnormal, specify:________________________

Ocular examination:

Head posture: 1. erect, 2. tilted

Visual Axes: 1. parallel, 2. deviated

Facial symmetry: 1. symmetrical, 2. asymmetrical

Extraocular movements: RE-  LE-  Binocular- 

(normal-N, restricted-R)

Visual acuity: **RE** **LE**

DISTANT –

PINHOLE –

WITH GLASSES –

NEAR _

REFRACTION/RETINOSCOPY:

Prescription	**Spherical**	**Cylindrical**	**Axis**	**BCVA**
RE				
LE				

2. **Adnexa** (1-Normal; 2-Abnormal)	☐	☐
3.**Sclera** (1-Normal; 2-Congested)		
4.**Conjunctiva** (1-Normal; 2-Conjunctival congestion; 3-Ciliary congestion; 4-Chemosis)	☐	☐
5.**Cornea** (1-Normal; 2-Opacity; 3-Vascularisation)		
6.**Anterior chamber** (1-Normal depth; 2-Shallow; 3. deep)	☐	☐
7.**Iris** (1-Normal colour & pattern; 2-Abnormal)		
8. **Pupil:** Size- ____in mm Shape -1. Round & regular; 2-Abnormal Reaction: Direct(1-Present; 2-Absent) Indirect(1.present, 2. absent) Near reflex(1. present, 2.absent)	☐	☐
Lens: Clarity- 1.clear, 2. opaque Cataract-CORTICAL –1.present, 2. absent If present- 1. immature 2. mature 3. hypermature NUCLEAR SCLEROSIS – 1. present, 2. absent If present 1. grade – 1 2. grade-2 3. grade-3 4. grade-4 POSTERIOR SUBCAPSULAR CATARACT 1. present, 2. absent	☐ ☐ ☐ ☐ ☐ ☐	☐ ☐ ☐ ☐ ☐ ☐

FUNDUS:	**RE**	**LE**
GLOW -		
MEDIA -		
DISC -		
C D RATIO -		
VESSELS -		
MACULA -		
BACKGROUND –		
IMPRESSION-		

DIAGNOSIS:

Investigations:

1.Ocular

A. Lacrimal patency: RE ☐ (1-Patent, 2-Blocked)

LE ☐

B. IOP: RE ☐Normal, 2-High) -

LE ☐ -

2.Urine sugar: ☐ (1-Present, 2-Absent)

3.Blood sugar: _______mg%

4.Any other:

Preoperative Keratometry:

Eye: ☐ (1-Right eye, 2-Left eye)

K_H (Dioptres)	Axis (Degrees)	K_V (Dioptres)	Axis (Degrees)	Preoperative astigmatism(A) $A=K_H-K_V$	Axis (Degrees)

A SCAN BIOMETRY: SRK II FORMULA.

K1	
K2	
AXL	
ACIOL	
PCIOL	

OPERATIVE PROCEEDURE: Manual Small Incision Cataract Surgery with Superior/Temporal Scleral Incisions with PMMA IOL implantation

INCISION: ☐

1. superior incision, 2. temporal incision

ANAESTHESIA: 1. PERIBULBAR ☐

2. SUBTENONS/TOPICAL

Date: ☐☐☐☐☐☐

Follow up Plan:

	Day-1	Day-15	Day-45
1.**Conjunctiva** (1-Normal; 2-conjunctival congestion; 3-ciliary congestion)	☐	☐	☐
2.**Section/Suture site** (1-Edges opposed; 2-Edges gaping)	☐	☐	☐
2.**Cornea** (1-Clear; 2-Hazy/Descmets folds)	☐	☐	☐
3.**Anterior chamber** (1-Normal depth; 2-Shallow, 3. deep)	☐	☐	☐
4.**Pupil** Size —in mm Shape -1. Round & regular; 2-Abnormal	☐	☐	☐
5.**Intraocular lens** (1-In situ; 2-decentered)	☐	☐	☐

Visual acuity: **RE** **LE**

DISTANT –

PINHOLE –

OPERATIVE COMPLICATIONS: 1. present, 2. absent

If present - specify ____________________

POST OPERATIVE COMPLICATIONS: 1. present, 2. absent

If present - specify ____________________

POSTOPERATIVE KERATOMETRY/ RETINOSCOPY:

1. DAY – 1. EYE- R/L

K1	AXIS	K2	AXIS	K=K1-K2	AXIS

PRESCRIPTION	SPHERICAL	CYLINDRICAL	AXIS	VISION
RE				
LE				

2. DAY – 15. EYE- R/L

K1	AXIS	K2	AXIS	K=K1-K2	AXIS

PRESCRIPTION	SPHERICAL	CYLINDRICAL	AXIS	VISION
RE				
LE				

3. DAY – 45. EYE- R/ L

K1	AXIS	K2	AXIS	K=K1-K2	AXIS

PRESCRIPTION	**SPHERICAL**	**CYLINDRICAL**	**AXIS**	**VISION**
RE				
LE				

SURGICALLY INDUCED ASTIGMATISM: DIOPTERS: AXIS:

DAY-1

DAY-15

DAY-45

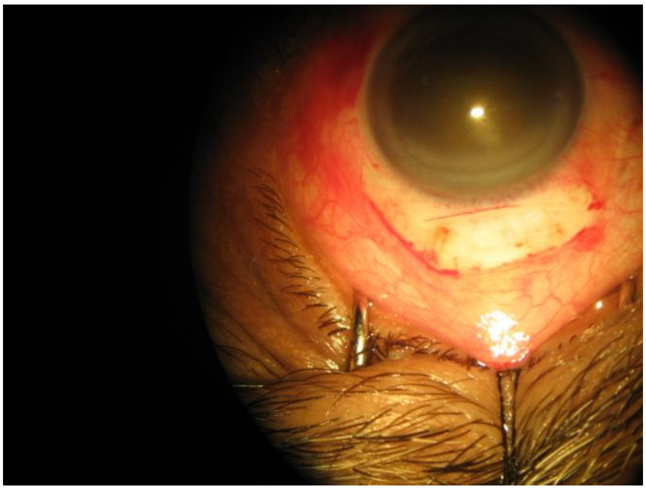
ANNEXURE III – PHOTOGRAPHS

Photograph 1: IOP measurement with schiotz tonometer

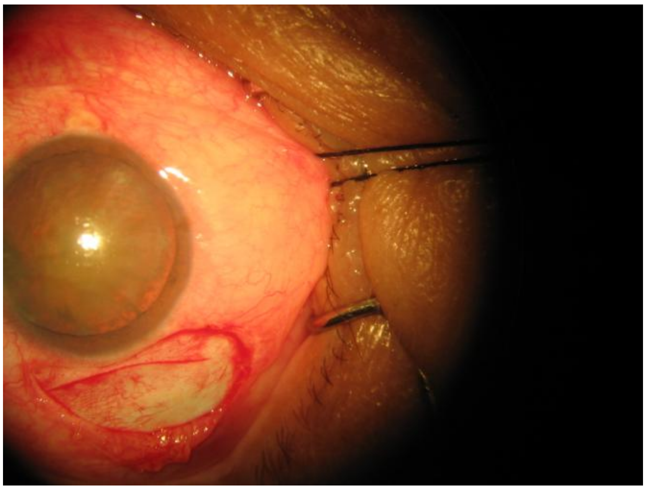
Photograph 2: Keratometry

Photograph 3: A-Scan

Photograph 4: Operating microscope



Photograph 5: Superior incision



Photograph 6: Temporal incision

ANNEXURE IV - MASTER CHART

					Pre OP							Post Operative													
						Keratometry			Astigmatism			BCVA			Astigmatism			SIA				Refraction			
Sl. No.	**IP No.**	**Gender**	**Age (Years)**	**Eye**	**Visual Acuity**	**K_H**	**K_V**	**PCIOL Power**	**Diopters (K1)**	**Axis (A1)**	**Type**	**Day 1**	**Day 15**	**Day 45**	**Diopters (K3)**	**Axis (A3)**	**Type**	**K2**	**A2**	**Intended Angle**	**Angle of error**	**Sphere**	**Cylinder**	**Axis**	**Near addition**
1	262782	F	72	L	3/60	47.00	46.00	17.00	1.00	180	WTR	6/36	6/36	6/36	1.50	180	ATR	0.50	180	90	90	-1.0	-1.5	90	+3
2	262758	F	65	R	PL PR	44.00	45.00	19.50	1.00	90	WTR	6/18	6/12	6/12	1.00	180	ATR	2.00	180	180	0	-1.5	-1.0	90	+3
3	262915	F	54	R	3/60	43.50	43.75	21.50	0.25	90	WTR	6/9	6/6	6/6	0.25	90	NIL	0.00	90	180	-90	-	-0.5	90	+3
4	263398	M	60	R	1/60	45.25	45.25	18.00	0.00	0	NIL	6/18	6/18	6/12	2.00	180	ATR	2.00	180	90	90	-	-1.5	90	+3
5	263600	M	60	L	6/60	44.50	46.00	21.00	1.50	90	WTR	6/9	6/9	6/9	0.70	90	WTR	0.80	180	180	0	-0.5	-1.5	90	+3
6	263591	M	54	L	6/36	42.00	43.25	19.50	1.75	90	WTR	6/9	6/9	6/9	0.60	90	WTR	1.15	180	180	0	-0.5	-	-	+3
7	263581	F	60	L	PL PR	46.00	44.00	20.50	2.00	180	ATR	6/12	6/9	6/9	1.00	180	ATR	1.00	90	90	0	-1.0	-1.5	90	+3
8	264832	M	77	L	PL PR	45.25	44.50	21.50	0.75	180	ATR	6/24	6/9	6/9	0.50	180	ATR	0.25	90	90	0	-	-0.5	90	+3
9	265168	M	65	R	6/36	44.50	44.50	20.00	0.00	0	NIL	6/9	6/9	6/9	2.00	180	ATR	2.00	180	90	90	-	-0.5	90	+3
10	265187	F	70	L	PL PR	43.00	43.25	20.00	0.25	90	WTR	6/9	6/9	6/9	1.00	180	ATR	1.25	180	180	0	-0.5	-1.0	90	+3
11	266054	F	50	L	6/36	43.50	43.00	22.00	0.50	180	ATR	6/9	6/9	6/18	2.25	180	ATR	1.75	180	90	90	-1.0	-1.5	90	+3
12	266060	M	80	L	6/24	44.50	44.50	21.50	0.00	0	NIL	6/12	6/9	6/9	0.70	90	WTR	0.70	90	90	0	-0.5	-1.0	90	+3
13	266831	M	69	R	6/36	42.00	42.25	20.50	0.25	90	WTR	6/9	6/9	6/9	0.70	180	ATR	0.95	180	180	0	-0.5	-0.5	90	+3
14	266947	M	48	R	6/60	44.50	44.25	17.50	0.25	180	ATR	6/9	6/12	6/12	2.20	90	WTR	2.45	90	90	0	-1.0	-	-	+2.5
15	267600	F	60	R	6/18	45.50	45.50	20.50	0.00	0	NIL	6/9	6/9	6/9	1.25	180	ATR	1.25	180	90	90	-	-1.5	90	+3
16	267568	F	60	R	1/60	45.25	45.00	23.50	0.25	180	ATR	6/9	6/9	6/9	1.00	180	ATR	0.75	180	90	90	-	-1.5	90	+3
17	267836	F	70	R	6/60	45.00	46.00	21.50	1.00	90	WTR	6/9	6/9	6/9	1.70	90	WTR	0.70	90	180	-90	+0.5	+0.5	180	+3
18	268277	F	60	R	6/36	46.50	45.50	19.50	1.00	180	ATR	6/9	6/9	6/9	0.00	0	NIL	1.00	90	90	0	-	+0.5	180	+3
19	268032	M	58	L	6/60	43.00	43.00	20.50	0.00	0	NIL	6/12	6/12	6/12	1.20	180	ATR	1.20	180	90	90	-1.0	-1.5	90	+2.5

					Pre OP							Post Operative													
						Keratometry			Astigmatism			BCVA			Astigmatism			SIA				Refraction			
Sl. No.	**IP No.**	**Gender**	**Age (Years)**	**Eye**	**Visual Acuity**	**K_H**	**K_V**	**PCIOL Power**	**Diopters (K1)**	**Axis (A1)**	**Type**	**Day 1**	**Day 15**	**Day 45**	**Diopters (K3)**	**Axis (A3)**	**Type**	**K2**	**A2**	**Intended Angle**	**Angle of error**	**Sphere**	**Cylinder**	**Axis**	**Near addition**
21	269559	F	60	R	6/60	42.50	41.75	21.00	0.75	180	ATR	6/9	6/9	6/9	1.50	180	ATR	0.75	180	90	90	-	-1.5	180	+3
22	270150	F	75	R	6/36	45.00	44.90	19.50	0.50	180	ATR	6/9	6/12	6/12	1.25	180	ATR	0.75	180	90	90	-0.5	-1.5	90	+2.5
23	270152	F	80	L	5/60	43.50	42.50	19.50	1.00	180	ATR	6/9	6/9	6/9	0.00	0	NIL	1.00	90	90	0	-	-0.5	90	+3
24	270996	F	70	R	6/12	42.25	42.75	20.50	0.50	90	WTR	6/9	6/18	6/18	1.75	180	ATR	2.25	180	180	0	-1.0	-1.5	90	+3
25	271013	F	70	L	6/24	41.50	40.50	22.00	1.00	180	ATR	6/9	6/9	6/9	###	180	ATR	0.50	180	90	90	-	-1.5	90	+3
26	276014	F	60	R	6/24	42.50	42.50	21.50	0.00	0	NIL	6/9	6/9	6/6	0.35	90	WTR	0.35	90	90	0	-	-0.5	90	+3
27	276012	M	65	R	6/36	44.50	45.00	21.00	0.50	90	AWT	6/18	6/18	6/12	0.50	90	WTR	0.00	0	180	0	-0.5	-1.5	90	+3
28	276015	F	60	R	1/60	42.50	43.50	23.00	1.00	90	WTR	6/9	6/9	6/9	0.80	90	WTR	0.20	180	180	0	-0.5	-0.5	90	+2.5
29	276083	F	60	R	PL PR	43.00	43.25	23.50	0.25	90	WTR	6/18	6/9	6/9	0.75	180	ATR	1.00	180	180	0	-1.0	-1.5	90	+2.5
30	276087	M	77	L	PL PR	45.00	44.25	22.50	0.75	180	ATR	6/24	6/18	6/18	1.50	180	ATR	0.75	180	90	90	-1.0	-1.0	180	+3
31	276081	F	60	R	1/60	44.50	43.25	20.50	1.25	180	ATR	6/12	6/9	6/9	1.25	180	ATR	0.00	0	90	-90	-1.0	-1.5	90	+3
32	276370	M	60	L	6/18	46.00	45.75	20.00	0.25	180	ATR	6/12	6/12	6/12	0.80	180	ATR	0.55	180	90	90	-1.0	-1.5	90	+3
33	276899	F	60	L	PL PR	46.00	45.00	24.00	1.00	180	ATR	6/9	612	6/12	0.66	180	ATR	0.34	90	90	0	-2.5	-0.5	90	+3
34	276863	F	60	R	6/36	42.50	42.00	20.50	0.50	180	ATR	6/9	6/9	6/9	0.33	90	WTR	0.83	90	90	0	-0.5	-0.5	90	+3
35	276897	M	55	L	PL PR	43.00	43.00	21.50	0.00	0	NIL	6/9	6/9	6/9	0.66	180	ATR	0.66	180	90	90	-	-1.5	90	+3
36	277184	M	50	L	6/24	43.50	43.00	20.00	0.50	180	ATR	6/9	6/9	6/9	0.70	180	ATR	0.20	180	90	90	-1.5	-1.5	90	+3
37	277175	M	70	L	PL PR	43.00	44.00	22.00	1.00	90	WTR	6/9	6/9	6/9	0.00	0	NIL	1.00	180	180	0	-0.5	-0.5	180	+3
38	277755	F	60	L	PL PR	46.00	46.75	22.00	0.75	90	WTR	6/6	6/6	6/6	1.25	180	ATR	2.00	180	180	0	-0.5	-0.25	90	+3
39	277763	M	65	L	PL PR	44.25	44.25	22.00	0.00	0	NIL	6/12	6/12	6/12	0.50	90	WTR	0.50	90	90	0	-	-0.5	90	+3
40	280581	F	70	L	3/60	42.50	42.00	22.00	0.50	90	WTR	6/9	6/9	6/9	0.66	90	WTR	0.16	90	180	-	-2	-2.0	60	+3

					Pre OP							Post Operative														
						Keratometry			Astigmatism			BCVA			Astigmatism			SIA				Refraction				
Sl. No.	IP No.	Gender	Age (Years)	Eye	Visual Acuity	K_H	K_V	PCIOL Power	Diopters (K1)	Axis (A1)	Type	Day 1	Day 15	Day 45	Diopters (K3)	Axis (A3)	Type	K2	A2	Intended Angle	Angle of error	Sphere	Cylinder	Axis	Near addition
41	283725	F	70	L	PL PR	47.25	46.50	19.00	0.75	180	ATR	6/12	6/12	6/12	2.00	180	ATR	1.25	180	90	90	-	-3.0	90	+3
42	283696	F	74	L	1/60	47.25	46.25	23.00	1.00	180	ATR	6/12	6/12	6/12	1.00	90	WTR	2.00	90	90	0	-1	-1.5	90	+3
43	287547	M	70	L	PL PR	45.00	43.00	21.50	2.00	180	ATR	6/12	6/12	6/12	0.66	180	ATR	1.34	90	90	0	-0.8	-2.5	110	+3
44	287640	F	80	L	PL PR	44.00	43.00	24.00	1.00	180	ATR	6/12	6/9	6/9	0.50	90	WTR	1.50	90	90	0	-1.3	-1.5	90	+3
45	288606	F	60	R	PL PR	44.00	43.75	20.50	0.25	180	ATR	6/9	6/6	6/6	0.80	90	WTR	1.05	90	90	0	-0.5	-0.5	90	+3
46	289684	M	65	L	3/60	43.00	43.50	21.00	0.50	90	WTR	6/12	6/9	6/9	0.60	180	ATR	1.10	180	180	0	-0.5	-1.0	180	+3
47	290002	F	50	R	1/60	44.50	44.50	22.00	0.00	0	NIL	6/9	6/9	6/9	0.50	180	ATR	0.50	180	90	90	-0.5	-1.5	90	+3
48	279074	F	60	L	PL PR	46.50	46.00	20.00	0.50	180	ATR	6/18	6/6	6/6	0.70	180	ATR	0.20	180	90	90	-1	-1.0	90	+3
49	279059	F	60	R	6/36	43.00	45.00	22.50	2.00	180	ATR	6/9	6/6	6/9	1.00	90	WTR	3.00	90	90	0	-	-1.0	90	+3
50	292451	M	70	R	6/24	44.75	44.75	21.00	0.50	90	WTR	6/12	6/12	6/12	0.35	90	WTR	0.15	180	180	0	-0.5	-1.0	90	+3

					Pre OP							Post Operative													
						Keratometry			Astigmatism			BCVA			Astigmatism			SIA				Refraction			
Sl. No.	**IP No.**	**Gender**	**Age (Years)**	**Eye**	**Visual Acuity**	**K_H**	**K_V**	**PCIOL Power**	**Diopters (K1)**	**Axis (A1)**	**Type**	**Day 1**	**Day 15**	**Day 45**	**Diopters (K3)**	**Axis (A3)**	**Type**	**K2**	**A2**	**Intended Angle**	**Angle of error**	**Sphere**	**Cylinder**	**Axis**	**Near addition**
1	267793	F	60	R	6/60	44.00	44.75	22.50	0.75	90	WTR	6/24	6/9	6/9	0.66	90	WTR	0.09	180	180	0	-	+1	180	+3
2	267064	M	60	R	6/18	45.00	45.00	19.50	0.00	0	NIL	6/24	6/9	6/9	0.25	180	ATR	0.25	180	90	90	-2	-1.5	90	+3
3	272301	M	70	L	6/24	41.50	42.00	19.00	0.50	90	WTR	6/9	6/9	6/9	0.75	90	WTR	0.25	90	180	-90	-	-1	90	+3
4	267040	F	60	L	2/60	46.50	45.00	20.50	1.50	180	ATR	6/24	6/9	6/9	0.66	180	ATR	0.84	90	90	0	-	-1.5	90	+3
5	267636	M	65	L	6/36	43.50	44.00	23.00	0.50	90	WTR	6/12	6/9	6/9	0.40	180	ATR	0.90	180	180	0	-1	-1.5	90	+3
6	267294	M	70	L	6/36	45.00	44.50	22.50	0.50	180	ATR	6/24	6/9	6/9	1.00	180	ATR	0.50	180	90	90	-1	-2	90	+3
7	267271	M	70	L	3/60	43.25	43.50	23.50	0.25	90	WTR	6/18	6/18	6/18	1.00	90	WTR	0.75	90	180	-90	-1.5	-1.5	90	+3
8	267293	M	65	L	PL PR	44.50	44.50	22.50	0.00	0	NIL	6/60	6/12	6/12	0.66	90	WTR	1.66	90	90	0	-	-1	180	+3
9	267874	M	65	L	6/24	44.25	44.00	21.50	0.25	180	ATR	6/36	6/6	6/6	0.80	180	ATR	0.55	180	90	90	-1	-1.3	90	+3
10	267870	F	60	R	6/36	46.00	45.75	24.00	0.25	180	ATR	6/60	6/6	6/9	0.25	180	ATR	0.00	0	90	-90	-1	-	-	+2.5
11	268617	M	60	L	6/18	46.00	46.00	18.50	0.00	0	NIL	6/60	6/12	6/18	0.30	180	ATR	0.30	180	90	90	+0.5	+1	180	+3
12	268614	F	60	L	6/60	45.25	46.50	23.50	1.25	90	WTR	6/60	6/9	6/9	1.50	90	WTR	0.25	90	180	-90	-	-1	90	+3
13	268806	M	70	R	1/60	46.00	45.50	23.00	0.50	180	ATR	6/24	6/18	6/18	0.25	90	WTR	0.75	90	90	90	-1	-1.5	90	+3
14	268894	M	65	R	6/12	44.75	45.75	17.50	1.00	90	WTR	6/24	6/12	6/12	0.60	90	WTR	0.40	180	180	0	-1	-1.5	90	+3
15	288892	F	80	L	6/24	44.50	44.00	21.00	0.50	180	ATR	6/9	6/9	6/9	0.25	180	ATR	0.25	90	90	0	-	-1	90	+3
16	268895	F	68	R	PL PR	43.00	42.75	22.00	0.25	180	ATR	6/9	6/9	6/9	0.25	180	ATR	0.00	0	90	-90	-0.5	-1.5	90	+2.5
17	269614	M	75	L	1/60	45.00	45.25	19.50	0.25	90	WTR	6/12	6/12	6/12	1.50	90	WTR	1.25	90	180	-90	-0.5	-2	90	+3
18	269318	M	65	R	2/60	43.75	44.75	22.00	1.00	90	WTR	6/24	6/18	6/18	1.00	90	WTR	0.00	0	180	0	-1	-1	90	+3
19	269785	M	70	R	PL PR	46.75	47.00	14.00	0.25	180	ATR	6/24	6/24	6/18	1.00	90	WTR	1.25	90	90	0	-1	-1	90	+3
20	269813	F	60	R	6/60	44.00	44.00	22.00	0.00	0	NIL	6/12	6/12	6/12	0.30	90	WTR	0.30	90	90	0	-1	-0.5	180	+3
21	270656	M	70	L	6/36	43.75	43.50	21.00	0.25	180	ATR	6/24	6/18	6/18	0.60	90	WTR	0.85	90	90	0	-1	-0.5	90	+3

					Pre OP							Post Operative													
						Keratometry			Astigmatism			BCVA			Astigmatism			SIA				Refraction			
Sl. No.	**IP No.**	**Gender**	**Age (Years)**	**Eye**	**Visual Acuity**	**K_H**	**K_V**	**PCIOL Power**	**Diopters (K1)**	**Axis (A1)**	**Type**	**Day 1**	**Day 15**	**Day 45**	**Diopters (K3)**	**Axis (A3)**	**Type**	**K2**	**A2**	**Intended Angle**	**Angle of error**	**Sphere**	**Cylinder**	**Axis**	**Near addition**
22	272338	M	60	R	6/36	43.50	47.50	21.00	0.00	0	NIL	6/12	6/9	6/9	1.00	90	WTR	1.00	90	90	0	-	-1.5	90	+3
23	272696	M	60	R	6/12	43.00	41.00	23.00	2.00	180	ATR	6/18	6/9	6/9	1.50	90	WTR	3.50	90	90	0	-.75	-1	90	+3
24	272665	M	60	L	1/60	42.50	44.00	23.50	1.50	90	WTR	6/9	6/9	6/9	1.70	90	WTR	0.20	90	180	-90	-1	-1	90	+3
25	272654	F	80	L	PLPR	48.00	46.00	22.50	2.00	180	ATR	6/12	6/9	6/9	1.00	180	ATR	1.00	90	90	0	-1	-1.5	90	+3
26	272983	F	60	L	1/60	45.00	44.50	20.50	0.50	90	WTR	6/12	6/12	6/12	0.25	90	WTR	0.25	180	180	0	-	-	-	+3
27	273191	M	65	L	6/60	48.50	49.00	20.50	0.50	90	WTR	6/12	6/9	6/9	0.00	0	NIL	0.50	180	180	0	+1.0	+1.0	180	+3
28	272987	F	60	L	PLPR	46.25	46.50	19.50	0.25	90	WTR	6/18	6/12	6/12	1.00	180	ATR	1.25	180	180	0	-1	-1	180	+3
29	273209	M	65	L	6/60	43.00	43.00	22.00	0.00	0	NIL	6/12	6/9	6/9	0.70	90	WTR	0.70	90	90	0	-	-1.5	90	+3
30	270251	M	58	L	6/24	43.50	42.00	22.50	1.50	180	ATR	6/6	6/6	6/6	0.50	90	WTR	2.00	90	90	0	-1.5	-1.5	90	+3
31	272701	M	60	L	6/24	43.75	44.25	19.00	0.50	90	WTR	6/9	6/9	6/6	1.00	90	WTR	0.50	90	180	-90	-	-	-	+3
32	274027	M	60	R	6/60	42.00	43.00	22.00	1.00	90	WTR	6/12	6/12	6/12	1.25	90	WTR	0.25	90	180	-90	-	-	-	+3
33	274477	M	66	L	6/18	45.25	45.00	21.50	0.25	180	ATR	6/9	6/9	6/9	1.25	90	WTR	1.50	90	90	0	-	-1.5	90	+3
34	274456	M	70	R	6/24	42.75	42.00	20.50	0.75	180	ATR	6/6	6/6	6/6	0.30	90	WTR	1.05	90	90	0	-	-0.5	90	+3
35	274380	F	48	L	1/60	47.00	46.50	22.50	0.50	180	ATR	6/12	6/9	6/9	1.25	90	WTR	1.75	90	90	0	-0.5	-0.5	90	+3
36	274405	M	60	L	6/36	44.50	45.00	21.50	0.50	90	WTR	6/6	6/6	6/6	0.50	90	WTR	0.00	0	180	0	-	-1.0	90	+3
37	274781	M	45	L	1/60	44.75	45.50	22.00	0.75	180	ATR	6/9	6/9	6/9	0.25	90	WTR	1.00	90	90	0	-0.5	-1.5	90	+3
38	274743	M	60	R	6/36	42.25	41.75	20.00	0.50	180	ATR	6/24	6/9	6/9	0.25	90	WTR	0.75	90	90	0	-0.5	-1.0	90	+3
39	274779	M	55	R	6/18	45.00	43.50	15.50	1.50	180	ATR	6/18	6/18	6/18	1.00	180	ATR	1.00	90	90	0	-1.0	-1.0	180	+3
40	275299	F	60	L	PLPR	42.25	42.00	21.00	0.25	180	ATR	6/12	6/9	6/9	0.25	90	WTR	0.50	90	90	0	-	-	-	+3

					Pre OP							Post Operative													
						Keratometry			Astigmatism			BCVA			Astigmatism			SIA				Refraction			
Sl. No.	**IP No.**	**Gender**	**Age (Years)**	**Eye**	**Visual Acuity**	**K_H**	**K_V**	**PCIOL Power**	**Diopters (K1)**	**Axis (A1)**	**Type**	**Day 1**	**Day 15**	**Day 45**	**Diopters (K3)**	**Axis (A3)**	**Type**	**K2**	**A2**	**Intended Angle**	**Angle of error**	**Sphere**	**Cylinder**	**Axis**	**Near addition**
41	275306	M	60	R	6/18	42.50	42.00	21.50	0.50	180	ATR	6/9	6/9	6/9	0.50	90	WTR	1.00	90	90	0	-	-	-	+3
42	275281	F	60	L	1/60	40.75	41.25	21.00	0.50	90	WTR	6/9	6/9	6/9	0.50	90	WTR	0.00	0	180	0	-0.5	-0.5	180	+3
43	275307	F	60	R	6/60	43.25	43.00	22.00	0.25	90	WTR	6/6	6/6	6/6	0.60	90	WTR	0.35	90	180	-90	-	-	-	+3
44	276009	F	60	L	6/60	43.25	43.00	20.50	0.25	180	ATR	6/9	6/9	6/9	0.75	90	WTR	1.00	90	90	0	-	+1	180	+3
45	276014	F	60	R	6/12	45.00	45.00	22.00	0.00	0	NIL	6/9	6/9	6/9	0.25	90	WTR	0.25	90	90	0	-	-	-	+3
46	276027	F	60	L	6/24	43.50	43.00	22.00	0.50	180	ATR	6/9	6/9	6/9	0.25	90	WTR	0.75	90	90	0	-1.0	-0.5	180	+3
47	276236	F	58	L	PL PR	45.25	45.00	21.50	0.25	180	ATR	6/6	6/9	6/9	0.25	90	WTR	0.50	90	90	0	-	-.1	90	+3
48	294802	F	75	R	PL PR	43.25	44.00	23.00	0.75	90	WTR	6/12	6/6	6/6	0.50	90	WTR	0.25	180	180	0	-	-1.0	90	+3
49	295726	M	70	L	PL PR	43.50	43.75	21.00	0.25	90	WTR	6/9	6/6	6/6	0.25	90	WTR	0.00	0	180	0	-	-0.5	90	+3
50	295755	F	75	L	6/24	44.50	43.75	20.00	1.00	180	ATR	6/9	6/12	6/12	0.50	180	ATR	0.50	90	90	0	-	-	-	+3

ANNEXURE IV

KEY TO MASTER CHART

A1 – Axis of preoperative astigmatism

A2 – Axis of surgically induced astigmatism

A3 – Axis of postoperative astigmatism

ATR – Against the rule astigmatism

BCVA – Best corrected visual acuity

F – Female

K1 – Preoperative astigmatism in diopters

K2 – Surgically induced astigmatism in diopters

K3 – Postoperative astigmatism in diopters

KH – Keratometry reading in horizontal meridian

KV – Keratometry in vertical meridian

L – Left eye

M – male

PL – Perception of light

PR – Projection of rays

R – Right eye

SIA – Surgically induced astigmatism

WTR – With the rule astigmatism